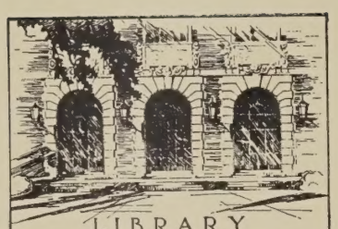

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Aveling & Porter, Ltd. .. .. Rochester
Blackstone & Co., Ltd. .. .. Rutland Works, Stamford
Davey, Paxman & Co., Ltd. .. Colchester
Fowler, J., & Co. (Leeds), Ltd.. Leeds
Garrett, R., & Sons, Ltd. .. Leiston Works, Suffolk
Hornsby, R., & Sons, Ltd. . Grantham
Horsfall Destructor Co., Ltd. .. 17, Victoria Street, S.W.
Marshall, Sons & Co., Ltd. .. Gainsborough
Ransomes, Sims & Jefferies, Ld. Ipswich
Robey & Co., Ltd .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Samuelson & Co., Ltd. .. .. Britannia Wks., Banbury, Oxon.

Air Compressors.

A.E.G. Electric Company, Ltd. Pembroke Hse., 133-135, Oxford Street, W.
Alley & Maclellan, Ltd. .. .. Sentinel Works, Glasgow
Anag Hilpert .. .. .. Glochenhofstrasse, 6, Nurnberg, Germany
Bailey, W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Belliss & Morcom, Ltd. .. .. Ledsam St. Works, Birmingham
British Humboldt Engineering Co., Ltd. .. .. } Dixon House, Lloyd's Avenue, E.C.
Broom & Wade, Ltd. .. .. High Wycombe
Brotherhood, P., Ltd. .. .. 53, Parliament Street, S.W.
Chesters Renfrew Engineering Co., Ltd. .. .. Renfrew, Scotland
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Consolidated Pneumatic Tool Co., Ltd. .. .. } Palace Chambers, 9, Bridge Street, Westminster, S.W.
Craig, A. F., & Co., Ltd.. Paisley, N.B.
Davey, Paxman & Co., Ltd. .. Colchester
Davy Brothers, Ltd. .. .. Sheffield
Daw, A. & Z. .. .. .. 11, Queen Victoria Street, E.C.
Entwisle & Gass, Ltd. .. .. Bolton
Escher Wyss & Co. .. .. 109, Victoria Street, S.W.
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Hughes & Lancaster .. .. 16, Victoria Street, S.W.
Ingersoll-Rand Co. .. .. 165, Queen Victoria St., E.C.
Jackman, J. W., & Co., Ltd. .. Caxton House, Westminster, S.W.
Korting Brothers, Ltd. .. .. 53, Victoria Street, S.W.
Lacy-Hulbert & Co., Ltd. .. 91, Victoria Street, S.W.
Lillesha'l Company, Ltd. .. Oakengates, Shropshire
Manlove, Alliott & Co., Ltd. .. Nottingham
Murray, Workman & Co., Ltd. Glasgow
Musker, C. & A., Ltd. .. .. Liverpool
Parsons, C. A., & Co. .. .. Heaton Works, Newcastle-on-Tyne
Price Air Lift Pump Co. .. Broadheath, near Manchester
Reavell & Co., Ltd. .. .. Ipswich
Richards, Geo., & Co., Ltd. .. Broadheath, near Manchester
Robey & Co., Ltd. .. .. .. Lincoln
Sandycroft Foundry Co., Ltd. .. Chester
Schäffer & Budenberg, Ltd. .. Whitworth Street, London Road, Manchester
Schram, Harker & Co. .. .. Cannon Street House, E.C.
Seagers, Ltd. .. .. .. Dartford
Siebe, Gorman & Co., Ltd. .. Neptune Works, Lambeth, S.E.
Thwaites Brothers, Ltd.. .. Bradford
Tilghman's Patent Sand Blast Co., Ltd. .. .. .. Broadheath, near Manchester
Vauxhall & West Hydraulic Engineering Co., Ltd. .. .. 45, Leadenhall Street, E.C.
Walker Bros. (Wigan), Ltd. .. Pagefield Ironworks, Wigan
Westinghouse Brake Co., Ltd.. York Road, King's Cross, N.
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Air Pump Discharge Recorder.

Lea Recorder Co. .. .. .. 28, Deansgate, Manchester

Air Pumps.

A.E.G. Electric Company, Ltd. Pembroke Hse., 133-135, Oxford Street, W.
Belliss & Morcom, Ltd. .. .. Ledsam St. Works, Birmingham
Borsig, A. .. .. Tegel, Berlin
British Westinghouse Electric and Manufacturing Co., Ltd. Trafford Park, Manchester
Caird & Rayner .. .. .. 777, Commercial Road, Limehouse, E.
Carruthers, J. H., & Co., Ltd. .. Polmadie Ironworks, Glasgow
Contra'to Condenser & Kinetic Air Pump Co., Ltd. .. .. } 4, Lloyd's Avenue, Fenchurch Street, E.C.
Friedenthal, F. .. .. .. River Engine Works, Preston
Manlove, Alliott & Co., Ltd. .. Nottingham
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Potter, A. C., & Co. .. .. Lant Street, S.E.
Price Air Lift Pump Co. .. Broadheath, near Manchester
Schäffer & Budenberg, Ltd. .. Whitworth Street, London Road, Manchester
Stott, S. S., & Co. .. .. .. Haslingden, near Manchester
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Alloys.—*(See Metals, &c.)*

Aluminium and Aluminium Goods.

British Aluminium Co., Ltd. .. 109, Queen Victoria St., E.C.
British Insulated & Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
Sterling Metals, Ltd. .. .. St. George's Works, Coventry
Ward, Thos. W., Ltd. .. .. Albion Works, Sheffield

Ammunition.

Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Vickers Limited .. .. .. Sheffie'd

Anchors.

Jessop, W., & Sons, Ltd. .. Sheffield
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Steel Co. of Scot'and, Ltd. .. 23, Royal Exchange Square, Glasgow
Wright, Joseph, & Co. .. .. Tipton

Arbitrators.

Kirk, W., Price & Co. .. .. 46, Watling Street, E.C.; and Albert Square, Manchester

Armour Plates.

Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Brown, John, & Co., Ltd. .. Sheffield
Cammell Laird & Co. Ltd. .. Cyclops Steel & Iron Works,
Vickers Limited .. .. .. Sheffield [Sheffield

Asbestos Goods, Fittings, &c.

Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Billington & Newton, Ltd. .. Longport, Staffordshire
Millar, Dennis & Co. .. .. Victoria Works, Bradford
Smith Bros. & Co. (Hyson), Ltd. Nottingham

Ash Ejectors.

Trewent, F. J., & Proctor .. 43, Billiter Buildings, E.C.

Astronomical Instruments.—*(See Instruments, Surveying.)*

Auctioneers, Valuers and Surveyors (Engineering).

Caiss, Cecil, & Kellett.. .. 55, Temple Row, Birmingham
Fuller, Horsey, Sons & Cassell.. 11, Billiter Square, E.C.
Kirk, W., Price & Co. . .. 46, Watling Street, E.C.; and Albert Square, Manchester

Axles.

Baume & Marpent .. .. Moyaux, Haine-St.-Pierre, Belgium
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bessemer, Henry, & Co., Ltd. .. Sheffield
Blake Boiler, Wagon & Engineering Co., Ltd. .. .. .. Darlington
Brown, Bayley's Steel Works, Ltd. Sheffield
Brown, John, & Co., Ltd. .. Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Glasgow Railway Eng. Co., Ltd. Govan, Glasgow
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Jessop, W., & Sons, Ltd.. .. Sheffield
Mair, Nixon & Ferguson, Ltd... Kettering
Patent Shaft & Axletree Co., Ltd. Wednesbury
Vickers Limited .. .. .. Sheffield

Barges and Lighters (Iron and Steel).

Alley & MacLellan, Ltd. .. Sentinel Works, Glasgow
Braby, Fred., & Co., Ltd. .. Fitzroy Wks., 352 to 364, Euston Road, N.W.
Finch, Edward, & Co., Ltd. .. Chepstow
Smith's Dock Co., Ltd. .. .. South Bank, S.O., Yorks.
Thornycroft, J. I., & Co., Ltd. .. Southampton
Vospel & Co., Ltd. .. .. Broad Street, Portsmouth
Watson, J. S. .. .. .. Gainsborough

Barrows.

Ash, Joseph, & Son .. .. Rea Street South, Birmingham
Cockburns Limited .. .. Clydesdale Works, Cardonald, N.B.
Mackies, Ltd. .. .. .. Berks Ironworks, Reading

Bars (Steel and Iron).

Allen, Edgar, & Co., Ltd. .. Sheffield
Beardmore, William, & Co., Ltd. Parkhead Ironworks, Glasgow
Bessemer, Henry, & Co., Ltd. .. Sheffield
Brown, Bayley's Steel Works, Ltd. Sheffield
Colville, David & Sons, Ltd. .. Motherwell, near Glasgow
Crowther, Henry, & Sons, Ltd. Cleckheaton
Firth, William, Ltd. .. Water Lane, Leeds [Wishaw
Glasgow Iron & Steel Co., Ltd... Wishaw Iron & Steel Works,
Hadfield's Steel Foundry Co., Ld. Hecla Works, Sheffield
Jessop, W., & Sons, Ltd. .. Sheffield
Leeds Forge Co., Ltd. .. .. Leeds
Motherwell Iron & Steel Co. .. Motherwell, N.B.
Patent Shaft & Axletree Co., Ld. Wednesbury
Scott's, Walter, Ltd. .. .. Leeds Steel Works, Leeds
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Steel Co. of Scotland, Ltd. .. 23, Royal Exchange Sq., Glasgow
Trussed Concrete Steel Co., Ltd. 50, Caxton House, Westminster, S.W.

Bearings (Ball and Roller).—*(See also Plummer Blocks.)*

Auto Machinery Co., Ltd. .. Coventry
Broom & Wade, Ltd. .. .. High Wycombe
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham
Goodchild, Geo. W., & Partner 30-32, Farringdon Road, E.C.
Hoffmann Manufacturing Co., Ld. Chelmsford
Main, Geo., & Co. .. .. .. Packe Street, Loughborough
Mair, Nixon & Ferguson, Ltd... Kettering
Royersford Foundry & Machine Co. (Inc.) .. .. 149, Queen Victoria Street, E.C.
Skefko Ball Bearing Co., Ltd... Carlton House, Regent St., S.W.

Bearings (Thrust and Footstep).

Broom & Wade, Ltd. .. .. High Wycombe

Belt Treatment.

Thomas & Bishop .. .. .. 119-125, Finsbury Pavement, E.C.

Belt Fasteners.

Boosey, W. E., & Co. .. .. 60, Water Lane, S.W.
Buhler, Hans, & Co. .. .. Esslingen, a.N., Germany
Phillips, J. W. & C. J. .. .. 23, College Hill, Cannon St., E.C.
Stone, J. B., & Co. .. .. 135, Finsbury Pavement, E.C.
Thomas & Bishop .. .. .. 119-125, Finsbury Pavement, E.C.

Belting (Leather, Canvas, &c.).

Cole, Henry A., & Co. .. .. Coronet Works, Liverpool
Gandy's Belt Manfg. Co., Ltd.. Wheatland Works, Seacombe, Cheshire
Gutta Percha & Rubber Mfg. Co. of Toronto, Ltd... .. .. Toronto, Canada
Hendry, James .. .. .. Bridgeton, Glasgow
India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, Essex
Lewis & Tylor, Ltd. .. .. Cardiff, England
McIntosh, Peter, & Sons .. 129c, Stockwell Street, Glasgow
Midd emore & Lamplugh, Ltd. Birmingham
New York Belting & Packing Co., Ltd. .. .. 11-13, Southampton Row W.C.
Reddaway, F., & Co., Ld. (Camel Brand) .. .. Pendleton, Manchester
Tullis, John, & Son, Ltd. .. St. Ann's Leather Wks., Glasgow
Webb & Son (Combs.), Ltd. .. Combs Tannery, Stowmarket
Willcox, W. H., & Co., Ltd. .. 23, Southwark Street, S.E.

Bleaching Machinery.

Edmeston, A., & Sons .. .. Patricroft, nr. Manchester
Entwisle & Gass, Ltd. .. .. Bolton

Blowers.—*(See Fans.)*

Boats.—*(See Motor Boats and Shipbuilders.)*

Boiler Compositions.—*(See Disincrustants.)*

Boiler Coverings.—*(See Non-Conducting Composition.)*

Boiler Furnaces.

Bennis, Ed., & Co., Ltd... .. Bolton
Brown, John, & Co., Ltd. .. Sheffield
Donkin Co., Ltd. (The Bryan) .. Chesterfield
Dowson & Mason Gas Plant Co., Ltd. .. .. Levenshulme, Manchester
Leeds Forge Co., Ltd. .. .. Leeds

Boiler Inspection Societies.

Manchester Steam Users' Association .. .. 9, Mount Street, Manchester

Boiler Insurance Companies.

National Boiler and General Insurance Co., Ltd .. .. } St. Mary's Parsonage, Manchester

Boiler Manholes.

Leeds Forge Co., Ltd. .. .. Leeds
M'Neil, C. .. .. Kinning Park Ironworks, Glasgow
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham

Boiler Mountings and Scientific Apparatus.

Amag-Hilpert .. .. .. Glochenhofstrasse, 6, Nurnberg, Germany
Baldwin, James, & Co. .. .. Devonshire Brass Works, Keighley
Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Bailey, W. H., & Co., Ltd. .. Albion Wks, Salford, Manchest'r
Billington & Newton, Ltd. .. Longport, Staffordshire
Cambridge Scientific Instrument Co., Ltd. .. .. .. Cambridge
Cockburns Limited .. .. Clydesdale Works, Cardonald, near Glasgow
Crosby Steam Gage & Valve Co. 147, Queen Victoria Street, E.C.
Eureka Pamp Company.. .. 53, Bothwell Street, Glasgow
France & Morgan .. .. .. Whitefield Brass Wks., Govan, Glasgow
Green & Boulding, Ltd. .. .. 28, New Bridge Street, E.C.
Griffin, John J., & Sons, Ltd. .. Kemble St., Kingsway, W.C.
Hopkinson, J., & Co., Ltd. .. Huddersfield
Howden, James, & Co. .. .. Scotland Street, Glasgow
Hubner & Mayer .. .. .. Vienna X1X, 6
Kater & Ankersmit .. .. 34, Fenchurch Street, E.C.
Lunken Company, Inc. .. .. 35, Great Dover Street, S.E.
Millar, Dennis & Co. .. .. Victoria Works, Bradford
National Boiler & General Insurance Co., Ltd. .. .. } St. Mary's Parsonage, Manchester
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Royles Limited .. .. .. Irlam, near Manchester
Russell, James, & Sons, Ltd. .. Crown Tube Wks., Wednesbury
Schäffer & Budenberg, Ltd. .. Whitworth St., London Road, Manchester
Smith, Sydney, & Sons, Ltd. .. Ba ford Brass Wks, Nottingh'm
Spencer, John, & Son, Ltd. .. Newburn Steel Wks., Newcastle-on-Tyne
Storey, I., & Sons .. .. .. Empress Foundry, Manchester
Thornycroft, J. I., & Co., Ltd... Southampton
Treasure, J. B., & Co. .. .. 8, Vauxhall Road, Liverpool
Turnbull, Alex., & Co., Ltd. .. Bishopbriggs, Glasgow

Boiler Plates.—*(See Plates, Iron & Steel.)*

Boiler Tube Scrapers.

Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C

Boilers (Steam).—*(See also Boilers, Water-tube).*

Abbott & Co. (Newark), Ltd. .. Newark-on-Trent
Bellamy, John, Ltd. .. .. Millwall, E.
Blake Boiler, Wagon & Engineering Co., Ltd. .. .. .. Darlington
Bodley Brothers & Co. .. .. Exeter
British Humboldt Engineering Co., Ltd. .. .. } Dixon House, Lloyd's Avenue, E.C.
British Niclausse Boiler Co., Ld. Caxton House, Westminster, S.W.
Burnet, L., & Co. .. .. .. Govan, Glasgow
Burrell, C., & Sons, Ltd. .. Thetford
Chaplin Alex., & Co. .. .. Govan, Glasgow
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Clayton, Son, & Co., Ltd. .. Hunslet, Leeds
Cochran & Co., Annan, Ltd. .. Annan, N.B.
Coltman, H., & Sons .. .. Loughborough
Coitman, Walter W., & Co., Ltd. Central Boiler Works, Loughborough
Craig, A. F., & Co., Ltd.. .. Paisley, N.B.
Dalglish, A. & W... .. .. Pollokshaws, Glasgow
Davey, Paxman & Co., Ltd. .. Colchester
Davy Brothers, Ltd. .. .. Sheffield
Day, Summers & Co., Ltd. .. Northam Ironworks, Southampton
Deadman, A., & Co., Ltd. .. King's Lynn
Escher Wyss & Co. .. .. 109, Victoria Street, S.W.
Fowler, J., & Co. (Leeds), Ltd... Leeds
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Garrett, R., & Sons, Ltd. .. Leiston Works, Suffolk
Grantham Boiler & Crank Co., Ld. Grantham
Hanna, Donald & Wilson .. Paisley, N.B.
Hannoversche Maschinenbau-Actien-Gesellschaft, vormals Georg Egestorff .. .. .. } Hannover-Linden, Germany
Hawthorn, R. & W., Leslie & Co., Ltd. .. .. Newcastle-on-Tyne
Hayes, Edward .. .. .. Stony Stratford, Wolverton
Hindley, E. S., & Sons .. .. Bourton, Dorset; and 11, Queen Victoria Street, E.C.
Howden, James, & Co. .. .. Scotland Street, Glasgow
Hudson, Thomas, Ltd. .. .. Coatbridge, N.B.
Isca Foundry & Engineering Co. Newport, Mon.
Kincaid, John G., & Co., Ltd. .. Clyde Foundry, Greenock
Lees, T. & R. .. .. .. Hollinwood, by Manchester
Maccoll & Pollock, Ltd. .. .. Sunderland
Manlove, Alliott & Co., Ltd. .. Nottingham
Marriott & Graham .. .. Plantation Boiler Works, Glasgow
Marshall, Sons & Co., Ltd. .. Gainsborough
McKie & Baxter .. .. .. Copland Wks., Govan, Glasgow
Merryweather & Sons .. .. 63, Long Acre, W.C.
Mumford, A. G., Ltd. .. .. Culver St. Ironw'ks, Colchester
Musgrave, John, & Sons, Ltd. .. Globe Iron Works, Bolton
North-Eastern Marine Engineering Co., Ltd. .. .. .. } Northumberland Works, Wallsend-on-Tyne
Penman & Co., Ltd. .. .. Strathclyde Street, Glasgow
Piggott, Thos., & Co., Ltd. .. Birmingham
Plenty & Son, Ltd. .. .. Eagle Ironworks, Newbury, Berks.
Ransomes, Sims & Jefferies, Ltd. Ipswich
Robey & Co., Ltd... .. .. Lincoln
Rollo, David, & Sons .. .. Fulton Engine Wks., Liverpool
Rose, Downs & Thompson, Ltd. Hull
Ross & Duncan .. .. .. Glasgow
Rowan, David, & Co. .. .. Glasgow
Rowland, B. R., & Co., Ltd. .. Climax Works, Reddish, near Manchester
Russell, Geo., & Co., Ltd. .. Motherwell, near Glasgow
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Schram, Harker & Co. .. .. Cannon Street House, E.C.
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Smedley Brothers, Ltd. .. .. Belper, Derbyshire
Stork Brothers & Co. .. .. Hengelo, Holland
Sulzer Bros... .. .. .. 30, Norfolk St., Strand, W.C.
Tangyes Limited .. .. .. Cornwall Works, Birmingham
Thornycroft, J. I., & Co., Ltd... Southampton
Toward, T., & Co., Ltd. .. .. 9, Ouseburn, Newcastle-on-Tyne
Vosper & Co., Ltd. .. .. Portsmouth
Wallsend Slipway & Engineering Co., Ltd. .. .. Wallsend
White, J. Samuel, & Co., Ltd... East Cowes, Isle of Wight
Wilson, William, & Co. .. .. Lilybank Boiler Wks., Glasgow
Yarrow & Co., Ltd. .. .. Glasgow
Yorkshire Boiler Co., Ltd. .. City Square, Leeds

Boilers (Water-tube).

Babcock & Wilcox, Ltd. .. .. Oriel House, Farringdon Street, E.C.
Beeley, Thomas, & Son, Ltd. .. Hyde Junction Ironwks, Hyde near Manchester
British Niclausse Boiler Co., Ld. Caxton House, Westminster S.W.
Davey, Paxman & Co., Ltd. .. Colchester
Hawksley, Wild & Co., Ltd. .. Sheffield
Hudson, Thomas, Ltd. .. .. Sheepford Works, Coatbridge, N.B.
Mumford, A. G., Ltd. .. .. Culver St. Ironw'ks., Colchester
Musgrave, John, & Sons, Ltd. .. Globe Iron Works, Bolton
Normand, Augustin, Ltd. .. 67, Rue du Perrey, Le Havre, France
Penman & Co., Ltd. .. .. Strathclyde Street, Glasgow
Rowland, B. R., & Co., Ltd. .. Climax Works, Reddish, near Manchester
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Stirling Boiler Co., Ltd. .. 58, Victoria Street, S.W.
Thornycroft, J. I., & Co., Ltd... Southampton
White, J. Samuel, & Co., Ltd... East Cowes, Isle of Wight
Yarrow & Co., Ltd. .. .. Glasgow

Bolt and Nut Making Machinery.

Greenwood & Batley Ltd. .. Albion Works, Leeds
Platt, Samuel, Ltd. .. .. Wednesbury

Bolts, Rivets, Nuts, Screws, &c.

Armstrong, Stevens & Son, Ltd. Whittall Street, Birmingham
Bayliss, Jones & Bayliss, Ltd... Wolverhampton
Beebee, A. .. .. Wednesbury
Fastnut, Ltd. .. .. .. 115, Newgate Street, E.C.
Grover & Co., Ltd. .. .. Wharf Road, N.
Guest, Keen & Nettlefolds, Ltd. 16, Broad Street, Birmingham
Kalker, E., & Co. .. .. .. Coventry
Kirby Banks Screw Co., Ltd. .. Meadow Lane, Leeds
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow
Marsden, S., & Son, Ltd. .. .. London Road, Manchester
Miller, Wm., & Sons .. .. Wolverhampton
Patent Shaft & Axletree Co., Ld. Wednesbury
Phœnix Bolt & Nut Co. .. .. Handsworth, nr. Birmingham

Boring Tools and Machinery.

New Calyx Drill & Boring Co. Ltd. .. .. } 120, East Ferry Road, Millwall, E.
Oil Well Supply Co. .. .. Dashwood House, 9, New Broad Street, E.C.
Potter, A. C., & Co. .. .. Lant Street, E.C.
Shaft Freezing Co., Ltd... .. 11, Ironmonger Lane, E.C.

Brakes (Railway).

Consolidated Brake & Engineering Co., Ltd. .. .. .. } Spencer House, South Place, E.C.
Vacuum Brake Co., Ltd. .. 32, Queen Victoria Street, E.C.
Westinghouse Brake Co., Ltd... York Road, King's Cross, N.

Brass Founders and Brass Finishers.

Bailey, W. H., & Co., Ltd. .. Albion Wks, Salford, Manchest'r
Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Billington & Newton, Ltd. .. Longport, Staffordshire
Bodley Brothers & Co. .. .. Exeter
Broadfoot, John, & Sons, Ltd... Whiteinch, Glasgow
Broughton Copper Co., Ltd. .. Manchester
Crosby Steam Gage & Valve Co. 147, Queen Victoria Street, E.C.
Delta Metal Co., Ltd. .. .. East Greenwich, S.E.
France & Morgan .. .. .. Whitefield Brass Wks., Govan, Glasgow
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Lunken Company, Inc. .. .. 35, Great Dover Street, S.E.
Millar, Dennis & Co. .. .. Victoria Works, Bradford
North-Eastern Marine Engineering Co., Ltd. .. .. .. } Northumberland Wks, Wallsend-on-Tyne
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Schäffer & Budenberg, Ltd. .. Whitworth St., London Road, Manchester
Sterling Metals, Ltd. .. .. St. George's Works, Coventry
Steven & Struthers .. .. Glasgow
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironwks., Glasgow
Storey, I., & Sons, Ltd. .. .. Empress Foundry, Manchester
Thornycroft, J. I., & Co., Ltd... Southampton
Wallsend Slipway & Engineering Co., Ltd. .. .. Wallsend

Brewery Plant.

Blair, Campbell & McLean, Ltd. Woodville St., Govan, Glasgow
Pontifex & Wood, Ltd. .. .. Union Foundry, Derby

Brick and Tile-Making Machinery.

Bradley & Craven, Ltd. .. .. Westgate Common Foundry, Wakefield
British Humboldt Engineering Co., Ltd. .. .. } Dixon House, Lloyd's Avenue, E.C.
Johnson, Wm., & Sons (Leeds), Ld. Armley, Leeds
Whittaker, C., & Co., Ltd. .. Accrington

Bridge Foundation Cylinders.

Clay Cross Co. .. .. .. Clay Cross, near Chesterfield
Hanna, Donald & Wilson .. Paisley
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Isca Foundry & Engineering Co. Newport, Mon.
Morton, Francis, & Co., Ltd. .. Garston, Liverpool

Bridges.—*(See Structural Engineering.)*

Briquette Machinery.

Johnson, Wm., & Sons (Leeds), Ld. Armley, Leeds

Buffers.

Brown, John, & Co., Ltd. .. Sheffield
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Midland Railway Carriage and Wagon Co., Ltd. .. .. Abbey Works, Shrewsbury
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Turton, T., & Sons, Ltd. .. Sheaf Works, Sheffield

Buildings (Iron & Steel).—*(See Structural Engineering.*

Buoys (Iron and Steel).

Bellamy, John, Ltd. .. .. Millwall, E.
British Welding Co., Ltd. .. 58, Victoria Street, Westminster, S.W.
Toward, T., & Co., Ltd. .. .. 9, Ouseburn, Newcastle-on-Tyne

Cable Laying Machinery.
Clarke, Chapman & Co., Lt .. Victoria Works, Gateshead-on-Tyne

Cables (Electric Light, Telegraph and Telephone).
British Insulated and Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
Dennis, W. F., & Co. .. .. 49, Queen Victoria Street, E.C.

Capstans (Steam, Hydraulic & Electric).
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Booth, Joseph, & Bros., Ltd. .. Rodley, Leeds
Campbell & Calderwood .. .. Soho Engine Works, Paisley
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Sandycroft Foundry Co., Ltd. .. Chester
Wild, M. B & Co., Ltd. .. Nechells, Birmingham

Carbon for Electrical Purposes (Manufacturers of).
Le Carbone .. .. 17, Water Lane, Great Tower Street, E.C.

Carburetters and Vaporisers.
Thornycroft, J. I., & Co., Ltd. Basingstoke

Carriage (Railway) Builders.
Baume & Marpent .. .. Moyaux, Haine-St.-Pierre, Belgium
Glasgow Railway Eng. Co., Ltd. Govan, Glasgow
Hurst, Nelson & Co., Ltd. .. Glasgow Rolling Stock and Plant Works, Motherwell
MacLellan, F. & W., Ltd. .. Clutha Works, Glasgow
Metropolitan Amalgamated Railway Carriage & Wagon Co., Ld. Saltley, Birmingham
Midland Railway Carriage and Wagon Co., Ltd. .. .. Abbey Works, Shrewsbury
Pickering, R. Y., & Co., Ltd. .. Wishaw, nr. Glasgow

Carriage (Railway) Fittings.
Kaye, Joseph, & Sons, Ltd. .. 93, High Holborn, W.C.

Cartridge Making Machinery.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Taylor & Challen, Ltd. .. .. Birmingham

Case-Hardening Materials.
Palfreyman, W. H., & Co. .. 17, Goree-Piazzas, Liverpool

Castings (Iron).
Alley & MacLellan, Ltd. .. Sentinel Works, Glasgow
Ashmore, Benson, Pease & Co., Ltd. Stockton-on-Tees
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bodley Brothers & Co. .. .. Exeter
Clay Cross Co. .. .. .. Clay Cross, near Chesterfield
Craig, A. F., & Co., Ltd. .. Paisley, N.B.
Daniell, S. A., Ltd. .. .. Birmingham
Darlington Forge Co., Ltd. .. Darlington
Entwisle & Gass, Ltd. .. .. Bolton
Finch, Edward, & Co., Ltd. .. Chepstow
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Herbert, Alfred, Ltd. .. .. Coventry
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Isca Foundry & Engineering Co. Newport, Mon.
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Mackies Limited .. .. .. Berks Ironworks, Reading
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Midland Railway Carriage and Wagon Co., Ltd. .. .. Abbey Works, Shrewsbury
Morton, Francis, & Co., Ltd. .. Garston, Liverpool
North-Eastern Marine Engineering Co., Ltd. .. .. .. Northumberland Wks., Wallsend-on-Tyne
Piercy & Co., Ltd. .. .. .. Birmingham
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Ransome, A., & Co., Ltd. .. Stanley Wks., Newark-on-Trent
Rollo, David, & Sons .. .. Fulton Engine Wks., Liverpool
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Shaw, W., & Co. .. .. .. Wellington Cast Steel Foundry, Middlesbro'-on-Tees
Storey, I., & Sons, Ltd. .. .. Empress Foundry, Manchester
Thornycroft, J. I., & Co., Ltd. .. Southampton
Unbreakable Pulley & Mill Gearing Co., Ltd. .. .. .. 48, West Gorton, Manchester
Vickers Limited .. .. .. Sheffield
Walker Bros. (Wigan), Ltd. .. Pagefield Ironworks, Wigan
Wallsend Slipway & Engineering Co., Ltd. .. .. Wallsend
Wallwork, Henry, & Co., Ltd. .. Manchester

Castings (Malleable Iron).
Bagshawe & Co., Ltd. .. .. Dunstable Works, Dunstable
Hadfield's Steel Foundry Co., Ld. Hecla Works, Sheffield
Parker Foundry Co. .. .. Derby
Tangyes Limited .. .. .. Cornwall Works, Birmingham
Vickers Limited .. .. .. Sheffield
Wallwork, Henry, & Co., Ltd. .. Manchester

Castings (Steel).
Allen, Edgar, & Co., Ltd. .. Imperial Steel Works, Sheffield
Ashmore, Benson, Pease & Co., Ltd. Stockton-on-Tees
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bessemer, Henry, & Co., Ltd. .. Sheffield
Brown, Bayley's Steel Works, Ld. Sheffield
Brown, John, & Co., Ltd. .. Sheffield
Cammell Laird & Co. Ltd. .. Cyclops Steel & Iron Works, Sheffield
Colville, David, & Sons, Ltd. .. Motherwell, near Glasgow
Darlington Forge Co., Ltd. .. Darlington
Fairley, James, & Sons .. .. Shadwell Street, Birmingham
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Jessop, Wm., & Sons, Ltd. .. Sheffield
Kidston, A. G., & Co. .. .. 155, Fenchurch Street, E.C.
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Parker Foundry Co. .. .. Derby
Reichwald, August, Ltd. .. Finsbury Pavement House, E.C.
Reiner, Arthur, & Co. .. .. 63, Queen Victoria Street, E.C.
Rollo, David, & Sons .. .. Fulton Engine Wks., Liverpool
Shaw, W., & Co. .. .. .. Wellington Cast Steel Foundry, Middlesbro'-on-Tees
Spencer, John, & Sons, Ltd. .. Newburn Steel Wks., Newcastle-on-Tyne
Steel Co. of Scotland, Ltd. .. 23, Royal Exchange Square, Glasgow
Vickers Limited .. .. .. Sheffield

Cement.
Greaves, Bull & Lakin, Ltd. .. Harbury, Leamington
Maxted & Knott, Ltd. .. .. Burnett Avenue, Hull
Smoothon Manufacturing Co. .. Jersey City, N.J., U.S.A.
Thomas & Bishop .. .. .. 119-125, Finsbury Pavement, E.C.
Wouldham Cement Co., Ltd. .. 35, Gt. St. Helen's, E.C.

Cement-Making Plant.
Aveling & Porter, Ltd. .. .. Rochester
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Johnson, Wm., & Sons (Leeds), Ld. Armley, Leeds
Klinger, Richard, & Co. .. .. 66, Fenchurch Street, E.C.
Krupp Aktiengesellschaft Grusonwerk .. .. Magdeburg-Buckau, Germany
Newell, Ernest, & Co., Ltd. .. Misterton, Gainsboro'
Pulsometer Engineering Co., Ld. Nine Elms Ironworks, Reading
Rochester Engineering Co., Ltd. Wickham, Rochester
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.

Centrifugal Drying Machines.
Manlove, Alliott & Co., Ltd. .. Nottingham
Pott, Cassels & Williamson .. Motherwell, near Glasgow
Watson, Laidlaw & Co., Ltd. .. 98, Dundas St. (South), Glasgow

Cesspool Exhauster.
Merryweather & Sons .. .. Greenwich Road, S.E.

Chains and Cables.
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Phillips, Alfred, & Co. .. .. Atlas Works, Tipton
Wright, Jos., & Co. .. .. Tipton, Staffordshire

Chains (Gearing).
Bagshawe & Co., Ltd. .. Dunstable Works, Dunstable
Coventry Chain Co. (1907), Ltd. Coventry
Renold, Hans, Ltd. .. .. Progress Works, Manchester
Westinghouse Brake Co., Ltd. 82, York Road, N.

Chemical Works (Plant for).
Alley & MacLellan, Ltd. .. Sentinel Works, Glasgow
Blair, Campbell & McLean, Ltd. Woodville Street, Govan, Glasgow
Dowson & Mason Gas Plant Co., Ltd. .. .. Levenshulme, Manchester
Manlove, Alliott & Co., Ltd. .. Nottingham
Piggott, Thos., & Co., Ltd. .. Birmingham

Chimneys.
Babcock & Wilcox, Ltd. .. .. Oriel House, Farringdon St., E.C.
Bellamy, John, Ltd. .. .. Millwall, E.
Clayton, Son, & Co., Ltd. .. Hunslet, Leeds
Steel Pipe Company, Ltd. .. Kirkcaldy, N.B.

Chucks.
Pratt, F., & Co., Ltd. .. .. Eagle Ironworks, Halifax
Rapid Magnetting Machine Co., Ltd. .. .. Crescent, Birmingham
Taylor, Charles (Birm'ham), Ld. Bartholomew St., Birmingham

Cloth Finishing Machinery.
Craig, A. F., & Co., Ltd. .. Paisley, N.B.

Clutches (Friction).
Bagshaw, J., & Sons, Ltd. .. Batley
Bevor, Dorling & Co., Ltd. .. Bowling Ironworks, Bradford
British Hele-Shaw Patent Clutch Co., Ltd. .. .. Suthers Street, Oldham
Croft & Perkins, Ltd. .. .. Power Works, Bradford
Edmeston, A., & Sons, Ltd. .. Patricroft, nr. Manchester
Entwisle & Gass, Ltd. .. .. Bolton
Kay, James C., & Co., Ltd. .. Barnbrook Works, Bury, Lancs.
Mackies, Ltd. .. .. .. Reading
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Unbreakable Pulley and Mill Gearing Co., Ltd. .. .. 48, West Gorton, Manchester
Wigglesworth, Frank, & Co., Ld. Mill Lane, Bradford

Clutches (Magnetic).
Drake & Gorham, Ltd. .. .. 66, Victoria Street, S.W.
Lugard, Cecil E., & Co. .. .. St. John's House, Chester

Coal Handling Plant.
Allen, Edgar, & Co., Ltd. .. Sheffield
Bleichert, Adolf, & Co. .. .. 99-100, Palmerston House, Bishopsgate St. Within, E.C.
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Leech, Goodall & Co. .. .. Hunslet (Pepper Road), Leeds
Maschinenfabrik Augsburg-Nurnberg A.-G. .. .. .. Augsburg, Bavaria
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Simon-Carves, Ltd. .. .. 20, Mount Street, Manchester

Cocks.—(*See Valves, Gas, Steam, Water, &c.*)

Coffee Machinery.
Waygood & Co., Ltd. .. .. Falmouth Road, S.E.

Coining Machinery.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Taylor & Challen, Ltd. .. .. Birmingham

Coke Rams.
Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich

Colliery Plant.
Alley & MacLellan, Ltd. .. Sentinel Works, Glasgow
Bennis, Ed., & Co., Ltd. .. .. Bolton
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Brown Hoisting Machinery Co. Cleveland, Ohio, U.S.A.
Clay Cross Co. .. .. .. Clay Cross, near Chesterfield
Clayton, Son, & Co., Ltd. .. Hunslet, Leeds
Finch, Edward, & Co., Ltd. .. Chepstow
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Hadfield's Steel Foundry Co., Ld. Hecla Works, Sheffield
Hathorn, Davey & Co., Ltd. .. Leeds [on-Tees
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, Worcester
Hornsby, R., & Sons, Ltd. .. Grantham [Worcester
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Isca Foundry & Engineering Co. Newport, Mon.
Jessop, Wm., & Sons, Ltd. .. Brightside Works, Sheffield
Leech, Goodall & Co. .. .. Hunslet (Pepper Road), Leeds
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster,
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester [S.W.
Sandycroft Foundry Co., Ltd. .. Chester
Scott, E., & Mountain, Ltd. .. Close Works, Gateshead-on-Tyne
Siemens Brothers Dynamo Wks., Ltd. .. .. Caxton House, Westminster, S.W.
Walker Bros. (Wigan), Ltd. .. Pagefield Ironworks, Wigan

Colliery Proprietors.
Brown, John, & Co., Ltd. .. Sheffield
Clay Cross Co. .. .. .. Clay Cross, near Chesterfield
Glasgow Iron & Steel Co., Ltd. .. Wishaw Iron & Steel Works, [Wishaw
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland

Compasses.
Negretti & Zambra .. .. 38, Holborn Viaduct, E.C.

Composition for Covering Boilers, &c.—(*See Non-Conducting Compositions.*)

Concrete Mixers.
Austin, F. C., Drainage Excavator Co. .. .. Railway Exchange, Chicago, Ill., U.S.A.
Ransome-ver Mehr Machinery Co. .. .. Caxton House, Westminster, S.W.
Whitaker Brothers, Ltd. .. Horsforth, Leeds [kenhead
Wilson, John H., & Co., Ltd. .. Dock Road, Seacombe, nr. Bir-

Concrete (Reinforced).
Johnson, Rd., Clapham and Morris, Ltd. .. .. .. Manchester
Leslie & Co., Ltd. .. .. .. Kensington Square, W.
Trussed Concrete Steel Co., Ltd. 50, Caxton House, Westminster, S.W.

Condenser Tube (Prevention of Corrosion).
Harris Patent Feed-Water Filter (1910), Ltd. .. .. .. 24, Grainger Street West, Newcastle-on-Tyne

Condensers (Evaporative).
Fr Douglas, & Sons, Ltd. .. Arbroath

Condensers (Fresh Water).—(*See Distilling (Water) Apparatus.*)

Condensers (for Steam Engines).
Allen, W. H., Son, & Co., Ltd. .. Queen's Eng. Works, Bedford
Balcke & Co., Ltd. .. .. Broadway Court, Broadway, Westminster, S.W.
Bellias & Morcom Ltd. .. .. Ledsam St. Works, Birmingham
British Westinghouse Electric and Manufacturing Co., Ltd. Trafford Park, Manchester
Caird & Rayner .. .. .. 777, Commercial Road, E.
Campbell & Calderwood .. .. Soho Engine Works, Paisley
Carruthers, J. H., & Co., Ltd. .. Polmadie Ironworks, Glasgow
Contraflo Condenser & Kinetic Air Pump Co., Ltd. .. .. 4, Lloyds' Avenue, Fenchurch Street, E.C.
Craig, A. F., & Co., Ltd. .. .. Paisley
Escher Wyss & Co. .. .. 109, Victoria Street, S.W.
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Fraser, Douglas, & Sons, Ltd. .. Arbroath
Friedenthal, F. .. .. .. River Engine Works, Preston
Hall, J. P., & Sons, Ltd. .. Peterborough
Harris Patent Feed Water Filter (1910), Ltd. .. .. .. 82, Victoria Street, S.W.
Harris Patent Feed-Water Filter (1910), Ltd. .. .. .. 24, Grainger Street West, Newcastle-on-Tyne
Hayward-Tyler & Co., Ltd. .. 99, Queen Victoria Street, E.C.
Kirkaldy, John, Ltd. .. .. 101, Leadenhall Street, E.C.
Klein Engineering Co. (1908), Ld. 94, Market Street, Manchester
Korting Brothers, Ltd. .. .. 53, Victoria Street, S.W.
Ledward & Beckett, Ltd. .. Sanctuary House, 33, Tothill Street, Westminster, S.W.
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Richardsons, Westgarth & Co., Ld. Hartlepool Engine Works, Hartlepool
Royles Limited .. .. .. Irlam, near Manchester
Simpson, James, & Co., Ltd. .. 101, Grosvenor Road, S.W.
Stott, S. S., & Co. .. .. .. Haslingden, near Manchester
Thornycroft, J. I., & Co., Ltd. .. Southampton
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow
Wheeler Condenser & Eng. Co. 2 & 3, Norfolk Street, Strand, W.C.
Whittaker, C., & Co., Ltd. .. Haslingden, near Manchester
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.
Wright, Jos., & Co. .. .. Tipton, Staffordshire

Constructional.—(*See Structural Engineering.*)

Controllers (Electrical).—(*See Motor Starters.*)

Conveyors.
Allen, Edgar, & Co., Ltd. .. Sheffield
Babcock & Wilcox, Ltd. .. .. Oriel House, Farringdon St., E.C.
Bagshawe & Co., Ltd. .. .. Dunstable Works, Dunstable
Barry, Henry & Co., Ltd. .. Aberdeen
Bennis, Ed., & Co., Ltd. .. .. Bolton
Bleichert, Adolf, & Co. .. .. 99-100, Palmerston House, Bishopsgate St. Within, E.C.
Broadbent, Robert, & Son, Ltd. Phœnix Ironworks, Stalybridge
Brown Hoisting Machinery Co. Cleveland, Ohio, U.S.A.
Bullivant & Co., Ltd. .. .. 72, Mark Lane, E.C.
Conveyor and Elevator Co. .. Accrington, Lancashire
Cunningham, T. L. .. .. Balfour House, Finsbury Pavement, E.C.
Figee .. .. Haarlem, Holland
Fraser & Chalmers, Ltd. .. Erith, Kent
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Gutta Percha & Rubber Mfg. Co. of Toronto, Ltd. .. .. .. Toronto, Canada
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, Worcester
Johnson, Wm., & Sons (Leeds), Ld. Armley, Leeds
Leech, Goodall & Co. .. .. Hunslet (Pepper Road), Leeds
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster, S.W.
Little, Gilbert, Co., Ltd. .. Horton Works, Bradford
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Newell, Ernest, & Co., Ltd. .. Misterton, Gainsboro'
Pfeiffer Gebr. .. .. .. Kaiserslautern, 74, Germany
Pohlig, J., A.-G. .. .. .. Cologne-Zollstock
Pott, Cassels & Williamson .. Motherwell, near Glasgow
Ransome-ver Mehr Machinery Co. .. .. 505, Caxton House, Westminster, S.W.
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Rochester Engineering Co., Ltd. Wickham, Rochester
Selson Engineering Co., Ltd. .. 86, Queen Victoria Street, E.C.
Watson, Laidlaw & Co., Ltd. .. 98, Dundas St. (South), Glasgow
Whittaker, C., & Co., Ltd. .. Accrington

Copper Ingots, Bars and Sheets.
Broughton Copper Co., Ltd. .. Manchester

Coppersmiths.
Birmingham Battery & Metal Co. Birmingham [Glasgow
Blair, Campbell & McLean, Ltd. Woodville Street, Govan,
Delta Metal Co., Ltd. .. .. East Greenwich, S.E.
Elmore's Metall-A.-G. .. .. Schladern, Sieg., Germany
North-Eastern Marine Engineering Co., Ltd. .. .. .. Northumberland Wks., Wallsend-on-Tyne
Storey, I., & Sons, Ltd. .. .. Empress Foundry, Manchester

Copying Presses.
Daniell, S. A., Ltd. .. .. Edward Street, Parade, Birmingham

Corrugated Boiler Furnaces.
Leeds Forge Co., Ltd. .. .. Leeds

Cotton Presses.
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Fawcett, Preston & Co., Ltd. .. 17, York Street, Liverpool
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Nasmyth, Wilson & Co., Ltd. .. Bridgewater Foundry, Patricroft, near Manchester
Piggott, Thos., & Co., Ltd. .. Birmingham
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd., Leeds
Stewart, Duncan, & Co., Ltd. .. London Road Ironworks, Glasgow
Tangyes Limited .. .. .. Cornwall Works, Birmingham

Couplings (Railway).
A.B.C. Coupler, Ltd. .. .. Queen Anne's Chambers, Tothill Street, S.W.
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Phillips, Alfred, & Co. .. .. Atlas Works, Tipton

Couplings (Shaft).
Bagshaw, J., & Sons, Ltd. .. Batley, Yorkshire
Boving, Jens Orten- & Co. .. 9½, Union Court, Old Broad Street, E.C.
Carver, C. F., Ltd. .. .. Nottingham
Croft & Perkins, Ltd. .. .. Power Works, Bradford
Mackies, Limited .. .. .. Berks Ironworks, Reading
Platt, Samuel, Ltd. .. .. Wednesbury
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Smith & Grace Screw Boss Pulley Co., Ltd. .. .. Thrapston
Taylor & Challen, Ltd. .. .. Birmingham
Unbreakable Pulley and Mill Gearing Co., Ltd. .. .. 48, West Gorton, Manchester
Wigglesworth Frank, & Co., Ld. Mill Lane, Bradford

Cranes, Travellers, Winches, &c.
Arrol, Sir William, & Co., Ltd. Dalmarnock Ironwks., Bridgeton, Glasgow
Babcock & Wilcox, Ltd. .. .. Oriel House, Farringdon St., E.C.
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Bléichert, Adolf, & Co. .. .. 99-100, Palmerston House, Bishopsgate St. Within, E.C.
Booth, Joseph, & Bros., Ltd. .. Rodley, Leeds
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Broadbent, Thos., & Sons, Ltd. Chapel Hill, Huddersfield
Brown Hoisting Machinery Co. Cleveland, Ohio, U.S.A.
Burnbank Engineering Co. .. 58, West Regent St., Glasgow
Butters Brothers & Co. .. .. 20, Waterloo Street, Glasgow
Chambers, Scott & Co. .. .. Motherwell
Chaplin, Alex., & Co., Ltd. .. Govan, Glasgow
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Cochrane, John .. .. .. Barrhead, N.B.
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Cowans, Sheldon & Co., Ltd. .. Carlisle
Craven Brothers, Ltd. .. .. Osborne Street, Manchester
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Deutsche Maschinenfabrik A.G. Duisburg, Germany
East Ferry Road Engineering Works Co., Ltd. .. .. Millwall, E.
Electromotors Ltd. .. .. Openshaw, Manchester
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Figee .. .. Haarlem, Holland
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Grafton & Co. .. .. .. Bedford
Grieve, John, & Co. .. .. Motherwell, Scotland
Hanna, Donald & Wilson .. Paisley, N.B.
Higginbottom & Mannock, Ltd. West Gorton, Manchester
Isca Foundry & Engineering Co. Newport, Mon.
Jack, Alexander, & Co. .. .. Whitegates Engineering Wks., Motherwell [S.W.
Jackman, J. W., & Co., Ltd. .. Caxton House, Westminster,
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster,
Marshall, Fleming & Co. .. Motherwell, N.B. [S.W.
Maschinenfabrik Augsburg-Nurnberg A.-G. .. .. .. 219, Caxton House, Westminster, S.W.
Mitchell-Williams Crane Co. .. 98, Leadenhall Street, E.C.
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Musker, C. & A., Ltd. .. .. Liverpool [Street, E.C.
Oil Well Supply Co. .. .. Dashwood House, 9, New Broad
Pohlig, J., A.-G. .. .. .. Cologne-Zollstock
Priestman Brothers, Ltd. .. Holderness Foundry, Hull
Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd., Leeds
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Royce Ltd. .. .. Trafford Park, Manchester
Russell, Geo., & Co., Ltd. .. Motherwell, near Glasgow
Sellers, William, & Co., Incorp.) Philadelphia, Penn., U.S.A.
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Smith, Thos., & Sons .. .. Rodley, near Leeds
Société du Nord de Liége .. 42, Perryn Road, Acton, W.
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironwks., Glasgow
Stothert & Pitt, Ltd. .. .. Bath
Tangyes Limited .. .. .. Birmingham
Taylor & Hubbard .. .. .. Leicester
Vaughan & Son, Ltd. .. .. Manchester
Waygood & Co., Ltd. .. .. Falmouth Road, S.E.
Whitaker Brothers, Ltd. .. Horsforth, Leeds
Wilson, John H., & Co., Ltd. .. Dock Road, Seacombe, nr. Birkenhead
Youngs .. .. Eyland St. Wks., Birmingham

Crank Axles.
Bessemer, Henry, & Co., Ltd. .. Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield
Jessop, W., & Sons, Ltd. .. Sheffield
Newburn Steel Works, Newcastle on Tyne
Thornycroft, J. I., & Co., Ltd. .. Southampton
Vickers Limited .. .. .. Sheffield
Wright, Joseph, & Co. .. .. Neptune Forge, Tipton, Staffs

Cream Separators.
Pott, Cassells & Williamson .. Motherwell, nr. Glasgow
Watson, Laidlaw & Co., Ltd. .. 98, Dundas St. (South), Glasgow

Creosoting Plant.
Cowans, Sheldon & Co., Ltd. .. Carlisle

Crucibles.
Doulton & Co., Ltd. .. .. Lambeth, S.E.

Crushing Machinery.—(*See Disintegrators and Mills.*)

Cupolas.
Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Green, George, & Co. .. .. Keighley [S.W.
Jackman, J. W., & Co., Ltd. .. Caxton House, Westminster,
Lilleshall Company, Ltd. .. Oakengates, Shropshire
Thwaites Brothers, Ltd. .. .. Vulcan Ironworks, Bradford

Cyanide Plant.
Daw, A. & Z. .. .. .. 11, Queen Victoria Street, E.C.

Destructors.
Dowson & Mason Gas Plant Co., Ltd. .. .. Levenshulme, Manchester
Heenan & Froude, Ltd. .. .. 4, Chapel Walks, Manchester
Horsfall Destructor Co., Ltd. .. 17, Victoria Street, S.W.
Manlove, Alliott & Co., Ltd. .. Nottingham
Meldrum Bros., Ltd. (in Liq.) .. Canal Works, Timperley, near Manchester

Disinerustants.
Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Dampney, J., & Co., Ltd. .. Bute Docks, Cardiff
Robey & Co., Ltd. .. .. Lincoln

Disinfectors.
Manlove, Alliott & Co., Ltd. .. Nottingham
Tullis, D. & J., Ltd. .. .. Kilbowie Ironwks., nr. Glasgow

Disintegrators.
Allen, Edgar, & Co., Ltd. .. Sheffield
Bradley Pulverizer Co. .. .. 87, Walbrook, E.C.
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hadfield's Steel Foundry Co., Ld. Hecla Works, Sheffield
Johnson, Wm., & Sons (Leeds), Ld. Armley, Leeds
Krupp Aktiengesellschaft Grusonwerk .. .. Magdeburg-Buckau, Germany
Leech, Goodall & Co. .. .. Hunslet (Pepper Road), Leeds
Little, Gilbert, Co., Ltd. .. Horton Works, Bradford
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Pfeiffer Gebr. .. .. .. Kaiserslautern, 74, Germany
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.
Sturtevant Engineering Co., Ltd. 147, Queen Victoria Street, E.C.

Distillery Plant.
Blair, Campbell & McLean, Ltd. Woodville St., Govan, Glasgow
Dowson & Mason Gas Plant Co., Ltd. .. .. .. Levenshulme, Manchester
Fawcett, Preston & Co., Ltd. .. Liverpool
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Pontifex & Wood, Ltd. .. .. Union Foundry, Derby

Distilling (Water) Apparatus.
Caird & Rayner .. .. .. 777, Commercial Road,
Chaplin, Alex, & Co. .. .. Govan, Glasgow
Kirkaldy, John, Ltd. .. .. 101, Leadenhall Street, E.C.
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Royles Limited .. .. .. Irlam, nr. Manchester

Diving Apparatus.
Siebe, Gorman & Co., Ltd. .. Neptune Works, S.E.

Draught.—(*See Forced and Induced Draught.*)

Draw Benches.
Fielding & Platt. Ltd. .. .. Atlas Works, Gloucester
Platt, Samuel, Ltd. .. .. Wednesbury

Drawing Instruments.
Drake & Gorham, Ltd. .. .. 66, Victoria Street, S.W.
Hall, B. J., & Co., Ltd. .. .. 39, Victoria Street, S.W.
Kern & Co. .. .. Aarau, Switzerland
Negretti & Zambra .. .. 38, Holborn Viaduct, E.C.
Shinn, C. E. .. .. .. 17, George Street, Tamworth
Stanley, W. F., & Co., Ltd. .. 286, High Holborn, W.C.
Thornton, A. G., Ltd. .. .. 28, King St. West, Manchester

Drawings, Tracings, &c.
Halden, J., & Co., Ltd. .. .. 8, Albert Square, Manchester
Kell, T., & Son .. .. .. 40, King Street, Covent Garden, W.C.
Stanley, W. F., & Co., Ltd. .. Railway Approach, London Bridge, S.E.

Dredgers (Suction).
Ferguson Brothers .. .. Port Glasgow
Goedhart Bros. .. .. .. Düsseldorf, Germany
Gwynnes Ltd. .. .. .. 81, Cannon Street, E.C.
Lobnitz & Co., Ltd. .. .. Renfrew

Dredging Machines.
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Dublin Dockyard Co. .. .. North Wall, Dublin
Ferguson Brothers .. .. Port Glasgow
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Goedhart Bros. .. .. .. Düsseldorf, Germany
Gwynnes Ltd. .. .. .. 81, Cannon Street, E.C.
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield
Hanna, Donald & Wilson .. Paisley, N.B.
Jessop, W., & Sons, Ltd. .. Brightside Works, Sheffield
Lobnitz & Co., Ltd. .. .. Renfrew, Scotland
Lubecker Machine & Mfg. Co. .. 30, Gt. St. Helen's, E.C.
Orenstein & Koppel - Arthur Koppel (Amalgamated) .. 27, Clements Lane, E.C.
Priestman Bros., Ltd. .. .. Holderness Foundry, Hull
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Simons, W., & Co., Ltd. .. .. Renfrew, N.B.
Smit, L., & Zoon .. .. .. Kinderdijk, Holland
Smulders, A. F. .. .. .. Schiedam, Rotterdam, Holland
Stothert & Pitt, Ltd. .. .. Bath

Drop Forgings.—(*See Forgings, Drop.*)

Drop Hammers.—(*See Hammers, Drop.*)

Drying Apparatus.
American Process Co. .. .. New York City, U.S.A.
Johnson, Wm., & Sons (Leeds), Ltd. Armley, Leeds
Keith, James, & Blackman Co., Ltd. .. .. .. 27, Farringdon Avenue, E.C.
Lacy-Hulbert & Co., Ltd. .. 91, Victoria Street, S.W.
Manlove, Alliott & Co., Ltd. .. Nottingham
Musgrave & Co., Ltd. .. .. St. Ann's Ironworks, Belfast
Sturtevant Engineering Co., Ltd. 147, Queen Victoria St., E.C.
Whittaker, C., & Co., Ltd. .. Haslingden, near Manchester
Witting, H. E. .. .. .. 9, Southampton Street, W.C.

Dust Collectors (*Mills, Factories, Breweries, &c.*).
Keith, James, & Blackman Co., Ltd. .. .. .. 27, Farringdon Avenue, E.C.
Rochester Engineering Co., Ltd. Wickham, Rochester
Sturtevant Engineering Co., Ld. 147, Queen Victoria Street, E.C.

Dust Shields for Bearings.
Vickers, Benjn. R., & Sons .. Leeds

Dynamite.—(*See Explosives.*)

Dynamos.—(*See Electric Lighting Plant.*)

Ebonite.
India Rubber, Gutta Percha and Telegraph Works, Co., Ltd. .. Silvertown, Essex
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Winter, F. .. .. 25, Goswell Road, E.C.

Economisers (Fuel).
Clay Cross Co. .. .. .. Clay Cross, near Chesterfield
Smith, R. H. .. .. .. Thirlmere Rd, Streatham, S.W.
Stork Brothers & Co. .. .. Hengelo, Holland

Electric Bells and Signals.
Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchester

Electric Cables.
British Insulated and Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, Essex

Electric Lighting Plant.—(*See also Switchboards, Motor Starters and Accessories.*)
A.E.G. Electric Company, Ltd. Pembroke Hse., 133-135, Oxford Street, S.W.
Allen, W. H., Son, & Co., Ltd... Queen's Eng. Works, Bedford
Alley & Macellan, Ltd. .. .. Sentinel Works, Glasgow
Becker, R., & Co. .. .. .. 53, City Road, E.C.
Bellias & Morcom Ltd. .. .. Ledsam St. Works, Birmingham
British Insulated and Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
British Thomson-Houston Co., Ltd. .. .. Rugby
Clarke, Chapman & Co., Ltd. .. Gateshead-upon-Tyne
Drake & Gorham, Ltd. .. .. 66, Victoria St., S.W.
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham
Electromotors Ltd. .. .. Openshaw, Manchester
Fowler, J., & Co. (Leeds), Ltd... Leeds
General Electric Co., Ltd. .. 67, Queen Victoria Street, E.C.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hall, J. P., & Co., Ltd. .. .. Oldham
Hartnell Wilson, & Co., Ltd. .. Kirkstall Road, Leeds
Howden James, & Co. .. .. Scotland Street, Glasgow
India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, Essex
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Jandus Arc Lamp & Electric Co, Ltd. .. .. Hartham Road, Holloway, N.
Lawrence, Scott & Co., Ltd. .. Norwich
Mavor & Coulson, Ltd. .. .. 47, Broad St., Mile End, Glasgow
Musker, C. & A., Ltd. .. .. Liverpool
Parsons, C. A., & Co. .. .. Heaton Works, Newcastle
Paul, Matthew, & Co., Ltd. .. Levenford Works, Dumbarton
Peebles, Bruce, & Co., Ltd. .. Edinburgh
Phœnix Dynamo Mfg. Co., Ltd. Thornbury Works, Bradford
Royce Ltd. .. .. Trafford Park Manchester
Siemens Brothers Dynamo Wks., Ltd. .. .. Caxton House, Westminster, S.W.
Sturtevant Engineering Co., Ltd. 147, Queen Victoria St., E.C.
Thornycroft, J. I., & Co., Ltd... Caxton Hse., Westminster, S.W.
Vickers Limited .. .. .. Sheffield

Electric Motors.
A.E.G. Electric Company, Ltd. Pembroke Hse., 133-135, Oxford Street, W.
Allen, W. H., Son & Co., Ltd. .. Queen's Eng. Works, Bedford
Becker, R., & Co. .. .. .. 53, City Road, E.C.
Beyer, Peacock & Co., Ltd. .. Gorton Foundry, Manchester
Booth, Joseph, & Bros., Ltd. .. Rodley, Leeds
British Thomson-Houston Co., Ltd. .. .. Rugby
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham
Electromotors Ltd. .. .. Openshaw, Manchester
General Electric Co., Ltd. .. 67, Queen Victoria Street, E.C.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hartnell, Wilson, & Co., Ltd. .. Kirkstall Road, Leeds
India Rubber, Gutta Percha & Telegraph Works Co., Ltd. .. Silvertown, Essex [chester
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Laurence, Scott & Co., Ltd. .. Norwich
Le Carbone .. .. 17, Water Lane, Great Tower
Mavor & Coulson, Ltd. .. .. 47, Broad St., Mile End, Glasgow
Musker, C. & A., Ltd. .. .. Liverpool
Parsons, C. A., & Co. .. .. Heaton Works, Newcastle
Peebles, Bruce, & Co., Ltd. .. Edinburgh
Phœnix Dynamo Mfg. Co., Ltd. Thornbury Works, Bradford
Sandycroft Foundry Co., Ltd. .. Chester
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Siemens Brothers Dynamo Wks., Ltd. .. .. Caxton House, Westminster, S.W.
Sturtevant Engineering Co., Ltd. 147, Queen Victoria St., E.C.
Vickers Limited .. .. .. Sheffield

Electric Tools.
Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.

Electrical Engineers.
Adams Manufacturing Co., Ltd. 106, New Bond Street, W.
A.E.G. Electric Company, Ltd. Pembroke Hse., 133-135, Oxford Street, W.
Allen, W. H., Son, & Co., Ltd... Queen's Eng. Works, Bedford
Barry, Henry, & Co., Ltd. .. Aberdeen
Bellias & Morcom Ltd. .. .. Ledsam St. Works, Birmingham
Beyer, Peacock & Co., Ltd. .. Gorton Foundry, Manchester
British Insulated and Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
British Thomson-Houston Co., Ltd. .. .. Rugby
Clarke, Chapman & Co., Ltd. .. Gateshead-upon-Tyne
Drake & Gorham, Ltd. .. .. 66, Victoria Street, S.W.
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham
Electric Control, Ltd. .. .. 177, Reid Street, Bridgeton, Glasgow
Electromotors Ltd. .. .. Openshaw, Manchester
Everett, Edgcumbe & Co., Ltd. 117, Victoria Street, S.W.
Ferranti Ltd. .. .. .. Hollinwood, Lancs.
General Electric Co., Ltd. .. 67, Queen Victoria Street, E.C.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hall, J. P., & Co., Ltd. .. .. Oldham
Hartnell, Wilson, & Co., Ltd. .. Kirkstall Road, Leeds
Hayward-Tyler & Co., Ltd. .. 99, Queen Victoria Street, E.C.
India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, Essex
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Mavor & Coulson, Ltd. .. .. 47, Broad St., Mile End, Glasgow
Parsons, C. A., & Co. .. .. Heaton Works, Newcastle
Peebles, Bruce, & Co., Ltd. .. Edinburgh
Phœnix Dynamo Mfg. Co., Ltd. Thornbury Works, Bradford
Royce Ltd. .. .. Trafford Park, Manchester
Sandycroft Foundry Co., Ltd. .. Chester
Scott, E., & Mountain, Ltd. .. Close Works, Gateshead-on-Tyne
Siemens Brothers Dynamo Wks., Ltd. .. .. Caxton House, Westminster, S.W.
Vickers Limited .. .. .. Sheffield

Elevators (Grain, Coal, &c.)
Bagshawe & Co., Ltd. .. .. Dunstable Works, Dunstable
Barry, Henry, & Co., Ltd. .. Aberdeen
Bennis, Ed., & Co., Ltd. .. .. Bolton
Bleichert, Adolf, & Co. .. .. 99-100, Palmerston House, Bishopsgate St. Within, E.C.
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Broadbent, Robert, & Son, Ltd. Phœnix Ironworks, Stalybridge
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Conveyor and Elevator Co. .. Accrington, Lancashire
Cunningham, T. L. .. .. .. Balfour House, Finsbury Pavement, E.C.
East Ferry Road Engineering Works Co., Ltd. .. .. Millwall, E.
Fraser & Chalmers, Ltd. .. .. Erith, Kent
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Heenan & Froude, Ltd. .. .. Worcester Engineering Works,
Johnson, Wm., & Sons (Leeds), Ltd. Armley, Leeds [Worcester
Leech, Goodall & Co. .. .. Hunslet (Pepper Road), Leeds
Little, Gilbert, Co., Ltd. .. Horton Works, Bradford
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Newell, Ernest, & Co., Ltd. .. Misterton, Gainsboro'
Pfeiffer Gebr. .. .. Kaiserslautern, 74, Germany
Poblig, J., A.-G. .. .. .. Cologne-Zollstock
Pott, Cassels & Williamson .. Motherwell, near Glasgow
Priestman Bros., Ltd. .. .. Holderness Foundry, Hull
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Rochester Engineering Co., Ltd. Wickham, Rochester
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Simon-Carves, Ltd. .. .. 20, Mount Street, Manchester
Smulders, A. F. .. .. .. Schiedam, Rotterdam, Holland
Watson, Laidlaw & Co., Ltd. .. 93, Dundas St. (South), Glasgow
Whittaker, C., & Co., Ltd. .. Accrington

Emery and Emery Cloth, &c.
Carborundum Co. .. .. .. 29, Clifton Street, E.C.
Davies, W. J., & Sons .. .. 109, Weston Street, S.E.
London Emery Works Co. .. Park, Tottenham, N.
Mitchell's Emery Wheel Co. .. Bradford, Manchester
Oakey, John, & Sons, Ltd. .. Westminster Bridge Road, S.E.

Emery Grinding Machinery.
Becker, R., & Co. .. .. .. 53, City Road, E.C.
Beyer, Peacock & Co., Ltd. .. Gorton Foundry, Manchester
Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
London Emery Works Co. .. Park, Tottenham, N.
Luke & Spencer, Ltd. .. .. Broadheath, near Manchester
Mitchell's Emery Wheel Co. .. Bradford, Manchester
Muir, Wm., & Co. .. .. .. Sherbourne Street, Manchester
Patrick, F. .. .. Oxford Street, Leeds
Rowland, B. R., & Co., Ltd. .. Reddish, near Manchester
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Sterne, L., & Co., Ltd. .. .. Crown Ironworks, Glasgow
Ward, H. W., & Co., Ltd. .. Lionel Street, Birmingham

Emery Wheels.
Carborundum Co. .. .. .. 29, Clifton Street, E.C.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
London Emery Works Co. .. Park, Tottenham, N.
Luke & Spencer, Ltd. .. .. Broadheath, near Manchester
Mitchell's Emery Wheel Co. .. Mill St., Bradford, Manchester
Rowland, B. R., & Co., Ltd. .. Reddish, near Manchester
Sterne, L., & Co., Ltd. .. .. Crown Ironworks, Glasgow

Engine and Boiler Fittings.
Amag-Hilpert .. .. .. Glochenhofstrasse 6, Nurnberg, Germany
Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Bell's United Asbestos Co., Ltd. 5½, Southwark Street, S.E.
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Drake & Gorham, Ltd. .. .. 66, Victoria Street, S.W.
Green & Boulding, Ltd. .. .. 28, New Bridge Street, E.C.
Hopkinson, J., & Co., Ltd. .. Huddersfield
Hubner & Mayer .. .. .. Vienna XIX/6
Lunken Company, Inc. .. .. 35, Great Dover Street, S.E.
M'Nell, C. .. .. Kinning Park Ironwks., Glasgow
Millar, Dennis & Co. .. .. Victoria Works, Bradford

Engine and Boiler Fittings.—*Continued*
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Royles Limited .. .. .. Irlam, near Manchester
Schäffer & Budenberg, Ltd .. Whitworth St., London Road Manchester
Storey, I., & Sons, Ltd. .. .. Empress Foundry, Manchester
Tangyes Limited .. .. .. Birmingham
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow

Engineers (Consulting and Inspecting).
Davis, E. J... .. .. .. Gt. Eastern Road, Stratford, E.
Hunt, Robert W., & Co. .. Norfolk House, Cannon St., E.C.

Engines (Air).
Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Bellias & Morcom Ltd. .. .. Ledsam St. Works, Birmingham

Engines (Blowing).
Bellias & Morcom Ltd. .. .. Ledsam St. Works, Birmingham
Davy Brothers, Ltd. .. .. Sheffield
Drysdale & Co. Ltd. .. .. Bon Accord Works, Yoker, [Glasgow, W.
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Gwynnes Ltd. .. .. .. 81, Cannon Street, E.C.
Lilleshall Company, Ltd. .. Oakengates, Shropshire
Maschinenfabrik Augsburg-Nurnberg A.-G. .. .. .. Nurnberg, S.W.
Thwaites Brothers, Ltd. .. .. Vulcan Ironworks, Bradford
Walker Bros. (Wigan), Ltd. .. Pagefield Ironworks, Wigan

Engines (Gas).
Anderston Foundry Co., Ltd. .. Glasgow
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Cameron, John, Ltd. .. .. Salford, Manchester
Campbell Gas Engine Co., Ltd. Halifax, England
Crossley Bros., Ltd. .. .. Manchester
Davey, Paxman & Co., Ltd. .. Colchester [E.C.
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street,
Dudbridge Iron Works, Ltd. .. Dudbridge, near Stroud
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Gardner, L., & Sons, Ltd. .. Patricroft, Manchester
Gutehoffnungshütte Coal, Iron, Steel and Engineering Co. .. Oberhausen-2, Rhineland
Haslam Foundry & Engineering Co., Ltd. .. .. Derby
Hindley, E. S., & Sons .. .. Bourton, Dorset
Hornsby, Richard, & Sons, Ltd. Grantham
Korting Brothers .. .. .. 53, Victoria St., Westminster,
Kynoch Ltd. .. .. .. Birmingham [S.W.
Langen & Wolf .. .. .. Milan
Lister, R. A., & Co., Ltd. .. Dursley, Glos.
Lilleshall Company, Ltd. .. Oakengates, Shropshire
Maschinenfabrik Augsburg-Nurnberg A.-G. .. .. .. Nurnberg, S.W.
Maschinenfabrik Thyssen & Co., A.-G. .. .. Mülheim-Ruhr
Mather & Platt, Ltd .. .. Manchester
National Gas Engine Co., Ltd... Ashton-under-Lyne, Manchester
Premier Gas Engine Co., Ltd. .. Sandiacre, Nottingham
Robey & Co., Ltd. .. .. .. Lincoln
Rodger, A., & Co. .. .. .. St. Helen's Engine Wks., Govan, Glasgow
Ruston, Proctor & Co., Ltd. .. Lincoln
Stamm, W. (Krupp-Grusonwerk) 25, College Hill, E.C.
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironworks, Glasgow
Sulzer Brothers .. .. .. 30, Norfolk Street, W.C.
Tangyes Limited .. .. .. Birmingham
Thornycroft, J. I., & Co., Ltd... Caxton House, Westminster,
White & Poppe, Ltd. .. .. Coventry [S.W.

Engines (Locomotive).
American Locomotive Co. .. Cortlandt Building, 30, Church St., New York, U.S.A.; and 26, Victoria Street, S.W.
Avenside Engine Co., Ltd. .. Bristol
Bagnall, W. G., Ltd. .. .. Castle Engine Works, Stafford
Baldwin Locomotive Works, The 500, North Broad Street, Philadelphia, U.S.A.
Barclay, Andrew, Sons & Co., Ld. Kilmarnock, N.B.
Beyer, Peacock & Co., Ltd. .. Gorton Foundry, Manchester
Borsig, A. .. .. Tegel, Berlin
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Cutbill-King & Co. .. .. 26, Nicholas Lane, E.C.
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street,
Fowler, J., & Co. (Leeds), Ltd... Leeds [E.C.
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Hannoversche Maschinenbau-Actien-Gesellschaft, vormals Georg Egestorff .. .. .. Hannover-Linden, Germany
Hawthorn, R. & W., Leslie & Co., Ltd. .. .. Newcastle-on-Tyne
Hudswell, Clarke & Co., Ltd. .. Leeds
Hunslet Engine Co., Ltd. .. Leeds
Kerr, Stuart & Co., Ltd. .. 1, Broad Street Place, E.C.
Manning, Wardle & Co., Ltd. .. Boyne Engine Works, Leeds
Nasmyth, Wilson & Co., Ltd. .. Bridgewater Foundry, Patricroft, near Manchester
North British Locomotive Co., Ltd. .. .. Administration Building, 110, Flemington St., Springburn, Glasgow
Orenstein & Koppel - Arthur Koppel (Amalgamated) .. 27, Clements Lane, E.C.
Peckett & Sons .. .. .. Atlas Loco. Works, Bristol
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Stephenson, Robert, & Co., Ltd. Darlington

Engines (Marine).
Bergius Launch & Engine Co. .. Dobbies Loan, Glasgow
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
Burrell, C., & Sons, Ltd. .. Thetford
Campbell & Calderwood .. .. Soho Engine Works, Paisley
Chaplin, Alex., & Co. .. .. Govan, Glasgow
Cochran & Co., Annan, Ltd. .. Annan, N.B.
Crabtree & Co., Ltd. .. .. Great Yarmouth
Day, Summers & Co., Ltd. .. Northam Ironworks, Southampton
Dodman, Alfred, & Co., Ltd. .. Highgate Works, King's Lynn
Fawcett, Preston & Co., Ltd. .. Liverpool
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Graziani, A. G., & Co. .. .. 22, Billiter Street, E.C.
Hanna, Donald & Wilson .. Paisley, N.B.
Hawthorn, R. & W., Leslie & Co., Ltd. .. .. Newcastle-on-Tyne
Hayes, Edward .. .. .. Stony Stratford, Wolverton
Lobnitz & Co., Ltd. .. .. Renfrew, Scotland
Maccoll & Pollock, Ltd. .. .. Sunderland
Mumford, A. G., Ltd. .. .. Culver St. Ironworks, Colchester
North-Eastern Marine Engineering Co., Ltd. .. .. Northumberland Wks., Wallsend-on-Tyne
Paul, Matthew, & Co., Ltd. .. Levenford Works, Dumbarton
Piercy & Co., Ltd. .. .. Broad St. Engine Works, Birmingham
Plenty & Son, Ltd. .. .. Englelronwks., Newbury, Berks
Renuie, G., & Co. .. .. .. Thames Street, Greenwich
Richardsons, Westgarth & Co., Ld. Hartlepool Engine Works, Hartlepool
Rollo, David, & Sons .. .. Fulton Engine Wks., Liverpool
Ross & Duncan .. .. .. Whitefield Works, Glasgow
Rowan, David, & Co. .. .. Glasgow
Schichau, F. .. .. .. Elbing-Danzig, Prussia
Sharer & Young, Ltd. .. .. Marmot Wks., Alloa, Scotland
Simons, W., & Co., Ltd. .. .. Renfrew, N.B.
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Smit, L., & Zoon .. .. .. Kinderdijk, Holland
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironworks, Glasgow
Sulzer Brothers .. .. .. 30, Norfolk Street, W.C.
Thornycroft, J. I., & Co., Ltd... Chiswick, W., & Southampton
Vauxhall & West Hydraulic Engineering Co., Ltd. .. .. 45, Leadenhall Street, E.C.
Vickers Limited .. .. .. Barrow-in-Furness
Vosper & Co., Ltd. .. .. .. Portsmouth
Wallsend Slipway & Engineering Co., Ltd. .. .. Wallsend
White, J. Samuel, & Co., Ltd... East Cowes, Isle of Wight
Yarrow & Co. Ltd. .. .. Glasgow

Engines (Oil).
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bergius Launch & Engine Co. .. Dobbies Loan, Glasgow
Blackstone & Co., Ltd. .. .. Rutland Works, Stamford
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
Britannia Engineering Co. (1910), Ltd. .. .. Colchester
Broom & Wade, Ltd. .. .. High Wycombe
Campbell Gas Engine Co., Ltd. Halifax, England
Crossley Bros., Ltd. .. .. Manchester
Diesel Engine Co., Ltd. .. .. 179, Queen Victoria Street, E.C.
Dudbridge Iron Works, Ltd. .. Dudbridge, near Stroud
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Gardner, L., & Sons, Ltd. .. Patricroft, Manchester
Graziani, A. G., & Co. .. .. 22, Billiter Street, E.C.
Hornsby, R., & Sons, Ltd. .. Grantham
Langen & Wolf .. .. .. Milan
Lister, R. A., & Co., Ltd. .. Dursley, Glos.
Maschinenfabrik Augsburg-Nurnberg A.-G. .. .. .. Nurnberg, S.W.
Meadows, Bickerton & Day, Ltd. Hazel Grove, near Stockport
Mirrlees, Bickerton & Day, Ltd. Hazel Grove, near Stockport
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Normand, Augustin, Ltd. .. 67, Rue du Perrey, Le Havre, France
Piercy & Co., Ltd. .. .. Broad St. Engine Works, Birmingham
Price, Charles & Son .. .. Broadheath, near Manchester
Reavell & Co., Ltd. .. .. Ipswich
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Iron Works, Lincoln
Sharer & Young, Ltd. .. .. Marmot Wks., Alloa, Scotland
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Sulzer Brothers .. .. .. 30, Norfolk Street, W.C.
Tangyes Limited .. .. .. Birmingham
Thornycroft, J. I., & Co., Ltd... Caxton House, Westminster.
Vosper & Co., Ltd. .. .. .. Portsmouth [S.W
White & Poppe, Ltd. .. .. Coventry
White, J. Samuel, & Co., Ltd... East Cowes, Isle of Wight
Wolseley Tool & Motor Car Co., Ltd. .. .. York Street, Westminster, S.W.

Engines (Portable).
Blackstone & Co., Ltd. .. .. Rutland Works, Stamford
Davey, Paxman & Co., Ltd. .. Colchester
Garrett, R., & Sons, Ltd.. .. Leiston Works, Suffolk
Hindley, E. S., & Sons .. .. Bourton, Dorset; and 11, Queen Victoria Street, E.C.
Hornsby, R., & Sons, Ltd. .. Grantham
Marshall, Sons & Co., Ltd. .. Gainsborough
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Ransomes, Sims & Jefferies, Ltd. Ipswich
Robey & Co., Ltd... .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Smedley Brothers, Ltd. .. .. Belper, Derbyshire
Thornycroft, J. I., & Co., Ltd... Caxton House, Westminster, S.W.
Wolf, R. .. .. Norfolk House, Cannon Street, E.C.

Engines (Pumping).
Bailey, W. H., & Co., Ltd. .. Albion Wks., Salford, Manchester
Barclay, Andrew, Sons & Co., Ltd. .. .. Caledonia Works, Kilmarnock, Scotland
Bellias & Morcom Ltd. .. .. Ledsam St. Works, Birmingham
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Caird & Rayner .. .. .. 777, Commercial Road, Limehouse, E.
Carruthers, J. H., & Co., Ltd... Polmadie Ironworks, Glasgow
Chesters Renfrew Engineering Co., Ltd. .. .. Renfrew, Scotland
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Davey, Paxman & Co., Ltd. .. Colchester
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker, [Glasgow, W.
East Ferry Road Engineering Works Co., Ltd. .. .. Millwall, E.
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Fraser & Chalmers, Ltd. .. .. 3, London Wall Buildings, E.C.
Fullerton, Hodgart & Barclay, Ltd. .. .. Vulcan Foundry and Engine Works, Paisley
Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Gwynnes Ltd. .. .. 81, Cannon Street, E.C.
Hathorn, Davey & Co., Ltd. .. Leeds
Lilleshall Company, Ltd. .. Oakengates, Shropshire
McOnie, A. & P. W. .. .. Govan, Glasgow
Manlove, Alliott & Co., Ltd. .. Nottingham
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Musgrave, John, & Sons, Ltd. .. Globe Iron Works, Bolton
Pratchitt Brothers .. .. Denton Ironworks, Carlisle
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Rice & Co. (Leeds), Ltd. .. .. Elland Road, Leeds
Robey & Co., Ltd... .. .. Lincoln
Simpson, James, & Co., Ltd. .. 101, Grosvenor Road, S.W.
Smith, Hugh, & Co. .. .. .. Possil Engine Works, Glasgow
Stott, S. S., & Co. .. .. .. Haslingden, near Manchester
Tangyes Limited .. .. .. Birmingham
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Engines (Stationary).
Allen, W. H., Son, & Co., Ltd... Queen's Eng. Works, Bedford
Alley & Macellan, Ltd. .. .. Sentinel Works, Glasgow
Bailey, W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Bellias & Morcom Ltd. .. .. Ledsam St. Works, Birmingham
Bever, Dorling & Co., Ltd. .. Bowling Ironworks, Bradford
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Brotherhood, P., Ltd. .. .. 53, Parliament Street, S.W.
Browett, Lindley & Co., Ltd. .. Patricroft, Manchester
Brown Bros. & Co., Ltd. .. Rosebank Ironwks., Edinburgh, N.B.
Campbell & Calderwood .. .. Soho Engine Works, Paisley
Chaplin, Alex., & Co., Ltd. .. Govan, Glasgow
Chesters Renfrew Engineering Co., Ltd. .. .. Renfrew, Scotland
Clarke, Chapman & Co., Ltd. .. Gateshead-upon-Tyne
Cochrane, J. .. .. Barrhead
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Coltman, H., & Sons .. .. Loughborough
Craig, A. F., & Co., Ltd. .. Paisley, N.B.
Davey, Paxman & Co., Ltd. .. Colchester
Davy Brothers, Ltd, ... Sheffield
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Donkin Co., Ltd. (The Bryan) .. Chesterfield
Douglas & Grant .. .. .. Dunnikier Foundry, Kirkcaldy, N.B.
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker, [Glasgow, W.
East Ferry Road Engineering Works Co., Ltd. .. .. Millwall, E.
Fawcett, Preston & Co., Ltd. .. Liverpool
Fowler J., & Co. (Leeds), Ltd... Leeds
Fraser & Chalmers, Ltd. .. .. 3, London Wall Buildings, E.C.
Fullerton, Hodgart & Barclay, Ltd. .. .. Vulcan Foundry and Engine Works, Paisley
Garrett, R., & Sons, Ltd. .. .. Leiston Works, Suffolk
Grantham Boiler & Crank Co., Ltd. Grantham
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Gutehoffnungshütte Coal Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Gwynnes Ltd. .. .. 81, Cannon Street, E.C.
Hannoversche Maschinenbau-Actien-Gesellschaft, vormals Georg Egestorff .. .. .. Hannover-Linden, Germany
Harvey Engineering Co., Ltd. .. Scotland Street Engine Works Glasgow
Hathorn, Davey & Co., Ltd. .. Leeds
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, Worcester
Hindley, E. S., & Sons .. .. Bourton, Dorset; and 11, Queen Victoria Street, E.C.
Hornsby, R., & Sons, Ltd. .. Grantham
Howden, James, & Co. .. .. Scotland Street, Glasgow
Isca Foundry & Engineering Co. Newport, Mon.
Lees, T. & R. .. .. .. Hollinwood, by Manchester

Engines (Stationary).—*Continued.*

Manlove, Alliott & Co. .. .. Nottingham
Marshall, Sons & Co., Ltd. .. Gainsborough
Maschinenfabrik Augsburg-Nurnberg A.-G. .. .. .. 219, Caxton House, Westminster, S.W.
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Murray, Workman & Co., Ltd. Glasgow
Musgrave & Co., Ltd. .. .. St. Ann's Ironworks, Belfast
Musgrave, John, & Sons, Ltd. .. Globe Iron Works, Bolton
Parsons, C. A., & Co. .. Heaton Works, Newcastle
Paul, Matthew, & Co., Ltd. .. Levenford Works, Dumbarton
Peckett & Sons .. .. .. Atlas Engine Works, Bristol
Peebles, Bruce, & Co., Ltd. .. Edinburgh
Piercy & Co., Ltd. .. .. Birmingham
Ransome, A., & Co. .. .. .. Stanley Works, Newark-on-Trent
Ransomes, Sims & Jefferies, Ltd. Ipswich
Reavell & Co., Ltd. .. .. Ipswich
Robey & Co., Ltd. .. .. Lincoln
Russell, Geo., & Co., Ltd. .. Motherwell, near Glasgow
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Samuelson & Co., Ltd., ... Britannia Wks, Banbury, Oxon.
Sandycroft Foundry Co., Ltd. .. Chester
Shanks, Thomas, & Co. .. .. Union Ironworks, Johnstone
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Sisson, W., & Co., Ltd. .. .. Gloucester
Smedley Brothers, Ltd. .. .. Belper, Derbyshire
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironwks., Glasgow
Stork Brothers & Co. .. .. Hengelo, Holland
Stott, S. S., & Co. .. .. .. Haslingden, near Manchester
Sulzer Bros. .. .. 30, Norfolk Street, Strand, W.C.
Tangyes Limited .. .. .. Birmingham
Taylor & Challen, Ltd. .. .. Birmingham
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster, S.W.
Tullis, D. & J., Ltd. .. .. Kilbowie Ironwks., nr. Glasgow
Vauxhall & West Hydraulic Engineering Co., Ltd. .. 45, Leadenhall Street, E.C.
Walker Bros. (Wigan), Ltd. .. Pagefield Ironworks, Wigan
Willans & Robinson, Ltd. .. Rugby, Warwickshire
Wolf, R. .. .. Norfolk House, Cannon St., E.C.

Engines (Traction).

Aveling & Porter, Ltd. .. .. Rochester
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
Burrell, C., & Sons, Ltd. .. Thetford
Davey, Paxman & Co., Ltd. .. Colchester
Fowler, J., & Co. (Leeds), Ltd. .. Leeds
Garrett, R., & Sons, Ltd. .. Leiston Works, Suffolk
Hornsby, R., & Sons, Ltd. .. Grantham
Marshall, Sons & Co., Ltd. .. Gainsborough
Pratchitt Brothers .. .. .. Denton Ironworks, Carlisle
Ransomes, Sims & Jefferies, Ltd. Ipswich
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Thornycroft, J. I., & Co., Ltd. .. Basingstoke
Wolseley Tool & Motor Car Co., Ltd. .. .. York Street, Westminster, S.W.

Engines (Winding).

Barclay, Andrew, Sons & Co., Ltd. .. .. Caledonia Works, Kilmarnock, Scotland
Bever, Dorling & Co., Ltd. .. Bowling Works, Bradford
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Chaplin, Alex., & Co., Ltd. .. Govan, Glasgow
Chesters Renfrew Engineering Co., Ltd. .. .. Renfrew, Scotland
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Davey, Paxman & Co., Ltd. .. Colchester
East Ferry Road Engineering Works Co., Ltd. .. .. Millwall, E.
Fawcett, Preston & Co., Ltd. .. Liverpool
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, Worcester
Hindley, E. S., & Sons .. .. Bourton, Dorset; and 11, Queen Victoria Street, E.C.
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster, S.W.
Lilleshall Company, Ltd. .. Oakengates, Shropshire
Pratchitt Brothers .. .. Denton Ironworks, Carlisle
Ransomes, Sims & Jefferies, Ltd. Ipswich
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Sandycroft Foundry Co., Ltd. .. Chester
Siemens Brothers Dynamo Wks., Ltd. .. .. Caxton House, Westminster, S.W.
Tangyes Limited .. .. .. Birmingham

Evaporators.

Blair, Campbell & McLean, Ltd. Woodville St., Govan, Glasgow
Burnet, L., & Co. .. .. .. Govan, Glasgow
Caird & Rayner .. .. .. 777, Commercial Road, E.
Fullerton, Hodgart & Barclay, Ltd. .. .. Vulcan Foundry and Engine Works, Paisley
Harvey Engineering Co., Ltd. .. Scotland Street Engine Works, Glasgow
Kirkaldy, John, Ltd. .. .. 101, Leadenhall Street, E.C.
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Richardsons, Westgarth & Co., Ltd. .. .. Hartlepool
Royles Limited .. .. .. Irlam, near Manchester
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow
Whittaker, C., & Co., Ltd. .. Haslingden, near Manchester

Excavators.

Atlantic Equipment Co. .. 30, Church St. New York, U.S.A.
Austin, F. C., Drainage Excavator Co. .. .. Railway Exchange, Chicago, Ill, U.S.A
Chaplin, Alex., & Co., Ltd. .. Govan, Glasgow
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Figee .. .. Haarlem, Holland
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Lobnitz & Co., Ltd. .. .. Renfrew, Scotland
Lubecker Machine & Mfg. Co. .. 30, Gt. St. Helen's, E.C.
Orenstein & Koppel-Arthur Koppel (Amalgamated) .. 27, Clements Lane, E.C.
Priestman Bros., Ltd. .. .. Holderness Foundry, Hull
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Smuilders, A. F. .. .. .. Schiedam, Rotterdam, Holland
Wilson, John H., & Co., Ltd. .. Dock Road, Seacombe, nr. Birkenhead

Exhausters.

Alldays & Onions (Pneumatic Engineering) Co., Ltd. Birmingham
Donkin Co., Ltd. (The Bryan) .. Chesterfield
Gwynnes Ltd. .. .. .. 81, Cannon Street, E.C. [S.W.
Korting Bros., Ltd. .. .. 53, Victoria St., Westminster.
Samuelson & Co., Ltd. .. .. Britannia Wks, Banbury, Oxon.
Standard Engineering Co., Ltd. Leicester

Expanded Metal.

Expanded Metal Co., Ltd. .. York Mansion, York Street, Westminster, S.W.

Explosives.

Curtis's & Harvey, Ltd. .. .. 3, Gracechurch Street, E.C.

Fans and Blowers.

A.E.G. Electric Company, Ltd. Pembroke Hse., 133-135, Oxford Street, W.
Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Allen, W. H., Son, & Co., Ltd. .. Queen's Eng. Works, Bedford
Barclay, Andrew, Sons & Co., Ltd. .. .. Caledonia Works, Kilmarnock, Scotland
Belliss & Morcom Ltd. .. .. Ledsam St. Wks., Birmingham
Brotherhood, P., Ltd. .. .. 53, Parliament Street, S.W.
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Churchill, Chas., & Co., Ltd. .. 9 to 15, Leonard Street, E.C.
Davidson & Co., Ltd. .. .. Sirocco Engin'r'g. Wks., Belfast
Dempster, R. & J., Ltd. .. .. Newton Heath, Manchester
Donkin Co., Ltd. (The Bryan) .. Chesterfield
Electric & Ordnance Accessories Co. Ltd. .. .. Aston, Birmingham

Fans and Blowers.—*Continued.*

Electromotors Ltd. .. .. Openshaw, Manchester
Gibbs, John, & Son .. .. 722-6, Duke Street, Liverpool
Gunther, W., & Sons .. .. Central Works, Oldham
Gwynnes Ltd. .. .. .. 81, Cannon Street, E.C.
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, Worcester
Howden, James, & Co. .. .. Scotland Street, Glasgow
Jackman, J. W., & Co., Ltd. .. Caxton House, Westminster S.W.
Keith, James, & Blackman Co., Ltd. .. .. 27, Farringdon Avenue, E.C.
Korting Bros. .. .. .. 53, Victoria Street. S.W.
Lilleshall Company, Ltd. .. Oakengates, Shropshire
Marsden, J., & Son .. .. 188, Regent Road, Liverpool
Murray, M'Vinnie & Co., Ltd. .. Mavisbank, Glasgow
Musgrave & Co., Ltd. .. .. St. Ann's Ironworks, Belfast
Parsons, C. A., & Co. .. .. Heaton Works, Newcastle
Paul, Matthew, & Co., Ltd. .. Levenford Works, Dumbarton
Samuelson & Co., Ltd. .. .. Banbury, Oxon
Simpson, Strickland & Co., Ltd. Dartmouth
Standard Engineering Co., Ltd. Leicester
Sturtevant Engineering Co., Ltd. 147, Queen Victoria Street, E.C.
Thermotank Ventilating Co., Ltd. 55, West Regent St., Glasgow
Thwaites Brothers, Ltd. .. Vulcan Ironworks, Bradford
Whittaker, C., & Co., Ltd. .. Haslingden, near Manchester

Feed Check Valves (Combination).

Green & Boulding, Ltd. .. .. 28, New Bridge Street, E.C.
Hopkinson, J., & Co., Ltd. .. Huddersfield
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow

Feed Water Filters.

Carruthers, J. H., & Co., Ltd. .. Polmadie Ironworks, Glasgow
Gutehoffnungshütte Coal, Iron Steel & Engineering Co. .. Oberhausen-2, Rhineland

Feed-Water Heaters.

Babcock & Wilcox, Ltd. .. .. Oriel House, Farringdon St., E.C.
Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Burnet, L., & Co. .. .. .. Govan, Glasgow
Caird & Rayner .. .. .. 777, Commercial Road, E.
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Green, George, & Co. .. .. Keighley
Holden & Brooke, Ltd. .. .. Sirius Works, West Gorton, Manchester
Kirkaldy, John, Ltd. .. .. 101, Leadenhall Street, E.C.
North-Eastern Marine Engineering Co., Ltd. .. .. Northumberland Wks., Wallsend-on-Tyne
Paterson Engineering Co., Ltd. 21, Amberley House, Norfolk Street, Strand, W.C.
Royles Limited .. .. .. Irlam, near Manchester
Shore, T., & Sons .. .. .. Etruria, Stoke-on-Trent
Tangyes Limited .. .. .. Birmingham
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow
Wheeler Condenser and Eng. Co. 2 & 3, Norfolk St., Strand, W.C.
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.
Wright, Jos., & Co. .. .. Tipton, Staffordshire

Feed-Water Regulators.

Thornycroft, J. I., & Co., Ltd. .. Basingstoke
White, J. Samuel, & Co., Ltd. .. East Cowes, Isle of Wight
Yarrow & Co., Ltd. .. .. Glasgow

Fencing.

Bayliss, Jones & Bayliss, Ltd. .. Wolverhampton
Miller, Wm., & Sons .. Wolverhampton
Morton, Francis, & Co., Ltd. .. Garston, Liverpool

Files.

Allen, Edgar, & Co., Ltd. .. Imperial Steel Works, Sheffield
Cammell Laird & Co. Ltd. .. Cyclops Steel & Iron Works, Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield
Jessop, W., & Sons, Ltd. .. Sheffield
Patent File & Tool Co., Ltd. .. 8, White St., Moorfields, E.C.
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Turton, T., & Sons, Ltd. .. .. Sheaf Works, Sheffield

Filtering Apparatus.

American Process Co. .. .. New York City, U.S.A.
Buhring's Patent Wate Purifying Co. .. .. 60, Wilson Street, E.C.
Caird & Rayner .. .. .. 777, Commercial Road, E.
Carruthers, J. H., & Co., Ltd. .. Polmadie Ironworks, Glasgow
Cockburns Limited .. .. Clydesdale Works, Cardonald, near Glasgow
Green, George, & Co. .. .. Keighley
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Gutehoffnungshütte Coal, Iron Steel & Engineering Co. .. Oberhausen-2, Rhineland
Harris Patent Feed-Water Filter (1910), Ltd. .. .. .. 82, Victoria Street, S.W.
Harris Patent Feed-Water Filter (1910), Ltd. .. .. .. 24, Grainger Street West, Newcastle-on-Tyne
Kirkaldy, John, Ltd. .. .. 101, Leadenhall Street, E.C.
Lipscombe, Fredk., & Co. .. 49, Queen Victoria Street, E.C.
Manlove, Alliott & Co., Ltd. .. Nottingham
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Möller, K. & Th., G.m.b.H. .. Brackwede, Germany
Paterson Engineering Co., Ltd. 21, Amberley House, Norfolk Street, Strand, W.C.
Puech, Armand .. .. .. Kingsway House, Kingsway, W.C.
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Royles Limited .. .. .. Irlam, near Manchester
Wells, A. C., & Co. .. .. 102, Midland Rd., N.W.
Wright, Jos., & Co. .. .. Tipton, Staffordshire

Filters (Air).

Möller, K. & Th., G.m.b.H. .. Brackwede, Germany

Fire Bars.

Rose, Downs & Thompson, Ltd. Old Foundry, Hull

Fire-Extinguishing Apparatus.

Merryweather & Sons .. .. 63, Long Acre, W.C.
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Flour Mill Machinery.—(*See Mill Machinery—Flour, Corn and Rice.*)

Forced and Induced Draught Apparatus.

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Bennis, Ed., & Co., Ltd. .. .. Bolton
Davidson & Co., Ltd. .. .. Sirocco Engineering Works, Belfast
Davy Bros., Ltd. .. .. .. Sheffield
Economic Forced Draught and Engineering Co., Ltd. .. .. 5, Castle Street, Liverpool
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham
Gibbs, John, & Son .. .. 722-6 Duke Street, Liverpool
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, Worcester
Howden, James, & Co. .. .. Scotland Street, Glasgow
Keith, James, & Blackman Co, Ltd. .. .. 27, Farringdon Avenue, E.C.
Mechan & Sons, Ltd. .. .. Scotstoun Iron Works, Glasgow
Meldrum Bros., Ltd. (in Liq.) .. Canal Works, Timperley, near Manchester
Murray, M'Vinnie & Co., Ltd. .. Mavisbank, Glasgow
Musgrave & Co., Ltd. .. .. St. Ann's Ironworks, Belfast
Standard Engineering Co. Ltd. Leicester
Sturtevant Engineering Co., Ltd. 147, Queen Victoria St., E.C.

Forges (Portable).

Becker, R. & Co. .. .. .. 53, City Road, E.C.
Sturtevant Engineering Co., Ltd. 147, Queen Victoria Street, E.C.
Standard Engineering Co., Ltd. Leicester
Thwaites Brothers, Ltd. .. .. Vulcan Ironworks, Bradford

Forging Machines and Plant.

Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Brett's Patent Lifter Co., Ltd. .. Coventry
Davis & Primrose .. .. .. Bangor Road, Leith
Davy Brothers, Ltd. .. .. Sheffield
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hetherington, J., & Sons, Ltd. Manchester
Mayer, W. & J. .. .. .. Birmingham
Rice & Co. (Leeds), Ltd. .. .. Elland Road, Leeds
Ryder, Thomas, & Son .. .. Turner Bridge Ironwks., Bolton
Ryder, William, Ltd. .. .. Beehive Works, Bolton
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow
Taylor & Challen, Ltd. .. .. Birmingham

Forging Presses.

Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Davy Brothers, Ltd. .. .. Sheffield
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
McOnie, A. & P. W. .. .. Govan, Glasgow
Rice & Co. (Leeds), Ltd. .. .. Elland Road, Leeds
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow
Stewart, Duncan, & Co, Ltd. .. London Road Ironworks, Glasgow

Forgings (Brass, Bronze, Copper, &c.).

Delta Metal Co., Ltd. .. .. East Greenwich, S.E.

Forgings (Drop).

Armstrong, Stevens & Son, Ltd. Whittall Street, Birmingham
Carron Company .. .. .. Carron, Stirlingshire, N.B.
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Rollo, David, & Sons .. .. Fulton Engine Wks., Liverpool
Vickers Limited .. .. .. Sheffield

Forgings (Iron and Steel).

Beardmore, William, & Co., Ltd. Parkhead Ironworks, Glasgow
Bessemer, Henry, & Co., Ltd. .. Sheffield
Brown, Bayley's Steel Works, Ltd. Sheffield
Brown, John, & Co., Ltd. .. Sheffield
Cammell Laird & Co. Ltd. .. Cyclops Steel & Iron Works, Sheffield
Carron Company .. .. .. Carron, Stirlingshire, N.B.
Colville, David, & Sons, Ltd. .. Motherwell, near Glasgow
Darlington Forge Co., Ltd. .. Darlington
Dennystown Forge Co. .. .. Dumbarton
Fairley, James, & Sons .. .. Shadwell Street, Birmingham
Fife Forge Co. .. .. .. Kirkcaldy, Scotland
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Hadfield's Steel Foundry Co., Ltd. .. .. Hecla Works, Sheffield
Hawthorn, R. & W., Leslie & Co., Ltd. .. .. Newcastle-on-Tyne
Hurst, Nelson & Co., Ltd. .. Glasgow Rolling Stock and Plant Works, Motherwell
Isca Foundry & Engineering Co. Newport, Mon.
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Jessop, Wm., & Sons, Ltd. .. Sheffield
Kirkstall Forge Co., Ltd. .. Near Leeds
Leeds Forge Co., Ltd. .. .. Leeds
Midland Railway Carriage and Wagon Co., Ltd. .. .. Abbey Works, Shrewsbury
North-Eastern Marine Engineering Co., Ltd. .. .. Northumberland Wks., Wallsend-on-Tyne
Rollo, David, & Sons .. .. Fulton Engine Works, Liverpool
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Steel Co. of Scotland, Ltd. .. 23, Royal Exchange Square, Glasgow
Thornycroft, J. I., & Co., Ltd. .. Southampton
Vickers Limited .. .. .. Sheffield
Wright, Jos., & Co. .. .. Tipton, Staffordshire

Foundry Plant.

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Britannia Foundry Co. .. .. Coventry
Green, George, & Co. .. .. Keighley
Jackman, J. W., & Co., Ltd. .. Caxton House, Westminster, S.W.
London Emery Works Co. .. Park, Tottenham, N.
Phillips, J. W. & C. J. .. .. 23, College Hill, Cannon St., E.C.
Poetter, G.m.b.H. .. .. .. Düsseldorf, Germany

Furnaces for Destroying Refuse.—(*See Disinfectors and Destructors.*)

Furnaces and Furnace Fittings.

A.E.G. Electric Company, Ltd. Pembroke Hse., 133-135, Oxford Street, W.
Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bennis, Ed., & Co., Ltd. .. Lancashire Stoker Works, Bolton
Böving, Jens Orten- & Co. .. 9½, Union Court, E.C.
Brett's Patent Lifter Co., Ltd. Coventry
Britannia Foundry Co. .. .. Coventry
Brown, John, & Co., Ltd. .. Sheffield
Churchill, Chas., & Co., Ltd. .. 9 to 15, Leonard Street, E.C.
Dowson & Mason Gas Plant Co., Ltd. .. .. Levenshulme, Manchester
Economic Forced Draught and Engineering Co., Ltd. .. .. 5, Castle Street, Liverpool
Fraser & Chalmers, Ltd .. 3, London Wall Buildings, E.C.
Griffin, John J., & Sons, Ltd. .. Kemble St., Kingsway, W.C.
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Horsfall Destructor Co., Ltd. .. 17, Victoria Street, S.W.
Howden, James, & Co. .. .. Scotland Street, Glasgow
Leeds Forge Co., Ltd. .. .. Leeds
Meldrum Bros., Ltd. (in Liq.) .. Canal Works, Timperley, near Manchester
Piercy & Co., Ltd. .. .. Broad St. Engine Works, Birmingham
Piggott, Thos., & Co., Ltd. .. Birmingham
Underfeed Stoker Co., Ltd. .. Coventry House, South Place, E.C.
Wallsend Slipway & Engineering Co., Ltd. .. .. Wallsend

Fusible Plugs.

Lunken Company, Inc. .. .. 35, Great Dover Street, S.E.
National Boiler and General Insurance Co., Ltd. .. .. St. Mary's Parsonage, Manchester

Galvanized Ironwork.

Ash, Joseph, & Son .. .. Rea Street South, Birmingham
Baldwins, Ltd. .. .. .. 5, Fenchurch Street, E.C.
Braby, Fred., & Co., Ltd. .. Fitzroy Wks., 352 to 364, Euston Road, N.W.
Harvey, G. A., & Co. .. .. Lewisham, S.E.
Ramshay & Marshall, Ltd. .. Birmingham

Galvanizers.

Ash, Joseph, & Son .. .. Rea Street South, Birmingham
Braby, Fred., & Co., Ltd. .. Fitzroy Wks., 352 to 364, Euston Road, N.W.
Harvey, G. A., & Co. .. .. Lewisham, S.E.
Morton, Francis, & Co., Ltd. .. Garston, Liverpool

Gas Engines.—(*See Engines, Gas.*)

Gas Exhausters.

Allen, W. H., Son, & Co., Ltd. .. Queen's Eng. Works, Bedford
Donkin Co., Ltd. (The Bryan) .. Chesterfield
Gwynnes Ltd. .. .. .. 81, Cannon Street, E.C. [S.W.
Korting Brothers, Ltd. .. .. 53, Victoria St., Westminster.
Samuelson & Co., Ltd. .. .. Britannia Works, Banbury, Oxon.
Sturtevant Engineering Co., Ltd. 147, Queen Victoria Street, E.C.

Gas Producers.

Baker, Joseph, & Sons, Ltd. .. Willesden Junction, N.W.
Bellamy, John, Ltd. .. .. Millwall, E.
Cameron, John, Ltd. .. .. Salford, Manchester
Campbell Gas Engine Co., Ltd. Halifax, England
Clayton, Son, & Co., Ltd. .. Hunslet, Leeds
Crossley Bros., Ltd. .. .. Openshaw, Manchester
Daniels, T. H. & J., Ltd. .. Stroud, Glos.
Davey, Paxman & Co., Ltd. .. Colchester
Dowson & Mason Gas Plant Co., Ltd. .. .. 39, Victoria Street, Westminster, S.W.
Dowson & Mason Gas Plant Co., Ltd. .. .. Levenshulme Manchester
Drake & Gorham, Ltd. .. .. 66, Victoria Street, S.W.
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Gas Power & By-Products Co., Ltd. .. .. 38, Bath Street, Glasgow
Hornsby, Richard, & Sons, Ltd. Grantham
Kynoch Ltd. .. .. .. Birmingham
Langen & Wolf .. .. .. Milan
Maschinenfabrik Augsburg-Nurnberg A.-G. .. .. .. 219, Caxton House, Westminster, S.W.
Pierson, J. & O. G. .. .. 47, Rue Lafayette, Paris
Poetter, G.m.b.H. .. .. Düsseldorf, Germany
Power Gas Corporation, Ltd. .. Stockton-on-Tees
Rodger, A., & Co. .. .. .. St. Helen's Engine Works, Govan, Glasgow
Ruston, Proctor & Co., Ltd. .. Lincoln
Stewart, Duncan, & Co., Ltd. .. London Rd Ironwks., Glasgow
Tangyes Limited .. .. .. Birmingham

Gas Works (Plant for)

Ashmore, Benson, Pease & Co., Ltd. Stockton-on-Tees
Clarke, Chapman & Co., Ltd. .. Victoria Works, Gateshead-on-Tyne
Clayton, Son, & Co., Ltd. .. Hunslet, Leeds
Donkin Co., Ltd. (The Bryan) .. Chesterfield
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Hanna, Donald & Wilson .. Paisley, N.B.
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Leech, Goodall & Co. .. .. Hunslet (Pepper Road), Leeds
Patent Shaft & Axletree Co., Ltd. Wednesbury
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham

Gases (Oxygen, &c.)

British Oxygen Co., Ltd. .. Elverton Street, S.W.
Knowles Oxygen Co., Ltd. .. Wolverhampton

Gauge Glasses.

Butterworth Bros., Ltd. .. Newton Heath Glass Wks, Manchester
Guilbert-Martin .. .. .. 9, Edmund Place, Aldersgate, E.C.
Klinger, Richard, & Co. .. .. 66, Fenchurch St., E.C.
Lunken Company, Inc. .. .. 35, Great Dover Street, S.E.
Schäffer & Budenberg, Ltd. .. Whitworth St., London Road, Manchester
Tomey, Joseph, & Sons, Ltd. .. Aston, Birmingham
Treasure, J. B., & Co. .. .. 8, Vauxhall Road, Liverpool

Gauges (Measuring).

Newall Engineering Co. .. Blackhorse Lane, Walthamstow, E.

Gauges (Pressure, Vacuum & Hydraulic).

Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Dobbie McInnes, Ltd. .. .. 57, Bothwell Street, Glasgow
Hannan & Buchanan .. .. 75, Robertson Street, Glasgow
Hopkinson, J., & Co., Ltd. .. Huddersfield
Hulburd Engineering Co., Ltd. 150, Leadenhall Street, E.C.
Lunken Company, Inc. .. .. 35, Great Dover Street, S.E.
Negretti & Zambra .. .. 38, Holborn Viaduct, E.C.
Phillips, J. W. & C. J. .. .. 23, College Hill, Cannon St., E.C.
Schäffer & Budenberg, Ltd. .. Whitworth St., London Road, Manchester
Smith's Injector Co. .. .. Oozells St. North, Birmingham
Storey, I., & Sons, Ltd. .. .. Empress Foundry, Manchester
Treasure, J. B., & Co. .. .. 8, Vauxhall Road, Liverpool

Gear Cutters.

British Insulated & Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
Brown, D., & Sons, Ltd. .. Huddersfield
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Lang, John, & Sons .. .. Johnstone, nr. Glasgow
Sonnenthal, E., Junr. .. .. Neue Promenade 6, Berlin, C.
Wallwork, Henry, & Co., Ltd. .. Manchester
Wrigley, E. G., & Co., Ltd. .. Foundry Lane Works, Soho, Birmingham

Gearing.—(*See Wheels, Geared.*)

Gearing (Speed Reducing).

Baker, Joseph, & Sons, Ltd. .. Willesden Junction, N.W.
Reid Gear Co. .. .. .. Linwood, near Paisley

Gelignite and Gunpowder.—(*See Explosives.*)

Girders.

Arrol, Sir William, & Co., Ltd. Dalmarnock Ironwks., Bridgeton, Glasgow
Clyde Structural Iron Co., Ltd. Clydeside Ironworks, Scotstoun, Glasgow
Craig, A. F., & Co., Ltd. .. .. Paisley, N.B.
De Bergue & Co., Ltd. .. .. Manchester
Heenan & Froude, Ltd. .. .. Newton Heath Ironworks, near Manchester
Isca Foundry & Engineering Co. Newport, Mon.
Lysaght, John, Ltd. .. .. St. Vincent Ironworks, Bristol
Measures Bros., Ltd. .. .. Southwark Street, S.E.
Mechan & Sons, Ltd. .. .. Scotstoun Ironworks, Glasgow
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Scott, Walter, Ltd. .. .. Leeds Steel Works, Leeds

Glazing.

Grover & Co., Ltd. .. .. Britannia Works, Wharf Rd., N

Gold-Crushing & Amalgamating Machinery.

Allen, Edgar, & Co., Ltd. .. Sheffield
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Chesters Renfrew Engineering Co., Ltd. .. .. Renfrew, Scotland
Davey, Paxman & Co., Ltd. .. Colchester
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield
Johnson, Wm., & Sons (Leeds), Ltd. Armley, Leeds
Krupp Aktiengesellschaft Grusonwerk .. .. Magdeburg-Buckau, Germany
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Robey & Co., Ltd. .. .. Lincoln
Sandycroft Foundry Co., Ltd. .. Chester
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.

Gold Dredgers.

Lobnitz & Co., Ltd. .. .. Renfrew, Scotland
Simons, W., & Co., Ltd. .. .. Renfrew, Scotland

Governors (Engine).

Boving, Jens Orten & Co. .. 9½, Union Court, E.C.
Campart, C. C. .. .. .. 49, Newgate Street, E.C.
Escher Wyss & Co. .. .. 109, Victoria Street, S.W.
Hartnell, Wilson, & Co., Ltd. .. Volt Works, Kirkstall Road, Leeds
Mason Regulator Co. .. .. Boston, Mass., U.S.A.
Pollock, Macnab & Highgate .. Shettleston, Glasgow
Schäffer & Budenberg, Ltd. .. Whitworth St., London Road, Manchester
Steven & Struthers .. .. Glasgow
Storey, I., & Sons, Ltd. .. .. Empress Foundry, Manchester
Tangyes Limited .. .. .. Birmingham

Graphite (Lubricating, &c.).

Dampney, J., & Co., Ltd. .. Cardiff
Graphite Products, Ltd. .. .. 218-220, Queen's Road, Battersea, S.W.

Grinding Machinery.

Allen, Edgar, & Co., Ltd. .. Sheffield
Becker, R., & Co. .. .. 53, City Road, E.C.
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield
Hardy Patent Pick Co., Ltd. .. Sheffield
Jackson, J. G., Ltd. .. .. 34, West George St., Glasgow
Jessop, W., & Sons, Ltd. .. Sheffield
Johnson, Wm., & Sons (Leeds), Ltd. Armley, Leeds
London Emery Works Co. .. Park, Tottenham, N.
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Newell, Ernest, & Co., Ltd. .. Misterton, Gainsboro'
Pfeiffer Gebr. .. .. .. Kaiserslautern, 74, Germany
Rowland, B. E., & Co., Ltd. .. Reddish, near Manchester
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.
Ward, H. W., & Co., Ltd. .. Lionel Street, Birmingham
Whittaker, C. & Co., Ltd. .. Accrington

Gun-Making Machinery.

Greenwood & Batley, Ltd. .. Albion Works, Leeds

Gunpowder and Gun-Cotton Machinery.

Greenwood & Batley, Ltd. .. Armley Road, Leeds
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.
Taylor & Challen, Ltd. .. .. Birmingham

Guns and Gun Forgings.

Brown, John, & Co., Ltd. .. Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Jessop, W., & Sons, Ltd. .. Brightside Works, Sheffield
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 3, East India Avenue, E.C.
Vickers Limited .. .. .. Sheffield

Hammers (Drop).

Brett's Patent Lifter Co., Ltd. .. Coventry
Massey, B. & S. .. .. .. Openshaw, Manchester
Platt, Samuel, Ltd. .. .. Wednesbury
Ross, R. G., & Son, Ltd. .. .. Glasgow

Hammers (Power).

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Consolidated Pneumatic Tool Co., Ltd. .. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.
Dudgeon, F. S. .. .. .. 30, Great St. Helen's, E.C.
Globe Pneumatic Eng. Co., Ltd. 150, Queen Victoria Street, E.C.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Ingersoll-Rand Co. .. .. .. 165, Queen Victoria Street, E.C.
Jackman, J. W., & Co., Ltd. .. Caxton House, Westminster, S.W.
Massey, B. & S. .. .. .. Openshaw, Manchester
Nasmyth, Wilson & Co., Ltd. .. Bridgewater Foundry, Patricroft, near Manchester
Piercy & Co., Ltd. .. .. .. Birmingham
Player, W. & J. .. .. .. Birmingham
Ross, R. G., & Son, Ltd. .. .. Glasgow [Bolton
Ryder, Thos., & Son .. .. Turner Bridge Ironworks,
Ryder, William, Ltd. .. .. Beehive Works, Bolton
Thwaites Brothers, Ltd. .. .. Vulcan Ironworks, Bradford

Hammers (Steam).—*(See Steam Hammers).*

Haulage Plants.

Barclay, Andrew, Sons & Co., Ltd. .. .. .. Caledonia Works, Kilmarnock, Scotland
Bullivant & Co., Ltd. .. .. 72, Mark Lane, E.C.
Heenan & Froude, Ltd. .. .. Worcester
Higginbottom & Mannock, Ltd. Crown Ironworks, West Gorton, Manchester
Lidgerwood Manufacturing Co. Caxton House, Westminster,
Ross, R. G., & Son, Ltd. .. .. Glasgow [S.W.
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Wild, M. B., & Co., Ltd. .. Nechells, Birmingham

Heating Apparatus.

Davidson & Co., Ltd. .. .. Sirocco Engineering Works, Belfast
Ferranti, Ltd. .. .. .. Hollinwood, Lancs.
Gibbs, Renton & Co., Ltd. .. Mill Street, Liverpool
Keith, James, & Blackman Co., Ltd. .. .. 27, Farringdon Avenue, E.C.
Korting Brothers, Ltd. .. .. 53, Victoria Street, S.W.
Musgrave & Co., Ltd. .. .. St. Ann's Ironworks, Belfast
Royles Limited .. .. .. Irlam, nr. Manchester
Standard Engineering Co., Ltd. Leicester
Sturtevant Engineering Co., Ld. 147, Queen Victoria St., E.C.
Tullis, D. & J., Ltd. .. .. Kilbowie Ironwks., nr. Glasgow
Westinghouse Brake Co., Ltd. 82, York Road, N.
Whittaker, C., & Co., Ltd. .. Haslingden, near Manchester
Witting, H. E. .. .. .. 9, Southampton Street, W.C.

Hinges.

Whitley & Valiant, Ltd. .. Ashton-in-Makerfield, Lancs.

Hoisting Machinery.—*(See also Cranes.)*

Babcock & Wilcox, Ltd. .. .. Oriel House, Farringdon Street, E.C.
Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Bleichert, Adolf, & Co. .. .. 99-100, Palmerston House, Bishopsgate St. Within, E.C.
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Brown Hoisting Machinery Co. Cleveland, Ohio, U.S.A.
Burnbank Engineering Co. .. 58, West Regent St., Glasgow
Chaplin, Alex. & Co .. .. Govan, Glasgow
Chesters Renfrew Engineering Co., Ltd. .. .. Renfrew, Scotland
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.
Craig, A. F., & Co., Ltd. .. Paisley, N.B.
Craven Brothers, Ltd. .. .. Osborne Street, Manchester
Davey, Paxman & Co., Ltd. .. Colchester
Deutsche Maschinenfabrik A.G. Duisburg, Germany
Electromotors Ltd. .. .. .. Openshaw, Manchester
Fairbanks Co. .. .. 15, Mallow St., Old St., E.C.
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Figee .. .. Haarlem, Holland
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Higginbottom & Mannock, Ltd. West Gorton, Manchester
Jack, Alexander, & Co. .. .. Whitegates Engineering Wks., Motherwell
Leech, Goodall & Co. .. .. Hunslet (Pepper Road), Leeds
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster,
Lilleshall Company, Ltd. .. Oakengates, Shropshire [S.W.
Maschinenfabrik Augsburg-Nurnberg A.-G. .. .. .. Augsburg-Nurnberg, Germany
Mitchell-Williams Crane Co. .. 98, Leadenhall Street, E.C.
Mork Patent Pulley Block Co., Ltd. .. .. 42-44, Moor Lane, E.C.
Musker, C. & A., Ltd. .. .. Liverpool
Oil Well Supply Co. .. .. Dashwood House, 9, New Broad Street, E.C.
Poblig, J., A.-G. .. .. .. Cologne-Zollstock
Priestman Brothers, Ltd. .. Holderness Foundry, Hull
Ransomes, Sims & Jefferies, Ltd. Ipswich
Rice & Co. (Leeds), Ltd. .. .. Elland Road, Leeds
Robey & Co., Ltd. .. .. .. Lincoln
Ross, R. G., & Son, Ltd. .. .. Glasgow
Royce Ltd. .. .. Trafford Park, Manchester
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Société du Nord de Liége .. 42, Perryn Road, Acton, W.
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.
Tangyes Limited .. .. .. Birmingham
Vaughan & Son, Ltd. .. .. West Gorton, Manchester
Waygood, R., & Co., Ltd. .. Falmouth Road, S.E.
Whitaker Brothers, Ltd. .. Horsforth, Leeds [kenhead
Wilson, John H., & Co., Ltd. .. Dock Road, Seacombe, nr. Birkenhead
Youngs .. .. Ryland St. Wks., Birmingham

Hose Pipes

Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Gutta Percha & Rubber Mfg. Co. of Toronto, Ltd. .. .. .. Toronto, Canada
Merryweather & Sons .. .. 63, Long Acre, W.C.
Middlemore & Lamplugh, Ltd. Birmingham
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Tullis, John, & Son .. .. St. Ann's Leather Wks., Glasgow
Willcox, W. H., & Co., Ltd. .. 23, Southwark Street, S.E.
Woodite Works .. .. .. Mitcham Common, Surrey
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Hydrants.

Alley & Maclellan, Ltd. .. .. Sentinel Works, Glasgow
Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B.

Hydraulic Machinery.

Arrol, Sir William, & Co., Ltd. Dalmarnock Ironwks., Bridgeton, Glasgow
Bailey, W. H., & Co., Ltd. .. Albion Wks., Salford, M'chester
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Brown Bros. & Co., Ltd. .. Rosebank Ironwks., Edinburgh, N.B.
Campbell & Calderwood .. .. Soho Engine Works, Paisley
Carruthers, J. H., & Co., Ltd. .. Polmadie Ironworks, Glasgow
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Cowans, Sheldon & Co., Ltd. .. Carlisle
Craig, A. F., & Co., Ltd. .. Paisley, N.B.
Craven Brothers, Ltd. .. .. Osborne Street, Manchester
Davy Brothers, Ltd. .. .. Sheffield
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker, [Glasgow, W.
East Ferry Road Engineering Works Co., Ltd. .. .. Millwall, E.
Fielding & Platt, Ltd. (Tweddell's System) .. .. .. Atlas Works, Gloucester
Fullerton, Hodgart & Barclay, Ltd. .. .. Vulcan Foundry and Engine Works, Paisley
Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B.
Greenwood & Batley, Ltd. .. Leeds
Hathorn, Davey & Co., Ltd. .. Leeds
Hayward-Tyler & Co., Ltd. .. 99, Queen Victoria Street, E.C.
Marshall, Fleming & Co. .. Motherwell, N.B.
McOnie, A. & P. W. .. .. Govan, Glasgow
Middleton, Robert .. .. Sheepscar Foundry, Leeds
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Musker, C. & A., Ltd. .. .. Liverpool
Nasmyth, Wilson & Co., Ltd. .. Bridgewater Foundry, Patricroft, near Manchester
Pitman, Percy .. .. .. Cropthorne, Pershore
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Rice & Co. (Leeds), Ltd. .. .. Neville Works, Elland Road, Leeds
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Shaw, John, & Sons (Salford), Ltd. .. .. Wellington Street Works, Salford, Manchester
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow
Société du Nord de Liége .. 42, Perryn Road, Acton, W.
Stewart, Duncan, & Co., Ltd. .. London Rd Ironwks., Glasgow
Tangyes Limited .. .. .. Birmingham
Vauxhall & West Hydraulic Engineering Co., Ltd. .. .. 45, Leadenhall Street, E.C.

Hydraulic Presses.

Arrol, Sir William, & Co., Ltd. Dalmarnock Ironwks., Bridgeton, Glasgow
Bailey, W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Bessemer, Henry, & Co., Ltd. .. Sheffield
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Davy Brothers, Ltd. .. .. Sheffield
East Ferry Road Engineering Works Co., Ltd. .. .. Millwall, E.
Fawcett, Preston & Co., Ltd. .. Liverpool
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Greenwood & Batley, Ltd. .. Leeds
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield
Hayward Tyler & Co., Ltd. .. 99, Queen Victoria Street, E.C.
Krupp Aktiengesellschaft Grusonwerk .. .. Magdeburg-Buckau, Germany
Manlove, Alliott & Co., Ltd. .. Nottingham
McOnie, A. & P. W. .. .. Govan, Glasgow
Middleton, Robert .. .. Sheepscar Foundry, Leeds
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Musker, C. & A., Ltd. .. .. Liverpool
Nasmyth, Wilson & Co., Ltd. .. Bridgewater Foundry, Patricroft, near Manchester
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd., Leeds
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Shaw, John, & Sons (Salford), Ltd. .. .. Wellington Street Works, Salford, Manchester
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow
Stewart, Duncan, & Co., Ltd. .. London Road Ironworks,
Stothert & Pitt, Ltd. .. .. Bath [Glasgow
Tangyes Limited .. .. .. Birmingham
Taylor & Challen, Ltd. .. .. Birmingham
Waygood & Co., Ltd. .. .. Falmouth Road, S.E.

Hydraulic Rams.

Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Keith, James, & Blackman Co., Ltd. .. .. 27, Farringdon Avenue, E.C.

Hydro-Extractors.

Broadbent, Thos., & Sons, Ltd. Chapel Hill, Huddersfield
Manlove, Alliott & Co., Ltd. .. Nottingham
Pott, Cassels & Williamson .. Motherwell, near Glasgow
Tullis, D. & J., Ltd. .. .. Kilbowie Ironworks, near Glasgow
Watson, Laidlaw & Co., Ltd. .. 98, Dundas St. (South), Glasgow

Hydrokineters and Temperature Equalisers.

Weir, G. & J., Ltd. .. .. Holm Foundry, Cathcart, Glasgow

Ice-Making Machines.

Allen, W. H., Son, & Co., Ltd. .. Queen's Eng. Works, Bedford
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Escher Wyss & Co. .. .. .. 109, Victoria Street, S.W.
Hall, J. & E., Ltd. .. .. Dartford Ironworks, Kent
Kirkaldy, John, Ltd. .. .. 101, Leadenhall Street, E.C.
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Pontifex & Wood, Ltd. .. .. Union Foundry, Derby
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Ransomes & Rapier .. .. 32 (Dept. H.), Victoria St., S.W.
Seagers, Ltd. .. .. .. Dartford
Sterne, L., & Co., Ltd. .. .. Crown Ironworks, Glasgow

Igniters (Electric).

Lodge Bros. & Co. .. .. .. 14, New Street, Birmingham

Incandescent Lamps.

British-Thomson Houston Co., Ltd. .. .. Rugby
English Electrical Co., Ltd. .. Nottingham

India-Rubber Goods.

Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Gutta Percha & Rubber Mfg Co. of Toronto, Ltd. .. .. .. Toronto, Canada
India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, Essex
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Winter, F. .. .. 25, Goswell Road, E.C.
Woodite Works .. .. .. Mitcham Common, Surrey

Indicators and Indicator Gear (Steam and Gas Engine).

Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Crosby Steam Gage & Valve Co. 147, Queen Victoria Street, E.C.
Dobbie McInnes, Ltd. .. .. 57, Bothwell Street, Glasgow
Hannan & Buchanan .. .. 75, Robertson Street, Glasgow
Negretti & Zambra .. .. 38, Holborn Viaduct, E.C.
Schäffer & Budenberg, Ltd. .. Whitworth St., London Road, Manchester

Injectors.

Bailey, W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Davies & Metcalfe, Ltd. .. .. Romiley, Manchester
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Green & Boulding, Ltd. .. .. 26, New Bridge Street, E.C.
Gresham & Craven, Ltd. .. .. Manchester
Holden & Brooke, Ltd. .. .. Sirius Works, West Gorton, Manchester
Jenkins Bros. .. .. .. 95, Queen Victoria Street, E.C.
Klinger, Richard, & Co. .. 66, Fenchurch Street, E.C.
Korting Brothers, Ltd. .. .. 53, Victoria St., Westminster, S.W.
Lunken Company, Inc. .. .. 35, Great Dover Street, S.E.
Manlove, Alliott & Co., Ltd. .. Nottingham
Schäffer & Budenberg, Ltd. .. Whitworth St., London Road, Manchester
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Smith's Injector Co. .. .. Ozells St. North, Birmingham
Willcox, W. H., & Co., Ltd. .. 23, Southwark Street, S.E.

Inks.

Higgins, C. M., & Co. .. .. 11, Farringdon Avenue, E.C.

Instruments (Electrical, Surveying, &c.).

Boss-Conzelmann, Johs. .. .. Onstmettingen, Wurtemberg
Boving, Jens Orten- & Co. .. 9½, Union Court, Old Broad
British Thomson Houston Co., Ltd. .. .. Rugby [Street, E.C.
Cambridge Scientific Instrument Co., Ltd. .. .. Cambridge
Davis, John & Son (Derby), Ltd. All Saints' Works, Derby
Engineering Supplies, Ltd. .. 28, Victoria Street, S.W.
Everett, Edgcumbe & Co., Ltd. 117, Victoria Street, S.W.
Griffin, John J., & Sons, Ltd. .. Kemble St., Kingsway, W.C.
Halden, J., & Co., Ltd. .. .. 8, Albert Square, Manchester
Kern & Co. .. .. Aarau, Switzerland
Lea Recorder Co. .. .. .. 28, Deansgate, Manchester
Negretti & Zambra .. .. 38, Holborn Viaduct, E.C.
Phillips, J. W. & C. J. .. .. 23, College Hill, Cannon St., E.C.
Porhydrometer, Ltd. .. .. 6, Lloyd's Avenue, E.C.
Stanley, W. F., & Co., Ltd. .. 286, High Holborn, W.C.

Insulating Materials.

Micanite & Insulators Co., Ltd. Walthamstow, E.
Newalls Insulation Co., Ltd. .. Mosley St., Newcastle-on-Tyne
Wiggins, F., & Sons .. .. 102 & 103, Minories, E.
Woodite Works .. .. .. Mitcham Common, Surrey

Insurance Companies.

National Boiler and General Insurance Co., Ltd. .. .. St. Mary's Parsonage, M'chester
Sun Fire Office .. .. .. 63, Threadneedle Street, E.C.

Iron Founders.—*(See Castings, Iron.)*

Iron Merchants.

Birch, John, & Co., Ltd. .. 2, London Wall Buildings, E.C.
Cooke, William, & Co., Ltd. .. Tinsley Steel, Iron & Wire Rope Works, Sheffield
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Henderson & Glass .. .. Liverpool
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow

Iron (Pig).

Brown, John, & Co., Ltd. .. Sheffield
Glasgow Iron & Steel Co., Ltd. .. Wishaw Iron & Steel Works, [Wishaw
Metropolitan Amalgamated Railway Carriage & Wagon Co., Ld. Saltley, Birmingham

Iron & Steel Buildings.—*(See Structural Engineering.)*

Iron and Steel Works (Plant for).

Ashmore, Benson, Pease & Co., Ld. Stockton-on-Tees
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Craig & Donald, Ltd. .. .. Johnstone, near Glasgow
Daiglish, A. & W. .. .. Pollokshaws, Glasgow
Davy Brothers, Ltd. .. .. Sheffield
Deutsche Maschinenfabrik A.G. Duisburg, Germany
Dowson & Mason Gas Plant Co., Ltd. .. .. 39, Victoria Street, S.W.
Fielding & Platt, Ltd. .. .. Gloucester
Green, George, & Co. .. .. Keighley
Harvey Engineering Co., Ltd. .. Scotland Street Engine Works, Glasgow
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Heenan & Froude, Ltd. .. .. Newton Heath Ironworks, near Manchester
Horsfall Destructor Co., Ltd. .. 17, Victoria Street, S.W.
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Leech, Goodall & Co. .. .. Hunslet (Pepper Road), Leeds
Lilleshall Company, Ltd. .. Oakengates, Shropshire
Marsden, H. R. .. .. .. Soho Foundry, Leeds
Maschinenfabrik Thyssen & Co., A.-G. .. .. Mulheim-Ruhr
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Poetter, G.m.b H. .. .. Düsseldorf, Germany
Pohlig, J., A.-G. .. .. .. Cologne-Zollstock
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd., Leeds
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow
Thwaites Bros., Ltd. .. .. Bradford

Jacks (Lifting).

Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Tangyes Limited .. .. .. Birmingham
Youngs .. .. Ryland St. Wks., Birmingham

Jointing Materials.

Almagam Limited .. .. 172, Great Portland Street, W.
Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Cooper, Edwin, & Co., Ltd. .. 86, Leadenhall Street, E.C.
Graphite Products, Ltd. .. 218-220, Queen's Road, Battersea, S.W. [E.
Hobdell, Way & Co., Ltd. .. St. John's House, 124-5, Minories.
House, Fredk., & Co. .. .. 30, Cuspel Street, Liverpool
Hudson, John, & Co.'s Successors 81a, Mansell Street, E.C.
Hulburd Engineering Co., Ltd. 150, Leadenhall Street, E.C.
Jenkins Bros. .. .. .. 95, Queen Victoria Street, E.C.
Klinger, Richard, & Co. .. .. 66, Fenchurch Street, E.C.
Le Bas, Edward, & Co. .. .. Dock House, Billiter Street,
Peters, C. A., Ltd. .. .. Derby [E.C.
Smooth-on Manufacturing Co. Jersey City, N.J., U.S.A.
Thomas & Bishop .. .. .. 119-125, Finsbury Pavement, E.C

Joists, Rolled (Iron and Steel).

Lanarkshire Steel Co., Ltd. .. Motherwell
Measures Bros., Ltd. .. .. Southwark Street, S.E.
Scott, Walter, Ltd. .. .. Leeds Steel Works, Leeds

Ladders, Steps, &c.

Heathman & Co. .. .. .. Parson's Green, Fulham, S.W.

Ladles.

Clayton Son, & Co., Ltd. .. Hunslet, Leeds
Lilleshall Company, Ltd. .. Oakengates, Shropshire
M'Neil, C. .. .. Kinning Park Ironworks, Glasgow

Lamps.—*(See also Electric Lighting Plant.)*

Brush Electrical Engineering Co., Ltd. .. .. Loughborough
English Electrical Co., Ltd. .. Nottingham
Jandus Arc Lamp & Electric Co., Ltd. .. .. Hartham Road, Holloway, N.
Standard Light Co., Ltd. .. Frankfort o/Maine, Germany
United Kingdom Lighting Trust, Ltd. (Dept. E.) .. .. .. 231, Strand, W.C.
Wells, A. C., & Co. .. .. 102, Midland Road, St. Pancras, N.W.
Westinghouse Cooper Hewitt Co., Ltd. .. .. 151-2, Great Saffron Hill, E.C.

Lathes.—*(See Machine Tools.)*

Launches and Yachts.

Alley & Maclellan, Ltd. .. .. Sentinel Works, Glasgow
Boulton & Paul, Ltd. .. .. Norwich
Burnet, L., & Co. .. .. .. Govan, Glasgow
Chaplin, Alex., & Co. .. .. Cranstonhill Engine Works Glasgow
Cochran & Co., Annan, Ltd. .. Annan, N.B.
Crabtree & Co., Ltd. .. .. Great Yarmouth
Day, Summers & Co., Ltd. .. Northam Ironworks, Southampton
Escher Wyss & Co. .. .. 109, Victoria Street, S.W.
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Hanna, Donald & Wilson .. Paisley, N.B.
Hayes, Edward .. .. .. Stony Stratford, Wolverton
McKie & Baxter .. .. .. Copland Wks., Govan, Glasgow
Normand, Augustin, Ltd. .. 67, Rue du Perrey, Le Havre, France
Ross & Duncan .. .. .. Whitefield Works, Glascow
Schichau, F. .. .. .. Elbing-Danzig, Prussia
Sharer & Young, Ltd. .. .. Marmot Works, Alloa, Scotland
Simons, W., & Co., Ltd. .. .. Renfrew, N.B.
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Smit, L., & Zoon .. .. .. Kinderdijk, Holland
Thornycroft, J. I., & Co., Ltd. .. Southampton, and Caxton House, Westminster, S.W
Vosper & Co., Ltd. .. .. Portsmouth
Yarrow & Co., Ltd. .. .. Glasgow

Laundry Machinery.

Manlove, Alliott & Co., Ltd. .. Nottingham
Tullis, D. & J., Ltd. .. .. Kilbowie Ironwks., nr. Glasgow

Leathers (Hydraulic, &c.)

Almagam Limited .. .. 172, Great Portland Street, W.
Middlemore & Lamplugh, Ltd. .. Birmingham

Lifts.

Bailey, W. H. & Co. Ltd. .. Albion Wks. Salford, Manchest'r
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Bleichert, Adolf, & Co. .. .. 99-100, Palmerston House, Bishopsgate St. Within, E.C.
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Hall, J. & E., Ltd. .. .. Dartford Ironworks, Kent
Otis Elevators .. .. .. 4, Queen Victoria Street, E.C.
Rice & Co. (Leeds), Ltd. .. .. Elland Road, Leeds
Tangyes Limited .. .. .. Birmingham
Waygood & Co., Ltd. .. .. Falmouth Road, S.E.

Light Railways.—*(See Railways, Light and Portable.*

Lighters.—*(See Barges.)*

Lighting Apparatus.—*(See also Electric Lighting Plant.)*

Brush Electrical Engineering Co., Ltd. .. .. Loughborough
Keith, James, & Blackman Co., Ltd. .. .. 27, Farringdon Avenue, E.C.
Standard Light Co., Ltd. .. Frankfort o/Maine, Germany
United Kingdom Lighting Trust, Ltd. (Dept. E.) .. .. .. 231, Strand, W.C.
Wells, A. C., & Co. .. .. 102, Midland Road, St. Pancras, N.W.
Westinghouse Cooper Hewitt Co., Ltd. .. .. 151-2, Great Saffron Hill, E.C.

Lightning Conductors.

Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchester

Lithographers.

Kell, Thos., & Son .. .. .. 40, King Street, Covent Garden W.C.

Lock Nuts and Nut-Locking Appliances.

"Amross" Positive Lock Washer Manufacturing Co. .. .. 59-61, Hatton Garden, E.C.
Bayliss, Jones & Bayliss, Ltd. .. Wolverhampton
Fastnut, Ltd. .. .. .. 115, Newgate Street, E.C.
Grover & Co., Ltd. .. .. Wharf Road, N.
Kalker, E., & Co. .. .. .. Coventry

Locomotive Engines.—*(See Engines, Locomotive.)*

Locomotives (Mountings for).

Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Hopkinson, J., & Co., Ltd. .. Huddersfield
Lunken Company, Inc. .. .. 35, Great Dover Street, S.E.
Storey, I., & Sons, Ltd. .. .. Empress Foundry, Manchester

Looms.

Craig, A. F., & Co., Ltd. .. Paisley, N.B.

Lubricants and Oils.

Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Graphite Products, Ltd. .. 218-220, Queen's Road, Battersea, S.W.
Price's Patent Candle Co., Ltd. Battersea, S.W.
Stern Sonneborn Oil Co., Ltd .. Royal London House, Finsbury Square, E.C.
Thomas & Bishop .. .. .. 119-125, Finsbury Pavement E.C.
Trier Bros. .. .. Caxton House, Westminster S.W.
Willcox, W. H., & Co., Ltd. .. 23, Southwark Street, S.E.

Lubricators.

Bell's United Asbestos Co. Ltd. 59½, Southwark Street, S.E.
Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Butterworth Bros., Ltd. .. .. Newton Heath Glass Wks., Manchester
Crosby Steam Gage and Valve Co. 147, Queen Victoria Street, E.C.
Guest, Keen & Nettlefolds, Ltd. Birmingham
Hulburd Engineering Co., Ltd. 150, Leadenhall Street, E.C.
Hunt & Mitton .. .. .. Ozells St. North, Birmingham
Klinger, Richard, & Co. .. .. 66, Fenchurch Street, E.C.
Korting Brothers, Ltd. .. .. 53, Victoria St., S.W.
Lunken Company, Inc. .. .. 35 Great Dover Street, S.E.
Peake, W. Toulmin, & Co. .. Whitestake, near Preston, Eng
Piggott, Thos., & Co .. .. Springhill, Birmingham
Schäffer & Budenberg, Ltd. .. Whitworth St., London Road, Manchester
Steam Cylinder Lubricator Co., Ltd. .. .. Gordon Works, Lower Broughton, Manchester
Tangyes Limited .. .. .. Birmingham
Trier Bros. .. .. Caxton House, Westminster,
Vickers, Benjn. R., & Sons .. Leeds [S.W.
Wilcox, W. H., & Co., Ltd. .. 23, Southwark Street, E.C.

Machine Tools.—*(See also Tools (Hand and Small) and Second-hand Tools, &c.)*

Allan, Robert S., & Co. .. .. Gateshead-on-Tyne
Archdale, Jas., & Co., Ltd. .. Ledsam Street, Birmingham
Barker, Spink, Lease & Co. .. Roose Works, Shipley, Yorks
Bateman's Machine Tool Co., Ld. Electric Works, Leeds
Becker, R., & Co. .. .. .. 53, City Road, E.C.
Bennie, James, & Sons, Ltd. .. Clyde Engine Works, Cardonald, Glasgow
Berry, F., & Sons .. .. .. Calderdale Ironworks, Sowerby Bridge
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Beyer, Peacock & Co., Ltd. .. Gorton Foundry, Manchester
Britannia Engineering Co. (1910), Ltd. .. .. Colchester
Brown, David, & Sons, Ltd. .. Huddersfield
Buck & Hickman, Ltd. .. .. 2 & 4, Whitechapel Road, E.
Buckton, Joshua, & Co., Ltd. .. Leeds
Burton, C. W., Griffiths & Co. .. 1, 2 & 3, Ludgate Square, E.C.
Butler, J., & Co. .. .. .. Victoria Ironworks, Halifax
Cameron, John, Ltd. .. .. Oldfield Road Ironwks., Salford
Campbells & Hunter, Ltd. .. Dolphin Foundry, Leeds
Carron Co. .. .. Carron, Stirlingshire, N.B.

Machine Tools.—(*See also Tools (Hand and Small) and Second-hand Tools, &c.*)—*Continued.*

Carter & Wright .. .. .. Woodside, Halifax
Chambers, Scott & Co. .. .. Motherwell
Churchill, Chas. & Co., Ltd. .. 9 to 15, Leonard St., E.C.
Clifton & Baird, Ltd. .. .. Empress Works, Johnstone, Scotland
Clifton & Waddell .. .. Johnstone, near Glasgow
Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.
Craig & Donald, Ltd. .. .. Johnstone near Glasgow
Craven Brothers, Ltd. .. .. Osborne Street, Manchester
Darling & Sellers, Ltd. .. Keighley
Davis & Primrose .. .. .. Etna Ironworks, Bangor Road, Keighley [Leith, N.B.
De Bergue & Co., Ltd. .. .. Manchester
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Droop & Rein .. .. .. Bielefeld, Germany
Drummond Brothers, Ltd. .. Engel Works, near Guildford
Fairbairn Macpherson .. .. Wellington Foundry, Leeds
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Goodchild, Geo. W., & Partner 30-32, Farringdon Road, E.C.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Harvey, G. & A., Ltd. .. .. Govan, Glasgow, W.
Heap, Joshua, & Co., Ltd. .. Ashton-under-Lyne
Herbert, Alfred, Ltd. .. .. Coventry
Hetherington, John, & Sons .. Manchester
Holbrook & Sons .. .. .. Stratford, E.
Jones, A. A., Pollard & Shipman, Ltd. .. .. East Park Road, Leicester
Jones & Lamson Machine Co. .. Jubilee Buildings, 97, Queen Victoria Street, E.C.
Kendall & Gent, Ltd. .. .. Victoria Works, Belle Vue, Manchester
Lang, J., & Sons .. .. .. Johnstone, N.B.
London Brothers, Ltd. .. .. 39, West Campbell St., Glasgow
Maclellan, P. & W., Ltd. .. Clutha Works, Glasgow
McOnie, A. & P. W. .. .. Govan, Glasgow
Muir, Wm., & Co., Ltd. .. .. Sherbourne Street, Manchester
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Neat, Charles, & Co. .. .. 112, Queen Victoria Street, E.C.
Niles-Bement-Pond Co. .. .. 111, Broadway, New York, U.S.A.
Niles-Bement-Pond Co. .. .. 23 & 25, Victoria Street, S.W.
Noble & Lund, Ltd. .. .. Felling, nr. Newcastle-on-Tyne
Parkinson, J., & Son .. .. Shipley, Yorkshire
Patrick, F. .. .. Oxford Street, Leeds
Pfeil & Co. .. .. 145-9, St. John Street, Clerkenwell, E.C.
Phœnix Dynamo Mfg. Co., Ltd. Thornbury Works, Bradford
Pollock & Macnab, Ltd. .. .. Bredbury, Manchester
Pratt & Whitney Co. .. .. Hartford, Conn., U.S.A.
Redman, C., & Sons .. .. Dunkirk, Halifax
Rice & Co. (Leeds), Ltd. .. .. Newtonwike, Elland Rd., Leeds
Richards, Geo., & Co., Ltd. .. Broadheath, near Manchester
Ryder, Thos., & Son .. .. Turner Bridge Ironworks, Bolton
Ryder, William, Ltd. .. .. Beehive Works, Bolton
Scott Bros. .. .. West Mount, Halifax
Scriven & Co. .. .. Leeds Old Foundry, Marsh Lane, Leeds
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Shanks, Thomas, & Co Union Ironworks, Johnstone
Smith Brothers & Co. (Glasgow), Ltd. .. .. Kinning Park, Glasgow
Smith & Coventry, Ltd. .. .. Ordsal Lane, Manchester
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow
Southgate Pile Driver Co. .. 12, Savage Gardens, E.C.
Spencer, James, & Co. .. .. Chamber Iron Works, Hollinwood, Manchester.
Stirk, John, & Sons, Ltd. .. Halifax [Halifax
Swift, George, & Sons .. .. Range Bank, Halifax
Tangyes Limited .. .. .. Birmingham
Taylor, Charles (Birm'ghm.), Ltd. Bartholomew St., Birmingham
Tullis, D. & J., Ltd. .. .. Kilbowie Ironwks., nr. Glasgow
Wagner & Co. .. .. .. Dortmund, Westphalia
Ward, H. W., & Co., Ltd. .. Lionel Street, Birmingham
Ward, Thos. W., Ltd. .. .. Albion Works, Sheffield
Winn, Charles, & Co. .. .. Granville Place, Birmingham
Wolseley Tool & Motor Car Co., Ltd. .. .. York Street, Westminster, S.W.

Manganese Steel Castings and Forgings.

Allen, Edgar, & Co., Ltd. .. Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield

Manhole Doors.

McNeil, C. .. .. Kinning Park Ironworks, Glasgow

Manufacturers.—(*See also Patent Law.*)

Mathematical Instruments (Makers).

Negretti & Zambra .. .. 38, Holborn Viaduct, E.C.
Stanley, W. F., & Co., Ltd. .. 286, High Holborn, W.C.
Thornton, A. G., Ltd. .. .. 28, King St. West, Manchester

Mechanical Engineers (Consulting).

Davey, Paxman & Co., Ltd. .. Colchester

Merchants (Machinery, &c.)

Birch, John, & Co., Ltd. .. 2, London Wall Buildings, E.C.
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow
Willcox, W. H., & Co., Ltd. .. 22, Southwark Street, E.C.

Metallic Packing.

Green & Boulding, Ltd. .. .. 28, New Bridge Street, E.C.
Hulburd Engineering Co., Ltd. 150, Leadenhall Street, E.C.
Lancaster & Tonge, Ltd. .. Pendleton, near Manchester
Newton & Nicholson .. .. Tyne Dock Corrugated Packing Works, South Shields
United Kingdom Self-Adjusting Anti-Friction Metallic Packing Syndicate, Ltd. .. .. 14, Cook Street, Liverpool
United States Metallic Packing Co., Ltd. .. .. Soho Works, Thornton Road, Bradford

Metals (Phosphor Alloys, &c.).

Atlas Metal & Alloys Co., Ltd. .. 52, Queen Victoria Street, E.C.
Billington & Newton, Ltd. .. Longport, Staffordshire
Bull's Metal & Melloid Co., Ltd. Yoker, nr. Glasgow
Delta Metal Co., Ltd. .. .. East Greenwich, S.E.
Eyre Smelting Co., Ltd. .. .. Barden Road Works, Tonbridge, Kent
Gemmell, W., & Co. .. .. 492, Argyle Street, Glasgow
Glyco Metal Co., Ltd. .. .. Manchester
Johnson, Richard, Clapham and Morris, Ltd. .. .. .. Lever Street, Manchester
Kidston, A. G., & Co. .. .. 155, Fenchurch Street, E.C.
Lunken Company, Inc. .. .. 35, Great Dover Street, S.E.
Magnolia Anti-Friction Metal Co. of Gt. Britain, Ltd. .. .. 49, Queen Victoria Street, E.C.
Muntz, P. H., & Co., Ltd. .. Alexandra Works, West Bromwich
Phosphor Bronze Co., Ltd. .. Sumner Street, S.E. [Sumner Street, S.E.
Reiner, Arthur, & Co. .. .. 63, Queen Victoria Street, E.C.
Saunders, J. T., & Co. .. .. 150, Queen Victoria Street, E.C.
Sterling Metals, Ltd. .. .. St. George's Works, Coventry
Steven & Struthers .. .. Glasgow
Storey, I., & Sons, Ltd. .. .. Empress Foundry, Manchester

Meters.

Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B.
Hulmer & Meyer .. .. Vienna, XIX 6
Lea Recorder Co. .. .. 28, Deansgate, Manchester
Siemens Bros. & Co., Ltd. Caxton House, Westminster, S.W.
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Mica Merchants.

Wiggins, F., & Sons .. .. 102, 103 & 104, Minories, E.

Mill Gearing.—(*See Wheels, Geared; also Shafting and Shaft Fittings.*

Mill Machinery (Flour, Corn & Rice).

Blackstone & Co., Ltd. .. .. Rutland Works, Stamford
Marshall, Sons & Co., Ltd. .. Gainsborough
Ransomes, Sims & Jefferies, Ltd. Ipswich
Robey & Co., Ltd. .. .. .. Lincoln
Robinson, T., & Son, Ltd. .. Rochdale
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.

Milling Cutters and Cutter Blanks.

Chatwin, Thomas .. .. .. Great Tindal St., Birmingham
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Jessop, W., & Sons, Ltd. .. Sheffield
Muir, Wm. & Co., Ltd. .. .. Sherbourne Street, Manchester
Neat, Charles, & Co. .. .. 112, Queen Victoria St., E.C.
Wrigley, E. G., & Co., Ltd. .. Foundry Lane Works, Soho, Birmingham

Mills (Paint, Oil, Mortar, &c.).

Blackstone & Co., Ltd. .. .. Rutland Works, Stamford
Krupp Aktiengesellschaft Grusonwerk .. .. Magdeburg-Buckau, Germany
Pratchitt Brothers .. .. Denton Ironworks, Carlisle
Smedley Bros., Ltd. .. .. Belper, Derbyshire
Whittaker, C., & Co., Ltd. .. Accrington

Mining Machinery.

Allen, Edgar, & Co., Ltd. .. Sheffield
Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Barclay, Andrew, Son & Co., Ltd. .. .. Caledonia Works, Kilmarnock, Scotland
Baume & Marpent .. .. Moyaux, Haine-St.-Pierre, Belgium
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Chesters Renfrew Engineering Co., Ltd. .. .. Renfrew, Scotland
Clay Cross Co. .. .. .. Clay Cross, near Chesterfield
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.
Davey, Paxman & Co., Ltd. .. Colchester
Daw, A. & Z. .. .. .. 11, Queen Victoria Street, E.C.
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Fowler, J., & Co. (Leeds), Ltd. .. Leeds
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield
Hardy Patent Pick Co., Ltd. .. Sheffield
Hathorn, Davey & Co., Ltd. .. Leeds [on-Tees
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-
Heenan & Froude, Ltd. .. .. Worcester Engineering Works,
Hornsby, R., & Sons, Ltd. .. Grantham [Worcester
Jessop, W., & Sons, Ltd. .. .. Sheffield
Johnson, Win., & Sons (Leeds), Ltd. Armley, Leeds
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Maschinenfabrik Thyssen & Co., A.-G. .. .. Mulheim-Ruhr
Pfeiffer Gebr. .. .. .. Kaiserslautern, 74, Germany
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Ransomes, Sims & Jefferies, Ltd. Ipswich
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Lincoln
Sandycroft Foundry Co., Ltd. .. Chester
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.
Standard Engineering Co., Ltd. Leicester
Tangyes Limited .. .. .. Birmingham
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Mint Machinery.

Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Taylor & Challen, Ltd. .. .. Birmingham

Mixers.

Davy Brothers, Ltd. .. .. Sheffield

Motor Boats.

Boulton & Paul, Ltd. .. .. Norwich
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster, S.W.
White, J. Samuel, & Co., Ltd. .. East Cowes, Isle of Wight
Wolseley Tool & Motor Car Co., Ltd. .. .. York Street, Westminster

Motor Cars.—(*See Motor Vehicles.*)

Motor Starters and Accessories.

Adams Manufacturing Co., Ltd. 106, New Bond Street, W.
Booth, Joseph, & Bros., Ltd. .. Rodley, Leeds
British Thomson-Houston Co, Ltd. .. .. Rugby
Cox-Walkers, Ltd. .. .. Darlington
Electric Control, Ltd. .. .. 177, Reid Street, Bridgeton, [Glasgow
Electric & Ordnance Accessories Co., Ltd. .. .. .. Aston, Birmingham
Electromotors Ltd. .. .. Openshaw, Manchester
Ferranti, Ltd. .. .. .. Hollinwood, Lancs.
Sandycroft Foundry Co., Ltd. .. Chester

Motor Vehicles.

Alley & Maclellan, Ltd. .. .. Sentinel Works, Glasgow
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
Broom & Wade, Ltd. .. .. High Wycombe
Price, Charles & Son .. .. Broadheath, near Manchester
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironworks, Glasgow
Talbot, Clement, Ltd. .. .. Barlby Rd, Ladbroke Grove, W.
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster, [S.W.
Wolseley Tool & Motor Car Co., Ltd. .. .. York Street, Westminster, S.W.
Yorkshire Patent Steam Wagon Co. .. .. Pepper Road, Hunslet, Leeds

Motors.—(*See Electric Motors.*)

Moulding Machines.

Britannia Foundry Co. .. .. Coventry
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Jackman, J. W., & Co., Ltd. .. Caxton House, Westminster,
London Emery Works Co. .. Park, Tottenham, N. [S.W.
Murray, Workman & Co., Ltd. Glasgow
Samuelson & Co., Ltd. .. .. Britannia Wks, Banbury, Oxon.

Name Plates.

Barns, W., & Son .. .. .. Queensland Road, Holloway, N.
Pryor, Edward, & Son .. .. 68, West Street, Sheffield
Tucker-Martin & Co., Ltd. .. 305, Old Street, E.C.
Vaughtons, Ltd. .. .. .. Livery Street, Birmingham

Non-Conducting Compositions.

Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Kenyon, Wm., & Sons, Ltd. .. Dukinfield, Manchester
Leroy, F., & Co. .. .. .. 20, Gray St., Commercial Rd, E.
Newalls Insulation Co., Ltd. .. Mosley St., Newcastle-on-Tyne
Toope's Asbestos Covering Co., Ltd. .. .. Stepney Square, Stepney, E.

Nut-Making Machines.

Greenwood & Batley, Ltd. .. Albion Works, Leeds
Platt, Samuel, Ltd. .. .. Wednesbury
Taylor & Challen, Ltd. .. .. Birmingham

Oil Cans.

Braime, T. F., & Co., Ltd. .. Hunslet, Leeds
Kaye, Jos., & Sons, Ltd. .. Lock Works, Leeds

Oil Extractors.

Alley & Maclellan, Ltd. .. .. Sentinel Works, Glasgow
Baker Oil Separator Co., Ltd. .. Union Works, Hunslet, Leeds
Holden & Brooke, Ltd. .. .. Sirius Works, West Gorton, Manchester
Kater & Ankersmit .. .. 34, Fenchurch Street, E.C.
Paterson Engineering Co. .. 21, Amberley House, Norfolk Street, Strand, W.C.
Rowland, B. R., & Co., Ltd. .. Reddish, near Manchester
Royles Limited .. .. .. Irlam, near Manchester
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Oil Filters.

Wells, A. C., & Co. .. .. 102, Midland Road, N.W.

Oil Mill Machinery.

Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Manlove, Alliott & Co., Ltd. .. Nottingham
Middleton, Robert .. .. Sheepscar Foundry, Leeds
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.
Waygood & Co., Ltd. .. .. Falmouth Road, S.E.

Oils.—(*See Lubricants.*)

Ore-Crushing Machinery.

Allen, Edgar, & Co., Ltd. .. Sheffield
Bradley Pulverizer Co. .. .. 37, Walbrook, E.C.
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Davey, Paxman & Co., Ltd. .. Colchester
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Hadfield Steel Foundry Co., Ltd. Hecla Works, Sheffield
Hornsby, R., & Sons, Ltd. .. Grantham
Jessop, Wm., & Sons, Ltd. .. Brightside Works, Sheffield
Johnson, Wm., & Sons (Leeds), Ltd. Armley, Leeds
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Robey & Co., Ltd. .. .. .. Lincoln
Sandycroft Foundry Co., Ltd. .. Chester
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.
Sturtevant Engineering Co., Ltd. .. .. 147, Queen Victoria Street, E.C.

Packing (Engine and Hydraulic).—(*See also Metallic Packing.*)

Ahlers Ad. .. .. Sunderland
Almagam Limited .. .. .. 172, Great Portland Street, W.
Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Davey, Paxman & Co., Ltd. .. Colchester
Green & Boulding, Ltd. .. .. 28, New Bridge Street, E.C.
Greene, Tweed & Co. .. .. Queen Anne's Chambers, Tothill Street, S.W.
Gutta Percha & Rubber Mfg. Co. of Toronto, Ltd. .. .. .. Toronto, Canada
Jenkins Brothers, Ltd. .. .. 95, Queen Victoria Street, E.C.
Klinger, Richard, & Co. .. .. 66, Fenchurch Street, E.C.
Lindsay, R. B., & Co. .. .. 28, Mair Street, Plantation, Bridge, S.E. [Glasgow
New Motor & General Rubber Co., Ltd. .. .. 374, Euston Road, N.W.
New York Belting & Packing Co., Ltd. .. .. 11-13, Southampton Row, W.C.
North British Rubber Co., Ltd. Castle Mills, Edinburgh
Peerless Rubber Manufacturing Company .. .. 16, Warren Street, New York, U.S.A.
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
United Kingdom Self-Adjusting Anti-Friction Metallic Packing Syndicate, Ltd. .. .. 14, Cook Street, Liverpool
United States Metallic Packing Co., Ltd. .. .. Soho Works, Thornton Road, Bradford
Walker, James, & Co. .. .. Lion Works, Garford Street, Poplar, E.
Willcox, W. H., & Co., Ltd. .. 22, Southwark Street, S.E.
Woodite Works .. .. .. Mitcham Common, Surrey

Painters and Decorators.

Paul, James, & Sons .. .. 386, Paisley Road, Glasgow

Paints, Varnishes, &c.

Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Dampney, J., & Co., Ltd. .. Cardiff
Kalbitum Paint Co., Ltd. .. Belvedere Wks, Belvedere, Kent
Metropolitan Amalgamated Railway Carriage & Wagon Co., Ltd. Saltley, Birmingham
Palfreyman, W. H., & Co. .. Goree-Piazzas, Liverpool
Shutt, W. .. .. 32, Muswell Road, Muswell Hill, N.W.

Paper-Making Machinery.

Douglas & Grant .. .. .. Kirkcaldy, N.B.

Patent Agents.

Alexander, E. P., & Son .. .. 306, High Holborn, W.C.
Cruikshank & Fairweather, Ld. 62, St. Vincent Street, Glasgow
Harris & Mills .. .. .. 23, Southampton Bldgs., W.C.
Jensen & Son .. .. .. 77, Chancery Lane, W.C.
Radford, R. Heber, Son & Squire 15, St. James Row, Sheffield
Raworth, John E. .. .. .. 70/71, Queen Anne's Chambers, Tothill St., Westminster, S.W.
Redfern, G. F., & Co. .. .. 15, South Street, Finsbury, E.C.
Thomson, W. E. M., & Co. .. 96, Buchanan Street, Glasgow
Vaughan & Son .. .. .. 57, Chancery Lane, W.C.
Watkins, Stephen, Son & Groves Aldwych Chambs., 170, Strand, W.C.
Withers, J. S., & Spooner .. 323, High Holborn, W.C.

Patent Law (Manufacturers under).

Rosser & Russell, Ltd. .. .. Queen's Wharf, Hammersmith

Pattern Makers.

Britannia Foundry Co. .. .. Coventry
Brown, D., & Sons, Ltd. .. Huddersfield
Piercy & Co., Ltd .. .. .. Birmingham

Perforated Metals.

Barns, W., & Son .. .. .. Queensland Road, Holloway, N.
Harvey, G. A., & Co. .. .. Lewisham, S.E. [N.B.
Hudson, Thomas, Ltd. .. .. Sheepford Works, Coatbridge,

Permanent Way.

Bagnall, W. G., Ltd. .. .. Castle Engine Works, Stafford
Birch, John, & Co., Ltd. .. .. 3, London Wall Buildings, E.C.
Bolling & Lowe .. .. .. Laurence Pountney Hill, E.C.
Cutbill-King & Co. .. .. 26, Nicholas Lane, E.C.
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street,
Isca Foundry & Engineering Co. Newport, Mon. [E.C.

Petrol Storage.

Boulton & Paul, Ltd. .. .. Norwich

Photography and Materials and Appliances for Photographic Printing and Copying Processes.

Fry, Ernest Bickerdsteth. .. 4 & 6, Victoria Avenue, Shipley, Yorks.
Halden, J., & Co., Ltd. .. .. 8, Albert Square, Manchester
Hall, B. J., & Co., Ltd. .. .. 39, Victoria Street, S.W.
Stanley, W. F., & Co., Ltd. .. Railway Approach, London Bridge, S.E.
Thornton, A. G., Ltd. .. .. 28, King St. West, Manchester

Picks, Shovels and Spades.

Hadfield's Steel Foundry Co., Ld. Hecla Works, Sheffield

Pile Drivers.

Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Lidgerwood Mfg. Co. .. .. Caxton Hse., Westminster, S.W.
Naamyth, Wilson & Co., Ltd. .. Bridgewater Foundry, Patricroft, near Manchester
Southgate Pile Driver Co. .. 12, Savage Gardens, E.C.
Whitaker Brothers, L d. .. Horsforth, Leeds

Piles and Pile Shoes.

British Steel Piling Co. .. .. Dock House, Billiter Street, E.C.
Jessop, W., & Sons, Ltd. .. Brightside Works, Sheffield
Le Grand & Sutcliff .. .. 125, Bunhill Row, E.C.
Ransome-ver Mehr Machinery Co. .. .. Caxton House, Westminster, S.W.
Southgate File Driver Co. .. 12, Savage Gardens, E.C.
United States Steel Products Co. 30/38, New Broad Street, E.C.

Pins (Taper).

Mountford, Fredk. .. .. Fremo Works, Granville St., Birmingham

Pipe Founders.—(*See also Tubes.*)

Ashmore, Benson, Pease & Co., Ld. Stockton-on-Tees
Clay Cross Co. .. .. .. Clay Cross, near Chesterfield
Isca Foundry & Engineering Co. Newport, Mon.
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading

Pipe Screwing and Cutting Machinery.

Heap, Joshua, & Co., Ltd. .. Ashton-under-Lyne
Platt, Samuel, Ltd. .. .. Wednesbury
Tangyes Limited .. .. .. Birmingham

Pipes (Large, and Lap-welded).—(*See also Tubes.*)

Ashmore, Benson, Pease & Co., Ld. Stockton-on-Tees
Bellamy, John, Ltd. .. .. Millwall, E.
British Welding Co., Ltd. .. 58, Victoria Street, Westminster
Clayton, Son & Co., Ltd. .. .. Hunslet, Leeds [ster, S.W.
Dempster, F. & J., Ltd. .. .. Newton Heath, Manchester
Howell & Co., Ltd. .. .. Brook Steel Works, Sheffield
Lysaght, John, Ltd. .. .. St. Vincent Ironworks, Bristol
Mannesmannröhren Werke .. Düsseldorf, Germany
Marshall, John, & Sons .. .. Glasgow
Mechan & Sons, Ltd. .. .. Scotstoun Ironworks, Glasgow
Metal & Machinery Syndicate .. 56 & 57, Aldermanbury, E.C.
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Russell, James, & Sons, Ltd. .. Crown Tube Wks., Wednesbury
Steel Pipe Company, Ltd. .. Kirkcaldy, N.B.
Stewarts & Lloyds, Ltd. .. .. 41, Oswald Street, Glasgow, and Nile Street, Birmingham

Pipes (Sanitary, Drain and Stoneware).

Doulton & Co., Ltd. .. .. Lambeth, S.E.

Pistons and Piston Rings.

Edmeston, A. & Sons .. .. Patricroft, nr. Manchester
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Lancaster & Tonge, Ltd. .. Pendleton, Manchester
Lockwood & Carlisle, Ltd. .. Eagle Foundry, Sheffield
McNeil, C. .. .. Kinning Park Ironwks, Glasgow

Planing Machines.—(*See Machine Tools.*)

Plates (Dished and Flanged).

Abbott & Co. (Newark), Ltd. .. Newark-on-Trent
Hudson, Thomas, Ltd. .. .. Coatbridge, N.B.

Plates (Iron and Steel).

Beardmore, William, & Co., Ltd. Parkhead Ironworks, Glasgow
Brown, Bayley's Steel Works, Ld. Sheffield
Brown, John, & Co., Ltd. .. Sheffield
Colville, David, & Sons, Ltd. .. Motherwell, near Glasgow
Glasgow Iron & Steel Co., Ltd. .. Wishaw Iron & Steel Works.
Jessop, Wm., & Sons, Ltd. .. Sheffield [Wishaw
Lanarkshire Steel Co., Ltd. .. Motherwell, N.B.
Leeds Forge Co., Ltd. .. .. Leeds [castle-on-Tyne
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Steel Co. of Scotland, Ltd. .. 23, Royal Exchange Square, Glasgow

Plummer Blocks.—(*See also Bearings.*)

Barrett, Arthur G., & Co. .. The Forge, Bradford
Carver, C. F., Ltd. .. .. Nottingham
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Mackies Limited .. .. .. Berks Ironworks, Reading
Mair, Nixon & Ferguson, Ltd. .. Kettering
Platt, Samuel, Ltd. .. .. Wednesbury
Richards, Geo., & Co., Ltd. .. Broadheath, near Manchester
Smith & Grace Screw Boss Pulley Co., Ltd. .. .. Thrapston
Taylor & Challen, Ltd. .. .. Birmingham
Unbreakable Pulley and Mill Gearing Co., Ltd. .. .. 48, West Gorton, Manchester

Pneumatic Tools.

Bennie, James, & Sons, Ltd. .. Clyde Engine Works, Cardonald, Glasgow
Campart, C. C. .. .. .. 49, Newgate Street, E.C.
Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.
Dudgeon, F. S. .. .. .. 30, Great St. Helen's, E.C.
Globe Pneumatic Eng. Co., Ltd. 150, Queen Victoria Street, E.C.
Howard Pneumatic Engineering Co., Ltd. .. .. 11, Tothill Street, Westminster, S.W.
Ingersoll-Rand Co. .. .. 165, Queen Victoria Street, E.C.
Piercy & Co., Ltd. .. .. .. Birmingham
Ross, R. G., & Son, Ltd. .. .. Glasgow
United States Metallic Packing Co., Ltd. .. .. Soho Works, Bradford

Polishing Machinery and Materials.

Piercy & Co., Ltd. .. .. Birmingham

Portable Engines.—(*See Engines, Portable.*)

Portable Railways.—(*See Railways, Light and Portable*)

Pottery and Encaustic Tile Machinery.

Bodley Brothers & Co. .. .. Exeter

Pressed Steel and Metal Work.

Armstrong, Sir W. G. Whitworth and Co., Ltd. .. .. .. Openshaw Works, Manchester
Braby, F., & Co., Ltd. .. .. Eclipse Ironworks, Glasgow
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Leeds Forge Co., Ltd. .. .. Leeds
Metropolitan Amalgamated Railway Carriage & Wagon Co., Ld. Saltley, Birmingham
Patent Shaft & Axletree Co., Ld. Wednesbury
Vaughtons, Ltd. .. .. .. Livery Street, Birmingham

Presses (Hydraulic).—(*See Hydraulic Presses.*)

Presses (Power).

American Process Co. .. .. New York City, U.S.A.
Brett's Patent Lifter Co., Ltd. .. Coventry
Fawcett, Preston & Co., Ltd. .. Liverpool
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hands, John, & Sons, Ltd. .. Cardigan Works, Birmingham
Platt, Samuel, Ltd. .. .. Wednesbury
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironworks, Glasgow
Taylor & Challen, Ltd. .. .. Birmingham

Printers and Stationers.

Bradbury, Agnew & Co., Ltd. .. 10, Bouverie St., Fleet St., E.C
Lincoln Printing Co. .. .. High Bridge Works, Lincoln

Propellers.—(*See Screw Propellers.*)

Propellers (Air).

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Billington & Newton, Ltd. .. Longport, Stoke-on-Trent
Donkin Co., Ltd. (The Bryan)—Air .. .. Chesterfield
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham
Sturtevant Engineering Co., Ld. 147, Queen Victoria Street, E.

Publishers.

Baker, E. .. .. John Bright St., Birmingham
Batsford, B. T. .. .. .. 94, High Holborn, E.C.
Chapman & Hall, Ltd. .. .. 11, Henrietta Street, W.C.
Constable, A., & Co., Ltd. .. 16, James Street, Haymarket, S.W.
Emmott & Co., Ltd. .. .. 65, King Street, Manchester
"Engineering" Ltd. .. .. 35 & 36, Bedford Street, W.C.
Gresham Publishing Co. .. 34-5, Southampton Street, W.C.
Griffin, Chas., & Co., Ltd. .. Exeter Street, Strand, W.C.
Lockwood, Crosby, & Son .. 7, Stationers' Hall Court, E.C.
Longmans, Green & Co. .. .. 39, Paternoster Row, E.C.
Macmillan & Co., Ltd. .. .. St. Martin's Street, W.C.
Spon, E. & F. N., Ltd. .. .. 57, Haymarket, S.W.
Whittaker & Co. .. .. .. White Hart Street, Paternoster Square, E.C.

Pulley Blocks.

Bailey, W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Bullivant & Co., Ltd. .. .. 72, Mark Lane, E.C.
Burnbank Engineering Co. .. 58, West Regent St., Glasgow
Fairbanks Co. .. .. .. 15, Mallow St., Old St., E.C.
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Tangyes Limited .. .. Birmingham
Vaughan & Son, Ltd. .. .. West Gorton, Manchester
Youngs .. .. Ryland St. Wks., Birmingham

Pulleys (Cast Iron).

Baguhaw, J., & Sons, Ltd. .. Batley, Yorkshire
Bodley Brothers & Co. .. .. Exeter
Carver, C. F., Ltd. .. .. Nottingham
Croft & Perkins, Ltd. .. .. Power Works, Bradford
Fraser, Douglas, & Sons, Ltd. .. Arbroath, Scotland
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Kay, James C., & Co., Ltd. .. Barnbrook Works, Bury, Lancs.
Mackies Ltd. .. .. .. Caversham Road, Reading
Platt, Samuel, Ltd. .. .. Wednesbury
Richards, Geo., & Co., Ltd. .. Broadheath, near Manchester
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Smith & Grace Screw Boss Pulley Co., Ltd... .. .. Thrapston
Taylor & Challen, Ltd. .. .. Birmingham
Thompson & Southwick, Ltd. .. Tamworth, Staffs.
Unbreakable Pulley and Mill Gearing Co., Ltd. .. .. 48, West Gorton, Manchester
Urquhart, Lindsay & Co., Ltd. Blackness Foundry, Dundee
Wigglesworth, Frank, & Co., Ld. Mill Lane, Bradford

Pulleys (Wood).

Buck & Hickman, Ltd. .. .. 2 & 4, Whitechapel Road, E.
Flender Company, The .. .. Broad Street House, New Broad Street, E.C.
Gandy Belt Mfg. Co., Ltd. .. Wheatland Works, Seacombe,
Platt, Samuel, Ltd. .. .. Wednesbury [Cheshire

Pulleys (Wrought Iron and Steel).

Bagshaw, J., & Sons, Ltd. .. Batley, Yorkshire
Barrett, Arthur G., & Co. .. The Forge, Bradford
Barry, Henry & Co., Ltd. .. Aberdeen
Bright's Patent Pulley Co., Ltd. Portadown, Ireland
Carver, C. F., Ltd. .. .. Nottingham
Croft & Perkins, Ltd. .. .. Power Works, Bradford
Crowther, Henry, & Sons, Ltd. Cleckheaton
Douglas, Lawson & Co. .. .. Birstall, near Leeds
Fraser, Douglas, & Sons, Ltd. .. Arbroath, Scotland
Hudswell, Clarke & Co., Ltd. .. Railway Foundry, Leeds
Mackies Ltd. .. .. .. Caversham Road, Reading
Platt, Samuel, Ltd. .. .. Wednesbury
Richards, Geo., & Co., Ltd. .. Broadheath, near Manchester
Smith & Grace Screw Boss Pulley Co., Ltd. .. .. Thrapston
Thompson & Southwick, Ltd. .. Tamworth, Staffs
Unbreakable Pulley and Mill Gearing Co., Ltd. .. .. 48, West Gorton, Manchester
Urquhart, Lindsay & Co., Ltd. Blackness Foundry, Dundee
Warden, A., & Co. .. .. .. 44-48, Shepherdess Walk, City Road, E.C.
Wigglesworth, Frank, & Co., Ld. Mill Lane, Bradford

Pulverizers.

Allen, Edgar, & Co., Ltd. .. Sheffield
Bradley Pulverizer Co. .. .. 37, Walbrook, E.C.
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.

Pumps (Air).—*(See Air Pumps.)*

Pumps (Centrifugal).

A.E.G. Electric Company, Ltd. Pembroke Hse., 133-135, Oxford Street, W. [Manchester
Allen, Marcus .. .. .. Elsinore Road, Old Trafford,
Allen, W. H., & Co., Ltd. Queen's Eng. Works, Bedford
Amag-Hilpert .. .. .. Glochenhofstrasse 6, Nurnberg, Germany
Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Bellis & Morcom Ltd. .. .. Ledsam Street Works, B'ham.
Borsig, A. .. .. Tegel, Berlin
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Campbell & Calderwood .. .. Shao Engine Works, Paisley
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker,
Entwisle & Gass, Ltd. .. .. Bolton [Glasgow, W.
Escher Wyss & Co. .. .. 109, Victoria Street, S.W.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Gunther, W., & Sons .. .. Central Works, Oldham
Gwynnes Ltd. .. .. .. 81, Cannon Street, E.C.
Hathorn, Davey & Co., Ltd. .. Leeds
Marshall, Sons, & Co., Ltd. .. Gainsborough
Paul, Matthew, & Co., Ltd. .. Levenford Works, Dumbarton
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Simons, W., & Co., Ltd. .. .. Renfrew, N.B.
Stork Brothers & Co. .. .. Hengelo, Holland
Sulzer Bros. .. .. 30, Norfolk St., Strand, W.C.
Tangyes Limited .. .. .. Birmingham
Vaughan & West Hydraulic Engineering Co., Ltd. .. .. 45, Leadenhall Street, E.C.
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Pumps (Colonial).

Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Caird & Rayner .. .. .. 777, Commercial Road, Limehouse, E.
Evans, Joseph, & Sons (Wolverhampton), Ltd. .. .. .. Wolverhampton [house, E.
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Pumps (Donkey).

Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Caird & Rayner .. .. .. 777, Commercial Road, Limehouse, E.
Cameron, John, Ltd. .. .. Oldfield Rd. Ironworks, Salford
Carruthers, J. H., & Co., Ltd. .. Polmadie Ironworks, Glasgow
Clarke, Chapman & Co., Ltd. .. Gateshead-upon-Tyne
Cochrane, John .. .. .. Barrhead, N.B.
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Evans, Joseph, & Sons (Wolverhampton), Ltd. .. .. .. Wolverhampton
Friedenthal, F. .. .. .. River Engine Works, Preston
Hathorn, Davey & Co., Ltd. .. Leeds
Mumford, A. G., Ltd. .. .. Culver Street Ironworks, Colchester [Tyne
Nichols Bros. .. .. .. Oakwellgate, Gateshead-on-
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Robey & Co., Ltd. .. .. .. Lincoln
Simpson, James, & Co., Ltd. .. 101, Grosvenor Road, S.W.
Tangyes Limited .. .. .. Birmingham
Toward, T., & Co., Ltd. .. .. 9, Ouseburn, Newcastle-on-Tyne
Vaughan & West Hydraulic Engineering Co., Ltd. .. .. 45, Leadenhall Street, E.C. [Tyne
Vosper & Co., Ltd. .. .. Portsmouth
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Pumps and Pumping Machinery.

A.E.G. Electric Company, Ltd. Pembroke Hse., 133-135, Oxford Street, W.
Allen, W. H., Son & Co., Ltd. .. Queen's Eng. Works, Bedford
Bailey, W. H., & Co. .. .. Albion Wks, Salford, M'chester
Barclay, Andrew, Sons & Co., Ltd. .. .. Caledonia Works, Kilmarnock, Scotland
Bellis & Morcom Ltd. .. .. Ledsam Street Works, B'ham.
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Bever, Dorling & Co., Ltd. .. Bowling Ironworks, Bradford
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
Broadfoot, John, & Sons, Ltd. .. Whiteinch, Glasgow
Caird & Rayner .. .. .. 777, Commercial Road, Limehouse, E.
Cameron, John, Ltd. .. .. Oldfield Rd. Ironworks, Salford
Campbell Gas Engine Co., Ltd. Halifax, England
Carruthers, J. H., & Co., Ltd. .. Polmadie Iron Works, Glasgow
Chaplin, Alex., & Co. .. .. Govan, Glasgow
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Clay Cross Co. .. .. .. Clay Cross, near Chesterfield

Pumps and Pumping Machinery.—*Continued.*

Cochrane, John .. .. .. Barrhead
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Davey, Paxman & Co., Ltd. .. Colchester
Davy Brothers, Ltd. .. .. Sheffield
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Drum Engineering Co. .. .. 33, Brook Street, Bradford
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker, Glasgow, W.
East Ferry Road Engineering Works Co., Ltd. .. .. .. Millwall, E.
Ellison, W. T., & Co., Ltd. .. Irlams-o'-th'-Height, Manchester
Escher Wyss & Co. .. .. 109, Victoria Street, S.W.
Eureka Pump Company .. .. 53, Bothwell Street, Glasgow
Evans, Joseph, & Sons (Wolverhampton, Ltd. .. .. .. Wolverhampton
Fawcett, Preston & Co., Ltd. .. Liverpool
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Friedenthal, F. .. .. .. River Engine Works, Preston
Fullerton, Hodgart & Barclay, Ltd. .. .. .. Vulcan Foundry and Engine Works, Paisley
Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B.
Glover & Hobson, Ltd. .. .. Albert Ironworks, Chelmsford
Greenwood & Batley, Ltd. .. Leeds
Gwynnes Ltd. .. .. .. 81, Cannon Street, E.C.
Hall, J. P., & Sons, Ltd. .. Peterborough
Hanna, Donald & Wilson .. Paisley
Hannoversche Maschinenbau-Actien-Gesellschaft, vormals Georg Egestorff .. .. } Hannover-Linden, Germany
Hathorn, Davey & Co., Ltd. .. Leeds
Hayward-Tyler & Co., Ltd. .. 99, Queen Victoria Street, E.C.
Holden & Brooke, Ltd. .. .. Sirius Wks., West Gorton, Manchester
Hornsby, R., & Sons, Ltd. .. Grantham [chester
Hughes & Lancaster .. .. 47, Victoria St. F.W.
Hunt & Mitton .. .. .. Ozells St. North, Birmingham
Isca Foundry & Engineering Co. Newport, Mon.
Isler, C., & Co., Ltd. .. .. Artesian Wks., Bear Lane, S.E.
Keystone Driller Co. .. .. Beaver Falls, Penna., U.S.A.
Kirkaldy, John, Ltd. .. .. 101, Leadenhall Street, E.C.
Korting Brothers, Ltd. .. .. 53, Victoria Street, S.W.
Lancaster & Tonge, Ltd. .. Pendleton, near Manchester
Le Grand & Sutcliff .. .. 125, Bunhill Row, E.C.
Lobnitz & Co., Ltd. .. .. Renfrew, Scotland
Lunken Company, Inc. .. .. 35, Great Dover Street, S.E.
Manlove, Alliott & Co., Ltd. .. Nottingham
Mason Regulator Co. .. .. Boston, Mass., U.S.A.
Merryweather & Sons .. .. 63, Long Acre, W.C. [ter
Mumford, A. G., Ltd. .. .. Culver St. Ironworks, Colches-
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Musker, C. & A., Ltd. .. .. Liverpool
Nasmyth, Wilson & Co., Ltd. .. Bridgewater Foundry, Patricroft, near Manchester
Nichols Bros. .. .. .. Oakwellgate, Gateshead-on-Tyne
Parsons, C. A., & Co. .. .. Heaton Works, Newcastle
Paul, Matthew, & Co., Ltd. .. Levenford Works, Dumbarton
Pearn, Frank, & Co., Ltd. .. Manchester
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Potter, A. C., & Co. .. .. Lant Street, S.E.
Pratchitt Brothers .. .. Denton Ironworks, Carlisle
Price Air Lift Pump Co. .. .. Broadheath, near Manchester
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich
Ransomes, Sims & Jefferies, Ltd. Ipswich
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd., Leeds
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Samuelson & Co., Ltd. .. .. Britannia Wks, Banbury, Oxon.
Sandycroft Foundry Co., Ltd. .. Chester
Schwade, Otto, & Co. .. .. 23-29, Fleet Street, E.C.
Scott, E., & Mountain, Ltd. .. Close Works, Gat-shead-on-Tyne
Sharer & Young, Ltd. .. .. Marmot Wks., Alloa, Scotland
Shaw, John, & Sons (Salford), Ltd. .. .. Wellington Street Works, Salford, Manchester
Simpson, James, & Co., Ltd. .. 101, Grosvenor Road, S.W.
Stork Brothers & Co. .. .. Hengelo, Holland
Stothert & Pitt, Ltd. .. .. Bath
Stott, S. S., & Co. .. .. .. Haslingden, near Manchester
Sulzer Bros. .. .. 30, Norfolk Street, Strand, W.C.
Tangyes Limited .. .. .. Birmingham
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster, S.W.
Thwaites Brothers, Ltd. .. Vulcan Ironworks, Bradford
Toward, T., & Co., Ltd. .. .. 9, Ouseburn, Newcastle-on-Tyne
Vaughall & West Hydraulic Engineering Co., Ltd. .. .. 45, Leadenhall Street, E.C.
Warner, Robert, & Co., Ltd .. 97, Queen Victoria Street, E.C.
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow
Westinghouse Brake Co., Ltd. .. York Road, King's Cross, N.
Wilcox, W. H., & Co., Ltd. .. 23, Southwark Street, S.E.
Witting Bros., Ltd. .. .. 49, Cannon Street, E.C.
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Pumps (Turbine).

A.E.G. Electric Company, Ltd. Pembroke Hse., 133-135, Oxford Street, W.
Allen, W. H., Son & Co., Ltd. .. Queen's Engineering Works, Bedford [Street, E.C.
Boving, Jens Orten- & Co. .. 9½, Union Court, Old Broad
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker, Glasgow, W.
Stork Brothers & Co. .. .. Hengelo, Holland

Pumps (Vacuum).

Blair, Campbell & McLean, Ltd. Woodville St., Govan, Glasgow
Broom & Wade, Ltd. .. .. High Wycombe
Evans, Joseph, & Sons (Wolverhampton), Ltd. .. .. .. Wolverhampton
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Reavell & Co., Ltd. .. .. Ipswich

Punching and Shearing Machines.

Becker, R., & Co. .. .. .. 58, City Road, E.C. [Bridge
Berry, F., & Sons .. .. .. Calderdale Ironworks, Bowerby
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Cameron, John, Ltd. .. .. Oldfield Rd. Ironwks., Salford
Craig & Donald, Ltd. .. .. Johnstone, near Glasgow
De Bergue & Co., Ltd. .. .. Strangeways Ironworks, Manchester
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Greenwood & Batley, Ltd. .. Albion Works Leeds
Hands, John, & Sons, Ltd. .. Cardigan Works, Birmingham
Hetherington, John, & Sons, Ltd. Manchester
McOnie, A. & P. W. .. .. Govan, Glasgow
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Pollock, MacNab & Highgate .. Shettleston, Glasgow
Reiner, Arthur, & Co. .. .. 63, Queen Victoria Street, E.C.
Rice & Co. (Leeds), Ltd. .. .. Elland Road, Leeds
Scott Bros. .. .. West Mount, Halifax
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Smith Brothers & Co. (Glasgow), Ltd. .. .. Kinning Park, Glasgow
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow
Tangyes Limited .. .. .. Birmingham

Pyrometers and Thermometers.

Foster Instrument Co. .. .. Letchworth, Herts.
Griffin, John J., & Sons, Ltd. .. Kemble Street, Kingsway, W.C.
Schäffer & Budenberg, Ltd. .. Whitworth Street, Manchester

Rail Benders.

Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Fielding & Platt, Ltd. .. .. Gloucester
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Tangyes Limited .. .. .. Birmingham
Youngs .. .. Ryland St. Wks., Birmingham

Rail Lifters.

De Bergue & Co., Ltd. .. .. Manchester
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Youngs .. .. Ryland St. Wks., Birmingham

Rails (Steel and Iron).

Bolling & Lowe .. .. .. 2, Laurence Pountney Hill, E.C.
Brown, Bayley's Steel Works, Ltd. Sheffield [Sheffield
Cammell Laird & Co., Ltd. .. Cyclops Steel & Iron Works,
Colville, David, & Sons, Ltd. .. Motherwell, near Glasgow
Kerr, Stuart & Co., Ltd. .. .. 1 & 2, Broad Street Place, E.C.
Steel Co. of Scotland, Ltd. .. 23, Royal Exchange Square,
White, Rd., & Sons .. .. Widnes, Lancs. [Glasgow

Railway and Contractors' Plant.

Alley & MacLellan, Ltd. .. Sentinel Works, Glasgow
Bagnall, W. G., Ltd. .. .. Castle Engine Works, Stafford
Beyer, Peacock & Co., Ltd. .. Gorton Foundry, Manchester
Birch, John, & Co., Ltd. .. 3, London Wall Buildings, E.C.
Bolling & Lowe .. .. .. 2, Laurence Pountney Hill, E.C.
Brown, Bayley's Steel Works, Ltd. Sheffield
Cutbill-King & Co. .. .. 26, Nicholas Lane, E.C.
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street, E.C.
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Fowler, J., & Co. (Leeds), Ltd. .. Leeds
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Hadfield's Steel Foundry Co., Ld. Hecla Works, Sheffield
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, Worcester
Hurst, Nelson & Co., Ltd. .. Glasgow Rolling Stock and Plant Works, Motherwell
Isca Foundry & Engineering Co. Newport, Mon.
Leeds Forge Co., Ltd. .. .. Leeds [S.W.
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster,
Lubecker Machine & Mfg. Co. .. 30, Gt. St. Helen's, E.C.
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow
McLachlan & Co., Ltd. .. .. Darlington
Murray, Workman & Co., Ltd. Glasgow
Orenstein & Koppel-Arthur Koppel (Amalgamated) .. 27, Clements Lane, E.
Patent Shaft & Axletree Co., Ltd. Wednesbury
Railway & General Engineering Co., Ltd. .. .. Midland Foundry, Nottingham
Smith's Dock Co., Ltd. .. .. South Bank, S.O., Yorks.
Société du Nord de Liége .. 42, Perryn Road, Acton, W.
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.
Stone, J. B., & Co. .. .. 135, Finsbury Pavement, E.C.

Railway Rolling Stock.—*(See Carriage, Wagon and Engine—Locomotive.)*

Railway Signals.

Isca Foundry & Engineering Co. Newport, Mon.
McKenzie & Holland, Ltd. .. 58, Victoria Street, S.W.
McKenzie, Holland & Westinghouse Power Signal Co., Ltd... 58, Victoria Street, S.W

Railway Wheels.—*(See Wheels, Railway.)*

Railways (Light and Portable).

Bagnall, W. G., Ltd. .. .. Castle Engine Works, Stafford
Birch, John, & Co., Ltd. .. .. 2, London Wall Buildings, E.C.
Bolling & Lowe .. .. .. 2, Laurence Pountney Hill, E.C.
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street, E.C.
Fowler, J., & Co. (Leeds), Ltd... Leeds
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Kerr, Stuart & Co., Ltd. .. .. 1, Broad Street Place, E.C.
Orenstein & Koppel-Arthur Koppel (Amalgamated) .. 27, Clements Lane, E.C.

Rawhide Wheels.—*(See Wheels, Rawhide.)*

Reducing Valves.—*(See Valves, Reducing.)*

Refrigerating Machinery.

British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
Hall, J. & E., Ltd... .. .. .. Dartford Ironworks, Kent
Haslam Foundry & Eng. Co., Ld. Union Foundry, Derby
Kirkaldy, John, Ltd. .. .. 101, Leadenhall Street, E.C.
Liverpool Refrigeration Co., Ld. Colonial House, Liverpool
Mirrlees, Watson Co., Ltd. .. Scotland Street, Glasgow
Pontifex & Wood, Ltd. .. .. Union Foundry, Derby
Pulsometer Engineering Co., Ld. Nine Elms Ironworks, Reading
Ransomes & Rapier .. .. 32 (Dept. H.), Victoria St., E.C.
Seagers, Ltd. .. .. .. Dartford
Shaft Freezing Co., Ltd .. .. 11, Ironmonger Lane, E.C.
Sterne, L., & Co., Ltd. .. .. Crown Ironworks, Glasgow
Witting, H. R. .. .. .. 9, Southampton Street, W.C.

Reversing Gears (Motor Boat).

Thornycroft, J. I, & Co., Ltd... Caxton House, Westminster, S.W.

Rice-Dressing Machinery.

Douglas & Grant .. .. .. Kirkcaldy, N.B.
Waygood & Co., Ltd. .. .. Falmouth Road, S.E.

Riveting Machines.

Arrol, Sir William, & Co., Ltd. Dalmarnock Ironwks., Bridgeton, Glasgow
Bennie, James, & Sons, Ltd. .. Clyde Engine Works, Cardonald, Glasgow
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
De Bergue & Co., Ltd. .. .. Manchester [gow, W.
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker, Glas-
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Globe Pneumatic Eng. Co., Ltd. 150, Queen Victoria Street, E.C.
McOnie, A. & P. W. .. .. Govan, Glasgow
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd., Leeds
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow

Rivets.—*(See Bolts, Rivets, &c.)*

Road Rollers (Steam, &c.).

Aveling & Porter, Ltd. .. .. Rochester
Barford & Perkins, Ltd. .. .. Peterborough
Fowler, J., & Co. (Leeds), Ltd. Leeds
Marshall, Sons, & Co., Ltd. .. Gainsborough
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln

Rockbreaker (Mechanical under Water).

Lobnitz & Co., Ltd. .. .. Renfrew, Scotland

Rock Drills.

Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Daw, A. & Z. .. .. .. 11, Queen Victoria Street, E.C.
Fraser & Chalmers, Ltd. .. .. 3, London Wall Buildings, E.C.
Ingersoll-Rand Co. .. .. 165, Queen Victoria Street, E.C.
Sohram, Harker & Co. .. .. Cannon Street House, E.C.

Roller Bearings.—*(See Bearings, Roller.)*

Rolling Mill Machinery.—*(See Iron and Steel Works, Plant for.)*

Rolling Mills (for Metals).—*(See also Iron and Steel Works, Plant for.)*

Rolls (Chilled and Grain).

Bayliss, Jones & Bayliss, Ltd... Wolverhampton
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.
Wright, Joseph, & Co. .. .. Neptune Forge, Tipton, Staffs.

Roofs (Iron, Steel and Zinc).—*(See Structural Engineering.)*

Rope Tramways.

Bleichert, Adolf, & Co. .. .. 99-100, Palmerston House, Bishopsgate St. Within, E.C.
Bullivant & Co., Ltd. .. .. 72, Mark Lane, E.C.
Cunningham, T. L. .. .. Balfour House, Finsbury Pavement, E.C.
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster, S.W.
Little, Gilbert, Co., Ltd. .. Horton Works, Bradford
Orenstein & Koppel-Arthur Koppel (Amalgamated) .. 27, Clements Lane, E.C.
Pohlig, J., A.-G. .. .. .. Cologne-Zollstock
White, Rd., & Sons .. .. Widnes, Lancs.

Ropes (Driving).

Hart, Thomas .. .. .. Blackburn
Kenyon, Wm., & Sons, Ltd. .. Dukinfield, Manchester
Taylor, John, & Sons (Bolton), Ld. Bolton, Lancashire
Wright, J. & E., Ltd. .. .. Birmingham

Ropes (Wire).—*(See Wire & Wire Rope Makers.)*

Runways.

Bleichert, Adolf, & Co. .. .. 99-100, Palmerston House, Bishopsgate St. Within, E.C.
Cunningham, T. L. .. .. Balfour House, Finsbury Pavement, E.C.
Higginbottom & Mannock, Ltd. Crown Ironworks, West Gorton, Manchester
Little, Gilbert, Co., Ltd. .. Horton Works, Bradford
Orenstein & Koppel-Arthur Koppel (Amalgamated) .. 27, Clements Lane, E.C.
Pohlig, J., A.-G. .. .. .. Cologne, Zollstock
Vaughan & Son, Ltd. .. .. West Gorton, Manchester

Rust Preventive.

Palfreyman, W. H., & Co. .. 17, Goree-Piazzas, Liverpool

Safety Apparatus.

Klinger, Richard, & Co. .. .. 66, Fenchurch Street, E.C.

Sand Blast Machines.

London Emery Works Co. .. Park, Tottenham, N.
Tilghman's Patent Sand Blast Co., Ltd... .. .. .. Broadheath, near Manchester

Sand (Moulding).

Mansfield Sand Co., Ltd. .. Mansfield, Notts.

Sanitary Appliances.

Doulton & Co., Ltd. .. .. Lambeth, S.E.
Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B. [S.W.
Hughes & Lancaster .. .. 47, Victoria St., Westminster,

Saw Makers.

Allen, Edgar, & Co., Ltd. .. Sheffield
Beardshaw, J., & Son, Ltd. .. Baltic Steel Works, Sheffield
Carron Co. .. .. Carron, Stirlingshire, N.B.
Carter & Wright .. .. .. Woodside, Halifax
Chambers, Scott & Co. .. .. Motherwell
Clifton & Baird, Ltd. .. .. Empress Works, Johnstone,
Davy Brothers, Ltd. .. .. Sheffield [Scotland
Fastnut Ltd. .. .. .. 115, Newgate Street, E.C.
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Patrick, F. .. .. Oxford Street, Leeds

Saw Mill Machinery.—*(See Wood-Working Machinery.)*

Scientific Instruments.—*(See Boiler Mountings and Scientific Apparatus.)*

Screens.

Leech, Goodall & Co. .. .. Hunslet (Pepper Road), Leeds
Pfeiffer Gebr. .. .. .. Kaiserslautern, 74, Germany

Screw Propellers and Propeller Blades.

Billington & Newton, Ltd. .. Longport, Stoke-on-Trent
Brown, John, & Co., Ltd. .. Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Friedenthal, F. .. .. .. River Engine Works, Preston
Haddfield's Steel Foundry Co., Ld. Hecla Works, Sheffield
Jessop, Wm., & Sons, Ltd. .. Sheffield
Little, Gilbert, Co., Ltd. .. Horton Works, Bradford
North-Eastern Marine Engineering Co., Ltd. .. .. .. Northumberland Wks., Wall-end-on-Tyne
Ross & Duncan .. .. .. Glasgow
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Thornycroft, J. I., & Co., Ltd... Southampton
Vickers Limited .. .. .. Sheffield

Screwing Machines.

Chatwin, Thos. .. .. .. Gt. Tindall St., Birmingham
Daniell, S. A., Ltd. .. .. Edward St., Parade, Birmingham
Heap, Joshua, & Co., Ltd. .. Ashton-under-Lyne [ham
Niles-Bement-Pond Co. .. .. Hamilton, Ohio, U.S.A.
Platt, Samuel, Ltd. .. .. Wednesbury
Shanks, Thomas, & Co. .. .. Union Ironworks, Johnstone
Tangyes Limited .. .. .. Birmingham

Search Lights.

British Thomson-Houston Co., Ltd. .. .. Rugby
Clarke, Chapman & Co., Ltd. .. Gateshead-upon-Tyne
Siemens Brothers Dynamo Wks., Ltd. .. .. Caxton House, Westminster, S.W.

Second-hand Tools, &c.

Britannia Engineering Co. (1910), Ltd. .. .. Colchester
Butters Bros. & Co. .. .. 20, Waterloo Street, Glasgow
Gemmell, W., & Co. .. .. 492, Argyle Street, Glasgow
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Ward, Thos. W., Ltd. .. .. Albion Works, Sheffield

Separators, Magnets, &c.

Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.
Pfeiffer Gebr. .. .. .. Kaiserslautern, 74, Germany
Rapid Magnetting Machine Co., Ltd. .. .. Birmingham

Shafting & Shaft Fittings.—*(See also Plummer Blocks and Bearings.)*

Bagshaw, J., & Sons, Ltd. .. Batley, near Leeds
Barrett, Arthur G., & Co. .. The Forge, Bradford
Barry, Henry, & Co., Ltd. .. Aberdeen
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Berlin-Anhaltische Maschinenbau A.G. .. .. Dessau, Germany
Bessemer, Henry, & Co., Ltd. .. Sheffield
Bodley Bros. & Co. .. .. Old Quay Foundry, Exeter
Bright's Patent Pulley Co., Ltd. Portadown, Ireland
Brown, Bayley's Steel Wrks., Ltd. Sheffield
Brown, John, & Co., Ltd. .. Sheffield
Carver, C. F., Ltd. .. .. Nottingham
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Craig, A. F., & Co., Ltd... .. Paisley, N.B.
Craven Brothers, Ltd. .. .. Osborne Street, Manchester
Croft & Perkins, Ltd. .. .. Power Works, Bradford
Crowther, Henry, & Sons, Ltd. Cleckheaton
Douglas, Lawson & Co. .. .. Birstall, near Leeds
Entwisle & Gass, Ltd. .. .. Bolton
Escher Wyss & Co. .. .. 109, Victoria Street, S.W.
Fife Forge Co. .. .. .. Kirkcaldy, Scotland
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Haddfield's Steel Foundry Co., Ld. Hecla Works, Sheffield
Hawthorn, R. & W., Leslie and Co., Ltd. .. .. Newcastle-on-Tyne
Hetherington, John, & Sons, Ld. Manchester
Hudswell, Clarke & Co., Ltd. .. Leeds
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Jardine, John .. .. Deeping Street, Nottingham
Jessop, W., & Sons, Ltd. .. Sheffield
Kay, James C., & Co., Ltd. .. Barnbrook Works, Bury, Lancs.
Kirkstall Forge Co., Ltd. .. Leeds
Mackies Ltd. .. .. Caversham Road, Reading
Mair, Nixon & Ferguson, Ltd... Kettering
Platt, Samuel, Ltd. .. .. Wednesbury
Richards, Geo., & Co., Ltd. .. Broadheath, near Manchester
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Smith & Grace Screw Boss Pulley Co., Ltd. .. .. Thrapston [castle-on-Tyne
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Taylor & Challen, Ltd. .. .. Birmingham
Trier Bros. .. .. Caxton House, Westminster, S.W.
Unbreakable Pulley and Mill Gearing Co., Ltd. .. .. 48, West Gorton, Manchester
Vickers Limited .. .. .. Sheffield
Warden, A., & Co. .. .. .. 44-48, Shepherdess Walk, City Road, E.C.
Wigglesworth, Frank, & Co., Ld. Mill Lane, Bradford

Sheerlegs.

Day, Summers & Co., Ltd. .. Northam Ironwks., Southampton

Sheet Metal Work, and Machinery.
Ash, Joseph, & Son .. .. Rea St. South, Birmingham
Braime, T. F., & Co., Ltd. .. Hunslet, Leeds
Standard Engineering Co., Ltd. Leicester
Taylor & Challen, Ltd. .. .. Birmingham

Shipbuilders.
Allsa Shipbuilding Co., Ltd. .. Troon, N.B.
Alley & Macfarlan, Ltd. .. Sentinel Works, Glasgow
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Boulton & Paul, Ltd. .. .. Norwich
Braby, Fredk., & Co. .. .. Deptford, S.E.
Brown, John, & Co., Ltd. .. Sheffield
Crabtree & Co., Ltd. .. .. Great Yarmouth
Day, Summers & Co., Ltd. .. Northam Ironwks.,Southampton
Dublin Dockyard Co. .. .. North Wall, Dublin [ton
Ferguson Brothers .. .. Port Glasgow
Finch, Edward, & Co., Ltd. .. Chepstow
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Hawthorn, R. & W., Leslie & Co., Ltd. .. .. Newcastle-on-Tyne
Hayes, Edward .. .. .. Stony Stratford, Wolverton
Isherwood, J. W. .. .. .. Zetland Bldgs., Middlesbrough
Kincaid, John G., & Co., Ltd. .. Clyde Foundry, Greenock
Lobnitz & Co., Ltd. .. .. Renfrew, Scotland
McKie & Baxter .. .. .. Copland Wks., Govan, Glasgow
Normand, Augustin, Ltd. .. 67, Rue du Perrey, Le Havre, France
Rennie, G., & Co. .. .. .. Thames Street, Greenwich
Ross & Duncan .. .. .. Glasgow
Schichau, F. .. .. .. Elbing-Danzig, Prussia
Shields Engineering & Dry Dock Co., Ltd. .. .. North Shields
Simons, W., & Co., Ltd. .. .. Renfrew, N.B.
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Smit, L., & Zoon .. .. .. Kinderdijk, Holland
Smith's Dock Co., Ltd. .. .. South Bank, S.O., Yorks.
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster,
Vickers Limited .. .. .. Barrow-in-Furness [S.W.
Wallsend Slipway & Engineering Co., Ltd. .. .. Wallsend
Watson, J. S. .. .. Gainsborough
White, J. Samuel, & Co., Ltd.. East Cowes, I. o. W.
Yarrow & Co., Ltd. .. .. Glasgow

Shovels and Spades.—(*See Picks, &c.*)

Sirens and Whistles.
Smith, Sydney, & Sons, Ltd. .. Basford Brass Wks, Nott'ngh'm

Sites (Industrial).
Great Western Railway Co. .. Paddington Station, W.
Northampton, Borough of .. TOWN CLERK, Northampton

Sleepers (Railway).—(*See also Permanent Way.*)

Slotting & Shaping Machines.—(*See Machine Tools.*)

Sluices.
Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich

Smelting Plant.
Fraser & Chalmers, Ltd.. .. 3, London Wall Buildings, E.C.

Smiths' Fires.
Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Thwaites Brothers, Ltd... .. Vulcan Ironworks, Bradford

Speed Indicators and Counters.
Dobbie, McInnes, Ltd. .. .. 57, Bothwell Street, Glasgow

Springs.
Brown, Bayley's Steel Wrks., Ltd. Sheffield
Brown, John, & Co., Ltd. .. Sheffield [ur. Glasgow
Cockburns Limited .. .. Clydesdale Works, Cardonald,
Smith Bros. & Hill, Ltd. .. Albert Spring Works, West Bromwich
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Sterne, L., & Co., Ltd. .. .. Crown Ironworks, Glasgow
Terry, Herbert, & Sons .. .. Redditch
Turton, Thos., & Sons, Ltd. .. Sheaf Works, Sheffield

Stamping Machinery.
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hands, John, & Sons, Ltd. .. Cardigan Works, Birmingham
Massey, B. & S. .. .. .. Openshaw, Manchester
Taylor & Challen, Ltd. .. .. Birmingham

Stampings (Brass, Bronze, Copper, &c.).
Delta Metal Co., Ltd. .. .. East Greenwich, S.E.

Stampings (Iron and Steel).
Armstrong, Stevens & Son, Ltd. Whittall Street, Birmingham
Boosey, W. E., & Co. .. .. 60, Water Lane, S.W.
Braime, T. F., & Co., Ltd. .. Hunslet, Leeds
Fowler, John, & Co. (Leeds), Ltd. Leeds
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Vaughtons, Ltd. .. .. .. Livery Street, Birmingham

Steam Cultivating Machines.
Aveling & Porter, Ltd. .. .. Rochester
Fowler, John & Co. (Leeds), Ltd. Leeds

Steam Hammers.
Brett's Patent Lifter Co., Ltd. Coventry
Cochrane, John .. .. .. Barrhead, N.B.
Davis & Primrose .. .. .. Etna Ironworks, Bangor Road,
Davy Brothers, Ltd. .. .. Sheffield [Leith, N.B.
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Massey, B. & S .. .. .. Openshaw, Manchester
Musker, C. & A., Ltd. .. .. Liverpool
Nasmyth, Wilson & Co., Ltd. .. Bridgewater Foundry, Patricroft, near Manchester
Pollock, MacNab & Highgate .. Shettleston, Glasgow
Ross, R. G., & Son, Ltd... .. Glasgow
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Thwaites Brothers, Ltd... .. Vulcan Ironworks, Bradford

Steam Pipes.
Foster Brothers, Ltd. .. .. Wednesbury
Metal & Machinery Syndicate.. 56 & 57, Aldermanbury, E.C.

Steam Rollers.—(*See Road Rollers.*)

Steam Separators.
Alley & Macfarlan, Ltd. .. .. Sentinel Works, Glasgow
Holden & Brooke, Ltd. .. .. Sirius Works, West Gorton,
Hopkinson, J., & Co., Ltd. .. Huddersfield [Manchester
Kay, James C., & Co., Ltd. .. Barnbrook Works, Bury, Lancs.
North-Eastern Marine Engineering Co. Ltd. .. .. Northumberland Wks., Wallsend-on-Tyne
Worthington Pump Co., Ltd... 153, Queen Victoria Street, E.C.

Steam Traps.
Alley & MacFarlan, Ltd. .. .. Sentinel Works, Glasgow
British Steam Specialties, Ltd. Bedford Street, Leicester
Cockburns Limited .. .. Clydesdale Works, Cardonald, near Glasgow
Edmeston, A., & Sons .. .. Patricroft, nr. Manchester
Geipel, Wm., & Co. .. .. Vulcan Works, St. Thomas St., S.E. [E.
Hobdell, Way & Co., Ltd. .. St. John's House, 124-5, Minories,
Holden & Brooke, Ltd. .. .. Sirius Works, West Gorton,
Hopkinson, J., & Co., Ltd. .. Huddersfield [Manchester
Hübner & Mayer .. .. .. Vienna, XIX/6
Kater & Ankersmit .. .. .. 34, Fenchurch Street, E.C.
Klein Engineering Co. (1908), Ltd. 94, Market Street, Manchester
Lancaster & Tonge, Ltd... .. Pendleton, Manchester
Royles Limited .. .. .. Irlam, near Manchester
Schäffer & Budenberg, Ltd. .. Whitworth St., London Road, Manchester

Steam Turbines and Fittings.
A.E.G. Electric Company, Ltd. Pembroke Hse., 133-135, Oxford Street, W.
Aston Chain & Hook Co., Ltd... Whitehorse Street, Aston, Birmingham
British Thomson-Houston Co., Ltd. .. .. Rugby
Bush Electrical Engineering Co., Ltd. .. .. 1, Kingsway, W.C.
Cockburns Limited .. .. Clydesdale Works, Cardonald, near Glasgow
Escher Wyss & Co. .. .. 109, Victoria Street, S.W.
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Howden, James, & Co. .. .. Scotland Street, Glasgow
Musgrave, John, & Sons, Ltd. .. Globe Iron Works, Bolton
Parsons, C. A., & Co. .. .. Heaton Works, Newcastle-on-
Stork Brothers & Co. .. .. Hengelo, Holland [Tyne
Thornycroft, J. I., & Co., Ltd... Southampton
Vickers Limited .. .. .. Sheffield
Wallsend Slipway & Engineering Co., Ltd. .. .. Wallsend
White, J. Samuel, & Co., Ltd... East Cowes, Isle of Wight
Willans & Robinson, Ltd. .. Rugby, Warwickshire

Steel and Iron Makers.
Allen, Edgar, & Co., Ltd. .. Imperial Steel Wks., Sheffield
Armstrong, Sir W. G., Whitworth and Co., Ltd. .. .. .. Openshaw Works, Manchester
Beardmore, William, & Co., Ltd. Parkhead Ironworks, Glasgow
Bessemer, Henry, & Co., Ltd. .. Sheffield
Braby, F., & Co., Ltd. .. .. Eclipse Ironworks, Glasgow
Brown, Bayley's Steel Works, Ltd. Sheffield
Brown, John, & Co., Ltd. .. Sheffield
Colville, David, & Sons, Ltd. .. Motherwell, near Glasgow
Cradock, Geo., & Co., Ltd. .. Wakefield, England
Darlington Forge Co., Ltd. .. Darlington
Fairley, James, & Sons .. .. Shadwell Street, Birmingham
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Glasgow Iron & Steel Co., Ltd. Wishaw, N.B.
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield
Howell & Co., Ltd. .. .. Brook Steel Works, Sheffield
Jackson, P. R., & Co., Ltd. .. Salford Rolling Mills, Manchester
Jessop, W., & Sons, Ltd. .. Sheffield [chester
Lanarkshire Steel Co., Ltd. .. Motherwell
Leeds Forge Co., Ltd. .. .. Leeds
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Motherwell Iron & Steel Co. .. Motherwell, N.B.
Patent Shaft & Axletree Co., Ltd. Wednesbury
Poldi Steel Works .. .. Napier Street, Sheffield
Ramsbay & Marshall, Ltd. .. Birmingham
Scott, Walter, Ltd. .. .. Leeds Steel Works, Leeds
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne [Glasgow
Steel Co. of Scotland, Ltd. .. 23, Royal Exchange Square,
Stewarts & Lloyds, Ltd... .. 41, Oswald Street, Glasgow, and Nile Street, Birmingham
Turton, T., & Sons, Ltd... .. Sheaf Works, Sheffield
Vickers Limited .. .. .. Sheffield

Steel and Iron Works (Plant for).—(*See Iron and Steel Works.*)

Steel (Tool, Special and High-Speed).
Allen, Edgar, & Co., Ltd. .. Sheffield
Armstrong, Sir W. G., Whitworth and Co., Ltd. .. .. .. Openshaw Works, Manchester
Beardshaw, J., & Son, Ltd. .. Baltic Steel Works, Sheffield
Braby, F., & Co., Ltd. .. .. Eclipse Ironworks, Glasgow
Cammell Laird & Co., Ltd. .. Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Jessop, W., & Sons, Ltd. .. Sheffield
Pearlite Steel Co. (1910), Ltd. .. Pearlite Steel Works, Royds Mill Street, Sheffield
Poldi Steel Works .. .. .. Napier Street, Sheffield
Vickers Limited .. .. .. Sheffield

Steering Gear.
Alley & Macfarlan, Ltd. .. .. Sentinel Works, Glasgow
Brown Bros. & Co., Ltd. .. Rosebank Ironwks., Edinburgh, N.B.
Carron Co. .. .. Carron, Stirlingshire, N.B.
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham

Stokers (Mechanical).
Babcock & Wilcox, Ltd... .. Oriel House, Farringdon Street, E.C. [Bolton
Bennis, Ed., & Co., Ltd... .. Lancashire Stoker Works,
British Niclausse Boiler Co., Ltd. Caxton Hse., Westminster, S.W.
Meldrum Bros., Ltd. (in Liq.) .. Canal Works, Timperley, near Manchester
Proctor, J., Ltd. .. .. .. Burnley, Lancashire
Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich
Underfeed Stoker Co., Ltd. .. Coventry House, South Place, E.C.

Stonebreakers.
Allen, Edgar, & Co., Ltd. .. Sheffield
Baxter, W. H., Ltd .. .. Leeds
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyds' Avenue, E.C.
Broadbent, Robert, & Son, Ltd. Phœnix Ironworks, Stalybridge,
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Goodwin, Barsby & Co. .. .. Leicester
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield
Jessop, W., & Sons, Ltd... .. Sheffield
Johnson, Wm., & Sons (Leeds), Ltd. Armley, Leeds
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Robey & Co., Ltd... .. .. Lincoln
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.
Whitaker Brothers, Ltd. .. Horsforth, Leeds

Structural Engineering.
Arrol, Sir William, & Co., Ltd. Dalmarnock Ironworks, Bridgeton, Glasgow
Ash, Joseph, & Son .. .. Rea Street South, Birmingham
Ashmore, Benson, Pease & Co., Ltd. Stockton-on-Tees
Baldwins Ltd. .. .. .. 5, Fenchurch Street, E.C.
Baume & Marpent .. .. Moyaux, Haine-St.-Pierre,
Bellamy, John, Ltd. .. .. Millwall, S.E. [Belgium
Boulton & Paul, Ltd. .. .. Norwich
British Humboldt Engineering Co., Ltd. .. .. Dixon House, Lloyd's Avenue, E.C.
British Steel Piling Co. .. .. Dock House, Billiter Street,
Clayton, Son, & Co., Ltd. .. Hunslet, Leeds [E.C.
Cleveland Bridge and Engineering Co., Ltd. .. .. .. Darlington
Clyde Structural Iron Co., Ltd. Clydeside Ironworks, Scots-
Craig, A. F., & Co., Ltd. .. Paisley, N.B. [toun, Glasgow
De Bergue & Co., Ltd. .. .. Manchester
Finch, Edward, & Co., Ltd. .. Chepstow
Findlay, Alex., & Co., Ltd. .. Motherwell, near Glasgow
Gutehoffnungshütte Coal, Iron, Steel and Engineering Co. .. Oberhausen-2, Rhineland
Hanna, Donald & Wilson .. Paisley [on-Tees
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-
Heenan & Froude, Ltd. .. .. Newton Heath Ironworks,
Isca Foundry & Engineering Co. Newport, Mon. [Manchester
Isherwood, J. W. .. .. .. Zetland Bldgs., Middlesbrough
Johnson, Rd., Clapham and Morris, Ltd. .. .. .. Manchester
Keep, F. A., Juxon & Co. .. Barn Street, Birmingham
Leech, Goodall & Co. .. .. Hunslet (Pepper Road), Leeds
Lysaght, John, Ltd. .. .. St. Vincent Ironworks, Bristol
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow
Maschinenfabrik Augsburg-Nurnberg A.-G. .. .. .. 219, Caxton House, Westminster, S.W.
Mechan & Sons, Ltd. .. .. Scotstoun Ironworks Glasgow
Metropolitan Amalgamated Railway Carriage & Wagon Co., Ltd. Saltley, Birmingham
Miller, Wm., & Sons .. .. Wolverhampton
Morton, Francis & Co., Ltd. .. Garston, Liverpool
Motherwell Bridge Co., Ltd. .. Motherwell, N.B.
Patent Shaft & Axletree Co., Ltd. Wednesbury
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Rex Roofing Co. .. .. .. Connswater, Belfast
Société du Nord de Liége .. 42, Perryn Road, Acton, W.

Sugar Machinery.
Blair, Campbell & McLean, Ltd. Woodville St., Govan, Glasgow
Craig, A. F., & Co., Ltd.. .. Paisley, N.B.
Davis & Primrose .. .. .. Etna Ironwks., Bangor Rd., Leith
Fawcett, Preston & Co., Ltd. .. Liverpool
Harvey Engineering Co., Ltd... Scotland Street Engine Works
Manlove, Alliott & Co., Ltd. .. Nottingham [Glasgow
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Pott, Cassels & Williamson .. Motherwell, near Glasgow
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Stamm, W. (Krupp Aktiengesellschaft Grusonwerk) .. .. 25, College Hill, E.C.
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironworks, Glasgow
Stork Brothers & Co. .. .. Hengelo, Holland
Watson, Laidlaw & Co. Ltd. .. 98, Dundas St. (South), Glasgow

Superheaters.
Babcock & Wilcox, Ltd... .. Oriel House, Farringdon St., E.C.
Bolton, A., & Co. .. .. .. 49, Deansgate, Manchester
Davey, Paxman & Co., Ltd. .. Colchester
Fraser & Chalmers, Ltd.. .. 3, London Wall Buildings, E.C.
Garrett, R., & Sons, Ltd. .. Leiston Works, Suffolk
McPhail & Simpson, Ltd. .. Wakefield
Mechan & Sons, Ltd. .. .. Scotstoun Iron Wks., Glasgow
Musgrave, John, & Sons, Ltd. .. Globe Iron Works, Bolton
Schmidt's Superheater Co. (1910), Ltd. .. .. 28, Victoria Street, S.W.
Simplex Superheater Co., Ltd. 34, Victoria St., Westminster,
Stork Brothers & Co. .. .. Hengelo, Holland [S.W.
Sugden, T., Ltd. .. .. .. 180, Fleet Street, E.C.
Superheater Units Co. .. .. 4, Castle Square, Swansea

Surveyors.—(*See Auctioneers, &c.*)

Switchboards and Accessories.
British Thomson-Houston & Co., Ltd. .. .. Rugby
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham

Switches and Crossings.
Baume & Marpent .. .. Moyaux, Haine-St.-Pierre
Heenan & Froude, Ltd. .. .. Worcester [Belgium
Isca Foundry & Engineering Co. Newport, Mon.
McKenzie & Holland, Ltd. .. 58, Victoria Street, S.W.
McKenzie, Holland & Westinghouse Power Signal Co., Ltd... 58, Victoria Street, S.W.
Railway & General Engineering Co., Ltd. .. .. Midland Foundry, Nottingham
Vickers Limited .. .. .. Sheffield
White, Rd., & Sons .. .. Widnes, Lancs.

Tanks.
Ash, Joseph, & Son .. .. Rea Street South, Birmingham
Baldwins, Ltd. .. .. .. 5, Fenchurch Street, E.C.
Bellamy, John, Ltd. .. .. Millwall, E.
Braby, Fredk., & Co., Ltd. .. Fitzroy Works, 352 to 362, Euston Road, N.W.
Clay Cross Co. .. .. .. Clay Cross, near Chesterfield
Clayton, Son, & Co., Ltd. .. Hunslet, Leeds
Clyde Structural Iron Co., Ltd. Clydeside Ironwks., Scotstoun,
Craig, A. F., & Co., Ltd.. .. Paisley, N.B. [Glasgow
Hanna, Donald & Wilson .. Paisley, N.B.
Harvey, G. A., & Co. .. .. Lewisham, S.E. [on-Tees
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-
Isca Foundry & Engineering Co. Newport, Mon.
Keep, F. A., Juxon & Co. .. Empire Works, Barn St., Birmingham
Lysaght, John, Ltd. .. .. St. Vincent Ironworks, Bristol
Mechan & Sons, Ltd. .. .. Scotstoun Ironworks, Glasgow
Metropolitan Amalgamated Railway Carriage & Wagon Co., Ltd. Saltley, Birmingham
Motherwell Bridge Co., Ltd. .. Motherwell, N.B.
Newton, Chambers & Co., Ltd. Thorncliffe Ironworks, near Sheffield
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich
Société du Nord de Liége .. 42, Perryn Road, Acton, W.
Toward, T., & Co., Ltd. .. .. 9, Ouseburn, Newcastle-on-Tyne

Tanners and Curriers.
Tullis, John, & Son, Ltd. .. St. Ann's Leather Wks., Glasgow
Webb & Son .. .. .. Stowmarket

Taper Pins.—(*See Pins, Taper.*)

Tar Mixing and Spraying Machines.
Railway & General Engineering Co., Ltd. .. .. Midland Foundry, Nottingham

Tea-Dressing Machinery.
Bever, Dorling & Co., Ltd. .. Bowling Ironworks, Bradford
Marshall, Sons & Co., Ltd. .. Gainsborough
Ransomes, Sims & Jefferies, Ltd. Ipswich

Telegraph Instruments.
British Insulated and Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, Essex

Telegraph Wire and Cables.
British Insulated and Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, Essex

Telegraphs (Engine and Steering).
Brown Bros. & Co., Ltd. .. Rosebank Ironwks., Edinburgh, [N.B.
Chadburn's (Ship) Telegraph Co., Ltd. .. .. Cyprus Road, Bootle, Lancs.

Telephones.
British Insulated and Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham

Testing Machines.
Bailey, W. H. & Co., Ltd. .. Albion Works, Salford, Manchester
Casella, C. F., & Co., Ltd. .. 11-15, Rochester Row, S.W.
Denison, Saml., & Son, Ltd. .. Far Hunslet, Leeds, S.
Foster Instrument Co. .. .. Letchworth, Herts.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Lea Recorder Co. .. .. .. 28, Deansgate, Manchester
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow
Tangyes Limited .. .. .. Birmingham

Thermometers.—(*See Pyrometers.*)

Time-Checking Machines.
Bailey, W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Buck & Hickman, Ltd. .. .. 2 & 4, Whitechapel Road, E.
Dey Time Registers, Ltd. .. 75, Queen Victoria Street, E.C.

Time Registers.
Dey Time Registers, Ltd. .. 75, Queen Victoria Street, E.C.

Tools (Hand and Small).—(*See also Machine Tools.*)
Alexander Engineering Co. .. 216-218, Goswell Road, E.C.
Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Armstrong, Stevens & Son, Ltd. Whittall Street, Birmingham
Beardshaw, J., & Son, Ltd., .. Baltic Steel Works, Sheffield
Birmingham Small Arms Company, Ltd. .. .. .. Sparkbrook, Birmingham
Buck & Hickman, Ltd. .. .. 2 & 4, Whitechapel Road, E.
Burton, C. W., Griffiths & Co... 1, 2 & 3, Ludgate Square, E.C.
Chatwin, Thos. .. .. .. Gt. Tindal St., Birmingham
Chesney Engineering Co., Ltd. 35, Chatsworth Rd., Stratford, E.
Churchill, Chas., & Co., Ltd. .. 9 to 15, Leonard St., Finsbury, E.C.
Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge St., Westminster, S.W.
Daniell, S. A., Ltd. .. .. Edward St., Parade, Birmingham
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Fastnut Ltd. .. .. .. 115, Newgate Street, E.C.
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Gardner, T. J. .. .. .. Narrow Wine Street, Bristol
Goodchild, Geo. W., & Partner 30-32, Farringdon Road, E.C.
Guest, Keen & Nettlefolds, Ltd. Birmingham
Heap, Joshua, & Co., Ltd. .. Ashton-under-Lyne
Le Bas, Edward, & Co. .. .. Dock House, Billiter St., E.C.
Neat, Charles, & Co. .. .. 112, Queen Victoria St., E.C.
Patent File & Tool Co., Ltd. .. 8, White St., Moorfields, E.C.
Pryor, Edward, & Son .. .. 63, West Street, Sheffield
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Stone, J. B., & Co. .. .. 135, Finsbury Pavement, E.C.
Taylor, Charles (Birm'm.), Ltd. Bartholomew St., Birmingham
Trimont Mfg. Co. .. .. .. 55-71, Amory St., Roxbury (Boston), Mass., U.S.A.
United States Metallic Packing Co., Ltd. .. .. Soho Works, Bradford
Vickers Limited .. .. .. Vickers House, Broadway, Westminster, S.W.
Ward, H. W., & Co., Ltd. .. Lionel Street, Birmingham
Wells, A. C., & Co. .. .. 102, Midland Road, St. Pancras
Widdowson, John H. .. .. Salford, Manchester [N.W.
Wrigley, E. G., & Co., Ltd. .. Foundry Lane Works, Soho, Birmingham

Tools (Pneumatic).—(*See Pneumatic Tools.*)

Torpedo Boats.
Hanna, Donald & Wilson .. Paisley [France
Normand, Augustin, Ltd. .. 67, Rue du Perrey, Le Havre,
Schichau, F. .. .. .. Elbing-Danzig, Prussia
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Smit, L., & Zoon .. .. .. Kinderdijk, Holland
Thornycroft, J. I., & Co., Ltd... Caxton House, Westminster, S.W.
White, J. Samuel, & Co., Ltd... East Cowes, Isle of Wight
Yarrow & Co., Ltd. .. .. Glasgow

Torpedoes.
Greenwood & Batley, Ltd. .. Albion Works, Leeds

Torsion Meters.
Chadburn's (Ship) Telegraph Co., Ltd. .. .. Cyprus Road, Bootle, Lancs.

Tramways and Tramway Plant.
Allen, Edgar, & Co., Ltd. .. Sheffield
Birch, John, & Co., Ltd... .. 10 & 11, Queen St. Place, E.C.
Bolling & Lowe .. .. .. 2, Laurence Pountney Hill, E.C.
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street,
Hadfield's Steel Foundry Co., Ltd. Hecla Works, Sheffield [E.C.
Hawthorn, R. & W., Leslie & Co., Ltd. .. .. Newcastle-on-Tyne
Hornsby, R., & Sons, Ltd. .. Grantham
Hurst, Nelson & Co., Ltd. .. Glasgow Rolling Stock and Plant Works, Motherwell
Isca Foundry & Engineering Co. Newport, Mon.
Jessop, Wm., & Sons, Ltd. .. Brightside Works, Sheffield
Kerr, Stuart & Co., Ltd... .. 1, Broad Street Place, E.C.
Miller, Wm., & Sons .. .. Wolverhampton
Orenstein & Koppel - Arthur Koppel (Amalgamated) .. 27, Clements Lane, E.C. [bury
Russell, James, & Sons, Ltd. .. Crown Tube Works, Wednesbury
Société du Nord de Liége .. 42, Perryn Road, Acton, W.

Tube-Making Machinery.
Fielding & Platt, Ltd. .. .. Atlas Works, Gloucester
Horsfall Destructor Co., Ltd. .. 17, Victoria Street, S.W.
Platt, Samuel, Ltd. .. .. Wednesbury

Tube Wells.
Isler, C., & Co., Ltd. .. .. Artesian Wks., Bear Lane S.E.
Le Grand & Sutcliff .. .. 125, Bunhill Row, E.C.

Tubes (Brass and Copper).—(*See also Pipes.*)
Birmingham Battery & Metal Co., Ltd. .. .. Birmingham
Broughton Copper Co., Ltd. .. Manchester
Delta Metal Co., Ltd. .. .. Dartmouth St., Birmingham
Elmore's Metall A.G. .. .. Schladern, Sieg.. Germany
Grice, Grice & Son, Ltd. .. Sheepcote Street, Birmingham
Mannesmannröhren Werke .. Düsseldorf, Germany
Muntz, P. H., & Co., Ltd. .. Alexandra Works, West Bromwich
Royles Limited .. .. .. Irlam, near Manchester
Yorkshire Copper Works, Ltd. Leeds

Tubes (Iron and Steel).
British Mannesmann Tube Co., Ltd. .. .. Salisbury House, London Wall, E.C.
British Steel Piling Co. .. .. Dock House, Billiter Street,
British Welding Co., Ltd. .. 58, Victoria Street, Westminster
Brown, John, & Co., Ltd. .. Sheffield [ster, S.W.
Clayton, Son & Co., Ltd... .. Hunslet, Leeds
Foster Brothers, Ltd. .. .. Wednesbury
Howell & Co., Ltd. .. .. Brook Steel Works Sheffield
Le Bas, Edward, & Co. .. .. Dock House, Billiter St., E.C.
Lewis, E., & Sons .. .. .. Wolverhampton
Mannesmannröhren Werke .. Düsseldorf, Germany
Marshall, J., & Sons .. .. Glasgow
Mechan & Sons, Ltd. .. .. Scotstoun Ironworks, Glasgow
Muntz, P. H., & Co., Ltd. .. Alexandra Works, West Bromwich
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Russell, James, & Sons, Ltd. .. Crown Tube Wks., Wednesbury
Russell, John, & Co., Ltd. .. Alma Tube Works, Walsall
Spencer, John, Ltd. .. .. Wednesbury
Steel Pipe Company, Ltd. .. Kirkcaldy, N.B.
Stewarts & Lloyds, Ltd... .. 41, Oswald Street, Glasgow; and Nile Street, Birmingham
Tubes Ltd. .. .. Birmingham
Weldless Steel Tube Co., Ltd... Ickneild Port Rd., Birmingham

Tug Boats.
Day, Summers & Co. .. .. Northam Ironworks, Southampton
Ferguson Brothers .. .. Port Glasgow [ampton
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Hayes, Edward .. .. .. Stony Stratford, Wolverton
Lobnitz & Co., Ltd. .. .. Renfrew
McKie & Baxter .. .. .. Copland Wks., Govan, Glasgow
Rennie, G., & Co. .. .. .. Thames Street, Greenwich
Ross & Duncan .. .. .. Glasgow
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Smit, L., & Zoon .. .. .. Kinderdijk, Holland
Smith's Dock Co., Ltd. .. .. South Bank, S.O., Yorks
Thornycroft, J. I., & Co., Ltd... Southampton, and Caxton House, Westminster, S.W.
White, J. Samuel, & Co., Ltd... East Cowes, Isle of Wight

Turbine Pumps.—(*See Pumps, Turbine.*)

Turbines.—(*See also Steam Turbines.*)
Allen, W. H., Son, & Co., Ltd... Queen's Eng. Works, Bedford
Boving, Jens Orten- & Co. .. 9½, Union Court, Old Broad
British Thomson-Houston Co., Ltd. .. .. Rugby [Street, E.C.
Escher Wyss & Co. .. .. 109, Victoria Street, S.W.
Gilkes, Gilbert, & Co., Ltd. .. Kendal, England
Günther, W., & Sons .. .. Central Works, Oldham
Pitman, Percy .. .. .. 3, Willcott Road, Acton, W.
Thornycroft, J. I., & Co., Ltd... Southampton
Vickers Limited .. .. .. Sheffield

Turnbuckles.
Engholm, A. Goldie .. .. 104, Newhall St., Birmingham

Turnstiles.
Ellison, W. T., & Co., Ltd. .. Irlams-o'-th'-Height, Manchester [S.E.
Isler, C., & Co., Ltd. .. .. Artesian Works, Bear Lane,
Le Grand & Sutcliff .. .. 125, Bunhill Row, E.C.

Turntables.
Ashmore, Benson, Pease & Co., Ltd. Stockton-on-Tees
Cowans, Sheldon & Co., Ltd. .. Carlisle
Heenan & Froude, Ltd. .. .. Newton Heath Ironworks, near
Isca Foundry & Engineering Co. Newport, Mon. [Manchester
Kerr, Stuart & Co., Ltd. .. .. 1, Broad Street Place, E.C.
Maschinenfabrik Augsburg-Nurnberg A.-G. .. .. .. 219, Caxton House, Westminster, S.W.
Patent Shaft & Axletree Co., Ltd. Wednesbury
Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Société du Nord de Liége .. 42, Perryn Road, Acton, W.

Typewriting and Calculating Machines.
Taylor's Typewriter Co., L'd. .. 74, Chancery Lane, W.C.

Tyre Rolling Mills.
Jackson, P. R., & Co., Ltd .. Salford Rolling Mills, Manchester

Tyres (Railway).
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bessemer, Henry, & Co., Ltd. .. Sheffield
Brown, Bayley's Steel Works, Ltd. Sheffield
Brown, John, & Co., Ltd. .. Sheffield [Sheffield
Cammell Laird & Co. Ltd. .. Cyclops Steel & Iron Works, Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Patent Shaft & Axletree Co., Ltd. Wednesbury
Vickers Limited .. .. .. Sheffield

Valuers.—*(See Auctioneers, &c.)*

Valuers (Engineers').
Fuller, Horsey, Sons & Cassell.. 11, Billiter Square, E.C.
Kirk, W., Price & Co. .. .. 46, Watling Street, E.C.; and Albert Square, Manchester
Radford, E. Heber, Son & Squire 15, St. James Row, Sheffield

Valve Gear.
Lees, T. & B. .. .. .. Hollinwood, near Manchester

Valves (Gas, Steam, Water, &c.).
Alley & MacLellan, Ltd... .. Sentinel Works, Glasgow
Auld, David, & Sons, Ltd. .. Whitevale Foundry, Glasgow
Bailey, W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Bell's United Asbestos Co., Ltd. Syl, Southwark Street, S.E.
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet Leeds
Blair, Campbell & McLean, Ltd. Woodville St., Govan, Glasgow
British Steam Specialties, Ltd. Bedford Street, Leicester
Cockburns Limited .. .. Clydesdale Works, Cardonald, near Glasgow
Crosby Steam Gage & Valve Co. 147, Queen Victoria Street, E.C.
Daw, A. & Z. .. .. .. 11, Queen Victoria Street, E.C.
Dewhurst's Engineering Co., Ltd. Sheffield
Donkin Co., Ltd. (The Bryan) .. Chesterfield
East Ferry Road Engineering Works Co., Ltd. .. .. Millwall, E.
Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B.
Gutta Percha & Rubber Mfg. Co. of Toronto, Ltd... .. .. Toronto, Canada
Hanna, Donald & Wilson .. Paisley, N.B.
Holden & Brooke, Ltd. .. .. Sirius Works, West Gorton, Manchester
Hopkinson, J., & Co., Ltd. .. Huddersfield [Manchester
Hübner & Mayer .. .. .. Vienna, XIX/6
Hulburd Engineering Co., Ltd. Hulburd, Leadenhall Street, E.C.
Jenkins Bros., Ltd. .. .. 95, Queen Victoria Street, E.C.
Lunken Company, Inc. .. .. 35, Great Dover Street, S.E.
Metallic Valve Co. .. .. Colonial House, Water Street, Liverpool
Millar, Dennis & Co. .. .. Victoria Works, Bradford
Patrick, F. .. .. Oxford Street, Leeds
Piggott, Thos., & Co., Ltd. .. Birmingham
Rice & Co. (Leeds), Ltd. .. .. Elland Road, Leeds
Royles Limited .. .. .. Irlam, near Manchester
Schäffer & Budenberg, Ltd. .. Whitworth St., London Road, Manchester
Smith Bros. & Co. (Hyson), Ltd Nottingham [Manchester
Smith's Injector Co. .. .. Oozells St. North, Birmingham
Storey, I., & Sons, Ltd. .. .. Empress Foundry, Manchester
Woodite Works .. .. .. Mitcham Common, Surrey
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Valves (for Pumps).
Witting Bros., Ltd. .. .. 49, Cannon Street, E.C.

Valves (Reducing).
Auld, David, & Sons, Ltd. .. Whitevale Foundry, Glasgow
Bailey, W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Cockburns Ltd. .. .. .. Clydesdale Engineering Works, Cardonald, near Glasgow
Hopkinson, J., & Co., Ltd. .. Huddersfield
Hübner & Mayer .. .. .. Vienna, XIX/6
Mason Regulator Co. .. .. Boston, U.S.A.
Royles Limited .. .. .. Irlam, near Manchester
Schäffer & Budenberg, Ltd. .. Whitworth St., London Road, Manchester
Sugden, T., Ltd. .. .. .. 180, Fleet Street, E.C.

Valves (Safety).
Bailey, W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Cockburns Ltd. .. .. .. Clydesdale Engineering Works, Cardonald, near Glasgow
Crosby Steam Gage & Valve Co. 147, Queen Victoria Street, E.C.
Hopkinson, J., & Co., Ltd. .. Huddersfield [E.
Hubner & Mayer .. .. .. Vienna XIX/6
Klinger, Richard, & Co. .. .. 66, Fenchurch Street, E.C.

Valves (Safety).—*Continued.*
Lunken Company, Inc. .. .. 35, Great Dover Street, S.E.
Royles Limited .. .. .. Irlam, near Manchester
Schäffer & Budenberg, Ltd. .. Whitworth Street, London Road, Manchester
Turnbull, Alex., & Co., Ltd. .. Bishopbriggs, Glasgow

Ventilators.
Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Allen, W. H., Son, & Co., Ltd... Queen's Eng. Works, Bedford
Boyle, E., & Son .. .. .. 64, Holborn Viaduct, E.C.
Dempster, R. & J., Ltd. .. .. Newton Heath, Manchester
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham
Gibbs, John, & Son .. .. .. 722 6, Duke Street, Liverpool
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, [Worcester
Keith, James, & Blackman Co., Ltd. .. .. 27, Farringdon Avenue, E.C.
Musgrave & Co., Ltd. .. .. St. Ann's Ironworks, Belfast
Royce Ltd. .. .. Trafford Park, Manchester
Standard Engineering Co., Ltd. Leicester
Sturtevant Engineering Co., Ld. 147, Queen Victoria St., E.C.
Thermotank Ventilating Co., Ltd. 55, West Regent St., Glasgow
Whittaker, C. & Co., Ltd. .. Haslingden, near Manchester

Vices.
Alexander Engineering Co. .. 214-218, Goswell Road, E.C.
Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Chesney Engineering Co., Ltd. 35, Chatsworth Rd., Stratford, E.
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Taylor, Charles (Birm'm.), Ltd. Bartholomew St., Birmingham

Vulcanite and Vulcanised Fibre.
North British Rubber Co., Ltd. Castle Mills, Edinburgh
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Winter, F. .. .. 25, Goswell Road, E.C.

Wagon (Railway) Builders.
Bagnall, W. G., Ltd. .. .. Castle Engine Works, Stafford
Baume & Marpent .. .. Moyaux, Haine-St.-Pierre, [Belgium
Blake Boiler, Wagon & Engineering Co., Ltd. .. .. .. Darlington
Glasgow Railway Engineering Co., Ltd. .. .. Govan, Glasgow
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees [Worcester
Heenan & Froude, Ltd. .. .. Worcester Engineering Works,
Hurst, Nelson & Co., Ltd. .. Glasgow Rolling Stock and Plant Works, Motherwell
Kerr, Stuart & Co., Ltd... .. 1 & 2, Broad Street Place, E.C.
Leeds Forge Co., Ltd. .. .. Leeds
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow
McLachlan & Co., Ltd. .. .. Darlington
Metropolitan Amalgamated Railway Carriage & Wagon Co., Ltd. Saltley, Birmingham
Midland Railway Carriage and Wagon Co., Ltd... .. .. Abbey Works, Shrewsbury
Patent Shaft & Axletree Co., Ld. Wednesbury
Pickering, R. Y., & Co., Ltd. .. Wishaw, near Glasgow

Wagons (Self-propelled).—*(See Motor Vehicles.)*

Wagons (Tip).
Bagnall, W. G., Ltd. .. .. Castle Engine Works, Stafford
Bellamy, John, Ltd. .. .. Millwall, E.
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon St. E.C.
Hadfield's Steel Foundry Co., Ld. Hecla Works, Sheffield
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Kerr, Stuart & Co., Ltd... .. 1, Broad Street Place, E.C.
Orenstein & Koppel-Arthur Koppel (Amalgamated) .. 27, Clements Lane, E.C.

Watches.
Smith, S., & Sons, Ltd. .. .. 9, Strand, W.C.

Water Cooling Plant.
Balcke & Co., Ltd. .. .. Broadway Court, Broadway, Westminster, S.W.
Kater & Ankersmit .. .. 34, Fenchurch Street, E.C.
Klein Engineering Co. (1908), Ld. 94, Market Street, Manchester

Water Purifying Apparatus.
Babcock & Wilcox, Ltd. .. Oriel Hse., Farringdon St., E.C.
Baker Oil Separator Co., Ltd. .. Melrose Street Works, Scarborough
Bellamy, John, Ltd. .. .. Millwall, E.
Buhring's Patent Water Purifying Co. .. .. 60, Wilson Street, E.C.
Green, George, & Co .. .. Keighley
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co. .. Oberhausen-2, Rhineland
Harris Patent Feed-Water Filter (1910), Ltd. .. .. 81, Victoria Street, S.W.
Harris Patent Feed-Water Filter (1910), Ltd. .. .. .. 24, Grainger Street West, Newcastle-on Tyne
Kennicott Water Softener Co. Ettingshall Works, Wolverhampton

Water Purifying Apparatus.—*Continued.*
Lassen & Hjort .. .. .. 52, Queen Victoria Street, E.C.
Lipscombe, Fredk., & Co. .. 49, Queen Victoria Street, E.C
Mather & Platt, Ltd. .. .. Salford Ironworks, Manchester
Meldrum Bros., Ltd. (in Liq.) .. Canal Works, Timperley, near Manchester
Paterson Engineering Co., Ltd. 21, Amberley House, Norfolk Street, Strand, W.C.
Puech, Armand .. .. .. Kingsway Hse, Kingsway, W.C.
Pulsometer Engineering Co., Ld. Nine Elms Ironworks, Reading
Rose, Downs & Thompson, Ltd Old Foundry, Hull
Royles Limited .. .. .. Irlam, near Manchester
Underfeed Stoker Co., Ltd. .. Covent y House, South Place,
Wright, Jos., & Co. .. .. Tipton, Staffordshire [E.C.

Water Wheels.
Barry, Henry & Co., Ltd. .. Aberdeen
Bodley Brothers & Co. .. .. Exeter
Davis & Primrose .. .. .. Bangor Road, Leith
Fraser & Chalmers, Ltd. .. 3, London Wall Buildings, E.C.
Pitman, Percy .. .. .. 3, Willcott Road, Acton, W.
Stothert & Pitt, Ltd. .. .. Bath

Weighing Machines.
Bennis, Ed., & Co., Ltd... .. Bolton
Denison, Saml., & Son, Ltd. .. Far Hunslet, Leeds, S.
East Ferry Road Engineering Works, Co., Ltd. .. .. Millwall, E.
Fraser & Chalmers, Ltd. .. Erith, Kent
Klein Engineering Co. (1908), Ltd. 94, Market Street, Manchester
Porhydrometer, Ltd. .. .. 6, Lloyd's Avenue, E.C.

Welding and Cutting Plant.
Acetylene Corporation Ltd. .. 49, Victoria Street, S.W.
Acetylene Illuminating Co., Ld. 268 and 270, South Lambeth Road, S.E.
A.E.G. Electric Company, Ltd. Pembroke Hse., 133-135, Oxford [Street, W.
British Insulated & Helsby Cables, Ltd. .. .. [S.W.
British Oxygen Co., Ltd. .. Prescot, Lancashire
Oxygen Welding Works, Ltd. .. Elverton Street, Westminster,
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Crowther, Henry, & Sons, Ltd., Cleckheaton	**Henry Crowther, Cleckheaton**
Cruikshank & Fairweather, Ltd., 62, St. Vincent St., Glasgow	**Patents, Glasgow**
Cunningham, T. L., Balfour House, Finsbury Pavement, E.C.	**Platoons, London**
Curtis's & Harvey, Ltd., 3, Gracechurch Street, E.C.	**Curtiss, or Gunpowder, London**
Cutbill-King & Co., 26, Nicholas Lane, E.C.	**Lockett, London**
Dalglish, A. & W., West of Scotland Boiler Wks., Pollokshaws, Glasgow	**Evaporate, Pollokshaws**
Dampney, J., & Co., Ltd., Bute Docks, Cardiff	**Dampney, Cardiff**
Daniell, S. A., Ltd., Edward Street, Parade, Birmingham	**Daniell, Birmingham**
Daniels, T. H. & J., Ltd., Stroud, Glos.	**Daniels, Stroud**
Darling & Sellers, Ltd., Keighley	**Darling Sellers, Keighley**
Darlington Forge Co., Ltd., Darlington	**Forge, Darlington**
Davey, Paxman & Co., Ltd., Standard Iron Works, Colchester	**Paxman, Colchester**
Davey, Paxman & Co., Ltd., 78, Queen Victoria Street, E.C.	**Paxman, London**
Davidson & Co., Ltd., Sirocco Engineering Works, Belfast	**Sirocco, Belfast**
Davies & Metcalfe, Ltd., Romiley, Manchester	**Exhaust, Romiley**
Davies, W. J., & Sons, 109, Weston Street, S.E.	**Emery, London**
Davis, E. J., & Co., Great Eastern Road, Stratford, E.	**Rapidising, London**
Davis, John, & Son (Derby), **Ltd.,** All Saints' Works, Derby	**Davis, Derby**
Davis & Primrose, Etna Iron Works, Bangor Road, Leith, N.B.	**Etna, Leith**
Davy Brothers, Ltd., Sheffield	**Motor, Sheffield**
Daw, A. & Z., 11, Queen Victoria Street, E.C.	**Guldnes, London**
Day, Summers & Co., Ltd., Northam Ironworks, Southampton	**Day Summers, Southampton**
De Bergue & Co., Ltd., Strangeways Ironworks, Manchester	**Debergue, Manchester**
Dean, Smith & Grace (1908), Ltd., Keighley	**Lathes, Keighley**
Delta Metal Co., Ltd., East Greenwich, S.E.	**Delta, London**
Delta Metal Co., Ltd., Dartmouth Street, Birmingham	**Extrusion, Birmingham**
Dempster, Moore & Co., Ltd., 49, Robertson Street, Glasgow	**Dempster, Glasgow**
Dempster, R. & J., Ltd., Newton Heath, Manchester	**Scrubber, Manchester**
Denison, Saml., & Son, Ltd., Far Hunslet, Leeds, S.	**Weigh, Leeds**
Dennis, W. F., & Co., 49, Queen Victoria Street, E.C.	**Fredennis, London**
Dennystown Forge Co., Dumbarton	**Forge, Dumbarton**
Deutsche Maschinenfabrik A.G., Duisburg, Germany	**[Sheffield**
Dewhurst's Engineering Co., Ltd., Sheffield	**Dewhurst, Attercliffe Road,**
Dey Time Registers, Ltd., 75, Queen Victoria Street, E.C.	**Countable, London**
Dick, Kerr & Co., Ltd., Abchurch Yard, Cannon Street, E.C.	**Dicker, London**
Diesel Engine Co., Ltd., 179, Queen Victoria Street, E.C.	**Dieselben, London**
Dobbie, McInnes, Ltd., 57, Bothwell Street, Glasgow	**Compass, Glasgow**
Dodman, A., & Co., Ltd., King's Lynn	**Dodman, King's Lynn**
Donkin Company, Ltd. (The Bryan), Chesterfield	**Donkin, Chesterfield**
Douglas & Grant, Dunnikier Foundry, Kirkcaldy, N.B.	**Douglas, Kirkcaldy**
Douglas, Lawson & Co., Birstall, near Leeds	**Pulleys, Birstall**
Doulton & Co., Ltd., Lambeth	**Doulton, London**
Dowson & Mason Gas Plant Co., Ld., 39, Victoria Street, S.W.	**Gaseous, London**
Dowson & Mason Gas Plant Co., Ld., Levenshulme, M'chester	**Gasify, Levenshulme**
Drake & Gorham, Ltd., 66, Victoria Street, Westminster, S.W.	**Accumulator, London**
Droop & Rein, Bielefeld, Germany	
Drum Engineering Co., 33, Brook Street, Bradford	**Drum, Bradford**
Drummond Brothers, Ltd., Engel Works, near Guildford	**Lathes, Guildford**
Drysdale & Co., Ltd., Bon Accord Works, Yoker, Glasgow, W.	**Bonaccord, Glasgow**
Dublin Dockyard Co., North Wall, Dublin	**Dockyard, Dublin**
Dudbridge Iron Works, Ltd., Dudbridge, near Stroud	**Humpidge, Cainscross**
Dudgeon, F. S., Ltd., 30, Great St. Helen's, E.C.	**Plasmo, London**
East Ferry Road Engineering Works Co., Ltd., Millwall, E.	**Hydrostatic, London**
Economic Forced Draught & Engineering Co., Ltd., 5, Castle Street, Liverpool	**Smoke, Liverpool**
Edmeston, A., & Sons, Ltd., Patricroft, nr. Manchester	**Edmeston, Patricroft**
Electric Control, Ltd., 177, Reid Street, Bridgeton, Glasgow	**Control, Glasgow**
Electric & Ordnance Accessories Co., Ld., Aston, Birmingham	**E.O.A., Birmingham**
Electromotors Limited, 49, Queen Victoria Street, E.C.	**Orders, London**
Electromotors Limited, Openshaw, Manchester	**Magnet, Manchester**
Elliot, George, & Co., Ltd., 16, Gt. George St., Westminster, S.W.	**Elliot Company, London**
Elliot, George, & Co., Ltd., Cardiff	**Elliot Company, Cardiff**
Ellison, W. T., & Co., Ltd., Irlams-o'-th'-Height, Manchester	**Ellisons Ltd., Irlams-o'-th' Height**
Elmore's Metall-A.-G., Schladern, Seig., Germany	**Elmores, Schladern, Germany**
Emmott & Co., Ltd., 65, King Street, Manchester	**Textile, Manchester**
Engholm, A. Goldie, 104, Newall Street, Birmingham	**Engholm, Birmingham**
"Engineering," Ltd., 35 and 36, Bedford Street, Strand, W.C.	**Engineering, London**
Engineering Supplies, Ltd., 28, Victoria Street, S.W.	**Proells, London**
English Electrical Company, Ltd., Nottingham	
Entwisle & Gass, Ltd., Bolton	**Foundry, Bolton**
Escher Wyss & Co., 109, Victoria Street, S.W.	**Neumuehle, London**
Eureka Pump Company, 53, Bothwell Street, Glasgow	**Meteorite, Glasgow**
Evans, Joseph, & Sons (Wolverhampton, Ld.), Wolverh'pton	**Evans, Wolverhampton**
Everett, Edgcumbe & Co., Ld., Collindale Wks., Hendon, N.W.	**Evergendos, London**
Everett, Edgcumbe & Co., Ltd., 117, Victoria Street, S.W.	**Everectus, London**
Expanded Metal Co., Ltd., York Mansion, York Street, S.W.	**Distend, London**
Eyre Smelting Co., Ltd., Barden Road Works, Tonbridge, Kent	**Eyrish, Tonbridge**

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Fairbairn, Macpherson, Wellington Foundry, Leeds	**Fairbairns, Leeds**
Fairbanks Co., 15, Mallow Street, Old Street, E.C.	**Fairbanks, London**
Fairley, James, & Sons, Old Mint, Shadwell Street, Birmingham	**Fairley, Birmingham**
Fasnut Ltd., 115, Newgate Street, E.C.	**Fasnut, London**
Fawcett, Preston & Co., Ltd., Liverpool	**Fawcett, Liverpool**
Ferguson Brothers, Port Glasgow	**Dredger, Port Glasgow**
Ferranti Ltd., Hollinwood, Lancs.	**Ferranti, Hollinwood**
Fielding & Platt, Ltd., Gloucester	**Atlas, Gloucester**
Fife Forge Co., Kirkcaldy, Scotland	**Fife Forge, Kirkcaldy**
Figee, Haarlem, Holland	**Figee-Haarlem**
Finch, Edward, & Co., Ltd., Chepstow	**Finch, Chepstow**
Findlay, Alex., & Co., Ltd., Motherwell, near Glasgow	**Findlay, Motherwell**
Firth, Thos., & Sons, Ltd., Norfolk Works, Sheffield	**Firth, Sheffield**
Firth, Thos., & Sons, Ltd., 8, The Sanctuary, Westminster, S.W.	**Mesmeric, London**
Firth, Thos., & Sons, Ltd., 144, St. Vincent Street, Glasgow	**Firmo, Glasgow**
Fleming & Ferguson, Ltd., Paisley, near Glasgow	**Phœnix, Paisley**
Flender Company, The, Broad St. House, New Broad St., E.C.	**Flenderim, London**
Foster Brothers, Ltd., Wednesbury	**Fosters, Wednesbury**
Foster Instrument Co., Letchworth, Herts.	**Foster Instrument, Letchworth**
Fowler, John, & Co. (Leeds), Ltd., 6, Lombard Street, E.C.	**Steamplow, London**
Fowler, John, & Co. (Leeds), Ltd., Steam Plough Works, Leeds	**Fowler, Leeds**
France & Morgan, Whitefield Brass Works, Govan, Glasgow	**France, Glasgow**
Fraser & Chalmers, Ltd., 3, London Wall Buildings, E.C.	**Vanner, London**
Fraser, Douglas, & Sons, Ltd., Arbroath, Scotland	**Fraser, Arbroath**
Friedenthal, F., River Engine Works, Preston	**Screw, Preston**
Fry, Ernest Bickersteth, 4 & 6, Victoria Avenue, Shipley, Yorks.	**Fry, Victoria Avenue, Saltaire**
Fuller, Horsey, Sons & Cassell, 11, Billiter Square, E.C.	**Fuller Horsey, London**
Fullerton, Hodgart & Barclay, Ltd., Vulcan Foundry and Engine Works, Paisley	**Vulcan, Paisley**
Gandy Belt Mfg. Co., Ltd., Wheatland Works, Seacombe, Cheshire	**Gandy, Birkenhead**
Gandy Belt Mfg. Co., Ltd., 97, Queen Victoria Street, E.C.	**Gandy, London**
Gardner, L., & Sons, Ltd., Barton Hall Engine Wks., Patricroft, Manchester	**Theorem, Patricroft**
Gardner, T. J., Narrow Wine Street, Bristol	**T. J. Gardner, Bristol**
Garrett, R., & Sons, Ltd., Leiston Works, Suffolk	**Garrett, Leiston**
Gas Power & By-Products Co., Ld., 38, Bath Street, Glasgow	**Fresco, Glasgow**
Geipel Wm., & Co., Vulcan Works, St. Thomas Street, S.E.	**Patella, London**
Gemmell & Co., 492, Argyle Street, Glasgow	
General Electric Co., Ltd., 67, Queen Victoria Street, E.C.	**Electricity, London**
Gibbins, R. C., & Co., Berkley Street, Birmingham	**Gibbins, Birmingham**
Gibbs, John, & Son, 726, Duke Street, Liverpool	**Ventilation, Liverpool**
Gibbs, Renton, & Co., Ltd., Mill Street, Liverpool	**Heating Liverpool**
Gilkes, Gilbert & Co., Ltd., Kendal, England	**Gilkes, Kendal**
Glasgow Iron & Steel Co., Ltd., Wishaw Iron & Steel Works, Wishaw	**Ingot, Wishaw**
Glasgow Railway Engineering Co., Ltd., Govan, Glasgow	**Expansion, Glasgow**
Glenfield & Kennedy, Ltd., Kilmarnock, N.B.	**Glenfield, Kilmarnock**
Globe Pneumatic Engineering Co., Ltd., 150, Queen Victoria Street, E.C.	**Pneumatoid, London**
Glover & Hobson, Ltd., Albert Ironworks, Chelmsford	**Albert, Chelmsford**
Glyco Metal Co., Ltd., Openshaw, Manchester	**Glyco, Manchester**
Goedhart Bros., Düsseldorf, Germany	**Goedhart, Düsseldorf**
Goodchild, Geo. W., & Partner, 30-32, Farringdon Rd., E.C.	**Whizzing, London**
Grafton & Co., Bedford	**Grafton, Bedford**
Grafton & Co., 120, Cannon Street, E.C.	**Graftonian, London**
Grantham Boiler & Crank Co., Ltd., Grantham	**Land, Grantham**
Graphite Products, Ltd., 218-220, Queen's Road, Battersea, S.W.	**Lustroso, London**
Graziani, A. G., & Co., Ltd., 22, Billiter Street, E.C.	**Graziani, London**
Great Western Railway, Paddington Station, W.	
Greaves, Bull & Lakin, Ltd., 9, Grove Road Bridge, Marylebone, N.W.	**Lias, London**
Greaves, Bull & Lakin, Ltd., Harbury, Leamington	**Greaves, Harbury**
Green & Boulding, Ltd., 28, New Bridge Street, E.C.	**Temperature, London**
Green, George, & Co., Keighley	**Cupola, Keighley**
Greene, Tweed & Co., Queen Anne's Chambers, Tothill Street, Westminster, S.W.	**Greene, Quancham, London**
Greenwood & Batley, Ltd., Albion Works, Leeds	**Greenwood Leeds**
Gresham & Craven, Ltd., Salford, Manchester	**Brake, Manchester**
Grice, Grice & Son, Ltd., Sheepcote Street, Birmingham	**Grice, Birmingham**
Grieve, John, & Co., Motherwell, Scotland	**Grieve, Motherwell**
Griffin, C., & Co., Ltd., Exeter Street, Strand, W.C.	**Explanatus, London**
Griffin, John J., & Sons, Ltd., Kemble Street, Kingsway, W.C.	**Gramme, London**
Grover & Co., Wharf Road, City Road, N.	**Adopted, London**
Guest, Keen & Nettlefolds, Ltd., 16, Broad St., Birmingham	**Nettlefolds, Birmingham**
Guest, Keen & Nettlefolds, Ltd., London	**Nettlefolds, London**
Guilbert-Martin, 9, Edmund Place, Aldersgate, E.C.	**Photophore, London**
Günther, W., & Sons, Central Works, Oldham	**Gunther, Oldham**
Gutehoffnungshütte Coal, Iron, Steel & Engineering Co., Oberhausen-2, Rhineland	**Hoffnungshuette, Oberhausenrhein**
Gutta Percha & Rubber Mfg. Co., of Toronto, Ltd., Toronto, Canada	**Guttaperch, Toronto**
Gwynnes Ltd., Hammersmith Ironworks, W., & 81, Cannon Street, E.C.	**Gwynne, London**
Hadfield's Steel Foundry Co., Ltd., Hecla Works, Sheffield	**Hadfield, Sheffield**
Halden, J., & Co., Ltd., 8, Albert Square, Manchester	**Halden, Manchester**
Hall, B. J., & Co., Ltd., 39, Victoria Street, S.W.	**Inspect, London**
Hall, J. & E., Ltd., 10, St. Swithin's Lane, E.C.	**Hallford, London**
Hall, J. & E., Ltd., Dartford, Kent	**Hallford, Dartford**
Hall, J. P., & Co., Ltd., Oldham	**Dynamo, Oldham**
Hall, J. P., & Sons, Ltd., Peterborough	**Hall, Engineers, Peterboro'**
Hands, John, & Sons, Ltd., Cardigan Works, Birmingham	**Machinery, Birmingham**
Hanna, Donald & Wilson, Abercorn Foundry, Paisley	**Donald, Paisley**
Hannan & Buchanan, 75, Robertson Street, Glasgow	
Hannoversche Maschinenbau-Actien-Gesellschaft, vormals Georg Egestorff, Hannover-Linden, German	**Hanomag, Hannover-Linden, Germany**

NAME AND ADDRESS OF ADVERTISER.	TELEGRAPHIC ADDRESS.
Hardy Patent Pick Co., Ltd., Sheffield	**Hardypick, Sheffield**
Harris & Mills, 23, Southampton Buildings, W.C.	**Privilege, London**
Harris Patent Feed-Water Filter (1910), **Ltd.,** 82, Victoria Street, S.W.	**Windtight, London**
Harris Patent Feed-Water Filter (1910), **Ltd.,** 24, Grainger Street West, Newcastle-on-Tyne	**Windtight, Newcastle-on-Tyne**
Hart, Thomas, Blackburn	**Hart, Blackburn**
Hartnell, Wilson, & Co., Ltd., Volt Works, Kirkstall Road, Leeds	**Hartnell, Leeds**
Harvey Engineering Co., Ld., Scotland St. Engine Works, Glasgow	**Maconie, Glasgow**
Harvey, G. & A., Ltd., Govan, Glasgow, W.	**Gandah, Glasgow**
Harvey, G. A., & Co., Lewisham, S.E.	**Cheaper, London**
Haslam Foundry & Engineering Co., Ltd., Derby	**Zero, Derby**
Hathorn, Davey & Co., Ltd., Sun Foundry, Leeds	**Hathorn, Leeds**
Hawksley, Wild & Co., Ltd., Brightside Boiler Works, Sheffield	**Hawksley, Sheffield**
Hawthorn, R. & W., Leslie & Co., Ltd., Newcastle-on-Tyne	**Locomotive, Newcastle**
Hayes, Edward, Watling Works, Stony Stratford, Wolverton	**Hayes, Stony Stratford**
Hayes, Edward, Palace Chambers, 9, Bridge Street, S.W.	**Seyah, London**
Hayward-Tyler & Co., Ltd., 99, Queen Victoria Street, E.C.	**Tylerox, London**
Head, Wrightson & Co., Ltd., Teesdale Ironworks, Thornaby-on-Tees	**Teesdale, Stockton-on-Tees**
Heap, Joshua, & Co., Ltd., Ashton-under-Lyne	**Heap, Ltd., Ashton-under-Lyne**
Heathman & Co., Parson's Green, Fulham, S.W.	
Heenan & Froude, Newton Heath Ironworks, Manchester	**Spherical, Newton Heath**
Heenan & Froude, 4, Chapel Walks, Manchester	**Heenan, Manchester**
Heenan & Froude, Worcester Engineering Works, Worcester	**Heenan, Worcester**
Henderson & Glass, Liverpool	**Vulcan, Liverpool**
Hendry, James, Laminated Leather Works, Bridgeton, Glasgow	**Laminated, Glasgow**
Herbert, Alfred, Ltd., Coventry	**Lathe, Coventry**
Hetherington, John, & Sons, Ltd., Manchester	**Heth, Manchester**
Higginbottom & Mannock, Ltd., Crown Ironworks, West Gorton, Manchester	**Crown, Gortonbrook**
Higgins, C. M., & Co., 11, Farringdon Avenue, E.C.	**Plicated, London**
Hindley, E. S., & Sons, Bourton, Dorset	**Hindley, Bourton-Dorset**
Hindley, E. S., & Sons, 11, Queen Victoria Street, E.C.	**Steamport, London**
Hobdell, Way & Co., Ld., St. John's House, 124-5, Minories, E.	**Hobnails, London**
Hoffmann Manufacturing Co., Ltd., Chelmsford	**Hoffmann, Chelmsford**
Holbrook & Sons, Stratford, E.	**Lathookol, London**
Holden & Brooke, Ltd., Sirius Works, West Gorton, Manchester	**Influx, Manchester**
Hopkinson, J., & Co., Ltd., Huddersfield	**Hopkinson, Huddersfield**
Hornsby, R., & Sons, Ltd., Spittlegate Iron Works, Grantham	**Hornsbys, Grantham**
Hornsby, R., & Sons, Ltd., 75B, Hornsby House, Queen Victoria Street, E.C.	**Hornsbys, London**
Horsfall Destructor Co., Ltd., 17, Victoria Street, S.W.	**Destructor, London**
House, Fredk., & Co., 30, Chapel Street, Liverpool	**Jointing, Liverpool**
Howard Pneumatic Engineering Co., Ltd., Fort Road, Eastbourne	**Inventions, Eastbourne**
Howard Pneumatic Engineering Co., 11, Tothill Street, Westminster, S.W.	
Howden, James, & Co., Ltd., Scotland Street, Glasgow	**Howden, Glasgow**
Howell & Co., Ltd., Brook Steel Works, Sheffield	**Howell, Sheffield**
Hübner & Mayer, Vienna XIX/6	**Rohrbruch, Vienna**
Hudson, John, & Co.'s Successors, 81A, Mansell Street, E.	**Adamantos, London**
Hudson, Thomas, Ltd., Sheepford Works, Coatbridge, N.B.	**Hudson, Coatbridge**
Hudswell, Clarke & Co., Ltd., Railway Foundry, Leeds	**Loco, Leeds**
Hughes & Lancaster, Liverpool	**Diagram, Liverpool**
Hughes & Lancaster, 16, Victoria Street, Westminster, S.W.	**Voidance, London**
Hulburd Engineering Co., Ltd., 150, Leadenhall Street, E.C.	**Unwavering, London**
Hunslet Engine Co., Ltd., Leeds	**Engine, Leeds**
Hunt & Mitton, Oozells Street North, Birmingham	**Mitton, Birmingham**
Hunt, Robert W., & Co., Norfolk House, Cannon Street, E.C.	**Metalados, London**
Hurst, Nelson & Co., Ltd., Glasgow Rolling Stock and Plant Works, Motherwell	**Nelson, Motherwell**
India Rubber, Gutta Percha and Telegraph Works Co., Ltd., 106, Cannon Street, E.C.	**Silvergray, London**
India Rubber, Gutta Percha and Telegraph Works Co., Ltd., Silvertown, Essex	**Graysilver, London**
Ingersoll-Rand Co., 165, Queen Victoria Street, E.C.	**Ingersoll, London**
Isca Foundry & Engineering Co., Newport, Monmouthshire	**Isca, Newport**
Isca Foundry & Engineering Co., St. Margaret's Mansions, 53, Victoria Street, Westminster, S.W	**Isca, London**
Isherwood, J. W., Zetland Buildings, Middlesbrough	**Isherwood, Middlesbrough**
Isler, C., & Co., Ltd., Artesian Works, Bear Lane, S.E.	**Isler, London**
Jack, Alexander, & Co., Whitegates Engineering Works, Motherwell, Scotland	**Cranes, Motherwell**
Jackman, J. W., & Co., Ltd., Caxton House, Westminster, S.W	**Molders, London**
Jackson, J. G., Ltd., 34, West George Street, Glasgow	**Scrutiny, Glasgow**
Jackson, P. R., & Co., Ltd., Salford Rolling Mills, Manchester	**Jacksons, Manchester**
Jandus Arc Lamp & Electric Co., Ltd., Hartham Road, Holloway, N.	**Jandunus, London**
Jardine, John, Deering Street, Nottingham	**Jardine, Nottingham**
Jenkins Bros., Ltd., St. Remi St., and Acorn Avenue, Montreal, Canada	**Pipkin, Montreal**
Jenkins Bros., Ltd., 95, Queen Victoria Street, E.C.	**Patapsco, London**
Jensen & Son, 77, Chancery Lane, W.C.	**Venture, London**
Jessop, Wm., & Sons, Ltd., Brightside Works, Sheffield	**Jessops, Sheffield**
Johnson, Richard, Clapham & Morris, Ltd., Lever Street, Manchester	**Metallicus, Manchester**
Johnson, Wm., & Sons (Leeds), **Ltd.,** Armley, Leeds	**Ronksley, Armley**
Jones, A. A., Pollard & Shipman, Ld., East Park Rd., Leicester	**Chucks, Leicester**
Jones & Lamson Machine Co., Jubilee Buildings, 97, Queen Victoria Street, E.C.	**Turretorum, London**

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Kalbitum Paint Co., Ltd., Belvedere Works, Belvedere, Kent	**Kalbitum, Belvedere**
Kalker, E., & Co., Coventry	**Kalker, Coventry**
Kater & Ankersmit, 34, Fenchurch Street, E.C.	**Rotarapes, London**
Kay, James C., & Co., Ltd., Barnbrook Works, Bury, Lancs.	**Kays, Engineers, Bury**
Kaye, Jos., & Sons, Ltd., Lock Works, Leeds	**Wedge, Leeds**
Kaye, Jos., & Sons, Ltd., 93, High Holborn, W.C.	**Lockencan, London**
Keep, F. A., Juxon & Co., Empire Works, Barn St., Birmingham	**Structures, Birmingham**
Keith, James, & Blackman Co., Ltd., 27, Farringdon Av., E.C.	**James Keith, London**
Kell, T., & Son, 40, King Street, Covent Garden, W.C.	**Lithographer, London**
Kendall & Gent, Ltd., Victoria Works, Belle Vue, Manchester	**Tools, Manchester**
Kennicott Water Softener Co., Ettingshall Works, Wolverhampton	**Watertanks, Wolverhampton**
Kenyon, Wm., & Sons, Dukinfield, Manchester	**Kenyon, Dukinfield**
Kern & Co., Aarau, Switzerland	**Kern, Aarau**
Kern & Co., Peninsular House, 4, Monument Street, E.C.	**Kernamat, London**
Kerr, Stuart & Co., Ltd., 1 & 2, Broad Street Place, E.C.	**Meliss, London**
Kerr, Stuart & Co., Ltd., Stoke-on-Trent	**California, Stoke-on-Trent**
Keystone Driller Co., Beaver Falls, Penna., U.S.A.	**Driller, Beaver Falls, Pa.**
Kidston, A. G., & Co., 155, Fenchurch Street, E.C.	**Suaviter, London**
Kincaid, John G., & Co., Ltd., Clyde Foundry, Greenock	**Kincaid, Greenock**
Kirby Banks Screw Co., Ltd., Meadow Lane, Leeds	**Hexagon, Leeds**
Kirk, Wheatley, Price & Co., 46, Watling Street, E.C.	**Indices, London**
Kirk, Wheatley, Price & Co., Albert Square, Manchester	**Indicator, Manchester**
Kirkaldy, John, Ltd., 101, Leadenhall Street, E.C.	**Compactum, London**
Kirkstall Forge Co., Ltd., Leeds	**Forge, Kirkstall**
Klein Engineering Co. (1908), Ltd., 94, Market St., Manchester	**Modernize, Manchester**
Klinger, Richard, & Co., 66, Fenchurch Street, E.C.	**Sustained, London**
Knowles Oxygen Co., Ltd., Wolverhampton	**Oxygen, Wolverhampton**
Korting Bros., Ltd., 53, Victoria Street, Westminster, S.W.	**Korting, London**
Krupp Aktiengesellschaft Grusonwerk, Magdeburg-Buckau, Germany	**Grusonwerk, Magdeburg**
Kynoch Ltd., Birmingham	**Kynoch, Birmingham**
Lacy-Hulbert & Co., Ltd., 91, Victoria Street, S.W.	**Percussive, London**
Lanarkshire Steel Co., Ltd., Motherwell	**Siemens, Motherwell**
Lancaster & Tonge, Ltd., Pendleton, near Manchester	**Pistons, Manchester**
Lang, John, & Sons, Lathe Makers, Johnstone, N.B.	**Lang, Johnstone**
Langen & Wolf, Milan	
Lassen & Hjort, 52, Queen Victoria Street, E.C.	**Tentwort, London**
Laurence, Scott & Co., Ltd., Norwich	**Gothic, Norwich**
Le Bas, Edward, & Co., Dock House, Billiter Street, E.C.	**Gramercy, London**
Le Carbone, 17, Water Lane, Great Tower Street, E.C.	**Lacombe, London**
Le Grand & Sutcliff, 125, Bunhill Row, E.C.	**Abyssinian, London**
Lea Recorder Co., 28, Deansgate, Manchester	**Recording, Manchester**
Ledward & Beckett, Ltd., Sanctuary House, 33, Tothill Street, Westminster, S.W.	**Preferment, London**
Leech, Goodall & Co., Hunslet (Pepper Road), Leeds	**Vertical, Leeds**
Leeds Forge Co., Ltd., Leeds	**Vulpes, Leeds**
Lees, T. & R., Hollinwood by Manchester	**Lees, Hollinwood**
Leroy, F., & Co., 20, Gray Street, Commercial Road, E.	**Efficiency, London**
Leslie & Co., Ltd., Kensington Square, W.	
Lewis, E., & Sons, Wolverhampton	**Lewis, Wolverhampton**
Lewis & Tylor, Ltd., Cardiff	**Belting, Cardiff**
Lidgerwood Mfg. Co., Caxton House, Westminster, S.W.	**Lidgerwood, London**
Lilleshall Company, Ltd., Oakengates, Shropshire	**Lilleshall, Oakengates**
Lincoln Printing Co., High Bridge Works, Lincoln	**Printing Co., Lincoln**
Lindsay, R. B., & Co., 38, Mair Street, Plantation, Glasgow	**Conical, Glasgow**
Lipscombe, Fredk., & Co., 49, Queen Victoria Street, E.C.	**Lipogram, London**
Lister, R. A., & Co., Ltd., Dursley, Glos.	**Machinery, Dursley**
Little, Gilbert, Co., Ltd., Horton Works, Bradford	**Laborless, Bradford**
Liverpool Refrigeration Co., Ltd., Colonial House, Liverpool	**Polar, Liverpool**
Lobnitz & Co., Ltd., Renfrew, Scotland	**Lobnitz, Renfrew**
Lockwood & Carlisle, Ltd., Eagle Foundry, Sheffield	**Piston, Sheffield**
Lockwood, Crosby, & Son, 7, Stationer's Hall Court, E.C.	**Crosby Lockwood, London**
Lodge Bros. & Co., 14, New Street, Birmingham	**Igniter, Birmingham**
London Emery Works Co., Park, Tottenham, N.	**Naxium, London**
Longmans, Green & Co., 39, Paternoster Row, E.C.	**Longmans, London**
Loudon Brothers, Ltd., 39, West Campbell Street, Glasgow	**Achilles, Glasgow**
Lubecker Machine and Manufacturing Co., 30, Gt. St. Helen's, E.C.	**Plasmo, London**
Lugard, Cecil E., & Co., St. John's House, Chester	**Lugard, Chester**
Luke & Spencer, Ltd., Broadheath, near Manchester	**Emery, Altrincham**
Lunken Company, Inc., 35, Great Dover Street, S.E.	**Lunken, London**
Lysaght, John, Ltd., St. Vincent Ironworks, Bristol	**Lysaght, Bristol**
MacColl & Pollock, Ltd., Sunderland	**Wreath, Sunderland**
Mackies Ltd., Caversham Road, Reading	**Machinery, Reading**
MacLellan, P. & W., Ltd., Clutha Works, Glasgow	**MacLellan, Glasgow**
MacLellan, P. & W., Ltd., 108A, Cannon Street, E.C.	**MacLellan, London**
Macmillan & Co., Ltd., St. Martin's Street, W.C.	**Publish, London**
McIntosh, Peter, & Sons, 129C, Stockwell Street, Glasgow	**Macintosh, Glasgow**
McKenzie, Holland, & Westinghouse Power Signal Co., Ltd., 58, Victoria Street, S.W.	**Powersig, London**
McKenzie & Holland, Ltd., 58, Victoria Street, S.W.	**Macksig, London**
McKie & Baxter, Copland Works, Govan, Glasgow	**Calidad, Glasgow**
McLachlan & Co., Ltd., Darlington	**Railway, Darlington**
McNeil, C., Kinning Park Iron Works, Glasgow	**Macneil, Glasgow**
McOnie, A. & P. W., Cessnock Engine Works, Govan, Glasgow	**Melada, Glasgow**
McPhail & Simpson, Ltd., Wakefield	**Saving, Wakefield**
Magnolia Anti-Friction Metal Co. of Gt. Britain, Ltd., 49, Queen Victoria Street, E.C.	**Magnolier, London**
Main, Geo., & Co., Packe Street, Loughborough	**Excelsior, Loughborough**
Mair, Nixon & Ferguson, Ltd., Kettering	**Bearings, Kettering**
Manchester Steam Users' Association, 9, Mount Street, Manchester	**Steam Users, Manchester**

Name and Address of Advertiser.	Telegraphic Address.
Manlove, Alliott & Co., Ltd., Nottingham	**Manloves, Nottingham**
Manlove, Alliott & Co., Ltd., 41 & 42, Parliament Street, S.W.	**Manloves, London**
Mannesmannröhren Werke, Düsseldorf, Germany	**Mannesrohr, Düsseldorf**
Manning, Wardle & Co., Ltd., Boyne Engine Works, Leeds	**Manning, Leeds**
Mansfield Sand Co., Ltd., Mansfield, Notts.	
Marriott & Graham, Plantation Boiler Works, Glasgow	**Marriott, Glasgow**
Marsden, H. R., Ltd., Soho Foundry, Leeds	**Marsden, Leeds**
Marsden, S., & Son, Ltd., London Road, Manchester	**Bolts, Manchester**
Marshall, Fleming & Co., Motherwell, N.B.	**Dellburn, Motherwell**
Marshall, John, & Sons, Glasgow Tube Works, Glasgow, N.B.	**Tube, Glasgow**
Marshall, Sons & Co., Ltd., Gainsborough	**Marshall, Gainsborough**
Marshall, Sons & Co., Ltd., 79, Farringdon Road, E.C.	**Engine, London**
Maschinenfabrik Augsburg-Nurnberg, A.-G., 219, Caxton House, Westminster, S.W.	**Klettillo, London**
Maschinenfabrik Thyssen & Co., Aktiengesellschaft, Mulheim-Ruhr	**Thyssenmaschine, Mulheim-ruhr**
Mason Regulator Co., Boston, Mass., U.S.A.	**Masonica, Boston, U.S.A.**
Massey, B. & S., Openshaw, Manchester	**Masseys, Openshaw**
Mather & Platt, Ltd., Salford Ironworks, Manchester	**Mather, Manchester**
Mavor & Coulson, Ltd., 47, Broad Street, Mile End, Glasgow	**Prodigious, Glasgow**
Maxted & Knott, Ltd., Burnett Avenue, Hull	**Energy, Hull**
Measures Bros., Ltd., Southwark Street, S.E.	**Measures, London**
Mechan & Sons, Ltd., Scotstoun Ironworks, Glasgow	**Nautical, Glasgow**
Meldrum Bros., Ltd., (In Liq.), Canal Works, Timperley, near Manchester	**Meldrum, Altrincham**
Merryweather & Sons, 63, Long Acre, W.C.	**Merywether, London**
Metal & Machinery Syndicate, 56 & 57, Aldermanbury, E.C.	**Pushfully, London**
Metallic Valve Co., Colonial House, Water Street, Liverpool	**Valve, Liverpool**
Metropolitan Amalgamated Railway Carriage and Wagon Co., Ltd., Saltley, Birmingham	**Metro, Birmingham**
Micanite & Insulators Co., Ltd., Walthamstow, E.	**Mytilite, London**
Middlemore & Lamplugh, Ltd., Birmingham	**Middlemore, Birmingham**
Middleton, Robt., Sheepscar Foundry, Leeds	**Hydraulic, Leeds**
Middleton Robt., 22, Walbrook, E.C.	**Intensifier, London**
Midland Railway Carriage & Wagon Co., Ld., Shrewsbury	**Midland, Shrewsbury**
Millar, Dennis & Co., Victoria Works, Bradford	**Dennis, Bradford**
Miller, Wm., & Sons, Wolverhampton	**Miller, Wolverhampton**
Mirrlees, Bickerton & Day, Ltd., Hazel Grove, near Stockport	**Economy, Hazel Grove**
Mirrlees Watson Co., Ltd., Scotland Street, Glasgow	**Mirrlees, Glasgow**
Mitchell's Emery Wheel Co., Mill Street, Bradford, Manchester	**Diameter, Manchester**
Mitchell-Williams Crane Co., 98, Leadenhall Street, E.C.	
Möller, K. & Th., G.m.b.H., Brackwede, Germany	**Eisenmoller, Bielefeld**
Mork Patent Fulley Block Co., Ltd., 42-44, Moor Lane, E.C.	**Nahmer, London**
Morton, Francis & Co., Ltd., Garston, Liverpool	**Ironsides, Liverpool**
Motherwell Bridge Co., Ltd., Motherwell, N.B.	**Bridge, Motherwell**
Motherwell Iron & Steel Co., Motherwell, N.B.	**Hoops, Motherwell**
Mountford, Fredk., Ld., Fremo Wks., Granville St., Birmingham	**Everything, Birmingham**
Muir, Wm., & Co., Ltd., Sherbourne Street, Manchester	**Britannia, Manchester**
Mumford, A. G., Ltd., Culver Street Ironworks, Colchester	**Mumford, Colchester**
Municipal Engineering and Contracting Co., Railway Exchange, Chicago, Ill., U.S.A.	
Muntz, P. H., & Co., Ltd., Alexandra Works, West Bromwich	**Muntz, West Bromwich**
Murray, M'Vinnie & Co., Ltd., Mavisbank, Glasgow	**Metallic, Glasgow**
Murray, Workman & Co., Ltd., Glasgow	**Effectual, Glasgow**
Musgrave Bros., Crown Point Foundry, Leeds	**Tools, Leeds**
Musgrave & Co., Ltd., St. Ann's Ironworks, Belfast	**Musgrave Limited, Belfast**
Musgrave, John, & Sons, Ltd., Globe Iron Works, Bolton	**Musgrave, Bolton**
Musker, C. & A., Ltd., Liverpool	**Muskers, Liverpool**
Nasmyth, Wilson & Co., Ltd., Bridgewater Foundry, Patricroft, near Manchester	**Nasmyth, Patricroft**
National Boiler & General Insurance Co., Ltd., St. Mary's Parsonage, Manchester	**National, Manchester**
National Gas Engine Co., Ld., Ashton-under-Lyne, Manchester	**National, Ashton-under-Lyne**
Neat, Charles, & Co., 112, Queen Victoria Street, E.C.	**Napthotic, London**
Negretti & Zambra, 38, Holborn Viaduct, E.C.	**Negretti, London**
New Calyx Drill & Boring Co., Ltd., 120, East Ferry Road, Millwall, E.	**Calyx, London**
New York Belting & Packing Co., Ltd., 11-13, Southampton Row, W.C.	**Nybelpa, London**
Newall Engineering Co., Blackhorse Lane, Walthamstow, E.	**Elevenfold, London**
Newalls Insulation Co., Ltd., Scottish Provident Buildings, Mosley Street, Newcastle-on-Tyne	**Newalls, Newcastle-on-Tyne**
Newell, Ernest, & Co., Ltd., Misterton, Gainsboro'	**Newells, Misterton, Gainsb'ro'**
Newton, Chambers & Co., Ltd., Thorncliffe Ironworks, near Sheffield	**Newton, Sheffield**
Newton & Nicholson, Tyne Dock Corrugated Packing Works, South Shields	**Corrugate, Tyne Dock**
Nichols Bros., Gateshead-on-Tyne	**Nichols, Engineers, Gates-**
Niles-Bement-Pond Co., 111, Broadway, New York, U.S.A.	**Nilesco, New York [head**
Niles-Bement-Pond Co., 23 & 25, Victoria Street, S.W.	**Niliacus, London**
Noble & Lund, Ltd., Felling, near Newcastle-on-Tyne	**Lathes, Felling**
Normand, Augustin, Ltd., 67, Rue du Perrey, Le Havre, France	
North British Locomotive Co., Ltd., Administration Bldg., 110, Flemington Street, Springburn, Glasgow	**Loco, Glasgow**
North British Rubber Co., Ltd., Castle Mills, Edinburgh	**Weba, Edinburgh**
North-Eastern Marine Engineering Co., Ltd., Northumberland Works, Wallsend-on-Tyne	**News, Wallsend**
Northampton, The Town Clerk, Northampton	**Town Clerk, Northampton**
Oakey, John, & Sons, Ltd., Westminster Bridge Road, E.C.	**Oakey, London**
Oil Well Supply Co., Dashwood House, 9, New Broad Street, E.C.	**Wellocoy, London**
Orenstein & Koppel-Arthur Koppel (Amalgamated), 27, Clements Lane, E.C.	**Alighting, London**
Otis Elevator Co., Ltd., 4, Queen Victoria Street, E.C.	**Lyndentree, London**
Oxygen Welding Works, Ltd., New Summer St., Birmingham	**Oxyweld, Birmingham**

Name and Address of Advertiser	Telegraphic Address
Palfreyman, W. H., & Co., 17, Goree-Piazzas, Liverpool	**Palfreyman, Goree-Piazzas, [Liverpool**
Parker Foundry Co., Derby	**Parker, Derby**
Parkinson, J., & Son, Shipley, Yorkshire	**Temples, Shipley**
Parsons, C. A., & Co., Heaton Works, Newcastle	**Turbo, Newcastle-on-Tyne**
Parsons, C. A., & Co., 8, Victoria Street, S.W.	**Silently, London**
Patent File & Tool Co., Ltd., 8, White Street, Moorfields, E.C.	**Ironheads, London**
Patent Shaft & Axletree Co., Ltd., Wednesbury	**Shaft, Wednesbury**
Paterson Engineering Co., Ltd., 21, Amberley House, Norfolk Street, Strand, W.C.	**Cumulative, London**
Patrick, F., Oxford Street, Leeds	
Paul, James, & Sons, 386, Paisley Road, Glasgow	
Paul, Matthew, & Co., Ltd., Levenford Works, Dumbarton	**Paul, Dumbarton**
Peake, W. Toulmin & Co., Whitestake, near Preston, Eng.	**Peake, Lostock Hall**
Pearlite Steel Co. (1910), **Ld.,** Pearlite Steel Works, Royds Mill Street, Sheffield	**Pearlite, Beeley Wood, Sheffield**
Pearn, F., & Co., Ltd., West Gorton, Manchester	**Pumps, Manchester**
Peckett & Sons, Atlas Locomotive Works, Bristol	**Peckett, Bristol**
Peebles, Bruce & Co., Ltd., Edinburgh	**Peebles, Edinburgh**
Peerless Rubber Manufacturing Company, 16, Warren Street, New York, U.S.A.	
Penman & Co., Ltd., 377, Dalmarnock Road, Glasgow	**Penman, Glasgow**
Peters, C. A., Ltd., Derby	**Peters, Derby**
Pfeiffer Gebr., Kaiserslautern 74, Germany	**Ipfeiffer, Kaiserslautern, [Germany**
Pfeil & Co., 145-9, St. John Street, Clerkenwell, E.C.	**Pfeil, London**
Phillips, Alfred, & Co., Atlas Works, Tipton	
Phillips, J. W. & C. J., 23, College Hill, Cannon Street, E.C.	**Colloquial, London**
Phœnix Bolt & Nut Co., Handsworth, nr. Birmingham	**Bolts, Birmingham**
Phœnix Dynamo Mfg. Co., Ltd., Thornbury Works, Bradford	**Dynamo, Bradford**
Phosphor Bronze Co., Ltd., Sumner Street, S.E.	**Phosbronze, London**
Phosphor Bronze Co., Ltd., Birmingham	**Phosphor, Birmingham**
Pickering, R. Y., & Co., Ltd., Wishaw, near Glasgow	**Pickering, Wishaw**
Pickering, R. Y., & Co., Ltd., 3, Victoria Street, S.W.	**Wagonload, London**
Piercy & Co., Ltd., Broad Street Engine Works, Birmingham	**Piercy, Birmingham**
Pierson, J. & O. G., 47, Rue Lafayette, Paris	**Luns, Paris**
Piggott, Thos., & Co., Ltd., Birmingham	**Atlas, Birmingham**
Piggott, Thos., & Co., Ltd., 63, Queen Victoria Street, E.C.	**Intersection, London**
Pitman, Percy, 3, Willcott Road, Acton, W.	**Hydromotor, London**
Platt, Samuel, Ltd., Wednesbury	**Platt, Wednesbury**
Player, W. & J., Birmingham	**Method, Birmingham**
Plenty & Son, Ltd., Newbury, Berkshire	**Plenty, Newbury**
Poetter G.m.b.H., Düsseldorf, Germany	**Construction, Dusseldorf**
Pohlig, J., A.-G., Cologne-Zollstock	**Jpohlig-Coln**
Poldi Steel Works, Napier Street, Sheffield	**Poldisteel, Sheffield**
Pollock & Macnab, Ltd., Bredbury, Manchester	**Macnab, Woodley**
Pollock, MacNab & Highgate, Shettleston, Glasgow	**Highgate, Shettleston**
Pontifex & Wood, Ltd., Union Foundry, Derby	**Zero, Derby**
Pontifex & Wood, Ltd., 175-177, Salisbury House, London Wall, E.C.	**Ponfex, London**
Porhydrometer, Ltd., 6, Lloyd's Avenue, E.C.	**Porhydro, London**
Pott, Cassels & Williamson, Motherwell, near Glasgow	**Pott, Motherwell**
Potter, A. C., & Co., Lant Street, S.E.	**Pyrula, London**
Power Gas Corporation, Ltd., Stockton-on-Tees	**Tetratomic, Stockton-on-Tees**
Pratchitt Brothers, Denton Ironworks, Carlisle	**Pratchitts, Engineers, Carlisle**
Pratt, F., & Co., Ltd., Eagle Ironworks, Halifax, England	**Pratt, Halifax**
Pratt & Whitney Co, Hartford, Conn., U.S.A.	**Pratwhit, Hartford, U.S.A.**
Premier Gas Engine Co., Ltd., Sandiacre, Nottingham	**Premier, Sandiacre**
Price Air Lift Pump Co., Broadheath, near Manchester	**Tilghmans, Altrincham**
Price, Charles, & Son, Broadheath, near Manchester	**Rocket, Altrincham**
Price's Patent Candle Co., Ltd., Belmont Works, Battersea, S.W.	**Belmont, London**
Price's Patent Candle Co., Ltd., Bromborough Pool, Liverpool	**Prices, Birkenhead**
Priestman Bros., Ltd., Holderness Foundry, Hull	**Priestman, Hull**
Priestman Bros., Ltd., 3, Laurence Pountney Hill, E.C.	**Priestman, London**
Proctor, Jas., Ltd., Burnley, Lancashire	**Proctor, Burnley**
Pryor, Edward, & Son, 68, West Street, Sheffield	**Pryor, Sheffield**
Puech, Armand, Kingsway House, Kingsway, W.C.	**Puechabal, London**
Pulsometer Engineering Co., Ltd., 11, Tothill Street, Westminster, S.W.	**Pulsometer, London**
Pulsometer Engineering Co., Ltd., Nine Elms Ironworks, Reading, Berks.	**Pulsometer, Reading**
Pulsometer Engineering Co., Ltd., 15, King Street, Leeds	**Pulsometer, Leeds**
Pulsometer Engineering Co., Ltd., 76, Oldhall St., Liverpool	**Pulsometer, Liverpool**
Pulsometer Engineering Co., Ltd., 160, St. Vincent Street, Glasgow	**Pulsometer, Glasgow**
Pulsometer Engineering Co., Ltd., 206, Corn Exchange Buildings, Manchester	**Pulsometer, Manchester**
Radford, R. Heber, Son & Squire, 15, St. James Row, Sheffield	**Radford, Sheffield**
Railway & General Engineering Co., Ld., Midland Foundry, Nottingham	**Dot, Nottingham**
Ramshay & Marshall, Ltd., Birmingham	**Ramshay, Birmingham**
Ransome, A., & Co., Ltd., 63, Queen Victoria Street, E.C.	**Ransome, London**
Ransome, A., & Co., Ltd., Stanley Works, Newark-on-Trent	**Ransome, Newark**
Ransomes & Rapier, Ltd., Waterside Ironworks, Ipswich	**Waterside, Ipswich**
Ransomes, Sims & Jefferies, Ltd., Orwell Works, Ipswich	**Ransomes, Ipswich**
Ransomes, Sims & Jefferies, Ltd., 9, Gracechurch Street, E.C.	**Anglia, London**
Ransome verMehr Machinery Co., Caxton House, Westminster, S.W.	**Vermehrico, London**
Rapid Magnetting Machine Co., Ltd., 13, The Crescent, Birmingham	**Borings, Birmingham**
Raworth, John E., 70-71, Queen Anne's Chambers, Tothill St., S.W.	
Reavell & Co., Ltd., B Dept., Ranelagh Works, Ipswich	**Reavell, Ipswich**
Reddaway, F., & Co., Ltd., 212, Shaftesbury Avenue, W.C.	**Firosis, London**
Reddaway, F., & Co., Ltd., 50 & 51, Lime Street, E.C.	**Reddaway, London**
Reddaway, F., & Co., Ltd., Pendleton, Manchester	**Anchorage, Manchester**
Redfern, G. F., & Co., 15, South Street, Finsbury, E.C.	**Invention, London**

NAME AND ADDRESS OF ADVERTISER.	TELEGRAPHIC ADDRESS.
Redman, C., & Sons, Dunkirk, Halifax	**Redmans, Engineers, Halifax**
Reichwald, August, Ltd., Lombard Street, Newcastle-on-Tyne	**Reichwald, N'castle-on-Tyne**
Reichwald, August, Ltd., Finsbury Pavement House, E.C.	**Reichwald, London**
Reid Gear Co., Linwood, near Paisley	**Reid, Linwood**
Reiner, Arthur, & Co., 63, Queen Victoria Street, E.C.	**Reinerism, London**
Rennie, G., & Co., Thames Street, Greenwich	**Probitate, London**
Renold, Hans, Ltd., Progress Works, Manchester	**Driving, Manchester**
Rex Roofing Co., Connswater, Belfast	**Rex Roofing, Connswater, Belfast**
Rice & Co. (Leeds), Ltd., Neville Works, Elland Road, Leeds	**Press, Leeds**
Richards, Geo., & Co., Ltd., Broadheath, near Manchester	**Richards, Altrincham**
Richardsons, Westgarth & Co., Ltd., Hartlepool	**Richardsons, Hartlepool**
Robey & Co., Ltd., Lincoln	**Robey, Lincoln**
Robinson, T., & Son, Ltd., Rochdale	**Robinson, Rochdale**
Rochester Engineering Co., Wickham, Rochester	**Rec, Rochester**
Rodger, A., & Co., St. Helen's Engine Works, Govan, Glasgow	**Triple, Glasgow**
Rollo, David, & Sons, Fulton Engine Works, Liverpool	**Rollo, Liverpool**
Rose, Downs & Thompson, Ltd., Old Foundry, Hull	**Rose, Hull**
Ross & Duncan, Govan, Glasgow	**Whitefield, Glasgow**
Ross, R. G., & Son, Ltd., Glasgow	**Glenros, Glasgow**
Rosser & Russell, Ltd., Queen's Wharf, Hammersmith	
Rowan, David, & Co., Glasgow	**Rowan, Glasgow**
Rowland, B. R., & Co., Ld., Climax Wks., Reddish, nr. Manchester	**Heroic, Reddish**
Royce Limited, Trafford Park, Manchester	**Switch, Manchester**
Royersford Foundry & Machine Co., Inc., 149, Queen Victoria Street, E.C.	**Scythes, London**
Royles Limited, Irlam, near Manchester	**Elyor, Cadishead**
Russell, G., & Co., Ltd., Motherwell, N.B.	**Russell, Motherwell**
Russell, James, & Sons, Ltd., Crown Tube Works, Wednesbury	**Russell, Wednesbury**
Russell, John, & Co., Ltd., Alma Tube Works, Walsall	**Alma, Walsall**
Ruston, Proctor & Co., Ltd., Sheaf Iron Works, Lincoln	**Ruston, Lincoln**
Ryder, Thos., & Son, Turner Bridge Ironworks, Bolton	**Rider, Bolton**
Ryder, William, Ltd., Beehive Works, Bolton	**Beehive, Bolton**
Samuelson & Co., Ltd., Banbury, Oxon	**Samuelson, Banbury**
Sandycroft Foundry Co., Ltd., near Chester	**Sandycroft, Hawarden**
Saunders, J. T., & Co., 150, Queen Victoria Street, E.C.	**Wilburtier, London**
Schaffer & Budenberg, Ltd., Whitworth St., London Rd., Manchester	**Manometer, Manchester**
Schaffer & Budenberg, Ltd., 77A, Queen Victoria Street, E.C.	**Pyrometer, London**
Schäffer & Budenberg, Ltd., 5, Wellington Street, Glasgow	**Injector, Glasgow**
Schichau, F., Engineer, Elbing-Danzig, Prussia	**Schichau, Elbing**
Schmidt's Superheating Co. (1910), **Ltd.,** 28, Victoria St., S.W.	**Ensulim, London**
Schram, Harker & Co., Cannon Street House, E.C.	**Schram, London**
Schumacher, Wwe. Joh., Cologne-on-Rhine 4	**Schumacherwerke, Koln**
Schwade, Otto, & Co., 23-28, Fleet Street, E.C.	**Ottosch, London**
Scott Bros., West Mount, Halifax	
Scott, E., & Mountain, Ltd., Close Works, Gateshead-on-Tyne	**Esco, Newcastle-on-Tyne**
Scott, Walter, Ltd., Leeds Steel Works, Leeds	**Bessemer, Leeds**
Scriven & Co., Marsh Lane, Leeds	**Scriven, Leeds**
Seagers, Ltd., Dartford	**Seagers, Dartford**
Sellers, Wm., & Co. (Incorp.), Philadelphia, Penn., U.S.A.	**Sellers, Philadelphia, U.S.A.**
Selson Engineering Co., Ltd., 85, Queen Victoria Street, E.C.	**Selig, London**
Shaft Freezing Co., Ltd., 11, Ironmonger Lane, E.C.	
Shanks, Thomas, & Co., Union Iron Wks., Johnstone, nr. Glasgow	**Shanks, Johnstone**
Shann, C. E., 17, George Street, Tamworth	**Shann, Tamworth**
Sharer & Young, Ltd., Marmot Works, Alloa, Scotland	**Marmot, Alloa**
Shaw, John, & Sons (Salford), **Ltd.,** Wellington Street Works, Salford, Manchester	**Prelum, Manchester**
Shaw, W., & Co., Wellington Cast Steel Foundry, Middlesbro'-on-Tees	**Wellington, Middlesbro'**
Shore, T., & Sons, Etruria, Stoke-on-Trent	**Pumps, Stoke-on-Trent**
Shutt, W., 33, Muswell Road, Muswell Hill, N.W.	
Siebe, Gorman & Co., Ltd., Neptune Works, London, S.E.	**Siebe, London**
Siemens Bros. & Co., Ltd., Caxton House, Westminster, S.W.	**Siemens, London**
Siemens Brothers Dynamo Works. Ltd., Caxton House, Westminster, S.W.	**Siembralos, London**
Simon-Carves, Ltd., 20, Mount Street, Manchester	**Simcar, Manchester**
Simons, W., & Co., Ltd., Renfrew, Scotland	**Simons, Renfrew**
Simplex Superheater Co., Ltd., 39, Victoria Street, S.W.	**Tubeless, London**
Simpson, James, & Co., Ltd., 101, Grosvenor Road, S.W.	**Aquosity, London**
Simpson, Strickland & Co., Ltd., Dartmouth, S. Devon	**Engineers, Dartmouth**
Sirius Autogenous Works Co., Carpenters Road, Stratford, E.	**Dogal, London**
Sisson, W., & Co., Ltd., Gloucester	**Sisson, Gloucester**
Skefko Ball Bearing Co., Ld., Carlton House, Regent St., S.W.	**Skefko, London**
Smedley Bros., Ltd., Belper, Derbyshire	**Smedleys, Belper**
Smit, L., & Zoon, Kinderdijk, near Rotterdam, Holland	**Smit-Zoon, Kinderdijk**
Smith Brothers & Co. (Glasgow), **Ltd.,** Kinning Park, Glasgow	**Planer, Glasgow**
Smith Bros. & Co., (Hyson), **Ltd.,** Nottingham	**Hyson, Nottingham**
Smith Bros. & Hill, Ltd., Albert Spring Works, West Bromwich	**Springs, West Bromwich**
Smith & Coventry, Ltd., Gresley Ironworks, Ordsal Lane, Manchester	**Gresley, Manchester**
Smith & Grace Screw Boss Pulley Co., Ltd., Thrapston	**Grace, Thrapston**
Smith, Hugh, & Co., Ltd., Possil Engine Works, Glasgow	**Possil, Glasgow**
Smith, R. H., Thirlmere Road, Streatham, S.W.	**Oikonomoi, London**
Smith, S., & Son, Ltd., 9, Strand, W.C.	**Smith, 9, Strand, London**
Smith, Sydney, & Sons, Ltd., Basford Brass Works, Nottingham	**Smiths, Nottingham**
Smith, Thos., & Sons, Steam & Electric Crane Works, Rodley, near Leeds	**Smith, Rodley**
Smiths' Dock Co., Ltd., South Bank, S.O., Yorks.	**Smiths', Middlesboro'**
Smith's Injector Co., Oozells Street North, Birmingham	**Mitton, Birmingham**
Smooth-on Manufacturing Co., Jersey City, N.J., U.S.A.	**Smooth-on, Jersey City, U.S.A.**
Smulders, A. F., Schiedam, Rotterdam, Holland	**Asmulders, Schiedam**
Société du Nord de Liége, 42, Perryn Road, Acton, W.	**Gummerson, London**
Sonnenthal, E., Junr., Neue Promenade 6, Berlin, O. 2	**Fraisapparat, Berlin**
Southern, James W., & Son, Ltd., 38, Store Street, Manchester	**Lignum, Manchester**
Southgate Pile Driver Co., 12, Savage Gardens, E.C.	**Sopidric, London**
Spencer, John, Ltd., Wednesbury	**Tubes, Wednesbury**
Spencer, John, & Sons, Ltd., Newburn Steel Works, Newcastle-on-Tyne	**Newburn, Newcastle-on-Tyne**
Spencer, John, & Sons, Ltd., Ouseburn Wks., Newcastle-on-Tyne	**Tyne, Newcastle-on-Tyne**
Spencer, John, & Sons, Ltd., 32, Victoria Street, S.W.	**Newburn, London**
Stamm, W., 25, College Hill, E.C.	**Pyxor, London**
Standard Engineering Co., Ltd., Leicester	**Standard, Leicester**
Standard Light Co., Ltd., Frankfort o/Maine, Germany	**Standardlicht, Frankfort o/Maine**
Stanley, W. F., & Co., Ltd., 286, High Holborn, W.C.	**Turnstile, London**
Stanley, W. F., & Co., Ltd., Railway Approach, London Bridge, S.E.	
Steam Cylinder Lubricator Co., Ltd., Gordon Works, Lower Broughton, Manchester	**Seafield, Manchester**
Steel Company of Scotland, 23, Royal Exchange Square, Glasgow	**Steel, Glasgow**
Steel Pipe Company, Ltd., Kirkcaldy, N.B.	**Aquilentus, Kirkcaldy**
Stephenson, Robert, & Co., Ltd., Darlington	**Rocket, Darlington**
Sterling Metals, Ltd., Stoney Stanton Road, Coventry	**Stermet, Coventry**
Stern-Sonneborn Oil Co., Ltd., Royal London House, Finsbury Square, E.C.	**Centumvir, London**
Sterne, L., & Co., Ltd., Crown Ironworks, Glasgow	**Crown, Glasgow**
Sterne, L., & Co., Ltd., Donington House, Norfolk Street, W.C.	**Elsterne, London**
Steven & Struthers, Brassfounders, Glasgow	**Bronze, Glasgow**
Stewart, Duncan, & Co., Ltd., London Road Ironworks, Glasgow	**Stewart, Glasgow**
Stewarts & Lloyds, Ltd., 41, Oswald St., Glasgow	**Lapweld, Glasgow**
Stewarts & Lloyds, Ltd., Nile Street, Birmingham	**Lloyds, Birmingham**
Stirk, John, & Sons, Ltd., Halifax	**Stirk, Halifax**
Stirling Boiler Co., Ltd., 58, Victoria Street, Westminster	**Stirlinico, London**
Stone, J. B., & Co., 135, Finsbury Pavement, E.C.	**Sightseer, London**
Storey, Isaac, & Sons, Ltd., Empress Foundry, Cornbrook, Manchester	**Stork, Manchester**
Stork Bros. & Co., Hengelo, Holland	**Maschinefabriek, Hengelo**
Stothert & Pitt, Ltd., Bath	**Stothert, Bath**
Stothert & Pitt, Ltd., 53, Victoria St., S.W.	**Stothert, London**
Stott, S. S., & Co., Haslingden, near Manchester	**Elevator, Haslingden**
Sturtevant Engineering Co., Ltd., 147, Queen Victoria Street, E.C.	**Sturtevant, London**
Sugden, T., Ltd., 180, Fleet Street, E.C.	**Tubularity, London**
Sulzer Bros., 30, Norfolk Street, Strand, W.C.	**Gebsulzer, London**
Sun Fire Office, 63, Threadneedle Street, E.C.	**Sun Fire, London**
Superheater Units Co., 4, Castle Square, Swansea	**Mechanics, Swansea**
Swift, George, & Sons, Range Bank, Halifax	**Swiftly, Halifax**
Talbot, Clement, Ltd., Barlby Road, Ladbroke Grove, W.	**Clemtal, London**
Tangyes Limited, Birmingham	**Tangyes, Birmingham**
Tangyes Limited, 35, Queen Victoria Street, E.C.	**Tangyes, London**
Taylor & Challen, Ltd., Derwent Foundry, Birmingham	**Derwent, Birmingham**
Taylor, Charles, (Birm'm.), Ld., Bartholomew Street, Birmingham	**Lathes, Birmingham**
Taylor & Hubbard, Leicester	**Lifting, Leicester**
Taylor, John, & Sons (Bolton), **Ltd.,** Bolton, Lancashire	**Ropery, Bolton**
Taylor's Typewriter Co., Ltd., 74, Chancery Lane, W.C.	**Glossator, London**
Terry, Herbert, & Sons, Redditch	**Springs, Redditch**
Thermo & Pressure Instruments, Ltd., 60, Salusbury Road, Kilburn, N.W.	**Troika, London**
Thomas & Bishop, 119-125, Finsbury Pavement, E.C.	**Velcling, London**
Thompson & Southwick, Ltd., Tamworth, Staffs.	**Pulleys, Tamworth**
Thomson, W. R. M., & Co., 96, Buchanan Street, Glasgow	**Inventions, Glasgow**
Thorn & Hoddle Acetylene Co., Ltd., 151, Victoria Street, Westminster, S.W.	**Incanto, London**
Thornton, A. G., Ltd., 28, King Street West, Manchester	**Drawing, Manchester**
Thornycroft, J. I., & Co., Ltd., Caxton House, Westminster, S.W.	**Thornycroft, London**
Thornycroft, J. I., & Co., Ltd., 5-11, Vauxhall Bridge Road, S.W.	**Manageable, London**
Thornycroft, J. I., & Co., Ltd., Basingstoke, Hants.	**Thornycroft, Basingstoke**
Thornycroft, J. I., & Co., Ltd., Woolston, Southampton	**Thornycroft, Southampton**
Thwaites Bros., Ltd., Bradford, Yorkshire	**Thwaites, Bradford**
Tilghman's Patent Sand Blast Co., Ltd., Broadheath, near Manchester	**Tilghmans, Altrincham**
Tomey, Joseph, & Sons, Ltd., Manor Glass Works, Aston, Birmingham	**Tomey, Birmingham**
Toope's Asbestos Covering Co. Ltd., Stepney Sq., Stepney, E.	**Toopes, London**
Toward, T., & Co., Ltd., 9, Ouseburn, Newcastle-on-Tyne	**Towards, Newcastle-on-Tyne**
Treasure, J. B., & Co., 8, Vauxhall Road, Liverpool	**Treasure, Liverpool**
Trewent, F. J., & Proctor, 43, Billiter Buildings, Billiter Street, E.C.	**Trewent, London**
Trier Bros., Caxton House, Westminster, S.W.	**Viscosity, London**
Trimont Mfg. Co., 55-71, Amory Street, Roxbury (Boston), Mass., U.S.A.	
Trussed Concrete Steel Co., Ltd., 50, Caxton House, Westminster, S.W.	**Kahncrete, London**
Tubes, Ltd., Birmingham	**Cylinders, Birmingham**
Tucker-Martin & Co., 305, Old Street, E.C.	
Tullis, D. & J., Ltd., Kilbowie Ironworks, near Glasgow	**Tullis, Clydebank**
Tullis, D. & J., Ltd., 1, Southwark Bridge Buildings, S.E.	**Kilbowie, London**
Tullis, John, & Son, Ltd., St. Ann's Leather Works, Glasgow	**Tullis, Glasgow**
Turnbull, Alex., & Co., Ltd., Bishopbriggs, Glasgow	**Valve, Glasgow**
Turton, T., & Sons, Ltd., Sheaf Works, Sheffield	**Turtons, Sheffield**
Unbreakable Pulley & Mill Gearing Co., Ltd., 56, Cannon Street, E.C.	**Horsepower, London**
Unbreakable Pulley and Mill Gearing Co., Ltd., 48, West Gorton, Manchester	**Strength, Manchester**
Underfeed Stoker Co., Ltd., Coventry House, South Place, E.C.	**Underfeed, London**
United Kingdom Lighting Trust, Ltd., 231, Strand, W.C.	
United Kingdom Self-Adjusting Anti-Friction Metallic Packing Syndicate, Ltd., 14, Cook Street, Liverpool	**Isham, Liverpool**
United States Metallic Packing Co., Ltd., Soho Works, Thornton Road, Bradford	**Metallic, Bradford**
United States Steel Products Co., 36-38, New Broad St., E.C.	**Steelmaker, London**
Urquhart, Lindsay & Co., Ltd., Blackness Foundry, Dundee	**Engineers, Dundee**

Name and Address of Advertiser.	Telegraphic Address.
Vacuum Brake Co., Ltd., 32, Queen Victoria Street, E.C.	**Solution, London**
Vaughan & Son, 57, Chancery Lane, W.C.	
Vaughan & Son, Ltd., West Gorton, Manchester	**Vaunting, Manchester**
Vaughtons, Ltd., Livery Street, Birmingham	**Emblems, Birmingham**
Vauxhall & West Hydraulic Engineering Co., Ltd., 45, Leadenhall Street, E.C.	**Vaporiform, London**
Vauxhall & West Hydraulic Engineering Co., Ltd., Luton, Beds.	**Vauxhall, Luton**
Vickers, Benjn. R., & Sons, Leeds	**Vickers, Leeds**
Vickers Limited, River Don Works, Sheffield	**Vickers, Sheffield**
Vickers Limited, Vickers House, Broadway, Westminster, S.W.	**Vickers, London**
Vosper & Co., Ltd., Broad Street, Portsmouth	**Repsov, Portsmouth**
Wagner & Co., Dortmund, Westphalia	**Wagner, Dortmunderfeld, Dortmund**
Walker Brothers (Wigan), Ltd., Pagefield Ironworks, Wigan	**Pagefield, Wigan**
Walker, James, & Co., Ltd., Lion Works, Garford St., Poplar, E.	**Lioncelle, London**
Wallsend Slipway & Engineering Co., Ltd., Wallsend	**Wall, Newcastle-on-Tyne**
Wallwork, Henry & Co., Ltd., Manchester	**Foundry, Manchester**
Ward, H. W., & Co., Ltd., Lionel Street, Birmingham	**Tudor, Birmingham**
Ward, T. W., Ltd., Albion Works, Sheffield	**Forward, Sheffield**
Warden, A., & Co., 44, 46, 48, Shepherdess Walk, City Road, N.	**Lytestrong, London**
Warner, Robert, & Co., Ltd., Walton-on-Naze, Essex	**Foundry, Walton-on-Naze**
Watkins, Stephen, Son & Groves, Aldwych Chambers, 170, Strand, W.C.	
Watson, J. S., Gainsborough	**Watson, Gainsborough**
Watson, Laidlaw & Co., Ltd., 98, Dundas Street (South), Glasgow	**Fugal, Glasgow**
Waygood, R., & Co., Ltd., Falmouth Road, S.E.	**Waygood, London**
Webb & Son (Combs.), **Ltd.,** Combe Tannery, Stowmarket	**Webb, Combs**
Weir, G. & J., Ltd., Holm Foundry, Cathcart, Glasgow	**Giweir, Glasgow**
Weldless Steel Tube Co., Ltd., Icknield Port Road, Birmingham	**Weldless, Birmingham**
Wells, A. C., & Co., 102, Midland Road, St. Pancras, N.W.	**Unbreakable, London**
Wells, A. C., & Co., Carnarvon Street, Cheetham, Manchester	**Unbreakable, Manchester**
Westinghouse Brake Co., 82, York Road, King's Cross, N.	**Westinghouse, London**
Westinghouse Cooper Hewitt Co., Ltd., 151-2, Great Saffron Hill, E.C.	**Hewittic, London**
Wheeler Condenser & Engineering Co., 2 & 3, Norfolk Street, Strand, W.C.	**Suspend, London**
White, J. Samuel, & Co., Ltd., East Cowes, Isle of Wight	**White, East Cowes**
White & Poppe, Ltd., Coventry	**Motors, Coventry**
White, Rd., & Sons, Widnes, Lancs.	**Rails, Widnes**
Whitley & Valiant, Ltd., Ashton-in-Makerfield, Lancashire	**Whitley, Ashton-in-Makerfield**
Whitaker Brothers, Ltd., Horsforth, Leeds	**Quarries, Leeds**
Whittaker, C., & Co., Ltd., Accrington	**Bricks, Accrington**
Whittaker, C., & Co., Ltd., ("V" Department), Union Foundry, Haslingden, near Manchester	**Radiate, Haslingden**
Whittaker & Co., White Hart Street, Paternoster Square, E.C.	
Widdowson, John H., Britannia Works, Ordsall Lane, Salford, Manchester	**Taps, Salford**
Wiggins, F., & Sons, 102, 103 & 104, Minories, E.C.	**Wiggins, Minories, London**
Wigglesworth, Frank, & Co., Ltd., Mill Lane, Bradford	**Clutch, Bradford**
Wild, M. B., & Co., Ltd., Nechells, Birmingham	**Hauling, Birmingham**
Willans & Robinson, Ltd., Rugby, Warwickshire	**Willans, Rugby**
Willcox, W. H., & Co., Ltd., 23, Southwark Street, S.E.	**Willcox, Southwark St., London.**
Wilson, John H., & Co., Ld., Dock Rd., Seacombe, nr. Birkenhead	**Engineers, Liverpool**
Wilson, John H., & Co., Ltd., 15, Victoria Street, S.W.	**Drague, London**
Wilson, William, & Co., Lilybank Boiler Works, Glasgow	**Boiler, Glasgow**
Winn, Charles, & Co., Granville Place, Birmingham	**Winn, Birmingham**
Winter, F., 25, Goswell Road, E.C.	**Instantly, London**
Withers, J. S., & Spooner, 323, High Holborn, W.C.	**Improvably, London**
Witting Bros., Ltd., 49, Cannon Street, E.C.	**Witting, London**
Witting, H. R., 9, Southampton Street, Holborn, W.C.	**Aloof, London**
Wolf, R., 7, Laurence Pountney Hill, E.C.	**Locomobile, London**
Wolseley Tool & Motor Car Co., Ltd., York Street, S.W.	**Sidleth, London**
Woodite Works, Mitcham Common, Surrey	**Woodite, Mitcham**
Worthington Pump Co., Ltd., 153, Queen Victoria Street, E.C.	**Pumping, London**
Wouldham Cement Co., Ltd., 35, Gt. St. Helen's, E.C.	**Enriching, London**
Wright, J. & E., Ltd., Birmingham	**Universe, Birmingham**
Wright, Jos., & Co., Tipton, Staffordshire	**Wright, Tipton**
Wright, Jos., & Co., 124, Victoria Street, Westminster, S.W.	**Penetration, London**
Wrigley, E. G., & Co., Ld., Foundry Lane Wks., Soho, Birmingham	**Cutters, Birmingham**
Yarrow & Co., Ltd., Glasgow	**Yarrow, Glasgow**
Yorkshire Boiler Co., Ltd., City Square, Leeds	**Casmey, Leeds**
Yorkshire Copper Works, Ltd., Leeds	**Tubes, Leeds**
Yorkshire Patent Steam Wagon Co., Pepper Road, Hunslet, Leeds	**Motor, Leeds**
Youngs, Ryland Street Works, Birmingham	**Oldens Birmingham**

KEY TO TELEGRAPHIC ADDRESSES.

Telegraphic Address.	Name and Address of Advertiser.
Abbott, Newark	**Abbott & Co (Newark), Ltd.,** Newark-on-Trent
Abyssinian, London	**Le Grand & Sutcliff,** 125, Bunhill Row, E.C.
Accumulator, London	**Drake & Gorham, Ltd.,** 66, Victoria Street, Westminster, S.W
Achilles, Glasgow	**London Brothers, Ltd.,** 39, West Campbell Street, Glasgow
Adamantos, London	**Hudson, John, & Co.'s Successors,** 81A, Mansell Street, E.
Admocar, London	**Adams Manufacturing Co., Ltd.,** 106, New Bond Street, W.
Adopted, London	**Grover & Co., Ltd.,** Wharf Road, City Road, N.
Afco, Glasgow	**Anderston Foundry Co., Ltd.,** Glasgow
Ahlers, Sunderland	**Ahlers, Ad.,** Sunderland
Ajax, Glasgow	**Bennie, James, & Sons,** Clyde Engine Wks., Cardonald, Glasgow
Albert, Chelmsford	**Glover & Hobson, Ltd.,** Albert Ironworks, Chelmsford
Alexengco, London	**Alexander Engineering Co.,** 214-218, Goswell Road, E.C.
Alighting, London	**Orenstein & Koppel-Arthur Koppel** (Amalgamated), 27, Clements Lane, E.C.
Allan, Gateshead	**Allan, Robert S., & Co.,** Gateshead-on-Tyne
Alldays, Birmingham	**Alldays & Onions (Pneumatic Engineering) Co., Ltd.,** Birmingham
Allen, Sheffield	**Allen, Edgar, & Co., Ltd.,** Imperial Steel Works, Sheffield
Alley, Glasgow	**Alley & Maclellan, Ltd.,** Sentinel Works, Glasgow
Alliance, Darlington	**Blake Boiler, Wagon & Engineering Co., Ltd.,** Darlington
Aloof, London	**Witting, H. R.,** 9, Southampton Street, Holborn, W.C.
Alma, Walsall	**Russell, John, & Co., Ltd.,** Alma Tube Works, Walsall
Aloyau, London	**Atlas Metal & Alloys Co., Ltd.,** 52, Queen Victoria Street, E.C.
Amproco, New York	**American Process Co.,** New York City, U.S.A.
Amross te, London	**"Amross" Positive Lock Washer Manufacturing Co.,** 59-61, Hatton Garden, E.C.
Anchorage, Manchester	**Reddaway, F., & Co., Ltd.,** Pendleton, Manchester
Anglia, London	**Ransomes, Sims & Jefferies, Ltd.,** 9, Gracechurch Street, E.C.
Angus, Newcastle	**Angus, George, & Co., Ltd.,** Newcastle-on-Tyne
Aquilentus, Kirkcaldy	**Steel Pipe Company, Ltd.,** Kirkcaldy, N.B.
Aquosity, London	**Simpson, James, & Co., Ltd.,** 101, Grosvenor Road, S.W.
Archdale, Birmingham	**Archdale, Jas., & Co., Ltd.,** Ledsam Street, Birmingham
Armstrongs, Birmingham	**Armstrong, Stevens & Son, Ltd.,** Whittall Street, Birmingham
Asmulders, Schiedam	**Smulders, A. F.,** Schiedam, Rotterdam, Holland
Asteroidal, Rugby	**British Thomson-Houston Co., Ltd.,** Rugby
Atlas, Birmingham	**Piggott, Thos., & Co., Ltd.,** Birmingham
Atlas, Gloucester	**Fielding & Platt, Ltd.,** Gloucester
Atlas, Sheffield	**Brown, John, & Co., Ltd.,** Sheffield
Auto, Coventry	**Auto Machinery Co., Ltd.,** Coventry
Autobuff, London	**A. B. C. Coupler, Ld.,** Queen Anne's Chambers, Tothill Street, S.W.
Aveling, Rochester	**Aveling & Porter, Ltd.,** Rochester
Babcock, London	**Babcock & Wilcox, Ltd.,** Oriel House, Farringdon Street, E.C.
Bagnall, Stafford	**Bagnall, W. G., Ltd.,** Castle Engine Works, Stafford
Bagshaw, Batley	**Bagshaw, J., & Sons, Ltd,** Batley, Yorkshire
Bagshawe, Dunstable	**Bagshawe & Co., Ltd.,** Dunstable Works, Dunstable
Baldwin, Engineers, Keighley	**Baldwin, James, & Co.,** Devonshire Brass Works, Keighley
Baldwin, Philadelphia	**Baldwin Locomotive Works, The,** 500, North Broad Street, Philadelphia, Pa., U.S.A.
Barclayson, Kilmarnock	**Barclay, Andrew, Sons & Co., Ltd.,** Caledonian Works, Kilmarnock
Barford, Peterborough	**Barford & Perkins,** Peterborough
Barry, Aberdeen	**Barry, Henry & Co., Ltd.,** Aberdeen
Battery, Selly Oak	**Birmingham Battery & Metal Co., Ltd.,** Birmingham
Bayley, Sheffield	**Brown, Bayley's Steel Works, Ltd.,** Sheffield
Bayliss, Wolverhampton	**Bayliss, Jones & Bayliss, Ltd.,** Wolverhampton
Beacon, Salford	**Bailey, W. H., & Co., Ltd.,** Albion Works, Salford, Manchester
Beardmore, Glasgow	**Beardmore, William, & Co., Ltd.,** Parkhead Forge, Rolling Mills and Steel Works, Glasgow
Beardshaw, Sheffield	**Beardshaw, J., & Son, Ltd.,** Baltic Steel Works, Sheffield
Bearings, Kettering	**Mair, Nixon & Ferguson, Ltd.,** Kettering
Beebee, Fallings Heath, Wednesbury	**Beebee, A.,** Wednesbury
Beehive, Bolton	**Ryder, William, Ltd.,** 141, Beehive Works, Bolton
Beeley, Hyde	**Beeley, Thomas, & Son, Ltd.,** Hyde Junction Ironworks, Hyde, near Manchester
Belfry, London	**Bell's United Asbestos Co., Ltd.,** 59½, Southwark Street, S.E.
Bellamy, London	**Bellamy, John, Ltd.,** Millwall, E.
Belliss, Birmingham	**Belliss & Morcom Ltd.,** Ledsam Street Works, Birmingham
Belmont, London	**Price's Patent Candle Co., Ltd.,** Battersea, S.W.
Belting, Cardiff	**Lewis & Tylor, Ltd.,** Cardiff
Bennis, Little Hulton, Bolton	**Bennis, Ed., & Co.,** Little Hulton, Bolton
Bergius, Glasgow	**Bergius Launch & Engine Co.,** Dobbies Loan, Glasgow
Berrys, Sowerby Bridge	**Berry, F., & Sons,** Sowerby Bridge, Yorkshire
Bessemer, Leeds	**Scott, Walter, Ltd.,** Leeds Steel Works, Leeds
Bessemer, Sheffield	**Bessemer, Hy., & Co., Ltd.,** Sheffield
Bird, London	**Bolling & Lowe,** 2, Laurence Pountney Hill, E.C.
Blackstones, Stamford	**Blackstone & Co., Ltd.,** Rutland Works, Stamford
Blazon, Glasgow	**Blair, Campbell & McLean, Ld.,** Woodville St., Govan, Glasgow
Bleichert, Leipzig	**Bleichert, Adolf, & Co.,** Leipzig-Gohlis 54
Bleichert, London	**Bleichert, Adolf, & Co.,** 99-100, Palmerston House, Bishopsgate St. Within, E.C.
Bodley, Exeter	**Bodley Bros. & Co.,** Old Quay Foundry, Exeter
Boiler, Glasgow	**Wilson, William, & Co.,** Lilybank Boiler Works, Glasgow
Boiler, Loughborough	**Coltman, Walter W., & Co., Ltd.,** Central Boiler Works, Loughborough

TELEGRAPHIC ADDRESS.	NAME AND ADDRESS OF ADVERTISER.
Bolts, Birmingham	**Phœnix Bolt & Nut Co.,** Handsworth, nr. Birmingham
Bonaccord, Glasgow	**Drysdale & Co., Ltd.,** Bon Accord Works, Yoker, Glasgow, W.
Bolts, Manchester	**Marsden, S., & Son, Ltd.,** London Road, Manchester
Borings, Birmingham	**Rapid Magnetting Machine Co., Ltd.,** 18, The Crescent, Birmingham
Borsig, Tegel	**Borsig, A.,** Tegel, Berlin
Boss, Leicester	**British Steam Specialties, Ltd.,** Bedford Street, Leicester
Boulton, Norwich	**Boulton & Paul, Ltd.,** Norwich
Braby, Glasgow	**Braby, F., & Co., Ltd.,** Eclipse Ironworks, Glasgow
Braime, Hunslet, Leeds	**Braime, T. F., & Co., Ltd.,** Hunslet, Leeds
Brake, Manchester	**Gresham & Craven, Ltd.,** Salford, Manchester
Bricks, Accrington	**Whittaker, C., & Co., Ltd.,** Accrington
Bridge, Motherwell	**Motherwell Bridge Co., Ltd.,** Motherwell, N.B.
Brins Oxygen, London	**British Oxygen Co., Ltd.,** Elverton Street, Westminster, S.W.
Britannia, Colchester	**Britannia Engineering Co.** (1910), **Ltd.,** Colchester
Britannia, Manchester	**Muir, Wm., & Co., Ltd.,** Sherbourne Street, Manchester
Britniclos, London	**British Niclausse Boiler Co., Ltd.,** Caxton House, Westminster, S.W.
Broadbent, Huddersfield	**Broadbent, Thos., & Sons, Ltd.,** Chapel Hill, Huddersfield
Broadbent, Stalybridge	**Broadbent, Robert, & Son, Ld.,** Phœnix Ironwks., Stalybridge
Broadfoot, Whiteinch	**Broadfoot, John, & Sons, Ltd.,** Whiteinch, Glasgow
Bronze, Glasgow	**Steven & Struthers,** Brass Founders, Glasgow
Bronze, Longport	**Billington & Newton, Ltd.,** Longport, Stoke-on-Trent
Broom, High Wycombe	**Broom & Wade, Ltd.,** High Wycombe
Brotherhood, London	**Brotherhood, Peter, Ltd.,** 53, Parliament Street, S.W.
Brownhoist, Cleveland, U.S.A.	**Brown Hoisting Machinery Co.,** Cleveland, Ohio, U.S.A.
Bucktons, Leeds	**Buckton, Joshua, & Co., Ltd.,** Leeds
Bullivants, London	**Bullivant & Co., Ltd.,** 72, Mark Lane, E.C.
Burnet, Glasgow	**Burnet, Lindsay, & Co.,** Moor Park Boiler Works, Govan, Glasgow
Burrell, Thetford	**Burrell, Chas., & Sons, Ltd.,** St. Nicholas Wks., Thetford, Norfolk
Butler, Halifax, England	**Butler, J., & Co.,** Victoria Ironworks, Halifax
Butters, Glasgow	**Butters Bros. & Co.,** 20, Waterloo Street, Glasgow
Calidad, Glasgow	**McKie & Baxter,** Copland Works, Govan, Glasgow
California, Stoke-on-Trent	**Kerr, Stuart & Co., Ltd.,** Stoke-on-Trent
Calyx, London	**New Calyx Drill & Boring Co., Ltd.,** 120, East Ferry Road, Millwall, E.
Camgas, Halifax	**Campbell Gas Engine Co., Ltd.,** Halifax, England
Cammell, Sheffield	**Cammell Laird & Co. Ltd.,** Cyclops Steel and Iron Wks., Sheffield
Cammellaco, London	**Cammell Laird & Co., Ltd.,** 9, Victoria St., Westminster, S.W.
Carborund, London	**Carborundum Co.,** 29, Clifton Street, E.C.
Cariss, Birmingham	**Cariss, Cecil, & Kellett,** 55, Temple Row, Birmingham
Carver, Nottingham	**Carver, C. F., Ltd.,** Alfred Street Mills, Nottingham
Casmey, Leeds	**Yorkshire Boiler Co., Ltd.,** City Square, Leeds
Castra, Renfrew	**Chesters Renfrew Engineering Co., Ld.,** Renfrew, Scotland
Caulking, London	**Consolidated Pneumatic Tool Co., Ltd.,** Palace Chambers, 9, Bridge Street, Westminster, S.W.
Cecampart, London	**Campart, C. C.,** 49, Newgate Street, E.C.
Centumvir, London	**Stern Sonneborn Oil Co., Ltd.,** Royal London House, Finsbury Square, E.C.
Chadburn, Liverpool	**Chadburn's (Ship) Telegraph Co., Ltd.,** Cyprus Road, Bootle, Lancs.
Chains, Coventry	**Coventry Chain Co.** (1907), **Ltd.,** Coventry
Chainwork, Birmingham	**Aston Chain & Hook Co., Ltd.,** Whitehouse Street, Aston, Birmingham
Chaplin, Glasgow	**Chaplin, Alex., & Co., Ltd.,** Govan, Glasgow
Charivari, London	**Bradbury, Agnew & Co., Ltd.,** 10, Bouverie St., Fleet St., E.C.
Chatwin, Birmingham	**Chatwin, Thos.,** Great Tindal Street, Birmingham
Cheaper, London	**Harvey, G. A., & Co.,** Lewisham, S.E.
Chucks, Leicester	**Jones, A. A., Pollard & Shipman, Ld.,** East Park Rd., Leicester
Cleavage, London	**Becker, R., & Co.,** 53, City Road, E.C.
Clemtal, London	**Talbot, Clement, Ltd.,** Barlby Road, Ladbroke Grove, W.
Cleveland, Darlington	**Cleveland Bridge & Engineering Co., Ltd.,** Darlington
Clifdell, Johnstone	**Clifton & Waddell,** Johnstone, near Glasgow
Clutch, Bradford	**Wigglesworth, Frank, & Co., Ltd.,** Mill Lane, Bradford
Cochrane, Barrhead	**Cochrane, John,** Barrhead, N.B.
Cockburn, Glasgow	**Cockburns Ltd.,** Clydesdale Works, Cardonald, near Glasgow
Coles, Derby	**Coles, H. J.,** Ltd., London Crane Works, Derby
Colloquial, London	**Phillips, J. W. & C. J.,** 23, College Hill, Cannon Street, E.C.
Coltmans, Loughborough	**Coltman, H., & Sons,** Midland Ironworks, Loughborough
Colville, London	**Colville, David, & Sons, Ltd.,** 54, Old Broad Street, E.C.
Colville, Motherwell	**Colville, David, & Sons, Ltd.,** Dalzell Steel and Iron Works, Motherwell, near Glasgow
Compactum, London	**Kirkaldy, John, Ltd.,** 101, Leadenhall Street, E.C.
Compass, Glasgow	**Dobbie, McInnes, Ltd.,** 57, Bothwell Street, Glasgow
Conical, Glasgow	**Lindsay, R. B., & Co.,** 38, Mair Street, Plantation, Glasgow
Construction, Düsseldor	**Poetter G.m.b.H.,** Düsseldorf, Germany
Contraflo, London	**Contraflo Condenser & Kinetic Air Pump Co., Ltd.,** 4, Lloyd's Avenue, Fenchurch Street, E.C.
Control, Glasgow	**Electric Control, Ltd.,** 177, Reid Street, Bridgeton, Glasgow
Conveyor, Accrington	**Conveyor & Elevator Co.,** Accrington, Lancashire
Cooke, Sheffield	**Cooke, William, & Co., Ltd.,** Tinsley Steel, Iron and Wire Rope Works, Sheffield
Copper Co., London	**Broughton Copper Co., Ltd.,** 122, Cannon Street, E.C.
Copper Co., Manchester	**Broughton Copper Co., Ltd.,** Manchester
Corrugate, Tyne Dock	**Newton & Nicholson,** Tyne Dock Corrugated Packing Works, South Shields
Corrugated, Glasgow	**Clyde Structural Iron Co., Ld.,** Clydeside Ironworks, Scotstoun, Glasgow
Countable, London	**Dey Time Registers, Ltd.,** 75, Queen Victoria Street, E.C.
Courteous, London	**Braby, Fredk., & Co., Ld.,** Fitzroy Works, 352 to 362, Euston Rd., N.W.
Cox-Walkers, Darlington	**Cox-Walkers, Ltd.,** Darlington
Crabtree, Yarmouth	**Crabtree & Co., Ltd.,** Great Yarmouth
Cradock, Wakefield	**Cradock, Geo., & Co., Ltd.,** Wire Rope Works, Wakefield
Craig-Donald, Johnstone	**Craig & Donald, Ltd.,** Johnstone, Renfrewshire, N.B.
Craig, Paisley	**Craig, A. F., & Co., Ltd.,** Paisley
Cranes, Motherwell	**Jack, Alexander, & Co.,** Whitegates Engineering Works, Motherwell, Scotland
Cranes, Rodley	**Booth, Joseph, & Bros., Ltd.,** Rodley, Leeds
Craven, Wakefield	**Craven & Craven,** Whetley Grove, Manningham, Bradford
Crosby Lockwood, London	**Lockwood, Crosby, & Son,** 7, Stationer's Hall Court, E.C.
Crosby, London	**Crosby Steam Gage & Valve Co.,** 147, Queen Victoria Street, E.C.
Crossleys, Openshaw	**Crossley Bros., Ltd.,** Openshaw, Manchester
Crown, Glasgow	**Sterne, L., & Co., Ltd.,** Crown Ironworks, Glasgow
Crown, Gortonbrook	**Higginbottom & Mannock, Ltd.,** Crown Ironworks, West Gorton, Manchester
Cryolite, London	**British Aluminium Co., Ltd.,** 109, Queen Victoria Street, E.C
Cumulative, London	**Paterson Engineering Co., Ltd.,** 21, Amberley House, Norfolk Street, Strand, W.C.
Cupola, Keighley	**Green, George, & Co.,** Keighley
Curtiss, or Gunpowder, London	**Curtis's & Harvey, Ltd.,** 3, Gracechurch Street, E.C.
Cutters, Birmingham	**Wrigley, E. G., & Co., Ltd.,** Foundry Lane Works, Soho, Birmingham
Cyclops, Gateshead	**Clarke, Chapman & Co., Ltd.,** Gateshead-upon-Tyne
Cylinders, Birmingham	**Tubes, Ltd.,** Birmingham
Dampney, Cardiff	**Dampney, J., & Co., Ltd.,** Bute Docks, Cardiff
Daniell, Birmingham	**Daniell, S. A., Ltd.,** Edward Street, Parade, Birmingham
Daniels, Stroud	**Daniels, T. H. & J., Ltd.,** Stroud, Glos.
Darling Sellers, Keighley	**Darling & Sellers, Ltd.,** Keighley
Davis, Derby	**Davis, John, & Son** (Derby), **Ltd.,** All Saints' Works, Derby
Day Summers, Southampton	**Day, Summers & Co., Ltd.,** Northam Ironworks, Southampton
Debergue, Manchester	**De Bergue & Co., Ltd.,** Strangeways Iron Works, Manchester
Dellburn, Motherwell	**Marshall, Fleming & Co.,** Motherwell, N.B.
Delta, London	**Delta Metal Co., Ltd.,** East Greenwich, S.E.
Dempster, Glasgow	**Dempster, Moore & Co., Ltd.,** 49, Robertson Street, Glasgow
Dennis, Bradford	**Millar, Dennis & Co.,** Victoria Works, Bradford
Derwent, Birmingham	**Taylor & Challen, Ltd.,** Derwent Foundry, Birmingham
Destructor, London	**Horsfall Destructor Co., Ltd.,** 17, Victoria Street, S.W.
Dewhurst, Attercliffe Road, Sheffield	**Dewhurst's Engineering Co., Ltd.,** Sheffield
Diagram, Liverpool	**Hughes & Lancaster,** Liverpool
Diameter, Manchester	**Mitchell's Emery Wheel Co.,** Mill Street, Bradford, Manchester
Dicker, London	**Dick, Kerr & Co., Ltd.,** Abchurch Yard, Cannon Street, E.C.
Dieselben, London	**Diesel Engine Co., Ltd.,** 179, Queen Victoria Street, E.C.
Distend, London	**Expanded Metal Co., Ltd.,** York Mansion, York Street, S.W.
Dockyard, Dublin	**Dublin Dockyard Co.,** North Wall, Dublin
Dodman, King's Lynn	**Dodman, A., & Co., Ltd.,** King's Lynn
Dogal, London	**Sirius Autogenous Work Co.,** Carpenters Road, Stratford, E.
Dolphin, Leeds	**Campbells & Hunter, Ltd.,** Dolphin Foundry, Leeds
Donald, Paisley	**Hanna, Donald & Wilson,** Abercorn Foundry, Paisley
Donkin, Chesterfield	**Donkin Company, Ltd. (The Bryan),** Chesterfield
Dot, Nottingham	**Railway & General Engineering Co., Ld.,** Midland Foundry, Nottingham
Douglas, Kirkcaldy	**Douglas & Grant,** Dunnikier Foundry, Kirkcaldy, N.B.
Doulton, London	**Doulton & Co., Ltd.,** Lambeth
Drague, London	**Wilson, John H., & Co., Ltd.,** 15, Victoria St., Westminster, S.W.
Drawing, Manchester	**Thornton, A. G., Ltd.,** 28, King Street West, Manchester
Dredger, Port Glasgow	**Ferguson Brothers,** Port Glasgow
Driller, Beaver Falls, Pa.	**Keystone Driller Co.,** Beaver Falls, Penna, U.S.A.
Driving, Manchester	**Renold, Hans, Ltd.,** Progress Works, Manchester
Drum, Bradford	**Drum Engineering Co.,** 33, Brook Street, Bradford
Dynamo, Bradford	**Phœnix Dynamo Mfg. Co., Ltd.,** Thornbury Works, Bradford
Dynamo, Oldham	**Hall, J. P., & Co., Ltd.,** Oldham
Economy, Hazel Grove	**Mirrlees, Bickerton & Day, Ltd.,** Hazel Grove, nr. Stockport
Edmeston, Patricroft	**Edmeston, A., & Sons, Ltd.,** Patricroft, nr. Manchester
Effectual, Glasgow	**Murray, Workman & Co., Ltd.,** Glasgow
Efficiency, London	**Leroy, F., & Co.,** 20, Gray Street, Commercial Road, E.
Eisenmoller, Bielefeld	**Möller, K. & Th.,** G.m.b.H., Brackwede, Germany
Electricity, London	**General Electric Co., Ltd.,** 67, Queen Victoria Street, E.C.
Elevator, Haslingden	**Stott, S. S., & Co.,** Haslingden, near Manchester
Elevenfold, London	**Newall Engineering Co.,** Blackhorse Lane, Walthamstow, E.
Elliot Company, Cardiff	**Elliot, George, & Co., Ltd.,** Cardiff
Elliot Company, London	**Elliot, George, & Co., Ltd** 16, Gt. George St., Westminster, S.W.
Ellisons Ltd., Irlams-o'-th'-Height	**Ellison, W. T., & Co., Ltd.,** Irlams-o'-th'-Height, Manchester
Elmores, Schladern, Germany	**Elmore's Metall-A.-G.,** Schladern, Sieg., Germany
Elsterne, London	**Sterne, L., & Co., Ltd.,** Donington House, Norfolk Street, W.C.
Elyor, Cadishead	**Royles Limited,** Irlam, near Manchester
Emblems, Birmingham	**Vaughtons, Ltd.,** Livery Street, Birmingham
Emery, Altrincham	**Luke & Spencer, Ltd.,** Broadheath, near Manchester
Emery, London	**Davies, W. J., & Sons,** 109, Weston Street, S.E.
Empress, Johnstone	**Clifton & Baird, Ltd.,** Empress Works, Johnstone, Scotland
Endazzle, London	**Acetylene Illuminating Co., Ltd.,** 268 and 270, South Lambeth Road, S.W.
Endeavour, London	**Birch, John, & Co., Ltd.,** 2, London Wall Buildings, E.C.
Endure, London	**Cooper, Edwin, & Co., Ltd.,** 86, Leadenhall Street, E.C.
Energy, Hull	**Maxted & Knott, Ltd.,** Burnett Avenue, Hull
Energy, Motherwell	**Chambers, Scott & Co.,** Motherwell
Engholm, Birmingham	**Engholm, A. Goldie,** 104, Newall Street, Birmingham
Engine, Leeds	**Hunslet Engine Co., Ltd.,** Leeds
Engine, London	**Marshall, Sons & Co., Ltd.,** 79, Farringdon Road, E.C.
Engineering, London	**"Engineering," Ltd.,** 35 and 36, Bedford Street, Strand, W.C.
Engineers, Dartmouth	**Simpson, Strickland & Co., Ltd.,** Dartmouth
Engineers, Dundee	**Urquhart, Lindsay & Co., Ltd.,** Blackness Foundry, Dundee
Engineers, Liverpool	**Wilson, John H., & Co., Ld** Dock Rd., Seacombe, nr. Birkenhead
Enriching, London	**Wouldham Cement Co., Ltd.,** 35, Gt. St. Helen's, E.C.
Ensulim, London	**Schmidt's Superheating Co.** (1910), **Ld.,** 28, Victoria St., S.E.

Telegraphic Address.	Name and Address of Advertiser.
E.O.A., Birmingham	**Electric & Ordnance Accessories Co., Ltd.,** Aston, Birmingham
Epa, London	**Alexander, E. P., & Son,** 306, High Holborn, W.C.
Equestrian, London	**Bradley Pulverizer Co.,** 37, Walbrook, E.C.
Esco, Newcastle-on-Tyne	**Scott, E., & Mountain, Ltd.,** Close Works, Gateshead-on-Tyne
Escutcheon, London	**Casella, C. F., & Co., Ltd.,** 11-15, Rochester Row, S.W.
Esto, Falkirk	**Carron Company,** Carron, Stirlingshire, N.B.
Etna, Leith	**Davis & Primrose,** Bangor Road, Leith, N.B.
Evans, Wolverhampton	**Evans, Joseph, & Sons (Wolverhampton, Ltd.),** Wolverhampton
Evaporate, Pollokshaws	**Dalglish, A. & W.,** West of Scotland Boiler Works, Pollokshaws, Glasgow
Everectus, London	**Everett, Edgcumbe & Co., Ltd.,** 117, Victoria Street, S.W.
Evergendos, London	**Everett, Edgcumbe & Co., Ld.,** Collindale Works, Hendon, N.W.
Everything, Birmingham	**Mountford, Fredk., Ltd.,** Fremo Wks., Granville St., Birmingham
Excelsior, Loughborough	**Main, Geo., & Co.,** Packe Street, Loughborough
Exhaust, Leeds	**Baker Oil Separator Co., Ltd.,** Union Works, Hunslet, Leeds
Exhaust, Romiley	**Davies & Metcalfe, Ltd.,** Romiley, Manchester
Expansion, Glasgow	**Glasgow Railway Engineering Co., Ltd.,** Govan, Glasgow
Explanatus, London	**Griffin, C., & Co., Ltd.,** Exeter Street, Strand, W.C.
Extrusion, Birmingham	**Delta Metal Co., Ltd.,** Dartmouth Street, Birmingham
Eyrish, Tonbridge	**Eyre Smelting Co., Ld.,** Barden Road Works, Tonbridge, Kent
Fairbairns, Leeds	**Fairbairn, Macpherson,** Wellington Foundry, Leeds
Fairbanks, London	**Fairbanks Co.,** 15, Mallow Street, Old Street, E.C.
Fairley, Birmingham	**Fairley, James, & Sons,** Old Mint, Shadwell Street, Birmingham
Falcon, Loughborough	**Brush Electrical Engineering Co., Ltd.,** Falcon Works, [Loughborough
Fasnut, London	**Fastnut Ltd.,** 115, Newgate Street, E.C.
Fawcett, Liverpool	**Fawcett, Preston, & Co., Ltd.,** Liverpool
Ferranti, Hollinwood	**Ferranti, Ltd.,** Hollinwood, Lancs.
Fife Forge, Kirkcaldy	**Fife Forge Co.,** Kirkcaldy, Scotland
Figee-Haarlem	**Figee,** Haarlem, Holland
Finch, Chepstow	**Finch, Edward, & Co., Ltd.,** Chepstow
Findlay, Motherwell	**Findlay, Alex., & Co., Ltd.,** Motherwell, near Glasgow
Firmo, Glasgow	**Firth, Thos., & Sons, Ltd.,** 144, St. Vincent Street, Glasgow
Firosis, London	**Reddaway, F., & Co., Ltd.,** 212, Shaftesbury Avenue, W.C.
Firth, Sheffield	**Firth, Thos., & Sons, Ltd.,** Norfolk Works, Sheffield
Flamma, London	**Acetylene Corporation, Ltd.,** 49, Victoria St, Westminster, S.W.
Flenderim, London	**Flender Company, The,** Broad St. House, New Broad St., E.C.
Forge, Bradford	**Barrett, Arthur G., & Co.,** The Forge, Bradford
Forge, Darlington	**Darlington Forge Co., Ltd.,** Darlington
Forge, Dumbarton	**Dennystown Forge Co.,** Dumbarton
Forge, Kirkstall	**Kirkstall Forge Co., Ltd.,** Leeds
Forward, Sheffield	**Ward, T. W., Ltd.,** Albion Works, Sheffield
Foster Instrument, Letchworth	**Foster Instrument Co.,** Letchworth, Herts.
Fosters, Wednesbury	**Foster Brothers, Ltd.,** Wednesbury
Foundry, Bolton	**Entwisle & Gass, Ltd.,** Bolton
Foundry, Bradford	**Bever, Dorling & Co., Ltd.,** Bowling Ironworks, Bradford
Foundry, Manchester	**Wallwork, Henry, & Co., Ltd.,** Manchester
Foundry, Portadown	**Bright's Patent Pulley Co., Ltd.,** Portadown, Ireland
Foundry, Walton-on-Naze	**Warner, Robert, & Co., Ltd.,** Walton-on-Naze, Essex
Fowler, Leeds	**Fowler, John & Co. (Leeds), Ltd.,** Steam Plough Wks., Leeds
Fraisapparat, Berlin	**Sonnenthal, Junr.,** Neue Promenade 6, Berlin, C. 2
France, Glasgow	**France & Morgan,** Whitefield Brass Works, Govan, Glasgow
Fraser, Arbroath	**Fraser, Douglas, & Sons, Ltd.,** Arbroath, Scotland
Fredennis, London	**Dennis, W. F., & Co.,** 49, Queen Victoria Street, E.C.
Fresco, Glasgow	**Gas Power & By-Products Co., Ltd.,** 38, Bath Street, Glasgow
Fribald, London	**Baldwin Locomotive Works, The,** 34, Victoria Street, S.W.
Fry, Victoria Avenue, Saltaire	**Fry, Ernest Bickersteth,** 4 & 6, Victoria Avenue, Shipley, Yorks.
Fugal, Glasgow	**Watson, Laidlaw & Co., Ltd.,** 98, Dundas St. (South), Glasgow
Fuller Horsey, London	**Fuller, Horsey, Sons & Cassell,** 11, Billiter Square, E.C.
Galvanolon, London	**A.E.G. Electric Company, Ltd.,** Pembroke House, 133-135, Oxford Street, W.
Gandah, Glasgow	**Harvey, G. & A., Ltd.,** Govan, Glasgow, W.
Gandy, Birkenhead	**Gandy Belt Mfg. Co., Ltd.,** Wheatland Works, Seacombe, Cheshire
Gandy, London	**Gandy Belt Mfg. Co., Ltd.,** 97, Queen Victoria Street, E.C.
Garrett, Leiston	**Garrett, R., & Sons, Ltd.,** Leiston Works, Suffolk
Gas, Leeds	**Clayton, Son, & Co., Ltd.,** Leeds City Boiler Works, Leeds
Gaseous, London	**Dowson & Mason Gas Plant Co., Ltd.,** 39, Victoria Street, S.W.
Gasholder, Stockton-on-Tees	**Ashmore, Benson, Pease & Co., Ltd.,** Stockton-on-Tees
Gasify, Levenshulme	**Dowson & Mason Gas Plant Co., Ltd.,** Levenshulme, Manchester
Gearing, Huddersfield	**Brown, D., & Sons, Ltd.,** Park Works, Lockwood, Huddersfield
Gebsulzer, London	**Sulzer Bros.,** 30, Norfolk Street, Strand, W.C.
Gegenstrom, London	**Balcke & Co., Ld.,** Broadway Court, Broadway, Westminster, S.W.
Gentyre, London	**Almagam Limited,** 172, Great Portland Street, W.
Gibbins, Birmingham	**Gibbins, R. C., & Co.,** Berkley Street, Birmingham
Gilkes, Kendal	**Gilkes, Gilbert, & Co., Ltd.,** Kendal, England
Giweir, Glasgow	**Weir, G. & J., Ltd.,** Holm Foundry, Cathcart, Glasgow
Glasses, Newton Heath	**Butterworth Bros., Ltd.,** Newton Heath Glass Works, Manchester
Glenfield, Kilmarnock	**Glenfield & Kennedy, Ltd.,** Kilmarnock, N.B.
Glenros, Glasgow	**Ross, R. G., & Son, Ltd.,** Glasgow
Glossator, London	**Taylor's Typewriter Co., Ltd.,** 74, Chancery Lane, W.C.
Glovers, Holbeck Lane, Leeds	**Glover, M., & Co.,** Leeds
Glyco, Manchester	**Glyco Metal Co., Ltd.,** Manchester
Goedhart, Düsseldorf	**Goedhart Bros.,** Düsseldorf, Germany
Gothic, Norwich	**Laurence, Scott & Co., Ltd.,** Norwich
Grace, Thrapston	**Smith & Grace Screw Boss Pulley Co., Ltd.,** Thrapston
Grafton, Bedford	**Grafton & Co.,** Bedford
Graftonian, London	**Grafton & Co.,** 120, Cannon Street, E.C.
Gramercy, London	**British Steel Piling Co.,** Dock House, Billiter Street, E.C.
Gramercy, London	**Le Bas, Edward, & Co.,** Dock House, Billiter Street, E.C.
Gramme, London	**Griffin, John J., & Sons, Ltd.,** Kemble Street, Kingsway, W.C.
Graysilver, London	**India Rubber, Gutta Percha & Telegraph Works Co., Ltd.,** Silvertown, Essex
Graziani, London	**Graziani, A. G., & Co.,** 22, Billiter Street, E.C.
Greaves, Harbury	**Greaves, Bull & Lakin, Ltd.,** Harbury, Leamington
Greene, Quancham, London	**Greene, Tweed & Co.,** 15, Queen Anne's Chambers, Tothill Street, Westminster, S.W.
Greenwood, Leeds	**Greenwood & Batley, Ltd.,** Albion Works, Leeds
Gresley, Manchester	**Smith & Coventry, Ltd.,** Gresley Ironworks, Ordsal Lane Manchester
Grice, Birmingham	**Grice, Grice & Son, Ltd,** Sheepcote Street, Birmingham
Grieve, Motherwell	**Grieve, John, & Co.,** Motherwell, Scotland
Grusonwerk, Magdeburg	**Krupp Aktiengesellschaft Grusonwerk,** Magdeburg-Buckau, Germany
Guldnes, London	**Daw, A. & Z.,** 11, Queen Victoria Street, E.C.
Gummerson, London	**Société du Nord de Liége,** 42, Perryn Road, Acton, W.
Gunpowder, London	**Curtis's & Harvey, Ltd.,** 3, Gracechurch Street, E.C.
Gunther, Oldham	**Günther, W., & Sons,** Central Works, Oldham
Guttaperch, Toronto	**Gutta Percha & Rubber Mfg. Co., of Toronto, Ltd.** Toronto, Canada
Gwynne, London	**Gwynnes Ltd.,** Hammersmith Ironwks., W., & 81, Cannon St., E.C.
Hadfield, Sheffield	**Hadfield's Steel Foundry Co., Ltd.,** Hecla Works, Sheffield
Halden, Manchester	**Halden, J., & Co., Ltd.,** 8, Albert Square, Manchester
Hall, Engineers, Peterboro	**Hall, J. P., & Sons, Ltd.,** Peterborough
Hallford, London	**Hall, J. & E., Ltd.,** 10, St. Swithin's Lane, E.C.
Hallford, Dartford	**Hall, J. & E., Ltd.,** Dartford, Kent
Hanomag, Hanover-Linden Germany	**Hannoversche Maschinenbau-Actien-Gesellschaft, vormals Georg Egestorff,** Hannover-Linden, Germany
Hardypick, Sheffield	**Hardy Patent Pick Co., Ltd.,** Sheffield
Hart, Blackburn	**Hart, Thomas,** Blackburn
Hartnell, Leeds	**Hartnell, Wilson, & Co., Ltd.,** Volt Works, Kirkstall Rd., Leeds
Hathorn, Leeds	**Hathorn, Davey & Co., Ltd.,** Sun Foundry, Leeds
Hauling, Birmingham	**Wild, M. B., & Co., Ltd.,** Nechells, Birmingham
Hawksley, Sheffield	**Hawksley, Wild & Co., Ltd.,** Brightside Boiler Works, Sheffield
Hayes, Stony Stratford	**Hayes, Edward,** Watling Works, Stony Stratford, Wolverton
Heap, Ld., Ashton-under-Lyne	**Heap, Jos., & Co., Ltd.,** Ashton-under-Lyne
Heating, Liverpool	**Gibbs, Renton & Co., Ltd.,** Mill Street, Liverpool
Heatizer, Manchester	**Bolton, A., & Co.,** 49, Deansgate, Manchester
Heenan, Manchester	**Heenan & Froude, Ltd.,** 4, Chapel Walks, Manchester
Heenan, Worcester	**Heenan & Froude, Ld.,** Worcester Engineering Wks., Worcester
Helical, London	**Citroën, André, & Co.,** 27, Queen Victoria Street, E.C.
Henry Crowther, Cleckheaton	**Crowther, Henry, & Sons, Ltd.,** Cleckheaton
Heroic, Reddish	**Rowland, B. R., & Co., Ltd.,** Climax Works, Reddish, near Manchester
Heth, Manchester	**Hetherington, John, & Sons, Ltd.,** Manchester
Hewittic, London	**Westinghouse Cooper Hewitt Co., Ltd.,** 151-2, Great Saffron Hill, E.C.
Hexagon, Halifax	**Carter & Wright,** Woodside, Halifax
Hexagon, Leeds	**Kirby Banks Screw Co., Ltd.,** Meadow Lane, Leeds
Hibou, London	**Burton, C. W., Griffiths & Co.,** 1, 2 & 3, Ludgate Square, E.C.
Highgate, Shettleston	**Pollock, MacNab & Highgate,** Shettleston, Glasgow
Hindley, Bourton-Dorset	**Hindley, E. S., & Sons,** Bourton, Dorset
Hobnails, London	**Hobdell, Way & Co., Ltd.,** St. John's House, 124-5, Minories, E.
Hoffmann, Chelmsford	**Hoffmann Manufacturing Co., Ltd.,** Chelmsford
Hoffnungshuette, Oberhausenrhein	**Gutehoffnungshütte Coal, Iron, Steel & Engineering Co.,** Oberhausen-2, Rhineland
Hoisting, Glasgow	**Carruthers, J. H., & Co., Ltd.,** Polmadie Ironworks, Glasgow
Hoops, Motherwell	**Motherwell Iron & Steel Co.,** Motherwell, N.B.
Hopkinson, Huddersfield	**Hopkinson, J., & Co., Ltd.,** Huddersfield
Hornsbys, Grantham	**Hornsby, R., & Sons, Ltd.,** Spittlegate Iron Works, Grantham
Hornsbys, London	**Hornsby, R., & Sons, Ltd.,** Hornsby House, 75B, Queen Victoria Street, E.C.
Horsepower, London	**Unbreakable Pulley & Mill Gearing Co., Ld.,** 56, Cannon St.,
Howden, Glasgow	**Howden, James, & Co.,** Scotland Street, Glasgow
Howell, Sheffield	**Howell & Co., Ltd.,** Brook Steel Works, Sheffield
Hudson, Coatbridge	**Hudson, Thomas, Ltd.,** Sheepford Works, Coatbridge, N.B.
Humboldtia, London	**British Humboldt Engineering Co., Ltd.,** Dixon House, Lloyd's Avenue, E.C.
Humpidge, Calnscross	**Dudbridge Iron Works, Ltd.,** Dudbridge, near Stroud
Hydraulic, Bristol	**Brazil, Straker & Co., Ltd.,** Vulcan Ironworks, Bristol
Hydraulic, Edinburgh	**Brown Bros. & Co., Ltd.,** Rosebank Ironworks, Edinburgh, N.B.
Hydraulic, Leeds	**Middleton, Robt.,** Sheepscar Foundry, Leeds
Hydromotor, London	**Pitman, Percy,** 3, Willcott Road, Acton, W.
Hydrostatic, London	**East Ferry Road Engineering Works Co., Ltd.,** Millwall, E.
Hypostile, Glasgow	**Boyle, R., & Son,** 110, Bothwell Street, Glasgow
Hypostile, London	**Boyle, R., & Son,** 64, Holborn Viaduct, E.C.
Hyson, Nottingham	**Smith Bros., & Co.,** (Hyson), **Ltd.,** Nottingham
Igniter, Birmingham	**Lodge Bros. & Co.,** 14, New Street, Birmingham
Improvably, London	**Withers, J. S., & Spooner,** 323, High Holborn, W.C.
Incanto, London	**Thorn & Hoddle Acetylene Co., Ltd.,** 151, Victoria Street, Westminster, S.W.
Indicator, Manchester	**Kirk, Wheatley, Price & Co.,** Albert Square, Manchester
Indices, London	**Kirk, Wheatley, Price & Co.,** 46, Watling Street, E.C.
Infiux, Manchester	**Holden & Brooke, Ltd.,** Sirius Works, West Gorton, Manchester
Ingersoll, London	**Ingersoll-Rand Co.,** 165, Queen Victoria Street, E.C.
Ingot, Wishaw	**Glasgow Iron & Steel Co., Ltd.,** Wishaw Iron and Steel Works, Wishaw
Injector, Glasgow	**Schäffer & Budenberg, Ltd.,** 5, Wellington Street, Glasgow
Inspect, London	**Hall, B. J., & Co., Ltd.,** 39, Victoria Street, S.W.
Instantly, London	**Winter, F.,** 25, Goswell Road, E.C.
Instrument, Cambridge	**Cambridge Scientific Instrument Co., Ltd.,** Cambridge
Insulator, Prescot	**British Insulated & Helsby Cables, Ltd.,** Prescot, Lancashire
Intensifier, London	**Middleton, Robt.,** 22, Walbrook, E.C.
Intersection, London	**Piggott, Thos., & Co., Ltd.,** 63, Queen Victoria Street, E.C.
Invention, London	**Redfern, G. F., & Co.,** 15, South Street, Finsbury, E.C.
Inventions, Eastbourne	**Howard Pneumatic Engineering Co., Ltd.,** Fort Road, Eastbourne

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Inventions, Glasgow	**Thomson, W. R. M., & Co.,** 96, Buchanan Street, Glasgow
Ipfeiffer, Kaiserslautern, Germany	**Pfeiffer, Gebr.,** Kaiserslautern 74, Germany
Ironheads, London	**Patent File & Tool Co., Ltd.,** 8, White Street, Moorfields, E.C.
Ironsides, Liverpool	**Morton, Francis, & Co., Ltd.,** Garston, Liverpool
Isca, London	**Isca Foundry & Engineering Co.,** St. Margaret's Mansions, 53, Victoria Street, Westminster, S.W.
Isca, Newport	**Isca Foundry & Engineering Co.,** Newport, Monmouthshire
Isham, Liverpool	**United Kingdom Self-Adjusting Anti-Friction Metallic Packing Syndicate, Ltd.,** 14, Cook Street, Liverpool
Isherwood, Middlesbrough	**Isherwood, J. W.,** Zetland Buildings, Middlesbrough
Isler, London	**Isler, C., & Co., Ltd., Artesian Works, Bear Lane, S.E.**
Jackson, Claycross	**Claycross Co.,** Claycross, near Chesterfield
Jacksons, Manchester	**Jackson, P. R., & Co., Ltd.,** Salford Rolling Mills, Manchester
James Keith, London	**Keith, James, & Blackman Co., Ld.,** 27, Farringdon Av., E.C.
Jandunus, London	**Jandus Arc Lamp & Electric Co., Ltd.,** Hartham Road, [Holloway, N.
Jardine, Nottingham	**Jardine, John,** Deering Street, Nottingham
Jenorten, London	**Boving, Jens Orten- & Co.,** 9½, Union Court, Old Broad St., E.C.
Jessops, Sheffield	**Jessop, Wm., & Sons, Ltd.,** Brightside Works, Sheffield
Jointing, Liverpool	**House, Fredk., & Co.,** 30, Chapel Street, Liverpool
Jpohlig, Coln	**Pohlig, J.,** A.-G., Cologne-Zollstock
Kahncrete, London	**Trussed Concrete Steel Co., Ltd.,** 50, Caxton House, Westminster, S.W.
Kalbitum, Belvedere	**Kalbitum Paint Co., Ltd.,** Belvedere Works, Belvedere, Kent
Kalker, Coventry	**Kalker, E., & Co.,** Coventry
Kays, Engineers, Bury	**Kay, James C., & Co., Ltd., Barnbrook Works, Bury, Lancs.**
Kenyon, Dukinfield	**Kenyon, Wm., & Sons,** Dukinfield, Manchester
Kern, Aarau	**Kern & Co.,** Aarau, Switzerland
Kernamat, London	**Kern & Co.,** Peninsular House, 4, Monument Street, E.C.
Kilbowie, London	**Tullis, D. & J., Ltd.,** 1, Southwark Bridge Buildings, S.E.
Kincaid, Greenock	**Kincaid, John G., & Co., Ltd.,** Clyde Foundry, Greenock
Klettillo, London	**Maschinenfabrik Augsburg-Nurnberg A.-G.,** 219, Caxton House, Westminster, S.W.
Knapping, Leeds	**Baxter, W. H., Ltd.,** Leeds
Korting, London	**Korting Bros., Ltd.,** 53, Victoria Street, Westminster, S.W.
Kynoch, Birmingham	**Kynoch Ltd.,** Birmingham
Laborless, Bradford	**Little, Gilbert Co., Ltd.,** Horton Works, Bradford
Lacombe, London	**Le Carbone,** 17, Water Lane, Great Tower Street, E.C.
Laminated, Glasgow	**Hendry, James,** Laminated Leather Works, Bridgeton, Glasgow
Land, Grantham	**Grantham Boiler & Crank Co., Ltd.,** Grantham
Lang, Johnstone	**Lang, John, & Sons,** Johnstone, N.B.
Lapweld, Glasgow	**Stewarts & Lloyds, Ltd.,** 41, Oswald Street, Glasgow
Lathe, Coventry	**Herbert, Alfred, Ltd.,** Coventry
Lathe, Shipley	**Barker, Spink, Lease & Co.,** Rosse Works, Shipley, Yorkshire
Lathes, Birmingham	**Taylor, Charles** (Birm'm.), Ltd., **Bartholomew St., Birmingham**
Lathes, Felling	**Noble & Lund, Ltd.,** Felling, **near Newcastle-on-Tyne**
Lathes, Guildford	**Drummond Brothers, Ltd.,** Engel Works, near Guildford
Lathes, Keighley	**Dean, Smith & Grace (1908), Ltd.,** Keighley
Lathookol, London	**Holbrook & Sons,** Stratford, E.
Lees, Hollinwood	**Lees, T. & R.,** Hollinwood, by **Manchester**
Lewis, Wolverhampton	**Lewis, E., & Sons,** Wolverhampton
Lias, London	**Greaves, Bull & Lakin, Ltd.,** 9, Grove Rd. Bridge, Marylebone, [N.W.
Lidgerwood, London	**Lidgerwood Mfg. Co.,** Caxton House, Westminster, S.W.
Lifter, Coventry	**Brett's Patent Lifter Co., Ltd.,** Coventry
Lifting, Glasgow	**Burnbank Engineering Co.,** 58, West Regent Street, Glasgow
Lifting, Leicester	**Taylor & Hubbard,** Leicester
Lignum, Manchester	**Southern, James W. & Son, Ltd.,** 38, Store Street, Manchester
Lilleshall, Oakengates	**Lilleshall Company, Ltd.,** Oakengates, Shropshire
Lioncelle, London	**Walker James, & Co., Ld.,** Lion Works, Garford St., Poplar, E.
Lipogram, London	**Lipscombe, Fredk., & Co.,** 49, Queen Victoria Street, S.W.
Lithographer, London	**Kell, T., & Son,** 40, King Street, Covent Garden, W.C.
Lloyds, Birmingham	**Stewarts & Lloyds, Ltd.,** Nile Street, Birmingham
Lobnitz, Renfrew	**Lobnitz & Co., Ltd.,** Renfrew, Scotland
Lockencan, London	**Kaye, Jos., & Sons, Ltd.,** 93, High Holborn, W.C.
Lockett, London	**Cutbill-King & Co.,** 26, Nicholas Lane, E.C.
Lockfast, London	**Bayliss, Jones & Bayliss, Ltd.,** 139 & 141, Cannon Street, E.C.
Loco, Bristol	**Avonside Engine Co.,** Bristol
Loco, Glasgow	**North British Locomotive Co., Ltd.,** Administration Bldg., 110, Flemington Street, Springburn, Glasgow
Loco, Gorton	**Beyer, Peacock & Co., Ltd., Gorton Foundry, Manchester**
Loco, Leeds	**Hudswell, Clarke & Co., Ltd.,** Railway Foundry, Leeds
Locomobile, London	**Wolf, R.,** 7, Laurence Pountney Hill, E.C.
Locomotive, Newcastle	**Hawthorn, R. & W., Leslie, & Co., Ld.,** Newcastle-on-Tyne
Locomotive, Newyork, U.S.A.	**American Locomotive Co.,** Cortlandt Building, 30, Church Street, New York, U.S.A.
Locomotive, Newyork, U.S.A.	**Atlantic Equipment Company,** 30, Church Street, New York,
Longmans, London	**Longmans, Green & Co.,** 39, Paternoster Row, E.C. [U.S.A.
Lugard, Chester	**Lugard, Cecil E., & Co.,** St. John's House, Chester
Lunken, London	**Lunken Company, Inc.,** 35, Great Dover Street, S.E.
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Sun Fire, London	**Sun Fire Office,** 63, Threadneedle Street, E.C.
Suspend, London	**Wheeler Condenser & Eng. Co.,** 2 & 3, Norfolk St., Strand, W.C.
Sustained, London	**Klinger, Richard & Co.,** 66, Fenchurch Street, E.C.
Swiftly, Halifax	**Swift, George, & Sons,** Range Bank, Halifax
Switch, Manchester	**Royce Limited,** Trafford Park, Manchester
T. J. Gardner, Bristol	**Gardner, T. J.,** Narrow Wine Street, Bristol
Tangyes, Birmingham	**Tangyes Limited,** Birmingham
Tangyes, London	**Tangyes Limited,** 35, Queen Victoria Street, E.C.
Tanks, Birmingham	**Ash, Joseph, & Son,** Rea Works, Rea Street South, Birmingham
Taps, Salford	**Widdowson, John H.,** Britannia Works, Ordsall Lane, Salford, Manchester [ton, Glasgow
Tay, Glasgow	**Arrol, Sir William, & Co., Ld.,** Dalmarnock Iron Works, Bridge-
Teesdale, Stockton-on-Tees	**Head, Wrightson & Co., Ltd.** Teesdale Ironworks, Thornaby-on-Tees
Temperature, London	**Green & Boulding, Ltd.,** 28, New Bridge Street, E.C.
Temples, Shipley	**Parkinson, J., & Son,** Shipley, Yorkshire
Tentwort, London	**Lassen & Hjort,** 52, Queen Victoria Street, E.C.
Tetratomic, Stockton-on-Tees	**Power Gas Corporation, Ltd.,** Stockton-on-Tees
Textile, Manchester	**Emmott & Co., Ltd.,** 65, King Street, Manchester
Theorem, Patricroft	**Gardner, L., & Sons, Ltd.,** Patricroft, Manchester
Thornycroft, Basingstoke	**Thornycroft, J. I., & Co., Ltd.,** Basingstoke
Thornycroft, London	**Thornycroft, J. I., & Co., Ltd.,** Caxton House, Westminster, S.W.
Thornycroft, Southampton	**Thornycroft, J. I., & Co., Ltd.,** Woolston, Southampton
Thwaites, Bradford	**Thwaites Bros., Ltd.,** Bradford, Yorkshire
Thyssenmaschine, Mulheimruhr	**Maschinenfabrik Thyssen & Co.,** Aktiengesellschaft, Mülheim-Ruhr [Manchester
Tilghmans, Altrincham	**Tilghman's Patent Sand Blast Co., Ltd.,** Broadheath, near
Tilghmans, Altrincham	**Price Air Lift Pump Co.,** Broadheath, near Manchester
Tomey, Birmingham	**Tomey, Joseph, & Sons, Ltd.,** Manor Glass Works, Aston, Bir-
Tools, Leeds	**Musgrave Bros.,** Crown Point Foundry, Leeds [mingham
Tools, Manchester	**Kendall & Gent, Ltd.,** Victoria Works, Belle Vue, Manchester
Toopes, London	**Toope's Asbestos Covering, Co., Ld.,** Stepney Sq., Stepney, E.
Towards, Newcastle-on-Tyne	**Toward, T., & Co., Ltd.,** 9, Ouseburn, Newcastle-on-Tyne
Town Clerk, Northampton	**Northampton,** THE TOWN CLERK, Northampton
Treasure, Liverpool	**Treasure, J. B., & Co.,** 3, Vauxhall Road, Liverpool
Trewent, London	**Trewent, F. J., & Procter,** 43, Billiter Bldgs., Billiter Street, E.C.
Tribrach, London	**Stanley, W. F., & Co., Ld.,** 13, Railway Approach, London Bridge,
Triple, Glasgow	**Rodger, A., & Co.,** St. Helen's Engine Works, Govan, Glasgow
Troika, London	**Thermo & Pressure Instruments, Ltd.,** 60, Salusbury Road, Kilburn, N.W.
Tube, Glasgow	**Marshall, John, & Sons,** Glasgow Tube Works, Glasgow
Tubeless, London	**Simplex Superheater Co., Ltd.,** 39, Victoria Street, West-
Tubes, Leeds	**Yorkshire Copper Works, Ltd.,** Leeds [minster, S.W.
Tubes, Wednesbury	**Spencer, John, Ltd.,** Wednesbury
Tubularity, London	**Sugden, T., Ltd.,** 180, Fleet Street, E.C.
Tubulous, London	**British Mannesmann Tube Co., Ltd.,** Salisbury House, London Wall, E.C.
Tudor, Birmingham	**Ward, H. W., & Co., Ltd.,** Lionel Street, Birmingham
Tullis, Clydebank	**Tullis, D. & J., Ltd.,** Kilbowie Ironworks, near Glasgow
Tullis, Glasgow	**Tullis, John, & Son, Ltd.,** St. Ann's Leather Works, Glasgow
Turbo, Newcastle-on-Tyne	**Parsons, C. A., & Co.,** Heaton Works, Newcastle
Turnstile, London	**Stanley, W.F., & Co., Ltd.,** 286, High Holborn, W.C.
Turretorum, London	**Jones & Lamson Machine Co.,** Jubilee Buildings, 97, Queen Victoria Street, E.C.
Turtons, Sheffield	**Turton, T., & Sons, Ltd.,** Sheaf Works, Sheffield
Tylerox, London	**Hayward-Tyler & Co., Ltd.,** 99, Queen Victoria Street, E.C.
Tyne, Newcastle-on-Tyne	**Spencer, John, & Sons, Ltd.,** Ouseburn Works, Newcastle-on-Tyne
Typhoon, London	**Alldays & Onions (Pneumatic Engineering) Co., Ltd.** 58, Holborn Viaduct, E.C.
Unappalled, London	**British Westinghouse Electric & Manufacturing Co., Ltd.,** 2, Norfolk Street, W.C.
Unappalled, Manchester	**British Westinghouse Electric & Manufacturing Co., Ltd.,** Trafford Park, Manchester
Unbreakable, London	**Wells, A. C., & Co.,** 102, Midland Road, St. Pancras, N.W.
Unbreakable, Manchester	**Wells, A. C., & Co.,** Carnarvon Street, Cheetham, Manchester
Underfeed, London	**Underfeed Stoker Co., Ltd.,** Coventry House, South Place, E.C
Universe, Birmingham	**Wright, J. & E., Ltd.,** Birmingham
Unwavering, London	**Hulburd Engineering Co., Ltd.,** 150, Leadenhall Street, E.C.
Vacuo, London	**Consolidated Brake & Engineering Co., Ltd.,** Spencer House, South Place, E.C.
Valve, Glasgow	**Turnbull, Alex., & Co., Ltd.,** Bishopbriggs, Glasgow
Valve, Liverpool	**Metallic Valve Co.,** Colonial House, Water St., Liverpool
Vanner, London	**Fraser & Chalmers, Ltd.,** 3, London Wall Buildings, E.C.
Vaporiform, London	**Vauxhall & West Hydraulic Engineering Co., Ltd.,** 45, Leadenhall Street, E.C.
Vaporize, London	**Caird & Rayner,** 777, Commercial Road, Limehouse, E.
Vaunting, Manchester	**Vaughan & Son, Ltd.,** West Gorton, Manchester
Vauxhall, Luton	**Vauxhall & West Hydraulic Engineering Co., Ltd.** Luton, Beds.
Vauxhall, Manchester	**Craven Brothers, Ltd.,** Vauxhall Works, Osborne St., Manchester
Velcling, London	**Thomas & Bishop,** 119-125, Finsbury Pavement, E.C.
Ventilation, Liverpool	**Gibbs, John, & Son,** 726, Duke Street, Liverpool
Venture, London	**Jensen & Son,** 77, Chancery Lane, W.C.
Vermehrico, London	**Ransome-verMehr Machinery Co.,** Caxton Hse., Westminster,
Vertical, Leeds	**Leech, Goodall & Co.,** Hunslet (Pepper Road), Leeds [S.W.
Vickers, London	**Vickers, Benjn. R., & Sons,** Leeds
Vickers, London	**Vickers Limited,** Vickers House, Broadway, Westminster, S.W.
Vickers, Sheffield	**Vickers Limited,** River Don Works, Sheffield
Vilvalle, London	**Beardshaw, J. & Son, Ltd.,** 38, Victoria Street, S.W.
Vires, Liverpool	**Brown, W. B., & Co. (Bankhall), Ltd.,** Globe Wks., Bankhall, Liverpool
Viscosity, London	**Trier Bros.,** Caxton House, Westminster, S.W.
Voidance, London	**Hughes & Lancaster,** 16, Victoria Street, Westminster, S.W.
Vulcan, Liverpool	**Henderson & Glass,** Iron Merchants, Liverpool
Vulcan, Paisley	**Fullerton, Hodgart & Barclay, Ld.,** Vulcan Foundry & Engine
Vulpes, Leeds	**Leeds Forge Company, Ltd.,** Leeds [Works, Paisley
Wagner, Dortmunderfeld, Dortmund	**Wagner & Co.,** Dortmund, Westphalia
Wagonload, London	**Pickering, R. Y., & Co., Ltd.,** 3, Victoria Street, W.C.
Wall, Newcastle-on-Tyne	**Wallsend Slipway & Engineering Co., Ltd.,** Wallsend
Waterside, Ipswich	**Ransomes & Rapier, Ltd.,** Waterside Ironworks, Ipswich
Watertanks, Wolverhampton	**Kennicott Water Softener Co.,** Ettingshall Works, Wolver-
Watson, Gainsborough	**Watson, J. S.,** Gainsborough [hampton
Waygood, London	**Waygood & Co., Ltd.,** Falmouth Road, S.E.
Weba, Edinburgh	**North British Rubber Co., Ltd.,** Castle Mills, Edinburgh
Webb, Combs	**Webb & Son** (Combs), **Ltd.,** Combs Tannery, Stowmarket
Wedge, Leeds	**Kaye, Jos., & Sons,** Lock Works, Leeds
Weigh, Leeds	**Denison, Saml., & Son, Ltd.,** Far Hunslet, Leeds, S.
Weldibrit, London	**British Welding Co., Ltd.,** 58, Victoria Street, S.W.
Weldless, Birmingham	**Weldless Steel Tube Co., Ltd.,** Icknield Port Rd., Birmingham
Wellington, Middlesbro'	**Shaw, W., & Co.,** Wellington Cast Steel Foundry, Middlesbro'-on-Tees
Wellocoy, London	**Oil Well Supply Co.,** Dashwood House, 9, New Broad Street, E.C.
Westinghouse, London	**Westinghouse Brake Co.,** 82, York Road, King's Cross, N.
White, East Cowes	**White, J. Samuel, & Co., Ltd.,** East Cowes, Isle of Wight
Whitefield, Glasgow	**Ross & Duncan,** Govan, Glasgow
Whitley, Ashton-in-Makerfield	**Whitley & Valiant, Ltd.,** Ashton-in-Makerfield
Whitworth, Openshaw	**Armstrong, Sir W. G., Whitworth & Co., Ltd.,** Openshaw Works, Manchester
Whizzing, London	**Goodchild, Geo. W., & Partner,** 30-32, Farringdon Road, E.C.
Wiggins, Minories, London	**Wiggins, F., & Sons,** 102, 103 & 104, Minories, E.
Wilburtier, London	**Saunders, J. T., & Co.,** 150, Queen Victoria Street, E.C.
Willans, Rugby	**Willans & Robinson, Ltd.,** Rugby, Warwickshire
Willcox, Southwark Street, London	**Willcox, W. H., & Co., Ltd.,** 23, Southwark Street, S.E. [S.W
Windtight, London	**Harris Patent Feed-Water Filter** (1910), **Ld.,** 82, Victoria St
Windtight, Newcastle-on-Tyne	**Harris Patent Feed-Water Filter** (1910), **Ltd.,** 24, Grainger Street West, Newcastle-on-Tyne
Winn, Birmingham	**Winn, Charles, & Co.,** Granville Place, Birmingham
Witting, London	**Witting Bros., Ltd.,** 49, Cannon Street, E.C.
Woodite, Mitcham	**Woodite Works,** Mitcham Common, Surrey
Wreath, Sunderland	**MacColl & Pollock, Ltd.,** Sunderland
Wright, Tipton	**Wright, Jos., & Co.,** Tipton, Staffordshire
Yarrow, Glasgow	**Yarrow & Co., Ltd.,** Glasgow
Zero, Derby	**Haslam Foundry & Engineering Co., Ltd.,** Derby
Zero, Derby	**Pontifex & Wood, Ltd.,** Union Foundry, Derby

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ENGINEERING.

ERRORS IN CHAIN-SURVEYING.

By Captain J. E. E. CRASTER, R.E.

THE following investigation was carried out in order to ascertain the size of the errors that occur in chain-surveying, and to trace them, as far as possible, to their proper sources. The chain-surveying here referred to consisted of long survey lines, measured across rough country, in all weathers. No special precautions were taken to ensure accuracy or to eliminate errors. Each line was chained once only.

The data for the investigation consisted of 208 lines, chained by forty surveyors. The correct length of each line had been found by trigonometrical triangulation, but was unknown to the surveyors, and in this way the actual error made in chaining each line was ascertained.

A few large errors occurred, and in most cases they were found on investigation to be due to mistakes in booking. In these cases the booking was corrected. The remainder of the large errors were due to unknown and abnormal causes. The inclusion of these abnormal errors would have spoiled the analysis, as it was intended to investigate only the causes of normal errors. For this reason all errors larger than fifty links were rejected. There then remained 196 lines, giving 92 positive and 104 negative errors.

To reduce the data to a form suitable for mathematical analysis, it was necessary to group together all lines of approximately the same length, and to find the mean error of each group. The following statement shows the results of this grouping :

27 lines between 70 and 80 chains in length, mean error 10.21 links.
32 lines between 80 and 90 chains in length, mean error 9.5 links.
23 lines between 90 and 100 chains in length, mean error 10.8 links.
34 lines between 100 and 110 chains in length, mean error 11.53 links.
21 lines between 110 and 120 chains in length, mean error 13.8 links.
30 lines between 120 and 130 chains in length, mean error 13.6 links.

The lines shorter than 70 and longer than 130 chains were too few in number to give a reliable mean error, or to affect the result of the calculations appreciably, and were therefore not included in the subsequent calculations. The errors made in measuring with a chain are of two kinds—namely :

1. Constant errors, due to the chain being too long or too short.

2. Variable errors, due to irregularities in the ground that prevent the chain being laid accurately.

The constant errors, being always of the same sign, will vary directly as the length of the measured line. That is, if d is the difference between the length of the chain and the standard, the error due to this cause in a line n chains long will be $n\,d$.

The variable error made in laying each chain may be sometimes positive and sometimes negative,* and the total error due to this cause will therefore vary as the square root of the length of the line. That is, if f is the variable error made in laying each chain, the total error due to this cause in a line n chains long will be $f\sqrt{n}$.

The final error due to the combination of the constant and variable errors will be the square root of the sum of their squares ; that is, $\sqrt{n^2\,d^2 + n\,f^2}$. Or, if y is the error in a line x chains long, then $y^2 = x^2\,d^2 + x\,f^2$. This is the equation of a hyperbola of eccentricity $\sqrt{d^2 + 1}$ and semi-latus rectum $\frac{f^2}{2}$.

The values of d and f may now be found by inserting for the probable error the mean errors as ascertained from the data, and for the length of the line the mean length of all the lines from which the mean error has been deduced.

Fig. 1. CURVE OF PROBABLE ERROR

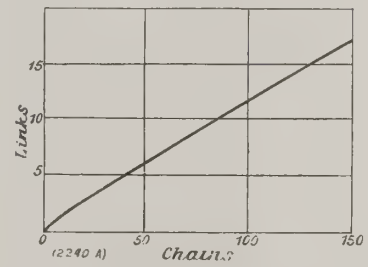
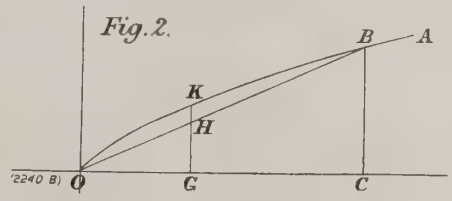


Fig. 2.



In this way the following six equations are derived from the six groups of lines that form the reduced data :—

$$10.2 = \sqrt{(75.3)^2\,d^2 + 75.3\,f^2} \quad . \quad . \quad (1)$$

$$9.5 = \sqrt{(85.4)^2\,d^2 + 85.4\,f^2} \quad . \quad . \quad (2)$$

$$10.8 = \sqrt{(94.3)^2\,d^2 + 94.3\,f^2} \quad . \quad . \quad (3)$$

$$11.53 = \sqrt{(105.1)^2\,d^2 + 105.1\,f^2} \quad . \quad . \quad (4)$$

$$13.8 = \sqrt{(114.7)^2\,d^2 + 114.7\,f^2} \quad . \quad . \quad (5)$$

$$13.6 = \sqrt{(124.1)^2\,d^2 + 124.1\,f^2} \quad . \quad . \quad (6)$$

It will be seen by inspection that these equations are to some extent discordant, and to obtain the most probable value of d and f it is necessary to solve them by the method of least squares. The weights of the equations are the number of lines from which each has been derived, and are as follow :—

No. 1, weight, 27 ; No. 2, weight, 32 ; No. 3, weight, 23 ; No. 4, weight, 34 ; No. 5, weight, 21 ; No. 6, weight, 30.

Solving these equations by the method of least squares, the values of d and f are found to be :—

$d = 0.108067$ link per chain.
$f = 0.375347$ link per chain.

The value of d, the error due to the chain not being the right length, is a good deal larger than might have been expected. This is probably due to the difficulty of standardising the ordinary steel chain, the length of which can only be altered by cutting out, or adding one or more of the small rings that join the links—a tedious and inaccurate process.

The curve of probable error for lines up to 150 chains in length is given in Fig. 1, annexed, and from it the probable error in any chained line may be determined.

When a chain survey is based upon points the distance between which has been determined by trigonometrical triangulation, as in the case of the Ordnance Survey, the greater part of the chain surveyor's errors can be eliminated. This is done by distributing the error uniformly along the whole length of the line. But even after this has been done, there will be a small residual error, because the surveyor's error does not in reality vary directly as the length of the line. The size of the residual error in any line may be found as follows :—

The probable error in a line n chains long will be $\sqrt{n^2\,d^2 + n\,f^2}$. If this error is distributed uniformly along the line, a correction of

$$\frac{1}{n}\sqrt{n^2\,d^2 + n\,f^2}$$

will be applied to each chain length. But the probable error at any point p chains from the beginning of the line is $\sqrt{p^2\,d^2 + p\,f^2}$, and the correction applied at this point is

$$\frac{p}{n}\sqrt{n^2\,d^2 + n\,f^2}.$$

The residual error is therefore the difference between these two quantities ; that is,

$$\sqrt{p^2\,d^2 + p\,f^2} - \frac{p}{n}\sqrt{n^2\,d^2 + n\,f^2}.$$

This may be represented graphically as shown in Fig. 2, in which O A represents the curve of probable error, a hyperbola of which the equation is $y = \sqrt{x^2\,d^2 + x f^2}$.

The probable error of any line of length O C is represented by B C. The error at any point G is represented by G K, and the correction applied at this point by G H. H K then represents the residual error at the point G.

To find the greatest possible residual error in any line, let us assume that the line O C is infinitely long. The point B will then lie on the asymptote to the curve O A, and the chord O B will become parallel to the asymptote. The greatest residual error that can arise will be represented by the vertical distance between the chord and the asymptote.

The equation for the asymptote is

$$y = d\,x + \frac{f^2}{2\,d},$$

and the equation for the chord is $y^1 = d\,x$.

The maximum value for the residual error is $y - y^1$; that is $\frac{f^2}{2\,d}$, or 0.66 link.

On the Ordnance Survey the greatest discrepancy

* Negative errors generally arise through the surveyor allowing the rear end of the chain to slip forward a little when it is pulled taut.

allowed between the chained length of a line and its length as obtained by trigonometrical triangulation is one link per thousand for maps on scales larger than $\frac{1}{2500}$, and two links per thousand for maps on the $\frac{1}{2500}$ and smaller scales. The limit of one per thousand is less than the probable error, and the residual error can therefore never be as great as 0.66 link. An error of this size is represented by a length of less than one hundredth of an inch on the $\frac{1}{500}$ scale, the largest scale used by the Ordnance Survey Department.

An error of two per thousand is rather less than twice the probable error, and the residual error in this case must therefore be less than 2×0.66 links; that is, less than 1.33 links. An error of 1.33 links will be represented by a length of $\frac{1}{250}$ of an inch on the $\frac{1}{2500}$ scale.

The residual error in every case is therefore too small to affect the accuracy of any of the Ordnance Survey maps.

THE INSTITUTION OF CIVIL ENGINEERS' CONFERENCE ON EDUCATION AND TRAINING OF ENGINEERS.

(*Concluded from page 863 of our last volume.*)

As reported in our last week's issue, the Conference of the Institution of Civil Engineers on Education and Training of Engineers was continued on Thursday, the 29th ult., when the proceedings were opened by Dr. W. C. Unwin, who, at 10 A.M., took the chair at a joint meeting of Sections I. (scientific training) and II. (practical training). Dr. Unwin's opening address is reprinted herewith :—

It has been thought desirable by the Council of the Institution to impose on the chairman of a section the duty of saying some introductory words. I think it may be taken for granted that it is now agreed that engineering training should include scientific instruction and practical and commercial experience. But very divergent views are held as to the relative importance of the different components of such a training and as to the order and duration of each. We must recognise at once that the field of engineering employment is a very wide one, and that different capacities are required in different parts of that field. It is therefore in no way surprising that persons whose opportunities of observation give them every right to express a definite opinion as to what is best for one special branch of engineering have arrived at conclusions very different from those held by others, whose field of work has been in a different branch. No system of engineering training can be arranged to meet all special demands, and it is the object of such a Conference as this to find out what is most essential in all courses of training and what modifications are practically possible to meet different cases.

First of all, I think it must be assumed that the engineering education we are specially charged to consider is that of young men whose aim it is to arrive ultimately at a professional status, such a status as membership of this Institution implies. Their hope is to be employed ultimately in the design and control and direction of engineering work. Of course, some of them may fail in capacity or may lack opportunity, and may drift to one of the many more commercial occupations allied to engineering, and even there the knowledge they have acquired will be a valuable asset. But at the outset a professional career is aimed at, and the system of engineering education must be arranged to meet that condition. It is probably only by educating many that the few can be found who have the capacity and character necessary to achieve considerable advances and to do work of national importance.

Now, very few young men at 18 can foresee into what line of employment they may be driven, and consequently the first or undergraduate stage of education must be broad, so as to fit students as far as possible for widely different spheres of work.

Perhaps the greatest defect of engineering education at present is the want of more provision for the higher and more specialised education of the few students of real capacity, discovered in the sifting process of an undergraduate course.

In spite of the general acceptance of the view that a study of scientific principles and their application is a necessary preliminary to a practical course in field or workshop, a certain jealousy of college education is still obvious in some practical engineers. While conceding in words that some scientific education is necessary to an engineer, they would in fact confine it to very elementary matters. They would greatly restrict the time given to it, and they are disposed to depreciate the value of any higher teaching, and even to regard it as mischievous and likely to unfit a man for the strenuous life of the manufacturing workshop.

I believe the idea that a college course unfits a man for practical work is a wholly mistaken one. There may be students who prove unfit for practical work in spite of college education. They would equally fail if their education was purely practical. There may be college courses, I am afraid it must be said there have been college courses, badly arranged, and teachers in colleges less competent than is desirable. But such things are inevitable. Nothing is more certain than that there has been a great improvement of college teaching of applied science in the last 20 years.

An employer who takes into his works college students is, I think, often disposed to expect from them an immediate availability which is unreasonable. It is not the main object of a college course to make a student acquainted with the details of any particular business; that is the proper object of the first year or two of practical work. It is not the main object of a college course to fit students specially for such work as will fall to them while in the lowest rank of the profession. The college course must contemplate the fitting of a student for his whole career and provide him with an intellectual equipment which will only gradually become useful as he rises to higher rank in his profession. The view of the employer who looks only to the immediate usefulness of the student is a shortsighted one.

Nevertheless, a college course is an unpractical and badly designed one if, at the end of it, a student is not more capable and useful from the first, in any type of workshop, than a lad without such a training. The college discipline is bad if he has not much more character and energy than the raw lad. His training has been a failure if he does not pick up the specialised details of any business to which he may be put far more rapidly than an untrained lad. I should like to suggest to those practical engineers who are implicitly, if not openly, hostile to college training, who would, at an rate, greatly restrict it, and who advocate lenghtened periods of workshop apprenticeship, that they exaggerate the value of such workshop experience as an ordinary apprentice gets. I am not, of course, considering the artisan apprentices who have to learn handicraft, but young men expecting to rise to positions of trust. Here and there are works where special trouble is taken with apprentices; but in general apprentices are left to pick up what knowledge they can with very little help, and in many cases, I think, a good deal of their time is absolutely wasted. Some skill of handicraft is no doubt acquired. But the engineer works with his head, not with his hands, and manual skill is of use to him only in exceptional cases.

I hope I do not in any way underrate the value, to mechanical engineers especially, of that kind of knowledge of materials, of tools, of processes, and of cost, which can only be learned in the workshop. But I think practical engineers forget how little of this valuable knowledge really comes to the works apprentice. The engineer of higher rank, who discusses matters with foremen and draughtsmen, who has responsibility for design and cost, and who is in a position to know the reason of all decisions, is learning in the workshop all his life, and naturally sets a high value on the knowledge slowly acquired by years of constant and close observation. So high a value that perhaps he ignores the importance of the scientific knowledge which was, somewhere and by some one, applied in bringing his business to a state in which it can be carried on successfully as a mere manufacture. But the knowledge which comes to those in responsible positions is not open to the ordinary apprentice, and he learns slowly, if at all, unless he brings to the works such a knowledge of principles and methods that he can interpret for himself what he sees. No system of workshop apprenticeship can, I think, be considered satisfactory unless someone is specially charged with care of the apprentices, whose duty it should be to make sure that they have opportunity of seeing a great variety of work and of helping them over their difficulties.

I believe employers will find—some of them have found already—that they owe a debt to the colleges, and that the college-trained student will prove, with a minimum of special experience, a valuable assistant, and in some cases the originator of real advances in practice. I should like to plead that in return the employer might be a little more ready to give college students a year or two years' run of the works, either without remuneration or with a small remuneration, just enough for disciplinary purposes. I do not think there would be any loss in the case of a properly trained student, and the employer would in many cases find an assistant worth keeping and promoting.

The subject down for discussion at the joint meeting was, according to the programme, "the relation of engineering employers and colleges from the point of view of the practical training of engineers." This was opened with two prepared contributions, one by Professor J. E. Petavel, and the other by Mr. J W. Horne. These we reprint in full on page 41 of the present issue. Professor Petavel elaborated a few of his points during the reading of his contribution. He drew attention to the fact that there were three alternatives to choose from. In the first, works training came before college. One objection to this was that a boy, in works, found it difficult to keep up his book-work sufficiently to keep pace with others when he returned to the college, but a second was that the lad lost touch with the employer whose works he had been through. Such a break necessitated a fresh start after college, and that was a handicap. In the second system practical training came after the college. To this there was the objection that the boy by that time was so old that he was not able to get into close touch with the men. The third was the sandwich system, to which one objection was that employers in some cases were not willing to concede the necessary privileges the system involved, as partial employment of the kind upset works routine, while, on the other hand, college courses were arranged for three years. The latter point could be altered; but if engineering students were a class apart, they would drop out of many valuable parts of university life, which, with a session different to that of the other students, it would be impossible for them to join. He pleaded for a broad college training, as it was impossible to foresee what work youths might ultimately turn to. He thought a laboratory convenient in that it brought together many typical machines from which the student might acquire a variety of knowledge which it would be hopeless for him to try to acquire in shops, as that would necessitate a training in 10 or 15 different works.

The Chairman first called upon Mr. Alexander Siemens, who spoke from the point of view of the employer. Manufacturing was carried on, he remarked, not for amusement, but for profit, and it was not practicable in many cases to arrange to take pupils. At the works of his firm they took them when they had vacancies, but it was impossible for them and for others to promise to take a definite number each year. They could not, under any circumstances, take lads who wanted to be away from the shops one or two afternoons a week. Such lads had better stay away altogether. He would remind the meeting that the Commissioners of the 1851 Exhibition had recently instituted bursaries for the purpose of assisting the completion of courses of engineering training in suitable cases.

Professor G. Kapp, with regard to the reference to these bursaries, said that in Birmingham maintenance and scholarship money was now given to lads worth educating. He supported the sandwich system, to which the chief objection was that ordinarily the slices, so to speak, were too thin. The usual college vacation was so short that, after a few days' rest after the examinations, there remained less than three months available for the shops. However, even under these conditions, they found some employers willing to take the lads. Offers were received from firms to take good boys, and such lads would profit, and return to their college work in a much more receptive and appreciative mind. In Scotland the six months' system was feasible. That was better, but was not applicable here, as college life could not be changed for one class of students. He thought the case might be met by a twelve-monthly scheme, or, rather, one year at college and fourteen months in the shops, extended far enough to give a four years' course at college. The lads should, of course, always return to the same works, as the employers thus had an opportunity of sifting out the lads, and at the end of the time the good lads would be able to fill positions of usefulness.

Herr F. zur Nedden said he was moved to speak by Sir William White's reference to Continental methods of training. In 1899 a committee had sat on this subject in Germany, and had come to several conclusions, which they were now, after twelve years' experience, in the act of reconsidering. The first point on which a decision had been reached in 1899 was that one year should be spent in works before the college training was taken. That had worked well on the whole. Secondly, a code of rules had been drawn up, regulating the training to be given in factories; these were, as nearly as was possible, similar to the rules recommended by the Institution of Civil Engineers' Committee of 1906, and were in Germany still adhered to. Thirdly, a list of suitable works had been drawn up—some 500 or so—at which students would be taken and educated in conformity with the code of rules. The last feature had given trouble. Employers would sign the contract required, but in practice found themselves unable to keep to the ideal, because business matters necessarily interfered. Universities had money to expend on salaries, but factories had not, and they could not make efficient arrangements for teaching. The thing had to be on a paying basis. Dividends were so important that the works manager had to consider current expenses. It appeared that the Revision Commission now sitting would probably decide that premiums should be allowed, and that wages could be paid out of this; also that, in additional return, the manufacturers should be bound to encourage the acquisition of knowledge by the students, either by supporting evening classes, providing teachers, libraries, &c. That the student, in return, should take the whole of his practical training at one factory, and would remain there

after finishing his college work for at least six months, in order that the employer might have the opportunity of selecting and engaging such men as might prove of value to him.

Mr. J. F. C. Snell thought it better that the students should proceed to college first, and then to works. There was then no break in theoretical work. The sandwich system was only a compromise. At 22 years of age, after college, a boy would be better able to absorb workshop information than would a raw youth of younger years. The profession had become highly developed, and after college a lad would prove more valuable to an employer. He would be able, for instance, to measure and take observations accurately. He thought insufficient attention had been given at the Conference to the service of drawing-office experience, which really was invaluable. The Institution would do lasting good if it appointed a sectional committee to take up this matter of education and work with the colleges, &c.

Mr. B. Hall Blyth, speaking as a civil engineer, reminded that engineering works and offices were kept open merely for profitable work, and not for educating pupils. He strongly disapproved of the attitude held by some professors that college training fitted a boy to occupy a salaried position in works. Even at the end of four years' practical training there was still much to be learnt, and a college student could not hope to take an active part in work until he had had practical experience.

Professor Wertheimer thought that very few, if any, professors actually held the view just attributed to them by Mr. Blyth. He wished to point out that at Boston, at the Massachusetts Institute of Technology, the boast was made that a post was secured for every student before he left. That was not so here generally, and the fault perhaps lay with the training here. However, at Bristol they had fortunately arrived at such a state. They had had difficulty, but it was past, and now they had more applications for lads than they could supply, employers frequently asking for a lad similar to such or such a one who had gone to them before from the college. He thought that, generally, the engineering students were not discouraged sufficiently. It was for the good of the youths that this should be done. They did not keep all their first-year students in the second year. Parents were advised to withdraw lads who seemed unsuited to the career. For the capable artisan they provided either a long course of evening study leading up to the degree, or scholarships enabling artisan students to stand the risk of leaving work to attend college courses. Bursaries were granted sufficient to support them till they returned to their ordinary avocations.

Sir W. White remarked that the needs of Canada and the United States were so different that no inference could be drawn from Professor Wertheimer's allusion to students over there. Young men trained here could equally well get work over there, provided they did not set employers against them by their conceit in book-work. At the very earliest possible moment it was essential to find out whether a lad had aptitude for an engineering career. Men who could do anything in the way of book-work were often quite unfitted for active engagement in engineering work. He recommended that the first year after school should be spent in works. He thought it obvious that if any lad was to receive teaching anywhere, it must be paid for, and it was right that the employer should be paid, unless he set himself up as a philanthropist, when he probably would not last long.

Mr. H. J. Spooner said he would welcome any step which would bring polytechnics, &c., into closer touch with the colleges. He thought college workshops gave relief to the mental strain, and a lad could learn things in a college workshop which would fit him better for the shops afterwards—for instance, accuracy of measurement, so important now in gauge-work, or the principles underlying machines such as gear-shapers. In some shops the man with a slide-rule had been usefully employed tuning up and increasing the speed and output of tools.

Professor S. P. Thompson had never found engineers openly hostile to college training as Dr. Unwin had suggested. They were eager to get men so trained. He preferred students who had had one year or more in the works. They were more receptive, and had a better idea of the proportionate value of what they were being taught. The six months' system was impossible. At Finsbury they had a two years' course, which could be extended if desired, but which was short enough to be interposed, if necessary, between school and work, or taken afterwards, if desired. Working up specially for degrees was not encouraged.

Mr. W. Patchell pointed out that, for a lad to learn what was worth learning in the shops, he should not be a supernumerary in a gang, such as he would have to be if he attended works for short periods or broken time. That was demoralising to the lad. He must be a useful hand. If present funds were better spent, he thought there would be money enough to deal with the question properly. Instead of poorly educating the mass, more care and money should be spent on those worth educating.

Section II.—Scientific Training.

This section met at 11.30, in the library, under the chairmanship of Dr. W. H. Maw, for the discussion of Professor S. M. Dixon's and Professor C. F. Jenkin's communications dealing with the value of a university degree in relation to professional competence. These communications, which were read by their authors, are reprinted on page 39 of this issue.

The Chairman, opening the discussion, said the paper which had just been read stated very clearly and, he thought, impartially the advantages which might be expected to accrue from the attainment of a university degree in engineering science. The authors were both men of experience, thoroughly acquainted with the work which a university degree entailed, and they both expressed their belief in the good influence which that work would exercise on the future career of the engineering student. He would say that that belief would be very generally shared by those who had considered the subject; but the object of the present Conference was not so much to indulge in beliefs or expectations as to evolve definite information as to facts, and he hoped that in the discussion they might be favoured with the experience of employers and employed as to the real value attached to university degrees in works and offices. It had been sometimes urged that the possession of a university degree should entitle its holder to at once receive, on entering an engineering works, a higher emolument than would be accorded to him if he did not possess such a degree; but from this view he strongly dissented. The commercial value of a young engineer to his employer depended upon a number of qualifications, of which many were in no way connected with his college work, and it would be unreasonable to expect any employer to take the possession of these qualifications for granted simply because a man had obtained a degree. But if the work through which a student had gone to attain his degree was sound, it should serve him in good stead in his practical career, and he might fairly be expected to advance more rapidly than one who had not had a similar training. If this result did not follow, then something was certainly wrong, and the sooner the reason was known the better. The fault, if it existed, might be due to defects in the training for the degree, or might arise from the fact that the period occupied in that training had rendered the student less receptive of the teachings of workshop practice. On this and many other points he hoped that information as to the result of practical experience would be forthcoming in the discussion.

Professor J. E. Fleming said that he was afraid he must advance some unorthodox views. He thought the value of university degrees, as they were at present awarded, was very small. There was nothing to be gained by ignoring facts, and it must be recognised that degrees were obtained as a result of written examinations held against time, and to be successful in which a man had to rely almost entirely on his memory. These conditions were entirely artificial, and corresponded in no way with the conditions met with in practical life. In practice one did not usually work against time, and did not rely entirely upon one's memory. The most useful memory was that which remembered where to find information, not that which simply amassed a quantity. The result of the examination system was that a degree was no criterion of the practical value of the man who possessed it. Candidates in general made far too much of the value of a degree in itself—of the mere letters after their names—and lost sight of the work the degree was supposed to indicate. Practical men thought nothing of degrees, and did not care if their assistants could write half the alphabet after their names. What they demanded was reliability, ability to reason, and accuracy. Some of these qualities could only come as a result of experience. He thought the whole examination system wanted turning inside out, and would like to see much more attention paid to *vivâ voce* work and practical examination. He would like to see the degree system abolished altogether.

Mr. Dugald Clerk said that he spoke as an employer. His experience of B.Sc. men was not so unfortunate as the remarks of Professor Fleming might have led one to expect. He had five men holding B.Sc. degrees in his London office, and they were all in every way practical, and were able to apply their theoretical knowledge in every-day work. He was not so sure, however, as to the place of a man with an engineering degree in a works. At the factory of the National Gas-Engine Company, at Ashton-under-Lyne, they had no B.Sc. men. It should be remembered that the evening classes of this country supplied a large amount of theoretical training, and he thought the class of men who made good works managers very largely received their technical education at them. There were some 700,000 students attending evening classes in England, as compared with about 13,000 in Germany, and the scientific knowledge which was required in workshops was very largely supplied, in England, from these classes.

Mr. A. P. Trotter spoke neither as an employer or a teacher, but as one who had some connection with the University of London. He had sat for eight years as a member of a board of studies for that University, but had always protested against the establishment of a degree in engineering. He did not believe in such things. Degrees should be given for theoretical work, and for things which could be taught at colleges. A degree in engineering or mining was an absurdity. Universities should confine themselves to fundamental principles which they could teach. Engineering could be learnt only in practice, and if universities attempted to deal with practical subjects, such as switchboard design, all they taught would be out of date in three years. We had heard much about university men in practical life in America, but he thought that up to recently the American system had mainly succeeded in producing a remarkable crop of swelled heads. Matters had, however, improved somewhat of late.

Colonel B. R. Ward, the next speaker, said that he noticed both Professor Dixon and Professor Jenkin laid considerable stress on the value of a good general education in students. His experience as a teacher of cadets entirely bore out this idea. He thought it absolutely necessary that students should be well instructed in what the Germans called "knowledge" subjects, such as history. What he might call the dead matter of engineering was, in fact, only half of engineering, and to enable anyone properly to apply that half, it was necessary that they should have a good education on the literary and general side.

Mr. James Glover agreed with Mr. Trotter that universities should carefully avoid attempting to teach the details of engineering, and should confine themselves to the principles. An important reason for this was that it was only while men were young that they could properly assimilate the principles. Later in life, when they were earning their living, they had no difficulty in learning any amount of technical detail; but if they did not grasp principles early, they were likely never to grasp them at all. He was not in agreement with Professor Fleming's somewhat contemptuous view of the value of degrees. When choosing among a number of men he would always be inclined to give preference to those having degrees of any kind. A degree at the lowest always stood for a certain amount of work done.

Professor Silvanus Thompson disagreed from the last speaker, who evidently thought that a degree had a face value. He had one of his own that was not worth sixpence, and never had been. The belief in degrees *per se* was a national failing. We were suffering from the curse of running after degrees simply that we could stick the letters after our names. Too many young men thought of degrees only from this point of view, and cared nothing for the work that the degree was merely an index of. In general estimation the Associateship of the Royal School of Mines was of less value than a B.Sc., but in reality it was of ten times the value. The same thing applied to the diploma given by certain colleges.

At this stage of the proceedings the discussion on Professor Dixon's and Professor Jenkin's papers was terminated by a vote of thanks to the authors, and after Dr. Maw had retired from the chair to make way for Professor Unwin, the three papers on "The Position and Uses of Engineering Laboratories in Relation to Education at College," by Professors W. E. Dalby, John Goodman, and Bertram Hopkinson, were read by their authors. These papers are reprinted on pages 40 and 41 of this issue.

The discussion on the second subject was opened by Mr. R. S. Ball. He began by saying that he agreed with Professor Hopkinson that laboratory apparatus should not be too complicated. He had been at the Massachusetts Institute of Technology for some years, both as a student and a teacher. They had there the best-equipped engineering laboratory in the world. It contained, among all manner of devices, a 200-horse-power triple-expansion engine, in which some twenty students were required to run a test. He thought experimental work of that order was much less valuable than work carried out on smaller and simpler apparatus, on which the students might possibly have to do their own erection. There were 1600 students at Massachusetts; but even in big colleges like that he would prefer to multiply the examples of simple apparatus rather than instal large and complicated machines. On the general question of the value of laboratories in engineering colleges, his opinion might, perhaps, be expressed in the remark of the Irishman, who thought the ocean was a great aid to navigation.

Mr. Dugald Clerk agreed that very much might be done with simple apparatus in laboratories. It was better that a student should have complete control of his own experiment rather than that he should simply take some small part in a large and complicated test. The difficulty with laboratory machinery was that it quickly got out of date, and in some cases manufacturers had loaned modern machines to colleges on the understanding that they should have copies of the reports of all tests carried out. The system was an excellent one for the colleges.

The Chairman, in closing the discussion, said that while it was possible to do very valuable work with small apparatus, it was desirable to have large apparatus in addition. If students were at times engaged on tests of a large engine. they got a much better idea of the scale of practical work than if they spent all their time with quite small machines. A twenty-four hours' trial run of a large engine was an education which students could never get when experimenting by themselves on a small scale.

Section III. (Practical Training).

The remainder of Thursday morning was occupied, so far as Section III. was concerned, with two discussions, which, like the others, did not keep very closely to the subjects chosen. The first was on "The Relation of Practical Training to College Study: whether, or to what extent, before, sandwiched, or after its conclusion." This was introduced by Professor Archibald Barr and Professor H. Louis, though in the absence of the latter that gentleman's contribution was read by Professor Welch. These contributions are reproduced on page 42 of this issue.

The first speaker at this meeting was Mr. H. Rolfe, who pointed out that the requirements of civil and mechanical engineers were totally different. One was concerned with fine work, accurate measurements and fits, interchangeability, &c., which did not enter in the same degree into the civil engineer's work. He would lay stress on drawing-office work. College students failed in designing things on scientific lines alone, not taking into account all the other important factors which influenced the subjects, such as pattern-work, machining, &c. Colleges should recognise these facts, as machines, &c., had to be made for a profit. Mathematical correctness of design might not be able to compete when it came to early delivery and other commercial factors. He was pleased to see that Sir Frederick Donaldson recommended foundry work, forging, and pattern-making at the Arsenal course; without knowledge of these a man was poorly fitted for his work.

Mr. W. B. Worthington said no rule could be laid down to meet all cases, and there was nothing to be gained by standardisation. He thought a boy who was to become a structural engineer should attend college first and then start on his apprenticeship. When going into an office a lad was soon put on structural steel work in order to familiarise him with design. Much of the principle of design could, however, be better learnt in college, and if drafted straight to an office he would waste time there acquiring laboriously mathematical knowledge which could be more quickly obtained at college. He assumed, of course, that the lad would have been given one year of shops first, in either case. To the mechanical engineer the sandwich system was comparatively easy. Work of the kind then encountered was more easily broken off; but in civil engineering a lad might have to break off right in the middle of a job, and on returning find it finished, and would then have to start afresh with something new.

The next speaker was Professor Turner, who supported Professor Barr's plan, but for other reasons. No solution had been reached after 25 years of discussion of this subject because conditions varied to such a degree. The college student required enough knowledge of the shops to be able to appreciate the training value of theory, and conversely with the shop lad. The ideal system could only be followed where every facility was obtainable, and money little object. Under such conditions, he had trained several lads on the three months sandwich system, which had answered admirably. The system was only suited to special cases.

Sir A. Binnie considered that while engineering training had improved, the results were not satisfactory, and the preparation of youths did certainly not fit them for appointments Colleges should have more consideration for their students. Going into a workshop was not civil engineering. Men went out into the world knowing nothing of their profession or its history, of which they themselves had to continue the development. They were narrow-minded, and even mechanical. He would like natural philosophy, as the words were used in their old sense, to be more studied; he wanted a civil engineer to have a knowledge of geology and physiography. He found classical reports and names unknown to candidates he had come in contact with, while there was a considerable degree of ignorance of surveying and the outdoor use of instruments. A man should go to college and get as broad a knowledge as possible. Practical ability was not always necessary. A bridge designer need not be able to do riveting; it was sufficient if he knew what could be done and when it was well done. Colleges should help to fit men to go out into the world. He recommended the study of the difficulties and influences which former engineers had to contend with on large works of which there were so many at hand at home, and better experience would be gained in this way than in time spent in shops.

Colonel Sir E. Raban thought more care should be taken of the average man. The best would care for himself, the worst would, in any case, drop out. He pleaded for a wide general education which developed a receptivity of mind. Men should have a broad grasp of affairs; it was not sufficient to turn a man out an engineer alone. As a constructional engineer had not time to learn everything, it was not possible for him to go through a mechanical course. College laboratories and workshops might be of assistance in such circumstances by giving men some idea of the mechanical side. He thought it impossible to work the sandwich system here, though it was easily possible in Canada, for instance. Some of the men filling the middle grades could well be left to do their own work in the best way possible, and a man with a receptive mind could pick up from such men valuable information of service to him. Attention to the administrative aspect was important, and colleges might give to their students a few indications along these lines. They always insisted on a man passing some time in the head office, where much was to be learnt; for instance, how it was letters could not always be answered the same day. The most important needs were that all should rest on a sound general and not a specialised education; that, if possible, university training should be included, that was, scientific training, with, perhaps, sufficient practical work to appreciate facts; that the men should be got out on to works of the kind they hoped to concern themselves with chiefly, as soon as possible.

The meeting then proceeded to the discussion of the subject of "Workshop Training as a Preliminary to Practical Training in other Branches of Engineering." This subject was introduced with prepared contributions from Mr. J. A. Brodie, Mr. J. M. Moncrieff, and Professor J. J. Welch. These are reproduced on pages 43 and 44 in this issue, but as the time was short, they were taken as read at the meeting. The first speaker was Mr. J. M. Moncrieff, who treated the subject from the civil engineer's point of view. There existed among engineers no attitude of jealousy towards college training, in proof of which assertion he stated that he had that morning come direct from the examination-room. Professors did sometimes think their students qualified to take up salaried positions. He had known cases of degree men applying for posts as assistants. They should not think of such a thing until after they had had practical work, and professors should help to dispel any such notions. They were no good without practical experience, and the age should not be more than twenty-two or twenty-three before they got it. Men could not learn everything, and training had to be kept within certain limits. Practical and commercial influences were non-existent in colleges, and could only be appreciated in actual work.

Mr. Gerald Stoney thought it desirable that the lads should come into close contact with the workmen, and feel the effect of the discipline of the shop. Not everyone could be made an engineer. His firm gave pupils great latitude, and allowed them thick and thin slices on the sandwich system, so that between sixteen and twenty-one years a lad could get three years' works and three sessions at college. Only 3 or 4 per cent., were permitted, however, to do this. If the proportion were larger the scheme would be unworkable.

The next speaker was Mr. C. W. Darley, who believed in college training, but thought that the sooner men got out on to work the better. Especially was this the case with men going out ultimately into the Colonies. Such men needed a great deal of experience before going abroad, because, in many of the Colonies, most of the work was done nowadays by day work, under the engineers themselves without the intervention of a contractor. Three or four years' practical training in England were at least necessary before going out. It would be found that most of the papers read and discussed before the Institution were by men very few of whom had had the advantage of a university training.

Mr. R. J. G. Reid followed, remarking that the papers opening the discussions made insufficient distinction between the needs of civil and mechanical enginers. In the case of mechanical engineering if the boy were to take his works training on leaving school he thought the lad should go first for one year into an engineer's office to find out what there was to be learnt. In the case of civil engineering, college should come first, followed by the office, but the term of apprenticeship need not be so long now as formerly. While he was articled he needed more technical knowledge than he could get in the office, and, therefore, attended evening classes. That need had now been filled by the colleges, and these can prepare the lads with knowledge which would be serviceable to them in the office.

Mr. Walter Hunter thought the speeches showed the Conference had been justified. He wished to read a statement in a letter from Mr. C. Mayne, municipal engineer, Shanghai, to the effect that, in his opinion, the English system of training turned out better men, with theory and practice better balanced, than either the American or Continental systems. The latter especially suffered from too much theory and too little practice.

The Chairman, Mr. Elliott Cooper, then closed the meeting of Section III. with a few general remarks on the discussions. He thought it manifest that detailed instruction could not be given in every branch with the idea of training for some possible future work. Civil engineers certainly needed some mechanical knowledge, but it was sufficient for them to know good and bad work. It was not necessary to make a mechanic of a future civil engineer. What was wanted in men going abroad was sound general engineering and scientific knowledge which would fit him for any post. All countries differed, and men could not be taught this variety of information. The local knowledge he found was nearly always picked up quickly. Nowadays engineers were no longer anxious to take pupils. Work was so specialised that they could not give an all-round training. Lads therefore go straight to contractors. Departmental work did not give such experience as a contractor's office did, but the latter must be a large one to afford good training. If the contractor was merely carrying out the work for engineers, a lad lost one most important part of the training. With regard to the sandwich system, he thought it better that for civil

engineers college should come before the practical training. Their work could not be dovetailed sufficiently to ensure a continual progress. College work was intended to familiarise men with the principles of natural philosophy, and going into works first rather spoilt the lad's appreciation of the facts then put before him. It might be possible to get in some practical training, however, but to break off the course of either one or the other was bad.

CONCLUSION OF THE CONFERENCE.

Shortly after 1 P.M. all three sections assembled in the theatre, and Mr. Alexander Siemens again took the chair. Mr. Siemens first called on Mr. A. F. Yarrow, who submitted that the Council should give its attention to the following :—

1. That the Council of the Institution be desired to use its influence in any way deemed practicable to secure a continuity of study between those public schools where the elements of science are taught and the universities and technical colleges, so that pupils leaving such public schools be suitably trained to follow at once a college course with advantage, so that, as it were, the college course may begin where the school training finished.

2. That, with a view to facilitate the above, a closer connection between the masters who teach science in public schools and the Institution of Civil Engineers is desirable.

3. That the Council of the Institution should endeavour to induce the universities and technical colleges to adopt such terms of study—say six months during the winter—so that the "sandwich system" can be adopted, if desired, which is not possible with the terms now customary.

4. That it is desirable that the Council should endeavour to produce some co-ordination between the colleges and the employers by making a systematic inquiry from the employers as to the conditions under which exceptional students, properly qualified, may be able to get practical training for a period of, say, 24 to 36 months on the "sandwich system" or not, when vacancies in such establishments occur.

Mr. Yarrow's proposals were not put to the meeting, but the President said the Council would take notice of them. With regard to general impressions of the Conference, the President said that gentlemen on the scholastic side complained that they were at a loss to know what they had to prepare the boys for. That, he thought, was probably their fault. He would remind them that some six years ago the Board of Education had tried to introduce the adoption of a standard examination, but the scheme came to nothing, because the schoolmasters could not agree among themselves as to what the syllabus should be. Perhaps another attempt might be made now. Recently at a surveyors' conference a syllabus had been successfully drawn up showing the qualifications which would allow a man to practise anywhere within the Empire. With regard to training he thought it bad to specialise too soon. University teaching should be scientific and wide in scope ; the student should be taught how to learn. Students, he thought, could not make proper use of laboratories unless they possessed some practical knowledge. After passing an examination lads should go for one year to works before college, taking more works experience, of course, again later.

In concluding his remarks the President expressed the thanks of the Conference to the Staff of the Institution, and to the Hon. Secretaries, whose labours had contributed so largely to the success of the meetings.

THE ROYAL AGRICULTURAL SOCIETY'S SHOW.

(Concluded from page 853 of our last volume.)

STEAM-ENGINES.

THE general arrangement of steam-wagons and steam-tractors has now become pretty well standardised, and it is therefore impossible to say more than that vehicles of these types were exhibited by Messrs. W. Tasker and Sons, Limited, of Andover, Wallis and Steevens, Limited, of Basingstoke, William Allchin, Limited, of Northampton, and Fodens, Limited, of Sandbach, Cheshire. We may note, however, that a new type of self-tipping wagon was shown by the Yorkshire Patent Steam-Wagon Company, of the Vulcan Works, Hunslet, Leeds. The special feature of this machine is that the body is mounted on small wheels running on slides, and can be traversed by a screw in a fore-and-aft direction over its frame. In the running position the wagon is supported by the frame from end to end, but for tipping purposes it is run back by the screw so as to overhang the frame, and it can thus be easily tipped. The wagon, in spite of the tipping feature, has therefore a long wheelbase, and is yet not abnormally long over all, when the body is screwed home into its running position.

A well-finished compound tractor with springs to both axles was shown by Messrs. Ransomes, Sims, and Jefferies, Ltd., of the Orwell Works, Ipswich. Full-sized traction-engines of the traditional type were also included amongst the exhibits at this stand. Of these, one was fitted with compound engines, and had its rear axle spring-mounted, enabling it to traverse rough roads at a reasonable speed.

OIL AND GAS-ENGINES.

Messrs. Davey, Paxman, and Co., Limited, of Colchester, show as their principal exhibit a gas-engine capable of developing 30 brake horse-power when running on producer-gas. Details of this engine are illustrated on page 6, Figs. 18 and 19. The producer used is of a new type, which we hope to describe later. The most interesting feature of the engine is the arrangement of gas and air-valves now illustrated. The air-valve spindle passes through the spindle for the gas-valve. Whatever the load on the engine, the air-valve always opens fully, but the opening of the gas-valve is controlled by the governor through the agency of a slotted lever. This lever is always rocked through the same angle by the link which actuates it, but the link which connects it with the gas-valve spindle can be shifted from one end of the slot to the other. When this shifting link is at the end nearest the fulcrum of the slotted lever, the gas-valve remains wholly closed, and when at the other is fully opened at each suction stroke. The position which this link occupies in its slot depends, however, on the governor, which can thus adjust the amount of gas admitted in exact proportion to the load on the engine. The engine has low-tension magneto ignition. The cylinder water-jacket is cast in one piece, and is fitted with a loose liner of hard close-grained metal. The lubrication of the working parts has been carefully considered. The main bearings and camshaft bearings are fitted with chain lubrication, consisting of chains which run in an oil-bath, and carry the oil on to the shaft, where it works along, and is finally thrown off at the ends, and led back to the oil-chamber again. The cylinder is fitted with forced lubrication, and the large and small ends of the connecting-rod are provided with sight-feed lubrication, the large end getting oil in the usual manner through the crank-pin, and the small end from a lubricator mounted in front of the liner. The levers and exhaust-valve are also fitted with lubricators. Only one cam is used to operate the exhaust and inlet-valves, and there are thus no overhung rollers. The roller on the exhaust-lever runs in an oil-bath, and carries a film of oil to the cam, and thence to the inlet-valve roller, thus minimising the wear on these parts.

Leyland Motors, Limited, of Leyland, Lancashire, exhibited three petrol-driven lorries, of different patterns. The largest weighs 5 tons, and is fitted with a four-cylinder engine capable of developing 40 horse-power. There are four speeds forward and a reverse, and the wheels have solid-rubber tyres, and are driven through double reduction gearing running in an oil-bath. An exhibit of a similar character was made by Messrs. J. and E. Hall, Limited, of Dartford, who show a 4-ton and a 5-ton petrol chassis.

The Eagle Engineering Company, of Warwick, showed in the "New Implement" class a 3½-horse-power petrol-engine. In this case the cylinder is fitted inside the water-tank, and thus consists of a mere liner only, which can readily be removed for inspection, if desired. The engine has high-tension magneto ignition, and is fitted with two fly-wheels.

Messrs. Petters, Limited, of Yeovil, Somerset, showed, in addition to their well-known ordinary oil-engines operating on the Otto cycle, two new two-cycle engines. Of these, one is mounted on wheels, and the other is a fixed engine. The crank-chamber serves as the air-compressor, the spent gases being blown out through a side port, when a second port communicating with this crank-chamber is uncovered by the piston. The oil-charge is forced into the cylinder at the end of the compression stroke, so that none can escape through the exhaust port, thus avoiding a frequent source of loss in two-cycle engines. The engine will run on crude oil, and a high economy of fuel is claimed. Forced lubrication is fitted both to the cylinder and to the crank-shaft, the oil supply to each being independent of the other.

Messrs. Barford and Perkins, of Peterborough, had on view one of the petrol-driven road-rollers which was fully described and illustrated on page 347 of our last volume. These rollers, we learn, are now made up to 14 tons in weight, and the ease with which they can be started up and despatched with a supply of repair material to a bad spot on a road is found to have a very favourable effect on the cost of road maintenance. As a "new implement" the firm are also exhibiting a light roller having rolls of riveted steel plate, which can be water-ballasted. This roller is fitted with a two-cylinder Aster engine, furnished with high-tension magneto ignition.

The extreme handiness of the small petrol-engine is reflected in the increasing number of them exhibited year by year at the Royal Show. It is worthy of notice that low-tension magneto ignition seems to be the favourite with the engines of this type of American origin, whilst here the high-tension system is preferred. The American engines, too, are very frequently governed on the plan of holding open the exhaust-valve, whilst here it is more usual to prevent the inlet valve opening. This latter plan, however, involves the use of mechanically-operated inlet valves in place of the more cheaply constructed automatic valves.

A very conveniently-arranged small petrol-electric plant was shown by Messrs. R. A. Lister and Co., Limited, of Dursley, Gloucestershire This was entered in the "New Implement" class, and received the award of a silver medal. The plant consists of a petrol-engine driving a small continuous-current generator, which feeds into batteries. The latter, however, are of very small capacity, their principal function being to render the plant self-starting. On switching on the lights, the generator automatically begins to motor the petrol-engine round, which is thus started, and then drives the generator, so that no heavy continuous demand is ever made on the batteries. When the lights are switched out, the engine stops either at once or as soon as the battery voltage is raised to a predetermined limit.

Messrs. Capel and Co., of 168, Dalston-lane, London, N., showed a variety of petrol-oil and gas engines. Two of these exhibits were entered in the "New Implement" class, the one being a self-contained petrol-electric generating plant, with the engine and dynamo mounted on the same bed-plate, whilst the other was a portable suction-gas plant rated at 14 brake horse-power, and this we illustrate in Fig. 20, page 7. The engine is of the builders' standard pattern, the cylinder having a liner independent of the main casting. Forced lubrication is fitted to the cylinder, whilst the crank-shaft has ring oilers. The gas plant has been designed specially for the conditions in which it is to be worked, and the makers state that it can be run on coke or charcoal as well as with anthracite as the fuel. The steam supply necessary for the producer is obtained by evaporation from a shallow pan fitted below the fire-bars. The heat required for this is supplied in part by radiation from the fire, and for the rest by the device of directing the exhaust gases from the engine into an expansion chamber below the water-pan. The provision of this chamber tends to make the steam supply more or less proportional to the load on the engine, and the chamber, moreover, acts as an effective silencer. The supply of water to the scrubber is provided by a pump driven by an eccentric on the engine cam-shaft, which forces the water through the cylinder jacket and thence into the top of the scrubber. The water finally escapes over a wire-mesh cooler, and the total supply required for a day's run is stated to be very small.

MISCELLANEOUS.

Messrs. W. T. Avery, Limited, of Birmingham, had a most varied collection of weighing machinery. Amongst other exhibits at this stand may be noted an attachment for cattle-scales. In practice, excreta from the animals are certain to collect under the platform, and since a link necessarily passes from this space up into the weighing-cabin, the latter is often invaded by most objectionable effluvia. To prevent this Messrs. Avery fit to this link a bell, the outer edge of which dips into an annular water-trough, which thus completely seals off, from the interior of the cabin, the space below the weighing-platform.

Several patterns of automatic weighing-machines for accurately weighing grain, coal, and fluids were also exhibited. The machine for weighing oil is particularly interesting. The hopper, which forms the scale-pan, when nearly full tilts a little, and

GAS-ENGINE AT THE NORWICH SHOW.

CONSTRUCTED BY MESSRS. DAVEY, PAXMAN, AND CO., LIMITED, ENGINEERS, COLCHESTER.

Fig. 18

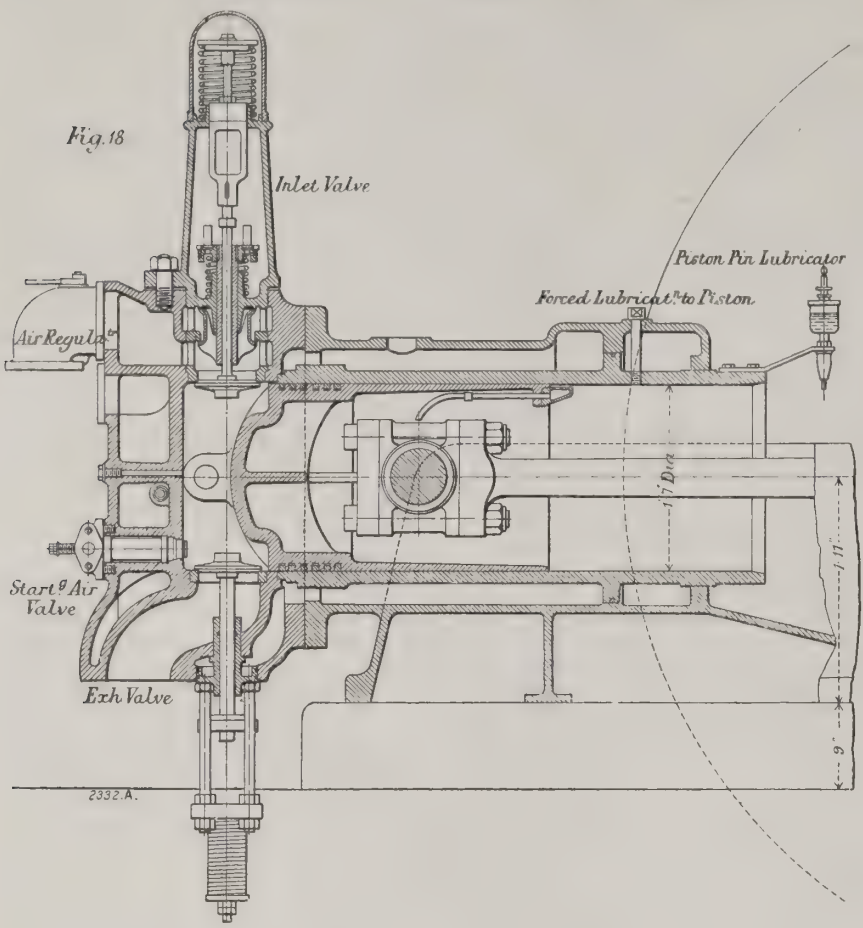
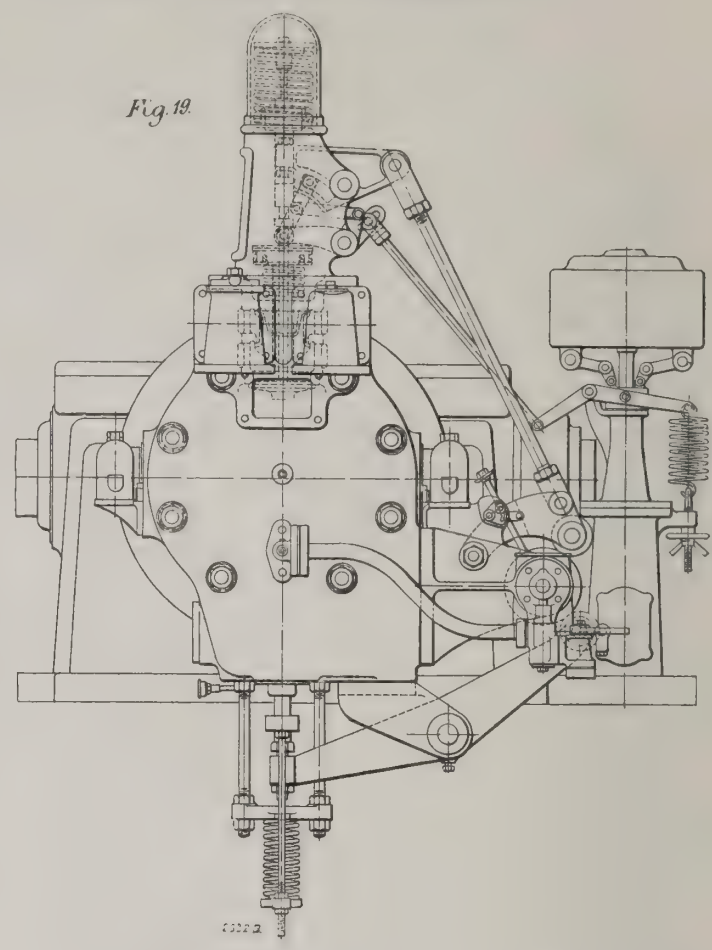


Fig. 19.



in so doing actuates link-work, which reduces the flow of oil to a dribble. When the exact weight has been run in, the hopper falls, and in the act causes a catcher to come in under the oil-spout. In this catcher any residual leakage is caught ready to be discharged into the hopper when it returns for a new charge. In falling the hopper also tilts, and empties the oil out of its forward end. This is shaped so that the liquid collects there and thus keeps the hopper tilted till it is emptied, save for a mere drain. The hopper is then automatically restored into position for filling, but the drain left in its forward end cannot get back into the bottom of the hopper, but is caught by a diaphragm and directed through a port into the general receiver. Hence, the final drain left, when the hopper is restored into the filling position, has all the time occupied in filling to escape in.

The principal exhibit at the stand occupied by Messrs. Holden and Brooke, Limited, West Gorton, Manchester, was a high-lift centrifugal pump, direct driven by a petrol-engine running at 1200 revolutions per minute. The pump shown has three impellers in series, and delivers 100 gallons per minute against a head of 100 ft. The only stuffing-box is at the suction end of the pump, and this is water-sealed. At the delivery end the shaft does not pass through the casing, but there is an internal bearing, and thus no stuffing-box is required here. This internal bearing is completely immersed in the water under pressure, by means of which the end thrust on the series of impellers is balanced. The whole shaft is allowed a slight end-play. If the pressure in the balance-chamber is too low, the shaft moves so as to increase the head there, and *vice versâ*. There is always a slight leakage through a drain from this balance-chamber, and any lubricant which escapes from the internal bearing is carried off through this drain, and does not mix with the water discharged through the delivery branch. Another exhibit at this stand consisted of a series of hand-wheels for cocks, valves, and the like. In these the rim is constructed as a helix of steel wire, and thus never gets hot, no matter what may be the temperature of the spindle on which the hand-wheel is mounted.

A remarkable series of castings of various kinds was shown at the stand of Messrs. Willans and Robinson, Limited, of Rugby. The firm supply complicated petrol-motor castings to many leading builders, but, perhaps, some of the apparently simpler forms exhibited are really of more interest. Thus they show some remarkable specimens of white-metal bushes, which can be put into place without further treatment. Also they produce cast yellow-brass rods, having properties analogous to drawn or rolled metal; and, further, they show some remarkable examples of solid cast-iron bars, which, though very dense and quite free from blow-holes, are yet soft and readily machined. Unfortunately, the methods adopted in producing these castings are specialities of the firm, so we can merely note the results here without elucidating them.

Undoubtedly, the exhibit made by the Associated Portland Cement Manufacturers, Limited, of Portland House, Lloyd's-avenue, E.C., was one of the most interesting in the Show. At this stand were to be seen fence-posts of reinforced concrete, which, whilst cheaper than oak posts, are much longer lived. Such posts are made in single moulds, the work being quite within the capacity of ordinary farm labour. Generally, sand and gravel are obtainable locally, so that freight has to be paid only on the cement. Water-tanks, likewise made of reinforced concrete, were also on view. These are reinforced with iron rods round the corners and wire netting elsewhere. A 100-gallon tank thus made costs about 11s. for labour and materials. This figure is exclusive of the mould, but as the same mould can be used for as many tanks as the farmer cares to instal, the amount to be attributed under this head to each tank is small. The mould in question is made of wood, and is thus light and easily transported. Block-making machines for making blocks for building purposes were also on view. Such blocks are now finding much favour in certain districts. One colliery company alone has erected 600 cottages built out of moulded concrete blocks. The cost of construction is stated to be generally much cheaper than with brick. The labour needed is less, and the blocks being much larger, the number of joints and the amount of mortar required is greatly reduced. The mixture usually used is about 4 to 1, and one machine will easily make per day 400 blocks measuring 16 in. by 9 in. by 9 in. Drain-pipes of cement-concrete were also shown, and were claimed to be substantially cheaper than the common tile pattern, though equally durable.

The most notable feature amongst the mill machinery exhibited by Messrs. Thomas Robinson, Limited, of Rochdale, was a plan-sifter in which, by adopting two cranks instead of one, vibration is entirely eliminated. This has also had the effect of reducing the power consumed by about a quarter. The same firm also exhibited a large range of wood-working machinery, in particular a two-spindle saw-bench for dimension sawing, with which very accurate work can be accomplished.

The Electrical and Ordnance Accessories Company, Limited, of Aston, Birmingham, showed samples of the Timkin roller-bearing, which has already been described and illustrated in our columns (see ENGINEERING, vol. xc., page 696). This is, of course, of American origin, but its manufacture has been greatly improved at the Aston Works. In motor-car service it has proved most reliable, and is, we understand, likely to become the standard type of bearing used on the omnibuses of the General Omnibus Company, who have made a very extended trial of it, with highly satisfactory results. Single bearings capable of taking a load of as much as 6 tons are now supplied.

A great variety of engineering sundries was exhibited at the stand occupied by Messrs. W. H. Wilcox and Co., of Southwark-street, London, S.E. These included Penberthy injectors, semi-rotary pumps, and also the ingenious slide-valve, seat facing-machine which we illustrated when it was first exhibited at the Gloucester Show of the Royal Agricultural Society.

Fastnut, Limited, of 60, Aldermanbury, London, E.C., exhibited, in addition to their well-known washers, a range of spanners, each jaw of which will take three sizes of nut, automatically adjusting itself to the grip required.

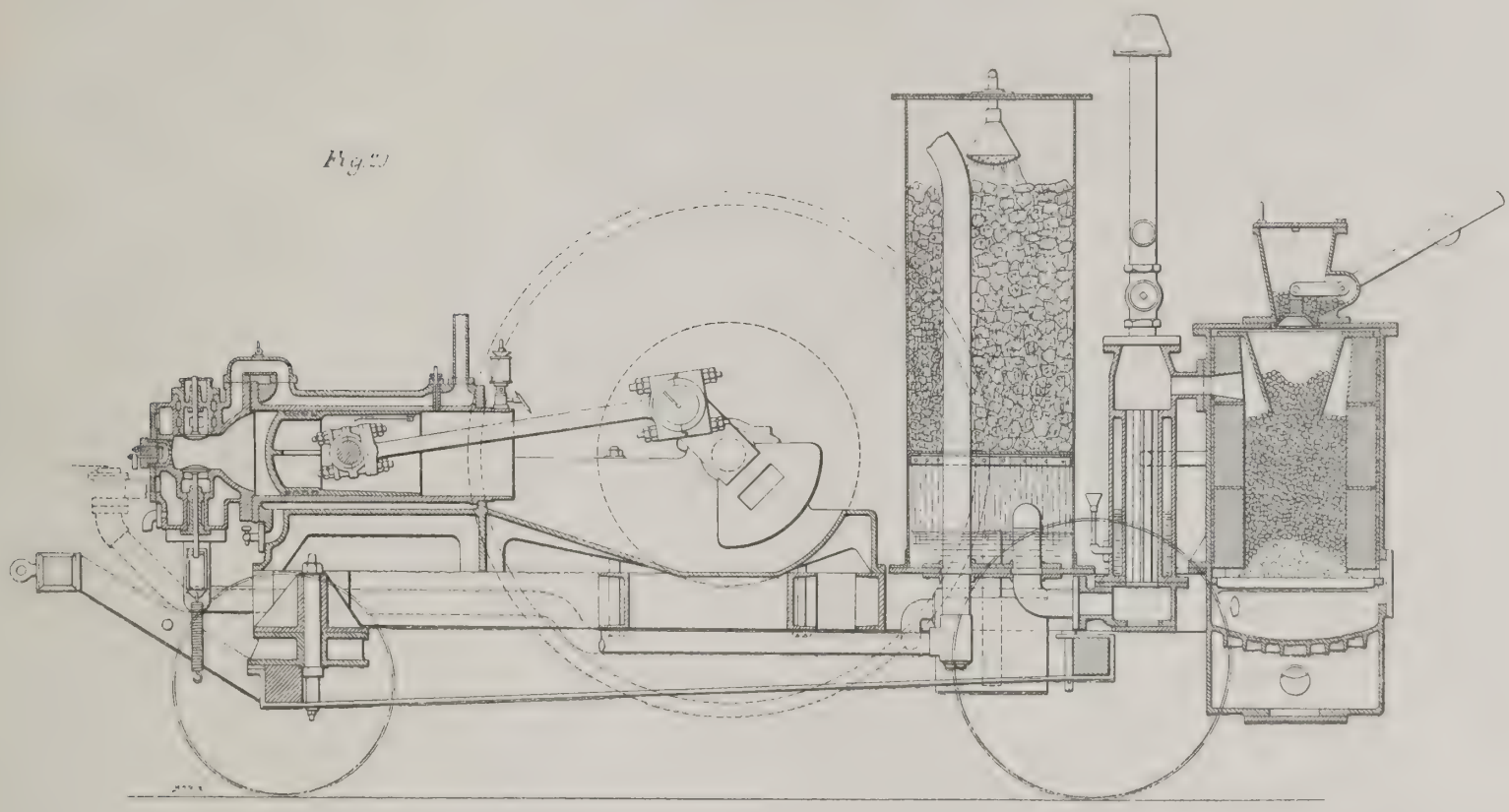
A very interesting exhibit was that of the Palmer Tyre, Limited, who showed in operation one of the ingenious machines used in laying the cords for a Palmer tyre.

The International Harvester Company of Great Britain, Limited, of 80, Finsbury Pavement, E.C., exhibited for the first time at a Royal Show a harvester and binder in which the binder attachment is driven by a small air-cooled petrol-engine.

PORTABLE SUCTION GAS-PRODUCER AND ENGINE.

CONSTRUCTED BY MESSRS. CAPEL AND CO., ENGINEERS, LONDON.

(*For Description, see Page* 5.)



DUNSTON POWER-STATION OF THE NEWCASTLE-ON-TYNE ELECTRIC SUPPLY COMPANY.

In the series of articles dealing with the generation and distribution of electric power on the North-East Coast, which appeared in our previous volume, reference was made to the new generating station which the Newcastle-on-Tyne Electric Supply Company, Limited, were building at Dunston-on-Tyne. No extended description of the station was, however, included in the articles, and we now propose to deal with it in some detail. The station was formally opened on the 5th inst., when a large number of colliery engineers and others visited it.

The construction of the Dunston station was decided upon, about three years ago, in order to enable the power company to cope with the business, which was increasing at the rate of about 20,000 horse-power a year. Although there was still some spare land available at Carville, it was considered better to locate the new installation of generating plant higher up the Tyne. This course was dictated partly with the idea of obtaining plenty of spare land in the neighbourhood of the station, to which it was hoped that new works requiring a large power supply would be attracted as a result of the advantageous terms which could be arranged. The company is already supplying large electro-chemical works near Carville, but the land available for further developments in that neighbourhood is not large, whereas at Dunston the spare land near the station is sufficient to meet the requirements of many years. The new station is built on a site of about 30½ acres, situated on the south bank of the Tyne, about three miles above the High Level Bridge at Newcastle, and some eight miles by river from Carville. The general lay-out of the station follows the unit principle which has long been advocated and practised by the consulting engineers, Messrs. Merz and McLellan, and does not depart in any radical way from other stations built by the same gentlemen. Various modifications and improvements on previous practice suggested by experience have, however, been incorporated into it, and both in virtue of its size, and as an example of the latest practice in power-station construction, the whole installation at Dunston is of much interest.

The general lay-out of the station is well shown in Figs. 1 to 3, on Plate I. It will be seen that it is divided into three main parts, consisting of a coal-store, a boiler-house, and an engine-room. The existing and prospective plant is shown in these figures, but rather than deal with this for the moment it will be well to treat each part of the station in detail, beginning from the coal-store. The noticeable thing about the main buildings, as about those at Carville, is the absence of brickwork and masonry. The whole erection is a steel-framed structure, containing generating plant, and not an architectural building, in which the plant is afterwards placed. The buildings are, in fact, entirely self-supporting, independently of any brickwork, and they are arranged so as to be extended at the minimum possible expense, the walls consisting in the main of corrugated iron and glass. This is well shown in Fig. 5, on Plate II., which is a view of the interior of the engine-room.

Coal-Store.—The coal-store comprises a corrugated iron roof supported on steel girders rising to a total height of 92 ft. from the ground. It is ultimately intended to have additional floors in this store, should it be necessary to increase the capacity, the subdivision of the coal with floors being advisable for ventilating purposes. The coal enters in trucks by railway sidings, shown at the right-hand side of Fig. 2, from which it is discharged into the coal-filler pit. Ultimately it may reach the power-station by river. The coal-conveyor runs from end to end of the coal-store and boiler-house, and is so arranged that the coal can either (*a*) be lifted out of the trucks and deposited in the store, or (*b*) be taken from the trucks and deposited in the coal-bunkers above the boilers, or (*c*) be lifted out of the store and deposited in the bunkers. The coal-handling plant consists of one coal-receiving hopper, into which trucks dump, one four-roll coal-breaker (to crush coal to pass a 2-in. ring), one jigging-screen and gear, and one gravity bucket-conveyor.

From the hopper over which the coal-siding passes the coal gravitates through a regulating-valve at the bottom on to the jigging-screen, from which the screened coal passes direct through a shoot into the stationary automatic filler, into which also the large pieces, after being broken in the coal-breaker, also pass. As will be seen in Fig. 1, the conveyor drive is placed on top of the coal-bunkers, whence the coal-buckets descend at the engine-room end of the boiler-house and pass through the boiler-house basement. When required the coal can be taken from the store by means of hopper shoots fitted with regulating-valves at the bottom, which feed a portable automatic filler delivering into the conveyor-buckets. The conveyor at the present time can handle 40 tons of coal per hour, and is capable of being speeded up above this rate.

Ash-Handling Plant.—The ash-handling plant is quite distinct from the coal-conveyor, and consists of hand-propelled ash-wagons running on rails laid below the ash-hoppers under the boiler-house floor. The arrangement can be best seen in Fig. 3. The rail-tracks along each side of the boiler basement are connected by a cross-over. At the end of each track there is a vertical hoist suitable for raising and automatically tipping the wagon into an ash-bunker. Each hoist and winch can lift, tip, and lower one half-ton ash-wagon in 15 seconds. The winches are driven by induction motors. The ash-bunker, which is situated between the coal-store and the boiler-house, can hold 100 tons of ashes. The bottom of it has a shoot and regulating-valve for discharging ashes into a railway wagon.

Boiler-House.—It will be seen from the plan, Fig. 2, that there is at present one boiler-house, although the station is designed for three. Each boiler-house will contain eight boilers in two rows of four, each row being sufficient for supplying one turbo-alternator unit. There is one coal-store, boiler-house, and set of coal-handling plant for each set of eight boilers, and one boiler-house to each two turbo-alternator units. There is one main steam-pipe, feed-water pipe, hot-well, feed-pump, and set of ash-conveying plant for each set of four boilers. There is one chimney and fan-motor for each two boilers, and there is one economiser, coal-shoot, and ash-shoot for each boiler. In the engine-room each turbo-alternator unit has a complete set of condensing plant and other auxiliaries normally driven from its own "unit" transformer; there being, however, one circulating-pump pit for each pair of circulating pumps. Unlike the arrangement at Carville, there is one set of common main bus-bars, divisible into two sections.

The boilers are of the Babcock and Wilcox marine type. Each unit of two boilers, stokers, superheaters, economisers, fan and chimney, can evaporate continuously under working conditions 60,000 lb. of water per hour, to steam at 200 lb. per square inch above the atmosphere, and superheated to 572 deg. Fahr. at the turbine stop-valve. With coal of 11,000 B.Th.U., under these conditions, the coal consumption does not exceed 4125 lb. per hour. Each boiler has a heating surface of 6725 sq. ft. and a grate area of 168 sq. ft. When forced each boiler can evaporate 37,500 lb. per hour under the same conditions. Each boiler is provided with a complete set of safety, steam, superheat, blow-off, feed, isolating, and other valves, as well as gauges, &c. The larger valves are Hopkinson's, and the smaller ones Dewrance's manufacture. There is a set of fixed tube-cleaning jets, and special arrangements have been made in the boiler casing for enabling samples of the furnace gases to be obtained at different points, while there is a mercury cup for thermometers, fitted to each superheater.

The boilers are carried on steel girders raised on steel columns independently of any brickwork—*i.e.*, all brickwork is removable without disturbing the boilers. The casing-plates of the boilers and superheaters are lined throughout with firebrick and "cellinsulite" slabs. The chain-grate stokers are fitted with wheels on the side frames, so that they may be run out on rails to facilitate repairs and cleaning.

The stoker driving-gear motors have overload spring clutches. A separate motor and driving gear is provided for each boiler. The general arrangement of the boiler can be seen in Figs 1 and 3, while Fig. 6, on Plate III., is a view inside the boiler-house showing the stokers.

Vertically above each boiler there is a Green's economiser, complete with motor-operated scrapers. Each economiser has 288 pipes, and under normal conditions the temperature of the flue gases is reduced to 300 deg. Fahr. at the base of the chimney, while the feed-water is raised from 80 deg. Fahr. to not less than 212 deg. Fahr. at boiler pressure. The economiser-house is an unusually clean and well-lighted place situated near the top of the boiler-house, 55 ft. above the floor level. The bottom of each economiser soot-chamber is arranged with slopes ending in a sliding door. Under these doors there is a line of rails running the full length of the boiler-house, with a movable soot truck, from which the soot is discharged into a hopper placed at one end of the boiler-house, whence it can be discharged into railway wagons.

Each pair of boilers has a chimney and a Davidson "Sirocco" induced-draught fan with water-jacketed bearings arranged with spherical seatings, wide gun-metal rings and large oil-wells, for continuous running. In this detail, as indeed may be noticed throughout the station, there are signs of special care being taken to permit of continuous running without difficulty. The whole design and arrangement of the boiler-house and its details is particularly symmetrical, and there is a marked absence of dark corners, awkward pipes and difficult passages. There is easy access and good lighting for all parts. One of the fans with its motor is illustrated in Fig. 9, on Plate IV.

Before leaving the boilers the steam-piping arrangement should be noticed. From each of the two rows of boilers the steam main is led down into its own main steam-receiver on the engine-room basement floor, whence rising pipes are taken to the steam-separator, and thence to the turbine stop-valves. Another steam-pipe joins the two main steam-receivers together through a U-bend situated between and beneath the turbines. The arrangement may be followed from Figs. 1 and 2. The steam-pipes are of solid-drawn mild steel, with flanges of forged steel, faced straight across after fixing to the pipe. Pipes of 7 in. in diameter and upwards have riveted flanges with beaded pipes. Smaller pipes have flanges screwed on to the pipes, which are then expanded. In most cases the branches on pipes 6 in. in diameter and over are fitted and riveted to the main pipes, but in some cases cast-steel T-pieces are used. Valves under 2 in. in diameter have gun-metal bodies, while larger ones have cast-steel bodies with phosphor-bronze fittings. Valves 5 in. and upwards have gun-metal by-passes. Joints are made with Dixon's graphite and stamped corrugated-metal rings.

The feed-piping is in the form of a complete ring, divided by means of isolating valves into separate sections for each boiler, so that each economiser can be fed from either of two adjacent sections, while each boiler can be supplied direct from the main when the economiser is isolated. The feed-pipes are solid-drawn steel heavily galvanised, T-pieces and bends being of cast iron. The blow-off pipe is of lap-welded steel, and feeds into a boiler-shell used as a blow-off sump. Exhaust and escape piping is also of lap-welded steel. Drain reservoirs are fixed on each side of the boiler-house, beneath the pump-room, in which all high-pressure clean drain water is collected and pumped back to the hot-well.

The water services provided for are five in number: (*a*) Fresh-water service from the town main to the tanks and distribution mains, and from tanks to hydrants and hot-well. (*b*) Salt-water supply (from river) from circulating water pipes to pumps, from pumps to tanks, from tanks to hydrants in the coal-store, boiler-house and engine-house, to fan-cooling water service and connections in other pipe mains This service also supplies the turbine bearings and oil-coolers. (*c*) The service from the salt-water tanks to the high-pressure pump, and from the pump to boiler-tube cleaning hydrants. (*d*) Air-pump discharge from pump to hot-wells, with branches and shut-off valves, so that it can be connected up to a special weigh-tank. (*e*) Circulating-water piping and valves to connect apparatus between main inlet and discharge-pipes.

There are two cast-iron hot-well tanks, each of 720 cub. ft. capacity; one cast-iron clean drain-tank of 80 cub. ft. capacity, and four cast-iron reserve water-tanks for fresh and salt water. Each hot-well has a Schilde water-meter arranged to meter either the whole quantity of the water passing through the feed-pumps or only the amount delivered direct from the air-pumps.

The lagging in the boiler-house consists of Newall's magnesia non-conducting composition with a canvas cover painted with bitumastic paint, the flanges being treated in the same way. Sheet lead is used as a protection on the boiler-drums.

In addition to the apparatus already mentioned there is a Paterson water-softening plant at the top of the pump-room.

Engine-Room.—Passing from the boiler-house up a few steps into the engine-room, the first things to be noticed are the feed-pumps, placed here out of the dust of the boiler-room, in the full light and on the level with the turbines. Steam feed-pumps have been adopted, there being three (one spare), of Messrs. Clarke, Chapman, and Co.'s make, to each boiler-house, each of which is capable of delivering 200,000 lb. of water per hour when working with and against a boiler-pressure of 210 lb. per square inch. Arrangements are made for reducing the amount of superheat delivered to the pump-cylinders, which have to work without any lubrication, the steam-pistons being very deep and having grooves for water packing. The exhaust steam from the pumps goes into the adjacent hot-wells through an exhaust-steam heater, there being a by-pass to the atmosphere if required.

Turbo-Alternators.—The engine-room at present is large enough to contain four turbo-alternators of 8000 kw. each. Three of these have already been installed. The first two sets were of the A.E.G. manufacture, while a third, of the Parsons type, by Messrs. Brown, Boveri, and Co., and Messrs. Richardsons, Westgarth, and Co., has now been put down. The particulars of this latter set are as follow:—The steady speed of the machine does not vary more than 2¼ per cent. between no load and a load of 5600 kw., this steady speed being attained in 5 seconds. A mechanical safety governor is provided to cut off the steam when the speed rises to 1400 revolutions per minute, and this can be tripped by hand. The alternator is of the rotating field type with steel slip-rings, and approximately gives a wave of the sine curve form. The direct-coupled exciter gives 220 volts, and arrangements are made so that excitation of the exciter field can take place from the direct-current system. The voltage regulation is as follows:—When the alternator is giving 5750 volts the throwing off of a non-inductive load of 553 amperes causes a rise not exceeding 10 per cent., the speed and excitation remaining constant, and in throwing off a load of 628 amperes with a power-factor of 0.9 the rise does not exceed 20 per cent. The exciting circuit is so arranged as to allow the alternator voltage to be raised from 5000 volts at no load to 5750 volts at 7000 kw. with a power-factor of 85 per cent., this being obtained when the windings are hot or cold. When delivering 5600 kw. continuously with a 0.9 power factor, the temperature rise does not exceed 45 deg. Cent. above the atmosphere measured by the thermometer, nor more than 50 deg. Cent. when delivering 6250 kw., and the alternator can deliver without dangerous heating, 6250 kw. continuously, 7000 kw. for one hour, and 9000 kw. for two minutes with a power-factor of 0.9. The condenser of the machine can pass 630,000 gallons of water per hour, and can condense 81,500 lb. of steam, and give a 97 per cent. vacuum and 95 per cent. vacuum when condensing 108,000 lb. of steam per hour, with circulating water at 50 deg. and 85 deg. Fahr. respectively.

Three-throw Edwards air-pumps are employed, and an auxiliary pump for raising the air-pump discharge to the hot-well, driven from the air-pump crank-shaft. The circulating-water pumps, which are placed in a pit, take 165 brake horse-power. All the motors in connection with the condensing plant are of the three-phase squirrel cage semi-enclosed type at 480 volts, and they will keep in step down to 300 volts.

Particulars of the A.E.G. sets are as follow:—The maximum output of each machine is 8000 kw. at 5750 volts and 40 cycles per second, the power-factor being unity. The turbine governors are arranged so that speed can be varied 5 per cent. above or below the normal speed while running. This regulation can be effected by hand, or, as is normally the case, electrically from the control-room. The steady speed of the machines does not vary more than 3 per cent. between no load and economical load, and varies less than 5 per cent. between no load and maximum load. There is a mechanical safety governor which cuts off steam when the speed rises to 1320 revolutions per minute, and which can, if necessary, be operated by hand.

The alternators have rotating fields with steel slip-rings and carbon brushes. The wave form is practically sinusoidal. The stators are in two pieces. The rotor windings are excited from exciters fixed on the shafts of the alternators, without outside bearings. The field winding and exciter are such as to allow the voltage of the alternator to be raised from 5000 volts at no load to 5750 volts at 8750-kilo-volt-amperes, with a power-factor of 85 per cent., hot or cold. The terminals are underneath the machine, and the cables are taken out through iron pipes laid in the foundations in such a way as to prevent any accidental contact with live metal. Arrangements are made for earthing the neutral point of the stator through a resistance. The arrangement of the end windings of the alternators are shown in Figs. 18 to 22, on page 9, while a view of the steam end of one of the sets is given in Fig. 10, on Plate IV.

The ventilation arrangements are important. Air is drawn from outside the building by means of a fan on the rotor-shaft, and sent out again through large galvanised iron ducts. These ducts debouch on the north side of the engine-room. The intakes are provided with a filter constructed of blanket carried by wooden frames When the turbines are running at no load and 5750 volts the drop of voltage in throwing on a non-inductive load of 700 amperes is 18 per cent., the speed and excitation remaining constant. The rise of voltage on throwing off a non-inductive load of 700 volts at the same pressure does not exceed 15 per cent.

Surface-condensers are employed capable of dealing with 450,000 gallons per hour of condensing water. When condensing 80,000 lb. of steam they maintain a steady vacuum of 97 per cent., and a vacuum of 95 per cent. when condensing 120,000 lb. of steam, with condensing water at 50 deg. Fahr., the air-pump discharge being at 85 deg. Fahr. The tube-plates are of rolled brass, secured to the shell by delta-metal collar-studs. The tubes themselves are of 99.5 per cent. copper. There is a complete set of valves and gauges, including relief-valve, and vacuum-breaking cock. Three-throw Edwards air-pumps are employed, direct-coupled to three-phase motors, and an auxiliary pump, with electric motor, is used for raising the air-pump discharge to the hot-well.

The circulating-pumps involved some special arrangements. The pumps themselves are situate below the level of the river in pits, 20 ft. 6 in. in diameter and 30 ft. deep, in the engine-room floor, there being one to each pair of pumps and turbines. The pumps are operated through vertical shafts by means of three-phase motors of 80 horse-power, situated on the engine-room floor. A small charging-pump is provided, also operated by a vertical shaft from a motor at the engine-room level, in each pit. The circulating water-pump motor has its weight taken by thrust collars of brass in the upper bearing.

Switch Gear.—The switch-gear arrangements at Dunston are, perhaps, the most interesting part of the station, showing as they do a considerable modification on previous practice. Instead of the usual elaborate switchboard, which forms a striking feature of most power-house engine-rooms, as at Carville, for example, the Dunston engine-room contains practically no high-tension switch-gear or electrical instruments at all. With the exception of certain high-tension panels of "Ironclad" type controlling the unit transformers which supply the auxiliaries belonging to each generating unit, and an indicating wall-ammeter for each generator, the high-tension gear and instruments are installed in a separate switch-house 150 yards away from the engine-room, where are placed both the main switches themselves and the operator and board controlling them. There is, however, in the engine-room near each generator a set of emergency gear for tripping the main high-tension generator switches, with which is interlocked a field switch. Apart from these and the direct-current gear for motor-generators, there are practically no electrical connections or cables visible at all in the engine-room.

The switch-gear may be conveniently separated under the following heads:—

The Control-Boards—in the control-room, for operating the high-tension switch-gear in the switch-house and engine-room.

Main High-Tension Switch-Gear—in the switch-house, controlling the generators, feeders, main bus-bars, and the station power and lighting transformers.

High-Tension Switch-Gear—in the engine-room, for controlling the "unit" transformers in the engine-room.

Low-Tension Gear—three-phase gear in the engine-room, controlling the auxiliaries, and direct-current switch-gear for exciting, lighting, battery-charging and locomotive-driving.

The Switch-House.—The switch-house is a building with concrete roof, 135 ft. long by 33 ft. broad by 32 ft. high. It has two floors, and is divided into two divisions. The front of the building contains, on the ground floor, the offices, lavatories, &c., for the control-room engineers. The control-room itself, containing the operating boards, is on the first floor of the building. The back part of the building, shut off by iron doors, is devoted to the switch-gear itself, the main oil-break switches and bus-bars being on the upper floor, the isolating switches, potential transformers, &c., being in brickwork cells on the lower floor. The bare high-tension connections between main switches, bus-bars, &c., are on the underside of the roof of the lower room, in full view and accessible from the lower room, with ladders, but out of reach of accidental contact.

The Control-Room.—The control-room is a well-lighted department, 40 ft. by 30 ft., with part glass roof. It is mainly occupied by the semi-circular operating switchboard for the feeders, and the smaller board for the generators. With a view to simplicity and facility for extensions, the various operating panels are arranged so that it may be possible at any time to change the particular feeder controlled by any individual operating panel. The control-gear is operated by means of direct current, at a pressure of 100 volts,

DUNSTON POWER STATION OF THE NEWCA

MESSRS. MERZ AND McLELLAN,

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Fig. 1.

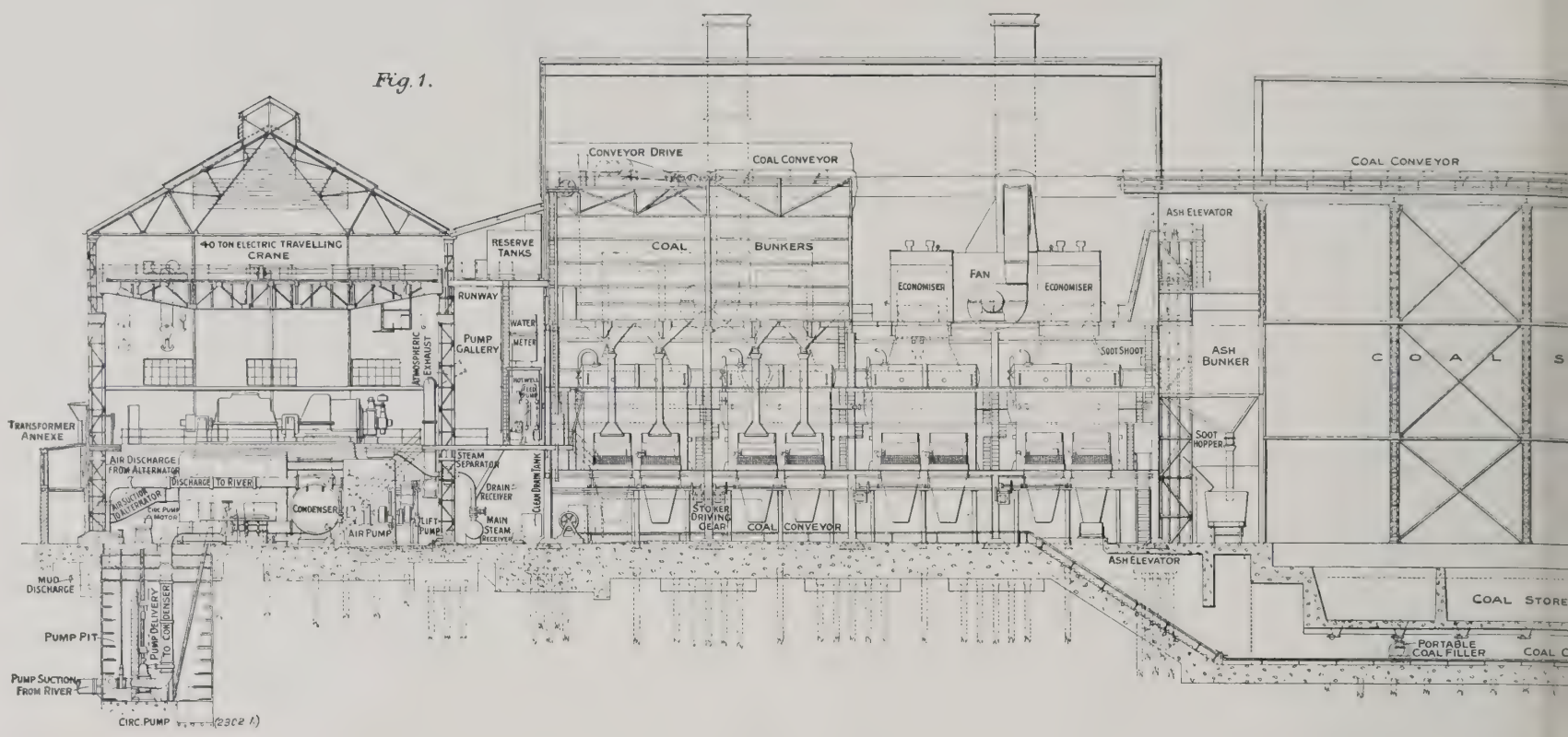

Fig. 2.

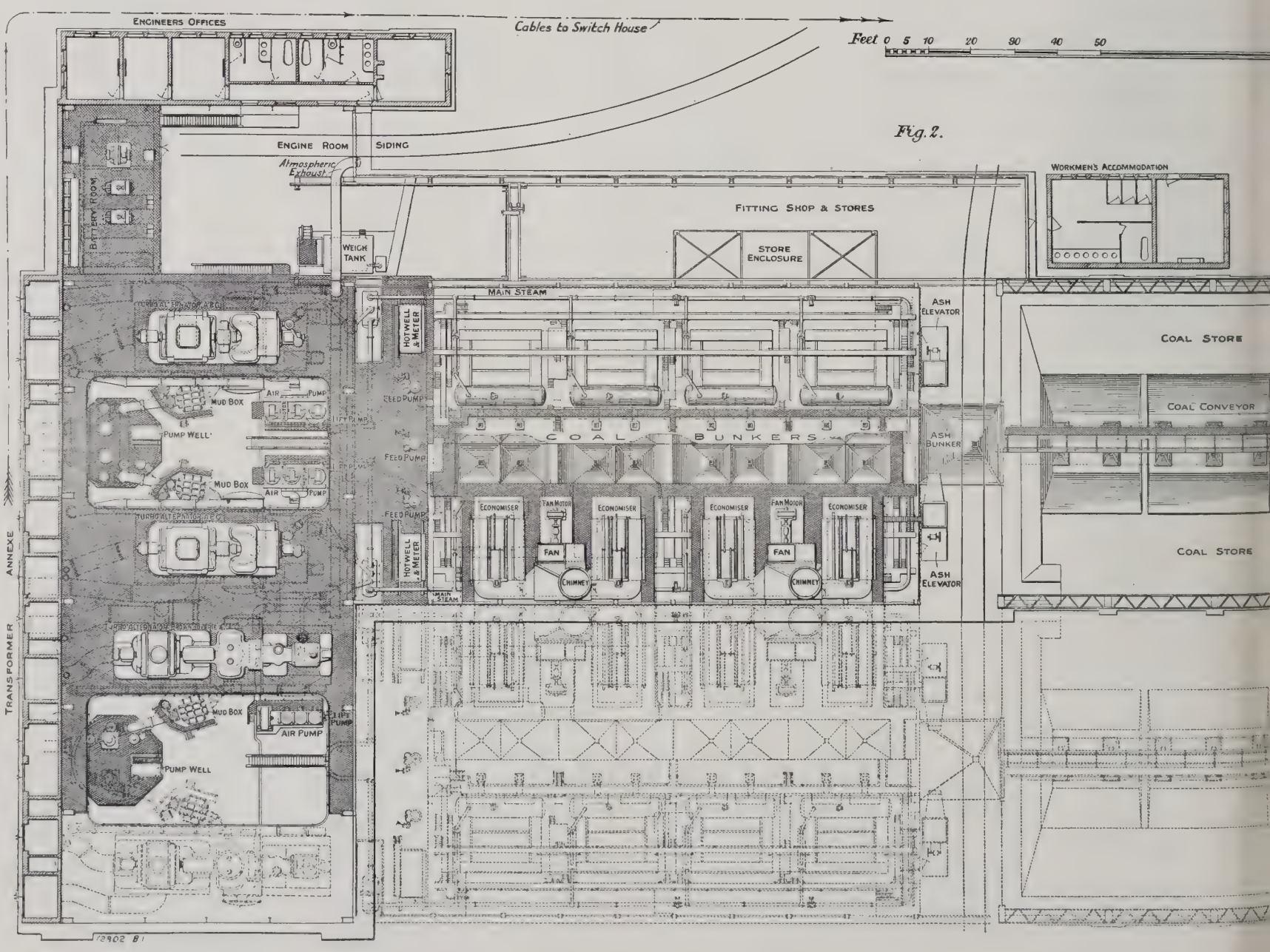

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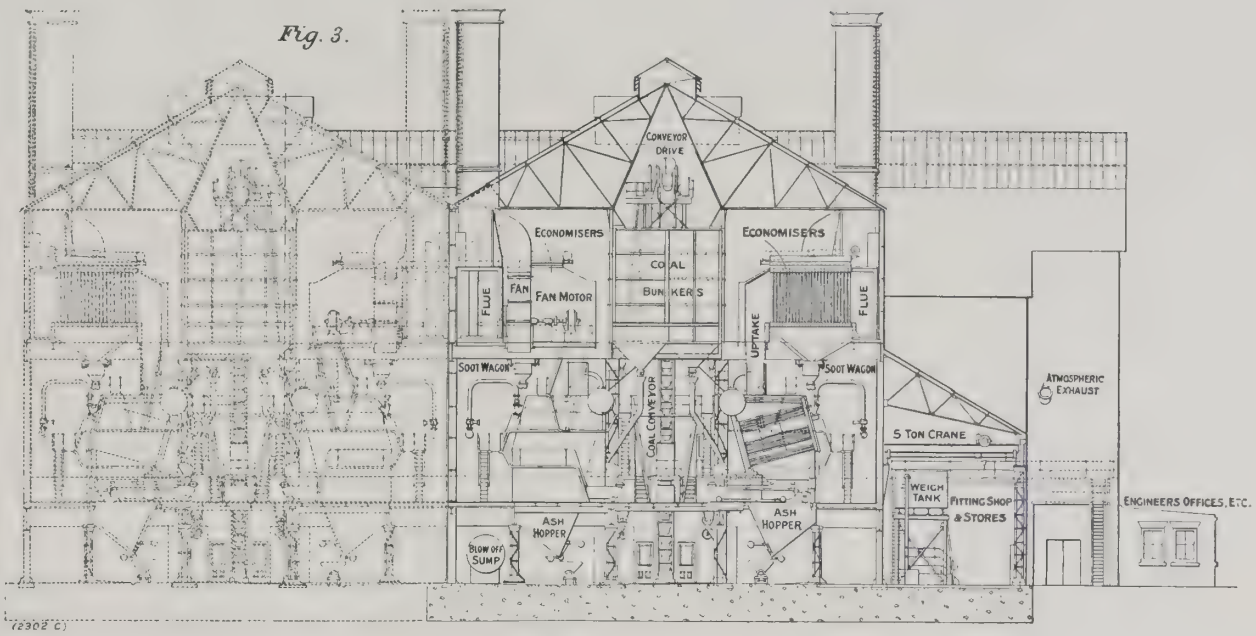
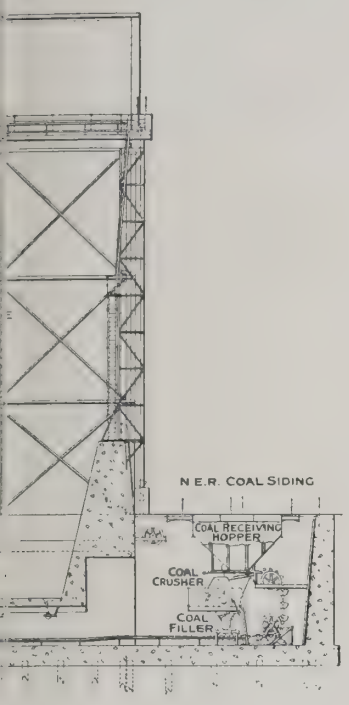
Fig. 3.





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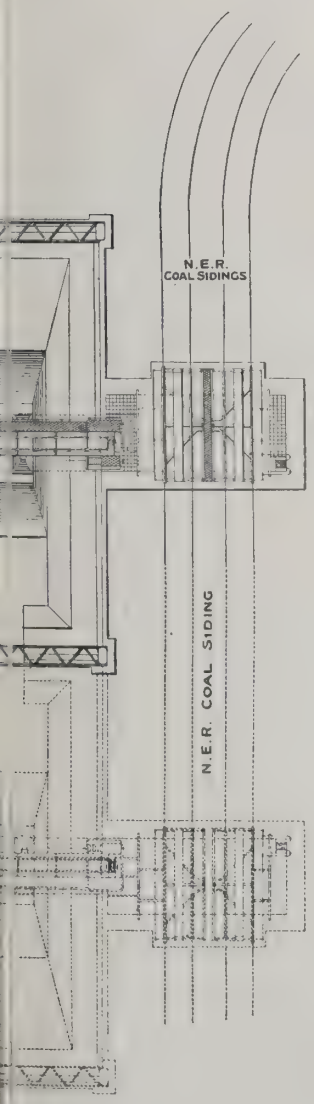


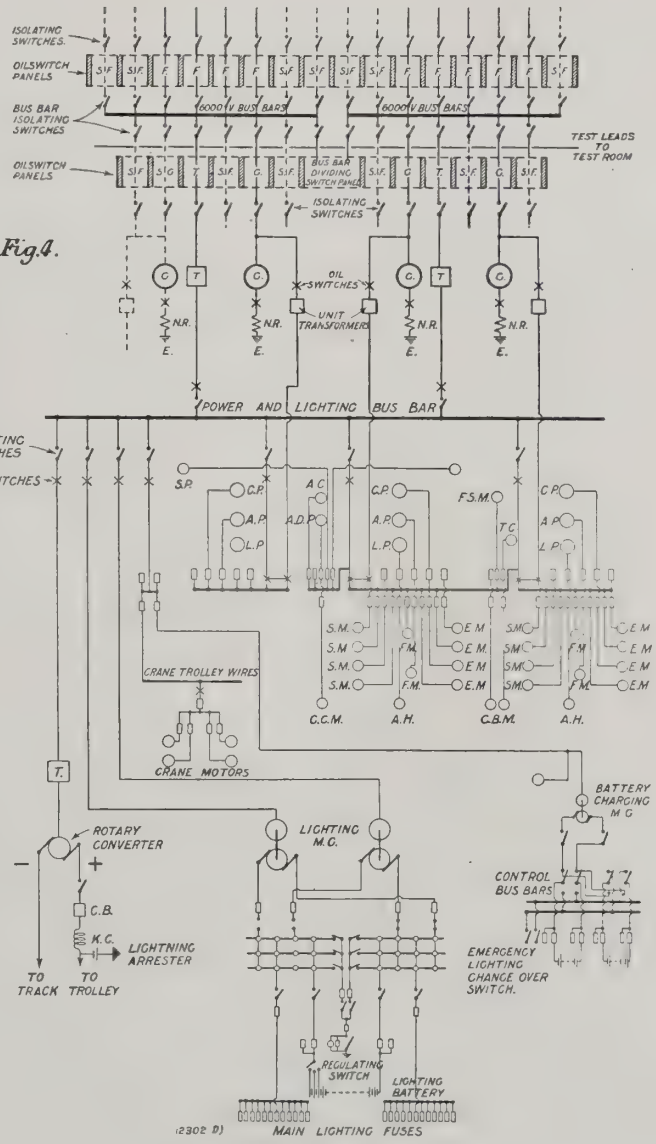


Fig. 4.

DETAILS OF GENERATING PLANT.

Turbines.

Makers	A.E.G	Richardsons, Westgarth, and Co.
Number of machines by each maker	2	1
Type	A.E.G.	2-cylinder Parsons
Type of blading	Impulse	Reaction
Arrrangement of steam passage	Single flow	H. - P. cylinder single flow, L.-P. cylinder part single-flow, part double flow
Specified steam pressure	190 lb. per sq. in.	190 lb. per sq. in.
,, superheat (normal)	190 deg. Fahr.	190 deg. Fahr.

Condensing Plant.

Makers of condensers ..	A.E.G.	Richardsons, Westgarth, and Co.
Number of condensers ..	2	1
Surface of each condenser	17,760 sq. ft.	13,000 sq. ft.
Number of tubes ,,	4162	4720
Arrangement of water passage	Go and return	"Contraflo"
Number and type of air-pumps	Three 3 - throw A.E.G. compound pumps	One 3- throw Edwards with Parsons augmentor
Speed of air-pump ..	200 r.p.m.	150 r.p.m.
Method of drive of pump	60-H.-P. motor	60 H.-P. motor
Number and make of circulating pumps	2 Sulzer	1 Greenwood and Batley
Speed of circulating pumps	390 r.p.m.	600 r.p.m.
Normal power required..	73 b.h.-p.	165 b.h.-p.

Alternators.

Makers	A E.G.	Brown, Boveri, and Co.
Continuous safe output	8000 K.V.A.	7000 K.V.A.
Maximum output for 1 hour	10,000 ,,	7800 ,,
Corresponding power-factor (at continuous and maximum load) ..	0.9	0.9
Voltage	5750	5750

from two small batteries specially used for this purpose. An interior view of the control-room is given in Fig. 11, on Plate IV., while a diagram of the connections of the station is given in Fig. 4, on Plate I.

Each generator-panel has a main ammeter and voltmeter, power-factor indicator, indicating watt-meter, field-ammeter, integrating watt-meter, &c. It has also a switch for controlling the governor of the turbine, and a rheostat hand-wheel in front, as well as a telegraph to each generator. At the end of the generator-board is a synchronising panel with rotary synchronoscope. Each feeder-panel on the feeder-control board has a separate set of instruments and a set of synchronising and volt-meter plugs for synchronising any other generating station with the machines at Dunston. The feeders are protected by Merz-Price balanced protective gear. Both the feeder and generator-panels have chop-over control-switches arranged to make or break the main oil-break switch immediately contact is made. The position of the main oil-break switch is indicated by the lighting of a red or blue lamp, and the last motion performed is automatically indicated by the position of a small coloured pin on the switch-handle.

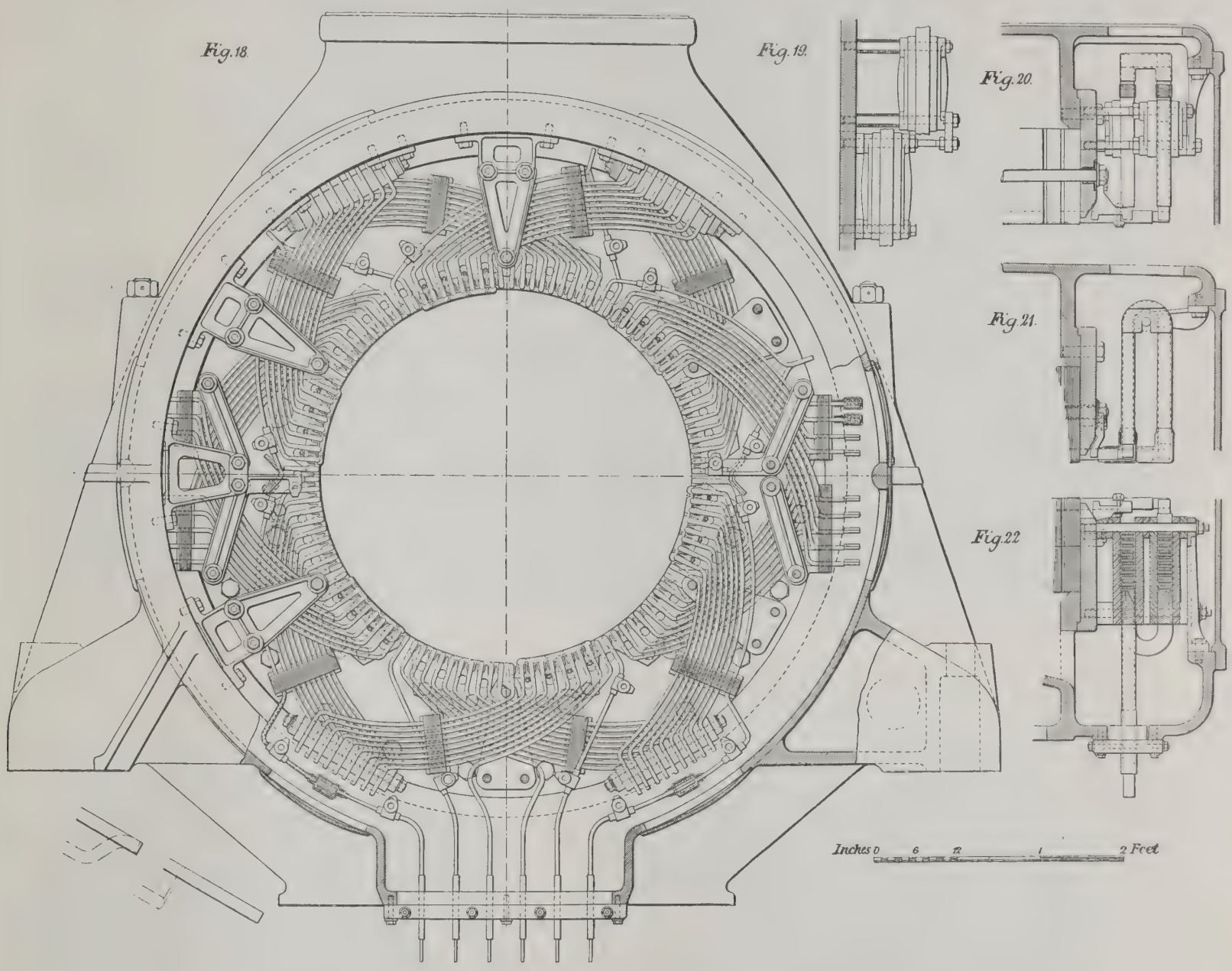
Switch-Room. — The switch-room itself has two storeys. Access is obtained to the upper storey through an iron door leading from the control-room, and to the lower storey from the passage-way under the control-room. The bus-bars and main oil-break switches are in the upper storey, the connections and isolating switches and current and potential transformers being in the lower storey. The cables from separate generators or feeders are brought up through the ground in separate brickwork cells opening on to the central passage-way in the lower chamber, and closed by expanded metal doors. From three-way dividing-boxes three single connections pass through the wall to brickwork cells on the other side, which are accessible from the outer passages running the length of the lower chamber. Each of the cells contains three single-pole main isolating switches as well as isolating switches for the potential transformers which are placed on the ground below in a small brick cell, protected by sheet-iron doors. From the main isolating switches the three connections are taken up through current-transformers to the bottom connection of the main oil break-switch in the ceiling, the switch itself being placed in the upper storey.

In the upper room three moulded stone tables run parallel to each other along the room, being continuous except for a division of some 6 ft. or 7 ft. in the middle. The main 6000-volt bus-bars rest upon insulators on the central table, which is 5 ft. high, and are protected by expanded metal screens running up to the ceiling for the whole length, thus forming a cage, in which the bus-bars are placed. The bus-bars are divided in the middle of the room by means of a main oil-break switch, capable of carrying 20,000 kw. continuously, and opening under any load likely to be met with. On the two side-tables are fixed the oil-break switches, the left side of the room being entirely devoted to feeders. As stated above, the three connections from the oil-break switch to the bus-bars are carried along the ceiling of the chamber below, and are brought up through three separate bus-bar isolating switches underneath the bus-bar table to the lower side of the bus-bar holding-down bolts. The general arrangement of the gear, as described above, is well shown in Fig. 13, on Plate V.

The main oil-break switches are of the British Thomson-Houston Company's type. Each of the three cylinders containing the actual switch is in a separate cell, and in front of each cell is a "uacolite" door to allow the escape of hot air, &c. The motors operating the switches are arranged to wind up a spring immediately the switch has operated, so that the make or break is instantaneous on the closing of the control switch on the control board. Each oil-brake switch can be made dead by means of isolating switches, there being one set for isolating it from the bus-bars, and one for isolating it from the incoming cables. The bus-bar isolating switches are situate under the bus-bar table, in the ceiling of the lower chamber; but the handles operating them are in the upper chamber on the side of the bus-bar table, each one being exactly opposite its own main switch. As stated, the isolating switches for cutting off the main switch from the tables are situate in the lower chamber. All the high-tension panels are provided with balanced protective gear. There is an air-compressor and set of compressor piping throughout the switch-house for cleaning purposes. A view of one of the main switches is given in Fig. 8, on Plate III., while a general view of the main switch-room is given in Fig. 12, on Plate IV. Various details of the switches are given in Figs. 14 to 17, on Plate V. Fig 7, on Plate III., shows the arrangement of the series transformer and isolating switches.

In addition to the switch-gear already described, there is in the engine-room a neutral isolating switch for each generator and a set of emergency tripping-gear. On the wall of the engine-room opposite each generator there is an indicating ammeter, and each generator also has its own "unit" transforming set in the transformer annexe. The leads for these transformers do not pass through the switch-house, but are taken directly from the generator terminals through "Ironclad" switch-gear of the Reyrolle type, which is placed in chambers on the northern side of the engine-room. The direct-current switch-gear principally consists of a 500-volt traction-board and a 100-volt power and lighting-board, as well as the main lighting distribution fuse-board. The main direct-current switchboard with the motor generators is situate in the corner of the engine-room.

The tables on page 12 give the principal particulars of plant installed.



FIGS. 18 TO 22. ARRANGEMENT OF END WINDINGS OF A.E.G. 8000-KW. ALTERNATOR.

34-HORSE-POWER FOUR CYLINDER PETROL-ENGINE FOR LIFEBOAT.

CONSTRUCTED BY THE WOLSELEY TOOL AND MOTOR-CAR COMPANY, LIMITED, ADDERLEY PARK, BIRMINGHAM.

(*For Description, see Page* 12.)

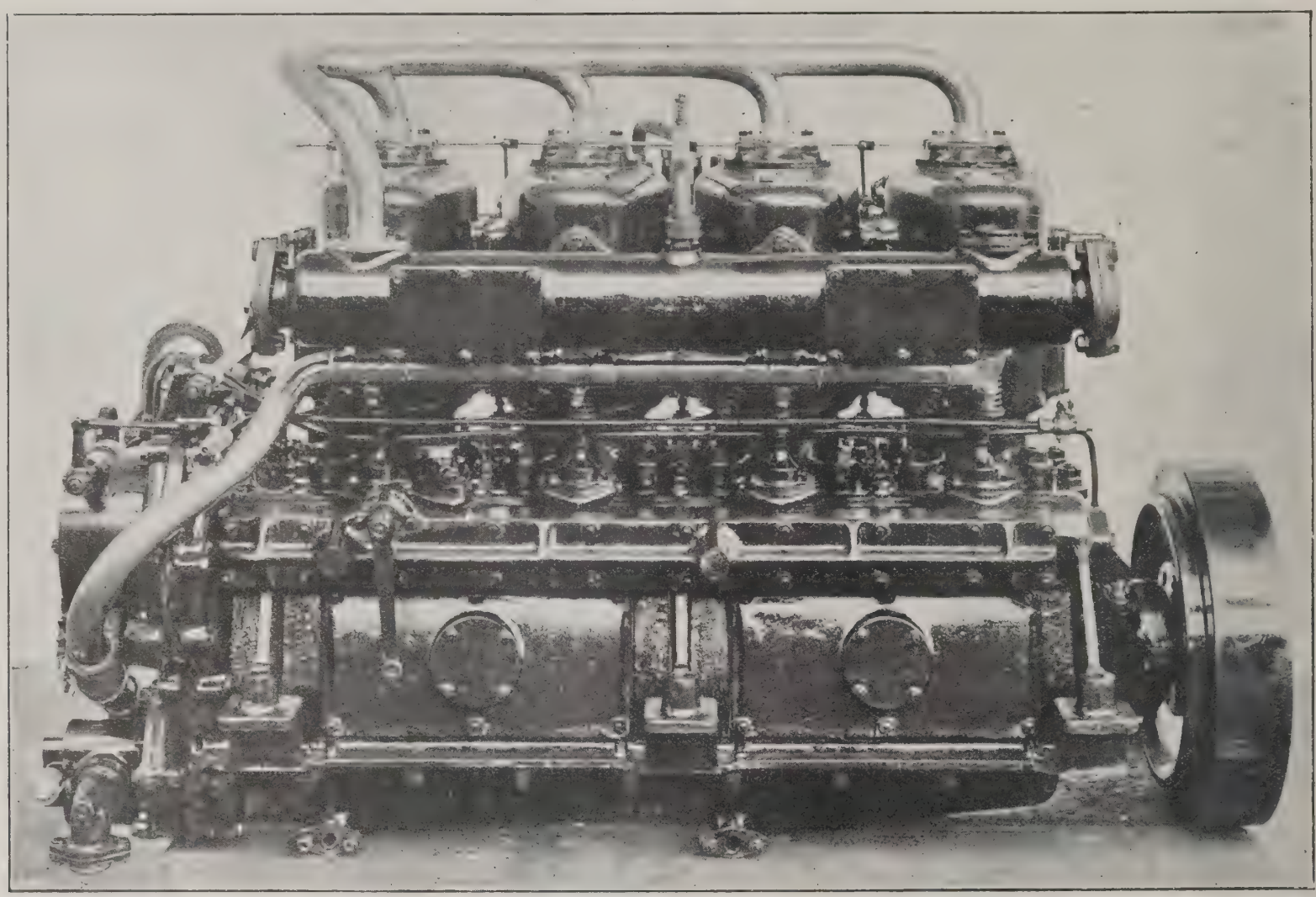


FIG. 1.

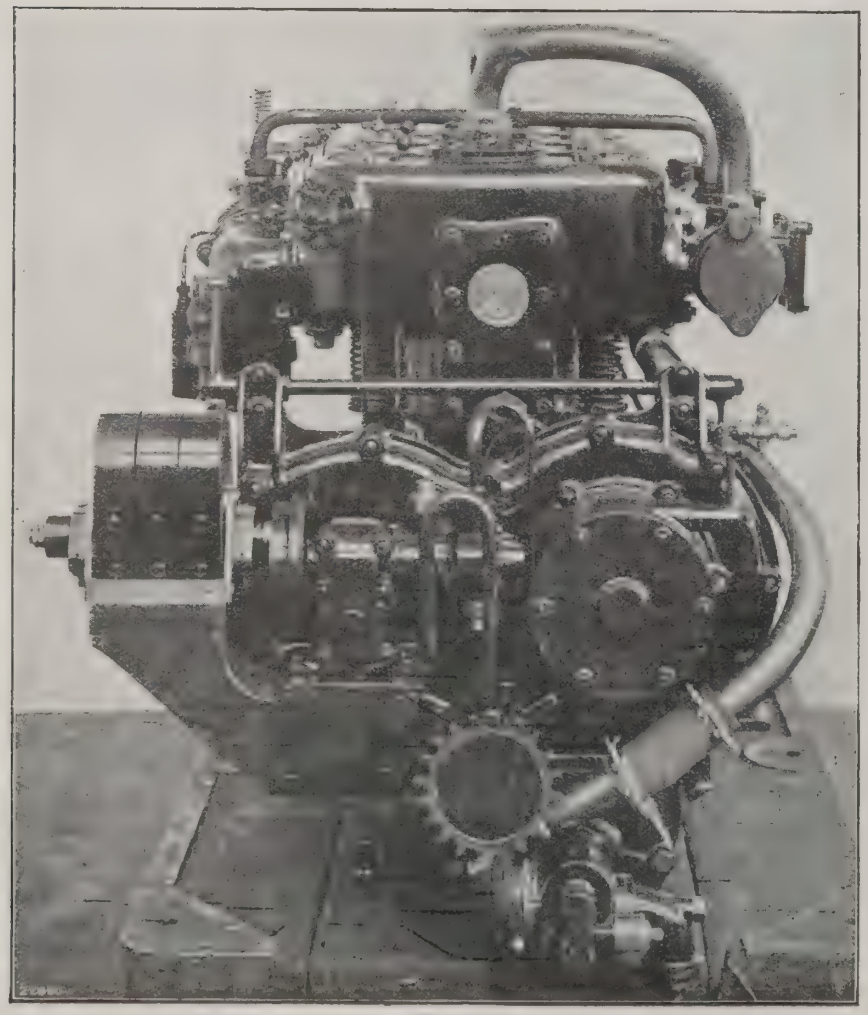


FIG. 2.

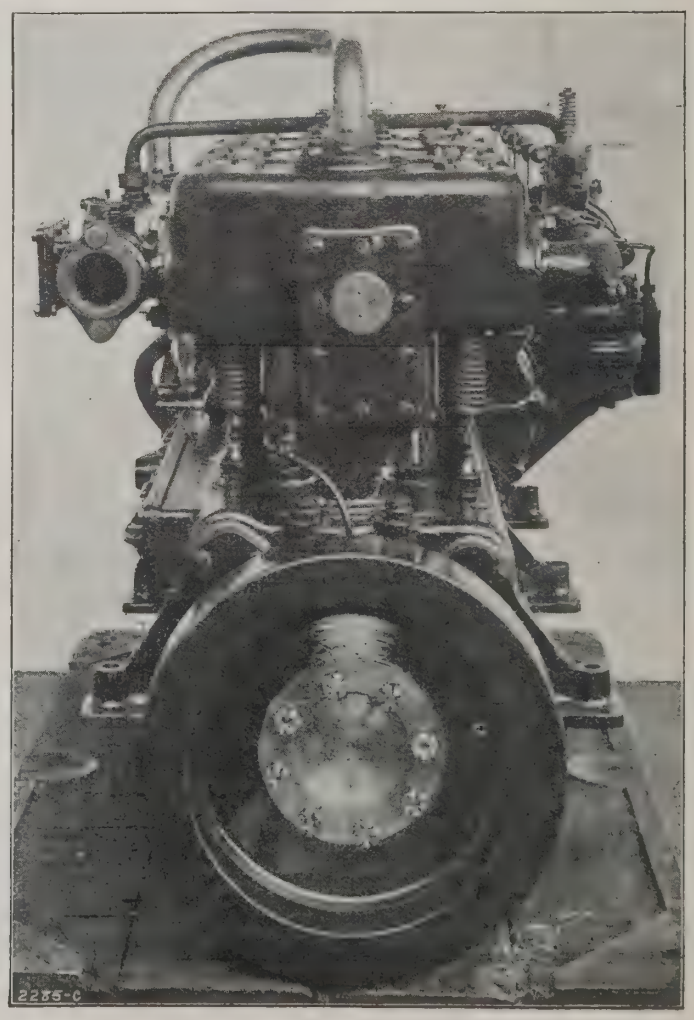


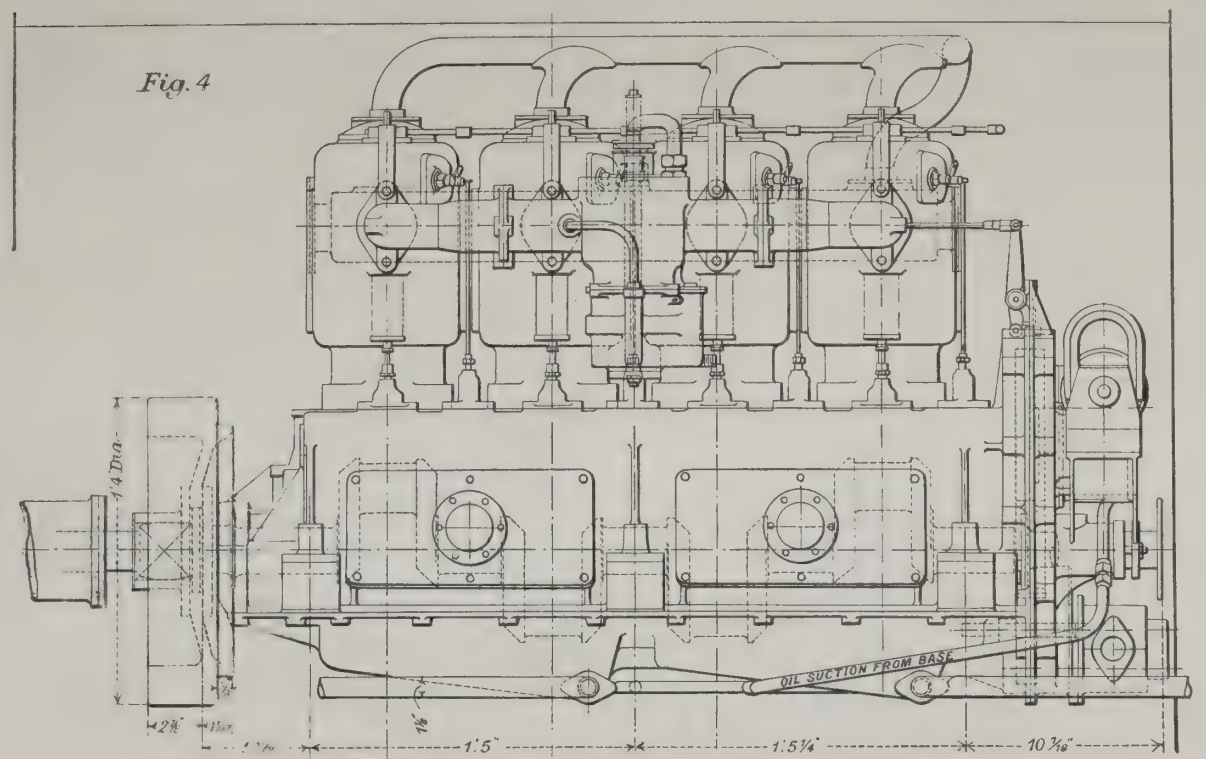
FIG. 3.

34-HORSE-POWER FOUR-CYLINDER PETROL-ENGINE FOR LIFEBOAT.

CONSTRUCTED BY THE WOLSELEY TOOL AND MOTOR-CAR COMPANY, LIMITED, ADDERLEY PARK, BIRMINGHAM.

(*For Description, see Page* 12.)

Fig. 4



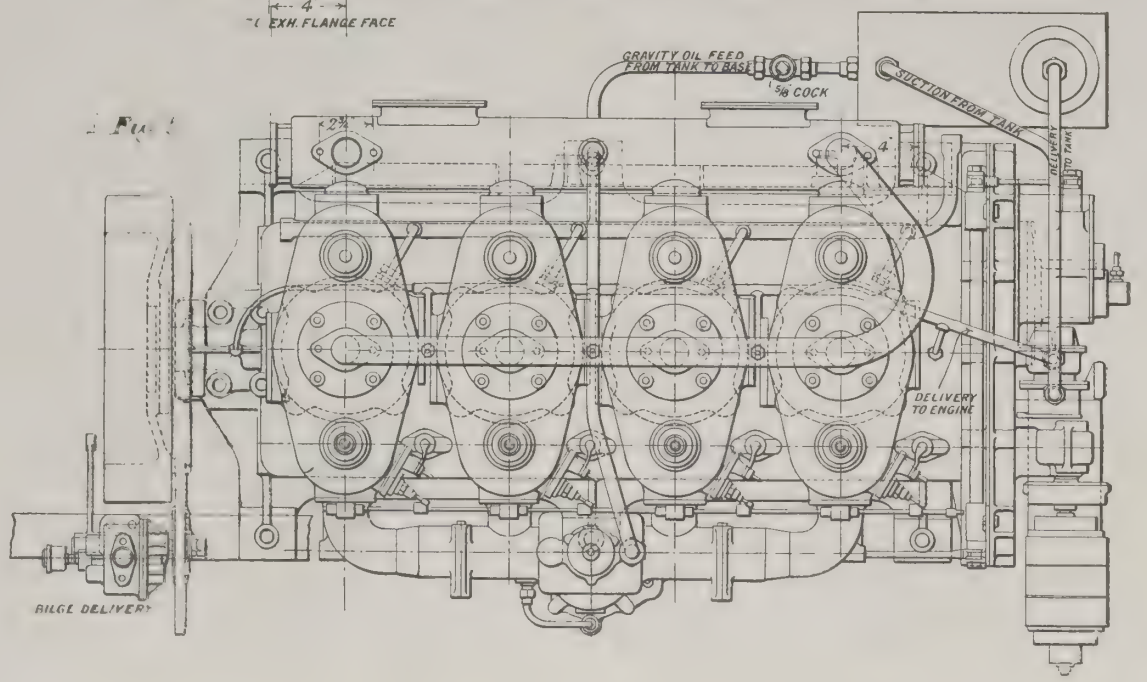


Fig. 6.

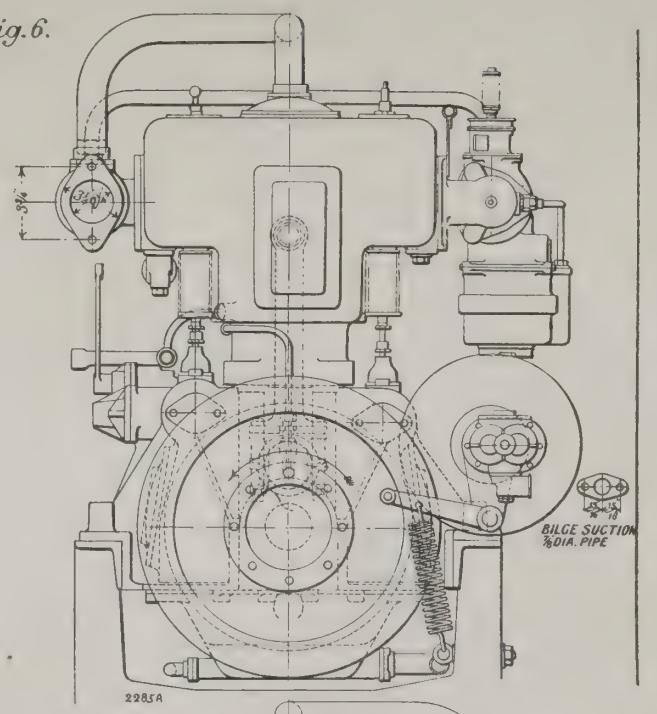
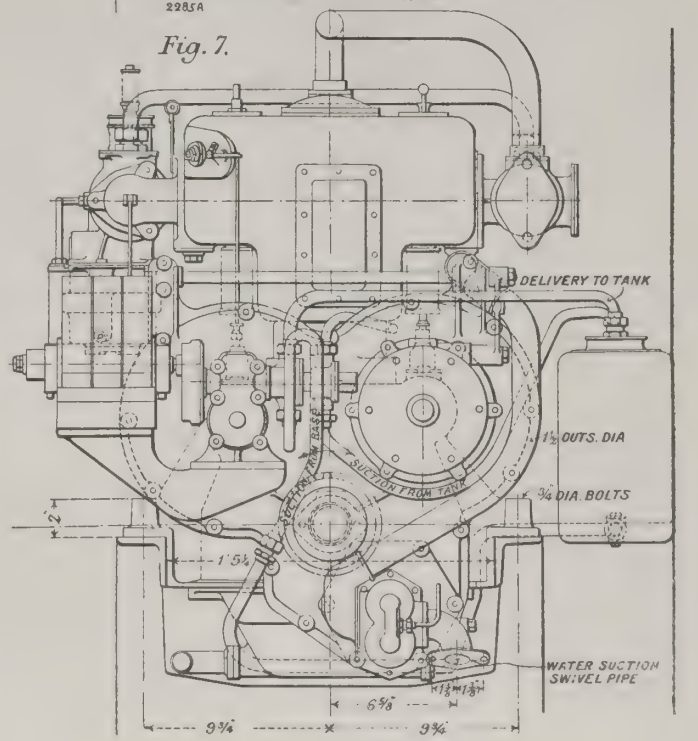


Fig. 7.



BOILER EQUIPMENT.

Contractors: Babcock and Wilcox.

Boilers:

Number of boilers installed	8
Type of boilers	Water-tube
Heating surface of boiler	6725 sq. ft.
,, superheater	1156 ,,
Grate area (per boiler)	168 ,,
Heating surface of economiser (per boiler)	2880 ,,
Normal working steam pressure	200 lb. per sq. in.
Normal evaporation per hour per boiler	30,000 lb.
Maximum evaporation per hour per boiler	37,500 ,,

Auxiliary Steam Plant:

Number of feed-pumps	3
Type of feed-pumps	Clarke, Chapman
Maximum capacity per hour, each	200,000 lb.
Disposal of feed-pump exhaust steam	Into hot-well tank

MAIN GENERATING UNITS (FURTHER DETAILS GIVEN ON PLATE I.).

Contractors	A.E.G.	Brown, Boveri, and Co.
Number of sets by each contractor	2	1
Output of each set (at maximum economy)	6500 kw.	6250 kw.
Output of each set (overload)	9000 ,,	7000 ,,
Speed	1200 r.p.m.	1200 r.p.m.

SWITCH-GEAR.

Main High-Tension Gear:

Contractors	The British Thomson-Houston Co., Ltd.
Bus-bars	3 (each of 2½ sq. in. section)
Voltage	5750
Generator panels	1200 amperes capacity
Feeder panels	500 amperes capacity
Step-up transformer panels	1200 amperes capacity
Bus-bar section panels	2000 amperes capacity
Power and lighting transformer panel	500 amperes capacity

Traction Rotary Converter:

Maker	The British Westinghouse Electric and Manufacturing Company, Ltd.
Output (full load)	200 kw.
Overload	25 p.c. for 2 hours
Speed at a frequency of 40 cycles per second	800 r.p.m.

Combined efficiency guaranteed:

At full load	91.0 per cent.
Three-quarters load	89.9 ,,
Half load	87.5 ,,
One-fourth load	81.2 ,,
Terminal voltage	500 to 550 d.c.

Lighting Motor Generators (Two):

Output (full load)	50 kw.
Speed at a frequency of 40 cycles per second	775 r.p.m.

Efficiency guaranteed:

At full load	78.5 per cent.
Three-quarters load	78.0 ,,
Half load	74.25 ,,
One-fourth load	62.0 ,,

Control Battery Charging Motor Generator:

Output (full load)	9 kw.
Speed at a frequency of 40 cycles per second	780 r.p.m.

Secondary Batteries:

Lighting battery:

Efficiency guaranteed when discharged at the one-hour rate	72 per cent. in watt-hours.
One-hour rate of discharge	1000 amperes at 100 volts.

Control Batteries (Two):

Efficiency guaranteed when discharged at the one-hour rate	72 per cent. in watt-hours.
One-hour rate of discharge	100 amperes at 100 volts.

WOLSELEY PETROL-ENGINES FOR MOTOR LIFEBOATS.

ON pages 10 and 11 we reproduce perspective views and drawings of a four-cylinder engine of 34 horse-power when running at 700 revolutions per minute, specially designed and constructed by the Wolseley Tool and Motor-Car Company, Limited, at their Adderley Park Works, Birmingham, for motor lifeboats, to be stationed one at St. Abbs and the other at Seaham Harbour. Each cylinder, of 5 in. bore by 6½ in. stroke, is cast singly, with heads and jackets in one piece, and mounted on a cast-iron crank-chamber, and are made interchangeable.

The walls are $\frac{7}{16}$ in. thick, and the water-jackets are $\frac{5}{16}$ in., made of close-grained cast iron. The cylinder liners are capable of withstanding an hydraulic pressure of 700 lb. per square inch, and the jackets of 50 lb. per square inch. The jackets are fitted with large covers at the sides, to ensure accurate coring, and to be used, when necessary, as manholes for cleaning purposes. The exhaust-valves are arranged on the port side, and the induction-valves on the starboard side. The crank-case is of cast iron, having six arms for bolting to the engine-bearers.

The crank-shaft is made of Vickers' nickel-chrome steel, and is carried in five bearings. The crank-shaft journals are 2⅝ in. in diameter, and the crank-pins 2½ in. in diameter. The total area of any pair of these journals is equal to 81 per cent. of the piston area, and the crank-pins to 37 per cent. The crank-shaft is so arranged that the bottom cover of the crank-chamber may be removed for inspection purposes without affecting the alignment of the shaft. The connecting-rods are made of high-grade steel and bushed with phosphor-bronze for the gudgeon-pins; the big ends are of phosphor-bronze, white-metalled. The pistons are of close-grained cast iron. Four piston-rings are fitted, the position of these rings being fixed by means of pegs fitted into the pistons. The main bearings are of phosphor-bronze, white-metalled.

The cam-shafts, as shown in Figs. 2, 3, 6, and 7, are arranged on each side of the engine, and are driven from the crank-shaft by enclosed metal gears. The starboard cam-shaft has ignition cams embodied for driving the low-tension ignition mechanism, and the port cam-shaft has an eccentric embodied for driving the air-pressure pumps.

The valve-operating plungers are adjustable, and fitted with hardened-steel rollers to work in phosphor-bronze plunger guides. Half-compression of the sliding type is fitted on the port side of the engine, and works in connection with the exhaust-cams. The ignition is of the "Bosch" low-tension magneto type, the make-and-break mechanism being operated by means of cams on the starboard cam-shaft; the tappets and rods are adjustable. The magneto has a fixed point of firing. In addition to the low-tension, provision is made for high-tension sparking-plugs. The carburettor is of the float-feed and spray type, so arranged that it is capable of running the engine satisfactorily when it is placed at a permanent longitudinal angle of one in four on a slipway, and at a momentary list to either port or starboard of 45 deg., and at a permanent list to either port or starboard of 25 deg. An annular float is fitted. An auxiliary jet is embodied to facilitate starting. The fuel supply to the carburettor is maintained by means of an air-pump of the plunger type, driven off the cam-shaft by means of an eccentric.

The engine is fitted with a centrifugal governor, so arranged as to act on a compensated throttle, independent of the hand control, and capable of controlling instantaneous variation from full load to light load within 12 per cent., and a steady variation of full load to light load of 6 per cent.

The water-cooled exhaust branch, fitted on the port side, is made of heavy-gauge oxy-acetylene welded steel, to exhaust aft, and so arranged that it will couple up to a water-cooled silencer.

A fly-wheel, of cast iron, of 16 in. in diameter, is fitted. All main bearings are lubricated by means of a pump, which positively forces oil to all important bearings, and feeds the centrifugal oilers which lubricate the big ends of the connecting-rods, The oil is pumped from a separate 2½-gallon tank to the bearings and centrifugal oilers. The oil which drains into the base is pumped therefrom and forced through a large strainer in the oil-tank. A supplementary lubricating system is embodied, whereby the bearings, connecting-rods, and pistons may be lubricated by splash.

THE INSTITUTION OF NAVAL ARCHITECTS.

*President's Address.**

YOUR ROYAL HIGHNESS, MY LORDS, LADIES, AND GENTLEMEN,—When the Council and Members of this Institution did me the honour to select me as their President in the spring of this year, I felt that in accepting that office—which I did with a high sense of its responsibilities—I had a difficult task before me, to follow with equal success in the footsteps of the very distinguished line of predecessors which have, from its inception, occupied the presidential chair. To succeed such men as Lord Hampton, Lord Ravensworth, Lord Brassey, Lord Hopetoun, Lord Glasgow, and Lord Cawdor is in itself an honour upon which I place a high value, and an incentive to me to maintain the high standard of tradition they have set.

Upon the untimely and lamented death which created the vacancy I am now called upon to fill I will not attempt to dwell. Such an occasion as this is not one for sad thoughts. Yet I would say just this, that in losing Lord Cawdor at the very beginning of this memorable year the Institution has shared in a very particular degree the loss which has been felt through a wide range of national enterprises. The call to high political office had come to Lord Cawdor at a time when his great administrative capacity had already been proved in other directions. His forceful personality and the zeal and vigour which he threw into his political work clearly marked him out as a leader whom men would be proud to follow. That the Institution of Naval Architects would have derived immense advantage from his wise and experienced leadership is an opinion which will, I think, be very generally shared.

Now the brilliant gathering which has assembled to-day to celebrate the Jubilee of the Institution of Naval Architects has been convened, as I understand it, for a twofold purpose. The occasion is, primarily, a commemorative one. The founding of this society fifty-one years ago marked an epoch in the history of naval architecture, which synchronised with the first construction of sea-going iron ships, with the introduction of protective armour, and with the advance to a position of great importance of the naval engineering element. I do not propose to pursue the train of thought which the contemplation of these subjects conjures up. They will be dealt with in the papers to be read by those distinguished naval architects, Sir William White and Sir Philip Watts, to whom this country, as well as this Institution, owes a deep debt of gratitude for their long, whole-hearted, and exceptional services to the profession which they so brilliantly adorn. Neither shall I trench on the engineering question, which no doubt will be adequately dealt with in his paper by Engineer Vice-Admiral Sir Henry Oram, whose skill and foresight have contributed largely to the very great importance of his department in the naval organisation of this country.

There existed, as you are aware, a much earlier society for the Improvement of Naval Architecture, founded shortly before the close of the eighteenth century. But its existence was a brief one, and, from the moment of its untimely dissolution until the middle of last century there had been no similar body in existence. The founding of the Institution of Naval Architects gave practical expression to the aspirations of the representatives of that most important science—the science whose principles govern the construction and equipment of ships—to incorporate themselves into a permanent body in order to advance by every legitimate means the wide and varied interests which form a common bond between its members. Among the primary factors that contribute to all progress in these matters are the educational facilities which are open to those desirous of taking up naval architecture or marine engineering as a career; the framing and administration of laws affecting the construction and safety of ships, and the promotion of investigation and research into numberless problems that await solution. These and similar questions have been, and are being, carefully considered, and the difficulties are being overcome by the combined efforts, and the voluntary work freely given, of the leaders of thought and action in this great section of our national industries.

We live in a period of incessant change and movement. One has only to glance back to the time of the last International Congress, held here in London in 1897, to see what remarkable developments have taken place in that brief period. Mr. Goschen, the then First Lord of the Admiralty, in his speech of welcome to the Congress expressed the hope that the outcome of that meeting would not result in discoveries which would make obsolete our fleet as it then existed. Since then fourteen years have elapsed, and what has happened? Displacement and speed have gone up by leaps and bounds, gun-power for attack and armour for defence have increased in efficiency with almost equal rapidity. Concentration of power has led to the creation of warships undreamt of in 1897. Improvements in propelling and auxiliary engines, and the introduction of new forms of fuel and combustion, have brought about equally startling results in speed, power of endurance, and methods of propulsion. Submarines, the dream of that fascinating writer, Jules Verne, are an accomplished fact; and if their range of action for attack is not yet equal to that of Captain Nemo's famous Nautilus, they are undoubtedly a great potential factor in our organisation for defence.

In the sister art of merchant-ship construction the advances made in recent years have been almost equally great, and the Transactions of this Institution contain remarkable evidence of the progressive spirit that has animated the designers and constructors of ships and their machinery during this period. Well deserved is the recognition that has now been freely accorded to this Society. Its growing membership and financial prosperity are valuable assets, but more valuable even than these is the constant and sympathetic interest of the great administrative departments of the State. The presence of their distinguished representatives to-day is a strong and welcome proof of this friendly attitude. But, above all, we value the gracious action of our Sovereign in extending his patronage to this Institution. By the granting of a Charter of Incorporation, His Majesty has undoubtedly established it upon a new and permanent foundation. Moreover, it was King George's intention, had circumstances permitted it, to have presided last year over the opening ceremony of these Jubilee Meetings. Had not the hand of death descended so untimely upon our bereaved nation little more than a twelvemonth ago, that intention would have been realised. As it is, we are fortunate in having had our invitation so graciously responded to this year by H.R.H. the Duke of Connaught. In accepting the Honorary Presidency of this Congress, and in consenting to open its proceedings, His Royal Highness has shown once again that mark of Royal interest in the intellectual activities of this realm which has signalised above all others the reigns of our august Sovereigns, King George V., King Edward VII. and Queen Victoria.

I alluded just now to the object of this gathering being twofold: the second aspect of its bearing upon our work is, in my judgment, no less important than the first. The International Congress in Naval Architecture and Marine Engineering, which forms the principal feature—if not the actual *raison d'être* of our Jubilee Meetings—is intended primarily to bring together from all parts of the world the great leaders in this sphere of industrial activity. These are the men whose brains have conceived the mighty structures, the floating fortresses and palaces that now compose our fleets of war and commerce. To

* Delivered by the Most Honourable the Marquis of Bristol at the Jubilee Meeting of the Institution of Naval Architects on July 4.

their energy and skill, to their infinite capacity for taking pains, to their splendid victories of mind over matter, we owe whatever we possess of value to those "that go down to the sea in ships and do business in great waters." That we should be honoured on this occasion by the presence of such distinguished representatives of other nations is a compliment of which we deeply appreciate the value and significance.

To some of these nations we, in our sea-girt islands, feel a debt of gratitude for many of the forward steps that have been taken, and many of the gaps that have been bridged, before ships could be built of the types and size and speed that we see afloat to-day. With others (of these nations) the bond lies in the debt they owe to those of our countrymen who have given freely of their technical skill and knowledge in helping to lay the foundation of the great young navies that are now counted among the leading naval powers of the world.

The Council desire to signalise the present occasion, and to do honour to their guests from abroad. They have accordingly resolved to add to their list of honorary members by inviting the distinguished personages whose names I am about to read, to become honorary members of the Institution—the highest distinction which it is in the power of the Council to confer. Before reading these names I would like to remind you that His Majesty the German Emperor was the first among reigning sovereigns to accept this distinction, and that Rear-Admiral H.I.H. Grand Duke Alexander Michaelovitch is the distinguished representative of the Russian Navy upon our existing list. The newly-elected honorary members are as follow:—H.M. the King of Norway, H.M. the King of Spain, H.M. the King of Sweden, H.I.H. Prince Henry of Prussia, H.I.H. Archduke Ferdinand, H.R.H. the Duke of Connaught, H.R.H. the Duke of Genoa, Prince Roland Bonaparte, Lord Rayleigh, Admiral Dewey, Admiral Togo, and Admiral Ijuin.

Meetings such as this are memorable landmarks in the history of an institution. My own appearance among you dates as it were from but yesterday, but there are many present who will recall the splendid reception which they themselves received during the delightful visits that have been paid to foreign capitals and British seaports—Paris, Berlin, Hamburg, Düsseldorf, Bordeaux, Glasgow, Newcastle, and Sunderland, Liverpool, Cardiff, Southampton, Belfast, Dublin. All these have shown what a welcome can be given to our Naval Architects and Marine Engineers. The present occasion furnishes a welcome opportunity to show our hosts of former days that we are not unmindful of their hospitality. Our Institution stands no longer alone; in all countries where the naval architecture counts, societies have sprung up, and under able leadership are sowing the seeds of knowledge and reaping the harvest of thought and experience. Their members are, in many cases, our members, and the bonds of friendship that have ever subsisted between us will, I earnestly hope, continue to strengthen with age.

Gathered as we are to-day under one roof to celebrate the first fifty-year stage of this journey of ours, I cannot but look forward with confidence to a future that bids fair to keep the science of naval architecture in the forefront of the march of human progress.

In conclusion, I will ask H.R.H. the Duke of Connaught to accept once more our hearty thanks for his great kindness in coming at considerable personal inconvenience, in the midst of the numberless engagements of this ever-memorable Coronation year, to preside over our inaugural meeting, and to allow me in the name of all assembled here to-day to send the following telegram to His Majesty the King, Patron of the Institution of Naval Architects:—

"HIS MAJESTY THE KING, WINDSOR CASTLE.

"Members of the Institution of Naval Architects and their guests, assembled in an International Congress to commemorate the Jubilee of this Institution, tender to your Majesty a dutiful message expressive of the loyalty of your Majesty's subjects, and of the respectful homage of their guests from abroad. Your Majesty's constant devotion to the Naval and Maritime interests of this realm leads us to hope that these meetings may prove worthy of your Majesty's gracious consideration.

"BRISTOL, President."

THE HISTORY OF THE INSTITUTION OF NAVAL ARCHITECTS AND OF SCIENTIFIC EDUCATION IN NAVAL ARCHITECTURE.*

By Sir WILLIAM H. WHITE, K.C.B., F.R.S., LL.D., D.Sc., D.Eng., Hon. Vice-President.

ON this occasion the Council have thought it desirable to have included in the programme of papers an epitome of the history of the Institution. The records of that history lie scattered in fifty volumes of the Transactions. The labour of compilation and condensation would necessarily be great if the task were undertaken by one who had not been personally cognisant of the principal events. Personal knowledge is of the greater importance in connection with the earlier periods of that history, because many of the records are incomplete, and only those who were then taking an active part in the conduct of the Institution can speak with full knowledge. There are few men among us now who were original members of the Institution; amongst these, Sir Nathaniel Barnaby, our respected Honorary Vice-President, would have been best qualified to perform the task had his strength permitted. He is the only survivor of the little group of men whose meeting on January 16, 1860, practically secured the establishment of this Institution. He was an original member, and his contributions to the Transactions commenced with the first volume. He became a Member of Council forty-six years ago, and has never failed to do his best in the service of the Institution. Unfortunately, Sir Nathaniel Barnaby did not feel equal to the task; the Council therefore requested me to undertake it. Owing, as I do, a deep debt of gratitude to the Institution—because action taken by its Council in 1863 led to the establishment of the Royal School of Naval Architecture and Marine Engineering, in which my professional education was received—there could be only one answer to that request. Sir Nathaniel Barnaby has been kind enough to supply information respecting certain incidents of the first five years, of which I had no personal knowledge. Even with that aid, the preparation of this paper has not proved an easy matter, although from 1866 onwards it is possible for me to speak of "what I have seen and heard."

In that year, as a student of the Royal School, I first attended the annual meetings of the Institution. Since that time I have been privileged to take part in most of the meetings held both at home and abroad. My membership dates from 1868, service on the Council from 1877, and for twenty-five years my name has stood on the list of Vice-Presidents. Failing Sir Nathaniel Barnaby—whose position is unique—there are few men left on our list who have had a longer acquaintance with the working of the Institution, or who have been more intimately concerned with its administration and development, and in telling the story my endeavour has been to state the facts simply and clearly, and without bias. If there has been any unconscious bias, it may be attributed to the strong personal attachment which I feel towards the Institution, and to a profound conviction that, having accomplished a great work in the past, the Institution will do an even greater work in the future by promoting knowledge of both the science and practice of shipbuilding and marine engineering, and by continuing to be the place of assembly most favoured by the naval architects and marine engineers of the world.

THE CONDITION OF NAVAL ARCHITECTURE IN 1860.

When the founders of the Institution met in January, 1860, to start the enterprise of which we are celebrating the Jubilee, conditions of an altogether unprecedented character prevailed. It was a period of transition, indeed almost of revolution, in regard to the design, construction, and propulsion of ships. The steam reconstruction of the Royal Navy was in full progress, after long hesitation and much opposition from advocates of sail-power. Armour had not long before been introduced as a protection for warships against horizontal shell-fire. The first French sea-going ironclads had been completed recently, and were undergoing trials. Great differences of opinion still continued as to the proper choice between following the French lead, or perpetuating the construction of wood-hulled line-of-battleships. After heated debate the first four British sea-going ironclads had been ordered in 1859, and these vessels were building when the Institution was founded. Almost simultaneously orders had been given to build a considerable number of unarmoured line-of-battleships and frigates, and to convert sailing-ships into screw-steamers. Amongst my earliest employment (as an apprentice to the master shipwright at Devonport) was work on one of the vessels, some of which were never completed.

The use of iron as the principal material for shipbuilding was in process of extension, yet wood still maintained its pride of place, especially for warships. Prior to the use of armour attempts had been made to build unarmoured frigates with iron hulls, and as the result of firing trials against targets representing the sides of those vessels it had been decided to employ them in transport service, and to revert to wood, as better fitted to withstand attacks from the naval ordnance of that time. Smooth-bore guns and spherical projectiles were still in common use, although Armstrong, before this date, had commenced to manufacture breech-loading rifled ordnance. Gun-mountings were of the most primitive character, and were practically unchanged from the preceding century; manual power was depended upon for working guns. The heaviest guns carried by British men-of-war were 68 pounders, weighing 95 cwt. Even in the latest types of warships then extant engine power was regarded as only auxiliary to sail power. That principle was adopted also in the designs of our first ironclads (the Warrior and her consorts), all of which were capable of proceeding and manœuvring under sail alone. Iron and steam were steadily making way, but conservative opinions were still widely held. The advocates of radical change were met with strenuous opposition, and this was natural enough, seeing that for centuries changes in shipbuilding and armaments had been few and small.

The introduction of armour protection in warships overcame objections to the use of iron for warship building which had been previously regarded as conclusive. In the mercantile marine the use of iron hulls had become more general, but in 1860 two-thirds of the mercantile tonnage built in Great Britain was in wood. Brunel and others had shown what could be done with the material. Striking illustrations of its merits and possibilities had been given in the Great Britain (1843) and in the Great Eastern, which had started on her first cruise in September, 1859, and was still on trial when the founders of this Institution met in January, 1860. Even now, nearly sixty years after the preliminary designs for the Great Eastern were put in hand by Brunel, one wonders at the boldness of the conception and the degree of success attained. That wonder grows when the Great Eastern is compared with the largest contemporary steamships of 1860. The finest Cunarder was 360 ft. long, 3300 tons (gross); the largest steamer in the Peninsula and Oriental service was a little more than 300 ft. in length and 2000 tons (gross); the Royal Mail Company had as their finest vessels steamers of about the same size as the Cunarders; the mail steamers on the Cape service were 180 ft. in length and 550 tons (gross); in the Royal Navy the largest wood-built line-of-battle ships were 260 ft. long, of 7000 tons displacement, and about 4000 horse-power. The Orlando class of frigates were 300 ft. long, of 5600 tons, and with engines as powerful as the line-of-battle ships; but they remained but a short time on service, as their structural strength proved insufficient for such powerful engines. The Great Eastern was 680 ft. in length, of nearly 19,000 tons (gross), and about 30,000 tons displacement, her engines developed a total of 10,000 horse-power; five or six times as powerful as the engines in the largest and fastest mail steamers of the period, and two-and-a-half times the power of the largest warships. Brunel made a gigantic experiment which proved a success on the technical side, although it resulted in a commercial failure. Scott Russell, one of the principals amongst the founders of the Institution, had been associated with Brunel and had undertaken the contract for the ship and her paddle-engines. For nearly half a century she remained unsurpassed in size, and she will always be regarded as having been a monumental structure which should have been preserved.

The theory of naval architecture as it existed in 1860 was sketched by Dr. Woolley in the first volume of the Transactions, and no better authority for dealing with the subject could have been found at that date. In that paper full acknowledgment was made of the valuable work done in the eighteenth century by French writers, and under the auspices of the Academy of Sciences. By these pioneer workers a mathematical theory of naval architecture had been initiated, and fundamental principles formulated. Dr. Woolley also indicated briefly the contributions which had been made subsequently by British writers, and suggested directions in which further investigations might be made with advantage. He illustrated and emphasised the inexact and incomplete state of scientific knowledge, but contended that it was essential for "naval architects to drink deeply of the well of scientific truth, and to be imbued largely with the spirit of philosophical inquiry." At that time, however, only a small proportion of British shipbuilders made any pretence to scientific knowledge or method; most were content to follow precedent and experience. In face of the radical changes consequent upon the introduction of steam power, iron hulls, and armour protection, as well as consequent developments of naval ordnance, time-honoured procedure in the designing of ships necessarily had to be abandoned. "Rules of thumb" based upon experience, and not upon fundamental principles, had to give place to scientific method; the trained naval architect began to come to his own. Practical experience still continued, and ever will remain, an essential part of successful engineering operations; but experience alone could no longer suffice as it had done throughout the long period when types of ships remained practically unchanged. Scientific knowledge and scientific analyses of the results of experience became necessary when entirely new conditions had to be dealt with. Novel types of ships had to be designed, in which dimensions, forms, structure, protection, propulsive apparatus, and armaments all constituted or involved departures from precedent, and new methods became a necessity.

The advantages of scientific method had been recognised long before the ironclad era began; indeed, the proofs of its beneficial influence lay open to those who cared to seek for them, and were summarised by Dr. Woolley. France had shown the way in this direction, and attempts had been made in Great Britain to rival French methods by the establishment of societies for the improvement of naval architecture and the founding of two schools of naval architecture, the first in 1811 and the second about thirty-seven years later. Both schools had been abolished prior to 1860 by politicians who were not capable of appreciating their value, British naval architects had to send their sons abroad for scientific instruction. Fortunately for this country, however, naval architects who had been trained in these schools remained available when the crisis of which a sketch has been given arose fifty years ago. These were the men who took the responsibility of the steam and ironclad reconstruction of the Navy, and also played a prominent part in founding this Institution.

FOUNDATION OF THE INSTITUTION OF NAVAL ARCHITECTS.

The need for such a society, as well as the demand for scientifically-trained naval architects which followed upon the events above described, had much to do with the immediate success which was obtained by this Institution. It was founded at a psychological moment, and all classes interested in shipbuilding welcomed it. Members of both the British Schools of Naval Architecture gave sympathy and active assistance, and they were joined by a little band of private shipbuilders and marine engineers, whose professional training had been received elsewhere, but who shared in the conviction that the time had come when the claims of science, as well as those of practice, must be recognised, if British shipbuilding was to maintain its ancient renown under entirely new conditions.

In the first volume of the Transactions may be found an interesting account written by the then secretary (Sir Edward Reed) of the preliminary steps which were taken by the founders prior to the meeting on January 16, 1860; the proceedings at that meeting and those at a second meeting held a fortnight later are also described. The principal facts may be briefly sumarised. About forty persons had been invited to attend the meeting; many of them were in sympathy with the proposal, but

* Paper read at the Jubilee Meetings of the Institution of Naval Architects, July 4, 1911.

only eighteen were present. Of these, ten were or had been in the shipbuilding department of the Royal Navy, Dr. Woolley, who had been principal of the second School of Naval Architecture, attended, and was accompanied by four of his pupils. Six gentlemen represented private firms of shipbuilders and marine engineers; one was a barrister, keenly interesting in canoeing and yachting, who became better known later on as "Rob Roy" McGregor. The list of men present who had been trained outside the Naval Service was small but representative. It included Scott Russell; John Penn, the eminent marine engineer; John White, of Cowes, member of a historic family of shipbuilders; Grantham, a recognised authority on iron shipbuilding; and the two principal surveyors of Lloyd's Register of Shipping, an organisation which had already done valuable work in assisting the development of the mercantile marine, and has since attained an unrivalled position in connection with the survey and classification of British and foreign shipping. This little company, after hearing the explanatory statement read by the secretary, had the courage to resolve unanimously as follows:—

"We who are present do now constitute ourselves an Institution of Naval Architects for the purpose of advancing the science and the art of naval architecture."

Without delay or adjournment steps were taken to give effect to this resolution. A list of officers of the Institution was considered and approved; Sir Edward Reed was elected permanent secretary; committees were appointed to consider and report on the general constitution and management of the Institution, the qualifications for admission of members and associates, and the names of persons who should be invited to join the Institution at its commencement. A fortnight later a second meeting of the founders and officers was held; the reports of committees were then received and dealt with: and within a month from this second preliminary conference the inaugural meetings of the Institution were held, extending over three days. At these meetings many valuable papers were read and discussed, and the Institution was fairly launched under most promising auspices. Throughout this stage the new Institution received kindly assistance from the Society of Arts, in whose rooms the first meetings were held, as have been all subsequent annual spring meetings. Limited space made it impossible to hold our present gathering in the hall around which so many memories have gathered during the last fifty years; but it is only right on this historic occasion to place on record once more our grateful acknowledgment to the Council of the Society of Arts for their long-continued courtesy and kindness.

Constitution and Organisation of the Institution.

A declaration of the "objects of the Institution" was made at the outset and printed in the first volume of the Transactions. This declaration has never been varied; it still adequately represents our work, notwithstanding the great changes which have occurred during the intervening period, and is now reproduced as an illustration of the wisdom and foresight of our founders.

Objects of the Institution.

"The objects of the Institution of Naval Architects—which was established to promote the improvement of ships, and of all that specially appertains to them—are comprised under three heads:—

"First, the bringing together of those results of experience which so many shipbuilders, marine engineers, naval officers, yachtsmen, and others acquire, independently of each other, in various parts of the country, and which, though almost valueless when unconnected, doubtless tend much to improve our navies when brought together in the printed transactions of an institution.

"Secondly, the carrying out by the collective agency of the Institution of such experimental and other inquiries as may be deemed essential to the promotion of the science and art of shipbuilding, but are of too great magnitude for private persons to undertake individually.

"Thirdly, the examination of new inventions, and the investigation of those professional questions which often arise, and were left undecided before the establishment of this Institution, because no public body to which professional reference could be made, then existed."

The constitution, bye-laws, and regulations of the Institution as originally framed equally illustrate the ability of those who were responsible for their settlement. These laws have been varied or amended in the light of subsequent experience and altered conditions, but the fundamental principles have been maintained. One passage in the statement of the first secretary, Sir Edward Reed, puts the matter clearly and may be quoted:—

"It was felt that the naval architect—to whom alone the ship as a complex whole is a subject of study—was the only proper person to give designation and character to the society, and consequently it was decided. . . . . that its title should be the 'Institution of Naval Architects.' But naval architects alone do not produce ships. With them must be associated—and closely associated, too—the shipbuilder, the man of science, the seaman, the engineer, the mast-maker, the rigger, the sail-maker, the smith, and others, or no ship could ever be built and equipped. Hence it was concluded that for the Institution of Naval Architects to become a vital and vitalising body it must draw into association with itself persons from all such classes. This it is proposed to do by the establishment of a class of associates—a class which it is believed will become very numerous, and will render most invaluable aid to the Institution."

For nearly twenty years after the Institution was started the number of associates exceeded that of professional members of the Institution, thus realising the anticipations of the founders. Since 1879 the conditions have been reversed and the professional side of the Institution has largely outgrown the associate class. While this increase in professional membership is a subject for congratulation, it is a matter for regret that a corresponding increase of associates has not taken place. Everything possible has been done by the Council to encourage that increase. The qualification for associateship has been framed on broad lines, and liberally interpreted; yet the number of associates on the roll of the Institution at the present time is no greater than was the corresponding number in 1862, although in the interval the number of professional members has increased twenty-fold. It is devoutly to be desired that before long there may come a marked change. Associates, according to the regulations, "shall be qualified, either by profession or occupation, or by scientific or other attainments, to discuss with naval architects the qualities of a ship, or the construction, manufacture, or arrangement of some part or parts of a ship or her equipment." Within these wide limits a great number and variety of persons exist who are interested in ships and shipbuilding—men of affairs, politicians, men of science, shipowners, seamen, engineers practising in many branches, manufacturers of materials, machinery and equipment, and many others. All of these can aid in the discussion and settlement of numerous and difficult problems incidental to the design, construction, and propulsion of ships; many of them are possessed of special knowledge and experience which entitle their opinions to great respect. The maintenance of British supremacy in shipping, both in the war fleet and the mercantile marine, is of vital importance, and can only be secured by the co-operation of all classes. It is undoubtedly true that the work done by the Institution of Naval Architects has furthered this great end, and has contributed in no small measure to the commanding position which British shipping now occupies. On public grounds, therefore, apart from the interests of the Institution itself, one may plead for a realisation of the hope expressed fifty years ago that the associate class "will become very numerous." It has already been conclusively demonstrated that this class can "render most invaluable aid to the Institution," and although the roll contains many eminent names, a much greater number of representatives of the class is desired. Associates have from the first had adequate representation on the Council and a large share in the management of the Institution, and all the presidents have been associates.

In this respect the Institution stands alone amongst technical societies, all others having professional presidents. The reason for the procedure which has been adopted was stated as follows in 1860:—"In view of the national interests likely to be advanced by the Institution it was thought better to waive the idea of a professional president." At the start, also, there was an additional reason, associates then far outnumbered professional members. But although that superiority in numbers has long since ceased to exist, the Council has hitherto reaffirmed the view taken fifty years ago, on each occasion when a president has been selected, and it is agreed by all who are familiar with the history of the Institution that this practice has given excellent results. Public men of eminence and high social standing have been ready to assume the office when selected, and many of them have served for long periods.

The first president was Lord Hampton (then Sir John Pakington), who, as First Lord of the Admiralty, had been responsible, in 1859, for ordering the construction of the Warrior, our first sea-going ironclad. For twenty years Lord Hampton held office, taking great interest in the affairs of the Institution, and doing much to promote its claims to public recognition and official support. In 1880 the Earl of Ravensworth succeeded Lord Hampton, and occupied the presidential chair for thirteen years. His intimate knowledge of shipping, and the high regard entertained for Lord Ravensworth by British shipowners and shipbuilders, made his period of office most advantageous to the Institution. When increasing age led Lord Ravensworth to tender his resignation, Lord Brassey became president. His name appeared in the first list of members and associates, and his interest in the Institution had continued for twenty years before his election to the chair. His term of office was unfortunately short, as he was called to the Governorship of Victoria in 1895, and was consequently compelled to resign the presidency. The Earl of Hopetoun became president in 1896, and did good service for five years until he was appointed the first Governor-General of the Australian Commonwealth. The Earl of Glasgow succeeded in 1901, bringing to the post ripe experience gained as an officer in the Royal Navy and Governor of New Zealand. For seven years Lord Glasgow served the Institution faithfully, and then decided to retire. Fortunately the constitution provides for a continuance on the Council of gentlemen who had served as presidents, so that at the present time the two surviving past presidents, Lord Brassey and Lord Glasgow, are still rendering valuable assistance in the management of the affairs of the Institution. Earl Cawdor became president in 1908; and, during the short period which intervened before his much-regretted death, gave evidence of the beneficial influence which his high character and conspicuous ability would have exercised upon the progress of the Institution had his life been spared. At the meetings in April last the Marquis of Bristol was unanimously elected to the presidency. His brilliant career as an officer of the Royal Navy, and the valuable service already rendered to the Institution in connection with the Jubilee celebrations, furnish good evidence that Lord Bristol will prove in all respects a worthy successor to the eminent presidents who have preceded him. It is permissible to hope that his influence will lead to large additions to the considerable number of associates of the Institution who are his brother officers in the Royal Navy.

In regard to election of vice-presidents also the practice of this Institution differs from that of other technical societies. From the first it was thought desirable to solicit the services of a number "of noblemen and gentlemen of great ability and eminence who are or have been closely connected with either the Royal or the Mercantile Navies, and who might be willing to act as vice-presidents." There has never been a lack of eminent men of these classes amongst the vice-presidents; many of them have taken an active part in the management of the institution. With these non-professional vice-presidents have been associated a certain number of professional vice-presidents, whose work as naval architects and marine engineers marked them out for this distinction. Other vice-presidents have been chosen from amongst gentlemen holding high official positions in connection with shipping organisations and from the officers of the Royal Navy. Amongst the latter the name of Admiral Sir John Dalrymple Hay stands pre-eminent, both on account of his connection with the Institution from its earliest days and the valuable services he has rendered.

For thirty years the choice of vice-presidents was practically made by the Council of the Institution, their recommendations having been always confirmed at general meetings of the members. During this long period no limit was fixed to the number of vice-presidents (which finally rose to 30) or to their period of service. In 1890 it was decided to introduce new rules. The maximum number of vice-presidents was fixed at 24; it was also provided that members and associates should have the right of voting by ballot in elections held to fill vacancies in the list, the council nominating candidates for election. This arrangement was continued until 1905, when a new class of honorary vice-presidents was created. In this new class are included gentlemen who occupy distinguished public positions, and others "who have given long and honourable service to that Institution." The Council has the power of election; there is no limit of numbers, and honorary vice-presidents are not subject to re-election annually, as are the presidents, vice-presidents, and treasurer.

Elected vice-presidents now number 16; when vacancies occur the Council nominates a list of candidates, and the members elect, as before, by means of ballot-papers. It will be seen that this arrangement provides for transfers from the list of elected vice-presidents to that of honorary vice-presidents, and so creates vacancies on the former list. Experience has shown that this plan promotes the interests of the Institution; there was previously no natural flow of promotion like that which results from the periodical advancement of vice-presidents to the presidential chair in other technical societies. All vice-presidents in both classes are entitled to sit and vote with the members of the Council, and actually take an important part in the proceedings.

Members of Council have included from the first representatives both of professional members and of associates. As the latter class constituted the larger proportion of the vice-presidents, it was decided to limit its further representation on the Council to about one-fourth of the representation given to professional members, but in the conduct of business of the Institution associates have always taken, and still take, a prominent and useful part. From the beginning there has been a considerable representation on the Council of professional officers serving at the Admiralty and the Royal Dockyards. Lloyd's Register of Shipping has also been represented from the first. In recent years the British Corporation and the Veritas Society have also been represented; and as time has passed and the interest of private shipbuilders and marine engineers has increased, their representation on the council has been much enlarged, with great advantage to the Institution.

During the first 20 years the members of council varied from 25 to 30, and the associate members from six to seven. In 1879 it was decided to fix the maximum for each class at 24 and 6 respectively. Up to that date the Council had practically co-opted new members, the list of nominations being presented *en bloc* to the general meetings, and adopted as a matter of course. It was then felt to be desirable to give the members and associates of the Institution a more direct voice in the election, and rules were made by which a nomination list was prepared each year by the Council, and a system of ballot-papers was introduced by means of which the votes were given. Nine years later it was determined that instead of an annual election of the whole Council there should be an annual retirement by seniority of six ordinary members and two associate members, who remained eligible for re-election; the ballot-lists for the election of their successors containing as many new names in each class as there were retirements. In 1905 it was decided to increase the members of the Council to 36 ordinary members and 12 associate members; nine of the former and three of the latter who had served longest on the Council retiring annually, and being eligible for re-election. That regulation still holds good, and under it the Council, including the president, past-presidents, vice-presidents, and honorary vice-presidents, has become a very large body, but it still remains effective, and is fully representative. When the new rules were presented to and approved by the members and associates of the Institution in April, 1905, the following statement was made:—"This Institution is the central institution of a great industry which is scattered all round the coast of this island, and the sister island—Ireland. It is a scattered constituency, and we wish always to have represented on the Council the various districts where shipbuilding and marine engineering are practised. It is of the greatest value to this Institution that such a system of local representation should be continued and extended, and that is always kept in view by the Council in making nominations of new candidates for the Council. We also wish to have both naval architecture and marine

engineering adequately represented. On the associates' side are included many classes in the community. We have shipowners, naval officers, representatives of great shipping institutions, yachtsmen, and scientific men interested in the practice and theory of shipbuilding and engineering. For all these reasons the Council have judged that it is desirable to make the changes described."

(To be continued.)

PROGRESS OF NAVAL CONSTRUCTION IN JAPAN.*

By Rear-Admiral MOTOKI KONDO, Inspector-General of Naval Construction, I.J.N., Member.

THE fact that the art of shipbuilding is not entirely modern in Japan was well illustrated by the models and pictures of our ancient war galleys which were on view last year at the Anglo-Japanese Exhibition. In this paper, however, I do not propose to go back to so remote a period, and I shall only deal with the progress of our naval construction since the introduction of European methods of shipbuilding in Japan.

It is interesting to mention in this connection that the keel of the first warship of this type ever built in Japan was laid in 1861, and it will thus be seen that our modern navy is nearly as old as this Institution.

I shall first give a brief account of the development of our naval dockyards, and then deal with the progress of naval construction in our country.

Navy Yards.—We have at present four navy yards—viz. :—Yokosuka, Kure, Sasewo, and Maidzuru, besides three smaller repairing yards at Ominato, Takeshiki, and Bako.

The Yokosuka Navy Yard is the oldest establishment of this kind in our country. It is situated in the Bay of Tokyo, not very far from the entrance to the bay, and was commenced in 1864 under the superintendence of the Tokugawa Regency. The technical staff at the time consisted entirely of French naval constructors, with their own foremen and leading hands under them, lent by the French Government.

At first the yard was not intended exclusively for naval work ; in fact, it was a sort of general shipbuilding yard. Subsequently this place passed into the possession of the Imperial Government, and was worked for some years under the direct superintendence of the Ministry of Public Works (since abolished), until, in 1872, it was transferred to the Imperial Navy, by whom it continues to be worked to this day.

TABLE I.—*Number, Aggregate Displacement, and Horse-Power of Warships Launched in Japan.*

Year.	Number	Displacement in Tons.	Horse-Power.	Remarks.
1890				
1891	2	4,908	6,100	A cruiser and a gunboat.
1892	1	3,126	7,500	A cruiser.
1893				
1894				
1895	1	2,657	8,500	A cruiser.
1896	2	1,772	6,000	A despatch boat.
1897	1	2,756	8,000	A cruiser.
1898				
1899				
1900	1	1,238	6,000	A despatch boat
1901				
1902	2	6,732	18,800	Two cruisers
1903	2	3,620	11,000	A cruiser and a gun-boat
1904				
1905	1	13,750	20,500	An armoured cruiser
1906	2	32,950	40,000	A battleship and an armoured cruiser
1907	5	54,350	44,000	A battleship, two armoured cruisers, a cruiser, and a despatch boat. Turbines for two ships made abroad
1908	1	1,350	..	A despatch boat. Turbines for one ship made abroad
1909				
1910	1	20,800	25,000	A battleship

Total since 1890, 22.

TABLE II.—*Number, Aggregate Displacement, and Horse-Power of Torpedo Craft Built in Japan.*

Year.	Number	Displacement in Tons.	Horse-Power.	Remarks.
1900	6	3 '1	4,200	All torpedo-boats.
1901	3	162	2,100	,, ,,
1902	5	981	15,100	3 destroyers ; rest torpedo-boats
1903	17	2589	16,200	2 ,, ,,
1904	4	331	18,600	1 ,, ,,
1905	12	4500	72,000	All destroyers.
1906	18	6750	108,000	,, ,,
1907	2	750	12,000	,, ,,
1908	1	375	6,000	Destroyer.
1909	1	375	6,000	,,
1910	1	1150	20,500	,,

But to return to the history of the establishment : the first sod was turned on September 27, 1865, and the first foundation-stone for the buildings was laid in March the next year. The first graving-dock was formally opened on February 7, 1870. Prior to 1885 all the ships launched in this yard were built of wood, but in this year the first composite ship, H.I.M.S. Katsuragi, was launched. H.I.M.S. Atago was the first iron ship built in this yard, and was launched in 1887. After this the progress of shipbuilding went on steadily, and after building several

* Paper read at the Jubilee Meeting of the Institution of Naval Architects, July 5, 1911.

TABLE III.—LIST OF WARSHIPS BUILT IN JAPAN.

Year Launched.	Name.	Where Built.	Displacement.	Type.	Material of Hull.	Machinery Particulars.	Propeller.	Remarks.
1862	Chiyoda	Ishikawajima	140	Gunboat	Wood	Direct-acting geared	Single-screw	Sold.
1875	Seiki	Yokosuka	897	Sloop of war	,,	Three-cylinder compound horizontal	,,	Lost off mouth of Fujikawa.
1876	Jingei	,,	1,450	Imperial yacht	,,	Diagonal	Paddle	Broken up.
1877	Amagi	,,	911	Sloop of war	,,	Three-cylinder compound horizontal	Single-screw	Sold.
1878	Banjo	,,	656	Gunboat	,,	Direct-acting horizontal	,,	
1882	Kaimon	,,	1,350	Corvette	,,	Return-acting compound horizontal	,,	
1883	Tenriu	,,	1,525	,,	,,	Ditto	,,	Lost during Russian war.
1885	Katsuragi	,,	1,480	,,	Composite	Ditto	,,	
1885	Yamato	Kobe	1,480	,,	,,	Ditto	,,	
1886	Musashi	Yokosuka	1,480	,,	,,	Ditto	,,	
1886	Maya	Kobe	612	Gunboat	Iron & steel	Direct-acting compound horizontal	Twin-screw	
1887	Atago	Yokosuka	612	,,	,,	Ditto	,,	Lost during Russian war.
1887	Chokai	Ishikawajima	612	,,	,,	Ditto	,,	
1888	Akagi	Kobe	612	,,	,,	Ditto	,,	
1888	Takawo	Yokosuka	1,750	3rd-class cruiser	,,	Ditto	,,	
1889	Yayeyama	,,	1,584	Despatch vessel	Steel	Direct-acting triple-expansion horizontal	,,	
1891	Hashidate	,,	4,278	2nd-class cruiser	,,	Ditto	,,	
1891	Oshima	Kobe	630	Gunboat	,,	Triple-expansion vertical	,,	Lost during Russian war.
1892	Akitsushima	Yokosuka	3,126	3rd-class cruiser	,,	,, ,, ,,	,,	
1895	Suma	,,	2,657	,, ,,	,,	,, ,, ,,	,,	
1896	Miyako	Kure	1,772	Despatch vessel	,,	,, ,, ,,	,,	Lost during Russian war.
1897	Akashi	Yokosuka	2,756	3rd-class cruiser	,,	,, ,, ,,	,,	
1900	Chihaya	,,	1,238	Despatch vessel	,,	,, ,, ,,	,,	
1902	Niitaka	,,	3,366	3rd-class cruiser	,,	,, ,, ,,	,,	
1902	Tsushima	Kure	3,366	,, ,,	,,	,, ,, ,,	,,	
1903	Uji	,,	620	Gunboat	,,	,, ,, ,,	,,	
1903	Otowa	Yokosuka	3,000	3rd-class cruiser	,,	,, ,, ,,	,,	
1905	Tsukuba	Kure	13,750	Armoured cruiser	,,	,, ,, ,,	,,	
1906	Ikoma	,,	13,750	,, ,,	,,	,, ,, ,,	,,	
1906	Satsuma	Yokosuka	19,200	Battleship	,,	,, ,, ,,	,,	
1907	Aki	Kure	19,800	,,	,,	Turbine	,,	
1907	Kurama	Yokosuka	14,600	Armoured cruiser	,,	Triple expansion vertical	,,	
1907	Tone	Saseho	4,100	2nd-class cruiser	,,	,, ,, ,,	,,	
1907	Yodo	Kobe	1,250	Despatch vessel	,,	,, ,, ,,	,,	
1907	Ibuki	Kure	14,600	Armoured cruiser	,,	Turbine	,,	
1908	Mogami	Nagasaki	1,350	Despatch vessel	,,	,,	Triple-screw	
1910	Kawachi	Yokosuka	20,800	Battleship	,,	,,	Twin-screw	

third-class cruisers, besides smaller craft, the first battleship ever built in Japan—H.I.M.S. Satsuma—was launched in 1906.

At present the dockyard has two large building-slips and three smaller ones, for destroyers and torpedo-boats. The largest slip has a gantry fitted over the whole length, provided with several cranes ranging up to 30 tons. The graving-docks are four in number, and the largest one is capable of taking ships of the largest dimensions now afloat.

The following figures will give some idea of the enormous growth of this place since it was first started :—

The number of workmen was only 960 in 1869, while we now have over 8000 all told. The extent of the grounds, which was but 21,700 tsubo (about 18 acres) in 1865, is now more than six times what it was then, being over 140,000 tsubo (about 116 acres).

The engineering department consists of foundry, smithy, machine-shop, boiler-shop, plumber's shop, &c. ; it is, in short, replete with all the appliances necessary for the construction of the heaviest engines and boilers for modern warships. The whole of the propelling machinery of H.I.M.S. Satsuma was made here, including the whole of the castings, all the important forgings, and the entire machining, as well as the water-tube boilers, which are of the Miyabara type. Even most of the auxiliary machinery was made here.

A good deal of repair work is also performed in this dockyard, and for a few years after the late war the place was very busy indeed, on account of alterations and repairs of captured ships that had to be executed over and above the new construction and ordinary repairs and overhaul of our own ships, and the number of workmen employed at the time was more than double what it is now.

The Kure Navy Yard, the second oldest yard in Japan, is situated in the Inland Sea, near Hiroshima. It was commenced in 1889, but it was not until just before the Chinese war that the place became of any very great importance. It has since been gradually developed, and at the present time it rivals Yokosuka Navy Yard in the extent of site, as well as in the amount and the quality of work turned out. There are two large building slips (one of them fitted with a gantry throughout the length of the slip), besides smaller ones for destroyers and torpedo-boats. There are two graving docks now in use and two more of larger size are under construction.

Seven warships and fifteen destroyers and torpedo-boats were built here during the last sixteen years, and to this dockyard belongs the honour of having turned out the first armoured vessel built in our country. It also holds the record for the quickest construction, having launched H.I.M.S. Ibuki in exactly six months after laying down the keel.

The engineering department here is on a similar scale to that in the Yokosuka Navy Yard, and the work turned out is fully equal in amount and quality to that of the latter place.

The ordnance department in this yard has the capacity for manufacturing guns and mountings up to the largest size, and almost the whole armament of all the warships built in Japan of late years has been made here. There are steel works and armour-plate works also belonging to this yard.

The Sasewo Navy Yard is in the Island of Kyushu, not very far from Nagasaki, and was started in 1890, but very little progress was made until just before the Chinese war. This yard is primarily intended for repair work. There are five large docks, of which three are under construction, and one small dry dock for minor craft. Besides the necessary appliances for all kinds of repair work, the dockyard has facilities for new construction, and has already built one second-class cruiser, and several destroyers and torpedo-boats fully equipped and engined. At present one second-class cruiser, Chikuma, of about 5000 tons, is approaching completion in this yard, being launched last April.

The Maidzuru Navy Yard is the most recent of our Navy yards, having been formally opened in 1901. This is the only yard we have at present in the Sea of Japan, and it is within easy reach of Osaka and other important towns by railway. This yard is also well equipped with appliances for repair work, as well as for new construction. So far, only six destroyers have been built here, but the place is fully equal to heavier work if required. There are two large (one building) and two small graving docks.

There are also three small navy yards in the auxiliary naval stations at Ominato, on the north-east coast ; at Takeshiki, in the Island of Tsushima ; and in Bako, in one of the islands of Pescadores. These yards are only intended for minor repair work, mostly for destroyers and other small craft, and the number of workmen employed is very small. There is a small floating dock for lifting ships up to about 1500 tons in each of the two first-mentioned yards, and there is a small dock in course of construction at Bako.

Ship Construction.—The first warship on the European model ever built in Japan was a small screw schooner called Chiyoda Gata (Fig. 1, page 16). She was built under the jurisdiction of the Tokugawa Regency at Ishikawajima, at the site now owned by the Ishikawajima Shipbuilding Company, situated on a delta in the mouth of the River Sumida. Her keel was laid on May 7, 1861, she was launched on July 2 the following year, and was completed in May, 1863. Her engines and boilers were constructed in the Shogun's workshop in Nagasaki, probably on one of the sites now belonging to the Mitsubishi Dockyard. It is interesting to note that not only her hull and fittings, but the whole of her machinery, were constructed by native workmen with the native materials, under the directions of Japanese officers, who were also responsible for the design.

Her principal particulars are as follows :—

Material of hull	Wood
Length between perpendiculars	97 ft. 4 in.
Breadth, extreme	16 ft.
Draught of water, mean	6 ft. 8½ in.
Displacement in tons	140
Indicated horse-power	60
Speed in knots	5
Boilers	Two multitubular
Engines	Direct acting, geared
Diameter of cylinders	Two 16-in.
Stroke of pistons	15¾ in.

This little gunboat saw active service during the civil war against the present Government, but was inadvertently run ashore and abandoned. She was ultimately refloated and captured by the Government forces. After serving several years in the Imperial Navy, she was transferred to a whaling company, who, I believe, have her still in service.

After this boat was built, no important naval construction was attempted for a considerable period, all the ships being acquired from abroad, and it was not until

the Yokosuka Navy Yard was in full swing in naval hands that attention was again drawn to this important branch of industry.

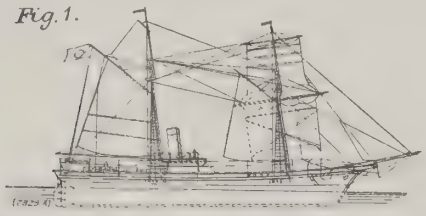
H.I.M.S. Seiki (Figs. 2 and 3) was the first warship built at Yokosuka Dockyard, and may be considered as the pioneer of all the warships built in our country. She was laid down on June 20, 1873; launched on May 5, 1875; and completed in June, 1876. She was built of wood, and was designed by M. Verny, the head of the French naval architects in the yard, and was built and engined by the French naval architects and engineers.

Particulars of H.I.M.S. "Aki" and "Kurama."

	"Aki."	"Kurama."
Type	First-class battleship	First-class armoured cruiser
Where built	Kure Navy yard	Yokosuka Navy yard
Date of launch	1907	1907
Length between perpendiculars	460 ft.	450 ft.
Breadth extreme	83 ft. 6 in.	75 ft. 6 in.
Depth	44 ,, 6 ,,	42 ,, 3 ,,
Draught	27 ,, 6 ,,	26 ft.
Displacement in tons	19,800	14,600
Horse-power	24,000	22,500
Type of machinery	Curtis turbines	Triple-expansion vertical engines
Speed	20	21¼
Armament	4 12-in. guns. 12 10-in. guns. 8 6-in. guns. 8 12-pdr. guns. 4 Maxim guns. 5 18-in. torpedo tubes.	4 12-in. guns. 8 8-in. guns 14 4.7-in. guns. 4 12-pdr., 3 3-pdr. guns. 4 Maxim guns. 3 18-in. torpedo-tubes.
Protection	9 in. belt. 2-in. deck. 9-in. barbette.	7-in. belt. 1½-in. deck. 7-in. barbette.

H. I. M. S. CHIYODAGATA (1861)
SCALE 1IN=64 FT

Fig. 1.



H. I. M. S. SEIKI (1873)
SCALE 1IN=64 FT

Fig. 2.

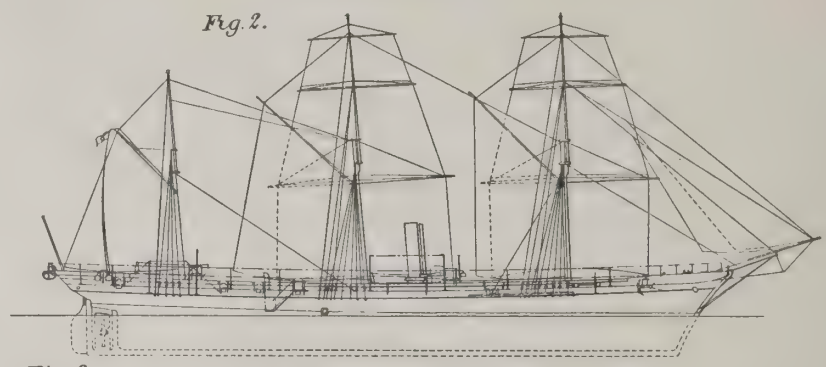
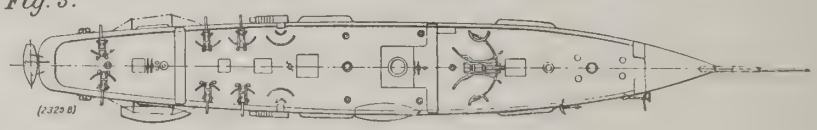


Fig. 3.



H. I. M. BATTLESHIP AKI . (1904)
Scale 1 In=64 Ft.

Fig. 4.

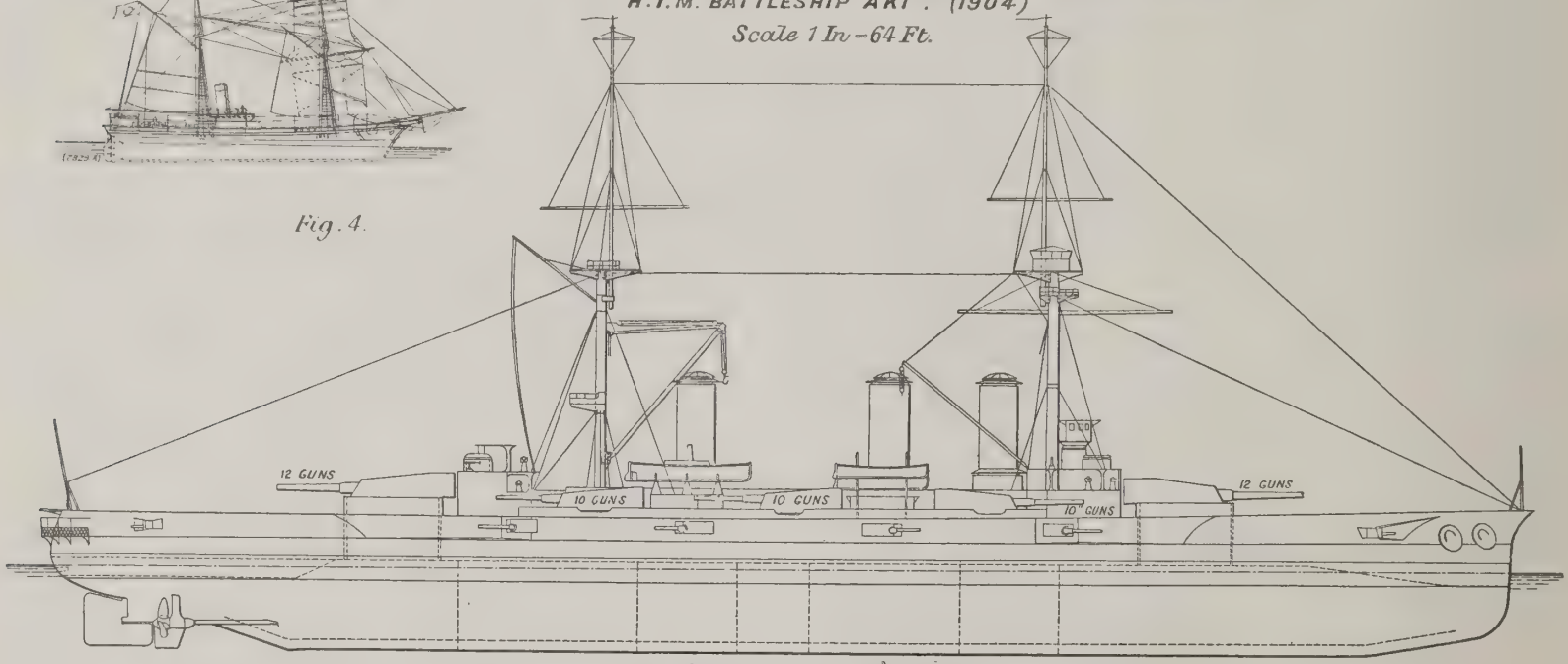
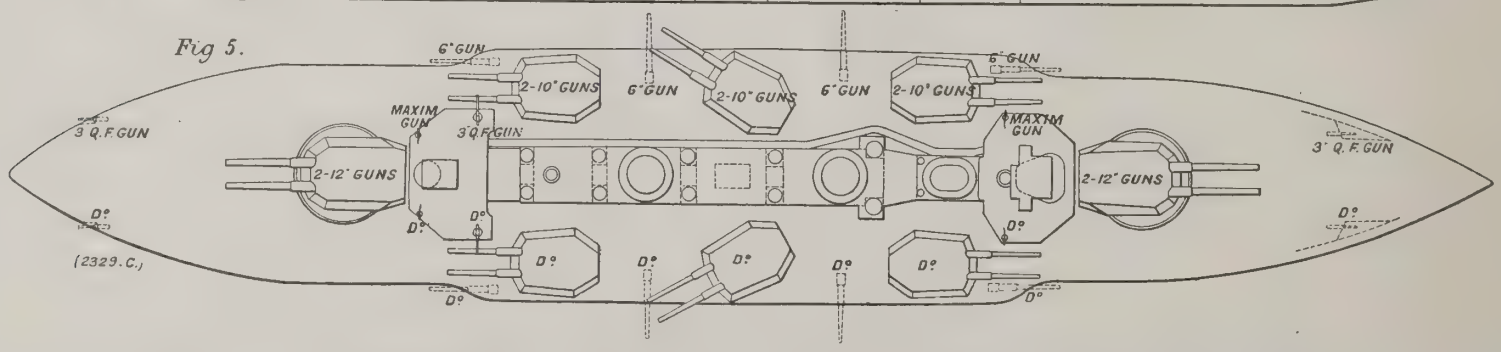


Fig 5.



The first composite ship built was H.I.M.S. Katsuragi. She was built at Yokosuka, and launched in 1885. She is a sloop-of-war of 1400 tons displacement, and is still doing service as a surveying vessel. During the construction of this vessel two foremen were lent by the British Government to initiate the Japanese workmen into the mysteries of manipulation of iron plates and bars.

The first iron ship, H.I.M.S. Atago, was also built at Yokosuka, and was launched in 1887. She was a gunboat of 612 tons displacement and 10 knots speed. She was lost during the late war, being run on rocks in a heavy fog. After this period practically all the ships built for the navy were of steel, ranging from gunboats to second-class cruisers in type and from 1250 tons to 4160 tons displacement. Until the laying down of H.I.M.S. Tsukuba in the Kure Navy Yard in 1904, which marked the new epoch in our naval construction, no ship of larger size than an unarmoured cruiser of a little over 4000 tons had hitherto been built, while this ship is an armoured cruiser of 13,750 tons. This event was all the more notable for the fact that she was commenced during the Russian War, and was the most powerful armoured cruiser in the world at the time, a position she held until the advent of the cruisers of the Invincible class. No doubt many of the members of this Institution will remember that she was one of the ships sent by the Japanese Government to take part in the Columbian Fête at Hampton Roads, and since then sent over to England in 1907.

The first battleship built in Japan was H.I.M.S. Satsuma, laid down in 1904 at Yokosuka, and she was the heaviest warship in the world at the time of her launch. She is now practically complete, having passed through her steam and gunnery trials successfully.

At the Kure Navy yard H.I.M.S. Aki was commenced in the same year. She is practically a sister-ship to the Satsuma, but is a little larger, and slightly more heavily armed. She will be finished in the course of the year.

A few particulars of H.I.M.S. Aki (Figs. 4 and 5) and H.I.M.S. Kurama (Figs. 6 and 7, page 17), an armoured cruiser built in Yokosuka, are given in the previous column.

Two battleships, the Kawachi and Settsu, of over 20,000 tons are under construction, the former at Yokosuka and the latter at Kure. They were launched last October and March respectively. A large armoured cruiser of 27,500 tons has also just been commenced at Yokosuka.

With regard to the torpedo-craft, we have had several torpedo-boats in service for years, but they were all ordered from abroad, being built up, taken to pieces, and sent over to Japan and rebuilt at home, and it was not until late years that we began to design and build these boats ourselves. In 1899 a third-class torpedo-boat was commenced at Yokosuka Dockyard, and three years later first-class boats were also laid down in Kure and second-class boats in Yokosuka and Sasewo. Since then altogether twenty-two boats of this class have been built in Japan.

The first destroyer built in our country was the Harusame, laid down at Yokosuka dockyard in 1902. She proved to be a very successful boat, and in all thirty-nine boats of this class have since been built in our dockyards and private yards. We have been singularly fortunate in their steam trials, as they have not only attained the estimated speed without difficulty, but we were exceptionally free from mishaps, only one instance of any serious accident occurring during the whole time, and even then there was no loss of life. At present we have two destroyers of 1150 tons displacement under construction, one at Maidzuru and one at Nagasaki.

Naval Construction in Private Yards.—At present we have two large private shipbuilding yards in Japan, capable of turning out the heaviest warships complete with their machinery. These are the Mitsubishi Dockyard, Nagasaki, and the Kawasaki Shipbuilding Company, Kobe. In the former, H.I.M.S. Mogami was built, complete with her turbine machinery, and they are at present building a second-class cruiser and a large destroyer for the navy. In the latter place, the despatch-boat Yodo and several destroyers and torpedo-boats were built, and they are building a second-class cruiser, a sister vessel to the one building at Nagasaki. Orders have just been placed with each of these firms for the construction of a large armoured cruiser, similar to the one building at

Yokosuka. Besides the above there are also several smaller firms capable of constructing destroyers and smaller craft, with the engines and boilers complete. Among these the Osaka Shipbuilding and Engineering Company, Osaka, and the Uraga Shipbuilding Company, each built two destroyers for the navy, and the H.I.M.S. Chokai, the sister-ship to the Atago, already mentioned, was built at Ishikawajima.

Personnel.—In the early years of Meiji (from the end of the 'sixties to the early 'seventies) when young students were sent abroad to study different branches of the naval profession, some of them were told off to investigate naval construction in its theoretical and practical aspects, and they made their studies in England and Scotland. Soon after this several young students were also sent to France for a similar purpose, and thus the nucleus of the naval constructors in our navy was formed. In the meantime the class of naval architecture was founded in the Imperial College of Engineering (under the Ministry of Public Works, since abolished), and some of the graduates entered the navy. After this a few graduates joined the navy each year, the college being since amalgamated with the Tokio University under the name of the Imperial University (under the Ministry of Education). Under the present *régime* one or two students of naval architecture are selected each year, and a special additional education given them by naval constructors to enable them to fit themselves for the service requirements. These students on graduating from the university are appointed assistant-constructors (ensign's rank) and enrolled in the Corps of Naval Constructors.

Until 1887 all naval constructors were civilians, but in that year a special military rank was formed for the technical corps, and naval constructors, constructing naval engineers, and ordnance constructors, were enrolled in this corps. In 1894 this branch was again subdivided into separate corps of naval constructors (naval construction and naval engineering) and ordnance constructors (including torpedo branch). At present constructors have similar ranks to other branches of naval officers, and follow the same regulations as to promotion, scale of pay, &c. They wear uniforms similar to the other non-executive branches of naval officers (the distinguishing colour of the piping being brown for the naval constructors and chocolate for the ordnance constructors).

The corps now comprise the following :—

	Corresponding Rank.
5 Inspectors-General.	Rear-Admiral.
6 Chief Inspectors.	Captain.
6 Inspectors	Commander.
24 Chief Constructors.	Lieutenant-Commander.
25 Constructors.	Lieutenant.
8 Assistant Constructors.	Ensign.
Total 74	

There are also several civilian officers employed on special duties. In the engineering branch several naval engineers are also employed along with the constructing engineers. These officers are given special instruction for the purpose.

It may be mentioned here that many of the officers, after leaving the college and serving in the dockyards for some years, were sent abroad for further studies in the profession, and several have gone through the regular course of naval construction in the Royal Naval College, Greenwich, in England, and l'Ecole d'Application du Génie Maritime, in France, through the courtesies of their respective Governments.

With regard to the workpeople, we have now a goodly number of skilled men available throughout our country, but formerly there was absolutely no source to draw upon. In fact, it is not too much to say that we had not only to bring up workmen for employment in our own naval works, but also for private firms, who had no other means of obtaining them. In this respect we were in an entirely different position from that which obtains in Great Britain and other European countries, inasmuch as, while in these countries private enterprise first developed, and very often the Government reaped the benefit thereof, in our country the Government had to take the initiative in nearly every industry, and naturally the workmen had to be trained in the Government works also. Of course these men were not expressly trained for the purpose of turning them over to private yards, but when they wished to leave the Government works to go to the private ones we never placed any very great restrictions in their way.

We have a class of men who rank between the foremen and the commissioned officers. These non-commissioned officers are civilians and are either chosen from leading hands who have shown a special aptitude in their trade, and also have the necessary education for the post they are to occupy, or are taken from the graduates of certain technical schools (with whom special arrangements had been made) after serving a certain period of time as ordinary workmen.

The number of workmen engaged in the naval construction and marine engineering in the Imperial Dockyards at the end of 1910 was as follows :—

	Shipbuilding.	Engineering.	Total.
Yokosuka	4,562	3177	7,739
Kure	3,551	2342	5,893
Sasewo	2,101	1839	3,940
Maidzuru	1,241	1378	2,619
Ominato	71	67	138
Takeshiki	124	97	221
Bako	61	65	126
Total	11,711	8965	20,676

We hear a good deal about the Japanese people being able to adapt themselves to new ideas and new methods, but the fact should not be lost sight of that the Japanese have always been well up in all branches of handicraft. Several branches of industry had reached a very high state of proficiency before the intercourse with the Western nations, and, although the extensive use of machinery was certainly new to our ideas, no great difficulty was experienced in adapting ourselves thereto. As a rule, our men are intelligent and versatile, and it was a comparatively easy matter to train them in different branches of shipbuilding and engineering.

On this account our men are peculiarly suited for delicate work, as, for instance, in the construction of hull and machinery of torpedo craft, which may account for the fact that these craft can be built at very much less cost at home than abroad.

We are at a great discount on account of lack of physique of our men where much manual labour is required, and thus we derive a great benefit from the modern inventions for dealing with heavy materials. Just to give an instance of the great saving in labour through the use of transporting appliances, I may cite the cases of H.I.M.S. Tsukuba and H.I.M.S. Ikoma, built in Kure before, and H.I.M.S. Aki, built after the installation of the gantry crane. While the latter ship is of some 6000 tons more displacement than the former, the amount spent on labour up to the time of launching for the latter ship was actually less than the corresponding figure for the two former.

I might mention, in passing, that our working hours are somewhat longer than those in British yards, being on the average about 9½ hours per day. The scale of pay is still very low, the average rate (including labourers) being rather under 1s. 6d. per day, or 9s. per week;

H.I.M ARMOURED CRUISER "KURAMA"
Scale 1 In.-64 Ft.

Fig. 6.

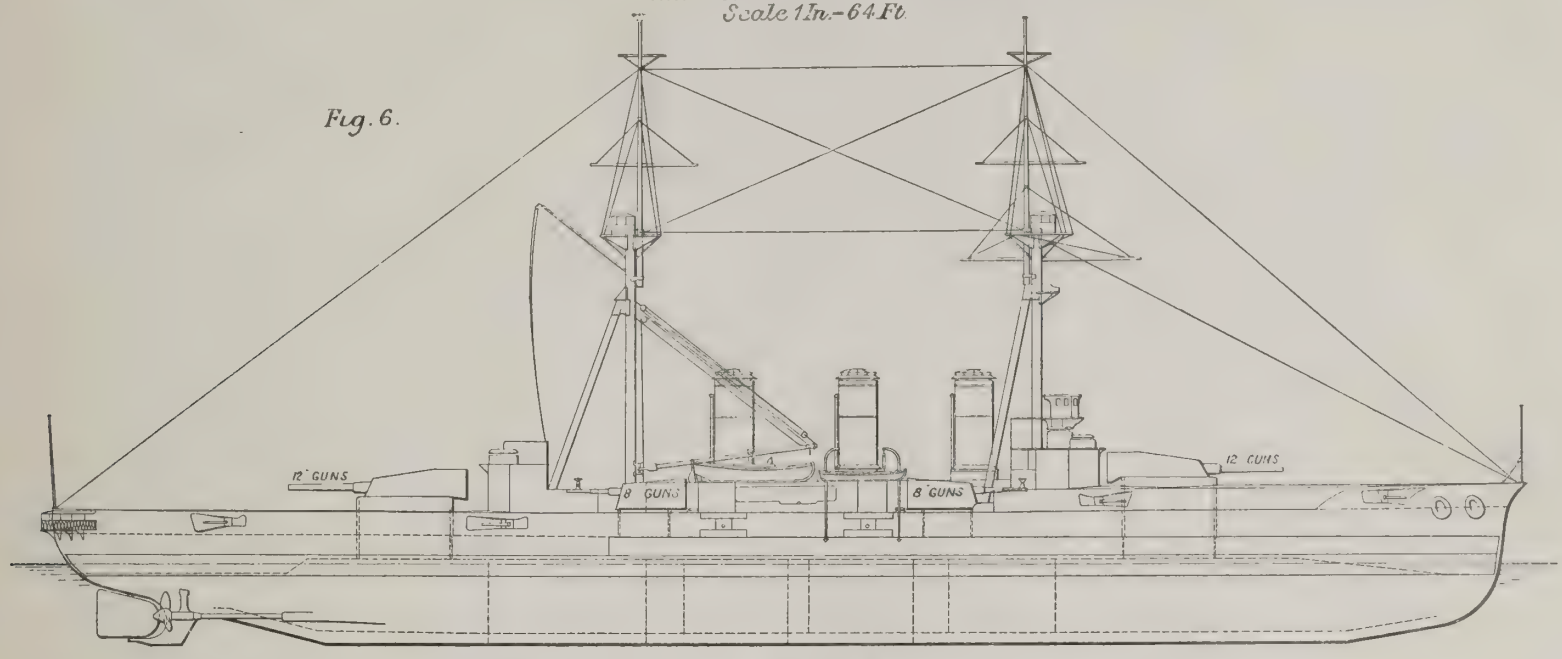


Fig. 7.

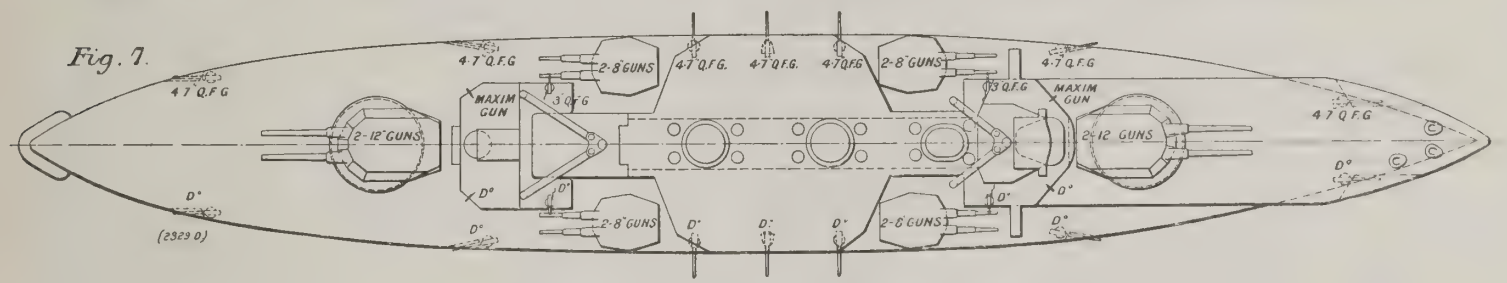


Fig. 8.

AGGREGATE DISPLACEMENT TONNAGE OF TORPEDO CRAFT BUILT IN HOME DOCKYARDS AND PRIVATE YARDS SINCE 1900.

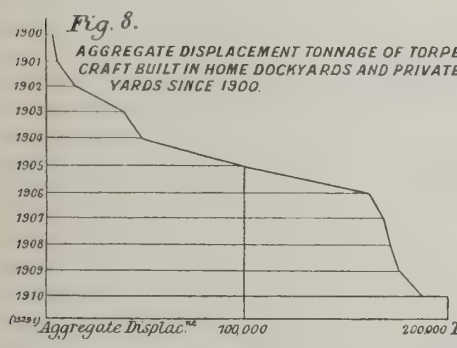
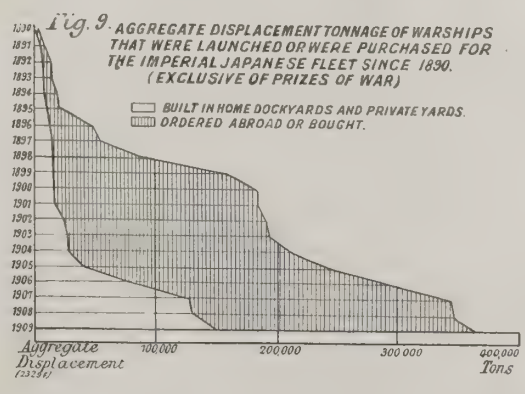


Fig. 9. AGGREGATE DISPLACEMENT TONNAGE OF WARSHIPS THAT WERE LAUNCHED OR WERE PURCHASED FOR THE IMPERIAL JAPANESE FLEET SINCE 1890. (EXCLUSIVE OF PRIZES OF WAR)

BUILT IN HOME DOCKYARDS AND PRIVATE YARDS.
ORDERED ABROAD OR BOUGHT.



but it is rising by leaps and bounds; it has more than doubled in the last ten years. The premium system is adopted to a limited extent for some work, and, so far, it seems to work without any obstacles.

Armour-Plate Manufacture.—The plant for the manufacture of armour-plates was first started in 1902 in Kure Navy Yard. After a certain period of time spent in experiments, &c., we are now able to produce armour-plates of reliable quality, and the output is fully equal to all our requirements for some time to come. I am not able to give a description of the process employed, as it is outside my profession; but I understand it is a special process invented by our own engineers, and, according to the results of the firing trials and physical and chemical tests conducted from time to time, the quality is fully up to the best armour-plate of the day.

I am pleased to say that, only three years after the works were started, plates of sufficiently reliable quality were turned out to justify their adoption on H.I.M.S. Tsukuba. In this respect the expectations of the most optimistic were surpassed.

Experience Gained during the late War.—One is apt to attach too much importance to the experiences gained during the war. No doubt much valuable information was obtained in tactical and strategical matters, though even there, I fear, much has been left unsolved. In naval construction, at any rate, I find that many questions we were anxious to have solved by war experience remain unsolved to this day. When we come to consider the number of times that actual battles took place during nearly a year and a half that the hostilities continued, we can easily understand that it is impossible that all the innumerable possible cases should take place. It is true that we have received confirmation of what we deemed most probable, which we could never have ascertained in peace time, but in the main it is safe to say that no new lessons have been learned by the war to revolutionise the art of naval construction. The Dreadnought is but the logical outcome of the progress of naval construction, and that type would have been arrived at sooner or later, even if the war had never taken place.

One point, however, which has been brought home forcibly to all, and to naval architects in particular, is the danger from fixed and floating mines. Even in this case the idea of protecting the under-water portion of the ship is new, as the Cesarevitch, built nine years ago, had a torpedo protection embodied in her construction; and if we provide the protection to the new ships, it can but be the development of the ideal first adopted in the Cesarevitch.

In minor points about equipments and fittings we have naturally gained considerable experience, but they are too numerous and trivial to be mentioned in a paper dealing with such broad subjects.

On pages 15 and 16 are tables, and on page 17 diagrams, which may help to show the progress of naval construction in Japan.

FIFTY YEARS' CHANGES IN BRITISH WARSHIP MACHINERY.*

By Engineer-Vice-Admiral Sir HENRY J. ORAM, K.C.B., Vice-President.

THE general progress of engineering in H.M. Navy from 1860 to 1897 has been previously dealt with in a paper read by two of our vice-presidents, Sir John Durston and Mr. Milton, at the international congress of this Institution in 1897, while a great deal has been written on the subject in various other papers, so that the scope for any additional or original *résumé* of events previous to 1897 is limited.

At the request of the Council, however, I have endeavoured to indicate more fully the conditions of naval engineering in 1860, and generally the changes and progress made during the fifty years' existence of this Institution.

In 1860 the Navy List included the following numbers of steamships, with propelling machinery manufactured by various firms between 1842 and 1859—132 ships of 400 nominal horse-power and upwards (including 23 paddle-ships), and 367 ships below 400 nominal horse-power (including 87 paddle-ships), giving a total of 499 ships, with a collective nominal horse-power of 116,540, or about 540,000 indicated horse-power.

In 1910 the number of warships was 585, but with a much increased total horse-power—of approximately 5,000,000.

The founding of this Institution coincided with the period when the definite abandonment of the paddle-wheel as the means of propulsion of warships had occurred and the screw had been adopted for propulsion. In all the warships built in 1860 screw-propellers were arranged for.

The earliest ships with screw-propellers had engines designed on the same lines as those fitted in paddle vessels and working at low revolutions. These were adapted to drive the screws by means of gearing, which increased the revolutions of the screws as compared with those of the engine; but in 1860 gearing had been dispensed with, and the engines on order were of the horizontal type, and designed to drive the screw direct, the revolutions of the engines being increased accordingly. These engines worked at from 34 to 105 revolutions per minute at full power, with piston speeds varying from 200 ft. to 550 ft. per minute.

All these earlier ships were fitted with jet condensers, except in the case of the small gunboats, which had non-condensing engines, the exhaust steam being discharged up the funnel. Stephenson's link motion for actuating the slide-valve and for reversing the engines was usually fitted, and it may be remarked that some form of Stephenson's link motion has remained as the standard valve-gear for reciprocating engines up to the present time. Many of the larger ships were provided with separate expansion valves.

The boilers under construction in 1860 were generally of the box tubular form, working at a steam-pressure of about 20 lb. per square inch, the earlier box-flue boiler having been discarded. The gunboats with non-condensing engines were, however, fitted with the low cylindrical type of boiler designed for a steam-pressure of 60 lb. per square inch.

At such early stages in the application of steam to warship propulsion during the transition period from paddles to screw, with a gradually rising steam-pressure, one would naturally expect a few mistakes to be made, and at this period there were cases of comparatively new screw ships which had their original engines and boilers removed and either converted, sold, or broken up, new engines and boilers being fitted. Many installations of copper boilers were also removed and replaced by iron ones.

Table I., page 20, has been prepared to show the leading particulars of the engines and boilers fitted in representative warships during the period covered by the existence of this Institution. The powers given and the figures based on them refer to those developed on the usual eight hours' trial, as these are more suitable for the purposes of this paper; the increase of power obtained by extra forcing of the boilers for shorter periods are neglected. Some of the earlier ships, however, for which the figures have been inserted, had trials of only two hours', or even less, duration. It must be understood, therefore, that most of the ships in the table, especially the later ones, can exert considerably more power for shorter periods than has been stated.

The warship fitted with the most powerful machinery in 1860 was the Warrior. She was described as a shot-proof frigate, and had engines of 1250 nominal horse-power. The machinery developed 5469 indicated horse-power on trial, giving the ship a speed of 14.3 knots. The engines were of Penn's trunk design of the simple-expansion type, with two cylinders. Each cylinder was fitted with a separate expansion-valve. The revolutions on trial were 54.25, which, with a 4-ft. stroke, gave a piston-speed of 434 ft. per minute. Metallic packing-rings were fitted to the pistons, the specification stating that they should be constructed "so as not to require the use of hemp or other packing behind them." There were two jet condensers, one for each cylinder, with double-acting air-pumps, which, with the feed-pumps and fire and bilge pumps, were worked directly off the main engine pistons. The boilers were of the box tubular type, and the dead-weight safety-valves were loaded to 22 lb. per square inch. The furnaces and tube-plates were specified to be of Low Moor or Bowling iron, two qualities of wrought iron which were familiar in Admiralty specifications until the introduction of wrought steel for such parts. The tubes were of brass, and it was specified that every part of the boiler was to be in contact with water or steam. The fire-grate was 900 sq. ft. in area, the boiler heating surface 22,500 sq. ft., and on trial 6.08 horse-power was obtained per square foot of grate.

This ship was fitted for working entirely under sail, and to suit the sails the funnel and waste-steam pipes were telescopic, and the gun-metal screw-propeller was of the lifting type, easily disengaged from the driving shaft. Cast iron, wrought iron, and gun-metal were the usual materials of this period; Muntz metal was used for pump rods, and white metal was allowed to be used "where desired." The specified time for completing the work ready to be put on board was eleven months, and the further time for fitting in the vessel was three months. As first fitted, the engines were reversed by hand gear; hand power was also used for steering the ship and working the capstan. Steam-engines were subsequently fitted in the ship for all these purposes, the first to be supplied being a steam capstan engine. The hull of the Warrior is still in existence as a hulk employed as a floating workshop in connection with H.M.S. Vernon.

Of the types of marine engines manufactured in 1860 the principal were those of the three leading makers, and distinguished by the names of these firms:—

Messrs. Maudslay.—This was a double piston-rod engine, with piston rods over and under the crank-shaft communicating with crossheads and guides fitted on the opposite side of the crank to that of the cylinder. This design was known as the "return connecting-rod" engine, and with the single screw then fitted allowed the horizontal engines to have a longer stroke and connecting-rod.

Messrs. Penn.—The trunk engine made by this firm was a favourite type, the absence of a piston rod making a short engine, well suited for the space available in a single-screw ship. Although with the lower pressures these engines worked remarkably well, difficulties with the trunk became pronounced as the steam pressure rose, and ultimately led to the abandonment of this type.

Messrs. Humphrys.—A development of the above design (Messrs. Humphrys, Tennant and Co.) consisted of leading one piston rod to a crosshead, from which rods were passed to the crosshead and guide on the opposite side of ship to that of the cylinder. This design, therefore, also had the return connecting-rod. The design, however, which is principally associated with the name of Messrs. Humphrys, is the direct-acting engine, having the connecting-rod between the cylinder and the crank, the disadvantages of the shorter connecting-rod being accepted. This design of Humphrys was the prototype of the direct-acting engine which ultimately became universal, and, as the introduction of twin screws allowed of longer strokes being arranged for, the direct-acting engine of the horizontal type with connecting rod between the cylinder and the shaft became the universal practice from about 1871 until the introduction of the vertical engine.

In the Appendix there are extracts from the report of an Admiralty Committee of 1858, giving their opinion on the relative merits of these types.

The horizontal engine had an advantage over the vertical type, in that it allowed the engines to be placed below the water-line, but a disadvantage existed in the large amount of floor space necessary. The highest powered horizontal engines were those of the Melpomene class of 9000 indicated horse-power ordered in 1887. At this time the engines used were of the triple-expansion type, with steam-pressure of 155 lb. per square inch. These engines obtained their large power by an increase of the steam pressure and of the revolutions, but they were by no means the largest horizontal engines in size, as will be seen by reference to Table I., page 20.

The change from the horizontal to the vertical type was made in 1885 for the large ships, but sloops and gunboats continued to have horizontal engines till 1887-8. With the further rise of boiler pressure in 1887 came the fitting of triple-expansion engines, which at first were of the three-cylinder design; but, as powers increased, the low pressure cylinder was divided to reduce the size, and the four-cylinder triple-expansion engine became common.

The more important improvements effected during the last fifty years have been in the direction of economy of fuel, and reduction of weight of machinery and of the space occupied by it. Concurrently with these advantages increased life and reliability of the machinery have been obtained by attention to details of construction and quality of workmanship and material.

Much has been done to satisfy the constant demand for reduction in weight by the selection of stronger materials for the more heavily stressed parts, and improvements in the method of producing the materials used has resulted in stronger and more reliable metal being available. This latter development includes, in the period under review, the invention of the Siemens furnace and the production of mild steel of reliable and uniform quality in forgings, plates, and castings; the manufacture of high-class seamless steel tubing for boiler-tubes and steam-pipes; the production of corrugated and other similar forms of furnaces, high-tension bronzes, metallic and asbestos packings, and other devices required for high-pressure steam. There has also been a multitude of improvements in machine tools, some of which, such as forging presses, riveters, flanging machines, welding plants, gauges, and measuring machines for securing accuracy of workmanship, have been essential to the turning out of high-class work, and have made possible many of the advances now under review; many others, if not essential to actual construction, have had a marked effect on rapidity of production and reduction of cost.

Improvement in economy has been chiefly effected by successive increases of steam pressure, although, in the early stages, the introduction of steam jackets and superheaters produced some direct saving at the lower pressures. Table II., page 21, shows how improvement in economy has accompanied the rise in steam pressures.

The earlier increases in steam pressures were closely connected with the type of condenser in use, for as soon as the surface condenser was successfully introduced, enabling the boiler to be supplied almost entirely with fresh feed water, the incrustation from deposits of lime and other salts was largely prevented. The liability of overheating the boiler-plates was thus diminished, allowing the pressures to be increased without danger to the heating surfaces.

It is worthy of note that the surface condenser was not a success on the first application, and was dropped for a time, being later reintroduced. Between 1860 and 1870 a large number of engines with surface condensers were fitted in vessels of the Royal Navy, the steam pressure being slightly increased, and being usually about 30 lbs. per square inch.

The simple-expansion engines of about 1870, with steam of 30 lbs. pressure, and fitted with steam jackets, superheaters, and surface condensers, were fairly economical, and were a considerable advance on those immediately preceding them. After the success of the surface condenser, renewed attention was given to the subject of higher steam pressure and the economy due to greater expansion, the theoretical consideration of which marked it out as promising greatly increased economy, if the practical difficulties could be overcome. When the steam pressure rose from 30 lbs. to 60 lbs., the type of boiler changed from the box to the cylindrical, so that this increased steam pressure could be safely carried, and the engine changed to the compound type.

Great difference of opinion existed among engineers as to the merits of the compound system, and probably no change made in marine engineering was the subject of greater controversy. Like the surface condenser, its first application; was made under unfavourable circumstances; in subsequent examples under more favourable conditions the system was remarkably successful, and became universal for marine purposes. It may be mentioned that some of the unsuccessful compound engines were fitted with steam pressure of only 35 lb. per square inch.

In the compound engines the steam jacket was retained as beneficial, but the superheater was abandoned. Superheaters were commonly fitted at the beginning of the period under review, and, although they were probably more of the nature of steam-driers, they were effective in their application, yet the difficulties encountered led to their ultimate complete abandonment.

The gain in economy, which resulted by the use of compound engines using steam of 60 lb., pressure, over the best previous type of simple surface-condensing engines using 30 lb. pressure was from 30 to 35 per cent. This was well authenticated, and represents the average of the replies

* Paper read at the Jubilee meeting of the Institution of Naval Architects, July 5, 1911.

given by the principal engineers and steamship-owning companies to questions of the Admiralty Committee which sat in 1872 on designs of ships of war.

After about 1872 the new engines for ships of the Royal Navy were of the compound type. The original steam pressure of 60 lb. per square inch was increased about the year 1880 to 90 lb., and then rapidly rose to 120 lb. per square inch, the ratio of the cylinder areas being increased with the steam pressure, so as to secure the full benefit from the greater expansion of steam.

After the practical success of one or two vessels fitted with triple-expansion engines, the ordinary compound engine was abandoned in favour of the former type. The success of this design, in association with higher pressures, is undoubted, and from 1885, with a few minor exceptions, all new reciprocating engines for the Navy have been on the triple-expansion principle, with steam pressure commencing at 130 lb. and increasing to 155 lb. per square inch in 1887. A further gain in economy of about 15 per cent. was thus effected.

This period saw the introduction of the evaporator for producing fresh water for make-up feed purposes. The rise of steam pressures and increased duty demanded from boiler-heating surfaces were rendering it necessary to avoid the introduction of any water which would produce even a small deposit on the heating surfaces.

The evaporator, by making it possible to use only fresh water in the boilers, cleared the way for further rises of pressure. These rises of pressure and the demands for reduction in weight and space allowed for machinery finally led to the introduction of the water-tube boiler, the satisfactory use of which at sea had now been made possible by the adoption of the evaporator.

For several years after 1887 the pressure was not advanced beyond 155 lb., except in the case of the torpedo gunboat Speedy, which worked at a pressure of 210 lb. per square inch, the steam of this pressure being generated in water-tube boilers of the Thornycroft type. This vessel is noteworthy as being the first fitted with water-tube boilers on a considerable scale in the British Navy. The pressure was gradually increased still further, until, in 1895, several cruisers were ordered with an engine-pressure of 250 lb. per square inch. This is the maximum pressure for which machinery installations for the Royal Navy have been designed.

An important improvement as regards reciprocating engines was the fitting in 1899 of a system of forced lubrication to the main engines of the torpedo-boat destroyer Syren. The two engines of this vessel were each of 3100 indicated horse-power, and ran at 400 revolutions per minute. The application of this system was most successful, and it was extended to the engines of other torpedo-boat destroyers, and in 1904 to the engines of the battleships of the Britannia class, and subsequently to others.

Great benefits were thus obtained, including the practical elimination of the troubles of hot bearings. At this period the speeds had increased in our largest propelling engines to 140 revolutions per minute in some cases, although 120 revolutions was the general practice; but to go beyond this speed was considered to be running risks of obtaining engines which would not be satisfactory on service. With a good system of forced lubrication, however, this difficulty was largely removed, and higher speeds of revolution would have been possible, with a consequent decrease in the weights of machinery, had not the introduction of the turbine made this unnecessary.

An improvement which has added to the working efficiency of the reciprocating engine has resulted from our greater knowledge of the principles involved in the balancing of the external forces acting in marine engines, by which smoothness of working and reduction of vibration have been effected. The reciprocating engine has proved a most excellent servant, and will, without doubt, continue to do useful work for a considerable time. It is the development of large and extended experience, and has become a very efficient machine.

The most important development in the period under review is the introduction of the steam-turbine, and a paper of this nature would not be complete without reference to Sir Charles Parsons, whose engineering ability has brought the turbine to such a state of perfection as to allow of its successful use in practically all warships and in many ships of the mercantile marine. Recently Sir Charles Parsons has also shown how to obtain the advantage of the economy of high-revolution turbines by gearing them to suit the slower revolution of propellers both for the slower-speed vessels of the mercantile marine and for reducing the consumption at low powers in ships of war. As he is himself reading a paper on the subject of the development of the steam-turbine, it will not be necessary for me to refer at any length to this question. The introduction of the Parsons steam-turbine was accompanied by a lowering of the boiler pressure from that in use at the time with reciprocating engines, as the advantage to be gained in economy by the use of very high pressures did not appear to be commensurate with the increased weight involved, especially as in the turbine a more fruitful source of economy existed in the lowering of the back pressure.

A paper published in 1899 by one of our honorary members, the eminent French Director of Naval Construction, M. L. E. Bertin, stated. "It is easier to raise the initial pressure than to lower the back pressure; these are the two principal means of improving the economic conditions." This was the engineering view current at that period, and it is therefore worthy of note that ten years later we should find ourselves abandoning the easier plan of raising steam pressures, and making every effort to effect the more difficult task of lowering the back pressures to the economical limit, a task in which considerable success has been attained.

The great advantage of the steam-turbine is that it allows us to utilise conveniently, to a greater extent than previously, the energy existing in the steam at the lower limits of temperature, and this has caused the condenser and air-pump design to be very carefully investigated, with excellent results as regards vacuum obtained. It was not uncommon with the reciprocating engine to consider a high vacuum as a doubtful advantage, but this is now the subject of a guarantee in most machinery contracts for turbines.

The first war-vessel fitted with turbines was the Viper, and this vessel obtained the very high speed of 33.838 knots. This ship was followed by the Cobra, but, unfortunately, both were wrecked before any extended experience was obtained. The next important application was in the third-class cruiser Amethyst, which carried out her trials in 1904. To compare the results obtained from the turbines with those from reciprocating engines, the Topaze, a sister vessel, carried out an exactly similar series of trials, every effort being made to obtain the best results in each ship. These trials established the general superiority of the turbine as regards high-power working, and formed the basis on which our warship turbines have since been designed. Since the date of these trials, the fitting of the turbine has become almost universal in the British Fleet.

The Dreadnought was the first battleship fitted with turbines. She was followed by the armoured cruisers of the Invincible class (41,000 shaft horse-power), the trials of all of which were quite satisfactory. In the latter ships the water consumption at full power averaged 12 lb. per shaft horse-power for turbines alone, while at a speed corresponding to 10 knots—viz., 3500 shaft horse-power—the average consumption was 22 lb. per shaft horse-power. The consumption of turbine machinery at very low powers, although recently improved, is still comparatively high, but it is compensated for by efficiency and economy at high power, and other advantages possessed by turbine machinery. A very large number of torpedo-boat destroyers have been fitted with turbines, and with oil fuel for boilers the result is a very effective combination.

Most existing turbine ships of large size have four shafts, the two on each side having turbines in series; while the smaller installations have three shafts, the two high-pressure turbines in the wings exhausting to the low-pressure in the centre. Recently, however, two-shaft arrangements with combined impulse and reaction turbines of various types have been introduced, and some have been already satisfactorily tried, notably those in the cruiser Bristol and the destroyer Brisk.

Proceeding next to the important question of weight of machinery, Table I., page 20, shows the horse-power obtained per ton of machinery at various periods. The development in floor space is equally interesting, and for large ships the following table shows the space occupied in typical ships of various periods, the power taken being that developed on the eight hours' or other long trial:—

Floor Space Occupied by Engines and Boilers.

		Sq. Ft. per Horse-Power.
Warrior	1860	0.785
Bellerophon	1865	0.79
Devastation	1870	0.69
Shah	1875	0.64
Edinburgh	1880	0.64
Howe	1885	0.615
Royal Sovereign	1890	0.495
Prince George	1895	0.543
Canopus	1900	0.406
New Zealand	1905	0.38
Collingwood	1910	0.357

Reliability of machinery has much increased during the fifty years under review, and this is proved by the comparative immunity from breakdowns of H.M. ships. It is more particularly evident when the large amount of steaming now carried out, both on naval manœuvres and general service, is compared with the much smaller amount done by earlier ships. Considering the increase in piston speed and revolutions of later ships, this must be considered especially satisfactory. These increases are shown in the following table:—

Piston Speeds and Revolutions.

	Date.	Piston Speed. Ft. per Min.	Revs. per Min.
Warrior	1860	440	55
Sultan	1870	639	71.5
Inflexible	1880	616	77
Royal Sovereign ...	1890	900	105
Albemarle	1900	960	120
Lord Nelson	1910	1000	125

The gradual and considerable increase of power of ships of the Royal Navy, both individually and collectively, has been previously referred to. The collective increase is shown in the following table, giving the total horse-power of ships in the Navy List at the end of decennial periods:—

	Reciprocating Engine. I.H.-P.	Turbine. S.H.-P.
1860	541,175	—
1870	576,980	—
1880	814,200	—
1890	1,453,200	—
1900	2,985,400	10,000
1910	3,510,530	1,470,450

These increases of power and speed cannot, of course, be obtained without corresponding additions in the quantity of fuel consumed by the fleet. The very considerable increase in this item of maintenance is shown in the next table:—

Fuel Consumed by the Fleet.

	Coal. Tons.	Heavy Oil. Tons.	Petrol. Tons.
1860	100,000	—	—
1870	150,000	—	—
1880	200,000	—	
1890	400,000	—	—
1900	900,000	—	
1910	1,440,000	43,500	3,500

The initial cost of the machinery will also naturally be expected to have risen considerably with its increased weight and power. This feature of the last fifty years is shown in Table III., page 21, giving the cost of machinery of typical ships in each of the decennial periods.

In tracing the development of the warship's propelling engine during the period under review, many interesting matters of detail might be referred to, but it is only possible to do this in the briefest manner.

Methods of increasing the quantity of steam produced from a given weight of boilers have always been attractive to warship engineers. Warships in 1860 had no such methods other than the ordinary funnel.

In the Navy the steam blast (first fitted in the Monarch in 1869) was an effective method of increasing the draught, and continued to be common until about 1884, when it was finally abandoned. This method was very wasteful of steam, and also of fresh water, although at that period the necessity of maintaining the feed water as fresh as possible was not as important a feature in the working of the boilers as at present. The heavy loss of fresh water, unavoidable with the blast system, led to the introduction of fan-engines in the stokehold in 1870. These early fans, however, were more in the nature of ventilators, ensuring an ample supply of air, and it was not until 1880 that the closed stokehold system was first tried, and what has been termed "forced draught" introduced. The introduction of this method of increasing the rate of burning coal was attended with many difficulties, and the higher temperatures resulting revealed the weak parts of the boilers of that period. These difficulties were at one time so serious with the type of boiler fitted in many warships as to cause great anxiety, and it is not too much to say that for some years they constituted a serious menace to the war efficiency of the fleet.

The locomotive boilers, especially those which were first ordered in 1887 for torpedo gunboats, gave a considerable amount of trouble in the endeavours to obtain a large output of steam from a small weight of boiler. The great difficulty of keeping the tube ends in the combustion chamber tight, due to inadequate circulation over the whole plate, led even to the extreme measure of fitting centrifugal pumps in the boilers for the purpose of obtaining a sufficient and definite circulation. It is very interesting to read, in the light of present experience, the suggestions of the principal engineers of this country (including locomotive engineers) to overcome the difficulties then encountered. In those days brass tubes and copper fire-boxes were considered necessary in locomotive boilers to allow of the heat being readily conducted to the water. Troubles were, however, by no means confined to locomotive boilers.

A considerable number of experiments were made in the endeavour to overcome these difficulties, including very exhaustive ones with various types of ferrules fitted in the tube ends for preventing leakage, and the introduction of the Admiralty pattern cap ferrule did much to maintain the efficiency of the boilers under forced draught conditions at this period. Other systems of forcing the fires were also experimented with, but experience showed the closed stokehold system to be most suitable to warship requirements.

Important changes have taken place in the period under review as regards auxiliary engines, especially in their more extended application for various purposes.

Table IV., page 21, gives a list of the auxiliary machinery as fitted in modern war vessels and their approximate powers, and also the auxiliary machinery fitted in the most powerful vessel of 1860, from which the very great importance of the auxiliary-engine work of modern warships as compared with that of the early types will be evident.

The table shows the large amount of steam which must now be used for purposes other than the propulsion of the ship, and what a considerable quantity of heat is contained in the exhaust steam for those engines. The adoption of the well-known closed exhaust system a few years ago has had a beneficial effect in greatly reducing the fuel expenditure for such auxiliary purposes.

With the increase in the power of machinery and in the number and variety of auxiliary engines, a demand has arisen for greater facilities for dealing with repairs. In 1860 new ships carried no machine-tools, and depended for machine tool work, when not in dockyard hands, upon the floating workshop attached to each of the principal ports. At the present time every ship above the rating of a destroyer carries a good equipment of modern lathes and other machine-tools, together with other up-to-date appliances capable of dealing with all ordinary defects that arise. Repair ships, with very complete outfits, are attached to various squadrons for dealing with items of greater magnitude. In addition, modern ships contain appliances for the health, convenience, and comfort of the crew, which require steam or distilled water, and create a considerable further demand on the boilers.

An important change has gradually taken place in the manner of working the auxiliary engines which are necessary for the use of the main engines and boilers. These were at first practically all worked by rods or levers from the main engines themselves, but they have been removed one by one and worked by independent engines. Although it is not so economical as regards steam consumption to drive these auxiliaries by separate engines as to drive

them from the main engines, the great convenience of the former arrangement has been recognised.

Considerable difficulty was often experienced in satisfactorily feeding the boilers by the main feed pumps when they were driven off the main engines, and about 1875 separately-driven feed-pumps were introduced, and there was thus removed considerable anxiety as regards the certainty of the supply of feed water to the boilers.

In 1878 a further development was made in fitting separate circulating pumps of the centrifugal type in place about 1875 in connection with searchlights and subsequently with the internal lighting of ships. No one more than the marine engineer appreciates the comfort attached to electric lighting, and the great aid it is to him in carrying out his duties satisfactorily.

Like all innovations, difficulties were experienced in the initial stages with the generating machinery, and even at present they are not quite unknown. The increased use of electric-motors for various purposes on board warships may be recorded as one of the principal changes engines adapted for capstan duty in the Hercules in 1866, while in recent years electric motors have displaced the steam-engine for driving the capstans. The steering-engine remains on much the same lines as first designed, and was first fitted about 1866. Boat-hoisting engines were first fitted in the Ajax in 1881. These first engines were steam-driven. Electric and hydraulic systems have since displaced the steam-engines in new ships. Hydraulic pumping-engines for use in connection with gun-working machinery were also first fitted in the Ajax in 1881. Thee

TABLE I.—PARTICULARS OF MACHINERY OF REPRESENTATIVE WARSHIPS AT DIFFERENT PERIODS BETWEEN 1860 AND 1910.

Name of Ship.	Date of Trial of Machinery.	Makers of Engine.	Screw.	Type of Machinery.	Details of Engines.			Number of Revolutions per Minute.	Piston Speed. Feet per Minute.	Duration of Trial.	I.H.-P. (Natural Draught).	Boiler Pressure.
					Number of Cylinders.	Diameter in Inches.	Stroke.					
							ft. in.			hours		lb. per sq. in.
Warrior	Oct., 1861	J. Penn and Sons	Single	Jet-condensing, simple horizontal trunk	2	112	4 0	54	434	1½	5,469	22
Conqueror	Apr., 1863	Ravenhill, Selkeld Co.	,,	Horizontal	2	71	3 0	61	366	..	2,050	20
Bellerophon	Sept., 1865	J. Penn and Sons	,,	Horizontal trunk, surface condensing	2	112	4 0	74	592	..	4,708	30
Northumberland	May, 1867	Ditto	,,	Horizontal trunk	2	112	4 4	60	520	..	6,620	25
Hercules	Jan., 1869	Ditto	,,	Ditto	2	118	4 6	71	639	2	8,530	30
Devastation	Oct., 1872	Ditto	Twin	Surface-condensing, simple horizontal trunk	4, 2 to each engine	80	3 3	77	500	2	6,652	30
Raleigh	Apr., 1874	Humphrys, Tennant, & Co.	Single	Horizontal	2	100	4 6	74	666	2	6,160	30
Shah	Apr., 1876	Ravenhill, Easton, and Co.	,,	Ditto	2	117	4 0	65	520	2	7,477	32
Inflexible	Nov., 1878	J. Elder and Co.	Twin	Surface-condensing, vertical	6, 3 to each engine	2 of 70, 4 of 90	4 0	73	584	6	8,483	60
Agamemnon	Aug., 1881	J. Penn and Sons*	,,	Vertical, convertible	Ditto	54	3 3	86	559	6	6,362	63
Edinburgh	Sept., 1883	Humphrys, Tennant, & Co.	,,	Vertical, tri-compound	Ditto	2 of 58, 4 of 75	3 6	88	616	6	6,820	64
Howe	Jan., 1886	Ditto Ditto	,,	Vertical, compound, surface condensing	Ditto	2 of 52, 4 of 74	3 9	94	705	4	7,730	90
Sans Pareil	Sept., 1888	Ditto Ditto	,,	Surface-condensing, triple-expansion vertical	Ditto	2 of 43, 2 of 62, 2 of 96	4 3	87	742	4	8,070	135
Blenheim	Jan., 1891	Ditto Ditto	,,	Ditto Ditto	12, 6 to each engine	4 of 36, 4 of 52, 4 of 80	4 0	95	760	8½	14,925	155
Royal Sovereign	Apr., 1892	Ditto Ditto	,,	Ditto Ditto	6, 3 to each engine	2 of 40, 2 of 59, 2 of 88	4 3	97	824	8	9,660	155
St. George	Jan., 1894	Earle's Company	,,	Ditto Ditto	Ditto	Ditto Ditto	4 3	100	850	8	10,500	155
Prince George	Sept., 1896	Humphrys, Tennant, & Co.	,,	Ditto Ditto	Ditto	Ditto Ditto	4 3	97	824	8	10,465	155
Canopus	Aug., 1899	Greenock Foundry	,,	Ditto Ditto	Ditto	2 of 30, 2 of 49, 2 of 80	4 3	108	918	8	13,780	300
Implacable	Mar., 1901	Laird's	,,	Ditto Ditto	Ditto	2 of 31½, 2 of 51½, 2 of 84	4 3	108	918	8	15,250	300
Albemarle	Jan., 1903	Thames Company	,,	Ditto Ditto	8, 4 to each set	2 of 33½, 2 of 54½, 4 of 63	4 0	120	960	8	18,300	300
New Zealand	Mar., 1905	Humphrys, Tennant, & Co.	,,	Ditto Ditto	Ditto	2 of 38 2 of 60, 4 of 67	4 0	120	960	8	18,400	210
Lord Nelson	Jan., 1908	Palmer's	,,	Ditto Ditto	Ditto	2 of 32¾, 2 of 52¾, 4 of 60	4 0	125	1000	8	17,450	235
						Rotor. Dia. in Inches.			Tip speeds*			
						H.P. L.P.			H.P. L.P.			
Dreadnought	Oct., 1906	Vickers (turbines by Parsons)	Quadruple	Parsons turbine engines	..	68 92	..	328	6050 8,600	8	24,700	250
Bellerophon	Oct., 1908	Fairfield Co.	,,	Ditto Ditto	..	68 92	..	324	6030 8,580	8	24,100	235
Collingwood	Jan., 1910	Hawthorn, Leslie, and Co.	,,	Ditto Ditto	..	68 92	..	324	6070 8,590	8	26,300	235
Neptune	Sept., 1910	Harland and Wolff (turbines by Brown)	,,	Ditto Ditto	..	82 109	..	332	7330 10,175	8	27,720	235

* Mean peripheral speed of blades in feet per minute.

TABLE I.—(*continued*).

Name of Ship.	Date of Trial of Machinery.	Description of Boilers.	Heating Surface.	Auxiliary Engines. Total Number.	Approximate I.H.-P. of all Auxiliary Engines.	Weight in Tons of					I.H.-P. per Ton of				Coal per I.H.-P. per Hour.
						Machinery and Boilers, with Water at Working Height. (*a*)	Engines, Main and Auxiliary. (*b*)	Boilers with Water at Working Height. (*c*)	Water in Boilers at Working Height. (*d*)	Water in One Boiler at Working Height.	Engines. As Column (*b*)	Boilers. As Column (*c*)	Water in Boilers. As Column (*d*)	I.H.-P. per Ton of Machinery, including Water. As Column (*a*)	
			sq. ft.												
Warrior	Oct., 1861	Rectangular, iron	22,500	8	350	898.23	421.63	476.6	171.7	17.17	12.97	11.47	31.87	5.67	3¾ to 5
Conqueror	Apr., 1863	Tubular	14,400	6	280	350	141	209	70	17.5	14.5	9 85	29.3	5.87	
Bellerophon	Sept., 1865	Ditto	19,000	9	500	987.8	471.1	516.7	139.5	15 5	10	9.1	33.7	4.78	
Northumberland	May, 1867	Rectangular	25,500	10	680	1144.6	464.6	680	211	19.2	14.25	9.73	31.4	5.77	3.8
Hercules	Jan., 1869	Tubular	22,800	12	600	1209.7	566.9	642.8	156.72	17.4	15	13.25	54.25	7.05	3.14
Devastation	Oct., 1872	..	13,000	16	880	971.95	484.25	487.7	125.8	19.1	13.73	13.64	52 87	6.85	3.12 to 4.42
Raleigh	Apr., 1874	Rectangular	17,800	14	900	950.6	403.6	547	144	16.0	15.25	11.25	42.8	6.48	3.77
Shah	Apr., 1876	Rectangular, tubular	21,000	21	1500	1263.8	548.4	721.4	170.68	17.06	13.65	10.35	43 6	5.87	3.2
Inflexible	Nov., 1878	Oval, single and double ended, iron	21,200	82	1400	1366.4	654.2	712.2	187.38	18.56	12.96	11.9	45.27	6.2	2.38 to 2.74
Agamemnon	Aug., 1881	Oval	17,700	30	1050	1144.7	542.6	602.1	156.55	15.65	11.7	10.55	40.7	5.55	3.12
Edinburgh	Sept., 1883	Oval	18,400	40	1200	1039	471.4	567.6	155.83	15.58	14.45	12.02	43.75	6.55	3.51
Howe	Jan., 1886	Oval	19,300	56	2800	1151	542.5	608.5	165.78	13.8	14.26	12 7	46.5	6.72	2.16
Sans Pareil	Sept., 1888	Cylindrical, single-ended, steel	19,600	92	2100	1090.29	509.19	581.1	132	18.8	15.85	13.87	61.14	7.4	1.88 to 2.6
Blenheim	Jan., 1891	Cylindrical, 6 double and 1 single-ended	38,500	66	2080	1542	788	754	181.02	25.86	18.95	19.8	82.5	9.68	2.2 (N.D.)
Royal Sovereign	Apr., 1892	Cylindrical, return-tube	19,500	70	3435	1158.8	562.9	595.9	138.68	17.33	17.15	16.2	69.5	8.34	2 (N.D.)
St. George	Jan., 1894	Cylindrical, 4 double and 1 single-ended	23,250	53	1895	1162	491.25	670.75	171.5	34.3	21.5	15.65	61.4	9.1	1.65
Prince George	Sept., 1896	Cylindrical, single-ended, steel	24,400	146	2080	1326.6	6 3.8	702.8	165.2	20.65	16.77	14.89	63.34	7.9	1.82 at 50 p. c. of full power
Canopus	Aug., 1899	Belleville, with economisers	33,807	66	4140	1231.3	664.9	566.4	35.625	1.78	20.72	24.3	387	11.17	1.72
Implacable	Mar., 1901	Ditto	37,164	69	4250	1408.9	769.7	639.2	42.66	2 183	19.81	23.89	358	10.82	1.87
Albemarle	Jan., 1903	Ditto	43,310	68	4260	1608.4	838	770.4	45.8	1.9	21.82	23.7	400	11.37	1.96
New Zealand	Mar., 1905	Cylindrical and Niclausse	46,050	61	3540	1789.1	867.8	921.3	123.55	5.9	21.2	20	149	10.28	2.1
Lord Nelson	Jan., 1908	Babcock and Wilcox	46,200	47	3900	1551.3	785.9	765 4	61.1	4.07	22.2	22.8	286	11.22	2.0
Dreadnought	Oct., 1906	Ditto	55,400	36	5200	1897.7	973.4	924.3	76.68	3.76	25.2	26.8	364	13	1.52
Bellerophon	Oct., 1908	Ditto	55,530	93	5825	1935.8	1014.5	921.3	68.0	3.76	23.8	26.2	355	12 6	1.55
Collingwood	Jan., 1910	Yarrow	63,414	96	6050	1983 5	1072.6	910.9	89.3	4.94	24.5	28.9	297	13.28	1.8
Neptune	Sept., 1910	Ditto	63,360	96	6050	2036.3	1108.9	927.4	96.0	5.33	25	29.9	288	13.64	1.464

of those which had hitherto been driven off the main engine. Separately-driven fire and bilge-engines were introduced in 1881. The main air-pump survived for some time as the last auxiliary engine driven off the main engines, and the replacement of this type by the separately-driven pump did not take place entirely until about 1902. Although the reciprocating pumps now fitted for these auxiliary purposes are very reliable, they are in their turn threatened with rivals in the shape of the turbo-pumps which are being perfected and used for various auxiliary purposes.

Electric generating engines were first fitted in ships which have taken place during the period under review. The engine first used for generating electricity was of the open type; then, about 1885, the Willans engine was generally used. A return was again made to the open type of engine about 1891, and about 1898 this was replaced in new ships by the enclosed forced lubricating-engine, which has been very successful. The turbo-generator has now made its appearance on board our ships; the great advantage of the turbine naturally commends itself.

There is not much to record in the development of capstan engines, except that the first so fitted were fire-engines are of the horizontal compound type, and have not changed much in design since those first fitted. Air-compressors for torpedo work were first adopted about 1880.

Steam boats were first carried by warships in 1869. The development in the engines and boilers of these boats has been on somewhat similar lines to that of the main propelling engines. Most of the present boats are fitted with water-tube boilers and two-cylinder forced-lubrication engines with surface condensers. A number of oil-motors have been tried, but these have not given entire satisfaction, although some are giving improved results. Superior types, however, to the ones at first

fitted are now being fitted, and the many paraffin and petrol motor-boats now being successfully introduced represent the tendency of development in this matter at the present time.

During the period under review the source of power has up till recently been coal, but within the last few years a powerful rival has appeared in the shape of liquid fuel. The inherent advantages of liquid fuel for the generation of steam in marine boilers, especially for warships, have been recognised for many years, but the practical difficulties which hindered its successful use for this purpose were not overcome till about 1904.

In the early experiments with liquid fuel the smoke which was given off was often very heavy, but now, where oil fuel only is burnt, as in some of our torpedo craft, the production of smoke is completely under control, except for a few minutes at lighting up, and even under these conditions very little need be made, while on ordinary running smoke can be prevented entirely, or readily kept down to such a minimum as will indicate the economy of combustion. Where both coal and oil are burnt the elimination of smoke is more difficult, but experience has shown that under these conditions the careful use of the modern appliances enables the smoke to be kept down to a lesser amount than with coal only, without interfering with the efficiency of the combustion.

Coming to progress in the use of oil as a source of power without the interposition of a boiler, internal-combustion oil-engines using heavy oil have been in use for many years in ships of the Royal Navy for driving dynamos; such engines are at present heavier than the actual steam reciprocating engines they replace, but if the boiler power, condenser, steam-pipes, &c., required to drive such reciprocating engines are taken into account, the difference in weight largely disappears. These oil-driven dynamos, for Service reasons, use oil of flash-point not less than 200 deg. Fahr., and the convenience which attends their use is considerable. This would be particularly the case in small ships which do not require to keep steam for drills, &c., and where motor-pumps for fire and similar purposes are available. Many initial difficulties were experienced in the working of these engines; the arrangement for the discharge of the exhaust gases was often inconvenient, and the fitting of oil-driven dynamos to later warships has been discontinued. These difficulties, however, have now been practically overcome with the further experience obtained, and recent reports respecting these engines are so satisfactory that their re-introduction will no doubt be considered.

TABLE II.—*Economy Due to Rise in Steam Pressure.*

Date.	Ship.	Load on Safety-Valves.	Horse-Power.	Coal per Hour per H.-P.
		lb. per sq. in.		
1848	Phœnix	6	400	
1856	Himalaya	18	2,000	
1858	Aboukir	20	1,533	
1860	Warrior	22	5,469	
1862	Defiance	20	2,500	
1864	Achilles	25	5,800	
1866	Bellerophon	30	6,500	
1870	Audacious	30	4,800	3.78
1872	Devastation	30	5,600	2.93
1874	Modeste	60	2,000	2.42
1876	Boadicea	70	5,300	2.4
1881	Satellite	90	864	2.5
1882	Polyphemus	125	840	3.32
1886	Mersey	110	6,300	2.5
1888	Narcissus	135	8,589	2.5
1888	Sans Pareil	135	14,500	2.26
1891	Superb	145	6,100	1.9
1893	Ramillies	155	9,443	1.7
1893	Sultan*	155	4,018	1.77
1896	Prince George ..	155	10,465	2.3
1897	Terrible	260	22,370	2.0
1898	Diadem	320	17,168	1.76
1899	Canopus	300	13,780	1.72
1902	Duncan	300	18,222	1.95
1904	Commonwealth ..	270	18,562	1.83
1904	Hindustan	210	18,562	1.76
1906	Dreadnought ..	250	24,712	1.52
1908	Bellerophon	235	24,091	1.55
1910	Neptune	235	27,721	1.46

* Trial after fitting with new boilers and engines.

The use of the internal-combustion engine for marine propulsion, during the period under review, does not provide much to record in the way of actual changes made, beyond the fact that these engines have been successfully installed in submarines and small craft. Little has been actually accomplished in warships. The large reduction in consumption of fuel obtained by the use of the oil-engine is, however, a great incentive to renewed effort to obtain satisfactory engines of large size, and the future is full of promise in this direction, and great changes may be anticipated in respect to the adoption of such engines for propulsion when the mechanical problems of their construction and of their reliability for continuous working have been satisfactorily solved.

No review of this kind would be complete without a few remarks respecting the officers and men who have charge of the machinery fitted in our warships, and the important changes which have taken place in their character and numbers.

The following table shows the great increase and corresponding importance of the engineering *personnel* which has taken place in the period under review:—

	Officers.	Men.
1860	1092	3,797
1870	1183	3,926
1880	795	5,056
1890	698	10,377
1900	970	24,805
1910	1461	37,221

To compare the total number employed in the engine-room department of a first-class ship in 1860 and 1910, we may take the Flag Ship of the Channel Squadron of 1860—viz., the Royal Albert, and the corresponding ship of the present day—viz., the Neptune, the present Flag Ship of the Home Fleet:—

	Horse-Power.	Engine-Room Complement. Officers.	Men.
1860. Royal Albert	500 N.H.-P.	7	20
1910. Neptune ...	25,000 S.H.-P.	7	224

The seven engineer officers in the Royal Albert consisted of:—

One chief engineer, two first assistants, two second assistants, and two third assistants, of whom only the chief engineer appeared in the Official Navy List. It was not until 1870 that junior engineer officers' names were inserted in the Navy List.

The twenty men of the Royal Albert consisted of five leading stokers and fifteen stokers, which staff had to be supplemented by hands from deck for coal-trimming when the ship was at sea under steam.

TABLE III.—COST OF MACHINERY.

Date.	Type of Vessel.	Name.	Total Weight of Machinery.	Cost.	H.-P.	Type of Engine.	Type of Boiler.	Load on Safety Valve.
			tons	£				lb. per sq. in.
1860	Armour plated broadside ship	Warrior	898	74,409	5,470	Horizontal, simple jet-condensing trunk	Rectangular	22
1870	Ditto	Sultan	1276	76,042	7,720	Horizontal trunk, surface-condensing.	Low pressure	30
1880	Battleship ..	Collingwood ..	1244	117,690	9,570	Vertical, compound	Elliptical	90
1880	Cruiser ..	Forth	568	50,000	5,700	,, ,,	Cylindrical	110
1890	Battleship ..	Royal Sovereign	1559	100,000	11,000	Inverted vertical, triple-expansion	,,	155
1890	Cruiser ..	Royal Arthur ..	1184	99,000	10,000	Ditto	,,	155
1900	Battleship	Albemarle .. .	1608	181,000	18,000	Vertical, triple 4-cylinder	Belleville with economisers	300
1900	Cruiser .	Kent	1789	217,000	22,000	,,	Ditto	300
1910	Battleship ..	Neptune	2036	258,000	25,000	Parsons turbines	Yarrow	235
1910	Cruiser ..	Indefatigable ..	3210	404,000	43,000	,,	Babcock and Wilcox	245

TABLE IV.—*Steam and Oil-Driven Auxiliary Machinery, excluding Hydraulic or Electric Motors.*

Description.	"St. Vincent." No.	"St. Vincent." I.H.P.	"Invincible." No.	"Invincible." I.H.P.	Old "Warrior." No.	Old "Warrior." I.H.P.
Main feed-pumps ..	3	140	8	366		
Auxiliary feed-pumps	6	150	8	366	2	80
Engine-room fire and bilge-pumps	4	70	4	65	1	40
Boiler-room fire and bilge-pumps	3	30	4	248		
Main air-pumps, twin	4	40	4	186		
Auxiliary air-pumps, single ..	2	10	2	7		
Oil-fuel pumps for boilers ..	6	15	10	8		
Oil-fuel tank-pumps in engine-room	2	2	2	2		
Lubricating oil-service pumps	8	15	6	20		
Water-service pumps	2	8	2	14		
Boiler-room air-compressors ..	3	270	4	320		
Torpedo air-compressors ..	3	150	Motor*			
Hydraulic pumps	3	1500	2	1640		
Dynamo engines	3	945	2	630		
Oil-driven dynamo	1	200	2	315		
Boiler-room fan-engines ..	24	220	31	460		
Circulating pumps	4	520	4	650		
Steering engines	2	1200	2	370	1	50
Capstan engine	1	300	1	320	1	130
Distilling pumps	4	10	6	44	1	20
Air-compressors for ash-ejectors or ash-hoists ..	3	55	..	..	2	30
Steam-boats	3	375	2	300		
Total	94	6225	106	6331	8	350

* Not included in total.

The gradual reduction in comparative number of engineer officers compared with men will be evident from an examination of this table. In 1860 mechanics entered for the service of the engine-room obtained recognition as junior officers. Such procedure would, of course, now be impossible, owing to the large increase in the number of mechanics carried on a warship consequent on the great extension of mechanical appliances which has recently taken place, and, although the number of engineer-officers in modern warships is small, there has been no diminution in the amount of mechanical skill proportionately present.

In connection with the preceding table, showing the numbers of engineer-officers from 1860 to 1910, it may be noted that 1910 was the last year in which any engineer-officers, as they have hitherto been known, passed into His Majesty's Service.

In concluding this review, it may be remarked that, although much satisfactory progress has been made during these fifty years, many interesting and difficult engineering problems, the solution of which will mean further advance, remain for the coming generation. There is no finality; developments are continually taking place, and great efforts are being made every day to obtain higher efficiency. There is plenty of scope for the enthusiast, and there can be no doubt that this Institution will continue to be the means of bringing details of progress made, and the possible lines of further advance, to the notice of the marine engineering profession generally, and of aiding and encouraging the labours of those who are working in the important field of experimental research, and of the practical application of the results of such to the advancement of naval architecture.

APPENDIX.

Extract from Report of an Admiralty Committee (1858).

"From the experience thus gained, the Committee have no difficulty in coming to this conclusion, that, of all the variety of engines that have been purchased by Government for our screw ships of war, the following are so far superior to all others that no engines of an older make should ever again be put on board. The engines to which they now refer are:—

"1. The single piston-rod engine, with the connecting-rod attached direct to the crank-shaft, and with a single flat guide.

"2. The engine commonly known as the trunk engine, and patented by Messrs. Penn and Sons.

"3. The double piston-rod engine.

"There can be no doubt, as already stated, that these three forms of construction for engines are not only better suited for the navy than any other kinds that have been purchased for men-of-war, but also that they are better suited for those purposes than any modifications of the steam-engine that have as yet been constructed.

"But another and a further question arises, and that is the question, the relative merits of these three engines. On this point the Committee would say that, if any one be found to be superior to the rest, or should an engine be found, on future examination and experience, superior to all others, the Government ought to adopt that engine, either when they are purchasing new engines, or when making engines in their own factories, because the Committee would strongly urge that all engines furnished to our men-of-war should have all that modern knowledge of steam machinery can produce; nor do they see any reason why engines should ever be received into the naval service at all in which there is any degree of inferiority whatever to other engines which may be procured.

"Bearing these principles in mind, the Committee, after the most careful examination of the actual performances of various engines, and carefully weighing the evidence which has been given, have arrived at the conclusion that for very small engines the single piston-rod engine, as adapted by Messrs. Humphrys, Tennant, and Dyke, is the best engine suited for the Navy. Indeed, it seems now to be almost universally admitted that the single piston-rod engine is superior to all other known engines for very small power; and it may be noticed that for the later-built gunboats two of our most eminent engineering firms adopted that construction.

"The Committee are of opinion, with our present knowledge of steam machinery, that up to 300 collective nominal horse-power there is no engine for men-of-war superior to the single piston-rod engine, with a single flat guide; and they are not prepared to say that above that power its qualities may not be found equally good; and that the trunk engine, as constructed by Penn and Sons, has answered so extremely well, more particularly where great power is required, that the Committee recommend that, with such improvements in the details of these two engines as experience points out, they should be considered for the present the naval engine.

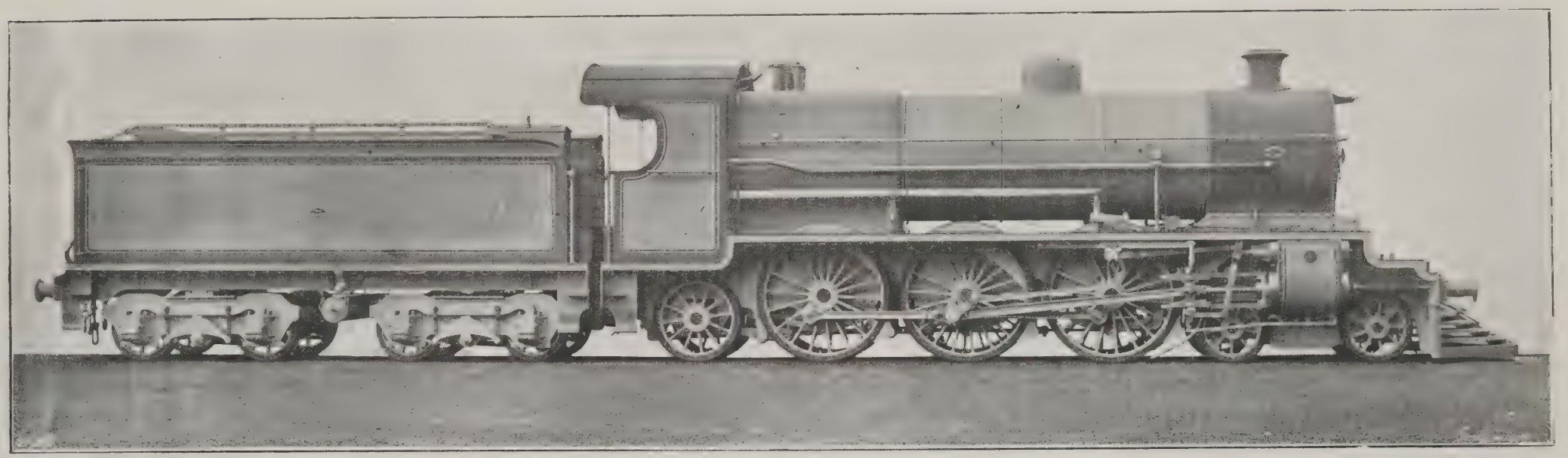
INSTITUTE OF MARINE ENGINEERS.—At the Royal Botanic Society Gardens on Friday, June 30, a reception and concert was held under the auspices of the Institute of Marine Engineers, when the High Commissioner for New Zealand, the Hon. Sir William Hall-Jones, K.C.M.G., made the presentation of the Gold Emblem of New Zealand, given by the marine engineers of New Zealand, to Mr. Frank Reddaway, J.P., of Manchester.

THE BRITISH MOTOR-BOAT CLUB.—This club will hold its annual London to Cowes race on Saturday, July 22. The race will start from Erith at 7.30 a.m., and will be for sea-going motor-yachts (according to M.M.A. definition) and estuary cruisers, fitted with internal-combustion engines, under M.M.A. rules, rating, and time scale. The course is from Erith to Cowes—176 nautical miles—and a silver cup, value 10*l.*, will be given for the first vessel completing the course.

VICKERS IRONCLAD CRANE PANELS.—A new design of crane panel is being introduced by the Electric and Ordnance Accessories Company, Limited, of Aston, Birmingham. Although these panels are of particularly substantial construction, both electrically and mechanically, they are considerably smaller and lighter than panels of the usual construction. The panels consist of a double-pole, quick-break main switch, with three or four double-pole branch fuses, enclosed in a cast-iron case, which is provided with lugs for fixing. The main fuses are mounted on the movable switch-arm, so that they can only be renewed when the switch is in the "off" position. Pilot lamps are mounted on the top of the case to indicate when the motors are entirely disconnected from the mains; connections for an inspection lamp are also provided. The panels are supplied to control one, three, or four motor circuits dealing with currents ranging from 50 to 400 amperes at pressures up to 600 volts.

PASSENGER LOCOMOTIVE FOR THE CENTRAL ARGENTINE RAILWAY.

CONSTRUCTED BY MESSRS. BEYER, PEACOCK, AND CO., LIMITED, GORTON, MANCHESTER.



THE illustration above represents an exceptionally heavy and powerful 4-6-2 type passenger engine, and is one of a number now being built by Messrs. Beyer, Peacock, and Co., Limited, Gorton, near Manchester, for the Central Argentine Railway, to the specification of Messrs. Livesey, Son, and Henderson, of London. The engine has outside cylinders and steam-chests, and is non-compound. The valves are of the piston type, and Walschaert's motion is employed. The boiler is of the Belpaire type, with steel shell plates, and is stayed with Stone's bronze stays. The tubes are of brass. The bogie at the front end is of the swing link pattern, and the trailing axle is mounted in a radial axle-box. The springs of the coupled and trailing axles are compensated in two groups, the compensating beams rocking on knife-edges instead of on pins, as is customary in British-built engines. The smoke-box is equipped with a Stone's "louvre" spark-arrester. There are four Ramsbottom safety-valves, each 3½ in. in diameter, and blowing off at 180 lb. pressure. Lubrication of the cylinders is effected by a Wakefield mechanical lubricator, actuated from one of the expansion links.

It will be seen that the tender is mounted on two bogies, which are of the compensating-beam type, and the brake-blocks are placed between the wheels. Both engine and tender are provided with steam-brakes working in conjunction with the automatic brake on the train.

The following are the leading particulars of the engine and tender:—

Gauge of rails	5 ft. 6 in.
Cylinders:	
Diameter	19 in.
Stroke	26 in.
Centre to centre	7 ft. 7 in.
Wheels:	
Diameter of bogie	3 ft. 2 in.
,, coupled	6 ft. 2½ in.
,, bogie	4 ft. 1 in.
	Radial axle-box.

Wheel-Base:	
Centre of bogie to front drivers	8 ft. 8¾ in.
Front to middle drivers... ...	6 ft. 7⅝ in.
Middle to hind drivers	6 ft. 7⅛ in.
Hind drivers to trailing axle ...	6 ft.
Bogie wheel-base	6 ft. 6 in.
Extreme wheel-base	31 ft. 3½ in.
Boiler:	
Length	14 ft. 4¾ in. Telescopic
Diameter outside at front ...	5 ft. 6¼ in.
Height of centre from rail ...	9 ft. 7¾ in.
Tubes:	
Number	257
Diameter	2 in.
Length between tube-plates .	14 ft. 10½ in.
Copper Fire-Box:	
Length inside	7 ft. 11¾ in.
Width inside	3 ft. 8⅝ in.
Height at front inside... ...	6 ft. 9½ in.
Height at back inside	5 ft. 5½ in.
Centre of boiler to roof inside ...	9½ in.
Fire-Box Casing:	
Length outside	8 ft. 8 in.
Width outside	4 ft. 4¾ in.
Centre of boiler to top of shell...	3 ft. 0$^{3}_{16}$ in.
Shape of top and how stayed ...	Belpaire
Heating Surface:	
Tubes	2001.5 sq. ft.
Fire-box	166 ,,
Total	2167.5 ,,
Area of fire-grate	29.5 ,,
Boiler pressure	180 lb. per sq. in.
Tractive power per pound of mean effective pressure in cylinder	126

Weight on Rails in Working Order:	Tns.	Cwt.	Qr.
Bogie-wheels	18	5	1
Front driving-wheels	15	7	0
Middle driving-wheels	15	10	1
Hind driving-wheels	15	3	3
Trailing wheels	12	16	2
Total	77	2	3

Tender:	
Water capacity	6000 gals.
Fuel capacity	260 cub. ft.
Wheels, diameter...	3 ft. 2 in.
Wheel-base...	Centre to centre of bogies, 13 ft.; centre to centre of bogie wheels, 6 ft.
Shape of tank	Sloping
Brake	Steam and hand-screw

Weight on Rails; Full:	Tns.	Cwt.	Qr.
Front bogie	29	0	0
Hind bogie	29	18	0
Total	58	18	0

NOTES FROM THE SOUTH-WEST.

Cardiff.—Labour troubles have restricted business, buyers and sellers preferring to hold their hands for the moment. The best large steam coal has made 18s. 6d. to 19s. per ton; secondary qualities have ranged between 16s. and 17s. 9d.; best ordinary bunker smalls between 10s. 3d. and 10s. 6d., and cargo smalls between 9s. to 9s. 3d. per ton. House coal has shown scarcely any change; the best ordinary qualities have made 14s. 6d. to 16s. 6d. per ton; No. 3 Rhondda large has brought 17s. to 17s. 6d. per ton, and smalls have made 10s. 6d. to 10s. 9d. per ton. No. 2 Rhondda large has been quoted at 11s. 9d. to 12s. 3d., and smalls 8s. to 8s. 6d. per ton. Foundry coke has realised 18s. to 20s. 6d., and furnace ditto, 16s. to 17s. per ton. As regards iron ore, Rubio has been quoted at 18s. 6d. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Death of Mr. I. T. Rees.—The death is announced of Mr. Ithel Treharne Rees, a mining and civil engineer and a member of the firm of Forster Brown and Rees, of Cardiff and Westminster. The deceased formerly lived at Penarth, but latterly he resided at Blaen-y-Pant, Malpas, Newport. He was born at Bassaleg, Monmouthshire, in August, 1852. He was articled to Messrs. Dobson, Brown, and Adams, of Cardiff. He was in charge of the sinking of Harris's Deep Navigation Colliery at Treharris, and afterwards joined Mr. Forster Brown as a partner. From 1879 to 1882 he held the position of Inspector of Mines for Glamorgan, acting under the late Mr. T. E. Wales. He was at his death president of the South Wales Institute of Engineers. He was also a member of the Institution of Civil Engineers and of the Surveyors' Institute.

Dowlais.—The works have been fairly active. The Goat Mill has been engaged on an Indian order for heavy steel rails, tin bar, &c. The Big Mill has been working on angles, flats, fish-plates, &c. The quantity of coal raised has been larger than usual.

Bristol University Degrees.—The Council of the Institution of Civil Engineers has decided to accept the degree of the University of Bristol in civil and mechanical engineering (awarded under new regulations) as exempting from an Institution examination for associate membership. Bristol degrees will also be recognised by the India Office as qualifications for appointments as assistant engineers in the Public Works Department of India.

CANADIAN PACIFIC RAILWAY.—The extensions and improvements proposed to be undertaken by the Canadian Pacific Railway Company this year will represent an outlay of about 6,000,000*l.* The extensions include a line to the Brazan coal-mines in Alberta, a line from Athabasca Landing to North Battleford, and another from Edmonton to Fort Mann.

THE ROYAL INSTITUTE OF PUBLIC HEALTH.—On August 15 next the Royal Institute of Public Health will hold its annual congress in Dublin for the third time. The first congress was held there in 1892. The meetings will take place at Trinity College, the University Board having kindly placed the halls at the disposal of the congress committee. The congress will be under the presidency of Her Excellency the Countess of Aberdeen, herself well known as an earnest and indefatigable worker in the cause of public health.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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With One Two-Page Plate and Four One-Page Plates of the DUNSTON POWER-STATION OF THE NEWCASTLE-ON-TYNE ELECTRIC SUPPLY COMPANY.

ENGINEERING.

FRIDAY, JULY 7, 1911.

ENGINEERING TRAINING AND ACHIEVEMENT.

THERE is appropriateness in the Conference of the Institution of Civil Engineers on the Education and Training of Engineers, held last week, being followed so closely by the International Congress of the Institution of Naval Architects. In the one case we had a full expression by many authorities of the requirements to be met by the engineer in the future; in the other, a comprehensive review of the work achieved by the engineers of the past, since the great majority of the papers read at the Congress were of an historical character. With this record of practical work done there is every reason to be satisfied, particularly in the case of Britain, and there is some assurance that thus far we have not suffered from any lack of appreciation of the need of sound training in order to ensure progress. At the Congress, too, convincing testimony has been offered by foreign delegates that our naval architects and engineers have assisted in promoting the training of their *confrères* of other nationalities. The progress made abroad has in the past been more or less evolutionary, although in recent years it has developed on more original lines. These later advancements in theory in foreign lands, the realisation of high efficiency, and the increase in the volume of work done, undoubtedly afford a strong incentive to all interested in our national industries to exert themselves still more in the direction of intense effort, in greater attention to the training of the younger members of the profession, and in the application in factories of a higher scientific knowledge. Thus, while the International Congress of the Naval Architects affords much satisfaction so far as the past is concerned, it incidentally justifies the Conference on the Training of Engineers from the point of view of the future.

The Conference must be pronounced a success, as it resulted in a thorough exchange of opinion on the fundamental principles of education, and no one can read the fairly full reports in our issues of last week and of this week without profit. Few will fail to be impressed with the importance as well as with the difficulties of the subject. Disappointment, however, will be experienced in many quarters from the fact that no attempt was made to crystallise opinion and to formulate general principles for the guidance of teachers, employers, and parents. We admit that the idiosyncracies of the students must influence the course of training in nearly every case, and that therefore a great latitude must be permitted in arranging the course. But the question arises whether guidance within wide limits would not have been of incalculable benefit. One must not forget, however, that in 1906 a committee of the Institution of Civil Engineers, under the chairmanship of Sir William White, investigated the whole question, and laid down recommendations in respect, firstly, of the preparatory education, and, secondly, of the advanced engineering training. These recommendations have been generally accepted as sound, but it would have been well to have utilised the opportunity afforded by the Conference to secure definite information as to how far these recommendations had been carried out, and how suitable they had proved, alike as regards the student, the college, and the factory. As Professor Barr pointed out, it was difficult to distinguish between the subjects dealt with at the different sections of the Conference, and it seems to us that, if it had been at all possible, it would have been more conducive to definite results if the subjects had been arranged so as to afford a consensus of opinion upon important questions of detail, which at present give rise to conflicting opinions.

There is first the vexed problem as to whether and how far practical training should be interposed between attendance at the secondary school and at the technical college. The recommendation of the Committee in 1906 was distinctly in favour of practical training being so interposed, and it is remarkable that 93 per cent. of those from whom opinions were then invited by the Committee were in favour of this proposal. In a recent article on the subject of the proposed bursaries by the Royal Commission for the allocation of the funds derived from the 1851 Exhibition (see page 693 of our last volume), we entered at considerable length into this question, and we are glad that the great majority of those who spoke at the Conference agreed with our view that practical work should precede theoretical study at the universities. There was, naturally, some difference of opinion as to the length of this practical course. The Committee already referred to recommended at least a year, and with this decision 72 per cent. of the opinions forwarded to the Committee agreed, while 21 per cent. thought a year insufficient. But the Committee, it will be remembered, was disposed to consider that two years, and even more, was the correct period for those who proposed to take up some branch of mechanical engineering. Employers should now, however, be satisfied with an expression of opinion in favour of this preference for factory work, leaving the time to be determined by each firm to suit the particular branch of engineering in which they are producers.

One gratifying feature of last week's Conference was the great importance attached by almost all the speakers, except the purely academical professors, to practical training. Some of the speakers raised the objection that the youth who had served one or two years before going to college experienced difficulty in again joining the ranks of practical workers at the end of his college course. This objection may hold in some cases, but in other instances arrangements are made whereby the youth returns to the same works. Messrs. Vickers, Limited, and other firms have almost ideal conditions, granting to apprentices who have shown themselves worthy of it the privilege of proceeding to college for two or three years after spending three years in the works, the whole period so spent at college to count as apprenticeship time, provided that the apprentice, in his periodical reports to the firm, discloses convincing proof that he is profiting by the special privileges granted. At the conclusion of the college course the pupil is bound to return to the same works, and the employer binds himself to take the student into his service, paying him a wage. The minimum payment is within the limits of a living wage; but it may be very much higher, according to the capability of the youth. This raises the question as to whether or not a degree or other evidence of college achievement is of commercial value. It is necessary to guard against the assumption that the possession of a degree is a guarantee that its holder is fitted for the charge or performance of responsible work; but, as the Chairman of Section II. (Scientific Training) pointed out on Thursday last week:—"If the work through which the student has gone to attain his degree is sound, it should serve him in good stead in his practical career, and he might fairly be expected to advance more rapidly than one who had not had similar training. If this result does not follow, then something is certainly wrong, and the sooner the reason is known the better." The idea seems to be held in some quarters that our manufacturing engineers have an actual objection to engineering degrees, but this idea is certainly unfounded—at all events as far as it relates to firms of high standing. The real state of the case, we consider, is this:—A young engineer of, say, twenty-three or twenty-four years of age will probably have had some six or seven years' training in college and workshop, and when such a man applies for an engagement the employer naturally considers how this time has been spent. If a good proportion has been devoted to gaining practical experience, and if, in addition, the applicant has secured a degree, then this degree is decidedly an asset of value. But if the degree has only been secured by the neglect of essential points of practical training, with the result that the applicant, though strong in theory, is weak in that knowledge of materials and of men which is so valuable in practice, then the applicant is likely to have to stand aside and give place to someone more calculated to be of real service to his employers.

The recommendation for the interposition of a practical course between the school and the technical college study may, as we have stated, be accepted as one general conclusion of the Conference, and it would have been well if such a conclusion had been embodied definitely in a resolution. The sandwich system possibly offers advantages in some cases, but the difficulty is to secure continuity either in practical or theoretical work. Six-month periods, alternating between college and factory,

are too short, apart altogether from the question as to how far they are permissible, without interfering with the aim of economic production.

There were some taking part in the Conference who held the view that frequent changes were disconcerting to the youth, and that the student looked upon the period in the workshop as a form of holiday, the general consensus of opinion seeming to be in favour of a complete course of three consecutive years being taken at the college, preceded by a period of practical training and succeeded by a further period in the factory. The recommendation has been made that in the final year at college, when the student was more or less specialising, he should seek a college in the district where his specialised work prevailed. In such case, for instance, the prospective marine engineer would go to Glasgow, and the textile engineer to Manchester, or Leeds, and so on, in order that the student might come into immediate and continuous contact with work in progess in the factory and with students and men who had been reared in the atmosphere of the industry. The difficulty, however, at present is that there is no attempt to standardise the curricula of technical colleges, and it would in many cases be impracticable to maintain satisfactory and complete continuity of study were the student passed from one college to another between the second and third years.

The course outlined at the Conference, while definite enough, loses sight of one important factor —that it ensures higher education only for the moneyed classes. Those who have followed the progress of all industries, and none more so than those of naval architecture and marine engineering, so completely reviewed in the historical papers read at this week's Congress of the Institution of Naval Architects, must recognise that much of the epoch-making work has been the product of men who have risen from the ranks. It was Lord Rosebery who brought convincing testimony from the world's records to prove that genius was discovered in poor more often than in wealthy circumstances. And this is true also in the case of that substitute for genius—the faculty of taking infinite pains. It were well, therefore, that the promising youth, whatever his social rank or financial resource, should be able to take full advantage of the best conditions. It was for this reason that we advocated that the Exhibition Bursaries, to which we have already referred, should be available for lads of humble circumstances worthy of special post-scholastic training at the works, college, and finally in the same works.

The Royal Corps of Naval Constructors, of which we heard so much at the Naval Architects' Congress, offers a good example alike in the course of training and in the stimulating results attained. The great progress achieved, as narrated in the papers on naval architecture, by Sir Philip Watts; on naval engineering, by Sir Henry Oram; on turbines, by Sir Charles Parsons; and on artillery, by Sir Andrew Noble; as well as in others, are most creditable; but it is no disparagement of the achievements of past workers to say that the future advances will call for higher scientific and practical abilities on the part of those who lead in industry. This is due to the difficulty of accomplishing successive improvements. There is also the evidence of keener competition indicated by the papers from some of our foreign friends. Their efforts are welcome from the standpoint of the advance of science, but must, as we have pointed out, awaken rivalry of the keenest kind, however friendly, if our commercial position is to be maintained. As with the marine industries, so with others, and thus it is incumbent upon the Institution of Civil Engineers and the kindred scientific associations to do all that is possible to aid in formulating guiding principles for the realisation of the highest efficiency in the principal of our national assets—the brain-power latent in youth.

THE NAVY ESTIMATES IN PARLIAMENT.

THE House of Commons passed the vote for shipbuilding on Wednesday after a somewhat desultory, and therfore unsatisfactory, debate. Under ordinary circumstances, one might assume that the absence of criticism on well-defined lines prognosticates confidence in the Government's policy towards the Navy; but the explanation is to be found rather in the prevalent state of lassitude in political matters generally, except, perhaps, those appertaining to the Constitutional question. This is unfortunate, because criticism is so essential in the maintenance of efficiency in the administrative departments, and in none more than at the Admiralty. The recent display of the preparedness of the Navy at the Coronation Review, and the progress of the battle exercises of the Fleet which followed, are no doubt reasons for satisfaction with the main question of the ability of the Fleet in commission to maintain our naval prestige. But there is at the same time, throughout the country, an undercurrent of suspicion that the financial consideration is weighing too strongly in the attitude of the Government in reference to the future. The Declaration of London has brought home the great need for a larger fleet of cruisers, and also for a closer union between the Royal and the Merchant Navies. This point was raised by Lord Charles Beresford, who has abundantly justified his ability as a critic within the House; and there will be a general consensus of opinion in favour of the plea put forward that the Admiralty ought to make preparation for utilising, to a greater extent, a number of fast ships in the merchant service for duty in the event of our food supply being menaced in war. This point, it will be remembered, has been frequently raised by Lord Brassey, who strongly favours perfect understanding between the Government and the owners of fast liners and fast Channel steamers, which latter, especially for scouting duty, might be of great use.

The First Lord of the Admiralty, in replying to the debate, urged that we were building suitable scouting cruisers in increased numbers, and gave promise, too, that next year more cruisers still would be provided; but he sheltered himself behind the need for secrecy, and refused to give any satisfying details regarding the proposals of the Admiralty for the defence of our trade routes. We are glad to note that such a high authority on Admiralty procedure, and on all questions affecting the maintenance of official secrets, as Sir William White should, on the same day as the debate in the House, have urged that there was a middle course in this matter, and that good must accrue from an intelligent discussion of Admiralty policy in the light of official information. It is true that his remarks applied more, perhaps, to details of construction and design, but the force of the argument is as great from the point of view of strategic and tactical questions. There is, of course, information which it would be suicidal to disclose, but many feel that in recent years the Admiralty have carried this refusal to take the public into their confidence to an unjustifiable length. Such experienced men of affairs as Mr. Balfour, Lord Charles Beresford, and Mr. Arthur Lee, have no desire to force the hands of the Government to an extent which would jeopardise our position in the event of war by the disclosure of essential facts, and they, like the great majority of citizens anxious to have confidence in the Admiralty administration, would be satisfied with a limited amount of information which would show that the Admiralty had grappled with the problem on broad and efficient lines.

There was, perhaps, less tendency to measure strength at future dates than in previous debates, but Mr. Balfour, in temperate language, impressed the Government with the importance of making such arrangements now as would enable the Navy to be prepared for any contingency at any date, and notably in 1914. These arrangements he was anxious to have applicable not only to battleships, but to the lighter craft essential to combating the anticipated conversion, even at sea, of foreign merchant ships into commerce-destroying cruisers under the new conditions created by the Declaration of London. Mr. Balfour also raised the question as to whether we were right in continuing to be satisfied with no gun between those of 13.5 in. or 12 in. calibre and the 4 in. bore. It is always difficult to hold the hand when one finds contemporaries taking a definite course, and there are many who are somewhat anxious as to whether the 4-in. gun will meet all the demands, when we find practically every Power adopting a gun of 6 in. or even greater calibre as secondary armament in battleships, in addition to 12 in. and 14 in. guns. Of course, the British Admiralty have gone on the assumption, based on logical grounds, that such guns are only for use in repelling torpedo attack, and consequently they refused to recognise the need for even secondary armament. Mr. McKenna, in replying to Mr. Balfour's contention for a complete consideration of this question, said that the problem depended on the type of the destroyer and the range of the torpedo. He admitted that the development of the torpedo in the last few years had been very remarkable, and stated that the Admiralty were considering the question with a perfectly open mind. The 4-in. gun was sufficient for a range up to 6000 or 7000 yards, but it might be that this was insufficient, and that a larger gun would require to be installed, so as to defeat the destroyer before the latter could get within range with its torpedoes.

THE JUBILEE MEETING OF THE INSTITUTION OF NAVAL ARCHITECTS.

ON January 16, 1860, eighteen British shipbuilders met, and constituted themselves "the Institution of Naval Architects, for the purpose of advancing the science and art of naval architecture." The constitution, objects aimed at, and qualifications for membership were prepared with marvellous prescience, with the result that the organisation has since grown in membership, in prestige, and in the wealth of influence continuously exerted towards the advancement of the science of naval construction in every department. This week a gathering of shipbuilders and engineers, representative of every nationality, is celebrating the jubilee of this organisation—a celebration which had, unfortunately, to be postponed last year, owing to the lamented death of King Edward VII., for many years the Patron of the Institution. All foreign technical societies and the most important British institutions have sent representatives, not only to rejoice with the members of the Institution of Naval Architects, but to pay homage to those who have done so much pioneer and successful work. Unfortunately, the limits of space available prevent our naming all of these representatives. We can only mention the principal of the delegations appointed by important societies:—The Académie des Sciences of France, Prince Roland Bonaparte; the Association Technique Maritime, Mons. L. E. Bertin, the *doyen* of the naval architects of France; the Schiffbautechnische Gesellschaft, the Geheimer Regierungsrat, C. Busley; the Verein Deutscher Ingenieure, Dr. Sorge; the Institution of Civil Engineers of Holland, Mr. A. van Gelder; the Collegio degli Ingegneri Navali e Meccanici, Signor Salvatore Orlando; the Japanese Society of Naval Architects, Constructor-Rear-Admiral Matsuo; the Swedish Institution of Naval Architects, Mr. A. Isakson; and the Society of Naval Architects and Marine Engineers of the United States, Mr. Stevenson Taylor. The Ministers of Marine of practically every country are represented by staff members of the Embassies resident in London, or by special delegates sent to this country to attend the Congress.

Meetings for the reading and discussion of papers were held in the mornings of Tuesday, Wednesday, and yesterday, and will be continued to-day, while the afternoons and evenings have been devoted to social functions, which are as influential in their effect on the advancement of the general aim. This point was enforced in several speeches made during the progress of the Congress, because, apart from the great advantage of the friendships thus formed, important problems are privately considered, perhaps with more direct interchange of personal knowledge than is sometimes possible publicly in these days of keen international competition and naval rivalry. Each of the functions will be noticed in due order in the course of our report, and it may be said at once that all proved most successful, a result consequent upon the admirable arrangements made by the Executive Council of the Institution, and by the Secretary, Mr. R. W. Dana, and furthered so willingly by the efforts of the Reception Committee and particularly of the stewards, who were most businesslike in their interpretation of the duties of their office.

The Congress opened on Monday evening with a reception by the President, the Most Honourable the Marquis of Bristol, Rear-Admiral, R.N., and the Marchioness of Bristol, at the Museum of the Royal United Service Institution, Whitehall. No more appropriate venue could have been chosen, because the members gathered in a naval atmosphere and amidst the replica of the achievements of the British warship designers of all ages, while those revered proofs of British prowess, with which the museum abounds, have—thanks to modern *ententes cordiales*—ceased to give rise to

unpleasant reflections on the part of our foreign visitors. The music too, provided by the Chapel Royal Choir, was appropriate to the occasion, so that the preliminary social gathering was in every respect a pronounced success.

The Inaugural Meeting.

The more serious business of the Congress was opened by a largely attended meeting of members and delegates from all countries, held in the Connaught Rooms, Great Queen-street, on Tuesday morning, when H.R.H. the Duke of Connaught, K.G., took the chair as Hon. President of the Congress. He was supported by the President, the Marquis of Bristol, by a Past-President, Lord Brassey, and by the leading foreign delegates. The postponement of the Congress from last year had one regrettable result. His Majesty King George V. had kindly promised to occupy the chair as Prince of Wales; and there was peculiar appropriateness in this, since he has had a life-long connection with the Navy and marine construction, and is, moreover, a patron of the Institution. His interest, all are glad to know, is still maintained, although be has succeeded to the more onerous and responsible duties of kingship.

The Duke, in opening the proceedings, said:

It is my pleasing duty, as your honorary president, to welcome all those who have come to attend the Jubilee meeting of the Institution of Naval Architects. As you are aware, this meeting was to have been held last year but for the sad calamity which then occurred, and on that occasion my nephew, our present King (then Prince of Wales), was to have presided. That meeting was obliged to be put off, but I am happy to think that we have been able to meet in this, the Coronation year of our present King. You will naturally feel that, as a keen sailor, his Majesty is in deep sympathy with the objects of our meeting, and he has charged me to express to you all his best wishes and his hope that the result of this year's congress may be of very lasting benefit, and that those whom we have the honour of seeing amongst us from foreign countries may enjoy their visit to England. I regret that as honorary president you have not a member of my family who is better acquainted with the great and important details of naval architecture, and that I appear before you as a mere amateur; but I assure you that, however little I may know of these important subjects, no one more appreciates the enormous advance that has taken place in naval architecture since you last met here in international congress in the Diamond Jubilee year of her late Majesty Queen Victoria, when my late brother was in the chair and addressed you. We have merely to look at the great ships now sailing on the waters to see the enormous advance that has been made during the last fourteen years. Advances of this kind cannot be made without consummate skill, consummate knowledge, and great application. I am sure that we in England appreciate the rivalry, the friendly rivalry, that exists in shipbuilding at the present time, and that we appreciate the fact that many great brains are at work to produce the wonderful results that we see before us at the present day. Those of us who had the pleasure of attending his Majesty's Naval Review at Spithead the other day could not help comparing the ships at this Coronation Review with those of only nine years ago; and when we consider in how short a space of time naval architecture has revolutionised itself we must recognise that the advance made is something colossal. Our newest battleship—I am open to correction—is the Neptune. We all saw her at Spithead, and thought how magnificent a ship she was; and our newest great Atlantic liner is the Olympic. We do not know where finality in size is going to end, and we certainly must recognise the wonderful combination of skill, knowledge, and mathematical work that can produce the wonderful ships of the present day. I suppose that, as in everything else, there is no finality, and that ships we may approve of and consider the best in the present day we may, perhaps, regard as old and rather interesting relics of the past when we meet again. I desire again to welcome you most warmly, and to assure you that it affords us the greatest pleasure to see you here to-day, and to enable you to see for yourselves what advances we are making in England.

At the conclusion of His Royal Highness's address, Rear-Admiral C. J. Briggs, Controller of the Navy, on behalf of the First Lord of the Admiralty, extended a welcome to the foreign members, and gave expression to the Admiralty's appreciation of the work done by the Institution. He referred to the high place that the officers of the Admiralty held in the organisation, and to the honours bestowed by the Institution also upon many executive officers of the Fleet. The Right Hon. Sydney Buxton, M.P., President of the Board of Trade, had intended to be present to similarly welcome the guests on behalf of the commercial department of the Government, but the Secretary, Mr. Dana, read a letter intimating his apologies and his great regret that a Cabinet meeting precluded him from attending.

The President, the Marquis of Bristol, then delivered the presidential address, which is reprinted in full on page 12 of this issue. Incidentally, the noble Marquis gave expression to the general sentiment of satisfaction that all present experienced at the earldom conferred upon Lord Brassey, a past-president of the Institution.

The History of the Institution of Naval Architects.

Sir William White, who has done yeoman service, not only for the Institution, but for the advancement of its aims and for the development of scientific shipbuilding generally, most appropriately read the first paper, which reviewed the history of the Institution and the progress of scientific education in naval architecture. This admirable *résumé* brought into strong relief the salient features of the Institution, and the continuous association of the organisation with the successive developments in shipbuilding, naval and mercantile. The first part of this paper is published in this week's issue (page 13), and the concluding part, which deals with the work of the Institution, will be published in next week's number. In this latter part Sir William referred to epoch-making communications to the Institution, and to the value of the keen discussions which had taken place on all subjects, notably on the constructive policy of the Admiralty for the time being. These controversies have been valuable in crystallising opinion, while the independent criticisms of Admiralty action has had a beneficial effect upon the policy pursued in respect both of broad principles and of details of design. There was quick appreciation and approbation by the great audience of Sir William's view as to the unfortunate changes which have recently taken place, under which no official communications have lately been made to the Institution respecting the designs of new British warships. He expressed the hope that before long there might be a reversion to the earlier and well-approved practice. It was not suggested that in future there should be disclosures of any information that would be indiscreet or improper, any more than there has been in the past. "As one familiar," Sir William said, "with the events of the last 45 years in our proceedings, I cannot recall one occasion where the public interests have suffered in consequence of the papers read and discussed, in which warship design and construction formed the subject."

Sir Nathaniel Barnaby was called upon by the President, and the greeting he received was enthusiastic, as he is the only survivor of the eighteen who were present at the constitution of the Institution fifty-one years ago. Sir Nathaniel, notwithstanding his great age, was heard in every part of the large hall in the few words of greeting which he gave, and was particularly happy in recalling the fact that the International Congress was being held on July 4, the great national holiday of our kinsmen in the United States of America.

Lord Brassey spoke next, and paid a well-merited tribute to Sir William White, referring to his work for the Institution, and particularly for the advancement of the profession of naval architecture. Since proficiency is aimed at, it was important, said his lordship, that the members of the profession should have dignity and honour bestowed upon them, and in this respect he referred to the work Sir William had done in bringing about the institution of the Royal Corps of Constructors at the Admiralty, and to his other efforts in connection with the Institution of Naval Architects.

Tributes by Foreign Delegates.

Several of the foreign delegates paid tributes to the Institution. Letters had been received from Dr. Schlick, Signor Soliani, and Sir George Holmes. M. Bertin was the first to speak, and was followed by Mr. Taylor, of the American Society; Dr. Sorge, a member of the Council of the Verein Deutscher Ingenieure; and Professor Busley, President of the Schiffbautechnische Gesellschaft. Each referred in appropriate terms to the high appreciation entertained in foreign countries of the Institution and of its work, not only in respect to the educational value of the papers contributed and the discussions which took place upon these, but also to the model constitution on which so many of the foreign institutions were founded. Like the others, Professor Busley referred to the unfailing sympathy and kindness shown to visitors at every meeting, and to the influence of personal friendships formed, which permitted a closer intimacy and more harmonious relationship, which was for the benefit of all countries. The German representatives, on behalf of their *confrères*, presented to the Institution a beautiful example of bronze statuary in the form of a craftsman.

The President, in acknowledging this magnificent mark of friendship, observed that, although he was British to the core, and proud of it, he was "made in Germany," having been born at the British Legation at Dresden, and that although he had left Germany early, he had always a warm interest in the affairs of that country. He paid a tribute to the Emperor Frederick and to the Emperor William, than whom there was no more popular monarch when he appeared in the streets of London.

The members and the guests from foreign countries partook of luncheon in the various rooms adjoining the Grand Hall, at the Connaught Rooms, and in the afternoon a visit was paid to the Exhibition at Shepherd's Bush, where the members and delegates were received by the Duke of Teck at the Garden Club. In the evening there was a reception at Lord Brassey's house at Park Lane, which has so often been the venue of such gatherings. The historic and scientific treasures of Lord Brassey's home were greatly appreciated, and, as ever, were a source of charm and interest to the large company which partook of the hospitality of Lord and Lady Brassey.

On Wednesday two sectional meetings were held between 11 and 1 o'clock, one at the Institution of Civil Engineers, and the other at the Institution of Mechanical Engineers. At the former meeting the President, the Marquis of Bristol, took the chair, and announced at the outset that the reading of Sir Andrew Noble's paper, dealing with progress in naval artillery, had been postponed until the meeting on the 7th inst.

Fifty Years' Architectural Expression of Tactical Ideas.

Admiral Sir Cyprian Bridge read the first paper, entitled "Fifty Years' Architectural Expression of Tactical Ideas." This paper is reprinted on page 37 of this issue.

The discussion was opened by Admiral of the Fleet Sir Gerard Noel, who was called upon by the President. Sir Gerard began by saying that he would have preferred that some one else than himself should speak first, as the paper appeared to be pre-eminently one on which the opinions of naval architects was desirable. He could personally vouch for the accuracy of the state of naval architecture fifty years ago, as presented in the paper, and when he looked on a famous picture representing Nelson in his cabin, he found that in almost all its details the cabin arrangement indicated might have represented those of his (the speaker's) first ship. There was undoubtedly little change in naval architecture over a long period of time, and he thought the great changes that later years had witnessed were due mainly to improvements in material, particularly in steel, which naval architects had been able to avail themselves of. Sir Cyprian Bridge had pointed out that the naval officers of early times had made their tactics to suit the vessels they had. This was very true, but it should be pointed out that officers of later days had matters much complicated for them by the fact that the material of their tactics was continually changing, and becoming obsolete. In connection with this matter it should also be pointed out that naval men were not in the habit of publishing their tactics to the world, and because an officer did not talk about his tactics, it did not follow that he had not got any. There was little doubt but that in recent years great stress had been laid on the question of the defensive features in warship construction, and he personally certainly considered the protection of the vital parts, so that ships could keep afloat, to be of the first importance.

Herr G. O. Hüllmann, Director of Naval Construction for Germany, thought that during the whole history of warship design the data on which tactics had been based were fixed by the naval architects. At the present time, however, the architects more and more wanted the assistance of naval officers. If architects were left too much to themselves now there was danger that development might tend in the wrong direction; although, similarly, if matters were left to naval officers only, they might also progress in an unsound course. It was essential that officers and architects should pull together. He had been looking yesterday at the picture of the Battle of Trafalgar in the United Service Institution, and it had reminded

him of the enormous difference in naval conditions that the advance of gun-power had made. This factor of gun-power well illustrated the necessity for officers and architects working together, as it was only by co-operation between them that a decision as to what was reasonable in that direction could be arrived at.

Rear-Admiral W. L. Capps, late Chief Constructor of the United States Navy, thought that the paper paid a profound compliment to the naval architect's profession. There was great difficulty in the naval architect getting a clear conception of what the ideals of the naval officer were. He had experienced this difficulty himself, and thought that the officer's ideals were not always crystallised. Sometimes they changed while a ship was being built. One of the greatest difficulties of the architect was in trying to carry out these ideas. Some six years ago he had prepared a memorandum for a 40,000-ton ship. From the architectural side such a development at that time would have been a straightforward matter, but many outside considerations came in, such as the questions of docks and facilities for repairs and other such matters, which had necessarily to develop *pari passu* with the size of ships. Then questions of speed, armour, and guns also came in, and the final decision as to how best to spend the money you had was in no way purely one of naval architecture. He quite agreed with Sir Cyprian Bridge that the best defence was overwhelming offence. This was the principle on which the ships of 200 years ago did themselves so much credit. They also depended much on their *personnel*, and that was very important, and introduced another condition. Ships must give reasonably sanitary conditions for their crews. Peace might last twenty years, and war only six months, and if the sanitary arrangements were not good the *personnel* would get into bad condition. The question of the lack of fixed principles among naval officers, which had been alluded to by Sir Cyprian Bridge, was one that he felt he ought not to touch. He thought he should say, however, that the question of the ultimate development of tactics was one that the future alone could decide. The results of an action between modern fleets were quite unknown, and there were, consequently, bound to be many divergent and changing views.

Rear-Admiral R. H. Bacon said that he felt considerable gratitude was owing to Sir Cyprian Bridge for his paper; indeed, even for the title of his paper, as it fixed one's ideas on the relation existing between naval architecture and tactics. He regretted, however, that the paper had not dealt with present-day ships. The sole and only object of tactics was to place your guns in the most efficient position as regards the enemy. Tactics were the handmaid of gun-fire and mobility. Up to 1850 mobility remained constant, but, with the coming in of steam, mobility continually increased up to about 1900. About that time mobility was also given to gun-fire. Guns did not change between 1600 and 1840; but even with the introduction of larger guns, the fighting efficiency was not quickly increased, because it took the *personnel* a long time to become accustomed to long-range fighting. Modern gun-fire, combined with speed, made long-range fighting possible. It was not feasible before the Dreadnought days to concentrate in one ship all the features that were necessary to take full advantage of long-range fighting, but when you had them, the combination of heavy guns with speed gave a ship which was able to comply closely with the requirements of modern tactics.

Rear-Admiral G. Dyrssen, President of the Admiralty Board of Sweden, who was the next speaker, said that he had much diffidence in speaking on the paper, as he had not read it before the meeting. He quite thought, with Rear-Admiral Capps, that the best form of defence lay in offence. He also thought the question of *personnel* of the first importance. There was a famous American admiral who said that if he got good men he would fight the enemy in paper ships. This was an exaggeration, but there was much truth in it. On the question of the various types of modern ships, he doubted if much was really settled on. Much was being done in the way of experiment, and it was doubtful if modern ships were an expression of modern tactical ideas. He thought the torpedo would exercise much influence in the future, and that those who relied on gun-power would ultimately have to modify their ideas in terms of the torpedo. In conclusion, he would repeat that the question of *personnel* was almost everything.

Professor Hovgaard said that he was a teacher at an American naval college, and that the paper would be of much value to him, as he was in the habit of giving his students lessons in naval history. He thanked the author for it. He would like to speak on the relation between tactical ideas and the cost of warships. History repeated itself, and in the 'eighties we had a somewhat similar deadlock between guns and armour to what we had to-day. There was, however, an essential difference in the two cases. In the 'eighties displacement was limited, largely by financial considerations, and naval architects could not build ships to carry the heavy armaments that are carried at the present time. The reason they did not build such ships was, however, not based on tactics. Modern developments were none the less due to tactics. If we wanted to get the full value of the heavy armaments now carried, it was necessary to introduce higher speeds and other modifications. This, of course, increased size, and he saw no reason to suppose that the limit had been reached—at least, not in the larger navies; it had in some of the smaller. In these strategic and tactical considerations determined the number of ships that were necessary, and from this, with limited resources, it was easy to see that the size of the individual ships was limited. He thought that although the large navies had not reached the limit of size, they were possibly approaching it.

Sir Cyprian Bridge, in replying, said that the subject of his paper was suggested to him by the Institution, or, rather, he should say, that he was asked for a history of tactics, but on considering the matter he found that there was not much tactics to give a history of. The history of ships, however, threw light on the history of tactics. He agreed with Rear-Admiral Capps that naval architects and naval officers did not always work together. But the important question was, what value should be given to naval officers' views. The principles of tactics did not change, and yet, as an example bearing on modern development, he would point out how frequently large modern Atlantic liners were quoted by naval officers as a proof that the limiting size of battleships had not been reached. That was all right, but it suggested that latter-day increase of size might be due to the development of naval architecture, and not to tactical needs at all. Rear-Admiral Bacon had spoken of the necessity of getting one's guns in the best position, and of mobility in fleets; but surely mobility was a relative term. Two steam fleets would be equally mobile, and he thought the whole matter ultimately came back to the *personnel*. Many years ago an Admiral had said "Give me wooden ships, and put the iron in my men." On the question of superior speed, on which Rear-Admiral Bacon made much, for instance, how were you to keep superior speed? Usually it was kept for very brief periods, and on that score, in his opinion, it could not be considered of very great importance.

The President, in closing the discussion on the paper and passing the thanks of the meeting to Sir Cyprian Bridge, said that on the question of naval officer's tactics not being fixed, he would say that from his personal knowledge this was not true of the late Admiral Tryon, who tried to copy the tactics of Nelson. None the less it was very difficult to settle tactics owing to the rapid advances which were made. The naval architects were really too good for the naval officers.

The Progress of Naval Construction in Japan.

The meeting then passed to the consideration of Rear-Admiral Motoki Kondo's paper on "The Progress of Naval Construction in Japan." In the absence of the author, this paper, which we reprint on page 15, was read by Chief Constructor Suyewo Nonaka.

The only speaker in the discussion was Professor Purvis, who said that in reference to the paragraph in the paper dealing with naval construction in private yards, he would like to point out that Japan, out of her limited programme, had recently given out two boats to be built in private yards. This policy of encouraging private building had now given Japan six yards capable of undertaking naval work.

The President, in thanking the author and the reader of the paper, referred to a paragraph in it which said that the Japanese had always been well up in all branches of handicraft. This was very true, and their wonderful success in adopting Western methods showed that if a people were well trained, they were always ready to take up any new work that came.

Experimental Tank Tests on Models of Submarines.

The third paper, "Results of Experimental Tank Tests on Models of Submarines," was then read by Mr. Mason S. Chace, its author. The paper, which we hope to reprint later, deals with experiments carried out at the United States Experimental Model Basin at the Navy Yard, Washington, and is concerned mainly with models of simple form, with bow and stern exactly alike and of canoe shape. Four models were dealt with, all derived from a parent form which was of circular cross-section. Stream-line curves and tabular data were given in the paper.

As the time available was very short, the President asked anyone who wished to speak on the paper to be very brief.

Mr. H. F. Hay said that he would just like to mention that he had been engaged on somewhat similar experiments and had dealt with both single and double models—that is, models in which the pressure hull and the external-resistance hull were both one, and models having two separate hulls—an inner circular one and an outer ship-form one. He thought the double hull not an ideal arrangement, and by modifying the simple spindle form of the pressure hull he had obtained a single hull form which appeared to have smaller resistance than any existing type of submarine. He would have pleasure in sending in further particulars of his experiments for the Transactions of the Institution.

After the thanks of the meeting had been expressed to Mr. Chace, the proceedings were adjourned.

Marine Turbines and Warship Machinery.

At the meeting held in the hall of the Institution of Mechanical Engineers, on Wednesday morning, Sir William White presided. There were four papers down for reading and discussion, three of which, being on ships' machinery, were taken together. The first was Professor A. C. E. Rateau's paper, entitled "The Rational Application of Turbines to the Propulsion of Warships." This is reprinted *in extenso* on page 31 of this issue. It was read in slightly curtailed form by the Chairman. The second paper was by the Hon. Sir C. A. Parsons, the subject being "The Marine Steam-Turbine from 1894 to 1910," while the third, by Engineer-Vice-Admiral Sir H. J. Oram, was entitled "Fifty Years' Changes in British Warship Machinery." Sir Charles A. Parsons's paper is reprinted in full on page 32, and that of Sir Henry Oram on page 18. Both papers were read by the authors, with slight omissions.

After the passing, in response to the Chairman's suggestion, of a vote of thanks to the authors, Lord Charles Beresford was invited to open the discussion. He wished, he said, to touch principally on one point, connected with the *personnel* of modern British warships. Whatever the quality of the guns or machinery provided in vessels of the Navy, there was no doubt whatever that the question of *personnel* was the most important thing of all to consider. He deplored the need for the remark in Sir Henry Oram's paper that the year 1910 marked the last "in which any engineer-officers, as they have hitherto been known, passed into H.M. Service." He wished to say that nothing could have been better than the working of the engineer's department under the old system. Was Admiral Oram satisfied with the proportion of officers to men? The figures he gave showed that the number of officers had scarcely increased, while that of the men had been greatly augmented, but the requirements of the Service had vastly grown. Japan, whose navy was maintained for peace, had a far more adequate complement than we had. The responsibility on the officers was immense. It was quite true that on an old flag-ship the engine-room complement may have consisted only of twenty men, compared with 224 of the corresponding ship of to-day; but it had to be remembered that in the old times, when it was necessary, hands were sent below from deck for trimming and other work.

Admiral H. I. Cone, of the United States Navy, said he wished to speak on Sir C. A. Parsons's remarks concerning the combination of recipro-

cating engines with turbines, or of geared turbines, or, in fact, of any device introduced with the object of improving the economy of turbines at low speeds. Were the advantages of such expedients sufficiently great to warrant the introduction of extra difficulties? Did the improved economy due to the use of reciprocating engines for low speeds compensate for the lowered efficiency of the combination at high speeds? The combination system was being tried in small high-speed vessels for the United States Navy, there being reciprocating engines for low speeds, with clutch or some connecting device whereby the engine could be thrown out at high speeds. Perhaps Sir Charles Parsons would say what disadvantages there were to this arrangement for small vessels. The combination installation on the Velox had been referred to. He would like to know why the engines were taken out of that vessel; perhaps it was because they could not get enough steam.

Mr. Borowicka, of the Austrian Navy, said he could not say the combination arrangement was making much progress with them. They did not look upon it altogether with favour, because it was complicated, and the ships of their navy did not go on long cruises or voyages, as did those of Great Britain, for instance, to the Colonies. Under these circumstances they thought that cruising turbines, combined with high-speed turbines in the same casing, best suited their requirements. Any improvement in ordinary turbine efficiency was only procurable by the introduction of special means.

Mr. Walter M. McFarland, of New York, referred briefly to the contract for the collier Neptune, which had been fitted with geared turbines, and had been given a dock trial just before he left the United States. Trouble with the air-pump had, unfortunately, delayed the complete trials, so that he had no information as to them; but he wished to say that the gear had been tested on a 40-hour continuous run at 7000 horse-power, and it was then that the figure of 98 per cent. efficiency had been obtained. He was one of the old-time officers of the United States Navy, and had been a member of the Board which sat under Mr. Roosevelt on the question of naval organisation. All their officers were now engineers. If such kindly expression had been given at that time as had been given that day by Lord Charles Beresford of the efficiency of engineers under the old *régime*, many heart-burnings would have been avoided. In response to a question, Mr. McFarland said the gearing on the Neptune was fitted with a modification of the floating cradle, embodying hydraulic cylinders.

Mr. A. E. Seaton felt that as this was not an oil-bearing country, he could not feel so keen on the oil-fuel question as some of his friends did. They had good coal, and he thought they should use that. Though the staff now provided might be ample for peace, and for cruising conditions when speeds were low and rests frequent, he was afraid it would prove insufficient for war. Admiral Oram had omitted mention of one fact connected with the introduction of the turbine—namely, the tenacity of purpose with which the campaign in its favour was prosecuted by the inventor. Had it not been for that, it might have been laughed out of use, as had been the case with other appliances. He thought in reports of trials of combined installations that care should be taken to debit each part of the system with its proper amount of steam, which should be clearly and carefully apportioned, so as to leave no vagueness as to what was and what was not included in the figures. He was in favour of the turbine because he thought it the best weapon with which to fight the internal-combustion engine.

Professor A. Rateau said he was glad of the opportunity of remarking on the development of the Parsons marine turbine, which had been extraordinary; the curve in the paper, of horse-power built, was rising at an extraordinarily rapid rate. That wonderful result was due no less to the persistency than to the inventive genius of Sir Charles Parsons. The installation on the Velox was very different from that of the French boat fitted by Messrs. Yarrow, or to that in the destroyer Chasseur, for in the former the engine was directly coupled to the turbine shaft, whereas in the latter system the engine was on a separate shaft, and worked always at its proper speed. He thought Sir Charles Parsons should have put the Rateau turbine in Class III, according to the subdivision in his paper, and not in Class IV., for his was a combination type, and had been so since the commencement of its application to marine work.

Sir C. A. Parsons said the aggregate construction had been taken as the reason for classification in the order given. In point of date M. Rateau was quite correct. The turbine would expand steam lower than the reciprocating engine, and in employing the combination principle there were any number of combinations which could be made. This system was, however, not very elastic, and was, therefore, not suitable for all warships. The reciprocating engines in the Velox would not run at a higher speed than that necessary for about 13 knots without knocking; above that they had to be disconnected. Gearing got over many difficulties, and with it it was possible to obtain economies like those procurable in land installations, with flat characteristics. Using by-passing in turbines, and running at or above the point of maximum efficiency, it was quite possible to obtain very good efficiency under all conditions. There was no more space required for geared than for ordinary turbines; sometimes even it was less, while the cost was also less. The gear design embodying three pistons under three journals was unnecessary. The floating cradle was not a good thing. All that was needed was for the pinion shaft to be allowed some end movement.

Engineer-Vice-Admiral Sir H. J. Oram was the last speaker. He said the Velox reciprocating-engines were removed because they were not powerful enough, and gave too low a speed. With regard to the Neptune he thought the number of officers and crew quite sufficient. It had to be remembered in comparing the number of officers in modern ships with the numbers in old ships that a large number of artificers were carried in the modern ship, and that they were equal in some respects to the engineering officers of the old ships.

Vibration Phenomena of Steamers.

On the termination of the discussion of the above-named papers the Chairman made a few remarks on a paper entitled "Our Present Knowledge of the Vibration Phenomena of Steamers," by Dr. O. Schlick. This paper, which was taken as read, we shall reprint in a future issue. The most interesting part, the Chairman said, of Dr. Schlick's paper was that which dealt with the vibration due to the action of the screw-propeller in water at the stern of a vessel in motion. He had been interested in that because part of the information had been secured by Dr. Schlick's help in connection with the Mauretania. There was really no vibration in the case of that ship; it was a tremor, which they wanted to get rid of. The cause of the tremor lay partly in the frictional and partly in the stream-line wake.

There was no discussion on Dr. Schlick's paper, in which the author differentiated between the vibration due to the reciprocating-engine parts and that which was purely propeller effect. The former, of course, was not present in turbine vessels, but the latter remained, and had to be dealt with in some way. The prediction that there would be no vibration in turbine vessels showed that the component influences at work were indifferently understood by persons making such statements.

Mr. A. Denny said they were making experiments on propellers. He judged from the paper that, so far, no formula of general application had been found.

The Chairman then adjourned the meeting until 11 A.M. on Thursday.

Luncheon at Lloyd's.

The Chairman and Committee of Lloyd's Register of British and Foreign Shipping entertained a large company of foreign guests and others to luncheon within their building in Fenchurch-street on Wednesday, and another company on Thursday. On the former day Mr. Thomas L. Devitt, the Chairman, presided, and, after the loyal toasts, gave "The Institution of Naval Architects," the Marquis of Bristol responding. The close association between Lloyd's and the Institution was naturally the theme of both speeches. Sir Edward Beauchamp, Bart., M.P., proposed "The Foreign Guests," and Dr. Max Predöhl, the Burgomaster of Hamburg, and Mr. A. Isakson replied. The latter, in addition to being President of the Swedish Institution of Naval Architects, is a Lloyd's surveyor.

In the afternoon there were two attractions. Many went to the Crystal Palace to the Festival of Empire and Pageant of London, being favoured by beautiful weather. A large company proceeded to the National Physical Laboratory at Bushy Park to attend the opening of the experimental tank.

The Opening of the National Experimental Tank.

The tank is practically a gift to the nation by Mr. A. F. Yarrow, who, it will be remembered, proposed, at the meeting of the Institution in Glasgow in 1901, that such a tank should be established, and a committee was then appointed to take such proceedings as were possible towards the realisation of the idea. Three years later Sir William White in a paper emphasised the value of such a tank, and suggested its location at the National Physical Laboratory, but, as with many such matters, the financial question was the principal difficulty. Mr. Yarrow, with characteristic generosity, solved the problem by offering 20,000*l.* for the construction of the tank, provided that a suitable fund could be raised for conducting the research work and for experimental investigations of a confidential character on behalf of private firms according to the accepted scale of fees. It was felt that a guarantee of 2000*l.* per annum for a period of ten years ought to be raised, and the Institution of Naval Architects succeeded in raising a fund producing 1340*l.*, the Executive Committee of the National Physical Laboratory undertaking the responsibility of finding the remaining proportion. An advisory committee, including many representatives of the Institution, was appointed, and there is special appropriateness in the completion of the scheme in the course of the interesting proceedings of this week.

The tank has already been described in ENGINEERING (see vol. xci, page 445), but it may be stated here that there are two water basins, the larger 550 ft. long by 30 ft. wide and 12 ft. 3 in. deep, and the smaller 63 ft. long, 5 ft. broad, and 3 ft. 3 in. deep. Suitable docks, of course, are arranged for storage, and for easy access to the models, which latter vary in length from 14 ft. to 20 ft. These models, which are formed by special machinery in paraffin wax, are towed along the water-way from a carriage electrically driven, which runs on rails secured on each side to the top of the tank walls. The speed of travelling can be varied from 1 ft. per second to 25 ft. per second.

At the opening ceremony, Sir Archibald Geikie, K.C.B., President of the Royal Society and Chairman of the General Board of the Laboratory, presided over a large gathering representative of every branch of scientific activity. In a brief introductory speech he referred to the importance of the occasion, the generosity of Mr. Yarrow, and offered a welcome to guests from other countries.

To Lord Rayleigh, O.M., F.R.S., as Chairman of the Executive Committee, fell the honour of declaring the tank open. In his address he passed a high encomium upon the late Dr. William Froude, for the ingenuity displayed in the application of the principles of dynamical similitude to the determination of the resistance of ship models, and in the devising of all apparatus for the purpose with a prescience of the necessities of the case which rendered any departure unnecessary, even in the light of later and extended experience. The first tank was completed in 1871 at Torquay, and there much valuable work was done up till 1879, when Mr. Froude died, since when research had been continued by his son, Mr. R. E. Froude, a Government tank being opened at Haslar in 1885. More recently similar tanks have been constructed—the first by the Dennys at Dumbarton, and others by various British firms, as well as by foreign governments and private firms. Having reviewed the history of the National Tank, and spoken of Mr. Yarrow's public-spirited munificence, Lord Rayleigh stated that it was because his friends failed to induce Mr. Yarrow to undertake the opening ceremony that the duty devolved upon him. He acknowledged, on behalf of the Executive Committee, the help given to the Committee by Mr. Froude, Dr. Glazebrook, M. Bertin, Professor Busley, Mr. Baker (the superintendent of the tank), and the engineers, Messrs. Mott and Hay. Lord Rayleigh then briefly, and with apt illustration, described the principle of dynamical similitude upon which tank experiments are based, and concluded by declaring the tank open, and expressing the hope that there would be fully realised all anticipations of a fruitful future.

Mr. Yarrow, who received a most cordial reception, next addressed the gathering. He first thanked

all who had been helpful in the realisation of the scheme, and especially Sir William White, and, proceeding, pointed to the need for a tank where shipbuilders could have tests made, if our prestige was to be maintained. He recalled the well-accepted fact of school-day experience that it was a very much easier task to get to the top of one's class than to remain there, and similarly, it must be realised that shipbuilders and engineers, if they had their country's welfare at heart, must, in addition to studying the success of their own firms, co-operate to do what was necessary for the advance of their profession, upon which the safety of our nation greatly depended. They had nothing to fear so long as the Admiralty, who had in the past led the way to progress, continued that policy, and gave encouragement to firms who had shown their keenness to initiate improvements and to lead rather than to follow. It was good to see firms keenly competing in the work of invention and improvement, but if those firms had to give up this policy and were forced to turn their attention solely to the reduction of cost, our prestige as a nation taking the lead in naval advance, would most certainly fall into other hands. There appeared a tendency to discourage special originative work, which was the secret of success, and to devote more attention to meet the immediate demands of greater competition, and to securing reduction in price. If this policy were carried too far, it would be fatal to future progress. This striving after cheapness would lead to the inevitable result of securing present gain at the sacrifice of future progress; for it must be borne in mind that if contractors were deprived of the margin of profit which enabled them to make investigations, it would put a stop to their enthusiasm in scientific advance. In conclusion, he said that he felt it a great privilege to have been the means of assisting to found the National Experimental Tank, which he hoped and trusted might not only be an advantage to the profession which was so dear to his hearers, but also to the country to which they were all so proud to belong.

The Marchioness of Bristol then set in motion the carriage towing a model in the tank, and it traversed the full length of the basin. On its return, the Marquis acknowledged the honour conferred upon his wife, and spoke of the practical utility of the research work to be undertaken in the tank.

Sir William White expressed the hope, on behalf of the Institution and of Mr. Yarrow, that the tank might be known as the "Froude tank," and the suggestion was approved by applause.

The guests afterwards visited other departments of the Laboratory, and took tea, which was served in the grounds, returning to town by special train. In the evening a festival concert in the Queen's Hall was largely attended, the Leeds Festival Choir, under the conductorship of Sir Charles Villiers Stanford, D.C.L., being the principal attraction. Supper was served later at the Queen's Hall, and Sir William White, in the course of the proceedings, proposed the health of Sir Charles Stanford, and Mr. Dana, the secretary of the Institution.

With the proceedings of yesterday, to-day, and to-morrow we shall deal in our next issue.

(*To be continued.*)

INDUSTRIAL NOTES.

AT the end of last week the gravity of the situation created by the seamen's strike had in no wise decreased, for although the seamen and firemen themselves appear to have been willing to accept terms, they would not do so on account of their being in sympathy with the dock labourers who were also on strike. In Hull, where the greatest trouble had been experienced, and where serious rioting had taken place, things were quiet at the end of the week, probably due to the importation into the town of 500 men of the London police. Put briefly, the situation at the end of last week was that the negotiations for a settlement had been broken off at Hull and things wore a threatening aspect, the men being held in check by the strong show of force in the town. In London, where the effects of the strike had not been much felt, a great dock strike was threatened, the men having put forward demands for an increase of (on the minimum wage) from 6d. an hour to 8d. with 1s. an hour for overtime. The terms agreed to by the men's officials in Liverpool were not accepted by 2000 of the men. Altogether, at the end of the week the outlook was gloomy.

It was known on Saturday that about half the shipowners in the country had formulated their scale of wages in accordance with the resolution arrived at during the conference held in London on Wednesday. These, speaking generally, represent an increase of about 10s. per month to the seamen. The rates agreed upon for crews signing on at Manchester were fixed on Friday as follow:—(1) General coasting trades, 29s. and the usual extras weekly. (2) Regular coasting and Continental liners, 32s. 6d. weekly. (3) Baltic, Eastern, Mediterranean, and South Atlantic: Seamen, 4*l.* 10s. monthly; firemen, 4*l.* 15s. monthly. (4) North Atlantic and St. Lawrence: Seamen, 4*l.* 10s. monthly; firemen, 5*l.* monthly. In Nos. 3 and 4, provisions to be found by the owners; No. 1, to remain as before. No. 2 represents an increase of 2s. 6d. per week for both seamen and firemen, while Nos. 3 and 4 represent an increase of 10s. monthly for both seamen and firemen. This scale was, however, refused by the men's leaders, who said they would not be satisfied with less than an advance of 5s. for weekly boats and an average up to 5*l.* 10s. for monthly boats.

The beginning of this week brought hope that matters would soon be settled satisfactorily and peace restored, for on Monday the outstanding differences between the shipowners and the men on strike in Liverpool and Hull were to a large extent settled. At other ports also, where the unsettlement had been less acute, this was also the case. At Hull, at the conference between the representatives of the employers and employed, under the presidency of Mr. Askwith of the Board of Trade, terms were arranged according to which the men agreed at once to return to work, having received considerable concessions. This, however, does not include 900 flour-millers, who are not yet satisfied with the offer made them. In Liverpool the outlook improved, but in Manchester things were less favourable, for there 4000 carters and several hundred railway employees came out on strike. At Bristol and Newcastle also the quay labourers refused to work incoming boats that had been diverted from other ports. In Hull the strikers who returned to work on Tuesday morning numbered about 20,000. They have not obtained all they asked for, but the wages of each class are increased, and the conditions of work are improved, and the men appear quite satisfied. The weekly wages of seamen at Hull and Goole will be 32s. 6d., and the monthly rates for firemen will be 4*l.* 15s. Questions relating to the Federation ticket, doctors' examination, and a weekly half-holiday, have also been settled. The case of dockers, and other shore workers was also settled, the men obtaining an additional ½d. per hour. In addition, the employers agree to meet the representatives of sections of workpeople as well as the chief classes concerned in the strike in order to discuss claims, a reasonable notice being given. The final clause of the agreement is, perhaps, the most important, as it relates to the interests of the community as a whole. It runs: "In the event of any question arising as to the interpretation of any clauses of this agreement, which cannot be settled by the parties concerned, no stoppage of work shall take place, but the matter shall be referred to the Board of Trade." Although the famine prices charged for flour in Hull on Saturday no longer hold, the price of flour is still high. This high price has, however, been largely due to the sectional strike of 900 millers.

In Liverpool practically the only men now out are a few scalers, who are mostly young fellows demanding increased pay, and some two or three hundred mates, second engineers, and seamen employed by the Alexandria and Cock Towing Companies. It is stated that, as a result of the strike, some 8000 men have joined the Dockers' Union, and there have been large additions to the Seamen's and Stewards' Unions. At the time of going to press Manchester was in a state of turmoil, the strike having resulted in rioting and bloodshed, and the strike in Glasgow had been renewed when the dockers, firemen, stewards, and cooks of the Allan and Anchor Lines came out. They refuse to go back till the quay labourers' terms have been met.

The twelfth annual report of the General Federation of Trade Unions has recently appeared, and shows a record of a very trying period in the history of the Federation; in fact, the financial reserve was less than at any time since 1902. The boilermakers' dispute alone cost the Federation over 53,000*l.* On March 31, last year, there were 135 societies on the books of the Federation, but during the year five societies left, the total membership at the end of the year being 697,391. During the year ending March 31, 1911, there were additions to the Federation which brought the membership up to 710,994. The report shows that the income, both from contributions and from interest, is lower by 1650*l.* 4s. 9d. than last year, the decrease being accounted for by the fact that in 1909-10 the boilermakers paid five quarters while in 1910-11 they only paid three, and the loss of income on investments is due to the withdrawals on account of Federation benefit. The total expenditure for the year was 74,952*l.* 17s. 11d., or an excess of expenditure over income of 39,648*l.* 14s. 2d., which excess was due to the claims made for benefit, for although the actual disputes were fewer than in 1909-10 the number of workers involved rose from 6418 to 23,635, and the cost of disputes rose from 8767*l.* 18s. 1d. to 72,321*l.* 19s. 10d. Disputes during the year affected 3.32 per cent. of the total membership of the Federation, and the average payments per head of those involved have exceeded 3*l.* 1s. 2d. All other expenditure shows a decrease of 17½ per cent. A comparison of income and expenditure covering the whole of the Federation's existence shows that the amount actually returned to the members in Federation benefit, 288,576*l.*, plus the balance of 61,235*l.*, exceeds the amount actually received in contributions and entrance fees (335,816*l.*) by 13,995*l.* The total reserve fund now stands at 61,235*l.* 7s. 7d., part of which, amounting to 10,486*l.* 15s. 1d., is practically at call, while the balance can be realised on six months' notice.

The South Wales Miners' Federation held a general conference of lodge delegates at Cardiff on Saturday last, when the general feeling of the delegates appears to have been that pressure should not be put on the Cambrian men to return to work, but that earnest efforts should be made to support them by levies, at least until after the National Conference to be held in London on July 28. The weekly grant ceased on Saturday last, but there are hopes among the men that it will be restarted. The question of a general Welsh strike was discussed, but no actual resolution was put to the meeting. It was, however, agreed to issue a manifesto to the English and Scottish miners explaining the position in South Wales, and also to send men to place the facts before the workmen. It was the feeling of the meeting that sectional fighting was no use, and that a national strike was the only way to secure a redress of grievances.

The conciliation board of the Northumberland coal trade met at Newcastle on Saturday last, and decided that with pays beginning on the following Monday and on July 10 the wages of underground workmen and "banksmen" be advanced by 1¼ per cent., making them 27½ per cent. above the basis of 1879. The wages of other classes of labour advanced in the usual proportion will be 22 per cent. above the standard. It is stated that, unless some agreement be arrived at within the next three months, there will be no further meeting of the board, as the miners have given notice to secure a minimum wage of 30 per cent. above the standard of 1879.

The labour conflicts, both in Sweden and Norway, are assuming a more serious form. In the first-named country the negotiations within the building trades have led to no results, and as the current strikes have not been terminated the Central Union of Swedish Employers has given notice that the Union, in order to defend its members, whose men have gone out on strike, has found it necessary to declare a lock-out, as far as all the members of the Union are concerned, from Monday, July 10. Further mediation, however, is likely to be attempted. Should it not succeed, some 40,000 men will be locked out. In Norway, mediation has been resorted to in vain, and no agreement having been arrived at by July 1, the Union of Norwegian Employers on that extended the notice of lock-out, so as to comprise some additional 16,000 hands. This second lock-out refers to 139 industries, viz., the iron industry as a body, and the following in the paper-making industry:—the Union Company, Skien; the Klosterfossen Company, Skien; the Embretsfos Company, Modum; the Hlunsfos factories, Christianssand.

THE JUNIOR INSTITUTION OF ENGINEERS.—The summer meeting of this Institution will take place at Felixstowe, Ipswich, Norwich, and Cambridge, from July 29 to August 5. Visits to various works are being arranged, also to the engineering laboratories, workshops, and colleges at Cambridge. In the evening of Friday, August 4, the Institution's summer dinner will be held at the University Arms Hotel, the President, Sir J. J. Thomson, F.R.S., being in the chair. The necessary arrangements are being carried out by the Secretary, Mr. Walter T. Dunn, 39, Victoria-street, Westminster.

THE LATE DR. G. J. STONEY.—We regret to announce the death of Dr. George Johnstone Stoney, F.R.S., which occurred on Wednesday, at his residence in London, in the eighty-sixth year of his age. The deceased gentleman made many valuable contributions to physics, and to him indeed is due the introduction of the term "electron" for the unit disembodied charge of electricity. At an earlier date in his career he served on the British Association Committee which introduced the now recognised system of electrical and magnetic units. He was elected a member of the Royal Society in 1861, and served long as a member of the Council, of which he was afterwards appointed one of the vice-presidents. His brother, Bindon Blood Stoney, was well known as engineer to the Dublin Port and Harbour Board. Mr. Gerald Stoney, F.R.S., who has been so closely associated with he development of the Parsons steam-turbine, is his son.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a firm tone, and 5500 tons of Cleveland warrants were done at 46s. 3½d. cash and 46s. 6d. one month. Closing sellers quoted 46s. 4d. cash, 46s. 7d. one month, and 47s. 0½d. three months. In the afternoon the market was steady, but no dealings were recorded. At the close of the day there were sellers at 46s. 4d. cash, 46s. 7d. one month, and 47s. three months. On Friday morning a stronger tone prevailed, and although the business was limited to two lots of Cleveland warrants, they were done at 46s. 5d. cash, and 47s. 1½d. three months. Sellers' closing prices were 46s. 5½d. cash, 46s. 8d. one month, and 47s. 1½d. three months. The afternoon session was easier in tone, and a small business of 1500 tons of Cleveland warrants changed hands at 46s. 4½d. cash, with sellers over at that figure, and at 46s. 7½d. one month, and 47s. 1d. three months. On Monday morning there was little life in the market, and the dealings consisted of only two lots of Cleveland warrants at 46s. 7d. one month, and at the close sellers quoted 46s. 4d. cash, 46s. 7d. one month, and 47s. 0½d. three months. In the afternoon quietness was again the ruling feature, and the turnover consisted of 1500 tons of Cleveland warrants at 46s. 6½d. one month, and closing quotations were 46s. 4d. cash, 46s. 7d. one month, and 47s. 0½d. three months sellers. On Tuesday morning there was no change in the tone of the market, and only one Cleveland warrant changed hands at 46s. 6d. one month. Closing prices were easier, at 46s. 3½d. cash, 46s. 6½d. one month, and 47s. three months sellers. Cash sellers of hematite quoted 61s., but there were no buyers. The afternoon session was dead idle, but sellers of Cleveland warrants quoted nominally ½d. up, at 46s. 4d. cash, 46s. 7d. one month, and 47s. 0½d. three months. When the market opened to-day (Wednesday) the tone was the turn stronger, and some 3500 tons of Cleveland warrants were done at 46s. 6½d. and 46s. 7d. one month. Closing sellers quoted 46s. 4½d. cash, 46s. 7½d. one month, and 47s. 1½d. three months. Hematite was quoted at 60s. cash buyers and 60s. 10½d. cash sellers. In the afternoon business was quite at a standstill, but quotations for Cleveland warrants were nominally steady, with sellers at 46s. 4½d. cash, 46s. 7½d. one month, and 47s. 1½d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde, 60s. 6d.; Calder and Gartsherrie, 61s.; Summerlee, 63s.; Langloan, 64s.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 64s.; Shotts (at Leith), 62s.; and Carron (at Grangemouth), 63s.

Sulphate of Ammonia.—A better inquiry exists for sulphate of ammonia this week, and the price is firmer. The current quotation for prompt lots is now 13*l.* 7s. 6d. per ton, Glasgow or Leith.

Scotch Steel Trade.—No change falls to be reported in connection with the state of the Scotch steel trade, with the exception that a little activity is noticeable in the clearing off of orders before closing down for the holidays, and there is a consequent increase in specifications. The shipbuilding yards in the lower reaches of the Clyde knock-off for holidays at the end of this week, and will have resumed work before the steel trade, so that specifications from that source for plates, angles, &c., are also rather better at the moment. On the other hand, no increase in new business has taken place, and buyers continue to pursue the policy of waiting for a fall in prices, which, however, has shown no signs of coming. Light steel material of all kinds and structural sections are in good demand, especially the former.

Malleable-Iron Trade.—The malleable-iron trade of the West of Scotland is practically without change, and the basis price for Crown bars is still 6*l.* per ton, less 5 per cent. for prompt delivery.

Scotch Pig-Iron Trade.—A fairly good business has lately been done in the ordinary qualities of Scotch pig-iron, principally with buyers in the South, but local consumers continue to purchase sparingly. The export demand is satisfactory, but owing to the trouble with the seamen and quay labourers, deliveries are being somewhat delayed. Hematite is still inactive, and no change has taken place in prices.

Shipbuilding.—The shipbuilding returns for the past month are very satisfactory, and bring up the output of the year to date to quite a respectable tonnage. The following are the figures for the different Scotch districts:—

	June, 1911.		Six Months, 1911.	
	Vessels.	Tons.	Vessels.	Tons.
The Clyde	23	52,474	135	309,860
The Forth	3	1,345	13	6,756
The Tay	..	..	9	8,807
The Dee	5	598	39	5,862
Total output ..	31	54,417	196	331,285

It is interesting to note that the June output for the Clyde yards is over the average for the six months just closed, and also that it brings the total for the year to date up to 309,860 tons. Only on one occasion has the output for the same period been greater, and that was in 1906—the year of the "Lusitania"—when the total figures amounted to 336,258 tons. A record may not be created this year, but if labour troubles are only overcome, there is likely to be quite a large output marked up against the year 1911. New orders are scarce at present, but contracts on hand ensure steady employment for some months ahead. It is just reported that the contract for the two new Empress steamers for the Atlantic service of the Canadian Pacific Railway Company has been secured by the Fairfield Shipbuilding and Engineering Company, Limited, Govan.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

National Insurance and Industry.—At the annual meeting of shareholders of Messrs. John Brown and Co., Limited, held in Sheffield, the chairman pointed out that, with their subsidiary concerns, the company employed between 40,000 and 50,000 men—wage-earners; and when they came to reckon up what the National Insurance charge would involve, it meant that something like 25,000*l.* a year would have to be found by the company. This amounted to about 1½ per cent. of their capital, or, to put it in another way, they would see 1½ per cent. taken from their dividends. Of course, that was perhaps, taking the worst view of the situation, but it was only right that shareholders should understand what these latest legislative projects really meant. In a short time they might be able to throw that charge on the cost of production, as in the case of the Compensation Act, but they must not be surprised if, during the first twelve months, it had a very serious effect upon their revenue.

Iron and Steel.—Half-yearly stocktaking has been responsible for an almost total suspension of buying during the past week, and the raw material market has been exceptionally quiet. Prices have remained at a dead level for some weeks past, and there is little prospect of any immediate alteration. The general tone of the market, however, is hopeful. Contracts are running out, and with stocks very low, manufacturers will shortly be compelled to replenish. The heavy output of manufactured iron and steel indicates a strong revival when consumers do come on the market. Lincolnshire irons, with little doing, show no change. Derbyshire makers, owing to the lower prices, are more favourably situated. Foundry sorts are making 50s. to 51s. The engineering houses are well supplied with orders, in many cases working overtime, but complaints are still rife of the unremunerative character of much of the work. Keen competition from abroad, and cutting at home, leave but little margin for profit, and with wages showing an all-round increase, the earnings of even those houses having important specialities are comparatively small for a time of such activity.

South Yorkshire Coal Trade.—Latest quotations are as follows:—Best branch hand-picked, 13s. to 14s.; Barnsley best silkstone, 11s. to 12s.; silkstone, 9s. to 10s.; Derbyshire house, 8s. to 9s.; large nuts, 7s. 3d. to 9s.; small nuts, 5s. 6d. to 6s. 6d.; Derbyshire brights, 10s. 3d. to 11s.; Yorkshire hards, 8s. 3d. to 9s. 6d.; Derbyshire, 8s. to 9s.; washed nuts, 7s. 9d. to 8s. 9d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. to 5s.; smalls, 1s. 6d. to 2s. 6d.

THE KAISER WILHELM CANAL.—The traffic through the Kaiser Wilhelm Canal, which dropped off in 1908, but recovered in 1909, continued to increase during 1910. Altogether 75,569 vessels, aggregating 7,579,339 registered tons, passed through the Holstein Canal, against 36,547 vessels, of 6,527,698 tons, in 1909. The number of steamships shows a very considerable increase, from 16,821 in 1909 to 21,033 in 1910, while the number of sailing vessels has actually decreased, from 18,334 in 1909 to 17,450 in 1910. Lighters, &c., have also increased, both in number (7086 against 3391) and in capacity (1,148,690 against 723,557 registered tons). The ships of the German Navy are not comprised in these statistics.

THE IRON AND STEEL INSTITUTE MEETING: THE TURIN MEETING.—Arrangements have been made to hold the Autumn Meeting of the above Institute at Turin on Monday and Tuesday, October 2 and 3, this year, when the following papers will, it is expected, be read:—(1) "Report on the Mineral Resources of Italy," by various authors; (2) "On the Autogenous Welding of Metals," by Dr. Francesco Carnevali (Turin); (3) "On the Application of Electrical Energy to the Manufacture of Iron and Steel in Italy," by Cav.-Ing. Remo Catani; (4) "On the Present State of the Iron and Steel Industries of Italy," by Signor Comm. Luigi Dompé and Cav. Francesco Sayerio Pucci; (5) "On New Industrial Processes for the Cementation of Steel," by Cav. Prof. Dr. Federico Giolitti; (6) "On Cementation with Gas Under Pressure," by Prof. Dr. F. Giolitti and Dr. Francesco Carnevali; (7) "On the Transformation of Steel Within the Limits of Temperature Employed for Heat Treatment," by Louis Grenet (Argenteuil, France); (8) "On Basic Slag," by V. Adolphe Kroll, Junr. (Frankfort-on-Main); (9) "On the Use of Titanium in Iron and Steel," by C. V. Slocum (Pittsburg); and (10) "On the Physico-Chemical Properties of Slag," by Prof. J. H. L. Vogt (Christiania). Members will, however, receive a final list of papers later. The following is a brief programme of the arrangements for travelling, &c.:—Members resident in Great Britain can travel together, and in order to avoid night travelling on the outward journey the party will stay one night in Paris and one night at Aix-les-Bains. Special reduced fares have been fixed in connection with these arrangements. The train will start from Holborn Viaduct (South-Eastern and Chatham Railway) at 9.30 a.m., on September 29, and passengers are expected to arrive at Turin on October 1, at 6.10 p.m. On October 1 and the two succeeding days badges and programmes will be distributed and members will be welcomed by the civic authorities; papers will be read and discussed, and places of interest visited on October 4 and 5. There will be excursions to Savona and Genoa, and from then to October 17 there will be visits to Rome, Naples, Terni, Florence, and Milan. There will also be a special excursion to the Island of Elba and to Piombino, on Friday and Saturday, October 6 and 7. Further particulars may be obtained from the secretary, Mr. G. C. Lloyd, 28, Victoria-street, Westminster, S.W.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The pig-iron market is still dull, but values of Cleveland kinds are rather stronger. Makers are not very keen sellers, as they anticipate improvement in values in the near future. Transactions are consequently confined to sales for early delivery, and it is significant that sellers will not quote forward except at higher rates than rule for early business. Production is now fairly well taken up, and as the autumn approaches the make should be more than fully absorbed, and stocks consequently reduced; but it must be borne in mind that we are still passing through what is usually a quiet period of the year. The better reports from the United States should assist to strengthen this market. No. 3 g.m.b. Cleveland pig is 46s. 7½d. f.o.b.; whilst No. 1 is 50s. 1½d.; No. 4 foundry, 46s. 1½d.; No. 4 forge, 46s.; mottled and white each 45s. 9d.; and Nos. 1, 2, and 3 East Coast hematite pig 61s. 6d.—all for early delivery. Business in foreign ore is still at a standstill. Prices show a rather downward tendency, but consumers declare that very substantial reductions will yet have to be made before a renewal of buying is at all likely. Rubio, of 50 per cent. quality, is quoted 19s. to 20s. ex-ship Tees. Coke is in fairly good request, the local consumption being heavy, and demand for shipment is fairly good, but the supply is ample. Average blast-furnace kinds are not more than 14s. 6d. delivered here, and foundry coke ranges from 16s. to 17s. f.o.b.

Manufactured Iron and Steel.—Though new orders are by no means plentiful, producers of nearly all descriptions of manufactured iron and steel are pretty well placed, several firms having made contracts which will keep them employed for some months. Manufacturers, under these conditions, are not pressing sales particularly, as they hope for improvement in values. Principal market quotations stand:—Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 12s. 6d.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 7s. 6d.; cast-iron railway-chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 10*l.* 15s.—sheets less 4 per cent., railway material net, and all other descriptions less 2½ per cent. discount.

Shipments of Iron and Steel.—June shipments were but small. This was what was anticipated, for June is usually a quiet shipping month, and this year loadings were checked by the Coronation holidays, and by the unfortunate seamen's strike. Pig iron cleared during last month averaged 4509 tons per working day, the total despatches being returned at 108,219 tons, 95,713 tons of which went from Middlesbrough and 13,506 tons from Skinningrove. For the previous month the total clearances of pig reached 142,559 tons, or a daily average of 5317 tons, and during June, last year, the despatches amounted to 117,957 tons, or an average of 4537 tons per working day. Of the pig iron sent from Skinningrove last month 12,430 tons went to Scotland, and 1076 tons to the Continent. Of the pig iron sent from Middlesbrough last month 75,523 tons went abroad, and 20,190 tons to coastwise customers. Japan was the largest receiver, taking 13,801 tons; whilst Italy took 12,293 tons; Germany, 11,638 tons; Scotland, 10,814 tons; and Canada, 7265 tons. Shipments of manufactured iron for June were given at 12,013 tons, 6071 tons going foreign, and 5942 tons coastwise, India once more being the largest customer with an import of 4035 tons. The steel cleared last month amounted to 28,354 tons, 23,216 tons of which went abroad and 5038 tons coastwise. The best customers were Canada, 4459 tons; India, 4449 tons; Japan, 3969 tons; and Victoria, 2203 tons.

THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.—The annual general meeting of the members of the above Institute will be held at the Philosophical Hall, Leeds, on Tuesday, July 18, at 3.30 p.m. The paper to be read and discussed at the meeting is on "Coal-Dust Experiments," by Mr. W. E. Garforth.

"ALL ABOUT PATENTS."—This is the title of a practical guide, in pamphlet form, for inventors, patentees, investors and manufacturers, by Mr. Clarence W. Crossley, issued at the price of 9d. net. It deals with a number of points of interest to the classes addressed, concerning inventions, patents covering same, and the working and sale of the latter.

CONTRACTS.—We are informed by the British Westinghouse Electrical and Manufacturing Company, Limited, that they have recently received a number of important orders, among which are:—Three 400-kw. rotary converter sets for the Tyneside Electric Development Company, Horden and Shotton Colliery; three 450-kw. rotary converter sets direct-current switch gear, &c., for the Greenock Corporation; one 500-kw. rotary converter and switch-gear for John Summers and Co., Limited; fifty magnetic brakes for the Manchester Corporation; one 2000-kw. 3000-revolutions per minute alternating-current turbo-generator set, with surface-condensing plant, &c., for the Blackburn Corporation; and one 1500-kw. high-pressure turbine (Impulse type) coupled to one 1600-kw. direct-current generator, and one 1100 alternating-current generator in tandem, with surface-condensing plant, Lea recorder, and Brown-Boveri regulator,

LARGE CRANES.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the description of the 200-ton electric Titan crane at the Fairfield Works, given in last week's ENGINEERING, we observe it is there stated that "No larger crane has, so far, been constructed." We would, however, point out that this is not the case, as there are already two larger cranes in operation, one of these being at His Majesty's dockyard, Devonport, and the other at the Imperial Japanese Navy dockyard, Yokosuka, both of which were designed and manufactured by us.

The following table will show the respective powers of these cranes in foot-tons :—

	Tons.	Radius, Feet.	Foot-Tons.
Fairfield Crane.			
Working load ...	200	75	15,000
Test load ...	250	75	18,750
Devonport Crane.			
Working load ...	160	95	15,200
Test load ...	240	95	22,800
Yokosuka Crane.			
Working load ...	200	95	19,000
Test load ...	250	95	23,750

Yours faithfully,
For COWANS, SHELDON, AND CO., Limited,
J. W. BROWN, Secretary.

Carlisle, July 3, 1911.

ST. PAUL'S BRIDGE.

TO THE EDITOR OF ENGINEERING.

SIR,—It appears the City is appointing three architects in reference to the above as a committee. But why not a composite one, with representatives of engineering and surveying as well? The addition of a well-known business man also would be an acquisition, together with someone who has shown special acquaintance with the whole aspect of the question. It is not merely to the "make-up" of the committee that objection can be taken, but to the matter of its origin. True, the City is generously offering to build a bridge, and naturally has undertaken the ordering of it, on what it believes to be the best lines. In doing so it is feared the matter is being considered as merely local, whereas it is at least metropolitan, if not national or imperial. It appears to be viewed also in its most limited aspect, as simply the matter of a bridge and its connections, whereas in the ultimate it is the question of at least a new main thoroughfare from the "Angel" to the "Elephant"—alternative, perhaps, to the proposal of the Royal Commission on London Traffic for a new north to south main avenue.

It seems to be forgotten, in fact, that we are in the midst of designing a new Metropolis, and must say good-bye to the practices of the past, in which one piece after another has been added without even general reference to the whole and to what may be expected to come after. Begun by the above Royal Commission, continued in a branch of the Board of Trade (perhaps also in some measure in the Roads Development Commission), the new draft plan may be said to be well on the way. But we still await the appointment of the body destined to formulate definitely the working plan for the reconstruction of the Metropolis in fulfilment of the recommendation of the Royal Commission.

Listening to the debate on the New Bridge Bill in Parliament, it was noticed as strange that the above matter was not once referred to; and, marvel, no Government oracle ventured a syllable on either question, surpassingly important as both are in relation to the Metropolis of the future.

Any reference, it is considered, which the City can impose on such a committee of its appointment must necessarily be very limited, even if it goes beyond the locale of the proposed bridge in the City. Whereas, it has been shown that the general question at issue stretches far beyond the City's nominal interest and jurisdiction. In view of that, therefore, any findings of such a committee must be considered unsatisfactory.

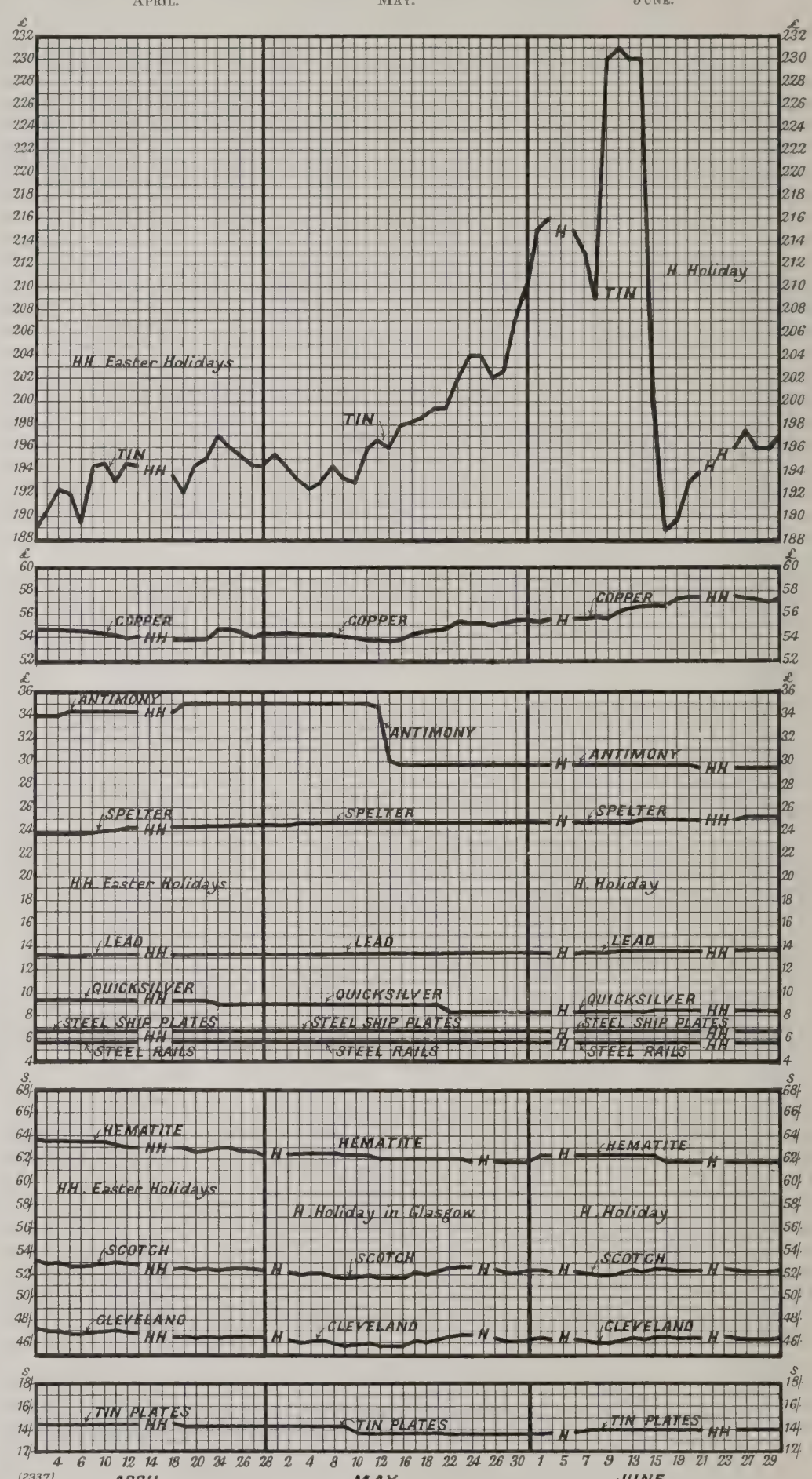
As a solution of the matter it is reckoned that the City, having acted so nobly, would, under the circumstances, be well advised to as gracefully withdraw from further contention. The onus of carrying the matter through as a whole would thus be left to Government and the prospective new body which could consider the project in its widest aspect, and carry it out as part of a well-devised general plan of the new Metropolis.

Yours truly,
London, July 3, 1911. O.B.I.T.

LONDON, TILBURY, AND SOUTHEND RAILWAY.—The proposed transfer of the London, Tilbury, and Southend Railway to the Midland Railway Company has been almost unanimously approved at a meeting of the present proprietors; and, subject to the approval of Parliament, the amalgamation may almost be regarded as a *fait accompli*. The Tilbury line was originally leased to Messrs. Peto, Brassey, and Betts, the contractors who built it, and who guaranteed an interest of 6 per cent. per annum upon the share capital for a term of fourteen years. In 1876 the guarantee expired, and the London, Tilbury, and Southend Railway Company, which had been incorporated in 1862, had to make the best of the property. The growth of Southend during the last thirty-five years has been very great, and the Tilbury system has, accordingly, become a solid and successful undertaking. The Tottenham and Forest Gate Railway, which connects the system with the Midland Railway, has been in operation since 1894. The object of the Midland Company in acquiring the London, Tilbury, and Southend lines is to obtain further access to the coast, so as to develop more watering place traffic. The original Midland undertaking was quite land-locked, but the Midland company has been gradually pushing to the coast; and it will now, no doubt, make great efforts to render Southend an even more attractive watering place than it is at present.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



(2337)

IN the accompanying diagrams each vertical line represents a market day, and each horizontal line represents 1s. in the case of tin-plates, hematite, Scotch and Cleveland iron, and 1*l.* in all other cases. The price of quicksilver is per bottle, the contents of which vary in weight from 70 lb. to 80 lb. The metal prices are per ton. Heavy steel rails are to Middlesbrough quotations. Tin-plates are per box of I.C. cokes.

TURBINES IN WARSHIPS.

*The Rational Application of Turbines to the Propulsion of Warships.**

By A. C. E. RATEAU, Member.

DURING the last ten years we have assisted at a considerable development of turbine engines in all navies. The success of these engines has been assured, because they are the only ones which enable us to solve the problem of speed, since the demand for high speed in every class of vessel increases daily. They have, however, other qualities which add considerably to the value of ships fitted with these engines. These qualities are principally endurance, the elimination of hull vibrations, economy of fuel at high speeds, and the fact that the engines are always ready and require no overhauling. Great importance must have been attached to these qualities to justify the adoption of these engines, as they have the grave fault of showing a low efficiency at ordinary speeds, which reduces by one-half one of the principal factors of the naval value of ships—viz., the radius of action

This reduction in radius of action does not have the same importance for all naval Powers. To Great Britain, whose wise policy has given her in all the seas of the world bases of supply not far distant from one another, endurance and constant readiness for action are qualities undoubtedly preferable to all others; consequently, the British Admiralty adopted turbines as soon as they were available, and they can, even now, continue to use them without other inconvenience than the extension of the fuel supply and the improvement of the means of utilising the same.

Other nations are not in the same position as regards turbines. They would have to provide in times of war the important convoys of supply, which, however well organised they may be, would form but an uncertain means of assistance, and would reduce the offensive naval war strength of the fleet by the number of the fighting units necessary for their protection. For these nations, therefore, the adoption of turbines has, far more than for Great Britain, meant increased expenditure, and they also have to suffer inconveniences of a strategical nature, which the greatest financial sacrifices can only reduce.

It is not surprising to find that some countries openly regret having followed the example of Great Britain, and that one of the most powerful of these is about to replace turbines by reciprocating engines for her new battleships. One may well hesitate to adopt such a radical course as to forego the advantages of turbines. Makers of turbines are, therefore, endeavouring to make these engines more economical at low speeds. The solution of the problem has been sought by making the propeller shafts revolve independently, so as to keep the turbines at a constant speed of rotation, thus securing a good efficiency; the transmitting gears are in such cases designed with toothed wheels or electric motors. Even admitting that by the introduction of these means of transmission there will not be a considerable loss of efficiency, their employment will always entail a certain complication and weakness, and the machinery so designed will lose two qualities that are most highly appreciated—viz., strength and simplicity.

In the present paper it is proposed to leave out of consideration these methods of transmission, and to keep to the study of what may be done with steam-engines only, turbines, and piston engines. By suitably combining them, it appears possible to improve greatly upon the actual consumption of steam, especially at reduced speeds. Turbines are now as well understood as reciprocating engines. We know that from the point of view of efficiency their advantages are limited by certain conditions. The piston engine has, in fact, an excellent efficiency when the steam has a mean pressure of 15 lb. to 30 lb. per square inch, but it becomes bad if the expansion is carried too far.

To utilise the expansion up to pressures approaching those obtained in the condensers, we must have cylinders of large dimensions, the attainment of which is impossible, and in which, moreover, friction losses and condensation would absorb the theoretical gain obtained by the increase of expansion. Turbines, on the contrary, have their best efficiency at low pressures, and are able to utilise the expansion beyond the condenser pressures; while they give rise to great losses at high pressures, due to the friction of the revolving parts in the steam space, also to leakages through the clearances between the moving and stationary parts. Marine turbines are further restricted to low velocities, instead of being able to utilise those which are best for a good efficiency. It is obvious, therefore, that, if we can have an arrangement of combined engines, arranged in series, in which the reciprocating engines utilise the energy of the steam only up to the limit of expansion suitable for a good efficiency, leaving to the turbine the duty of utilising the expansion down to condenser pressures, we shall then have an engine much superior, whatever be the speed of the ship, to one consisting exclusively of turbines or reciprocating engines.

Ever since 1900 we had foreseen the necessity of a combination of the two kinds of engines. At the meeting of this Institution of 1904* we described the arrangement installed, according to our ideas, by Messrs. Yarrow and Co., on board a small torpedo-boat. In this arrangement the reciprocating engines and the turbines were independent; by working the reciprocating engines only we could obtain very economical results at low speeds. But we must take account of the qualities as well as the faults of each engine; we have managed to gain some advantages, although we cannot eliminate all the faults.

In 1906 we fitted the French destroyer Voltigeur with an improved arrangement of engines. The power is distributed on three shafts (centre shaft reciprocating engine, with turbines on wing shafts). The engines are so designed that when going at full power the distribution is equal on these shafts. Up to a speed of 20 knots the reciprocating engines exhaust into the turbines, but above this speed the engines become independent. We would therefore have realised a perfect engine up to a speed of 20 knots, if the reciprocating engines and the turbines had been designed solely with the view to obtaining better results by working by stages; but, instead of this, they were designed more particularly with the object of obtaining the maximum efficiency at full power.

However this may be, the Voltigeur has undeniably demonstrated the superiority of the system, because below 20 knots the consumptions are slightly above those obtained in destroyers of the same class fitted with reciprocating engines. Above 20 knots, notwithstanding the presence of the reciprocating engines (which under such conditions are not advantageous), the consumptions remain less than those of all other destroyers, even with turbines only. This is due to the superior efficiency obtained with multicellular turbines. See Figs. 1 and 4, showing respectively the arrangement of machinery of the Voltigeur, and the comparative curves of consumption of the Voltigeur, Chasseur (with reaction turbines), and Carabinier (with reciprocating engines). In the author's opinion the best arrangement is the following:—

Combined Engines for Battleships and Cruisers.—The propulsive power is distributed on four shafts, each pair (port and starboard) being worked by an absolutely independent set of engines. In each set a reciprocating engine drives the wing-shaft, and exhausts into a turbine which drives the inner shaft.

The reciprocating engines and the turbines are designed to develop a power equally distributed on the four shafts when running at maximum speed. At cruising speeds the reciprocating engines develop much more power than the turbines. The reciprocating engines should naturally be able to run ahead and astern without engaging the turbines. This design includes an exhaust direct to the condenser; this exhaust opens at the moment when the normal exhaust to the turbines closes by means of two connected valves. These valves are operated automatically when starting, thus avoiding any error or loss of time. It appears unnecessary to introduce astern turbines on the centre shafts; but this could be arranged without much difficulty.

With such an arrangement the following advantages are obtained:—

1. *Maximum Speed.*—For the same weight of machinery, relatively to the propelling engines, there will be an increase of the maximum power from 15 to 20 per cent., which corresponds to an increase of speed from 5 to 7 per cent. of the maximum speed—say 1 to 1.5 knots for battleships intended for 20 knots.

Fig. 1. DESTROYER "VOLTIGEUR"

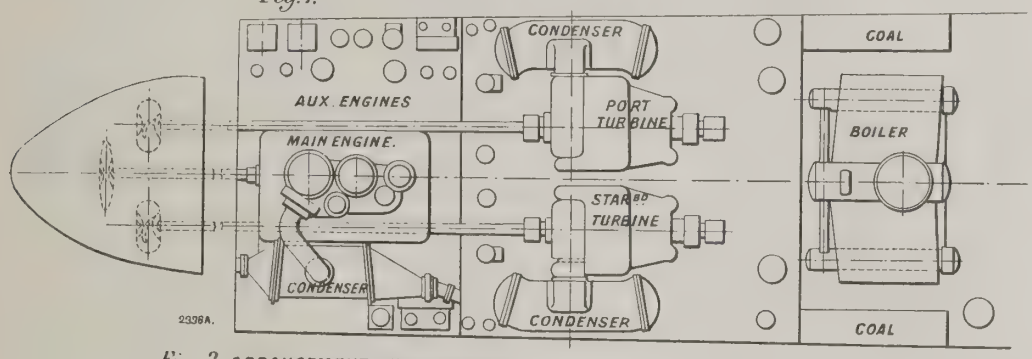


Fig. 2. ARRANGEMENT OF TURBINES.

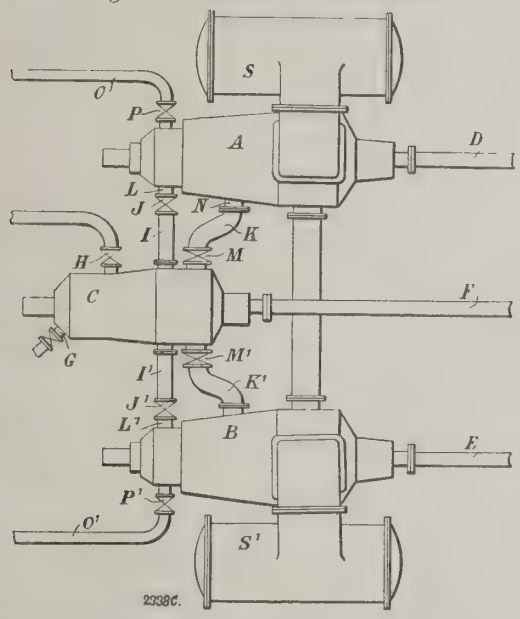


Fig. 3. CURVES SHEWING THE SLIP OF THE PROPELLERS IN RELATION TO SPEED. DESTROYER "VOLTIGEUR"

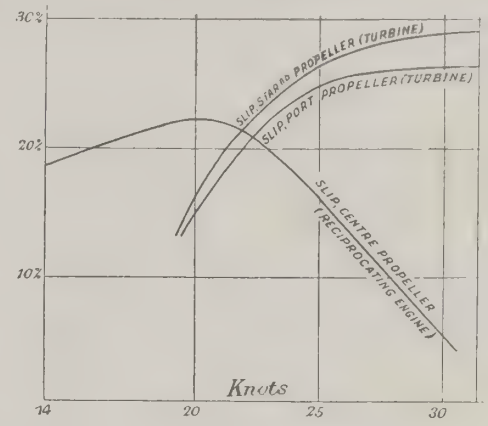
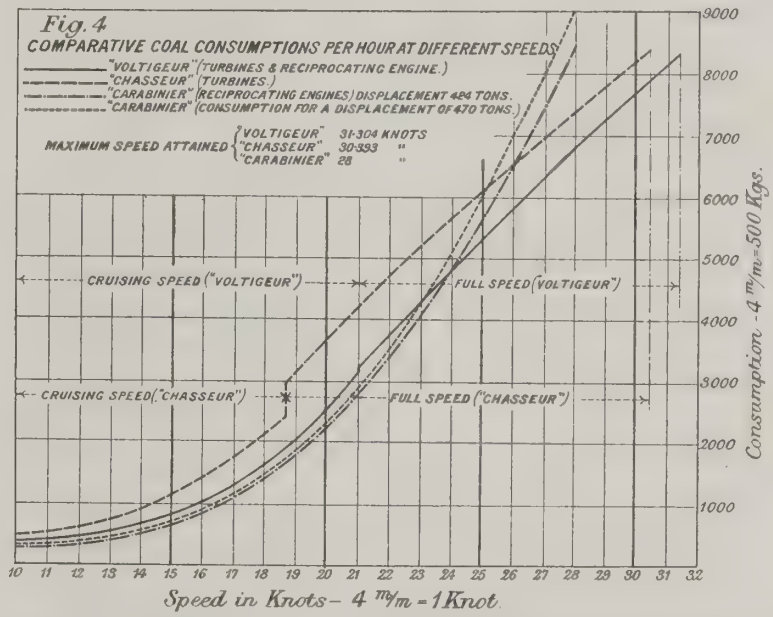


Fig. 4

COMPARATIVE COAL CONSUMPTIONS PER HOUR AT DIFFERENT SPEEDS


"VOLTIGEUR" (TURBINES & RECIPROCATING ENGINE.)
"CHASSEUR" (TURBINES.)
"CARABINIER" (RECIPROCATING ENGINES) DISPLACEMENT 424 TONS.
"CARABINIER" (CONSUMPTION FOR A DISPLACEMENT OF 470 TONS.)
MAXIMUM SPEED ATTAINED "VOLTIGEUR" 31·304 KNOTS
"CHASSEUR" 30·393 "
"CARABINIER" 28 "
CRUISING SPEED ("VOLTIGEUR")
FULL SPEED ("VOLTIGEUR")
CRUISING SPEED ("CHASSEUR")
FULL SPEED ("CHASSEUR")
9000
8000
7000
6000
5000
4000
3000
2000
1000
Consumption - 4 m/m = 500 Kgs.
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Speed in Knots - 4 m/m = 1 Knot.

* Paper read at the Jubilee meetings of the Institution of Naval Architects, July 5, 1911.

* Transactions of the Institution of Naval Architects, vol. xlvi., page 168; also ENGINEERING, vol. lxxvii., page 515.

2. *Cruising Speed.*—At this speed the consumption will probably be less than that of ships with reciprocating engines only, and it will not reach one-half of that with turbines. By comparison with the latter the radius of action will be doubled, or, if preferred, it may reduce the fuel supply in the same proportion.

3. *Manœuvring.*—When manœuvring in port it will be found that the arrangement of wing shafts driven by the reciprocating engines is a more favourable one than that of vessels with two or three propellers driven by reciprocating engines only. When manœuvring in squadrons, stations will be as easily kept as by other ships, because the regulation of speed can be adjusted by the operation of the stop-valve on the reciprocating engines.

Arrangement of Turbines for Scouts and Destroyers.

It will be readily understood that, although the distribution of the propelling machinery on four shafts does not present any inconvenience in large ships, it is difficult to achieve in the scout and destroyer classes.

If it is intended to apply the combined system in these small vessels, it will be necessary to adopt an arrangement with three shafts, similar to that of the Voltigeur, in which, at certain speeds, the reciprocating engine on the centre shaft will exhaust into the wing turbines; but in order to retain sufficient manœuvring qualities, it will be necessary to put astern turbines on the wing shafts, and a direct exhaust from the reciprocating engine to the condenser, so as to make this engine independent for manœuvring in harbour.

This arrangement may, perhaps, be thought complicated. To simplify it we may adopt the arrangement recently installed on the White Star Line vessels—two reciprocating engines driving the wing shafts, and both exhausting into the same turbine, placed on the centre shaft, and, when manœuvring, direct to the condenser. But the almost universal opinion is that it is wise to give up entirely the use of reciprocating engines for scouts and destroyers. These ships must be capable of developing at full power a considerable speed; they must, therefore, always be ready to pass from an ordinary cruising speed (14 to 16 knots) to very high speeds. On the other hand, the number of men composing the crew is limited through lack of accommodation, and it is necessary without greatly reducing their offensive value, to limit to the strictest minimum the numbers of the engine and boiler-room *personnel*.

The various conditions involve the use of engines and boilers of great flexibility and strength, and requiring the least manual effort; under these circumstances turbines and liquid fuel are essential. The difficulty is to have a good efficiency at ordinary cruising speeds. In order to overcome this, the cruising turbine, which utilises the expansion of the steam between the receiver pressure and the corresponding pressure at the exhaust into the high-pressure turbine, has been designed for the required speed. But the power developed by this cruising turbine being very small, it is not possible to make it work a propeller shaft by itself. It is, therefore, always placed on a shaft already driven by one of the main turbines. The result has been that the speed of rotation of this cruising turbine, which should be high in order to obtain a good efficiency, has been reduced by the speed of rotation of the main turbine, an obviously low speed, since it is proportional to that of the ship, and also because the cruising turbine does not come in except at moderate speeds of the ship. The efficiency, therefore, is always poor.

On the new French destroyers there are only two propelling-shafts, each shaft being driven by an independent turbine, as has been the practice since 1898, when the torpedo-boat No. 243 was used for experiments on the adoption of turbines for small ships. The results of these experiments were communicated by the author to this Institution in 1904.

The old cruising turbines, high-pressure and low-pressure, have been fitted in the same casing, end to end, thus obtaining all the advantage of great simplicity; but it is evident that the "cruising" part of these large turbines cannot give better results than the cruising turbines of engines arranged in separate groups. To avoid these inconveniences, and the use of toothed-wheel gears or electric motors, we have proposed the follow-arrangement, in which the high-pressure turbine maintains constantly at low-vessel speeds a relatively high velocity of rotation, and, in consequence, a higher efficiency.

Arrangement of Turbines.

The ship is propelled by three screws; each shaft is driven by a turbine; only the two-wing turbines being arranged for going astern (see Fig. 2, page 31). The centre turbine C is fitted with a steam inlet at the forward end G and with a by-pass H. The exhaust of the turbine C is connected with pipes I, I′ to the inlets L, L′ forward of the turbines A and B, and also by pipes K, K′ to some points N, N′ farther aft, in the parts of the distributers of these turbines; these have further an inlet of live steam forward through the pipes O, O′. All these pipes are fitted with valves.

When cruising at 15 knots, for example, the valves M, M′, P and P′ being shut, the turbine C receives steam through G and exhausts into the forward ends of the turbines A and B, which receive no other steam. If the speed has to be increased, we open the by-pass H; the connections of the turbine C with A and B remaining the same. For higher speeds, steam will be admitted through O or O′ into one of the turbines A or B, or both, if necessary; but, to avoid having compression at the exhaust of the turbine C, the exhaust is let out forward at N, N′ in the turbines A and B; when the valve M opens, it must at the same time close the valve J. In these conditions the live steam, after having worked in the first wheels of the turbines A and B, mixes with the steam exhausting from C, and the whole works in the last wheels.*

Thanks to this arrangement, the turbine C always works at great speed, but the power developed on the three shafts will not be equally distributed, as at low speeds the centre shaft develops relatively more power than at high speeds. If, for example, the power produced at a moderate speed on the shaft F is 44 per cent. of the whole, and on each wing-shaft D and E 28 per cent., the proportion at high speed may become 16 per cent. on F and 42 per cent. on each shaft D and E. The variations of slip of the propellers correspond to these variations of power.

At low speeds, nearly all the power being on the centre shaft, the slip of its propeller is great, say, from 25 to 30 per cent., while the slip of the wing-propellers is small. The conditions will remain similar so long as the live steam is admitted to the centre turbine only. When live steam is admitted into the wing-turbines the work produced by the centre turbine increases very little, the increase of power being almost entirely due to the wing-propellers. Their slip increases at the same time as that of the centre screw decreases, and the speed of rotation of the latter rises far less quickly than that of the wing screws. The best results have thus been obtained—namely, that at ordinary cruising speed a centre turbine does duty as a cruising turbine, having a very high speed of rotation. While cruising, it is not necessary to have both condensers working. The exhaust of the turbines A and B can be advantageously connected by means of the pipe T, which is of ample section to maintain an even pressure between the two condensers. In this way, during a long run at low speed, we can economise the motive power necessary to work one of the sets of pumps.

The arrangement which has just been described is not more complicated than that which consists in putting two independent turbines on two shafts only. It has the advantage of being lighter and of entailing less steam consumption at cruising speeds. At high speeds it has the same advantages as the well-known systems of equally distributed power on three shafts, in which the centre shaft is driven by a high-pressure turbine, and the wing shafts by low-pressure turbines, which do not receive any other steam than the exhaust of the high-pressure.

The manœuvring qualities of the ship are increased principally for harbour work, where a great advantage is gained by the action of the centre propeller on the rudder; in fact, it is only necessary to steam ahead with the centre propeller, while the others are manœuvring ahead or astern, and to join the exhaust of the turbine C with any point of the pipe T. This extension of manœuvring qualities is all the more important, as, with the increase in length of destroyers, it becomes more and more difficult for them to enter and moor in a harbour without the aid of tugs.

Necessity for Careful Design of Propellers.

In the above description we have purposely left out the question of propellers, which requires particular attention. It will not be inappropriate to conclude this paper by an account of the method of calculation for propellers in those two particular cases. We shall confine ourselves to describing the difficulties.

For the arrangement of turbines only it is not sufficient to make a design suitable for one speed only. If, for example, we are only requiring to have the best efficiency at high speed, where the three shafts have about the same number of revolutions, the same design for the three propellers may be adopted. At low speeds, on the other hand, the centre turbine develops a power relatively greater than the others, and its propeller revolves faster than the wing ones; in order, therefore, to obtain a suitable efficiency for cruising speed, the centre propeller, generally smaller than the others, must be very carefully designed.

In the case of the combination arrangement with reciprocating engines and turbines, the former develop at low speeds a power relatively high in comparison to those developed by the turbines; this difference decreases in proportion to the increase of speed, and almost disappears at the maximum speed. The slip of the propellers of the reciprocating engines decreases when that of the turbines increases. In designing propellers these peculiarities must be taken into account, and also the difficulty of associating for the same work propellers whose pitches are very different.

The curves in Fig. 3, page 31, show the data obtained during the official trials of the Voltigeur, and they indicate the importance of the variation of slip. The slip of the propeller of the reciprocating engine increases up to a speed of 20 knots; because up to this speed nearly all the power is supplied by this engine, and also because of the influence of the stern wave, which on the measured mile where the trials were made became defined in the neighbourhood of 24 knots.

Above 20 knots, the turbines come into operation, and the slip of the propeller of the reciprocating engine decreases until it reaches a very small value at the maximum speed. Just the contrary happens with the slip of the wing propellers, which is zero at the start, and increases rapidly until it reaches 26 per cent. and 28 per cent. Notwithstanding this relatively high value for the slip of the wing propellers at the maximum speed, the efficiency of the machinery remains good, as is shown by the excellent results obtained at the trials. The Voltigeur has really obtained a speed of 31.4 knots instead of 28 knots required by the contract specification.

* This is exactly what happens in the Rateau land-turbines, compound type, a great number of which are working in factories.

Let us also point out the remarkable difference in the increase of slip of the wing propellers, although they are similar and symmetrical. This difference certainly arises in great part from the fact that the powers developed by the two wing turbines are not equal; also because, owing to the presence of the centre screw, the stream-lines of the water as it reaches the wing-propellers are not symmetrical.

THE MARINE STEAM-TURBINE FROM 1894 TO 1910.*

By the Hon. Sir Charles A. Parsons, K.C.B., D.Sc., LL.D., F.R.S., Vice-President.

The application of the steam-turbine to the propulsion of vessels was entertained as early as 1884, but its development was not seriously considered till 1892, when the economy of the condensing turbine as applied to driving dynamos had excelled that of the compound reciprocating engine for the same purpose.

A pioneer association, called the Marine Steam-Turbine Company, Limited, was formed in 1894, whose object was the investigation of the subject. The prospectus opened with the following paragraph:—

"The object of the company is to provide the necessary capital for efficiently and thoroughly testing the application of Mr. Parsons's well-known steam-turbine to the propulsion of vessels. If successful, it is believed that the new system will revolutionise the present method of utilising steam as a motive power, and also that it will enable much higher rates of speed to be attained than has hitherto been possible with the fastest vessels."

From the first it was obvious that the turbine was suitable to fast rather than to slow vessels, and, consequently, it was decided to commence by building an experimental vessel of the smallest size consistent with the possibility of attaining exceptional speed. This vessel, the Turbinia, 100 ft. in length, 9 ft. beam, 6 ft. in depth, and 42 tons displacement, after many alterations to her machinery, developed 2400 horse-power on trials, and attained a maximum speed of 34½ knots. The machinery and trials of the little vessel were fully dealt with in the report of Professor J. A. Ewing, F.R.S., to be found in the Appendix to the paper read before the members of the Institution in June of 1903.† The trials of the Turbinia threw some additional light on the phenomenon of cavitation previously observed by Sir John Thornycroft and Mr. Sydney Barnaby, and demonstrated the necessity for very wide blades, and a sufficiency of total area in the propellers of such vessels. It was also shown that propellers of relatively small diameter and high revolutions could be designed to approach very closely in efficiency to propellers of large diameter and normal revolutions. Further, the reconstruction of the turbines showed clearly the gain in weight and efficiency by subdividing the power over turbines in series on the steam on different shafts. The net results of these trials proved that turbine propelling machinery was more economical than reciprocating machinery for high-speed vessels.

At this stage the pioneer association was transferred to a new company, the Parsons Marine Steam-Turbine Company, Limited, for dealing with the system on commercial lines. The first order was in 1899 for a destroyer, the Viper, from the British Admiralty, Sir William White being then Director of Naval Construction. The principal dimensions were the same as the 30-knot type of that period, but the speeds guaranteed were 31 knots ahead and half full-speed revolutions astern. Her maximum speed during a one hour's special trial, but with approximately full weights on board, was 36.5 knots, and under contract conditions of coal consumption was 33.38 knots. The economy in coal consumption at high speeds was good and she fulfilled in every respect the contract conditions, but the results of cruising speeds showed the desirability of modifications in the turbines in future designs to improve the economy at cruising speeds, and in all subsequent war vessels cruising turbines or cruising elements have been added at the high-pressure end of the turbine installation. In some very recent vessels impulse elements, in others geared high-pressure turbines, are being employed for the same purpose. At about the same time as the Viper was ordered, Messrs. Sir W. G. Armstrong, Whitworth, and Co., Limited, placed an order for the machinery of another destroyer, the Cobra. The machinery of the Cobra was a duplicate of that fitted in the Viper. The Cobra on a three hours continuous run maintained the mean speed of 34.6 knots.

It was very early realised that the suitability of the turbine for steam of very low pressure, which had been proved by the high percentage of power realised in the low-pressure portion of land turbines, would find an important application in ships by working the turbine from the exhaust of reciprocating engines, but not until 1901 was the first combination vessel, the Velox, a 30-knot destroyer, laid down as a speculation by the Parsons Marine Steam-Turbine Company, Limited. Her main propelling machinery was nearly a duplicate of the Viper's, but in order to increase the economy at speeds below 13 knots, two triple-expansion engines of 150 horse-power each were coupled to the low-pressure turbine shafts through flexible and detachable clutch-couplings. At low speeds the reciprocators exhausted into the high-pressure turbines; at speeds above 13 knots the engines were uncoupled. The vessel was acquired by the Admiralty in 1903. The same year H.M.S. Eden, of practically the same dimensions as the Velox, was launched, and cruising

* Paper read at the Jubilee meetings of the Institution of Naval Architects, July 5, 1911.

† "The Steam-Turbine and its Application to the Propulsion of Vessels," by the Hon. C. A. Parsons. Read before the Institution of Naval Architects, June, 1903.

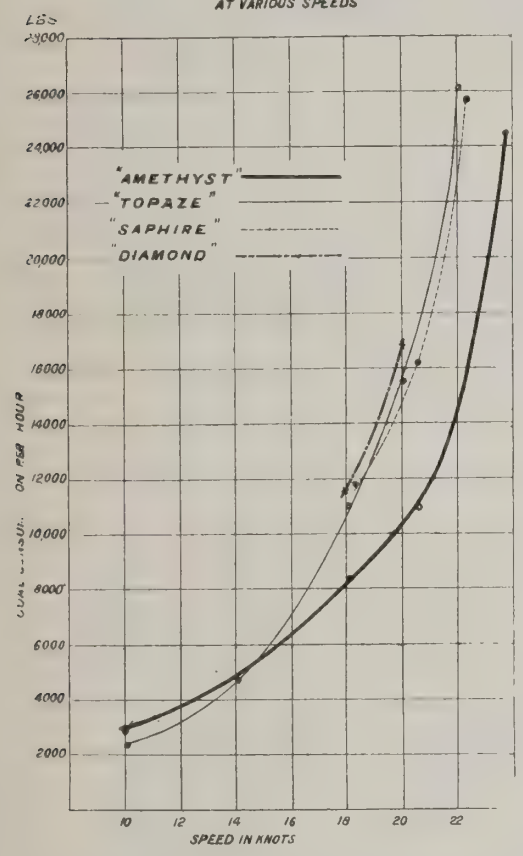
turbines in series were fitted in her instead of reciprocating engines.

The Admiralty carried out a series of comparative trials at cruising speeds with the Eden and Velox, and a sister vessel with reciprocating engines, of which the table below is a summary.

Water Consumption per Hour at various Cruising Speeds.

	Lbs. per hour.
At 11 knots—Velox, using piston engines exhausting into ordinary turbines	8,650
Eden, using cruising turbines exhausting into ordinary turbines	16,146
Piston-engined destroyer ...	14,892
At 13 knots—Velox, using high-speed turbines only	24,375
Eden, using cruising turbines exhausting into ordinary turbines	21,230
Piston-engined destroyer ...	18,140
At 15 knots—Velox, using high-speed turbines only	32,750
Eden, using low-pressure cruising turbines exhausting into ordinary turbines	28,000
Piston-engined destroyer ...	28,750
At 18 knots—Eden, using low-pressure cruising turbine exhausting into high-speed turbines	41,050
Piston-engined destroyer ...	45,645

FIG. 1. COAL CONSUMPTION PER HOUR AT VARIOUS SPEEDS



In 1902 the Admiralty placed the order for the third-class cruiser Amethyst with turbines, and for three sister vessels with reciprocating-engines of 10,000 horse-power. The turbine installation of the Amethyst was of the usual three-shaft arrangement, the high-pressure turbine driving the centre propeller, and the two low-pressure turbines in parallel on the steam driving the wing propellers, a high-pressure cruising turbine and an intermediate-pressure cruising turbine being also directly coupled through flexible claw couplings to the low-pressure turbine shafts; these latter were in series on the steam with the main high-pressure turbine. The trials of these vessels* conclusively proved the superiority of the turbine in water consumption (Fig. 1). At speeds of 15 knots, the water consumption of the turbine vessel was equal to that of the reciprocating vessels, and at higher speeds the superiority of the turbine was considerable, while at the designed speeds of 21¾ knots it reached 30 per cent., and at the maximum coal consumption allowed by the specification, the power developed, as estimated from the curve of resistance of the vessel, by the turbine vessel exceeded the power developed by the reciprocating vessel by 42 per cent. The maximum speed attained by the Amethyst was 23.6 knots as against 22.3 knots for her sister ships. The increased efficiency derived from the cruising turbines was very marked at low speeds, at some speeds 20 per cent. of the total power being developed by them.

Subsequent to the official trials arrangements were made for utilising the auxiliary exhaust in the turbines, when a further increase in economy was obtained.

The comparative trials of these vessels had a great influence upon the future of the turbine.

* See ENGINEERING, November 18, 1904.

As a general rule, the larger and faster the vessel, the more easy it had been to arrive at a satisfactory and profitable all-turbine solution as regards efficiency and first cost. Below the sea speed of 16 knots, the solution is not altogether favourable, and very few such vessels have been fitted. A slight lowering of the boundary of suitable speed exists in very large vessels, and also may be effected by the employment of the impulse principle at the high-pressure end, as more fully explained later.

This most important question of applying the turbine to lower-speed vessels has from the commencement received consideration, and one satisfactory solution appeared to lie in the combination system to which we shall further allude later. Another solution with a somewhat different scope has more recently been investigated; it is the use of double helical gearing of the De Laval class on a large scale for gearing the high-pressure portion only, or in some cases the whole of the turbines on to the screw shafting. Both of these solutions have given satisfactory results, but the reduction gearing appears to be the more important as applicable to vessels of all speeds. Both systems are described more fully later.

The first turbine battleship Dreadnought was laid down at Portsmouth in October, 1905. The primary contract for the whole of the machinery was placed with Vickers Sons and Maxim, Limited, the Parsons Marine Steam Turbine Company, Limited, being sub-contractors for the turbines. She has four shafts, two high-pressure and two low-pressure turbines, and two cruising turbines are coupled to the low-pressure turbine shafts. The astern turbines consist of a high-pressure astern portion in a separate casing on the high-pressure ahead shaft, in series with a low-pressure astern portion incorporated in the main low-pressure-turbine casing. The cruising turbines are in parallel, and not in series, on the steam as in the Amethyst; the high-pressure, low-pressure, cruising, and astern turbines comprise one propelling unit on each side of the vessel.

We may quote a summary of the advantages of the system, the reasons given by the First Lord of the British Admiralty for the adoption of the Parsons turbine in the Dreadnought and succeeding ships as determined by a committee on naval design:—"The question of the best type of propelling machinery to be fitted was most thoroughly considered. While recognising that the steam-turbine system of propulsion has, at present, some disadvantages, yet it was determined to adopt it because of the saving in weight and reduction in number of working parts, and reduced liability to breakdown, its smooth working, ease of manipulation, saving in coal consumption at high powers, and hence boiler-room space, and saving in engine-room complement; and also because of the increased protection provided for with this system, due to engines being lower in the ship—advantages which more than counterbalance the disadvantages. There was no difficulty in arriving at a decision to adopt turbine propulsion from the point of view of sea-going speed only. The point that chiefly occupied the committee was the question of providing sufficient stopping and turning power for purposes of quick and easy manœuvring. Trials were carried out between the sister vessels Eden and Waveney, and the Amethyst and Sapphire, one of each class fitted with reciprocating and the other with turbine

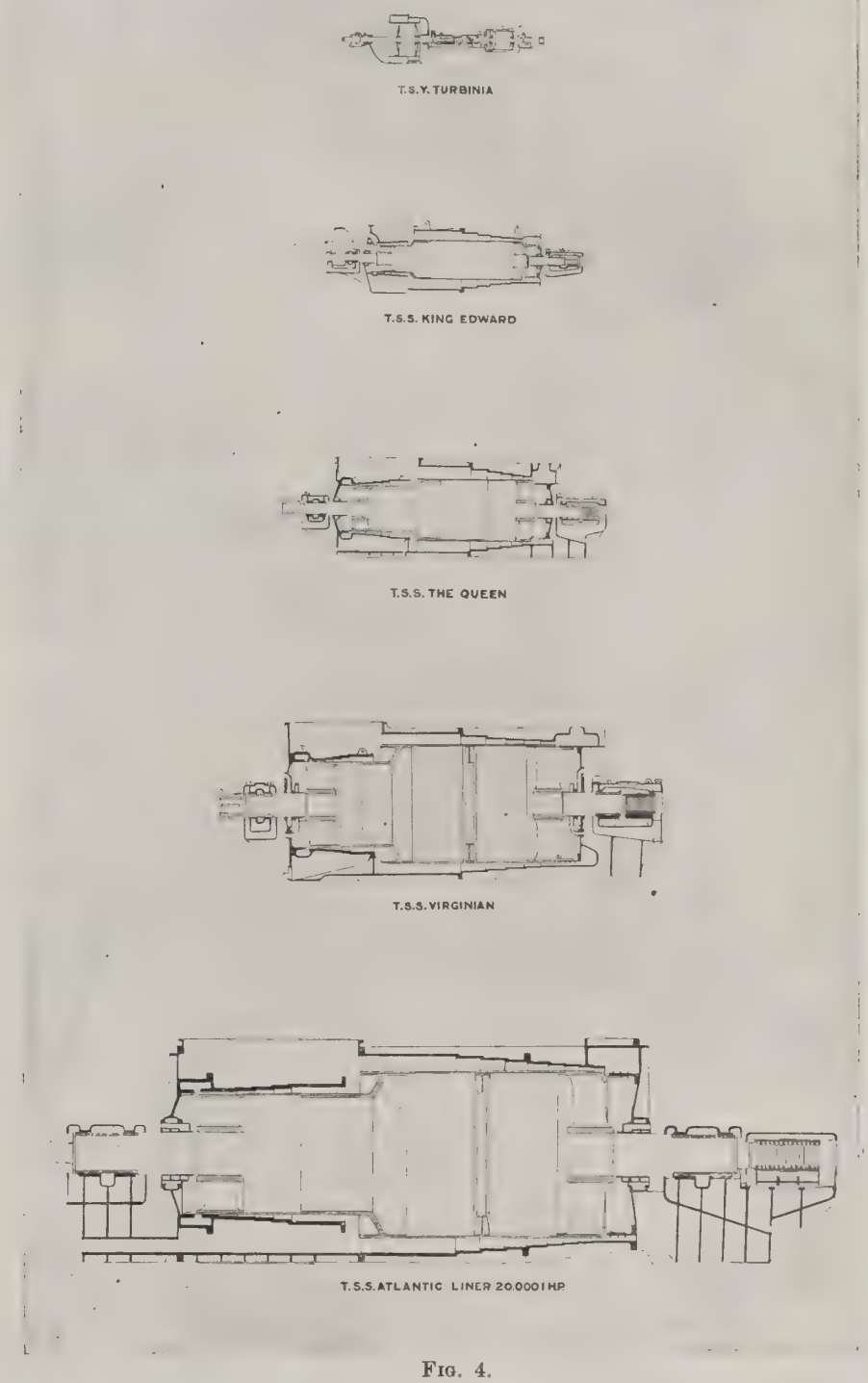


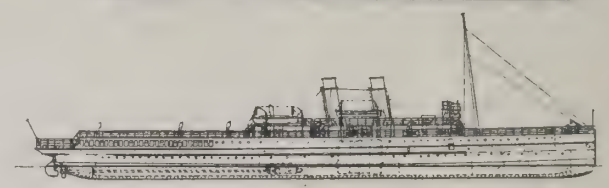
FIG. 4.

THE MARINE STEAM-TURBINE FROM 1894 TO 1910.

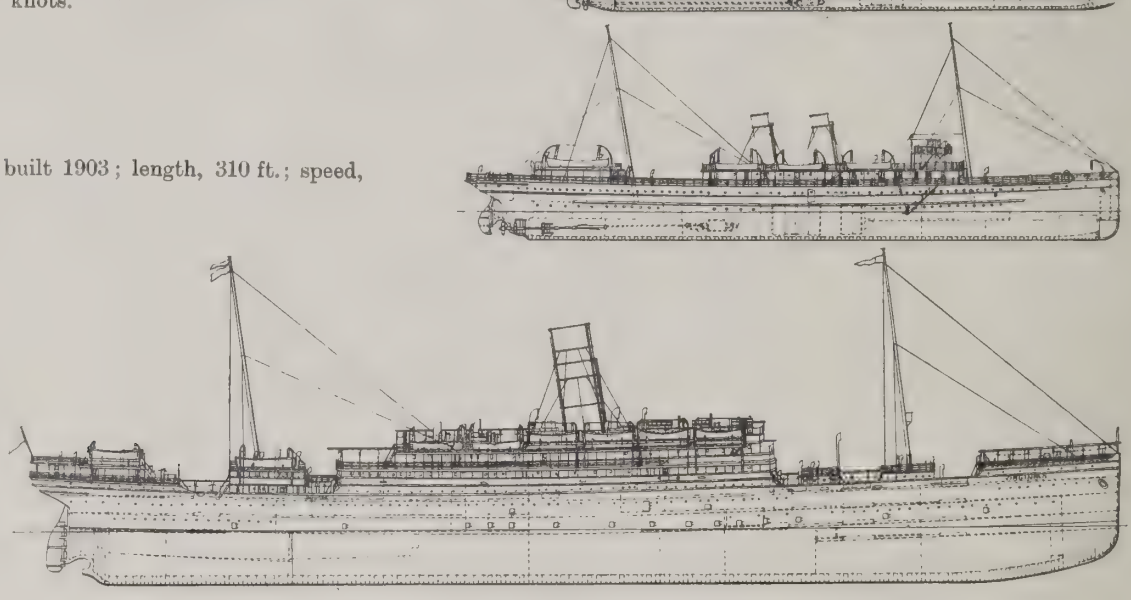
"Turbinia:" built 1894; length, 100 ft.; displacement, 44½ tons; horse-power, 2300; speed, 32¾ knots.

"King Edward:" built 1901; length, 250 ft.; displacement, 650 tons; shaft horse-power (estimated), 3500; speed, 20.48 knots.

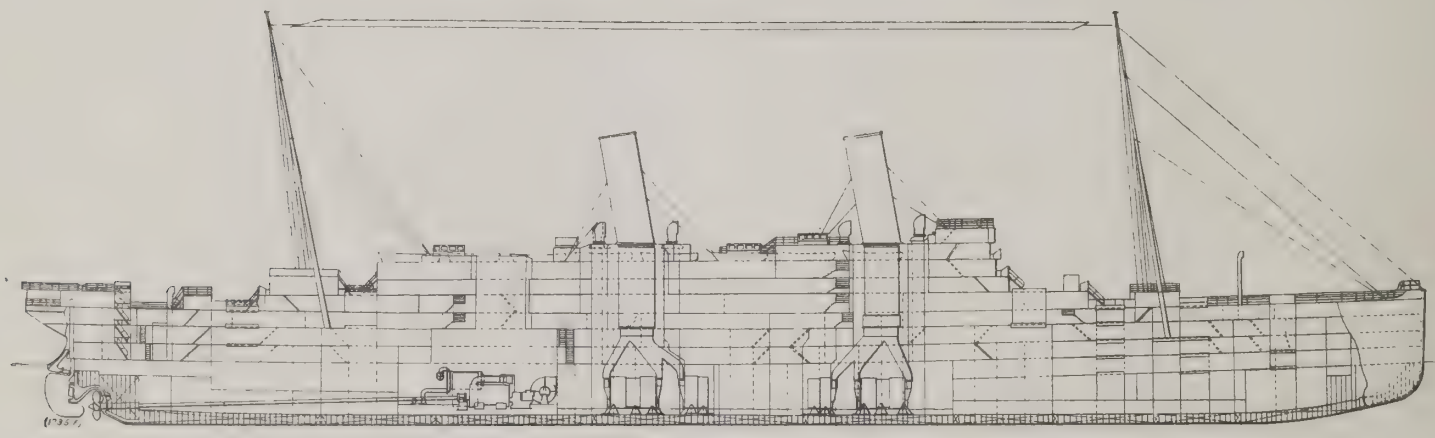
"Queen Alexandra:" built 1902; length, 270 ft.; displacement, 750 tons; shaft horse-power (estimated), 4000; speed, 21.625 knots.



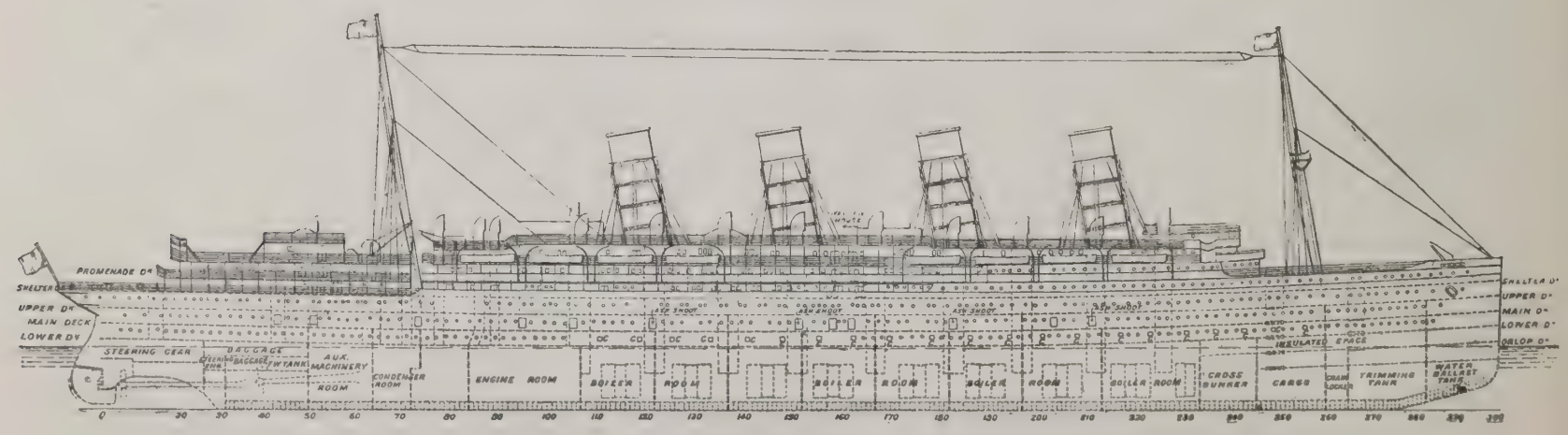
"The Queen:" built 1903; length, 310 ft.; speed, 21.76 knots.



"Virginian," built 1905; length, 530 ft.; displacement, 13,000 tons; estimated shaft horse-power, 12,000; speed, 19.1 knots.



"Carmania:" built 1905; length, 675 ft.; displacement, 30,000 tons; shaft horse-power, 21,000; speed, 20½ knots.



"Mauretania" and "Lusitania:" built 1907; length, 785 ft.; displacement, 40,000 tons; shaft horse-power, 74,000; speed, 26 knots.

FIG. 5. DIAGRAM SHOWING GROWTH IN SIZE OF TURBINE-PROPELLED MERCHANT SHIPS.

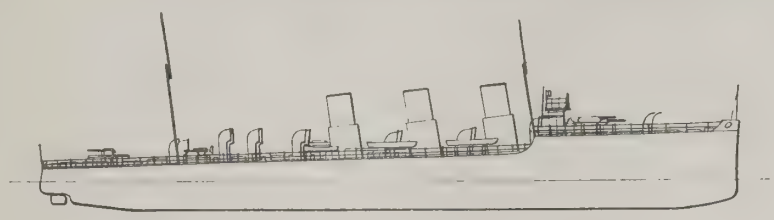
THE MARINE STEAM-TURBINE.

"Turbinia:" built 1894; length, 100 ft.; displacement, 44½ tons; horse-power, 2300; speed, 32¾ knots.

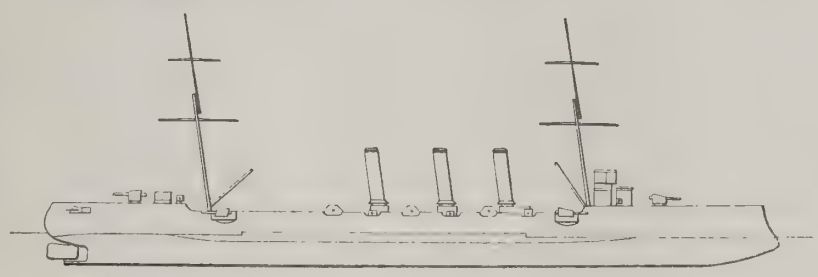
H.M. torpedo-boat destroyer "Velox:" built 1902; length, 210 ft.; displacement, 420 tons; shaft horse-power, 8000; speed, 27.12 knots.

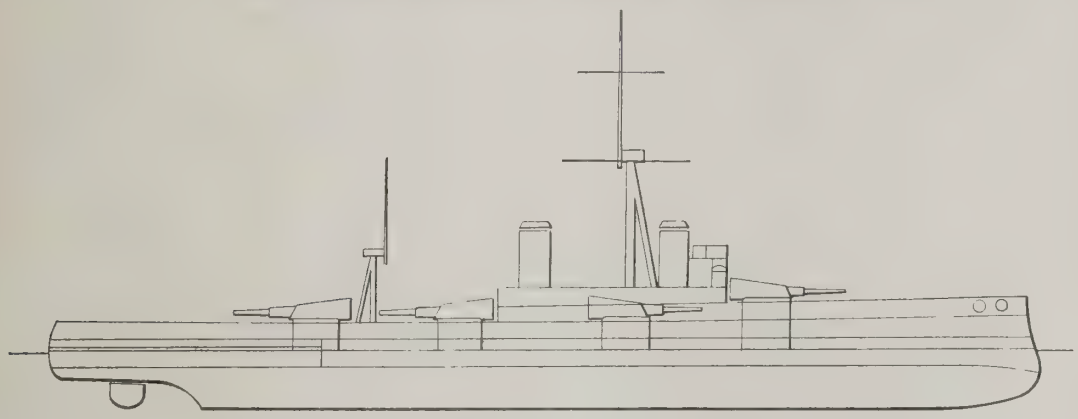
H.M. torpedo-boat destroyer "Eden:" built 1903; length, 220 ft.; displacement, 540 tons; shaft horse-power, 7000; speed, 26.22 knots.

H.M. torpedo-boat destroyer "Swift:" built 1908; length, 345 ft.; displacement, 2170 tons; shaft horse-power, 35,000; speed, 35.3 knots.

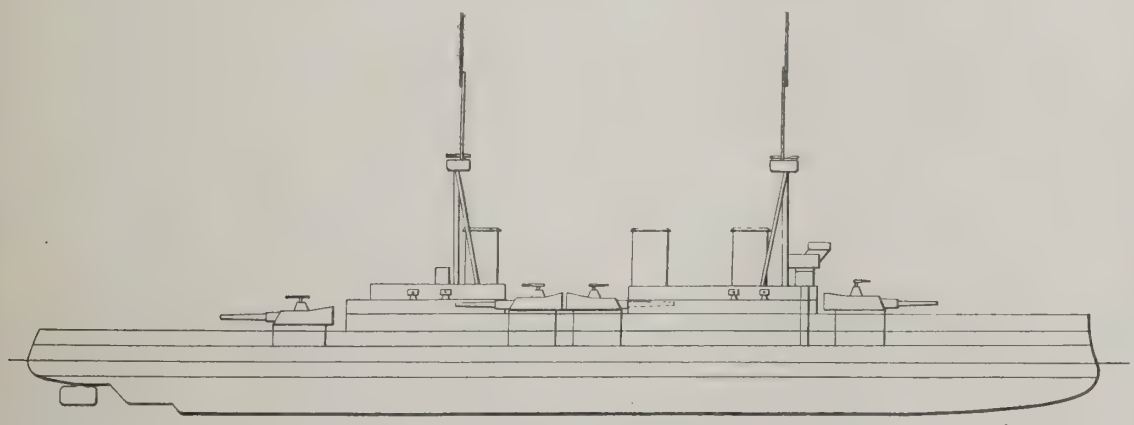


H.M. 3rd-class cruiser "Amethyst:" built 1905; length, 360 ft.; displacement, 3000 tons; shaft horse-power (estimated), 14,200; speed, 23.63 knots.





H.M. Battleship "Dreadnought:" built 1906; length, 490 ft.; displacement, 17,900 tons; shaft horse-power, 24,712; speed, 21.25 knots.



H.M. Armoured Cruiser "Invincible:" built 1908; length, 530 ft.; displacement, 17,250 tons; shaft horse-power, 42,000; speed, 26 knots.

FIG. 6. DIAGRAM SHOWING GROWTH IN SIZE BETWEEN 1894 AND 1908 OF TURBINE-PROPELLED WARSHIPS.

engines; experiments were also carried out at the Admiralty experimental works at Haslar, and it was considered that all requirements promise to be fully met by the adoption of suitable turbine machinery, and that the manœuvring capabilities of the ship when in company of a fleet, or when working in narrow waters, will be quite satisfactory.

Sir Henry Oram, the Engineer-in-Chief of the Fleet, in his address as President of the Junior Institution of Engineers,* stated that at full power the steam consumption of the Dreadnought was 13.48 lb. per shaft horse-power per hour, while in the succeeding battleships of the class it averaged 13.01 lb., and in the three cruisers of the Invincible class 12.03 lb. With reciprocating engines nearly 16 lb. would be a fair average, and it thus follows that a great reduction in boiler weights was permissible.

* See ENGINEERING, vol. lxxxviii., page 703.

Again the high efficiency of the low-pressure turbine made it well worth while to pass the exhaust steam from the auxiliary engines to this turbine instead of to the condenser. Indeed, the exhaust steam in some battleships has been proved to be alone sufficient to drive the vessel at a speed of 5 to 6 knots.

The coal consumption at full power of the three 26-knot armoured cruisers of the Invincible class ranged from 1.2 lb. to 1.7 lb. per shaft horse-power per hour, the average for the three ships being 1.47 lb. per shaft horse-power. In the three cruisers of the Minotaur class, with piston engines, it was 1.8 lb., and in the six cruisers of the Duke of Edinburgh or Warrior class 2.1 lb. per indicated horse-power per hour. On the thirty hours' endurance trial at 70 per cent. of the total power, the turbines also proved more efficient, although the advantage was not so marked. At one-fifth power the coal consumption of the three Invincible cruisers averaged 2.4 lb. per shaft horse-power per hour, as compared with 1.87 lb. per indicated horse-power per hour in the Minotaurs and 2.05 lb. in the Duke of Edinburgh cruisers.

In the mercantile marine the first vessel to be fitted with turbines was the Clyde passenger steamer, King Edward, built to the joint ownership of Captain John Williamson, Messrs. Denny, of Dumbarton, and of the Parsons Marine Steam-Turbine Company, Limited. Her length is 250 ft., and, with 3500 horse-power, she attained a speed of 20.48 knots. Her success led to the construction of a second vessel for the Clyde passenger traffic in 1903, and in the same year the Queen was built for the Dover and Calais route. All these vessels have three shafts, the high-pressure turbine in the centre exhausting into two low-pressure turbines on the wing shafts. Thus, by 1904, two of the most suitable fields for the marine turbine had been entered, namely, for vessels of war and cross-channel and passenger service, and, by 1905, the turbine was being adopted for nearly all new cross-channel steamers of high speed built in this country, and about a year later by the British Admiralty for all new construction.

The application to large liners remained as yet untouched. The first vessels to be fitted with turbines for Transatlantic service were ordered by the Allan line, viz., the Victorian and Virginian. This marked a notable step in advance in the application of the new system to ocean-going ships of high speed. At this juncture the late Lord Inverclyde appointed a commission of experts to investigate the suitability of the turbine for two express Cunarders for the New York route. After most careful consideration of all data then available, and in view of much additional experimental research conducted by the committee, as well as tests on large land turbines, and on existing turbine vessels, the committee unanimously recommended turbines in preference to reciprocating engines for the Mauretania and Lusitania of 70,000 horse-power and 24½ knots sea speed. The performance of these vessels has justified the decision; a mean speed of 26 knots has been maintained in favourable weather across the Atlantic, and an average speed of 25½ knots has been maintained on many successive voyages. This step completed the entry of the turbine into all classes of fast vessels for which it was at the time deemed suitable, and its adoption for fast vessels has since been almost universal.

In 1904 the general policy of granting licences on easy terms was decided upon by the Parsons Marine Steam-Turbine Company, and by the end of 1905 a large number of shipbuilding and engineering firms had acquired marine licences, the number having considerably increased up to the end of 1910. It is now clear that the broad policy then adopted has been conducive to the exceptionally rapid adoption of the turbine. Turbines of the Parsons type are now being built in the principal engineering works of France, Germany, Austria, Italy, Russia, Spain, Belgium, Sweden, and Denmark, as well as in Japan and the United States of America. The curve of horse-power (Fig. 2, page 36) completed and on order each year up to the end of 1910 shows the development which has taken place since the introduction.

Since the construction of the turbines of the Turbinia in 1897, which were in series on the steam and on three shafts, there has been no very notable increase in economy in steam per shaft horse-power, excepting that due to size and consequent reduction of leakage and steam friction losses, the reason being that the turbines of the Turbinia were designed with as high a velocity ratio as has been found compatible with weight and space, and that her condensers were of ample size.

In marine turbine design the chief governing factors are weight and cost dependent on a limited surface speed of turbine, which is governed by the maximum speed of revolution allowed by the propeller, and from the commencement a judicious compromise has been arrived at between turbine and propeller. Such limitations will, however, be materially reduced, should geared turbines come into use, and higher coefficients of turbine efficiency would then become possible and compatible with moderate first cost and weight; the question of propeller efficiency would be more easily dealt with, and the gain in total propulsive efficiency thereby would be substantial.

TYPES OF TURBINE.

There are four principal types of turbine now in use for marine work:—

1. The compound class, introduced in 1894 in the

Turbinia, in which there are a very large number of turbines on drums in series, with small pressure-drops at each turbine and low steam velocities. Generally the guide-vanes are identical with the moving vanes, each taking half the pressure-drop, but occasionally the moving vanes are formed like cups or buckets, and then the whole pressure-drop is taken on the guides. This class comprises, say, 90 per cent. of all marine-turbines at the present time.

2. The multiple impulse compounded or Curtis type introduced in the Revolution and in the Creole in 1904 and the Salem in 1906. This system differs radically from the compound class, in that there are comparatively few stages, large pressure-drops take place at the guides or nozzles, and the high steam velocities generated are absorbed in a sinuous course between several rows of moving and fixed buckets.

3. A combination of the two types (1) and (2), in which the earlier part of the expansion is taken by the impulse type and the low-pressure part by the compound type. The impulse Parsons, with one impulse-wheel, the Brown-Curtis with several impulse-wheels, the A.E.G. turbines and others are instances of this type.

FIG. 2.

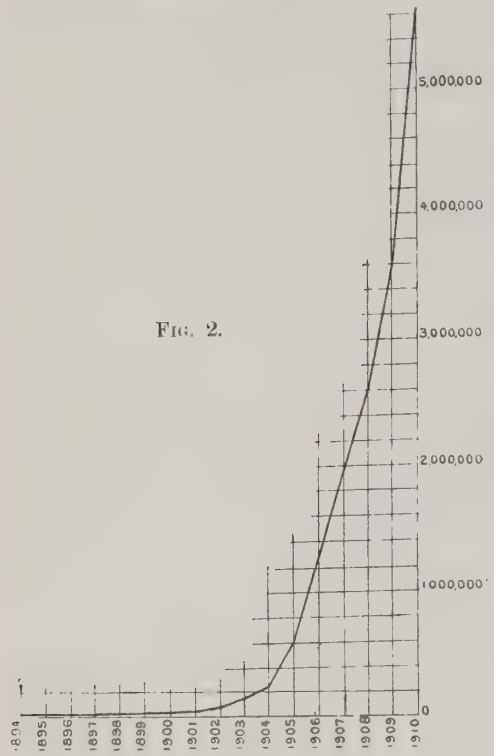


FIG. 2.—Diagram showing total horse-power of Parsons' steam-turbines applied to marine propulsion, completed and under construction each year from 1894 to December, 1910.

4. The multiple or compound De Laval wheel type, in which there are a large number of simple bucket wheels working in separate chambers. The pressure drops are moderate, and take place wholly in the guides, which form the passage-way from chamber to chamber. The Rateau, the Zoelly, the Bergman, and others are instances.

After type (1), type (3) has received the largest use in marine work, more especially in Germany. Each class or type has its advantages and disadvantages, but within the scope of the paper it is not possible to do more than make a few general remarks.

The compound class has low steam velocities, and there is no cutting action of the blades by the steam. Its efficiency, when the blades are of reasonable length, and leakage consequently small, is the highest, as the skin friction losses in the blades and of the moving drums and dummy pistons are small. On the other hand, when the design necessitates very short blades, as may occur at the high-pressure end, then the efficiency is reduced by leakage.

The multiple impulse type has a lower efficiency because of the skin friction losses of the steam circling through the blades at high velocity, and from the spilling of the steam from the buckets. On the other hand, it is less subject to leakage than the compound, and in the case of the first wheel of a series there is no leakage at all, and the only losses are skin friction and spilling. One impulse wheel, therefore, is a good substitute in certain cases for the initial stage of the compound, and in this design no diaphragms or shaft packings are required. The advantage of replacing several initial stages of the compound by several multiple impulse wheels in chambers separated by diaphragms and shaft packings, is somewhat questionable, and on it a difference of opinion exists.

Class (4) has small leakage losses, but involves relatively more skin friction loss from the large surface of the many discs revolving in the steam, which in the initial chambers is of high density.

THE COMBINATION SYSTEM.*

The Velox, in 1901, as has been stated, was the first combination vessel. The system was described and advocated by me in my Presidential Address of the Institute of Marine Engineers, in January, 1905. The Otaki, of 464 ft. length, 9900 tons dead-weight capacity, built and engined by Messrs. Denny, of Dumbarton, in 1908, for the New Zealand Shipping Company, was the second; the sister vessels, the Orari and Opawa, were fitted with triple-expansion engines. The diagram (Fig. 3), which is taken from a paper by Engineer-Commander W. McK. Wisnom, R.N., before the Institution of Engineers and Shipbuilders in Scotland, vol. liii., page 279, gives the comparative results.

About the same time the Laurentic and Megantic were laid down by Messrs. Harland and Wolff, for the Canadian service. They are 565 ft. in length, and about 20,000 tons displacement. The first was fitted with triple-expansion engines driving the side screws, and a low-pressure turbine driving the centre screw. The latter vessel was fitted with the usual quadruple expansion engines and twin screws. In service it is stated that the combination vessel consumes 12 to 14 per cent. less coal than the sister vessel.

In 1909 Messrs. Harland and Wolff commenced the Olympic and Titanic, of 882 ft. 9 in. in length, and about 60,000 tons displacement, the arrangement of combination machinery being similar to that of the Laurentic, with a collective horse-power of 30,000, the designed sea speed is 21 knots. The same firm is fitting the combination system in the Demosthenes, of 19,500 tons displacement, to steam 13 knots, being built for Messrs. George Thompson and Co., Limited, and also in a large ship for the Royal Mail Steam Packet Company's service to the South American republics.

The Orient Line ordered combination machinery for the Orama, laid down in 1910 for their Australian mail service. The vessel is 550 ft. long, and of about 18,000 tons displacement, and is being constructed and engined by Messrs. John Brown and Co., Limited, Clydebank. All these ships have triple-screws, each reciprocating engine driving a wing-shaft and propeller, while the turbine, taking the exhaust steam from both engines, works the centre screw. This arrangement has the advantage that, in manœuvring and for going astern, the piston engines only are used, and thus there is no need for an astern turbine. At St. Nazaire, in France, an intermediate liner, the Rochambeau, is being built, and she has four shafts, the reciprocating engines driving the inner shafts and the turbines the wing propellers.

REDUCTION GEARING BETWEEN THE TURBINE AND THE PROPELLER.*

Several forms of gearing have been proposed. Electrical gearing was fitted, I believe, by the Heilmann Company, in a small vessel about thirteen years ago, but little is known of the results. Continuous-current generators and motors were originally proposed, but of late years some form of alternating-current transmission has been preferred by the advocates of the system.

Within the last few months a 50-ft. vessel has been fitted by Mr. Henry Mavor, of Glasgow, with his form of alternating-current generator and motor, and a suction-gas engine directly coupled to the generator. A quick reversal or graduation of speed of the propellers can be effected without altering the speed of the engine by this method. The efficiency of the electrical transmission is said to reach 88 per cent. The same means of transmission is applicable to the steam turbine.

An hydraulic transmission-gear has been developed by Mr. Föttinger, and has been fitted in two small vessels. The efficiency of transmission is said to reach 86 per cent.

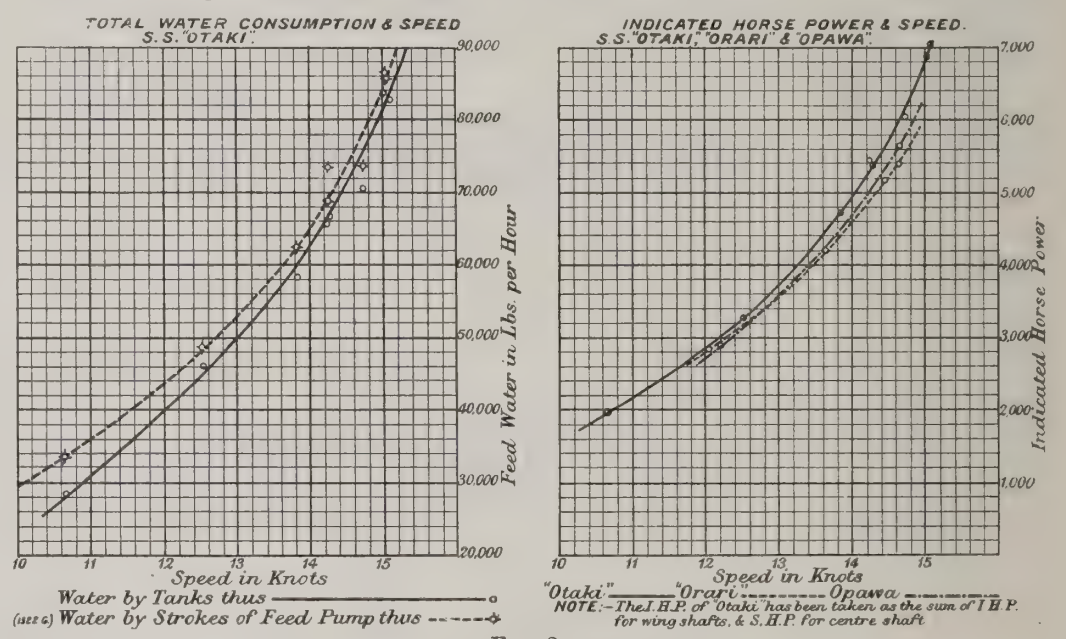


FIG. 3.

The first application of geared turbines was made by the Parsons Marine Steam-Turbine Company in a 22-ft. launch in 1897. Double helical reduction gear between the turbine and the propeller has so recently been the subject of papers before this Institution, that it is unnecessary to say more than that it promises to be an important factor in many marine turbine installations in the future. With an efficiency of over 98 per cent., and a remarkable absence of wear, it will add considerably to the efficiency of turbine installations even in fast vessels, and, what is of greater importance, it makes the turbine applicable to all classes of vessels. The London and South-Western Railway Company have recently decided to fit two new steamers of 5000 horse-power and 20 knots speed with geared turbines. They will have twin-screws, and a high-pressure and a low-pressure turbine will be geared on to each screw shaft, similarly to the arrangement in the Vespasian.

Although the manufacture of land turbines began to be general on the Continent in 1900, it was not till 1902 that the first turbine-propelled vessel was ordered by the French Admiralty, a torpedo boat, length 130 ft., 94 tons displacement, and 26½ knots speed. She had three shafts, and the turbines, which were built by the Parsons Marine Steam-Turbine Company, at Wallsend-on-Tyne, were in series similar to those of the Turbinia, but with one cruising turbine coupled to the low-pressure turbine which drives the centre shaft, and a reversing turbine in the low-pressure casing.

In 1906 a second vessel, the Chasseur, was ordered, a destroyer of 210 ft. length, 458 tons displacement, 9000 horse-power, and 30.4 knots speed. Her arrangement of turbines differed from that of British destroyers, inasmuch as only one cruising turbine was fitted, and the machinery was arranged in two compartments, one abaft the other. In 1906 it was decided that the six battleships of the Danton class should be fitted with reaction turbines. The Danton was the first to be completed. She was built and engined by the La Seyne Works, of the Forges et Chantier Company. She is 475 ft. length, 84 ft. 7 in. beam, and 18,374 tons displacement. The designed speed was 19.25 knots, with 22,500 shaft horse-power, but on her contract trial she maintained 20.66 knots in choppy seas, and during part of the run exceeded 21 knots. Similar results have been obtained in sister ships.

Two more battleships were laid down in 1910 of 542 ft. length, 23,467 tons displacement, and 20 knots designed speed with 28,000 shaft horse-power. Since 1908 the French Admiralty have ordered no vessels with reciprocating engines. In 1909 a change was made in destroyer practice, all the boats being fitted with twin-screws, and in some the combination impulse reaction turbines with an impulse-wheel followed by reaction blading.

The first marine turbines fitted in a merchant steamship built in France were made in 1908 at the works of Cie Electro-Mécanique for the Mediterranean steamer Charles Roux, of 9000 horse-power and 19 knots speed. The Transatlantic liner France, of 688 ft. length, 25,460 tons displacement, and 23 knots speed, with steam turbines of 40,000 shaft horse-power, is now approaching completion. The Newhaven for the Newhaven and Dieppe service has been completed, and has averaged 23.85 knots, mean of two cross-channel trips. There is also building in France the intermediate liner Rochambeau. In Germany the marine turbine was first introduced into the torpedo-boat destroyer S 125, ordered towards the end of 1902. This vessel was one of the class of six boats ordered that year, the remaining boats having the ordinary type of reciprocating engines. In the following year the cruiser Lübeck was ordered by the German Admiralty to be fitted with Parsons turbines. A series of comparative trials were made with this vessel and a sister vessel, the Hamburg, fitted with reciprocating engines. The results obtained on service of the destroyer S. 125 and the cruiser Lübeck, as compared with those of the sister vessels fitted with reciprocating engines, were conclusive in favour of the turbine boats. The destroyer S 125 wa

* "The Combination System of Reciprocating Engines and Steam-Turbines," by the Hon. C. A. Parsons and Mr. R. J. Walker, before the Institution of Naval Architects, April 9, 1908.

* Paper on "The Application of the Marine Steam-Turbine and Mechanical Gearing to Merchant Ships," by the Hon. C. A. Parsons, before the Institution of Naval Architects, March 18, 1910, and "Twelve Months' Experience with Geared Turbines in the Cargo Steamer Vespasian," by the Hon. C. A. Parsons and Mr. R. J. Walker, before the Institution of Naval Architects, April 5, 1911.

fitted with the ordinary three-shaft arrangement of turbines, and also cruising turbines.

The turbines of the cruiser Lübeck were arranged on four shafts, each of which in the first trial carried two screw propellers. The shafts on each side of the ship are driven by a high-pressure and a low-pressure turbine. Cruising turbines arranged in series were also fitted. An independent high-pressure reversing turbine was fitted to each shaft. This latter arrangement has not since been repeated; such reversing turbines are now always arranged and worked in series.

Following shortly on the completion of the S 125, the new destroyer G 137 was commenced. This vessel was the most powerful destroyer built up to that time in Germany, the turbine machinery arranged in two engine-rooms being nearly double the power of the S 125. Designed for a speed of 30 knots, she attained 33.08 knots on a three hours' run. All destroyers subsequent to the trials of G 137 have been fitted with turbines, and in some of the later vessels twin screws have been adopted. Meanwhile, following the Lübeck, the protected cruisers Stettin, Dresden, Augsburg, and Ersatz Condor, were equipped with turbine engines.

In 1907 the large armoured cruiser Von der Tann was ordered to be built by Messrs. Blohm and Voss, of Hamburg, and she has been followed by the Moltke, Goeben, and cruiser J. All these great cruisers are fitted with turbines of the Parsons type, with a four-shaft arrangement similar to that adopted in recent British armoured cruisers. On her contract trials the Von der Tann developed about 80,000 horse-power, and attained a maximum speed of 28 knots.

Reciprocating engines were fitted in German battleships until 1909, when two vessels were ordered with steam-turbines of the Parsons type. These vessels will be completed next year, and their trials will be of much interest, although their power and speed are inferior to those of the armoured cruisers. It is understood that later battleships of 1910 and 1911 programmes are also to be fitted with turbines. The Imperator, a new large liner building for the Hamburg-Amerika line by the Hamburg Yard of the Vulcan, has Parsons (series) turbines, and Blohm and Voss are contracting for a second similar vessel for the same owners.

The first vessel to be fitted with Parsons turbines in the United States was the passenger steamer Governor Cobb. This vessel, built by the W. and A. Fletcher Company in 1905, is 290 ft. long, 2900 tons displacement, and 20.5 knots speed. The arrangement of machinery is identical with that adopted in the King Edward. Following the Governor Cobb, the next vessels to be designed with turbines for passenger service were the Yale and Harvard, of 4600 tons displacement, 10,000 horse-power, and 22½ knots speed; the Old Colony, of 3800 tons displacement and 20 knots speed, and the Camden and Belfast, of 1820 tons displacement, with a speed of 19 and 18½ knots respectively. At about the same time as the Governor Cobb was ordered, the United States Government placed the contract for the three scout cruisers Birmingham, with twin-screw reciprocating engines; Salem, with Curtis turbines, and the Chester, with Parsons turbines. The turbines of the Salem were arranged on two shafts, and in the Chester on four shafts in two engine-rooms, one abaft the other.

Up to the time when the scout cruisers were ordered the Curtis type of turbine had been fitted only to a small vessel named the Revolution, and to the mercantile steamship Creole. It is understood that the turbines have since been removed from both these vessels. The Salem was therefore regarded as an experimental vessel, so far as the Curtis turbines were concerned, whereas the Chester with Parsons turbines represented one of a series of cruisers of which the Amethyst was the pioneer.

Cruising turbines in series were fitted in the Chester, one on each of the low-pressure turbine shafts. Astern turbines were only fitted on two of the four shafts, being incorporated in the exhaust casings of the low-pressure turbines. The comparative trials of these three vessels have from time to time been reviewed in leading technical journals. The contract speed was 24 knots, and on the full-power trial the Birmingham attained 24.325 knots, the Salem 25.947 knots, and the Chester 26.52 knots.

In 1907, before the competitive trials of the scout cruisers were completed, the battleship North Dakota was ordered by the Navy Department from the Fore River Company, and it was decided to fit her with Curtis turbines of about 25,000 horse-power, her sister ship the Delaware being fitted with reciprocating engines. These two vessels were completed last year, and have been subjected to competitive trials both under contract conditions and on sea service.

Early in 1909, on the conclusion of the tests of the scout cruisers, the Navy Department decided to adopt the Parsons type of turbines for the new battleships now building—viz.: Utah, Florida, of the 1908 programme, of 21,800 tons displacement and 28,000 horse-power, and later on the Wyoming and Arkansas of 26,000 tons displacement and 30,000 horse-power. The trials of the Utah will take place shortly, and the future policy of the Navy Department in regard to battleships will doubtless be decided in view of the results obtained. Meantime, it has been decided to fit reciprocating engines in one battleship now building. Since 1907 all contracts for new destroyers awarded by the United States Navy Department have specified turbine engines.

In Japan four merchant vessels were fitted with Parsons turbines in 1908. Two of these, the Tenyo Maru and Chiyo Maru, were built at the Mitsu Bishi Dockyard at Nagasaki, the turbines for which were constructed by the Parsons Marine Steam-Turbine Company, Limited. Two others, the Hirafu Maru and the Tamura Maru were built and engined by Messrs. Denny, of Dumbarton.

The volunteer steamers Sakura Maru and Umegaka Maru were built and engined with Parsons turbines in 1908-1909 by the Mitsu Bishi Company. The Mogami, a despatch vessel for the Imperial Japanese Navy, was completed in the summer of 1908. There are also at present under construction for the Imperial Japanese Navy two cruisers and two high-speed destroyers with turbines of that type.

For larger warships the Japanese Admiralty have adopted Curtis turbines in the Ibuki armoured cruiser and Aki battleship, both of which were launched in 1907. Both these vessels have been tried and the results published. Subsequently it has been decided to adopt the Parsons type in the large armoured cruiser now building for the Japanese Navy by Messrs. Vickers, and in three sister ships to be built in Japan. The Japanese Admiralty has also taken a licence for the manufacture of the Parsons steam-turbines in the national dockyards.

In Italy the cruiser San Marco is the first turbine ship for the Royal Italian Navy. On her trials she attained a speed of 23.7 knots, being nearly two knots in excess of the speed attained by a sister vessel, the San Georgio, fitted with reciprocating machinery. The Città di Catania and the Città di Palermo, two passenger vessels of 3500 tons displacement and 23 knots speed, were recently put on service for the Italian State Railway Company. At the present time there are under construction in Italy for the Royal Italian Navy, Parsons turbines for four battleships, and several other vessels.

Parsons Turbines Completed and under Construction.

	War Vessels.		Mercantile Vessels.		Yachts.		Total.	
	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.
Great Britain and Colonies	156	2,480,300	62	631,000	6	17,000	224	3,128,300
United States	25	392,000	6	40,000	4	12,200	35	444,200
Germany	26	757,600	1	60,000	..	..	27	817,600
France	18	292,800	4	62,000	..	..	22	354,800
Japan	7	213,100	7	76,000	..	..	14	289,100
Italy	9	163,100	2	24,000	..	..	11	187,100
Brazil	3	38,400	..	..	..	..	3	38,400
Argentine	4	72,000	..	..	..	..	4	72,000
Peru	..	..	2	15,000	..	..	2	15,000
Chili	2	50,000	..	..	..	..	2	50,000
China	3	19,000	..	..	..	..	3	19,000
Portugal	1	11,000	..	..	..	..	1	11,000
Sweden	1	7,000	..	..	..	..	1	7,000
Denmark	2	8,000	..	..	..	..	2	8,000
Spain	16	102,500	..	..	..	..	16	102,500
Russia	4	168,000	..	..	..	..	4	168,000
Austria	4	95,000	..	..	..	..	4	95,000
Belgium	..	..	3	34,000	..	..	3	34,000
Total	281	4,869,800	87	942,000	10	29,200	378	5,841,000

All the principal navies of the world are now following the lead of the British Admiralty. In Russia four large battleships of high power are under construction. In Austria the scout Admiral Spaun was ordered in 1907, and on her trials she attained a speed of 27.07 knots, with 25,000 shaft-horse-power. Three battleships and 12 torpedo-boats are now on order in Austria with Parsons turbines, some of which are now building. Sweden and Denmark have recently ordered their first turbines for warships:—a 7000 horse-power set for a 21-knot cruiser in the case of Sweden, and engines of 4000 horse-power for some twin-screw torpedo-boats in the case of Denmark. In Spain three battleships, three destroyers, and ten torpedo-boats, comprising the important recent naval programme of this navy, are to be fitted with turbine machinery. Portugal is having one destroyer built. Brazil has now two turbine scout cruisers, Bahia and Rio Grande do Sul, on service. These two vessels on trial averaged a speed of 27¼ knots. The Argentine Government are adopting turbines for their four new destroyers, now being built by Messrs. Cammell Laird and Co. China is having three small cruisers built. Belgium does not possess a war navy, but three turbine vessels have been built for the Government passenger line, the Princesse Elisabeth, of a speed of 24.03 knots in 1905, and the two vessels Jan Breydel and Pieter de Coninck, of speeds 24.3 knots. Peru possesses two passenger steamers, Huallaga and Ucayali, of 6000 tons displacement and 19 knots speed. The British Colonies of Canada, Australia, and New Zealand are having various classes of war vessels fitted with the turbine system.

Fig. 4, page 33, illustrates the progressive increase in the size of marine turbines.

Fig. 5, page 34, illustrates the progressive increase in the size of turbine-propelled merchant vessels.

Fig. 6, page 35, illustrates the progressive increase in the size of turbine-propelled war vessels.

Table on this page.—Parsons turbines completed and under construction May 31, 1911, in various countries.

List of Principal Papers Referring to the Marine Steam-Turbine.

"The Marine Steam-Turbine and Its Application to Fast Vessels," by the Hon. C. A. Parsons, C.B. Read before the Institution of Engineers and Shipbuilders in Scotland, February 19, 1901.

"The Steam-Turbine and Its Application to the Propulsion of Vessels," by the Hon. C. A. Parsons, C.B. Read before the Institution of Naval Architects, London, June 26, 1903. ENGINEERING, vol. lxxvi., pages 48 and 101.

"The Parsons Marine Steam-Turbine," by the Hon. C. A. Parsons, C.B. Read before the Association Internationale Permanente des Congrès de Navigation, Milan, 1905.

"Progress made in the Application of the Parsons Turbine to Marine Propulsion," by R. J. Walker. Read before the Liverpool Engineering Society, February, 7, 1906. ENGINEERING, vol. lxxxi., page 220.

"The Steam-Turbine on Land and at Sea," by the Hon. C. A. Parsons. Read before the Royal Institution of Great Britain, May 4, 1906.

"Development of the Marine Steam-Turbine," by the Hon. C. A. Parsons and R. J. Walker. Read before the Institute of Marine Engineers, September 29, 1906. ENGINEERING, vol. lxxxii., page 471.

"Marine Steam-Turbine Development," by the Hon. C. A. Parsons and R. J. Walker. Before the North-East Coast Institution of Engineers and Shipbuilders, March 15, 1907.

"Some Practical Points in the Application of the Marine Steam-Turbine," by the Hon. C. A. Parsons and H. Wheatley Ridsdale, Before the Institution of Naval Architects, June 25, 1907. ENGINEERING, vol. lxxxiv., page 61.

"The Combination System of Reciprocating Engines and Steam-Turbines," by the Hon. C. A. Parsons and Mr. R. J. Walker. Before the Institution of Naval Architects, April 9, 1908. ENGINEERING, vol. lxxxv., page 511.

"The Expansive Working of Steam Attainable in Steam-Turbines," by the Hon. C. A. Parsons. Before the Greenock Philosophical Society, January 15, 1909.

"Notes on the Trials and Performances of the S.S. Otaki, Fitted with a Combination of Reciprocating and Turbine Machinery," by Engineer-Commander W. McK. Wisnom, R.N. Before the Institution of Engineers and Shipbuilders in Scotland, August 4, 1909. ENGINEERING, vol. lxxxviii., page 179.

"Propelling Machinery for Warships," by Engineer-Vice-Admiral H. J. Oram, C.B. Before the Junior Institution of Engineers, November 16, 1909. ENGINEERING, vol. lxxxviii., page 703.

"The Application of the Marine Steam-Turbine and Mechanical Gearing to Merchant Ships," by the Hon. C. A. Parsons, C.B. Before the Institution of Naval Architects, March 18, 1910. ENGINEERING, vol. lxxxix., page 379.

"Twelve Months' Experience with Geared Turbines in the Cargo Steamer Vespasian," by the Hon. C. A. Parsons, C.B., and R. J. Walker. Before the Institution of Naval Architects, April 5, 1911. ENGINEERING, vol. xci., page 461.

In the "Evolution of the Parsons Steam-Turbine," by Alex. Richardson, will be found a full review of this subject. (Offices of ENGINEERING.)

FIFTY YEARS' ARCHITECTURAL EXPRESSION OF TACTICAL IDEAS.*

By Admiral Sir CYPRIAN BRIDGE, G.C.B.

NAVAL Architecture is the handmaid of Tactics. Warship design is meant to give expression to the tactical ideas and intentions of the epoch. If we examine the succession of types of men-of-war which have appeared during any particular period, we shall be in a position to discern what the tacticians of the time had in view. Regarding tactics, naval architecture, to use a phrase rather common not long ago, is "History from the Monuments." An investigation of the material remains found on the sites of very ancient cities has enabled scholars to give us a conception of early civilisation and culture, so investigation of the designs of the various ships constructed in the last half-century will furnish us with a clue to the state of tactical knowledge and aspiration during that period. The necessary limits of this paper will allow only our own Navy and its principal ships to be dealt with at all fully. Nevertheless, we shall find the field chosen large enough to contain the illustrations required.

It is just over fifty years since the Institution of Naval Architects was founded; and the date of its foundation nearly coincided with the beginning of a time of extraordinary innovation in naval construction for the purposes of war. In the year 1860 what may be called the seventeenth-century type of man-of-war was still represented in the British Navy. We had two sailing line-of-battle ships in sea-going commission as flag-ships on foreign stations, and several sailing frigates were employed in distant waters. This does not, however, give an exhaustive account of the persistence of the type to which those ships belonged. The steam line-of-battle ships, steam frigates, and steam corvettes—which we were producing in considerable numbers—still had several years of life before them, and resembled in design, appearance, and armament the older classes. The only difference was that, in addition to their sails the later craft had steam propulsion. The gun, as the weapon without a rival, conspicuously dominated tactics.

We have to compare this persistence of a generally uniform type of warship through more than two centuries with the many rapidly succeeding changes that have appeared in the last fifty years. The earlier persistence can in no way be attributed to want of intellectual capacity in the leading naval officers of the day, or to insufficient experience.

When this Institution arose, the tactical aspect of naval architecture was in essentials what it used to be in the days of Blake. Signs of impending change were indeed visible; but they were still too few to disturb seriously the general uniformity of warship design. There is a very remarkable fact to be observed in connection with that long maintained uniformity. This fact makes the contrast between it and the multitude of variations in the last fifty years truly startling. Before the end of the eighteenth century tactical ideas had undergone a great change; but the type of ship remained the same and there was no demand that it should be altered to suit the new tactics. The old method of trying to preserve a rigid line in a fleet action, and of bringing one ship against an individual opponent, had been superseded by the method which we associate with the names of Rodney, of Suffren, and especially of Nelson, viz., that of bringing a number of ships against a smaller number. This led to decisive, and, indeed, to overwhelming victories. It adds to the merit of the great tacticians named that they did their work effectually with the tools which they found in existence. When we consider the course of ship-designing during the half-century just ended, we shall find a very different state of affairs.

This will appear in an enumeration of the several types produced. In the old type, so long adhered to, the object was to mount a battery of many guns. For the line-of-battle the tendency was not to alter the type of

* Paper (slightly abbreviated) read at the Jubilee Meetings of the Institution of Naval Architects, July 5, 1911.

ship or the system of gun mounting, but to increase—within limits—the number of guns. Thus the 44 and the 50-gun ships fell out of the "line," and the 64-gun ship gave way more and more to the 74. In 1860 the object above mentioned was still kept in view. The Warrior, launched in that year, was intended to have a broadside of twenty guns. Her sister ship, the Black Prince, was to have the same. Indeed, except the turret-ship Prince Albert and the Bellerophon, every armoured ship launched between 1859 and 1868 had a broadside—allowing for "pivot" guns—of at least twelve guns.

In June, 1860, Captain Cowper Coles, at the United Service Institution, read a paper entitled "Shot-proof Gun-shields as Adapted to Iron-cased Ships." His proposed ship was really a turret-ship; and it is remarkable that she was to have nine turrets with two guns each, giving, on most bearings, a broadside of 18 guns. This shows that even with him the principle of the numerous battery prevailed.

With the ships that we began to launch in 1871 there came a notable change. From that year down to 1875 we launched fifteen ships, all with turrets and all with a considerably reduced number of guns, though some were of much larger calibre.

In this survey it is to be remembered that the British Navy only is considered at all fully; but the conditions which prevailed in it resembled closely those to be observed in other navies. We ourselves sometimes copied what was being done abroad; and more often we had imitators in foreign fleets. The French, if not the original proposers, were at any rate the first who dared to bring into practical use the armour-clad sea-going man-of-war. The Gloire, launched in 1859, the year before the foundation of the Institution of Naval Architects, may be regarded as the parent of modern armoured ships.

Similarly, the Americans first treated the turret-ship as a practical addition to a fighting fleet; and were enabled by circumstances to be the first to subject the type to the test of actual fighting.

The Austrians were the first of the moderns to make deliberate use of the ram-attack in battle, and by so doing widely extended the introduction of the ram-bow into the naval architecture of the contemporary world.

As regards the Gloire, it has to be said that her type did not indicate a new tactical idea or principle. Like the ships of Blake or of Nelson, she was to have a broadside of as many guns of reasonable power as she could carry when her other weights had been provided for. We have already noticed this feature of the Warrior's design. The number of guns soon began to diminish, and the weight of individual guns to be increased. If we omit the Northumberland, of the same type as the Minotaur, launched in 1863, no ship launched between the year just named and 1887—that is to say, during nearly a quarter of a century—had on a broadside a number of guns which ran into double figures.

Was this due to tactical or to other reasons? Did the ships so armed express a principle of tactics, or was their armament suggested by other considerations? It would seem that in fixing a ship's armament, at the time in question, the governing influence was that of the defensive armour. It was assumed that no gun would be effective if its projectiles could not perforate armour as thick as that carried by the ship herself. This included, or, at any rate, allowed for, a belief that the ship to be fired at would have a side wholly plated with such armour. Acceptance of this view rendered inevitable increase in power of individual guns and decrease in the number of guns on the broadside of any one ship. On this there ensued a vehement and still unended practice-ground contest between gun and armour.

The effects are to be seen in the types of ship produced in different periods. From 1860 to 1870, both years included, we had launched twenty-three armoured ships, of which—not including the converted Royal Sovereign—only three were turret-ships.

From the beginning of 1871 to the early part of 1875 we launched eight armoured ships, all with turrets. There was then a short time during which we launched broadside ships, one, the Téméraire, being of mixed type. In 1879 we reverted to the turret-type, and since that date practically every armoured ship which we have built has had turrets, or, what may be considered a variety of them, barbettes.

The time referred to did furnish some war experience. It included, besides less important conflicts, the American Secession War and the Austro-Italian War in the Adriatic. In the former of these wars armour-clad vessels were first used in belligerent operations on a considerable scale. The war was peculiar in its nature. It was a contest between two belligerents, one of whom had a large navy and the other had scarcely any navy at all. The naval operations consisted principally of engagements between ships and land fortifications. As regards naval tactics on their most important side, viz., the tactics of fleets fighting against fleets, the war furnished no guidance. Nevertheless, the turret-ship made her way into our Navy—at first, as we have seen, but slowly. The small number of vessels of the type which during ten years we added to our Fleet supplies evidence of the inconsiderable tactical importance then attached to the type.

The great change introduced in 1871, the virtual abolition of the broadside system of arming ships, occurred at a time when the contest between the gun and armour was in full progress. Naval attention was concentrated on the problems of making a ship invulnerable with armour, and of finding a gun that would neutralise the desired invulnerability. Tactical considerations receded into the background.

In a naval action in the Adriatic an impressive incident occurred. The Austrians sank an enemy's ship by attacking her with the ram. It was rapidly accepted that this indicated the possibility of devising a new, or reviving an ancient, method of tactics. It was hoped, indeed it seemed to have been believed by some, that this would do away with the superiority in defensive efficiency, which was being claimed for protecting armour. The immediate sequel, however, was that the armour became thicker and the guns individually heavier.

As the defensive armour thickened, so it shrank in surface; and a large proportion of an armour-clad ship was either not defended by armour at all or only by armour of moderate resisting power. The names "iron-clad" or "armour-clad" became obsolete, and were deliberately replaced by the less definite term "armoured." On this, tactics emerged from the obscurity of the previous few years. The French equipped their ships with a secondary armament of guns capable of dealing with the unarmoured or thinly armoured parts of an opponent's ship. Before long we followed suit, putting secondary guns into ships not originally intended to carry them, or deliberately designing ships meant to have a secondary armament.

The weapon—as has been said—dominates tactics; and, as the gun is the principal weapon of fleets, naval tactics have been based on what the gun can do. There are other weapons by no means without importance. Their importance, however, is limited, because they are effective only in special circumstances. The ram has been spoken of already. When conditions are favourable to its use it is a highly effective weapon. The difficulty is to bring about the desired conditions, and this difficulty is so great that the conditions must be rare. In 1871 we adopted as a weapon of war the Whitehead locomotive torpedo. Here, again, it is not the effect of the torpedo, but the possibility of planting it where its full effect will be felt, that is likely to be miscalculated.

It is a remarkable fact that the adoption of the locomotive torpedo and the limitation of a ship's gun-armament to a small number of the heaviest guns that she could carry occurred almost simultaneously. We did not ignore the importance of the torpedo; but we did not make any tactical provision for dealing with its attacks. We made only arrangements for passive defence, by a more minute internal subdivision of a ship's hull, and afterwards by providing obstructions, such as nets.* We did, however, produce special craft which were to use the new weapon, viz., torpedo boats; and we devised a system of tactics for them. This discloses a very interesting state of affairs. A new weapon had come into existence; tactical methods of employing it, involving the construction of a novel class of vessel, had been devised; and yet tactics were silent as to the means of counteracting its employment. Reliance was placed on passive defence arrangements exclusively. We may attribute this to a new conception of the functions of ships of war of the most important class. For more than two hundred years the military value of the warship had been calculated upon what she was capable of doing to an enemy. This was now changed, and her military value was assumed to be based upon what she could endure at the hands of an opponent. She was formally likened to a fortress. A very distinguished authority, writing in 1859, called the ships in our principal fleets "our floating Channel and Mediterranean fortresses." We must believe that this was the consequence of devoting great attention and great talents to the work of trying to render an enemy's attack innocuous by providing a ship with the passive defence of impervious armour. The alternative and older method of frustrating an enemy's attack by bringing against him a superior fire seems at this time to have been given up as hopeless. The probability is that it was regarded—insensibly, perhaps—as hopeless because of the greatly reduced number of shots that could be fired in a given time from the small number of guns that were mounted in a ship. The position, as to defence against the old weapon, the gun, and the new weapon, the torpedo, was that tactics had nothing to say.

The silence of tactics may be ascribed to the then accepted belief that warship design and armament should be based on the intention of destroying an enemy's ship by a single blow. The destructive blow was to be delivered either by the ram at close quarters, or by the torpedo at a moderate distance, or by the heavy gun at longer ranges. No one stopped to inquire into the feasibility of this, or into the relative efficiency of the three weapons. Passive defence, by armour or other material expedient, was deemed both necessary and sufficient.

It is surely worth our while to ascertain why this should have been so. If we examine the then predominant notions in our general policy of defence, we shall find that they favoured the defensive, and largely the passively defensive. It was accepted, perhaps generally, but certainly by the governing authorities, that the British Isles, and especially the great naval ports in them, were likely to be attacked in force by powerful enemy. The old plan, which, under such leaders as Hawke, St. Vincent, and Nelson, had proved so effective—viz., the preventing of the enemy from getting near enough to deliver his attack—seems to have been forgotten. It was taken for granted that we could not stop our enemy from coming to any point at which he wished to arrive; and that all that we could do was to get behind our fortifications and under their shelter fight him as well as we could. That this would mean abandoning the sea to an opponent, with all the prodigious consequences of such procedure seems not to have been understood.

The waters in which our fleets were wont to anchor were studded with armour-clad forts. It was to these works of defence that the eminent authority above quoted had likened our more important ships. Standing on the defensive was, as it were, in the air; and the prevailing sentiment governed the conception of what a man-of-war ought to be. If she could be made so, she was to be impenetrable by an enemy's projectiles. Somebody heard, or dreamt that he had heard, the Navy crying to the naval architect: "For God's sake keep out the shells!" Armour was again thickened, and, being thickened, was again reduced in area; so that shells were effectually kept out of a part, a gradually diminishing part, of the ship, whilst free ingress to the rest of her above water was conceded to them. It was not seen that there was a reasonably effectual method of keeping an enemy's shells from entering any part of the ship, armoured or unarmoured, viz., by overwhelming him with the fire of your own guns. Admiral Farragut had said: "The best armour is the return fire." Like most apophthegms, this looks at first sight exaggerated. The truth that it contains was not recognised. So, in individual ships, armour was given greater power of resistance, whilst guns decreased in number. The power of a gun was, indeed, increased; but with the object of enabling it to send its projectiles through the more resisting armour on an opponent's hull. The Devastation, Thunderer, and Dreadnought, launched between 1870 and 1875, gave expression to the dominant ideas of the day, when tactical principles attracted so little attention that the word "tactics" was rarely heard, and when it was heard it was applied to the practice evolutions or drill of a fleet.

If tactics ceased to attract attention, naval architecture by no means stood still. Naval architects were every day showing that they could meet every reasonable demand. If the results of their efforts had no great tactical importance, that was certainly no fault of theirs. A particularly brilliant period in the history of naval architecture coincided with a period of marked dulness in naval tactics. To what are we to ascribe this paradoxical condition? We are justified in ascribing it to the absence of fixed principles from the minds of those whose proper sphere was tactics. Perhaps, without foreseeing the effects of their procedure, they gave up being tacticians in order to deal with details of naval architecture. It is not easy to find any other explanation of the variety of types of ship produced during the period under notice. The variety by itself was sufficient to prove that there was no fixity of tactical principle. It also disclosed symptoms of a belief that architectural design should regulate tactics and not tactics regulate design. Historical monumental proof of this exists in the ships constructed at the time.

The French, who have shown greater aptitude than any other people for treating naval affairs scientifically, were the first to break away from the position above indicated. They understood that a battle between fleets would not be a mere matter of perforating or failing to perforate a restricted area of thick armour. They had a vivid perception of the great tactical principle that concentration of the effect of weapons should be the end aimed at, and that concentration of the weapons themselves is merely the means. Therefore they armed their ships in accordance with the principle. Other nations had to follow their example. The ships launched or designed for our own Navy during the last dozen years of the nineteenth century and the first two or three years of the twentieth supply monumental evidence of the reviving but far from dominant influence of tactics.

To follow the course of naval architecture within the last half-dozen years would be likely to lead us into contentious questions, which, in a paper like the present, it is best to avoid. Attention, nevertheless, may be properly invited to some aspects of it which appear to reproduce the conditions of the time when the turret-ship excluded other types of ship from the fleet. The object then was to obtain great concentration of defensive and offensive material in individual ships, and that object has reappeared of late. Another object was to make the concentration more powerful than any other country had made it. Here, again, we can observe similarity to the aims of the earlier period. The accompanying circumstances now are like those that showed themselves then. There is now, as there used to be before, an oscillation in superiority of material power as exhibited in the augmented displacements and weights of guns. To-day one country has the bigger ships and heavier guns; to-morrow this kind of superiority has gone to some other country, which, in its turn, will be surpassed in these things. The important question that we have to face is this: Is the oscillation due to recognition of tactical principles, or is it a contest in architectural development? That question, we may be sure, will be answered, if not by this generation, then by a future one, and the ships which the great navies of the world are adding, and have lately added, to their lists will remain, whether or not as efficient components of a fighting fleet, at any rate, as monuments to show the world the extent to which, at this present day, the principles of naval tactics found adequate expression in architectural design.

* There is not room in this paper to deal with the class of craft called "destroyers," which, though they have been converted into merely larger torpedo boats, were originally introduced with the deliberate object of acting against torpedo boats. Their adoption was based on a real tactical principle, which, owing to the plan of using them as torpedo boats, had been lost sight of.

THE TASMANIAN GOVERNMENT RAILWAYS.—Mr. G. Wishart Smith, general manager of the Midland Railway of Western Australia, has been appointed sole commissioner of the State Government Railways of Tasmania.

THE INSTITUTION OF CIVIL ENGINEERS.

CONFERENCE ON EDUCATION AND TRAINING OF ENGINEERS, 1911.

(*Concluded from page 868 of our last volume.*)

SECTION II.—SCIENTIFIC TRAINING.

*The Value of a University Degree in Engineering Science in Relation to Professional Competence.**

By Professor STEPHEN MITCHEL DIXON, M.A., B.A.I., M. Inst. C.E.

THE competent engineer is one who can deal effectively with materials and men. While it cannot be claimed that three or four years' good work at an engineering school gives this competence, still it can be shown that for the ordinary man it is the best method of obtaining the necessary preliminary training, and so the university degree becomes the first step of a long ladder leading to eminence in the profession.

The training of the engineer may be divided into theoretical and practical, but this is merely for convenience in discussion, because the two divisions can never be separated entirely. Speaking broadly, however, the theoretical part or basis of the engineer's education is that which is more or less complete, as far as most men are concerned, when they receive the degree in engineering. The practical part of his education, beginning at college, should continue as long as the engineer remains in practice.

The unique position held by the Institution of Civil Engineers in this country would have seemed favourable to the early systematising of engineering education, but fortunately this has not happened. By wise encouragement, the individual efforts of those seriously interested in engineering education have arrived at solutions of the problems involved, and the experience gained by others should enable us to choose methods giving the best results. Moreover, the evils due to a too early standardisation, which would have given a cramped and narrow system, have been avoided, If we examine the courses which at present lead to degrees in engineering science, we see the results of this policy. It will be seen that a broad and sound training in the underlying principles, education in its true sense, and not the mere imparting of information, have been the objects sought.

While it has been said that both sides of the engineer's training begin at college, there is no doubt that the work carried out for the degree must deal mainly with principles, and should be as broad as possible. Details of current practice will be noticed only as illustrations of principles. In dealing with materials, the engineer needs a knowledge of mathematics, physics, and chemistry; and if he is to avoid mistakes, his knowledge must be very exact, and at his fingers' ends. The courses in mathematics, physics, and chemistry naturally lead to those in surveying, stresses in structures, and properties of materials. All these are technical subjects, it is true, but they can be far better and more easily taught in the class-room, field, laboratory, and drawing-office of a university than in the engineer's office. When the student has a sound knowledge of the principles involved in the study of these subjects, he will make rapid progress in the details of practice.

Instruction in the above subjects, important as it is, should form only part of the general education of the young engineer, if he is to be fitted to hold more than a subordinate position in the engineering profession, for, as stated earlier, the engineer must deal with men as well as materials.

A liberal education is essential: literature, history, philosophy, all subjects which tend to broaden a man's outlook should be studied, and this is even more necessary in the case of engineering students than in the case of those who intend to follow other professions. Of course, unless a university education leads to further reading and research, one of the most desired objects is not obtained; but, owing to the nature of his employment, the engineer frequently has for several years few opportunities for reading outside his work, and so should make up for this by the keenness of his interest in these so-called "outside subjects" while at college. We take it for granted that the successful man in any other of the professions will be one who has already made his mark at the university, and it is certain that the success in a great measure is due to the trained ability which enables the possessor to influence his fellow-men. The general culture which comes from college life as well as from college study is an asset in the engineering profession not to be despised and not easily obtained. The man who leads his fellow-students in the class-room, in sports, or in the debating society, is equipped in a very real way for success in his profession.

The work done at engineering schools is serious and painstaking. Much has been written lately about examinations and degrees in engineering, but those familiar with the work of engineering colleges can testify that the profession has no reason to fear that the status of the civil engineer will not be upheld by the graduates in engineering. The final examination is but a very small part of the requirements for a degree. Three or four years of solid work under personal teaching sifts out a large proportion of those entering on the courses, while at the same time few students who possess industry and average ability should fail to satisfy the present requirements in the specified time.

No system of education is above criticism. If we take an interest in the objects of the system, we should see that our criticism is fair and helpful. At present the university method is recognised as the only generally applicable method in every country but our own. The objections to the system in this country may be found stated by two classes of engineers: Those who have in their early days entered university courses and then dropped them before grasping the meaning of the instruction offered, and those who have risen to eminence in their profession before university training in this country became general. The former are answered by the fable of Æsop of the fox who tried to make the best of a serious accident; the latter are reminded that competition in the profession is becoming keener every day. English engineers now find in every country friendly rivals who have spent a large part of their time at engineering colleges, and it would be unjust to the rising generation if they were not able to start with advantages equal to those of their competitors. It is not long since that it was not unusual to find, in some of the larger engineering schools in America, English students attracted by the superior equipment and facilities for research. At present our students are more fortunate. At home they can, at well-equipped colleges, receive instruction which is admitted to be efficient and up to-date. In fact, the stream of students from newly-developing countries without engineering schools of their own is being in part diverted from the United States to this country.

In arranging this discussion on engineering education for members of the profession who have already attained eminence in its practice, the Council of the Institution had evidently in view the one difficulty which exists for the moment in England. While in other professions a university degree is regarded as the first requisite, and so leads directly to employment, there is still a feeling in some quarters that the university graduate is rather in the way in an engineer's office. Matters, however, in this way are improving. Once engineering firms recognise the advantage of having assistants thoroughly trained in the principles underlying practice, and whose training also fits them specially for adopting new ideas rapidly, they will be only too glad to co-operate with the universities in completing the education of the engineer. A method already adopted on some railways in the United States and in Australia has been in work for some time on at least one railway at home. In this case we have the principle of co-operation firmly established, by which the college graduate obtains his practical experience in the best way possible. Entering the service of the company under a small but gradually increasing salary, the graduate in engineering is under agreement to stay a specified time. During this period the engineering staff of the company consider that there is an obligation on their part to see that the duties of the junior assistant are so arranged as to give him a wide experience. One railway company in the United States reports that the services of men so trained by them are so eagerly sought by other companies that they cannot satisfy the demand. This principle of co-operation might be extended largely, and the greatest gainers in the end will be the employers, while at the same time the status of the junior engineer will be greatly improved; and not only this, but by the interest thus taken in engineering colleges by engineers in practice, modifications in the courses may be suggested, and students will be encouraged by the knowledge that the training, the successful conclusion of which is indicated by a degree, is recognised by the leaders of the profession as the right and necessary preliminary to practice.

* Read at meeting of Section II., held Thursday, June 29, 1911.

*The Value of a University Degree in Engineering Science in Relation to Professional Competence.**

By Professor CHARLES FREWEN JENKIN, M.A., M. Inst. C.E.

IN order to estimate the value of a degree in engineering science, it is necessary to understand clearly what the possession of the degree means. It means that the graduate has spent some years in passing through a carefully-arranged course of study in those fundamental subjects which should form the basis of engineering education, and also that he has attained a certain standard of proficiency in them as far as that can be tested by examinations.

It is no longer necessary to urge the importance of theoretical training. Engineering education should consist of three parts—a basis of general scientific study; a middle structure of applied science—that is, of science specialised, extended and adapted with a view to its bearing on professional practice; and, lastly, that kind of knowledge of practice which can be gained only by coming directly in contact with it.

This is now recognised by the Institution of Civil Engineers, which requires proof that applicants for admission shall have had both theoretical and practical training. The latter can only be obtained by an apprenticeship or its equivalent, and I sincerely hope that the Institution will always maintain its requirements in this respect, and not accept a knowledge of college workshops as equivalent to a knowledge of real practice, which it can never be. I am aware that much that is useful can be taught in college workshops, but I believe that it is better for the student to learn these things in the real shops, where he will at the same time acquire a fund of practical experience which he cannot in college. As Sir William Siemens said, "College teaching should deal very much with principles and very little with details."

The first part of the training—the theoretical part—with which we are specially concerned, can be obtained more or less efficiently in various ways. It is this part which the entrance examination is intended to test, but a degree is a very much better proof of the possession of a good theoretical training than any examination can be. This is the first reason I would bring forward for regarding a degree as of value.

That an examination is in general a poor expedient for ascertaining a student's proficiency is becoming more widely recognised every day; it is, however, less unsatisfactory when held on the completion of a definite course of study than when it is used to test general scientific knowledge. Further, the degree course contains much that cannot be included in the examination at all; for example, much of the student's time is spent in the laboratory learning how to measure accurately all sorts of physical quantities, and to carry out tests on all sorts of machines—steam, electric, hydraulic, &c. Laboratory training can only be obtained in a college; its value is very great. To quote my father's words, "There is no teaching more practical, more immediately fertile in results, than that which can be given by the man of science in his laboratory." Again, there is the teaching in the drawing-office, where the student learns to use his theory in the preparation of actual designs, and the field course of surveying, during which he learns to handle his instruments skilfully and accurately. These are all implied in the degree; but it is almost impossible to take any account of them in an examination. To quote Dr. Ewing's reference to the Institution examinations in his admirable paper on engineering education, read at the recent Imperial conference:—"To pass an examination in certain sciences is one thing; to have had the advantage of a university or college course in which the same sciences are well taught is quite another thing."

The value of a degree may be considered from another point of view. What training is best for the boy when he leaves school—best in a wide sense? Is it better for him to go to college or not? for this is what the degree implies. To spend some years at a university is an education in itself and will be a permanent asset in the boy's life. The value of this part of education was well stated by W. B. Rogers, the founder of the famous Massachusetts Institution of Technology in Boston:—"We believe," he says, "that the most truly practical education, even in an industrial point of view, is one founded on the thorough knowledge of scientific principles, and which unites with habits of close observation and exact reasoning a large general cultivation."

This general cultivation is the feature of all university life—specially perhaps in the older universities. It is a matter on which we may congratulate ourselves that the two oldest universities now open their gates to engineering students.

The value of a degree may be considered from a third point of view. Sir James Inglis, in his presidential address in 1908, said: ". . . it ought to be laid down as a principle that all public money derived from rates and taxes should be, so far as it is applied to engineering construction, expended under the direction or control of definitely qualified engineers, as is already the case in many countries."

If the engineering profession is to be brought under State control, as medicine is, and also the law—in a modified sense—it would appear to be wise to make the basis of qualification as broad as possible by recognising the engineering degrees of the universities as a necessary qualification, rather than a certificate by a single institution, even though that institution were our own.

An engineering degree then may be looked at in three lights: As a guarantee that the holder has had the best theoretical training and has profited to some extent thereby; as the final step in that type of liberal education at the universities of which England is justly proud; as a broad basis on which State recognition of our profession may be founded.

The regulations drawn up by the Institution for the admission of students and members are wisely framed at present so as to recognise many different types of training; but if the reasons I have advanced in favour of the engineering degree are valid, it would be well for us to look forward to a time, not too far distant, when the possession of a degree shall be a necessity in engineering as it is in medicine.

* Read at meeting of Section II., held Thursday, June 29, 1911.

*The Position and Uses of Engineering Laboratories in Relation to Education at College.**

By Professor WILLIAM ERNEST DALBY, M.A., B.Sc., M. Inst. C.E.

THE outstanding feature of our modern system of scientific education is the laboratory. It is now recognised as an essential instrument in all branches of scientific education. The reason is not far to seek. In a lecture-room a student hears things, but in a laboratory he does things; and a normal student remembers what he does, and forgets the greater part of what he hears. A youth anxious to become an engineer is generally born with a desire to do things; and thus the material which we have to train in our engineering colleges is peculiarly susceptible to laboratory teaching. Through the work he does in the laboratory comes the desire to hear rightly in the lecture-room.

An engineering laboratory may be designed from the two distinct points of view of teaching and research. The two ideas are complementary to one another rather than antagonistic, and both must be kept in view in the general design of the laboratory of a great school.

From the point of view of teaching, the individual items of the apparatus provided should be numerous, typical, and small, so that there may be plenty of experiments for small groups of students to carry out for themselves. For example, five 20-horse-power steam-engines, each properly equipped with measuring apparatus, are better than one 100-horse-power engine. Later in the course a student may form one of a large group testing a large steam-engine, but his early work on the smaller

* Read at meeting of Section II., held Thursday, June 29, 1911.

plant will enable him to perform his part with a comprehensive knowledge of what is being done by the other members of the group. He will thus do the work more intelligently.

In an engineering laboratory the students must do the job, and not watch the job done by the professor on a large and expensive piece of apparatus too costly to be entrusted to them.

From the point of view of research, the chief provision to be made is space, time, and a workshop in which research apparatus can be made, together with apparatus sometimes of an expensive kind, but often inexpensive. Any of the apparatus provided for the instructional course may, from time to time, be made the subject of a research; but in such an event it must be withdrawn temporarily from the routine work of the laboratory.

The equipment of an engineering laboratory cannot be specified without a clear idea of what it is that we aim to teach.

Amongst the many things that may be put down, three, I think, stand out clearly—namely:—

1. The fundamental principles on which engineering science is based.

2. The physical properties of the materials of construction.

3. The methods of measuring that elusive thing, energy, in the many guises it assumes.

The fundamental principles upon which engineering practice is based are few in number, but their applications are almost infinite. A principle can only be thoroughly grasped through a study of its applications. Hence a principle should be taught by means of applications selected from those which have a bearing upon engineering. For example, both the astronomer and the engineer must thoroughly apprehend the principles embodied in Newton's laws of motion. The budding astronomer might fitly be taught by applications of these laws to the solar system. An engineer would learn them by their applications to the motion of machinery, the flow of water, and, may I say, the balancing of engines. But the inversion of the selection would be disastrous both for the astronomer and the engineer, although the aim is to teach both of them exactly the same principle. The engineering teacher has a vast and interesting field of applications from which to make his selection, and the suitability of his choice will depend largely upon the extent of his scientific knowledge and practical experience.

All students of engineering should gain some familiarity with the physical properties of steam and gases and with the materials of construction. There should be a complete equipment of small testing-machines in order to provide for numerous individual experiments simultaneously, together with some large machines for research work.

The fundamental principles of thermo-dynamics should be taught through their applications to estimate the efficiency of heat motors of all kinds. There should be a full equipment of heat motors small enough to be entrusted to a group of two or three students, together with a few large engines and typical steam-plant for the more extended study of the subject.

A student learns a great deal by testing heat-engines. He learns how to measure the flow of energy when it is associated with such diverse agents as gas, steam, water, and ether, and in the form of mechanical energy. In the making of the heat balance-sheet he unconsciously, perhaps, uses the principle of the conservation of energy whilst he is consciously hearing lectures of how this principle underlies the science of thermo-dynamics, and how this science enables him to estimate with justness the performance of the engine he actually tested in comparison with the ideal engine of thermo-dynamics.

Time prevents me from enlarging on the educational value of the work in the electrical laboratory. The elusive nature of the agent with which electrical energy is associated makes the work both fascinating and absorbing.

Above all, in passing through the course, the student should catch something of the spirit of research which should brood over every engineering laboratory, from the smallest to the greatest. If he is successful in this, he will go forth trained to think for himself and to act for himself, and with a desire to add his contribution to the vast accumulation of scientific and practical knowledge which is our heritage from the great thinkers and engineers of the past—men whose names are famous not only on the roll of the Institution of Civil Engineers, but on the larger roll of the British Empire.

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*The Position and Uses of Engineering Laboratories in Relation to Education at College.**

By Professor JOHN GOODMAN, M. Inst. C.E.

THE value of engineering laboratories for educational purposes, and for obtaining experimental data of an engineering character, is now so extensively recognised, that it is quite unnecessary to spend time in discussing the general question; but since the equipment, the nature of the work done, and the methods of carrying on the work vary so widely in the laboratories of different colleges, it appears to be desirable to discuss these questions with a view to increase their usefulness and efficiency.

Object of Laboratory Training.—It is well at the outset to recognise that the equipment and scope of an engineering laboratory differ essentially from that of a college workshop. The work carried on in the latter is mainly for the purpose of teaching the art or trade of engineering (as to whether such workshops should be attached to colleges or not is a much debated point, upon which very definite opinions on both sides are held), but the work done in the former has the sole object of teaching the principles which underlie that art or trade. It is possible, in certain cases, that laboratory work may overlap that proper to the workshop, but in general the functions of the two are distinct, and must not be confused.

However able a teacher may be, it must often happen that students do not get a thorough working knowledge of a subject from attending a course of lectures, although they may have no difficulty in following the treatment during its delivery; if, however, properly-schemed laboratory work can be arranged to run concurrently with the lectures the student is brought more closely into touch with the concrete side of his subject, and thereby not infrequently discovers his own shortcomings. It is, of course, well that he should be brought face to face with difficulties, and, instead of being spoon-fed, he should, in the early stages, be left severely alone to worry out his problems; but if actually beaten, then, and not until then, should the director of the laboratory come to his assistance. Such a course will often arouse interest where lectures fail, and will reveal to him discrepancies between theory and experiment; inquiry into the reason for such discrepancies are of real educational value; and if the student possesses "grit," it will be a great incentive to him to dive more deeply into the matter. Later in life, when such difficulties arise on a larger scale, his familiarity with scientific methods of dealing with obscure problems will enable him to attack them with a directness and certainty that are lacking in the untrained man.

Amongst other important phases of laboratory work the following appear to be worthy of special note:—

The engineering laboratory affords the student an excellent training in the carrying out of experiments for the purpose of obtaining accurate data, and he cannot fail to be early impressed with the paramount importance of keeping all the conditions of the test constant except the two variables under consideration. He, moreover, discovers that absolute accuracy in data is rarely, if ever, attainable, and therefore the use of many significant figures is not only absurd, but tends to deception. In the author's laboratory the first work done by students consists in the measurement of certain quantities by three or four different methods, with the object of impressing upon them the fact that the methods themselves are not perfectly accurate, and, even if they were so, the personal equations of the workers would affect the result obtained. It is believed that it is important for students to realise early that extreme care in the choice of methods and in the use of apparatus is essential if any high degree of accuracy is required.

In certain cases the laboratory work is valuable in showing how far theory and experiment agree, but great care is necessary in order to prevent students jumping to the conclusion that there is actual disagreement because their own imperfect, inaccurate experiments do not give the results that the theoretical treatment would lead them to expect. It is, however, believed that it is a mistake in the first instance to insist on students worrying about minute accuracy. Until their ideas get somewhat broadened, such attempts at accuracy absorb a large amount of time quite out of proportion to the importance of the result obtained, but later on a certain amount of experimental work requiring a high degree of accuracy is a most excellent training.

Equipment.—Before purchasing apparatus for the equipment of an engineering laboratory, it is of great importance that a general scheme should be drawn up, setting forth definitely and clearly the lines on which the proposed work is to proceed; in the author's opinion the aim should be to make all apparatus as simple as possible, and each piece should be designed to bring out clearly one particular point, all unnecessary complication being dispensed with. Teachers are very liable to forget that the average student is unable to appreciate the refinements and intricacies of highly complex and elaborate apparatus, which, as a rule, completely mystifies him. Distinction must always be drawn between apparatus which may be used by the staff for their own education and for research work and that required exclusively for students. In this connection it is suggested that it is better to make use of commercial tackle, such, for example, as ordinary pulley-blocks, screw-jacks, &c., rather than the amateurish polished brass and painted wooden models so often offered for sale for use in colleges.

The experimental steam-engines found in college laboratories are frequently fitted with a maze of intricate appliances for the purpose of enabling the engine to be worked under a great variety of conditions, with the result that students are very liable to get erroneous ideas as to the essentials of any given type of engine. Such engines are necessarily not stock articles, hence they have to be specially constructed for the purpose, and are, therefore, very costly. The author suggests that it would be better in every respect to purchase two or three commercial engines of different types for testing purposes rather than crowd so much complication on to one experimental engine. Unfortunately, all apparatus soon gets out of date, and unless a college is very wealthy it cannot afford to clear out the old-fashioned machinery every few years and replace it with new. In some cases enterprising firms lend engines and plant to colleges for testing purposes on condition that the results of all tests shall be supplied to the makers in return for the loan, and when the firm in question brings out an improvement the obsolete plant is exchanged for the new. The arrangement from the college point of views is, of course, ideal, and the firms in question are not entirely losers by the bargain.

In all tests where a great variety of conditions may prevail, it is impossible, on account of time, for one group of students to work under each set of conditions, therefore it appears to be desirable that a definite scheme of testing should be drawn up, which may possibly take years to complete; then as each result is obtained, it should be plotted on a squared paper chart exhibited in the laboratory, thus enabling each group of students to benefit by the results previously obtained. If isolated tests are made under random conditions they are robbed of much of their educational value, and the results obtained are of little or no permanent value.

The extent to which stereotyping should be allowed in the work of an engineering laboratory is one well worthy of the most earnest discussion; all will be agreed that it is an utterly bad system to have the apparatus required for each experiment set out permanently in working order, and to give printed detailed instructions and log-sheets to each student, which he mechanically follows. The following of such a system entirely crushes all originality, and makes the student into a mere machine. In the early stages of the laboratory course some approach to this system may be tolerated perhaps, that is, during the period in which the student is learning to take and book observations; but after he has once got over the initial stages he ought to rig up his own apparatus, check it for accuracy, make out his own log-sheets, and reduce his results. Of course he requires more supervision when working under such conditions, but he certainly gains experience of a far more valuable character than under a stereotyped system. The extent to which he can go in this direction largely depends upon whether he has been in commercial engineering workshops before taking up his college course. In tests of a more important character it often happens that the student lacks the necessary manipulative skill required for carrying out the experiments if he has not had a previous practical training in works.

Laboratory Routine.—The staff of an engineering laboratory usually consists of a director with one or more assistants and skilled mechanics. It is of vital importance that the director should be a man familiar with practical work, or he may unwittingly encourage students to play with unreal problems, which tend to divert their attention from the actual difficulties that arise in the life of an engineer. The author on one occasion visited a technical school in which the students were observed to be busily engaged in testing the buckling strength of wooden matches, from which strut data was to be evolved.

A considerable amount of skill and much tact is required of the director who gets his laboratory to run smoothly and efficiently. The following regulations are found greatly to assist in smooth running:—

All observations to be recorded in note-books or on authorised log-sheets, and not on odd scraps of paper.

The results, after reduction, to be entered neatly, with necessary curves, sketches, descriptions, and explanations, in a laboratory note-book, having alternate pages of squared paper.

The most important results to be entered in a record-book kept permanently in the laboratory.

The students' note-books to be inspected by the director or assistant in charge after the entry of each experiment, and no fresh experiment to be started upon before the previous one is completed and entered up.

A large sheet posted up in the laboratory, having a vertical column for each experiment and a horizontal line for each student, to be starred with an india-rubber stamp as each experiment is completed. By this means the work already done by each student can be seen at a glance.

Much inconvenience is sometimes caused by students not returning measuring-instruments and other apparatus to the proper place after the completion of the experiment. Therefore each student in the Leeds University is provided with brass checks, similar to those used in works, and when he requires to use thermometers, indicators, &c., he goes to the stores and deposits his check with the storekeeper for each piece of apparatus. The check is hung on a peg close to where the apparatus is kept. If he fails to return the apparatus at the proper time and in good order, he is charged for it by a reduction from his laboratory deposit.

In order to keep a record of the time spent in the laboratory, special sheets are put up every day, which are initialled by the student to certify his attendance before he leaves.

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*The Position and Uses of Engineering Laboratories in Relation to Education at Colleges.**

By Professor BERTRAM HOPKINSON, M.A., B.Sc., F.R.S., M. Inst. C.E.

THE classification and analysis of the phenomena presented to the engineer in the practice of his art conveniently called "Engineering Science," occupies a position intermediate between biology, which is mainly based on the observation of Nature, and physics, which is chiefly experimental. It is founded on the laws of motion, of heat, and of electricity, whose action is investigated in the physical laboratory; but it is concerned with the working of these laws under conditions comparable in their complexity with those under which the same laws work in living things. This is obviously true of the greater natural forces, such as the winds and tides, whose action it is the engineer's business, so far as possible, to control. It is impossible to bring these things into the laboratory, and to subject them to experimental analysis, though experiment may be of great help in interpreting observation of them. In other branches of engineering science—for example, in the study of the production and use of power—there is not the same physical limitation on experiment, but there is a commercial limitation which is

* Read at meeting of Section II., held Thursday, June 29, 1911.

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just as effectual. Complete experiments on a full scale under commercial conditions cannot be made because no one will pay for them, or allow his business to be disturbed while they are being made. Moreover, the commercial element and the human element are the most important among the conditions under which engineering phenomena go on and which determine their course. In a laboratory experiment they are as little reproducible as is the texture of a full-sized wind. Thus engineering science must be based on the intelligent observation of things as they occur in practice. As in biology, experiments in an engineering laboratory may be of great assistance, but in interpreting their results it must never be forgotten that the artificial control of conditions, which is of the essence of experiment, is of itself a disturbing factor, analogous to that general effect on the subject of a vivisector's operation, which always lessens, and may destroy, the value of his conclusions when applied to the normal animal. On the other hand, it cannot be doubted that the necessary difference between natural conditions and the artificial atmosphere of the laboratory is less far-reaching and its effects are more readily foreseen in engineering than in biology. Experiment plays a part which, though still subsidiary, is relatively more important. Especially is this the case in the applications of electricity.

The position of the engineering laboratory as an instrument of education is not quite the same thing as its position in relation to research, but is closely related to it. In a discussion, some twenty years ago, on the proposal to establish an Engineering School in Cambridge, it was pointed out, by way of justifying the innovation to that ancient university, that it was as good an education thoroughly to test a steam-engine as to determine the velocity of light. It might well have been said that it was better, for in the engine trial the student is introduced to phenomena under conditions which, in their complexity, resemble those of real life, and which can only partially be controlled. He can vary steam-pressure, load, and perhaps speed, but he cannot, within the limits of an ordinary trial, control such important factors as the dryness of the steam-supply, or the temperature of the cylinder walls. Thus he learns in a simple way to use his judgment in interpreting data, and to recognise how in a complex mechanism it is impossible to vary a single element without at the same time affecting a number of others. This training of the faculties of criticism and observation is valuable to anyone, whatever profession he is going to follow, and it cannot be obtained in the same degree from the experiments ordinarily performed by students of similar standing in a physical laboratory. To the engineering student there is the additional advantage that he sees the application of scientific principles to things of the same sort as he will meet with in after-life.

These considerations, together with a frank recognition of the fact that by no possibility can the conditions of practical work be completely reproduced in the laboratory, lead to a fairly definite conception of its position and uses. In the first place, industrial apparatus, even of a simple character, is too complicated to be used as a means for demonstrating elementary physical laws to students who are quite ignorant of their working. Hence work in the engineering laboratory proper should be preceded by a short course of ordinary physical experiment under the simplest possible conditions. Provision is made for this in nearly all college courses, and it is unnecessary to discuss it in detail. Assuming that he has thus acquired a knowledge of the fundamental scientific principles, the student's work in the engineering laboratory will be directed largely to tracing their operation under more complex circumstances. For this purpose small units of plant of a simple character are quite adequate. Everything that such a student can learn in an engineering laboratory in the time at his disposal he can get from a 10-horse-power engine, from a 5-ton testing-machine, and from plant on a similar scale in the other branches of his study. A triple-expansion engine teaches him no more than a compound; a four-cylinder petrol-motor little, if anything, more than a single-cylinder gas-engine. In fact, the smaller and simpler machines are better for his purpose, because they are more easily handled, and he can be left more to himself. The author remembers seeing in a technical school an engine of several hundred horse-power, which was being tested by some fifteen or twenty students. They were taking readings according to a set scheme, one reading a thermometer, another a pressure-gauge, and so on, and all the readings were being entered on a beautiful printed sheet. On the same day he happened to speak to a schoolmaster, who described how he was in the habit of setting his boys two or three at a time to indicate the laundry-engine at his school, and test its steam consumption with an improvised condenser. There cannot be much doubt that the schoolboys learnt more than the students, and that the money paid for that large engine would have been better spent on twenty small engines.

But, though small, the machines in the engineering laboratory should be real commercial machines, such as are bought and sold in the ordinary course of business, and the students should use them under ordinary working conditions. This is, of course, quite consistent with the use of the most elaborate measuring arrangements that the ingenuity of the professor or demonstrators can devise, provided that they are such as a commercial user of the machine would tolerate. For instance, a gas-engine may have thermometers stuck all over it, it may suck its air through a hole for the purpose of measurement, and it may discharge its exhaust into a calorimeter, but it is not to be run at less than its normal speed in order to get better indicator diagrams, nor is the valve-setting to be altered for the purpose of improving the measurement of the air. Extreme variation of conditions is necessary for the purpose of research; but the ordinary student is not doing research, nor is it his object to learn in detail about the working of a special machine. His use for the engineering laboratory is to learn generally how to extract from an experiment conducted under severe limitations all the information that it is capable of affording. In doing so he will consolidate the knowledge of natural laws, which he is supposed to have acquired previously in an ordinary physical laboratory, and will learn their limitations; he will also pick up many facts about the working of machines which may or may not be of direct use to him, according as he meets with these particular types in after-life or not. But these are by-products, and in the author's view the engineering laboratory should be designed and organised with a single eye to the primary educational use which has been indicated.

SECTION III.—PRACTICAL TRAINING.

*The Relation of Engineering Employers and Colleges from the Point of View of the Practical Training of College Students.**

By Professor JOSEPH ERNEST PETAVEL, D.Sc., F.R.S., Assoc. M. Inst. C.E.

A GOOD general education, a wide scientific knowledge, and a sound practical training constitute qualifications essential for success in the engineering profession. The engineering employer and the university teacher are therefore co-partners, jointly responsible for the success of the educational work; and it follows that some close co-operation is eminently desirable.

Any discussion of the relationship between employers and teachers must be primarily based on some definite understanding with regard to the aim of university teaching and the qualifications attainable by the average college student. On both these questions a considerable divergence of opinion exists, and it is merely with the object of providing, as briefly as possible, a basis for systematic discussion that the following apparently somewhat dogmatic statements have been drafted.

1. A boy intending to qualify as a civil or mechanical engineer would pass the university matriculation examination at the end of his school career, and afterwards spend a year in a mechanical workshop before entering the university.

2. The university teaching should be scientific in its nature and wide in scope. A reasoned discussion of present practice and future possibilities should take precedence over merely descriptive treatment. The student should be taught to understand fundamental principles and make an intelligent use of mathematical analysis, not to memorise unimportant details and empirical formulæ. Finally, early specialisation should be discouraged. The educational work of the university is brought to a successful termination when the student has been taught how to learn.

3. The object of the engineering laboratory is to afford illustrations of the principles referred to in the lectures, to familiarise the student with the methods of testing materials or machines, and to prepare him for the practical training which it cannot replace.

4. The university degree implies a certain standard of work, knowledge, and intelligence, but the ultimate success of the graduate as an engineer will depend primarily on his personal characteristics, and secondarily on the opportunities offered him during and after his practical training.

The engineering employer cannot anticipate that a university graduate will be of much assistance during the first few months, but should require him to reach a satisfactory standard of efficiency before the end of the first year, and expect him to deserve some reasonable remuneration during his second year.†

5. The head of an engineering department is always glad to select and recommend a man suitable for any position which is offered.

6. The engineering employer can co-operate in the educational work of the university by a frank and friendly criticism of the methods adopted. By offering to take college graduates on a six months' trial he can form a personal judgment of the qualifications of the men and select those best suited for the work he requires.

The Relation of Engineering Employers and Colleges from the Point of View of the Practical Training of College Students.‡

By JAMES WILLIAM HORNE, B.Sc., Assoc. Inst. C.E.

THE requirements of the Institution's bye-laws relating to election are: A sound general education developed on lines suited to subsequent scientific study; a complete knowledge of those branches of science which form the basis of engineering; and practical training under actual engineering conditions, adapted—to quote from the last report of the Council—to fit persons to take part in the design, as well as in the control and direction of engineering works.

The Committee on Engineering Education and Training, in their report of 1906, made it very clear that youths training as engineers should, if possible, spend at least two years of that training in systematic scientific study at a fully-equipped engineering college, in order to make themselves more efficient for their future professional career, and in part to fulfil the requirements for election into the Institution. The committee at that time could only generalise as to the most suitable period when the young engineer should proceed to college for this scientific education. This admirable and exhaustive report has exerted a very effective influence in improving the system of engineering education and training, and, as a result, the engineering training of the university and college type of to-day is a great improvement on apprenticeship practice existing some years ago. The university and college type of trained engineer is of recent creation, and in every field of engineering his influence is being felt. This type has undoubtedly come to stay, and will be produced by these institutions in ever-increasing numbers.

The consensus of opinion among engineers of experience and standing of the present day appears to be that the youth who wishes to become an up-to-date engineer and have a successful career in the profession, having reached matriculation standard at school, should preserve the continuity of theoretical study and proceed at once to the university or college for two or more years. In support of this opinion, though it is encroaching on the subject of another note to this conference, I quote from Mr. Ellington's presidential address to the Institution of Mechanical Engineers in March, 1911:—

"I have always felt that the first eighteen months was more or less wasted, and that that period should have been spent at college. I hold strongly the opinion that it is best for the majority of youths who are about to commence their engineering training to go to college on leaving school."

Opinions of well-known engineers on those lines will have the effect of sending a still greater number of youths to college before entering on their practical training.

Recommendation No. 13 of the 1906 report says:—

"The committee reaffirm the conviction, expressed when they issued their inquiry, that the sympathetic assistance of employers is essential to improvement in engineering education and training."

And, as bearing on the same subject, the following is taken from the introduction to Mr. Zur Nedden's excellent book on workshop practice:—

"It is the many-sidedness of the practical work of the young engineer which, after due cultivation, builds up the 'engineering instinct,' without which no engineer can be successful. Workshop experience necessitates observation, reflection, ability, tact and hard work, and the engineer's success later in life will depend greatly upon the exercise of these faculties in the workshop years."

Many engineering employers, during the last few years, have recognised that systematic scientific education of the modern university and college type is very essential to the future progress of engineering science, and in consequence have extended sympathetic assistance to college students by granting to them facilities to obtain practical experience in their workshops, in order that they might have the opportunity to build up that "engineering instinct" which is so necessary to become a successful engineer. The authorities of the universities and colleges, also recognising the necessity for this workshop period after the completion of the college course, endeavoured, and with very considerable success, to arrange with a number of engineering firms in the industrial centres in which they are situated to co-operate with them in granting college students the privilege of this workshop training. But what strikes one, after a careful study of the apprenticeship schemes as arranged by the college authorities, is that the co-operation between college and employer is not sufficiently definite, as will be seen from the following, taken from the scheme of one of our best organised colleges:—

"Students who desire to serve their apprenticeship with one of the after-mentioned firms must communicate direct with the firm and make their own arrangements."

By this system it is possible, and, as a matter of fact, in my own experience in many instances it has happened, that suitable students, possessing the necessary personality and "engineering instinct," will lose much time, after leaving college, through having been unable to make arrangements to proceed to their practical training at once, and that others will have promising engineering careers blighted by being unable, through lack of influence and means, to arrange for their practical training.

It is an undoubted fact that only a certain proportion of engineering students who finish their college course successfully are suitable to proceed to the workshop for practical training, and the purpose of this note is to suggest an arrangement to ensure that engineering employers shall be asked to give facilities for the practical training of only the most suitable students.

The professors of engineering subjects in the universities and colleges are, as a rule, qualified engineers, who have had considerable experience of works practice, and, in consequence, they are in a unique position, after three years' close contact with the students, to select the most suitable, from the point of view of ability, personality, and grit, to take full advantage of their years of workshop practice, and this method of selection would ensure that want of influence, poverty, or social circumstances, would be no bar to a suitable student completing his engineering training. The selection could be made before the completion of their course, and arrangements made so that no time should be lost.

In the provincial industrial centres it would not seem to be a very difficult problem to arrange for a close and definite co-operation between the engineering employers and the heads of the engineering departments of the colleges on the above lines, in view of the fact that the "civic" universities, such as Manchester, Birmingham, &c., and the technical colleges, such as Glasgow, have been built and highly-equipped by contributions from the local captains of industry, who in this way have shown a living interest in the advancement of scientific training.

The governors of these provincial colleges, in order to

* Read at joint meeting of Sections II. and III., held Thursday, June 29, 1911.

† The second year after graduation, or, as explained in paragraph 1, the third year of practical experience.

‡ Read at the joint meeting of Sections II. and III., held Thursday, June 29, 1911.

have the education thoroughly in keeping with the advance in industrial methods, have adopted a liberal policy in their methods of management; and in order always to be in close contact with the various industries in their district, they have adopted the wise policy of co-opting leading representatives of the various firms to act on the committees of each department.

It would appear, therefore, to be a simple matter for each centre to form a strong committee, in connection with the college, composed of these influential representatives and the heads of the engineering departments.

The duties of this committee would be:—

1. To consider the selection of students made by the professors.

2. To make arrangements with the firms who are willing to grant facilities for practical training to start these immediately on the conclusion of the college course.

3. To arrange that Recommendation 9 of the Report is carried out as far as possible.

4. To induce a still greater number to grant such facilities.

The question of an arrangement on the same lines between the colleges and polytechnics in London and engineering employers is much more complicated and more difficult to solve. In London a number of unconnected colleges and polytechnics came into existence during the latter part of the nineteenth century, due in a great measure to the subsidising of engineering training by the wealthy and generous City Companies, with the result that there is not as yet any central governing body who could act in unison with the various colleges and with engineering employers in London and the provinces to arrange for the practical training of all the most suitable students educated in the London colleges. In consequence of this condition of affairs, each college has had to make its own arrangements, with the result that many capable students have been unable to arrange for their practical training.

The Imperial College of Science and Technology has now been in existence for some years, and has nearly completed its equipment in all departments of science, an equipment which I believe is second to none, and will soon be in a position to produce students of the very highest standard of college training for whom the very best facilities for workshop training must be found. Why should united action not be possible between the Imperial College of Science and the polytechnics? Why should not a central committee be formed, with its headquarters at the College of Science, composed of the heads of engineering departments of these unconnected colleges, and representatives from the London managers of engineering employers and manufacturers, to work on lines already suggested in the case of the provinces? This committee would be able to see that all the most suitable students in London would obtain their practical experience.

There is still another important problem which is worthy of mention in this note, a problem which has arisen in England during the last few years owing to the advance made in general education, and which is now pressing for solution. I am personally most deeply interested in it, and I consider this Conference a most favourable opportunity to bring it to the notice of college authorities and the representatives of county education committees in England. During the last few years, engineering firms in this country have developed a very keen interest in the better education of the engineer apprentice who starts his apprenticeship at sixteen years of age. Every encouragement is given to him to attend evening continuation classes, and several firms allow the best of them to attend classes one or two afternoons a week. The result of this interest is that a certain proportion of these have, by means of such facilities, been able to reach a standard of education which qualifies them to proceed to a fully-equipped college for two or three years of specialised study in the day time. Want of means and lack of an adequate system of scholarships with maintenance allowances, however, prevent them from proceeding further in their ambition.

These apprentices, trained in this manner, are a very valuable asset to the nation, and I would suggest to the Education authorities that they should adopt a scheme whereby the best of them would derive the benefit of systematic scientific education in the day time at one of the fully-equipped colleges. The organisation of such a scheme must ensure that poverty or social circumstances shall not prevent access to the highest forms of training that the community can provide.

SECTION III.—PRACTICAL TRAINING.

*The Relation of Practical Training to College Study.**

By Professor ARCHIBALD BARR, D.Sc., M. Inst. C.E.

DISCUSSIONS on the training of engineers no longer turn upon questions as to the value, on the one hand, of education in those branches of science which deal with the properties of materials and the physical laws that condition the work of the engineer, and on the other, of actual contact with and participation in engineering practice. Various topics are set down for consideration at this Conference, but the terms in which they are defined presuppose an agreement that both education in science and practice in the carrying out of work are necessary parts of any general system of training for those entering the profession.

Our immediate subject for discussion naturally divides itself into two parts:—(1) the relation—or it may be the contrast—between the two branches of the engineer's training in kind; (2) the relation in respect to time.

The nature and the mode of attainment of a suitable practical training will be discussed under other sections, but the present may be the most suitable opportunity for considering how the time spent in college can best be employed.

In defining the topics with which the Conference is to deal the council has used the words "education" and "study" in referring to college work, and avoided the terms "instruction" and the much-misused expression "technical training." This is as it should be. The end to be kept in view in a college course is the education of the student, and the result is to be measured not by the amount of detailed knowledge he has gained, but by the extent to which his mind has been developed, and by the insight he has gained into the principles underlying successful practice. The alternatives before the colleges are: (*a*) the offering to the student, in the limited time at his disposal, of a general course of study that may form a basis for practice in any department of our wide profession; or (*b*) the provision of a number of courses, from among which the student may select the one that appears to bear most directly on the particular branch he expects to follow.

If I may state my own view, it is that little specialisation should be attempted, if for no other reason than that the young engineer, if he has the elements of success in him, cannot foresee the trend his career will take. The best college course is the one that is most educational, and this will be the course that gives the student the broadest outlook upon his profession. It need deal little with the details of specialised practice; these can best be learned in the workshop, the field, or the drawing-office. Men who are successful in engineering practice seldom follow in later life the particular line of work in which they have been trained; and of two men, one of whom has a thorough grasp of general principles, and the other a knowledge only of the details of one branch—however intricate that knowledge may be—the former is in a much better position to take advantage of such opportunities of advancement as may come within his reach. Moreover the conditions of practice, even in one limited sphere, are constantly changing. The college course should, then, be on broad lines, and should aim at giving the student a thorough grasp of general principles, illustrated by examples of their application in various branches of practice.

The question as to the order in which the two sections of the engineer's training should be pursued is also one that admits of no general answer. What will be best for one man may not suit another. Much depends upon the special circumstances of the pupil in regard to his mental qualities and attainments, the facilities he can command for study, and the opportunities he may have for securing practical training when he desires to enter upon it. Moreover, other things being equal, a man who has had a practical training is better able to benefit by a course of study in engineering science; and, on the other hand, a man who has had a sound training in science is in a better position to take full advantage of his apprenticeship or pupilage. But he cannot have it both ways. In favour of the college course being taken first, and pupilage or apprenticeship entered upon after graduation, it may be urged with good reason that by the continuity secured in the pupil's education, the danger of his losing the habit of systematic study, and his grip of what he has already learned at school, is avoided. Further, he will enter on his practical training with his mind disciplined and developed by his study of science, and experience comes most quickly and with most lasting effect to one who can place each item as it presents itself in its proper place in a connected system of knowledge based upon general laws, the workings of which he has learned to recognise.

Further, if the college course is entered upon after practical training is completed, the pupil severs his connection with the firm under whom he has been trained, and he may have to make a fresh start in life when he leaves college.

In favour of practical training following directly after school, it is urged, also with good reason, that the initial stages at least of apprenticeship or pupilage should be got over at an early age. A man man who has gone through a complete course of study in a university or technical college will necessarily have reached an age at which he may take less kindly than the school-boy will to the drudgery of initiation into the routine of practice in the workshop or the office. Again, the man who takes his apprenticeship or pupilage first, goes up to college with such a knowledge of his needs as will enable him to appreciate the value of what is offered for his assimilation. Furthermore, any lengthened course of study, without the correcting influence of experience of the requirements and limitations imposed by the conditions of practice, is liable to become altogether too "theoretical" in his outlook and his attitude of mind.

The disadvantages of postponing the college course to a late period in the pupil's training can be mitigated, to some extent, by private study or attendance upon evening classes, during the period of actual training, and good results follow in the case of men of special ability and perseverance; but the time and energy that can be at the pupil's disposal for evening work are limited compared with those he could command in a complete curriculum of day study at a university or technical college.

There is, then, something to be said on both sides, but as both systems cannot be followed, the best that can be done, in order to have in large measure the benefits of both, appears to me to be to adopt what has been called the "sandwich system."

It is sometimes assumed that the advocates of the sandwich system commit themselves to a particular disposition of the slices of study and practice and some definite quantitative relationship between their volumes. No hard-and-fast specification need be made. What is here meant is any arrangement that permits of college study being begun at a time not too distant from the close of the pupil's school-days; that provides that during the later part of his studies the student will have the benefit of some measure of experience in the actual conditions of practice, and that ensures that the latter part of his practical training will be taken after he has had his mind disciplined by a course of study in pure and applied science. Whether a short period of practical work—say a year or so—should immediately follow school, or, on the other hand, the first year course at college (in pure science) should come first, depends, in my opinion, upon the circumstances of each pupil as regards his state of preparation for higher studies and the facilities he can command for entering upon practical work when he desires to do so. I do not think any rule should be laid down.

Many objections have been raised to the sandwiching of study and practice. One is that the usual college session of eight or nine months leaves too thin slices of practice if the college course is taken in consecutive sessions. I agree with this view. When the system is adopted the college session should be limited to six months, as is done in some universities and colleges. Another objection is that engineering firms will not be disposed to take men on for six-month periods, with breaks of equal duration. Any pupil who finds it impossible to get entry to practical work on these lines must take his training in some other way; but hundreds of students do find openings that permit of thus sandwiching their training. The system is not new; it is, indeed, the oldest followed by university students of engineering science; it has been adopted by generations of students since the Glasgow Chair of Engineering was founded in 1840, and my own experience during the forty years I have been connected with its working has given me the firm conviction that it affords the best kind of training for the great majority of men entering the profession.

In conclusion, I would plead that the institutions should give a latitude in the systems of training that they will recognise. Let it not be forgotten that no two of the men who have made our profession what it is have entered it by the same path, and that many of the most eminent of them have had no training that would to-day be recognised as a normal one, either in respect to education or to practice. Men differ in natural qualities as much as wood and stone and steel, and the tools and treatments that will fashion a useful product out of one, may make a sorry job of it when applied to others. Let the system of training differ in different districts, if needs be, and let the courses of study offered by the colleges vary in substance and in method. We cannot dictate to members of the profession the terms and conditions on which they will take apprentices or pupils, and it will be destructive of much that is best in the influence a teacher may have on his student if he is forced by any detailed regulation to work upon lines inconsistent with his bent, and contrary to the dictates of his own experience. There is need in the profession for men of widely different qualifications: let us not aim at turning out our recruits like so many forgings stamped in one set of dies.

*The Relation between Practical Training and College Education for Engineers.**

By Professor HENRY LOUIS, M.A., M. Inst. C.E.

IN the discussion of this question, it seems advisable to determine in the first place what are the points upon which there is practically a general agreement. All agree, I believe, that every engineer must have practical training, and though there may be still some who hold that when he has this all knowledge of theory is superfluous, I venture to say that no engineer of any eminence holds that view to-day, so that I shall commence with the assumption that training in both theory and practice is generally considered as indispensable to the engineer. As to the relative amounts of knowledge of either branch, and the character of such knowledge, there is a wide divergence of views. Possibly all will agree that there is nothing that has a greater influence upon the success of an engineer's career than the ability to deal with men. This is in many cases an innate ability, though it can undoubtedly be cultivated and developed; it is often said that one of the drawbacks of a college education is that it does not call out these traits of a young man's character, but in my opinion this charge is due to an imperfect appreciation of the scope of a college training. Mere attendance at lectures and laboratories will certainly not do much towards attaining this object, but it must be remembered that attendance at lectures and laboratories is only a part of college life. In the relations between teachers and students, and still more in those among the students themselves, a British college forms one of the best schools in existence for teaching tact, good temper, honesty of purpose, and that sportsmanlike sense of fair play which form the best foundation for dealing with men of all classes. Participation in college societies, intellectual and athletic, as well as the large degree of self-government allowed to students' representative bodies, tend to foster a sense of order and responsibility, and to develop a power of administration, which are of great value in after-life. Again, it has been sometimes urged that our colleges fall short in the matter of discipline, that in a works a young man will more readily acquire the all-important habits of punctuality and promptitude which in a college are not always inculcated with sufficient strictness. For this charge there may, I believe, be some foundation, but the defect is in no way essential to a college system; the remedy once pointed out is easy to apply, and I have

* Read at meeting of Section III., held on Thursday, June 29, 1911.

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every confidence that the importance of its application is becoming more and more generally recognised. Indeed, I think it may fairly be argued that a college training is of quite as much value in the development of character as in the acquisition of knowledge.

There is no portion of the engineer's training upon which greater diversity of opinion exists than there is in respect of the manual training that should go towards making up the education of an engineer, and, curiously enough, this diversity is specially characteristic of the various branches of the engineering profession. Mechanical engineers, and to a lesser extent also electrical engineers, insist that a lengthy apprenticeship to the manual portion of the trade is indispensable, whereas the "Civil" engineer looks upon it as wholly superfluous. The one insists that the pupil must learn how to use the hammer and the file, the other sees no reason why he should touch the shovel or the pick. For my part I cannot see why, if a man can build a bridge without being a skilled riveter, he must be a skilled fitter before he can build the engine that is to run over it. Still more curious is the anomaly in the two closely cognate branches of mining engineering: most metal miners look upon practical acquaintance with the use of the miner's tools as an important part of the mining engineer's training, whilst the coal-miners hold that any such manual skill is entirely unnecessary. Personally, I am inclined to think that this profound faith in the necessity of manual skill is to a great extent a piece of fetishism, a survival of the old apprenticeship system, which used to be the only avenue leading into any branch of the engineering profession. I will not go so far as to say that manual skill is useless to the engineer, but I am convinced that most of us rate it far too highly. It is pretty clear that the object cannot be the acquisition of manual skill for its own sake, but rather for the purpose of gaining familiarity with the properties and working of the materials which the student will have to employ for constructional work, though I should be hard put to it to explain why an architect should not be compelled to serve his time as a stone-cutter on precisely the same principle.

Where views as to the need for manual work diverge so widely it is hopeless to attempt to lay down any rules generally applicable to the training in such work. This, however, does not apply to the whole of the subject of practical training, of which manual work is only one, and probably not the most important, part. If it be granted that actual technical experience amongst the men who are engaged in doing engineering work is essential, it will, perhaps, be fairly admitted also that the college is not the place to attempt to acquire such experience, and that any attempt to imitate works practice in a college is necessarily bound to result in failure.

A college is the place to learn principles, and not practice. If this be admitted, it is not a very long step further to argue that the knowledge of principles ought to precede the study of their application, and that therefore college teaching should precede, and not follow, practical training. Whilst I hold this to be true, I also believe that many teachers will concur in my view that a moderate amount of practical training may be useful in the later stages of a college career, as giving more definiteness to the student's work, and showing him more clearly the objective towards which his theoretical studies should be directed.

This is, broadly, the conclusion to which my experience is leading me. I do not find that the sandwich system in its true form—six months at college and six months in works—is satisfactory upon the whole, and think that it frequently results in both college work and the practical work being badly done. On the other hand, after three or four years passed in the workshop, a young man usually finds it difficult to come back to his studies, and is not likely to make as good progress as if he had come to college straight from school. Of course, every teacher can quote numerous cases of highly successful students trained in one or other of these methods, but I am dealing here with generalities, and not with the more exceptional cases. I am inclined to think that the method now generally adopted for coal-mining students is one that embodies the soundest general principles; these students have often seen a little coal-mining or practical engineering of some kind before they come to college; they take a three years' college course, spending their long vacations at a colliery, where they are usually put to going underground regularly with one of the officials, and thus getting accustomed to seeing how work ought to be carried on, whilst they also spend a portion of their time in the drawing-office and the colliery offices. After taking a college degree, the law insists that they shall have three years' practical experience underground before they are allowed to take the examination for a certificate as a colliery manager.

The above general system, suitably modified, would probably be applicable to all branches of engineering. Directly on leaving school, I would have the engineering student pass his matriculation examination, then go to a suitable works (using this word in its widest sense) for three to six months, then come to college for his three years' course, returning to the same, or to a different works, for two or three months during each long vacation, and then finally serve a two or three years' apprenticeship. I think that any manual work is best done in the time between school and college. Many teachers will probably support my view that an engineering degree course should extend over four years, instead of three as at present—a view that I have advocated for many years, and to which I find that general opinion is now gradually trending. Every branch of engineering to-day has assumed a high degree of complexity, and I do not think that seven years is too long a period to devote to the acquisition of the necessary technical knowledge, whilst I venture to think that this is best divided up in the manner I have indicated.

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*Workshop Training as a Preliminary to Practical Training in other Branches of Engineering.**

By JOHN ALEXANDER BRODIE, M.Eng., M. Inst. C.E.

IN introducing this subject I have thought it well to assume that the youth about to take up engineering as a profession is of average ability and circumstances, about 17 years of age, that he has had a good general education, a superior mathematical training, and preferably an experimental knowledge of one science subject. He should also have been trained to think for himself, to express his views clearly and concisely in speech, and to report in writing on any matter which may be put before him. If he has been accustomed to act as schoolboy captain or to work to the orders of his captain in sports and athletics, so much the better, and he should be encouraged to keep up his connection with healthy outdoor sports.

By some it is thought that training in school and college workshops is of considerable value, and whilst this is, no doubt, better than no training in workshops at all, I take the view that workshop practice, to be of real value to the engineer who proposes to advance in his profession, must be conducted under commercial workshop conditions in which considerations of time, money, discipline, organisation, and enterprise are factors of importance.

At the age named the youth should have sufficient strength of character and physique to take care of himself in the workshop atmosphere, and he is yet sufficiently young to adapt himself to the dirty conditions of work, the muscular exertion, and the somewhat rough-and-ready manners of the workmen with whom he must learn to work on a friendly footing if he is to obtain their help and assistance.

Probably all experienced engineers are to-day agreed that a period of practical training both in shops or works and drawing-office is of undoubted advantage to the engineer, much increasing the value of his services as an assistant, and adding to the weight of his advice and opinion at a later stage in his career. Important points for consideration are: (1) The class of workshop he should enter; (2) the class of work most likely to be helpful in his future career; and (3) the length of time which can be given to works and drawing-office training.

As the result of experience I am firmly convinced that the best type of workshop is one in which the materials used and the classes of work done should be as varied as possible. If repair and maintenance work is done so much the better.

It will generally be found that in a comparatively small works the youth's ability will be more fully utilised, the necessity for quickness and accuracy more quickly brought home to him, and he will also have the advantage of being more directly under the eye of the master.

As against this view, it is often considered that training with a well-known firm more than counterbalances the advantages obtainable in a small general workshop, and it must be admitted that training in a great works, especially if followed by a pupilage or subsequent experience in one of the best offices, is still looked upon as a good introduction to the profession, particularly for those desirous of taking up work of a public character.

For the youth who does not propose to remain in the workshop it is not, I think, so necessary that he should learn to equal the workman in his knowledge and ability to execute any one class of work as that he should acquire an intelligent knowledge of the processes and methods of treatment of the various metals and other engineering materials.

Perhaps of greater importance than anything else is the ability to form a correct opinion of the capability of the men in a workshop, a knowledge of their methods of thought and work, a study of the systems adopted to get work pushed through to completion, and generally such knowledge as will enable him to handle men advantageously when occasion requires.

The importance of obtaining some practical experience in a works' drawing-office should on no account be overlooked, as efficiency and speed as a draughtsman, combined with some ability to design, has been the first step in the rise of many men who have advanced to the higher positions in the profession.

It should also not be forgotten that the young engineer may at any time be called upon to proceed abroad to take charge of works under conditions wholly unknown in this country, and, speaking from my own experience, I can say that the knowledge of workshop practice in materials such as the metals, wood, stone, and cement, together with drawing-office experience, have been of the greatest assistance in settling points of importance when away from the experienced and helpful friends who are generally available for consultation in this country.

With regard to the period of time which should be given to practical work at this stage in the young engineer's career, I would, wherever possible, allow for three years in works and drawing-office, especially if, as in many cases, it is necessary or desirable that the youth should, on the completion of the additional period of study, desire to get a start in an office or works in this country.

It is my experience that a youth with three years' practical workshop training as a preliminary to his college education would have much less difficulty in getting a useful start in the profession than the youth who only had a college training. In the one case, having obtained his degree, he is probably well worth starting at once on a small salary and should pay his way on any class of work. In the other case, a considerable time will usually elapse before he settles down to real work, and it does occasionally happen that the university man's estimate of his own value as an assistant is not reached in practice for a considerable period.

What I understand to be the practical objection raised to the acquisition of practical experience before taking a college course is that young engineers are generally unable to keep up their ability to study or to improve their technical education during the practical training in workshops. I number amongst my friends a large number of men who obtained most of their theoretical training whilst working the full workshop and drawing-office hours at a time when the facilities for acquiring such knowledge were not by any means so general as they are to-day. I have, consequently, little sympathy with young engineers who cannot do so, or with those who think it necessary that young engineers should work a reduced number of hours in the workshop so that they may be able to give greater time to study and to improve their theoretical work. It used to be, and is, I believe, still, the almost universal workshop practice not to give important work to short-time men, and, therefore, a youth working short time is seriously handicapped in obtaining practical experience of value.

Short hours should not be allowed as a general practice, and though it may be a good thing to allow additional time for study, this should be within the works or under some form of control. I am aware of many cases in which these well-intentioned allowances of time for study have been abused, and I believe that even after a day's hard muscular work mental training may with advantage be continued, especially during the winter months, when little in the nature of healthy outdoor exercise is possible.

I can perhaps best conclude these remarks by relating an experience of my own when being shown over a Continental works by a young engineer under 21 years of age. He conversed quite easily with me in English, and from my inquiries I was satisfied that he had an excellent knowledge of the technical processes and of the results obtained in the works which he was showing me over. I also found he had a good knowledge of Spanish, and I understood that he was equally acquainted with three other languages in addition to his native language. I found he was a college student studying for his Doctor of Science degree. In his spare time he was being paid to conduct the foreign correspondence of the firm. I also found that a director of the works in question was a teaching professor at the university, and on consideration I came to the conclusion that both in the interests of the students, the manufacturing processes, and the professor himself, the arrangement appeared a good one.

It appears probable that if our youths of to-day cannot or will not stand the strain of the severe training which has in the past given good results, they will probably have to take a position behind those who are prepared to do so. It may on the whole be better that they should take up work better suited to somewhat easy-going methods, and it cannot be doubted that there are many lines of life in which young men can more easily and quickly acquire both money and position than in the engineering profession. Even with hard work, deep thought, foresight, organising power, a clear grasp of the situation, determination, and strong common-sense, success in engineering is not always assured.

* Read at meeting of Section III., held Thursday, June 29, 1911.

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*Workshop Training as a Preliminary to Practical Training in other Branches of Engineering.**

By JOHN MITCHELL MONCRIEFF, M. Inst. C.E.

IN the consideration of the training of students entering the engineering profession without intending to follow the purely mechanical branches, there is no question more frequently raised than that of the desirability, or otherwise, of a training in the workshops of a mechanical engineer. Those engineers who in the past have had the benefit of such a training generally hold that it has been of the greatest benefit to them in their subsequent career.

It will be of use to consider the question in the following form:—What ought the student to learn during such a period of workshop training, and how does the knowledge to be gained during this period bear upon subsequent practical work in other branches of engineering?

In dealing with this question it is only possible to touch upon some of the more important points in an introduction to a discussion.

(1) The student will, or ought to, learn the value of discipline and the necessity of order, punctuality, and continuity in work.

(2) He will acquire a personal knowledge of the various materials used in the manufacture of machinery. This personal knowledge is entirely different from anything which can be obtained by any amount of reading or laboratory work. He will actually feel the materials as he works with them, and his knowledge not only of what can be done, but of what can reasonably be done with them, will be greatly extended.

(3) He will learn the use of hand and machine tools, and how much can reasonably be done in a given time with their aid under ordinary commercial working conditions. I do not mean that the student will thus acquire a complete knowledge of working costs, but he ought insensibly to develop that most valuable faculty of being able to judge whether this or that method of work is the more economical, and as to whether it is suitable to the materials being dealt with.

(4) He will see the order in and foresight with which work is distributed throughout the shops so as to ensure

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that the whole, though composed of innumerable units, shall all work to one common end with due regard to economy.

(5) By working at the vice, the lathe, the pattern-makers' bench, in the smithy, in the foundry, or in the boiler-shop or bridge-yard, he will learn the various processes through which work passes, and he should become imbued not only with the scientific side, but, at this stage, still more importantly with the commercial side of engineering work.

(6) By working side by side with workmen he will have the opportunity of studying their characters and modes of thought. He will learn what a man may reasonably be expected to do, and also what it would be foolish to require of him. My personal experience is that workmen have a keen scent for a man who has worked alongside of them and is qualified to sympathise with their difficulties or justly to condemn their deficiencies. The influence of an engineer who has had such personal contact is immeasurably superior to that of one who has merely had a bowing acquaintance with labour.

The value of such personal contact is not confined to influence over workmen; it extends to subsequent business life when dealing with experienced engineers, whether consulting or manufacturing, and especially the latter, who not seldom make the criticism that such and such an engineer "has no real practical knowledge of the work. He merely is a paper man."

(7) The student in the works should also begin to learn some of the limitations of the application of science to practical work. It is, or ought to be, common knowledge that that which on the surface appears scientifically desirable may be practically foolish and wasteful both of time and money.

(8) If the student's mind be of true engineering bent he will unconsciously acquire a knowledge of the relative proportions of details of machinery and structures, and his eye and mind will be trained by the daily study of work which embodies the accumulated experience and extended study of others who are preceding him in the same walk of life.

(9) A period of training in the practical side of mechanical engineering will impress on the student the great importance of accuracy. My own experience has been that if a youth be trained originally to appreciate the importance of a hundredth of an inch, he can easily be trained subsequently to deal with coarser measures, such as cubic feet or cubic yards. On the contrary, a man whose early training has been in cubic yards generally scorns any attempt to get him to think in hundredths of an inch, however important that small dimension may actually be.

(10) By working actually at vice or bench or machine in a dividend-earning concern, the student is brought into personal touch with the money-value of time, labour and plant, and is forced to realise that without full recognition of such money-value, success in everyday life will not be attained.

(11) A thorough grounding in all this valuable experience and knowledge is to be gained within the gates of a mechanical or structural engineering concern, and all within an area of comparatively limited extent.

No subsequent training on large works of construction can so fully and quickly and efficiently supply all the desiderata of training which have been outlined above.

(12) What important engineering work was ever carried out without the use of mechanical appliances?

Let us assume that a young man is placed as a junior assistant on the construction of docks, bridges, harbour works, or any large work. The first things which force themselves on his notice are locomotives, pumps, cranes, concrete-mixing machines, dredgers, piling-machines, sawmills, power-houses, air-compressors, electric plant, and machinery of great variety. He has also to deal with workmen of various kinds, skilled and unskilled.

All these are spread over a considerable area, and he will, in all probability, have but little opportunity of obtaining more than what has been described above as a mere bowing acquaintance with any one of them until troubles arise, as they invariably do, demanding that experience which ought to have been acquired by actual personal contact with men and things.

(13) Further, what can be expected of a designer of machinery, ships, bridges, structural steel and ironwork, water-works, gas-works, electric plant, or any other of the varied productions of engineering, if he has had no mechanical training? The answer may be given in the words of a works manager, who criticised the design of some of the details of dock-gates which his firm were carrying out to a consulting engineer's designs, as follows: "The work might almost as well have been made of solid silver."

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*Workshop Training as a Preliminary to Practical Training in other Branches of Engineering.**

By Professor JOHN JOSEPH WELCH, M.Sc., M. Inst. C.E.

IT is, I take it, admitted that a practical course of considerable duration under commercial conditions is necessary to the complete training of a student who desires to become fully equipped for entry into any one of the branches of engineering, although, possibly, in these days the fact requires somewhat more emphasis than was formerly necessary. Scott-Russell, writing in 1867 concerning the then newly-formed Royal School of Naval Architecture at South Kensington, stated that the question as to whether a theoretical or practical training best fitted an engineer for his profession had before then been the subject of much debate, and had been decided generally in favour of the practical course, a fact that Mr. Ellington also pointed out in his recent presidential address to the Institution of Mechanical Engineers. In the paper already referred to, Scott-Russell affirmed his conviction that both scientific and practical training were essential, and pointed out how this was attained in the arrangements made at South Kensington. Since that time much has been done to emphasise the need of proper scientific training, and few will be found to question the wisdom of the Council of this Institution in insisting upon a high standard of theoretical knowledge in those desiring membership. Also, and to at least an equal degree, their emphasis upon the need of practical training commands approval, and the unanimous opinion of the important committee, which reported to this Institution in 1906, that engineering training must include several years of practical work, as well as a proper academic training, is one which is not likely to be seriously challenged. The committee recommend that the practical training should, in general, commence with at least a year's work in mechanical engineering workshops, even for those who do not intend specially to devote themselves at a later stage to mechanical engineering; and the desirability and feasibility of this preliminary workshop training are the subjects which it is desired to open up for discussion by means of this note.

In considering the latter subject the point of view of the employer must always be borne in mind, for, however desirable the training may be, it is the employer alone who can make it possible; and whole-hearted co-operation between the employer and the engineering colleges is essential if the best results are to be obtained, and if the course recommended by the committee is to be generally adopted in practice. The committee, indeed, recognised that difficulties might be encountered in carrying out their suggestion, and anticipated that employers might consider the arrangement objectionable in their interests. This anticipation has not been falsified by experience, and it is known that in many cases objection has been raised to the apprentice leaving for college just at a time when he was becoming of distinct value to the employer.

In attempting to appraise the value of this preliminary training it seems convenient to consider separately the case of those students who intend following up what may be summarised as general mechanical engineering, and those who intend to devote themselves to branches of engineering in which machinery is not so extensively employed.

Dealing with the former case first, the student may, immediately after that period, desire to take up his college work, or he may continue his practical training in an office. In each case he would find the introductory workshop course helpful. Most colleges provide a course of study during the first year which is common to all sections of engineering, and the lectures on, say, applied mechanics are more easily comprehended by those students who have seen at close quarters and handled the machines and details taken for the illustration of principles. It goes without saying that these students find one great advantage of the early training in the ease with which they can understand the allusions to technical details in the specialised courses.

If, on the other hand, the student after his preliminary course goes into an office, he will, in all probability, be early introduced to specifications of work, and here again he will find his early experience useful in understanding the terms used. Or he may be employed drawing out details and fixing sizes, and his work at the shop will enable him to appreciate dimensions and proportions much better than he could hope to do without that experience.

Further, the lad who enters the works at a comparatively early age gets into closer contact with the workman, and the workman seems more willing to teach him at that stage than after the college period is passed. This close association in the works enables the student to gain the point of view of the artisan, a point of some importance to those who may subsequently be placed in charge of men. Then, again, this immersion into a commercial atmosphere immediately after leaving school comes as a pleasant break in his scholastic studies, introduces him to new interests, and enormously widens his outlook by the time he is called upon to take up his college work; and he does so with a better appreciation of the goal towards which he is tending than is possible to one without such preliminary training. It should, perhaps, be added that this early workshop experience is occasionally useful in convincing some young men who thought of taking up engineering as a profession that they had mistaken their vocation, and they have been able to select some more congenial sphere without any important loss of time. The discovery of unfitness would probably not have been made so early had the college training been taken first.

For all these reasons, then, it is considered that an introductory workshop course for those intended for the general mechanical engineering profession is of distinct importance; and it is significant that a similar course is now insisted on for German shipbuilders and engineers before taking their theoretical course at a high school, although former students were allowed to get their high-school training without such practical experience.

The length of training recommended by the Committee of this Institution seems adequately to meet all requirements; and it has been found that periods very materially in excess of one year, interposed between school and college, tend to make it difficult for the student to pick up again the threads of his interrupted mathematical and other theoretical studies.

Considering next the case of "Civil" engineers and others not so closely associated with the design and care of machinery, one speaks here with some diffidence on account of less intimate knowledge of all the conditions; but, remembering the increasing use of plant and machinery of all kinds in all branches of engineering, it seems that in this case also a preliminary workshop training must be of very distinct use. It will be obvious, without special reiteration, that some of the advantages claimed above are equally relevant to the "Civil" engineer. It would help him in his early college course and in his subsequent office work; and he would probably gain from the use of tools during this period a better idea of the mechanical properties of materials than he is likely to obtain at any subsequent stage.

The early training in the regularity and under the discipline inseparable from a commercial establishment is not to be lightly esteemed, and may easily influence the student for good throughout his subsequent career. It is arguable, however, that in the case considered, the preliminary course could be somewhat shortened as compared with that for the mechanical engineer, and that from six to nine months would furnish all the experience needed.

As already indicated, it is known that many employers do not favour this short introductory course preparatory to college training: and some question the wisdom of this latter training altogether. It has been stated that many students, who originally went to works with the idea of proceeding to college after twelve months, have been persuaded to continue their practical training to the completion of their apprenticeship, and to rest content with such theoretical knowledge as they could gain at evening classes after their day's work. On the other hand, there are other employers fully persuaded of the wisdom of this introductory course, and who give the necessary facilities.

It is hoped that employers will freely give the Conference the benefit of their experience in this important matter, to the end that the young engineer may receive the most perfect practical and theoretical training which experience can devise, to fit him for duties which seem ever increasing in complexity and responsibility.

* Read at meeting of Section III., held Thursday, June 29, 1911.

FOREIGN ENGINEERING PROJECTS.

WE give below several notes of colonial and foreign engineering projects. Further data concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C.

Canada: H.M. Trade Commissioner for Canada reports that tenders are invited by the Board of Commissioners of Montreal for the construction of the final filters and appurtenances in connection with the new city filtration works. The final filters are to be of concrete masonry, having a net filtering area of about six acres, and a height of from 20 ft. to 25 ft. Electrically-worked machines for cleaning the filters, apparatus for heating and ventilating them, and cast-iron piping and valves for conveying and controlling the water, are to be furnished. Sealed tenders, on the proper form, marked "Tender for Final Filters and Appurtenances," will be received at the office of the Board of Commissioners, City Hall, Montreal, up to noon on July 13. It will be observed that the time for the receipt of tenders is short, and this intimation will only be of use to those firms having agents in Canada who can be instructed by cable. A deposit of 65,000 dols. (about 13,350*l.*) is required with each tender. With reference to the proposed dredging of St. John Harbour East (Courtenay Bay), the Imperial Trade Correspondent at St. John, New Brunswick, reports that tenders are invited by the Department of Public Works, Ottawa, for the construction of a breakwater, and of wharves, the dredging of a channel and basin, and the construction of a dry dock and ship-repairing plant of the first class. Sealed tenders, on the proper forms, marked "Tender for Harbour Works in Courtenay Bay, St. John, N.B.," will be received by the Secretary, Department of Public Works, Ottawa, up to 4 p.m. on August 10. A deposit of 500,000 dols. (about 102,700*l.*) will be required with each tender. The *Daily Witness* (Montreal) publishes a notice inviting tenders for the construction of a section of about 185 miles of the Hudson Bay Railway—viz., from Pas Mission to Thicket Portage. Tenders, on the proper forms, marked "Tender for Construction of Hudson Bay Railway," will be received at the Department of Railways and Canals, Ottawa, up to 4 p.m. on August 1. Each tender must be accompanied by an accepted bank cheque for 200,000 dols. (about 41,100*l.*). The *Witness* also states that tenders are shortly to be invited for the construction of the Halifax and Eastern Railway, and of the line round the north shore of the Bras d'Or Lakes in Nova Scotia.

Switzerland: H.M. Vice-Consul at Zurich reports that tenders are invited by the Swiss Federal Railways Administration for works in connection with the construction of a tunnel 8135 m. in length between Tecknau and Olten. Tenders, marked "Tunnel du Hauenstein," will be received at the Direction Générale des Chemins de Fer Fédéraux, Berne, up to July 31.

Mexico: The *Diario Oficial* contains the terms of a contract under which Mr. William Hann McLachlan is granted a ninety-nine years' concession for the construction of a railway in the State of Mexico—viz., from Toluca to Caleras, passing close to Villa del Valle. Six years are allowed for the completion of the line, and five years are permitted during which construction material may be imported duty free.

Argentine: With reference to the contract for port works in the Military Port at Bahia Blanca, H.M. Consul at Buenos Aires reports that the successful tenderers were Messrs. Dickerhoff and Widman, Limited, of Nuremberg, and Mr. F. H. Schmidt, of Altona. The *Boletin Oficial* contains a decree approving the plans, drawn up by the General Directorate of Railways, for the construction of a section, 50 miles in length, of the Puerto Deseado-Lago Buenos Aires line. The cost of the work is estimated at 1,624,000 pesos gold (about 325,000*l.*), which amount includes the rolling-stock,

THE WORKS OF MESSRS. BROWN, BOVERI, AND CO., BADEN.

AMONGST the important engineering establishments to be inspected by the members of the Institution of Mechanical Engineers during their summer meeting in Switzerland this month, the first to be visited will be that of Messrs. Brown, Boveri, and Co., at Baden. The firm named was established as a private company in 1891 by

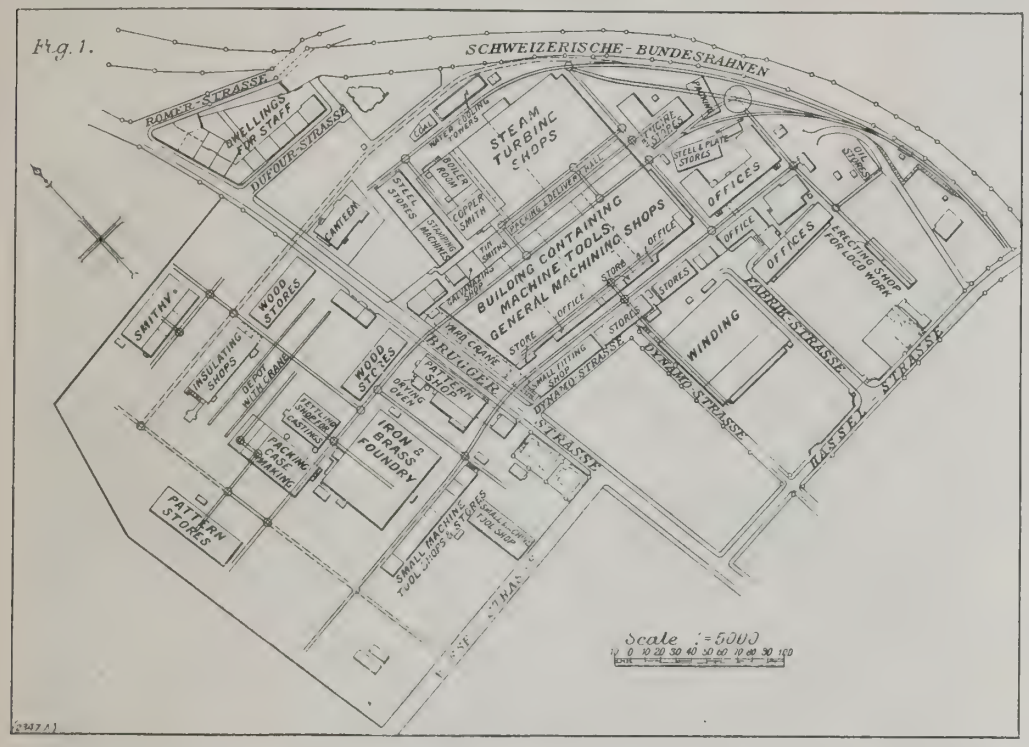


FIG. 2. GENERAL VIEW OF WORKS.

many, and this was also transformed into a share company in 1900. During 1902 they founded the Compagnie Electro-Mécanique at Le Bourget, near Paris, and in 1904 the Tecnomasio Italiano Brown, Boveri, Milan. This latter was enlarged in 1908 by amalgamation with the Unione Elettrotecnica Italiana and Gadda and Co. Branch establishments were then founded at Christiania in 1905, in London during 1906, and at Vienna, Budapest, and Rotterdam in 1910. In 1910, also, Messrs. Messrs. C. E. L. Brown and W. Boveri, and suitable works were built by them at Baden, near Zurich. At these works they manufactured almost exclusively electrical machinery up to the beginning of 1900. In 1900 the company was transformed into a share company with a capital of 12,500,000 francs (500,000*l.*), that undertook the manufacture and further development of the Parsons steam-turbine. In the early days of the company—*i.e.*, in the years 1892 and 1893—the total number of people employed by them was under two hundred, whereas at the present time the Baden works have a total staff of 3700. Taking into account their works and agencies at Baden, Mannheim, Paris, Milan, Christiania, London, Vienna, Budapest and Rotterdam, Messrs. Brown, Boveri, and Co. employ a total staff of over 10,000.

As far back as 1898, Messrs. Brown, Boveri, and Co. established a branch at Mannheim, Germany, and this was also transformed into a share company in 1900. During 1902 they founded the Compagnie Electro-Mécanique at Le Bourget, near Paris, and in 1904 the Tecnomasio Italiano Brown, Boveri, Milan. This latter was enlarged in 1908 by amalgamation with the Unione Elettrotecnica Italiana and Gadda and Co. Branch establishments were then founded at Christiania in 1905, in London during 1906, and at Vienna, Budapest, and Rotterdam in 1910. In 1910, also, Messrs. Brown, Boveri, and Co. took over the share capital of the Elektrizitäts-Gesellschaft Alioth, München-stein-Bâle, and also that of the Isaria-Zähierwerke, Munich. Both these works now practically belong to Messrs. Brown, Boveri, and Co.

The works of the firm at Baden, which will be visited by the members of the Institution of Mechanical Engineers on Monday, the 24th inst., occupy at the present time an area of 380,000 square metres (450,000 square yards), of which 45,000 square metres (53,800 square yards) is covered by the various shops and buildings. The accompanying plan, Fig. 1, shows the Baden works as they now stand.

Before entering into a detailed description of the sundry departments, a few general particulars may here be given. All the bays, forming the different shops, are served by overhead electric travelling-cranes, forty-two in number, with lifting powers ranging from 2 to 30 tons, these cranes being driven by 126 electric motors. The various shops contain a total of over 1700 machine-tools, among which are a large number of the latest types of American automatic and semi-automatic machines. All these machines are driven, either separately or in series, from overhead transmission shafts through belting, by means of over 320 electric motors developing a total of about 2200 horse-power. The average current consumption for light and power amounts to about 1300 kilovolt-amperes. The current required is supplied by the two hydro-electric generating stations of the town of Baden, and also, in case of need, by the generating station of Beznau-on-the-Aar.

The rapid development of the company is principally due to the high quality and excellent workmanship of their products, and also to the special interest which the firm have taken in alternating-current technics, and the advocacy of the use of alternating current at a time when the practical use of this form of current was new and required development. The firm were also the first to introduce the use of the Parsons steam-turbine on the Continent, and to recognise its great value. Licenses were taken out by them for the greater number of the Continental countries, and they were so successful in modifying the constructional details to meet the demands of Continental practice that the Parsons steam-turbines, as constructed by Messrs. Brown, Boveri, and Co., were the first to replace the reciprocating type of engine in most of the electric generating stations on the Continent.

At first, as is well known, the power of a single unit rarely exceeded 3000 horse-power, but great progress has been made since then, and as an instance of this it may be mentioned that Messrs. Brown, Boveri, and Co. have now in course of construction several steam-turbines of 25,000 horse-power, and have on order, in their diverse works, at the present time, turbines for an aggregate horse-power of 750,000. These large units, and also the large marine turbines which the Mannheim works supply to the German Navy, under agreement with the "Turbina" Deutsche Parsons Marine A.-G., Berlin, are built at the Mannheim works. Their Baden works are laid out more especially for the construction of the smaller and medium-size turbines. They have, however, in hand at the present time at these latter works two large units, one of 18,000 horse-power for Buenos Aires, and one of 25,000 horse-power for the Rheinische-Westfälische Elektrizitäts-Werk, Essen.

Since the date at which they commenced the construction of steam-turbines, in 1900, Messrs. Brown, Boveri, and Co. have built over 1100 such engines, having a total of over 2,700,000 horse-power, distributed among current-generating stations and practically every industrial application, including mining, metallurgy, paper and textile works, marine propulsion, &c. The development

in the use of the steam-turbine for industrial purposes has been assisted in a marked degree by the well-known pioneer work which Messrs. Brown, Boveri, and Co. have done in connection with the design of alternators.

Notwithstanding the fact that the steam-turbine has always been from the very beginning an economical prime mover, strong efforts have been and are constantly being made to increase still further its advantages, and, as a result, important improvements have repeatedly been introduced. Thus several years ago the Parsons turbine of the pure reaction type was fitted with an impulse wheel for the purpose of utilising the very high pressure stages, this improvement embodying the double advantage of keeping the high temperatures out of the cylinder and making a much shorter design of turbine possible.

Messrs. Brown, Boveri, and Co. have also given their attention to the development of condensing plant. They now build for surface-condensing installations five different sizes of pumping sets, having on one and the same shaft the circulating, air, and condensed-water pumps, besides the impulse steam-turbine for driving the whole. Similar pumping sets are also built for electric-motor drive. Among their advantages are extreme simplicity and safety in running, and they occupy but a limited space, while allowing the very highest vacua to be reached. The firm also build turbo-compressors and blowers, which can be direct coupled to high-speed electric-motors or steam-turbines. The conditions under which these machines work often require a varying output, and this being obtained by speed variation, the steam-turbine is admirably suited for driving.

As is well known, Messrs. Brown, Boveri, and Co. were the pioneers in applying three-phase current to traction on railways, and the lines they have thus equipped are known as representative types, such, for example, as the Burgdorf-Thun line, built in 1899, the first of its kind, and the electrification, in 1905, of the Simplon Tunnel line. In this connection a passing reference may be given to other interesting lines which have been equipped by them, among which are the Seetalbahn, 5500 volts, single-phase; the Martigny-Orsières line, 8000 volts, single-phase; the Gergal-Santa Fé line, South Spain, 5500 volts, three-phase. They have in hand at the present time equipments for the Wiesenthalbahn, 15,000 volts, single-phase; for the Prussian State Railway, Dessau-Bitterfeld, a 600-horse-power goods locomotive, 15,000 volts, single-phase; for the French Southern Railway, 12,000-volt single-phase locomotives; for the Rhätische Bahnen, seven locomotives, 10,000 volts, single-phase.

Among their other specialities may be mentioned that they have designed a system of electric train-lighting apparatus which has been adopted, to the exclusion of all others, by the Swiss Federal Railways; 900 such apparatus have been supplied by them to the Paris-Orleans Railway Company, who have recently ordered 160 more. They also build heavy electric-motors for all kinds of current, and have supplied recently one of 2500 horse-power for rolling-mill driving at the Dudelingen Works, this being for three-phase alternating current; also direct-current winding motors for mines—viz., the Rastenberg, Volkenroda, La Mourière, Mauveschacht Mines, and others. Of late, the double-commutator motor, of the Déri type, has found favour as a winding motor, owing to its easy reversibility, and the range of power over which it is capable of regulation. Their single-phase commutator motors are finding extensive application for the direct driving of ring spinning-frames, cranes, &c.

The general arrangement of the Baden works is, as we have stated, shown by the plan, Fig. 1, above referred to, while a general view is given in Fig. 2, page 47. A good idea of the various shops and of the work they turn out is afforded by the views, Figs. 3 to 19, which we publish this week on Plates VI. to IX., and on the present page. Of these illustrations Fig. 4 shows a steam-turbine of 3000 horse-power running at 3000 revolutions, coupled direct to a three-phase generator of 2000-kw. capacity at 3150 volts and periodicity of 50. Fig. 5 illustrates a blast-furnace blower of a capacity of 32,000 to 25,000 cub. ft. of air per minute at a pressure of 11 lb., 18 lb., and 24 lb. per sq. in. This was built to be coupled direct to a Rateau turbine to develop from 2000 to 2800 horse-power. Fig. 6 shows a blower built for steel works, of a capacity of 5300 to 28,250 cub. ft. per minute at 35.6 lb. to 5.7 lb. per sq. in. This is shown coupled direct to a Brown-Boveri turbine of 3250 horse-power running at 2500 revolutions with steam at 128 lb. pressure, superheated to 250 deg. Cent. Fig. 7, Plate VII., is an illustration of a turbo-compressor set of 4060 cub. ft. per minute at 85 lb. pressure, driven by a Brown-Boveri exhaust-steam turbine of 740 horse-power at 3800 revolutions, for a French colliery company. Fig. 8 represents another turbo-compressor set of 2225 cub. ft. capacity, direct coupled to a 500 horse-power Brown-Boveri-Parsons turbine running at 4500 revolutions, using saturated steam at 7 kg. per square centimetre (99 lb. per square inch). direct to a 7000-horse-power water-turbine at a speed of 128.5 revolutions; the generator is a 3200-volt 45-period machine. Fig. 19, subjoined, represents the erecting-shop for large generators and motors, and shows a stator for a 17,000-kilovolt-ampere 10,500-volt, 50-period generator for a speed of 250 revolutions.

In close proximity to the offices is a large building, which covers the older part, if we may so style it, of the plant. In this are carried out a large number of mechanical operations, mostly in connection with electrical machinery. The building measures 170 m. (557 ft.) in length, and 60 m. (197 ft.) in width. It contains a large variety of lathes for all the detail parts entering into the

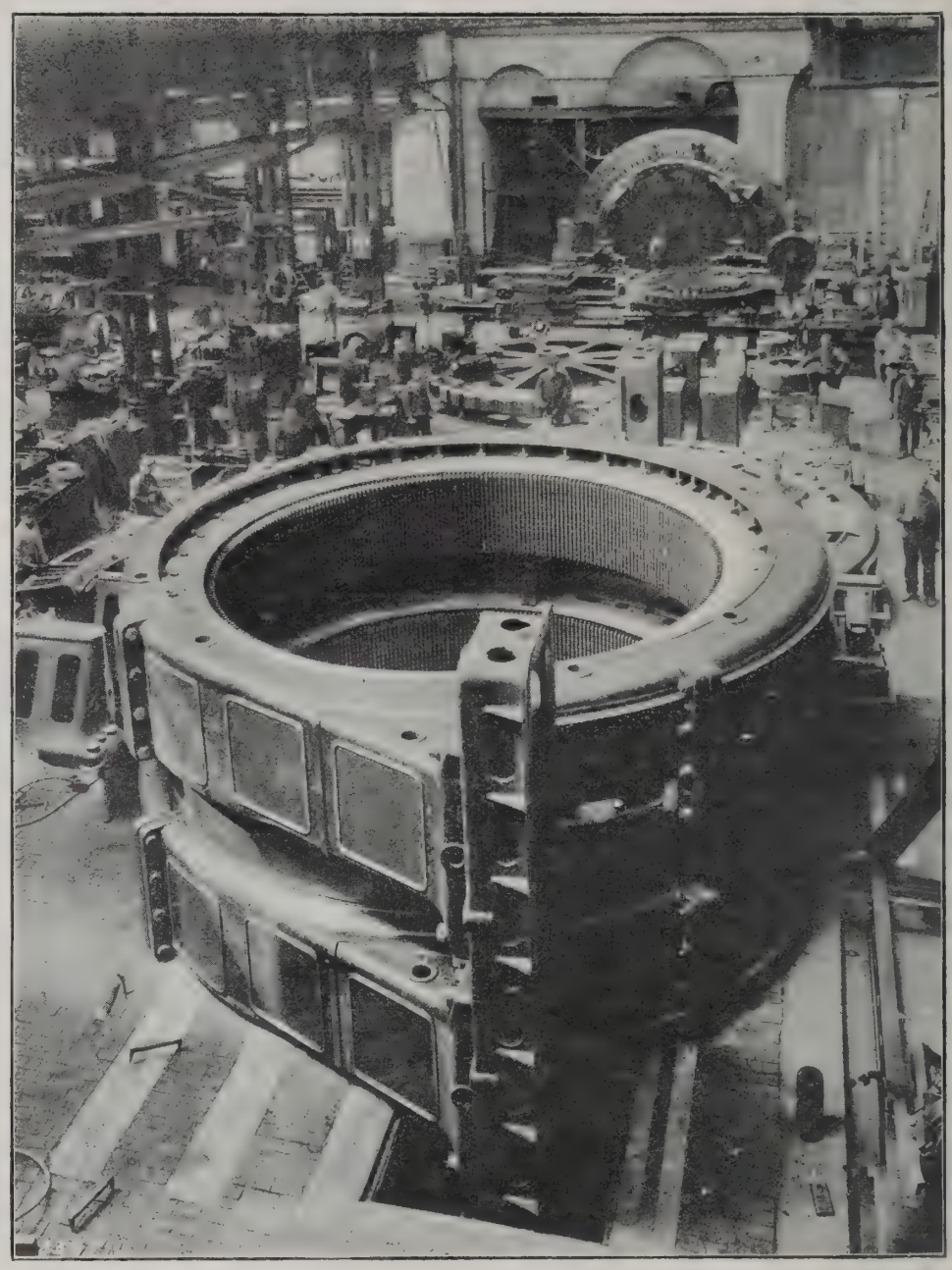


FIG. 19. ERECTING-SHOP FOR LARGE GENERATORS AND MOTORS.

Fig. 9 shows two blast-furnace blowers of 25,000 cub. ft. capacity per minute each. Fig 10 is a view in the compressor fitting and erecting shop. Fig. 11, Plate VIII., illustrates a 30,000-cub.-ft. blower direct coupled to a 450-volt continuous-current shunt-wound motor of 1100 horse-power at 1770 to 2000 revolutions. Fig. 12 illustrates condensing-pump sets in one of the testing-rooms. Fig. 13 is a view in the transformer, motor, and generator winding-room. Fig. 14 represents the winding-shop for slow and high-speed motors and generators. Fig. 15, Plate IX., illustrates the segments of a stator for a three-phase 4850-kw., 3200-volt, 45-period generator at 128.5 revolutions. Fig. 16 is a view in the erecting-shop for alternating and continuous-current motors. Fig. 17 shows the erecting-shop for double commutator motors. Fig. 18 illustrates a three-phase generator for coupling construction of electric dynamos and motors; automatic screw-cutting machines for screws and bolts; semi-automatic Gisholt lathes, which are mostly used for turning the covers, spiders, and other elements of electric motors, each piece being finished at one setting on the machine; other semi-automatic lathes for repetition work; a variety of grinding-machines for shafts, of milling machines, &c. All the smaller machine-tools are driven by belting from overhead shafts, the larger ones having separate electrical drives. The whole of the power used throughout the works is obtained from the hydro-electric stations above referred to, and two-phase current at 110 volts is employed, this also applying to the lighting. The western end of the building is occupied by lathes for turbine work and by an erecting-shop for low-speed generators, for commutators, and for single and three-phase motors.

On two sides of this same building are two

THE WORKS OF MESSRS. BROWN, BOVERI, AND CO., BADEN, SWITZERLAND.

(*For Description, see Page* 45.)

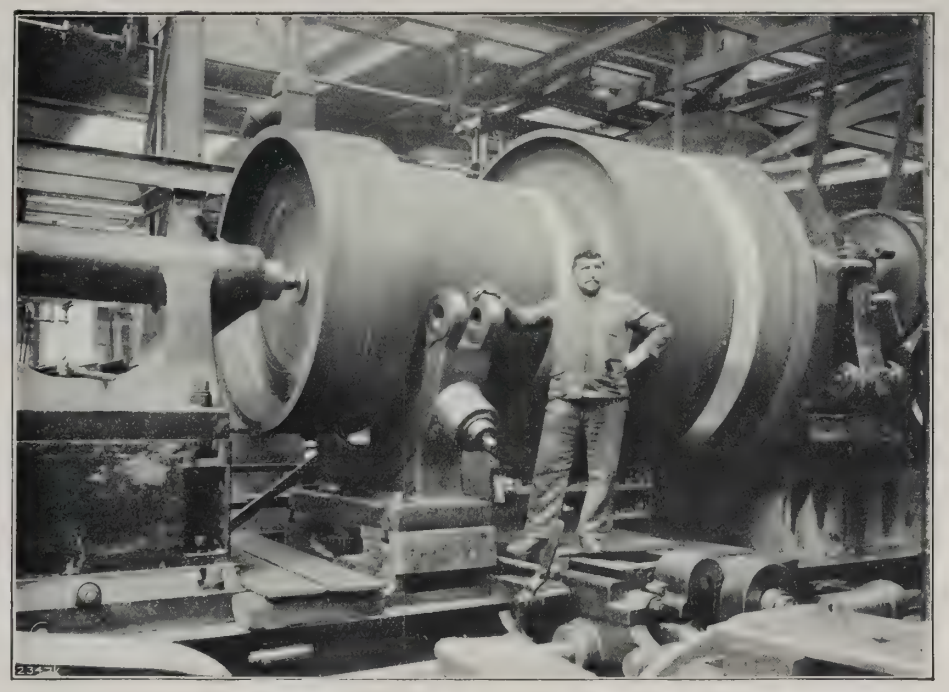


FIG. 3. STEAM-TURBINE ROTOR IN LATHE.

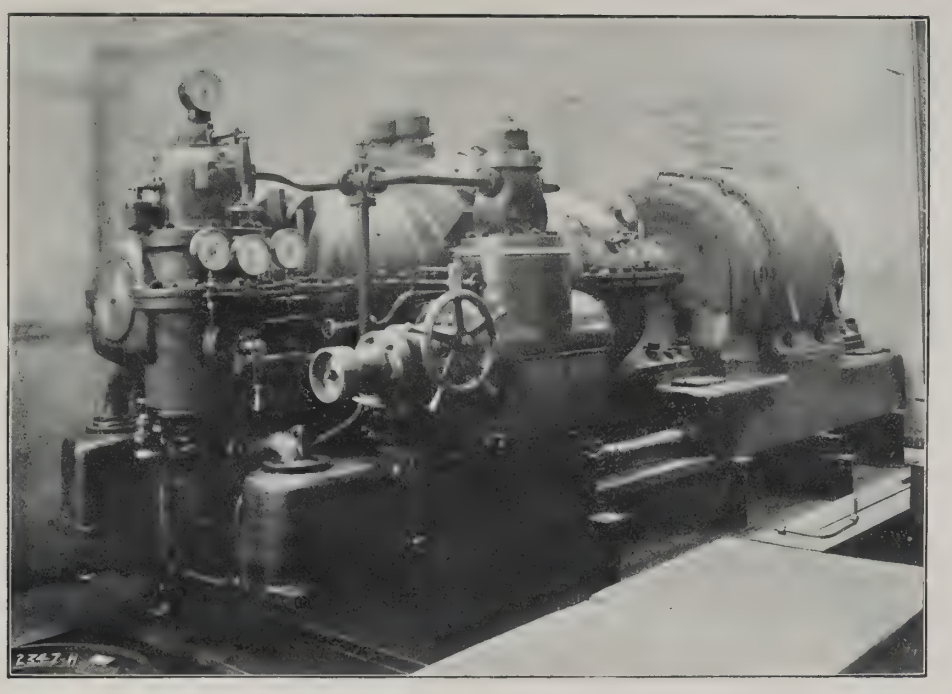


FIG. 4. 3000-H.-P. TURBINE COUPLED TO 2000-KW. THREE-PHASE GENERATOR.

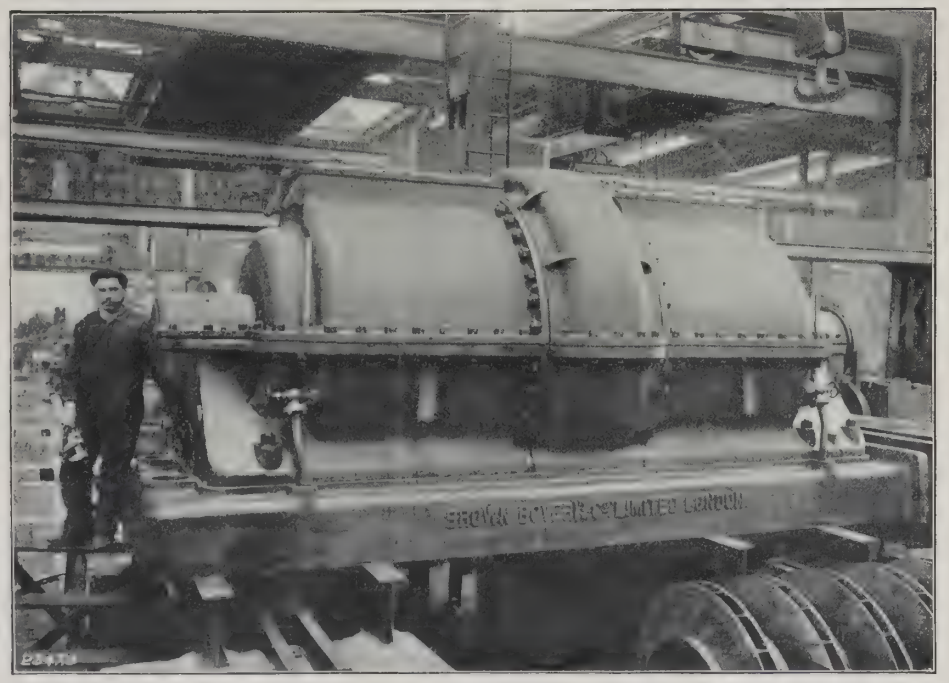


FIG. 5. BLAST-FURNACE BLOWER; 32,000–25,000 CUB. FT. CAPACITY PER MINUTE.

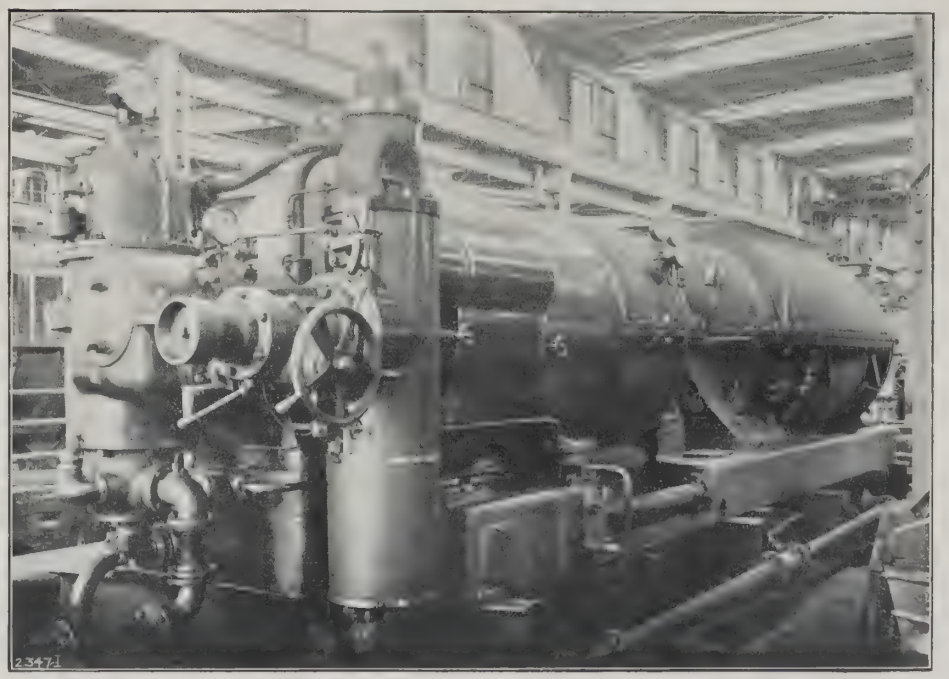


FIG. 6. BLOWER FOR STEEL WORKS, 5300–28,250 CUB. FT. CAPACITY PER MINUTE, COUPLED TO BROWN BOVERI 3250-H.-P. TURBINE.

(*To face Page* 46.)

THE WORKS OF MESSRS. BROWN, BOVERI, AND CO., BADEN, SWITZERLAND.

(*For Description, see Page* 45.)

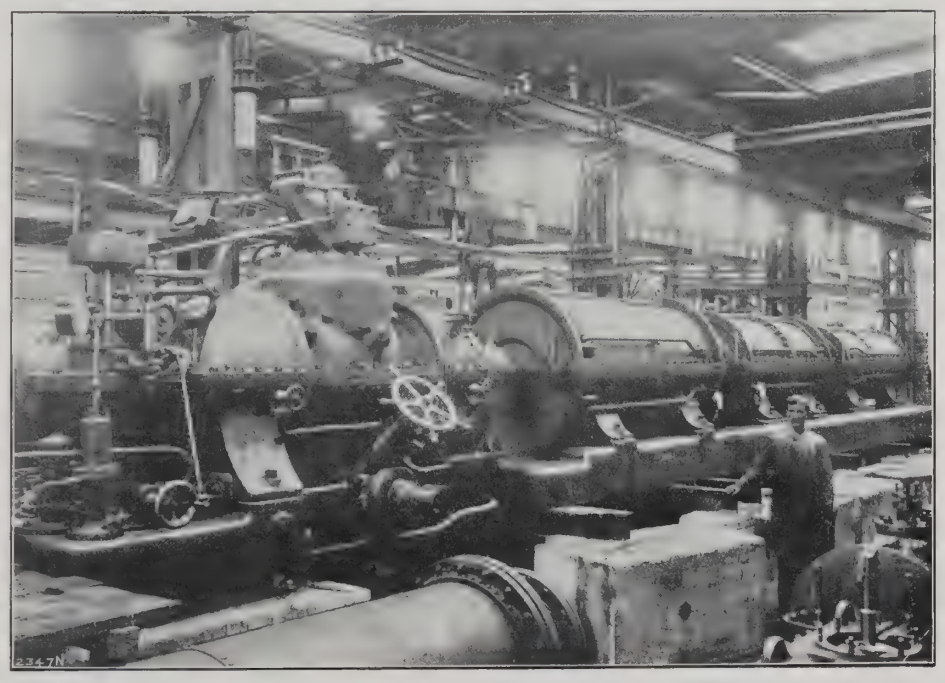


FIG. 7. 740-H.-P. TURBINE COUPLED TO COMPRESSOR OF 4060 CUB. FT. CAPACITY PER MINUTE, AT 85 LB. PER SQ. IN. PRESSURE.

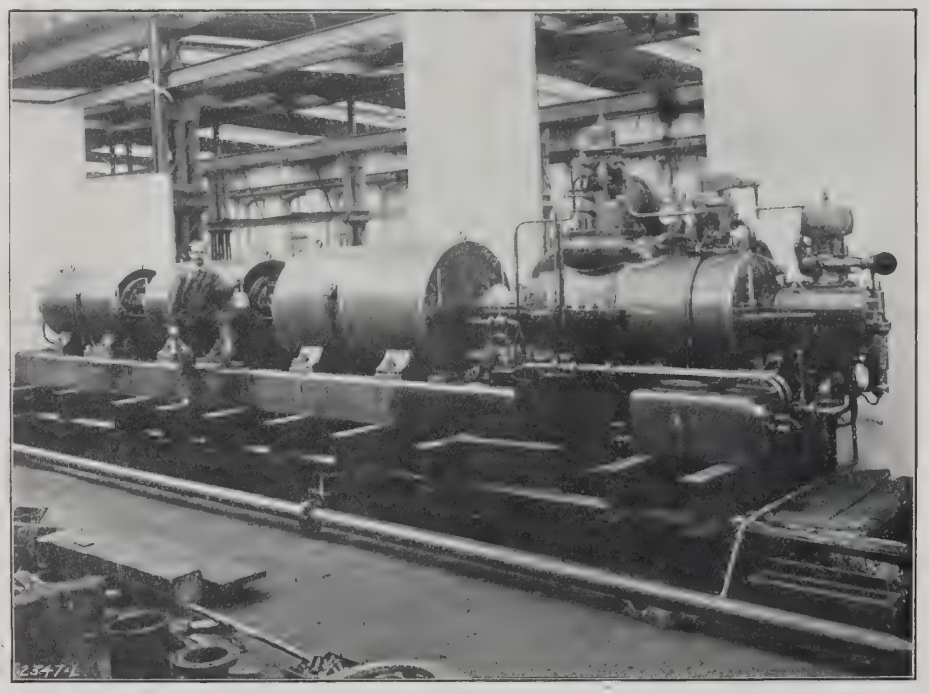


FIG. 8. 500-H.-P. TURBINE COUPLED TO COMPRESSOR OF 2225 CUB. FT. CAPACITY PER MINUTE, AT 78 LB. PER SQ. IN. PRESSURE.

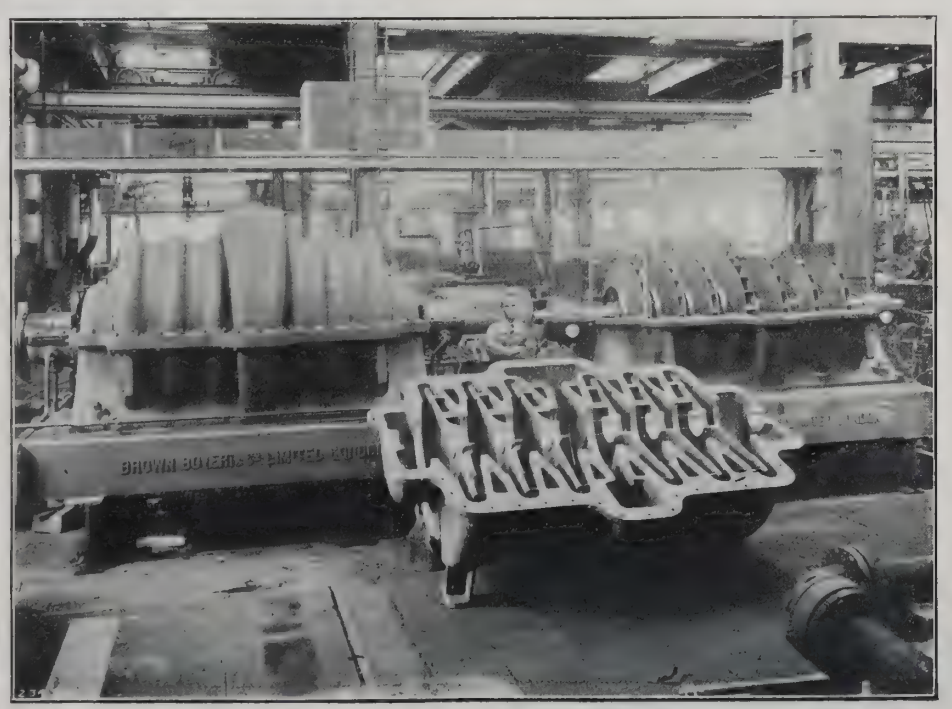


FIG. 9. TWO BLAST-FURNACE BLOWERS, 25,000 CUB. FT. CAPACITY PER MINUTE.

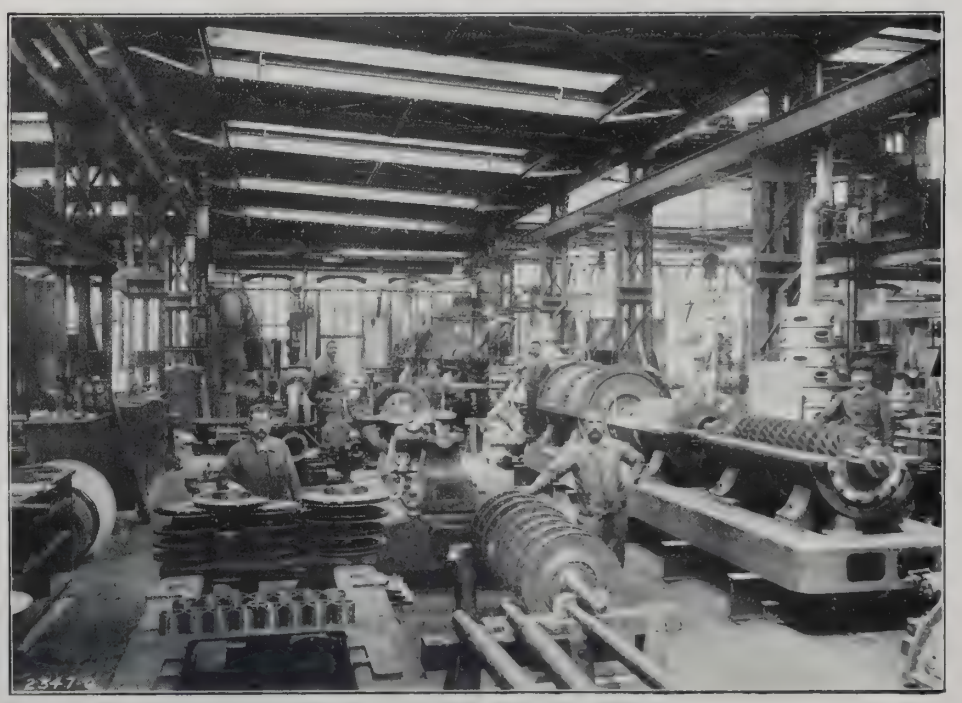


FIG. 10. COMPRESSOR FITTING AND ERECTING SHOP.

THE WORKS OF MESSRS. BROWN, BOVERI, AND CO., BADEN, SWITZERLAND.

(*For Description, see Page* 45.)

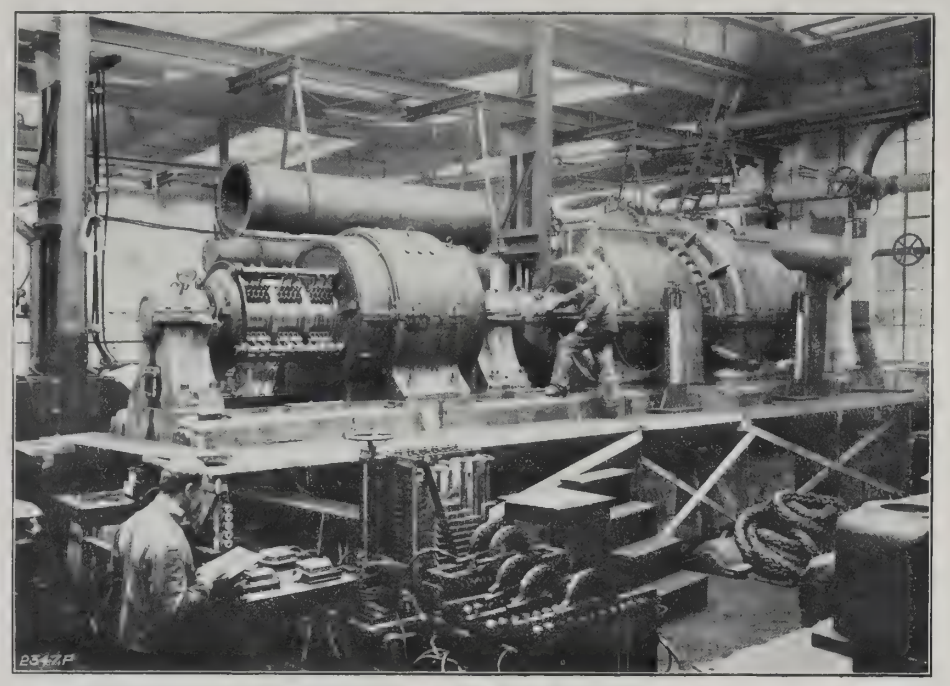


FIG. 11. ELECTRICALLY-DRIVEN TURBO-BLOWER OF 30,000 CUB. FT. CAPACITY, UNDER TEST.

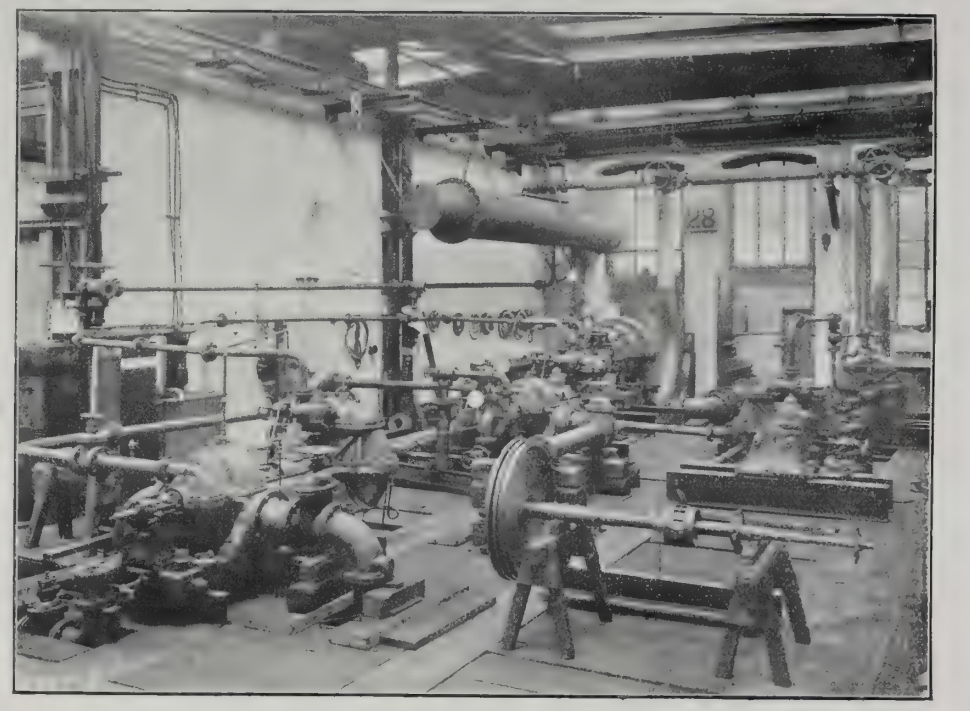


FIG. 12. CONDENSER-PUMP SETS UNDER TEST.

FIG. 13. WINDING-SHOP; TRANSFORMERS, MOTORS, AND GENERATORS.

FIG. 14. WINDING-SHOP; SLOW AND HIGH-SPEED MOTORS AND GENERATORS.

THE WORKS OF MESSRS. BROWN, BOVERI, AND CO., BADEN, SWITZERLAND.

(*For Description, see Page* 45.)

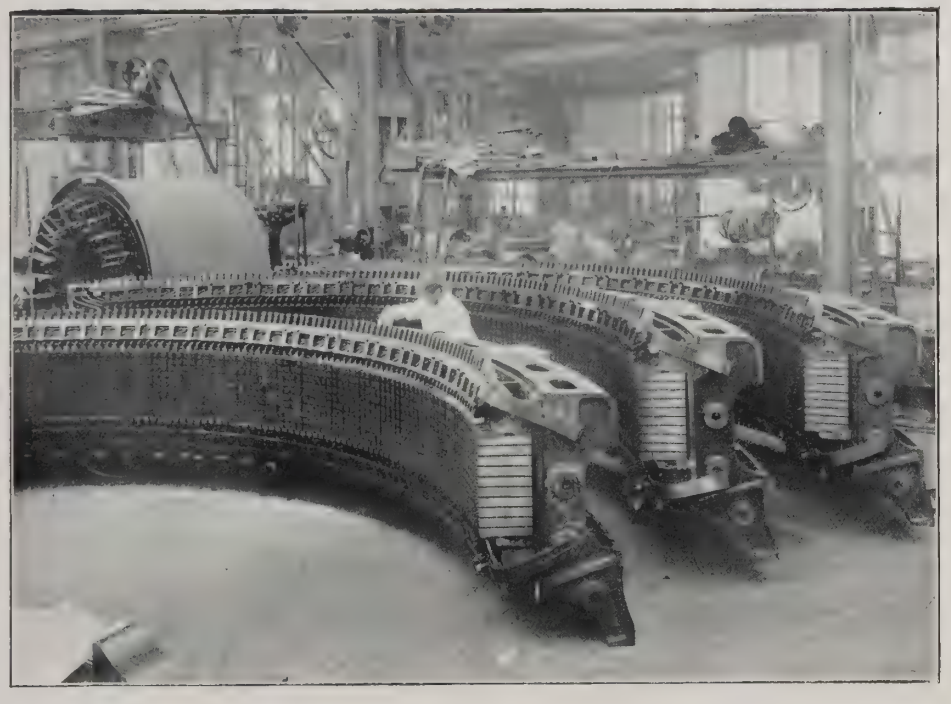


FIG. 15. WINDING SEGMENTS OF THREE-PHASE 4850-KW. GENERATOR.

FIG. 16. ERECTING-SHOP; ALTERNATING AND CONTINUOUS-CURRENT MOTORS.

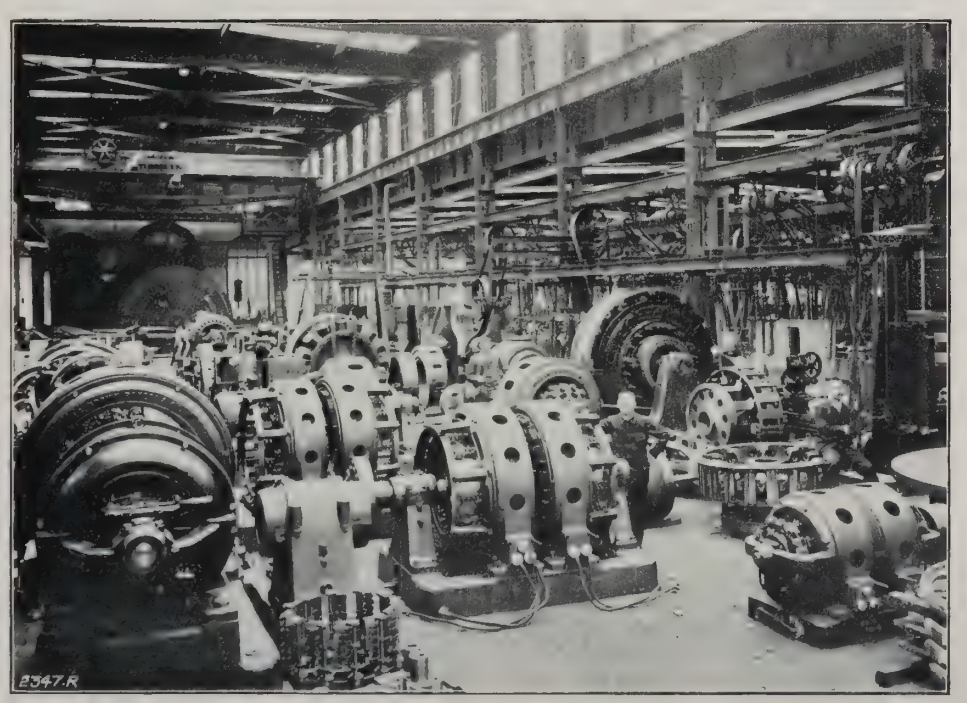


FIG. 17. ERECTING-SHOP; DOUBLE COMMUTATOR MOTORS.

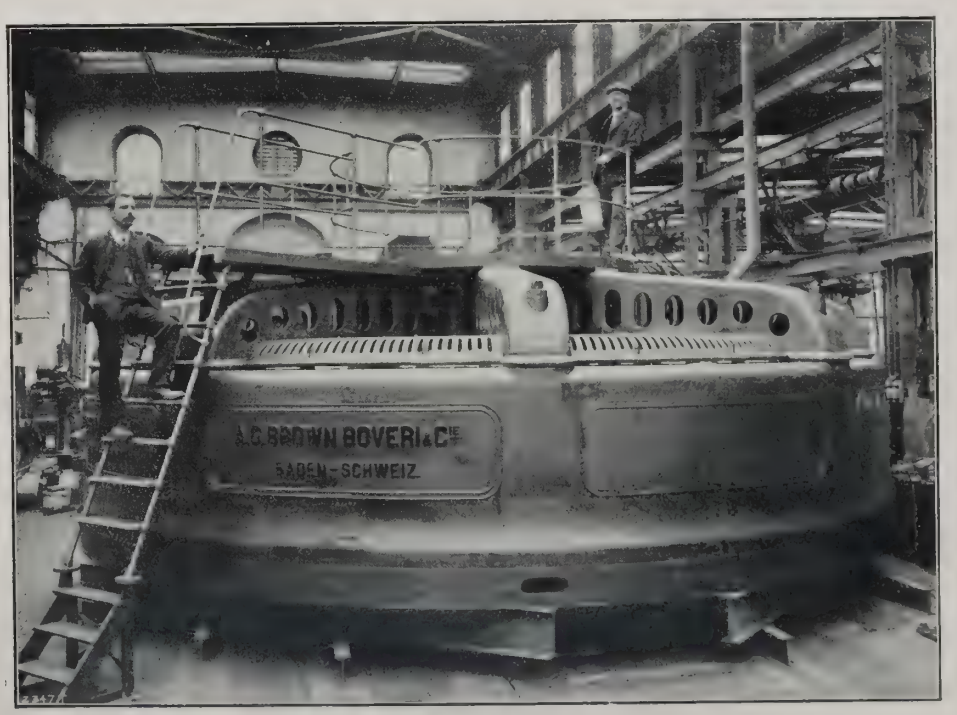


FIG. 18. ERECTING-SHOP; THREE-PHASE GENERATOR FOR COUPLING DIRECT TO 7000-H.-P. WATER TURBINE

inspecting departments for the checking of the detail parts entering into the construction of electrical machinery and steam-turbines.

Close to one of the inspecting departments, and in an underground room, is a measuring-machine made by Messrs. Pratt and Whitney, placed here for the purpose of assuring a constant temperature. This machine enables errors in measurement down to a thousandth of a millimetre to be detected, and is of great service in enabling the engineers to maintain their gauges perfectly accurate. Close to this is a tensile testing-machine for ascertaining the strength, elastic limit, and elongation of iron, steel, and different alloys used throughout the works, also the strength of turbine-blades fitted in their groovings.

In the same building there are three large horizontal and vertical milling-machines for grooving the armatures for high-speed generators, and for cutting keyways in large shafts. Also gear-cutting machines for cutting gears on the revolving system up to a diameter of 2 m. (6 ft. 6 in.). There is also a high-speed milling-machine which has a feed of 550 mm. (21.5 in.) per minute, taking a cut of 10 mm. ($\frac{3}{8}$ in.) deep and 100 mm. ($3\frac{15}{16}$ in.) broad; and, in addition, a number of millers equipped for general work. The bays in this building, as in all the others throughout the works, are equipped with electric overhead travelling-cranes for loads ranging from 2 to 30 tons, as above stated, according to the work to be handled in each respective bay.

The turning-shop contains lathes of different makes, these being used for turning steam-turbine parts and those of electric generators. Among them are heavy lathes for machining large turbine-shafts. In Fig. 3, Plate VI., is shown one of the large lathes for turning turbine rotors. The low-speed generator erecting-shop, which adjoins the turning-shop in the western end of the building, contains an hydraulic press for pressing the armatures and bearing-ends on the shafts.

In a line with this building is the pattern-shop, having two floors, the larger patterns being manufactured on the ground floor. This shop is equipped with modern machinery, exhausters for removing the dust, chips, &c., being fitted to each machine. Adjoining the pattern-shop are the iron and brass foundries, as shown in the plan, Fig. 1. Both foundries contain a number of moulding-machines for moulding in series small cast-iron and brass pieces.

The steam-turbine fitting and erecting department is parallel with the machining building. It is 95 m. (312 ft.) in length and 60 m. (197 ft.) in width, and is divided into eight bays. The first bay on the east side is set apart for general grinding work, and forms also a repair shop for carrying on the general repairs to machinery throughout the works. On the floor above this is the tool-making department, thoroughly equipped for the manufacture of all kinds of tools, jigs, and gauges used in all the machine-shops, including cutters, reamers, spiral drills, taps, &c., all being hardened and ground. Each shop throughout the works has its own tool-room, which is kept regularly supplied with tools for repeat work from a tool-store, in which all the tools are admirably classified. In fact, the cutting-tools and gauges manufactured by Messrs. Brown, Boveri, and Co. for their own use are most excellent specimens, which compare favourably in every respect with those of other firms who have made tool manufacture their speciality.

In the next bay of the steam-turbine fitting and erecting department is the erecting-shop for high-speed electric generators for coupling to turbines. Then follows the erecting-shop for turbines, blowers, and compressors, and condensing machinery; and the boring-mill shop, which has a series of horizontal boring-machines for boring cylinders up to 4 m. (13 ft.) in diameter and 7 m. (23 ft.) in length. The remaining bays are set apart for the erecting of all turbine work.

At the western end of this same building, and close to the boiler-room, are two steam-turbines which act as a stand-by to supply current throughout the works for power and lighting, should an accident occur to the hydro-electric current-generating stations above mentioned. These turbines are coupled to two-phase generators. In the same bay is another very interesting feature of the works —viz., the highly developed turbo-generator testing department. This consists of a battery of five boilers for the generation of steam up to the highest temperatures for testing purposes, and a duplicate condensing system connected up to the ten beds on which sets can be simultaneously or independently tested. All turbo-generators are tested before leaving the works.

Alongside the boiler-house is the coppersmiths' and pipe-shop, and in close proximity are the sheet dépôt and the stamping-shop for the manufacture of stampings for dynamo armatures.

The winding-shop for the manufacture of field-coils for machines of all sizes and powers is a separate building, measuring 50 m. (197 ft.) square. It also contains the transformer department and a testing-room. This winding department forms one of the most interesting features of the works, as it is admirably equipped in all respects. It includes the manufacture of transformers, and contains a complete installation for drying the transformers; in this the complete transformer, up to the largest size and for the highest tension, is placed in a vacuum stove filled with its oil, and in this way all moisture is removed. In an upper storey of the same building is the winding section for small motors, &c., where female labour is mostly employed.

Various other shops and stores are distributed at convenient positions throughout the works, as shown in the plan (Fig. 1). The smithy, a clean, carefully-lighted and ventilated shop, is at the north end of the works. It measures 50 m. (164 ft.) in length and 25 m. (82 ft.) in width, and contains three steam-hammers served by open fires, and two re-heating furnaces. Messrs. Brown, Boveri, and Co. purchase their large forgings and about two-thirds of their castings from outside sources. Close to the smithy is a two-storey building, containing a large variety of most ingenious machines for braiding wires; further south being the fitting-shop for castings, containing sand-blast machines; and to the extreme southern end the fitting and erecting-shop for switchboards and for the railway-lighting apparatus.

A canteen has been provided by the firm. This is managed by a club formed by the men who choose to take their mid-day meal at the works. They appoint their own committee, who deal with all matters connected with the canteen, and all profits made are set apart for reducing the cost of the food and drink supplied.

The men are paid at daily rates and by piece-work, wages being paid to the workmen fortnightly. They live at Baden and in the neighbouring townships and villages, where Messrs. Brown, Boveri, and Co. have provided for them dwelling facilities. Further developments in this respect are under contemplation. The men, together with the other employés, are insured against accident by the firm, and have their own sick-fund.

THE JUBILEE MEETING OF THE INSTITUTION OF NAVAL ARCHITECTS.

(*Concluded from page* 28.)

THE Jubilee meeting of the Institution of Naval Architects, of which the proceedings up to the 5th inst. were dealt with in our last issue, were continued on Thursday, the 6th inst., when technical papers were read at meetings in the buildings of the Institution of Civil Engineers and of the Institution of Mechanical Engineers. In both cases the proceedings opened at 11 A.M.

THE DEVELOPMENT OF SHIPBUILDING IN JAPAN.

The meeting at the Institution of Civil Engineers was presided over by Lord Brassey, and the first paper taken was that on "The Development of Merchant Shipbuilding in Japan," by Dr. S. Terano and Mr. M. Yukawa. In the absence of the authors this paper, which we hope to reprint in a later issue, was read by Dr. K. Suyehiro, of the Department of Naval Education, of Japan.

The discussion was opened by Professor F. P. Purvis, of Tokio University, who said that the paper gave an excellent summary of the development of Japanese Shipbuilding. He noted that in one place it was mentioned that there were now 230 private yards in Japan, but that the majority were of very small size. He would like to point out, however, that many of these yards were capable of building ships of up to 1000 tons, and that with very small appliances they produced very good results. In general, the yards experienced no difficulty in getting Japanese-built engines for the steamers they constructed, but the supply of boilers was more restricted, and some of the yards had consequently put down boiler-manufacturing plant of their own. He recommended anyone interested in the progress of Japanese shipbuilding to pay a visit to one of the six recent steamers of the Nippon Yusen Kaisha, during their visits to the Port of London. It would, indeed, be a good idea to take a trip to Antwerp in one of them.

Dr. S. J. P. Thearle, referring to Professor Purvis's suggestion that one should pay a visit to one of the Nippon Yusen Kaisha's Japanese-built steamers, said that he had had an excellent opportunity of seeing one of these boats, as he had been to the Coronation Review on board of her. He had been much impressed with the excellence of the workmanship, and would particularly like to mention the teak deck, which was the most magnificent piece of work of its class which he had ever seen. Referring to the Act, of 1896, for the encouragement of shipbuilding, he would like to say that in 1897 certain ships were built in England for Japan under his personal supervision, and one of the conditions of the contract was that complete drawings and models should be supplied to the owners in such detail as to enable later similar ships to be built in Japan. Arrangements of this class had been of great assistance to Japan in building up her industry. Although the greater part of the shipbuilding material was now supplied from abroad, Japan had plenty of natural resources, and no doubt in the future she would produce much of it herself.

Mr. A. Isakson, President of the Swedish Institution of Naval Architects, said that he had recently been in Japan, and that the paper had been of great interest to him. On the question of the importation of foreign material into that country, he would like to mention that while at Kobe he saw a floating-dock under construction, the whole of the material for which was of Japanese manufacture. There was little doubt that the Japanese steel works would greatly develop in the future. He had been much impressed by the Mitsu-Bishi Dockyard, which he considered one of the most wonderful in the world. Those who had not visited it could hardly have any idea of its extent and completeness. He had also been very much struck by the physique of the workmen, and as they received only from 1 to $1\frac{1}{2}$ yen a day, he could hardly understand why shipbuilding could not be carried out more cheaply in Japan than in Europe, even allowing for the greater cost of material.

Sir William White said that he had had some experience in connection with the advances made by Japan, and would point out that the policy carried out by her, of making it a condition of contract that a certain number of Japanese students should be received into the works carrying out a contract, and associated closely with it, had greatly assisted towards the wonderful developments that had taken place. None the less, the progress was astonishing, and represented the creation of the Japanese marine in about 16 years. The rate at which the shipbuilding industry had progressed possibly had something to do with the fact that costs were still high, although labour charges were low. It was probable that the whole organisation was still so new that the various interests concerned had not yet shaken down to a proper balance. Ultimately, it was quite possible that Japan might become a serious shipbuilding competitor of Europe. He was tempted to say something about the question of subsidies. Adam Smith had laid it down that direct encouragement of this sort might be useful in the early days of industries, but held that a period would come later at which the encouragement was undesirable. He noted that the original Act for the encouragement of shipbuilding had been drawn up to cover a period of 15 years, but that as soon as it ran out it had at once been extended for a further period of 10 years. His impression of the history of subsidies in general was that once started they were very difficult to stop. It was probable, however, that the Japanese shipbuilders had no wish to see them stopped.

The Chairman associated himself with all that had been said about the wonderful skill and industry exhibited by Japan in creating her shipbuilding trade in such a short space of time. None the less, he thought that we as a nation could not altogether regret that for some time yet Japan would look to us for assistance towards the still greater developments which she would without doubt make.

Dr. K. Suyehiro then briefly thanked the meeting for its attention to the paper, and stated

the regret of the authors at their inability to be present.

Fifty Years' Development in Mercantile Ship Construction.

The reading of the second paper was then proceeded with. This, by Dr. S. J. P. Thearle, Chief Ship Surveyor to Lloyd's Register, dealt with "Fifty Years' Developments in Mercantile Ship Construction," and we reprint it on page 69. It was read by its author.

Mr. J. Foster King opened the discussion. He thought that Dr. Thearle's paper gave a very wide and interesting review of the history of mercantile shipbuilding, and that within the limits allowable it would have been impossible to go into more detail than he had done. There was, however, one small point he would like to raise; that was, the remarkable simplicity of construction which was employed now as compared with the practice of twenty-five years ago. The features necessary to stiffen a ship had practically been removed from the inside to the outside. This was a development for which the shipowner should be particularly grateful. In reference to modern double-bottom constructions, he would say that they had several times been put to the best possible test—that was, the test of bad usage—and had shown themselves most satisfactory. He had had one very bad case of grounding, and although the plating was seriously perforated, there was no damage to floors or tunnel construction

Dr. G. B. Hunter said that he would like to echo the remarks of the paper in reference to the Great Eastern. She was a most remarkable and able specimen of shipbuilding. In reference to the question of the improvement in shipbuilding practice of recent years, he wished to express the appreciation of shipbuilders in general for the sympathetic attitude exhibited by the Committee of Lloyd's Register, and by Dr. Thearle personally, towards their efforts in the direction of improvement. There was a point in reference to the first use of cellular double bottoms he would like to raise. Unless he was mistaken, his firm had introduced the longitudinal frame system in a boat built in 1876. This was an earlier date than that given in the paper.

Mr. Stevenson Taylor, President of the Society of Naval Architects and Marine Engineers of the United States, who was called upon by the Chairman, said that he was rather surprised at being asked to speak on the paper just read. He had rather expected to reserve his remarks for the later one, which dealt with shipping on the Great Lakes. With the permission of the meeting he would deal with the two together. He was very glad to have Dr. Thearle's contribution, and it would be particularly useful for future reference. In the matter of the developments on the Great Lakes he would point out that there America had a field in which she was free from the competition of England or Germany, or any other country. The existence of the lakes was really responsible for the development of the industries, the materials for which were transported over them. The wonderful developments there had shown what his country could do in the shipbuilding industry, and it was his belief that his people would not be prepared permanently to allow the whole of their carrying trade to be dealt with in ships built even by such leading maritime countries as England, Germany, and Japan.

Mr. T. Utley said that he thought there was one point on which finality in ship design was far from being reached. This had reference to the question of the lighting and ventilation of passenger ships. Some few years ago a side light 16 in. in diameter was the largest that it was possible to fit into a ship's structure, and even on the Olympic the largest size was only 24 in. by 19 in. The question of the size of lights in passenger steamers was of very great importance, and he thought that Lloyd's and the Board of Trade should modify their rules in reference to frame spacings in order to allow better arrangements than were now possible to be fitted.

The Chairman, in closing the discussion, said that he always took great interest in anything that was said about the Great Eastern, as his father had been the largest shareholder in her. He thought her commercial failure was due to the fact that she had no superiority in speed over her rivals. As one interested in sailing-ships, he could not help feeling some regret at their gradual supersession by steamers. Forty-nine years ago he had, when anchored off Cape St. Vincent, seen some forty sailing-ships lying in shelter at the same time. In the same waters to-day one could see nothing but steamers, and yet the winds were still blowing across the seas as they had ever done. It seemed a pity that they should not be utilised, and he suggested that the apparent coming of the internal-combustion engine might possibly lead to a revival of the system of using auxiliary power on sailing-vessels.

Ore Transportation in America and Sweden.

At this stage Lord Brassey retired from the chair in favour of Sir William White, and Professor Sadler read the paper on "Shipping on the Great Lakes," by Mr. Frank E. Kirby and Mr. A. P. Rankin; while Mr. J. Johnson read his paper on "Recent Developments in the Sea Transportation of Swedish Ore." There was no discussion on either of these papers, which are reprinted on pages 57 and 62 of this issue.

The paper dealing with the "Design and Service Performance of the Trans-Pacific liners Tenyo Maru and Chiyo Maru," by Dr. S. Terano and Professor Baron C. Shiba, was taken as read, and there was no discussion on it. We hope to reprint this paper later.

The proceedings of this section thus terminated for the day.

Naval Engineering in Japan.

The meeting held in the hall of the Institution of Mechanical Engineers on the morning of the 6th inst. was presided over by Admiral Sir Gerard H. Noel, and began at 11 A.M. The first paper to be taken was one by Engineer-Rear-Admiral Terugoro Fujii, Engineer-in-Chief of the Japanese Navy, and was entitled "Progress of Naval Engineering in Japan." This paper, which we hope to reprint in an early issue, gave an account of the development of steam machinery in the Japanese navy, the introduction of which commenced in 1863, with the gunboat Chiyoda Gata. The paper gave descriptions and brief particulars of the Miyabara and "navy-type" water-tube boilers, now largely used in Japanese warships, alluded to the adoption of turbines, and gave the results of trials of Japanese-built turbines. Particulars of the *personnel* were also given, with a few particulars as to the cost of machinery, the latter being summarised by the author in the words that, "generally speaking, the cost of propelling machinery in Japan seems slightly less than it is in Europe and America. This is probably due to the lower wages of workmen, notwithstanding the higher price of imported materials." Although wages are rising rapidly, the average pay of workmen is about 1s. 4d. per day of about 10 hours. The author concluded with some remarks upon the effect of war upon machinery, stating that during the whole course of the recent war the machinery developed no "defects such as to affect the action of the fleet," although in some cases warships were continuously under steam for over 2000 hours. "The only noticeable trouble which our engineers experienced was the leakage of both main and auxiliary condenser tubes. Also," continues the author, "I may add that the spare parts of auxiliary machinery were found indispensable, they having been used very often." With torpedo-boats and destroyers no serious troubles were experienced.

In the absence of the author, the paper was read by Engineer-Commander Keijiro Matsui.

The first speaker on the subject of this paper was Mr. A. E. Seaton, who thought the invitation extended to him to speak first not altogether inappropriate, for no less than thirty years ago he had been asked to take certain pupils, and on his consenting, two Japanese gentlemen had come to him for instruction. One of these was a now well-known Japanese Admiral. He came to him well-educated for that time, as education went in Japan, but knowing very little English, and he had helped him in that subject of necessity. The demand for knowledge, for the reasons and factors influencing design, on the part of these and other Japanese students who came to him, had resulted in the production of his book. He had had the honour of designing the machinery of what might be termed the first modern warship of Japan. At a time also when the British boats of the "Gem" class could only maintain, by dint of very hard work, a speed of 12½ knots, the Japanese, wanting something better, had adopted his advice and fitted boilers which gave 14 knots. The real point of the paper was brought out towards its conclusion and was concerned with the effect of war upon ships' machinery. The picture there given was a very gratifying one. The Japanese were a people who would not be betrayed into buying cheap things. They insisted on the best, and the result under war conditions was as shown in the paper. As a people, he thought that they purchased with economy; they could get as much out of a sovereign as anybody. The paper dealt with only naval matters, but, of course, the merchant marine had shown equally great development, both for passenger, tramp, and other services. He thought the people gained much by approaching subjects without prejudice, or engineering and other bias. If one could divest oneself of preconceived ideas, or the influence of the opinion of the "man in the street," it would be much the better.

Admiral H. J. Cone, Engineer-in-Chief of the United States Navy, said he had been much impressed with the class of merchant ship now flying the Japanese flag and plying between the United States and Japan. The vessels he had inspected were particularly well equipped throughout. They were taking traffic away from the United States and European countries.

Captain Tuxen said he belonged to a small navy, but one of old and proud traditions (Denmark). Their experience had been that it was very difficult to improve in the right way without making some mistakes. The Japanese had made immense progress, which had not been offset by any failures, and he thought they must congratulate the Japanese, therefore, on the cleverness of their engineers.

Mr. J. M. Allen said his firm had done much work for the Japanese, and he was interested, therefore, to hear that their Miyabara boiler had given such satisfaction.

After a brief acknowledgment by Commander Matsui, on behalf of the author, of the remarks passed on this paper, the Chairman said that he had had the privilege of seeing something of the Japanese, as he had been on the China Station during and after the war. On visiting Japan after the war he was shown over the dockyards at Yokosuka, Kure, and Sasebo, and could not help noticing that a state of great activity was still being maintained. Their works and methods showed them to be progressive. Everything was up to date.

Training of Naval Architects.

The next paper was one by Professor Flamm, entitled the "Scientific Study of Naval Architecture in Germany." This paper we print on another page of this issue. It was concerned primarily with an account of the methods of education followed at the Königliche Technische Hochschule zu Berlin in Charlottenburg. Professor Flamm explained that he had hoped to show by means of cinematograph films what class of work was kept before the attention of students. The films were photographs of propellers, showing cavitation effects, &c., taken at Charlottenburg. Owing to the strong daylight in the hall it was impossible to exhibit these at the Thursday meeting, and their display was therefore postponed until Friday morning at 10.30, special arrangements for darkening the hall having meantime been made. With these cinematograph views, and the discussion to which they gave rise, we refer in due order in a later part of this report, under the heading "Propeller Phenomena."

The discussion on Professor Flamm's paper was opened by Sir William White, who thought the Institution indebted to the author for the detailed account of the course of training at Charlottenburg. He had made a study of technical education in most parts of the world, and had gone, among other places, to Charlottenburg. The methods adopted there were not all of them applicable here. There were, for instance, here no leaving certificates given by the secondary schools. The German system provided such certificates, which were presented to the university by intending students, and were accepted as proof of sufficient ability. He had known cases, as a result of this difference, of Englishmen wishing to study at Charlottenburg experiencing difficulty in convincing the authorities of their fitness to take up the work. Then, again, the German system involved a four-years' course, the English one of three years. There was more breadth and greater freedom in the German course as far as the first examination. Here we had no great critical intermediate examination, as in Germany. The work here was progressive and cumulative up to the final examination, with account taken of the work done by the students during the sessions. This he thought the more satisfactory

arrangement, as it was an undoubted fact that many students capable of excellent work could not acquit themselves satisfactorily at examinations. This system involved the use of internal examiners familiar with the work of the students and college course, but these must be coupled in some measure with examinations held under external examiners in order to keep the standard to the necessary level. The German system was distinguished for the minute subdivision of the subjects taught. Subjects were not separated to the same extent here. Perhaps separation went too far in Germany and not far enough here. The ideal lay somewhere between the two. These remarks applied to the relation of naval architecture and marine engineering. He was a naval architect, but he had received instruction in marine engineering. Mr. Seaton was a marine engineer and had received instruction in naval architecture, and, he thought, in both cases to their mutual advantage. The course of the French Genie Maritime combined both. Whatever methods, however, were adopted in the German system, with their reputation for thoroughness or organisation, and working on the knowledge of what had already been done elsewhere, it might be taken for granted that the Germans had taken their steps deliberately, and they were, therefore, well worth the study of others.

Professor C. H. Peabody, one of the delegates from the United States, spoke next; he said he wished to emphasise the points made by Sir W. White. When he had been to Charlottenburg he had been impressed with the great similarity of the work done there to that done at the colleges in the United States, though he had expected to find it very different. The United States schools formerly followed the tutorial system, but had since changed to the lecture system. Professor Flamm had laid great stress upon the tutorial system, which they had partly abandoned. This tendency in Germany was interesting. He strongly dissented from the suggestion that a youth should have some workshop experience preliminary to college work. His experience showed that such a course was not attended by good results on the whole, though it was sometimes advantageous. He hoped that no steps would be taken in the direction of making this compulsory. It was bad to break off the work of the school. It added to the age at which the student came to college. It was extremely unfortunate that in Germany the age was of necessity as high as twenty-one. The age of nineteen was too high—higher, at any rate, than it ought to be—for the average youth to come to college. He had found that youths coming to him at the age of seventeen had done themselves the greatest credit. It was desirable that they should get early to their real work.

Sir W. White here interposed a remark on the subject of training, stating that the Institution of Civil Engineers' conference of last week had shown, he thought, that the bulk of opinion was against Professor Peabody's view, and favoured some preliminary practical work, and that in Germany, where they had had twelve years' experience of the interposition of one year's practical work before college, the tendency was rather to lengthen that period than to shorten it.

Professor Hovgaard followed, remarking on the clearness of the statement placed before them. The system was well adapted to the desired end, and had been evolved with much forethought. He thought practical training necessary at some stage or other, but was not prepared to say at what stage; it must be procured, however, at some period. The advantages derived from it were both direct and indirect. Men became familiar with tools and methods, but they also came into contact with the workmen, and so came to see things from a point of view that it was impossible to attain later. With regard to the so-called tutorial method as he understood it, the aim of the system was to make the lectures work hand in hand with the practical work and design. The course he advised for naval constructors followed this system, the lectures being followed by the application of information so conveyed to the practical work of design.

Professor Marbec, of the École du Genie Maritime, said the teaching of the two professions of marine engineering and naval construction formed parts of one whole in France. The course of education was the same for both, and members passed from one division to the other. If there appeared to be special aptitude for one side, a special course was made to suit the circumstances. When their naval constructors finished their course they could take charge of work in either of the two branches. They had practically two periods, the first being given up to marine engineering, and the other to ship design. Each was preceded by a short course of the other, so as to bring out the bearing of one upon the other. The fusion of the two branches so far as the courses of education went in France was absolute.

Mr. S. W. Barnaby understood that Professor Peabody's point referred to the time at which practical training was necessary. There was still much dispute on the point, and he was of Professor Peabody's mind. The boys were better for going straight on with their theoretical training, and it should not be broken into by practical work.

Mr. A. E. Seaton considered it most important that the young men should have their ideas turned into practical directions. There was much to be learnt in connection with launches, the lifting and handling of heavy weights, and a vast number of other practical matters which could not be taught in the shops.

Mr. A. J. Maclean, of New York, referred to Sir W. White's remarks on training, and said that though that gentleman had studied the question of technical education in all parts of the world, there was certainly one institution he had not visited, that was the Webb Naval Academy, of New York. In his young days the founder, Mr. Webb, had experienced great difficulty in securing information he needed, and had formed the resolution that, fortune favouring him, he would found an institution at which such instruction would be procurable. In due course Mr. Webb was able to give concrete form to his wish. The college had now existed for seventeen years, and for fifteen of these he (Mr. Maclean) had held the chair. They took lads of from fifteen to twenty; they much preferred young men. The syllabus closely resembled that given in Professor Flamm's paper. Practical work was followed in the course, including, for instance, lining off in a moulding-loft. They went thoroughly into all the calculations regarding both ships and machinery. Their lads were readily taken up on the completion of their courses; they refused government posts, as they were easily able to get better positions and salaries. Arrangements were made for them to get sea training, and this was chosen for them according to their decision on graduating.

Dr. A. Denny said he started at 16 with three years in the works, accompanied by evening classes, this being followed by the course at the Royal Naval College at Greenwich. In Germany the students were 21 before they began their courses. He admitted that his training preliminary to the college had been somewhat imperfect, but it was otherwise with regard to the Admiralty men, who were well prepared for it. If the German course carried mathematics, for instance, higher than did that at the Royal Naval College, he thought it must go very high indeed. His son started in the same way and had been trained under Professor Peabody. One of the solutions was the sandwich system, which was possible on the six months' plan in Scotland. In this way they could get four courses into three years. He thought it would be found, however, that all methods had been known to give good results. He wished to ask what became of the vast number of young men turned out by the colleges. Did they ultimately obtain employment? The production in the United States and in Germany, he was afraid, out-ran the demand. Here that stage had not yet been reached. He thought the training question capable of summary by the statement that any system properly carried out would produce good results.

Mr. E. A. Sperry, one of the delegates from the United States, thought it would generally be found that young men got positions in proportion to their capabilities, with stress on the "capabilities."

Mr. J. M. Allen followed with the remark that in his experience the sandwich system had proved unsatisfactory. College men had airs, and there was often trouble between them and the foreman. He thought three years' works first was best. His firm were in the habit of granting facilities for college instruction after three years' works experience.

Professor Flamm, in replying to the discussion, said that at Charlottenburg they had men from all over the world, and had found many of them first-rate students. It was, of course, impossible to grant them facilities greater than those accorded to their own men. Equality was necessary, and some line had to be fixed. The age at which the course finished was rather great, but they did not like to give the technical man a lower standing than the men of other professions. They therefore granted equivalent degrees, and this rendered similar schooling necessary. They had abandoned the dual system, and had thought specialisation better, because one man was incapable of acquiring complete knowledge in both. They also believed in allowing the men sufficient free time to enable them to gain some knowledge of the world and general matters. Too constant application to a limited subject was inadvisable. In the summer holidays the men went to sea or to works and earned money, spent subsequently while at their studies. With regard to the quantity of students, efforts had been made to keep the supply within the requirements, but the men were well fitted for other work, such as that encountered in connection with land work. He was pleased to say that, whatever their actual course of study, the best books of the world, among which were many by English authors, formed the foundation of their knowledge.

The Chairman thought that Germany was looked upon in the eyes of the world as an organised nation. One result of that organisation which had been mentioned in the paper appealed to him. It was the military service required of young men. He would like to see it here for physical reasons. One year of military training would greatly improve our students.

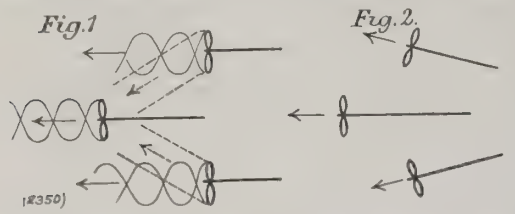
Cavitation.

The next paper taken was entitled "Some Further Notes on Cavitation," and was by Mr. Sydney W. Barnaby. This was read by the author, and is reprinted on page 55 of the present issue.

Dr. A. Denny said he did not agree with Mr. Barnaby's theory. Thrust as high as 16 lb. per square inch was not uncommon in their experience, with good results. He knew of one case where it was as high as 22 lb. With regard to the use of the term "efficiency," now that tanks were common he thought some standard meaning should be adopted for terms used. Efficiency should include the hull effect. It should be brake horse-power compared with indicated. Spectacle-frames, brackets, &c., form some of the penalties of the use of twin screws, and should be included in the expression for efficiency. In their tank the actual thrust was measured, and the turning moment could be measured separately for one, two, three, or four screws. They drove the screws until a point was obtained at which the resistance and propulsion curves crossed. They found the subject to be one in which the further they went the further they wanted to go. Some day he hoped to place their results before the Institution. It was because there were so many problems involved that he wished the Bushey tank to be reserved for scientific work. The results obtained in their own tank were accurate to a practical degree. Referring to a portion of Professor Flamm's paper, he would say that sea-water was not homogeneous. It contained air, which was liberated under the action of the propeller. He would like to know the limiting velocity of the water when this action occurred.

Professor Flamm spoke next, regretting that it had been impossible for him to exhibit photographs in connection with his paper, as they proved, he considered, that the greatest effect was given by the suction rather than by the thrust. The surface of the water was drawn down and a hollow formed on the surface above the revolving screw. If there were thrust present, the surface would be raised rather than lowered. Also it was found that air was sucked in in front of the propeller. Where there was cavitation he found the thrust to be greatest; but if air came down to the screw, the thrust was destroyed. In shallow-draught boats, therefore, it was advisable to prevent the inflow of air by means of a flat board or surface over the screw. When a vessel was passing through waves the depth of water over the propeller was sometimes so reduced that the thrust was destroyed, and this might be one of the reasons why ships with heavily-loaded propellers lost so much speed in bad weather. The spiral developed in the water when cavitation occurred was cylindrical and parallel, as shown by his photographs. He had carried out some experiments in connection with the propulsion of the Siemens Schuckert airship, which were of

some interest. This airship had sets of three propellers, as in the accompanying diagram, Fig. 1. It was found that if the two outside propellers were set to work, a sharply-defined cylindrical horizontal column of air was set in motion behind and in line with the axis of each propeller. The third propeller was between and somewhat behind the other two, and when that also was set in motion it was found



that the streams from the two other propellers were drawn in towards the third, as shown by the dotted lines. Each propeller singly developed parallel flow or column of moving air. The expedient had therefore been adopted of setting the forward screws at an angle, so that their streams should not flow into the third, as in diagram Fig. 2.

Mr. A. E. Seaton said no tanks were available in his day, and he had had to use an ordinary dinghy for the purpose. Hanging over the counter he had made observations which had been good enough to be serviceable, and many of the things now known were capable of examination in this manner.

At the close of the discussion, Mr. Barnaby asked Dr. Denny if he would mind stating the conditions under which a propeller with 22-lb. thrust had been used, to which Dr. Denny replied that it was a steamer in channel service.

Collapsing of Beams and Elastic Curve Strips.

The last paper for consideration was one by Professor Marbec, entitled "Notes on the Collapsing of Beams and Elastic Curve Strips." This was read in abstract for the author by Lieutenant Boris. There was no discussion on it, and the meeting immediately afterwards adjourned.

Luncheon at Lloyd's.

At the conclusion of the reading and discussion of papers on Thursday, the 6th inst., many of the members lunched at Lloyd's Register of Shipping in Fenchurch-street. After the loyal toasts that of "The Institution of Naval Architects" was drunk, and replied to by Dr. Archibald Denny; it was followed by that of "Delegates from Foreign Countries," coupled with the names of Mr. Stevenson Taylor and M. Bertin. Lord Furness proposed the toast of "Lloyd's Register and its President, Mr. Thomas L. Devitt." The latter referred to the eleven scholarships in naval architecture and marine engineering maintained by the Register. Speaking of the Society's new rules for the construction of steel vessels, Mr. Devitt said that since they came into operation in July, 1909, plans had been dealt with for the marvellous total of 1555 vessels, of 3,278,000 tons. The total tonnage now under construction in the United Kingdom — viz., 1,476,394—was the largest on record. The tonnage actually under construction at the present time at home and abroad to class at Lloyd's Register was 1,237,600 tons, and this was the highest figure on record with the exception of the period March, 1901, to March, 1902. Of the sea-going vessels under construction abroad no less than 57½ per cent. were to be classed with Lloyd's.

Reception at the United States Embassy.

In the afternoon the members of the Congress and their lady friends were received at Dorchester House, the Embassy of the United States, by the Hon. Mr. and Mrs. Whitelaw Reid. The reception was largely attended, and after the treasures of the magnificent mansion had been inspected, tea was served in the garden.

The Jubilee Banquet of the Institution.

The Jubilee Banquet was held in the Grand Hall of the Connaught Rooms, which was charmingly decorated in appropriate designs. There was a very large attendance of ladies and gentlemen. After dinner, the President, the Marquis of Bristol, stated that he had received a telegram from King George V., in reply to the loyal greeting sent from the inaugural meeting of the congress (see page 13 *ante*). The telegram was as follows:—

I am commanded by the King to thank the members of the Institution of Naval Architects for their expression of loyalty. His Majesty hopes the congress may be attended with every success.

The following telegram had also been received by the Duke of Connaught from the German Emperor:—

Please forward my sincerest and warmest congratulations to the members of the Institution of Naval Architects on the occasion of the jubilee meetings now held in London. May the Institution, of which I have had the honour of being an honorary member for sixteen years, always remain what it has been—a powerful promoter of naval building and engineering—and serve to unite in friendly intercourse the prominent men of all countries who devote their time to the noble task of shipbuilding and engineering.

After the loyal toasts, the Right Hon. Walter Runciman, M.P., President of the Board of Education, proposed the toast of "Our Guests," which was replied to by Vice-Admiral de Montferrand, President of the Armaments Commission of the French Navy, Geheimer Oberbaurat Hüllman, Director of Naval Construction of the German Navy, Rear-Admiral W. L. Capps, Chief Constructor of the United States Navy, and Major-General E. Feratti, of the Italian Navy. Sir William White next gave "Kindred Societies," and replies were made by Rear-Admiral Matsuo, of the Japanese Society, Mr. A. Isakson, of the Swedish Institution, and Signor Salvatore Orlando, of the Italian Society. The toast of "The Institution of Naval Architects," proposed by Rear-Admiral G. Dyrssen, President of the Swedish Admiralty Board, and replied to by the Marquis of Bristol, concluded the proceedings.

Propeller Phenomena.

An additional meeting was held at the Institution of Mechanical Engineers on the morning of Friday, the 7th inst., at 10.30 A.M., Engineer-Vice-Admiral Sir J. Durston being in the chair, in order to enable Professor Flamm to show his lantern-slides and cinematograph views illustrating screw-propeller investigations carried out at Charlottenburg. Professor Flamm explained that in their tank they had a working screw depending from a carriage running above the tank. The movement of the carriage was dependent on the pitch and speed of the screw, but they had also an attachment by which they could load the carriage in order to represent ship resistance, &c. This consisted of a weight suspended by a line passed over a pulley and attached to the carriage. The arrangement included a balance, so that alteration in the load could be noted. The views were taken with an exposure of $\frac{1}{1000}$ second, and showed excellently the physical effects attendant upon the working of the screw at different speeds. The screw, of course, moved through the water and drove the carriage. Arc lamps provided means of illumination through the glass sides of the tank.

Professor Flamm's views were in two series, both connected with the same subject. One film on the cinematograph was in illustration of what happened when a stream of water impinged on a curved hinged plate. The plate was suspended at one side on an axis parallel to the axis of curvature, and it was shown that when a jet of water was directed on to the convex side from the end nearest the axis, the plate rose to meet the jet instead of being thrust out of the way. This suction effect, Professor Flamm contends, exists in the case of the curved surface of a propeller. Some slides and the other films illustrated the suction effect on the water surface and the entraining of air, and the development of the cavitation spirals. Several of the lantern-slides have already been reproduced in ENGINEERING,* and need not therefore be repeated. It will suffice to state that they formed excellent illustrations of the effects to which Professor Flamm wished to draw attention, as did also the cinematograph views. The latter were particularly fascinating, the appearance and disappearance of the various phenomena being easily followed, as the representation of the screw and carriage passed across the sheet. The confusion resulting behind a propeller drawing air was extremely well seen, as was also the formation of the air-pipe down to the front of the propeller from the surface. The cavitation spiral and the central worm were also very distinctly seen. Professor Flamm explained the conditions of speed under which the screws were working, and also mentioned that, when air was sucked down to the propeller, the balance apparatus showed that the thrust was altogether destroyed.

Sir John I. Thornycroft, who re-opened the discussion on the paper, which had been read at the meeting on the previous day, said Professor Flamm had gone to a great amount of trouble to make the effects apparent which otherwise could not be easily recorded. He was sorry so much attention seemed to have been directed to the suction of air, for most engineers had been familiar with this for some time. He would like to see experiments carried out far enough below the surface to prevent air getting down to the screw. A flat surface arranged over the water where the tendency is greatest for air to be drawn down greatly increased the power developed by screws. Builders recognised that at the present day, and flat sterns were provided to prevent this suction with lightly-immersed screws. In connection with Professor Flamm's other demonstration—of the inability of a stream to detach itself from a curved surface—his own experiments with curved stern lines confirmed this, as did also that of the late Mr. Froude and the work with the Ramus model.

Mr. A. Isakson, Sweden, remarked that probably many had watched screws immersed to depths of 5 ft. or 6 ft. down in the clear water in some seas. He had recently watched them in the Indian Ocean, and had observed at the tip of each blade a bright air-bubble. He thought a means might be found of examining the partial vacuum effect at these points by boring holes through the propeller to the boss and shaft and putting them in communication with suitable gauges. The method, he thought, was quite feasible and might lead to interesting and valuable information.

Dr. A. Denny remarked that Professor, Flamm had conclusively proved by his photographs that the column of water leaving the screw was parallel and that no water was thrown outwards. There was no such centrifugal action, and he hoped that would prove the deathblow to the ideas of all inventors whose freaks were intended to counteract this action which did not exist. He had made observations of cavitation at sea on the King Edward. When that vessel had been run astern the screws did not suck air down, but there was cavitation, and spirals came off. In reference to his remarks of the previous day, he wished to observe, in order to dispel possible misapprehension, that only three or four of their apprentices were allowed to take their practical training on the sandwich system, and these were selected men. They could not do it for all.

At the conclusion of the discussion, Professor Flamm stated that he hoped, with financial assistance from the Government, to continue his experiments to include the action of two and three screws, and also the influence of a rudder fitted behind, and he hoped some day to lay the results before the Institution.

After a hearty vote of thanks the meeting terminated, most of the members adjoining to the Institution of Civil Engineers, where another meeting was in progress, a report of which follows.

Progress of Shipbuilding in Italy.

Proceedings were resumed also at the Institution of Civil Engineers at 10.30 A.M. on Friday, the 7th inst., with the President, the Marquis of Bristol, in the chair. The first business was the consideration of Colonel G. Russo's paper on "Fifty Years' Progress of Shipbuilding in Italy." It was read by Mr. R. W. Dana, the Secretary.

The paper began by paying a tribute to such men as Penn, Maudslay, Hawthorn, and Armstrong, and pointing out that they had amply repaid the debt owing by England to Italy for skilled assistance in shipbuilding which had been given in the sixteenth century. It then dealt with the general progress of the art in Italy from 1860, pointing out that although at that date there were about 100 yards devoted to the building of wooden ships, the industry rapidly declined in the early years of the period under review. Even after the introduction of iron for ship-work, the industry did not advance so rapidly in Italy as in some other countries, and in 1885 a policy of encouragement by means of subsidies or remission of duty on imported material was inaugurated. This policy of encouragement was still in operation. The paper gave some details of the various famous Italian yards, such as those of Ansaldo-Armstrong, Odero, Fratelli Orlando, &c. It also dealt with the progress of battleship design and construction, and discussed

* Vol. lxxxvii., page 810.

such famous examples and types as the Deulio, the Pietro Micca, the Italia, the Re Umberto, and the Regina Margherita. Some account of the Italian Registry of Shipping, the Registro Italiano, was also given, and a reference made to the schools of naval architecture and engineering at Genoa and Naples.

Sir William White opened the discussion. He said that it had been his good fortune to be associated for thirty years with the naval side of Italian shipbuilding, and that he had come to know many of the officers and constructors who had been responsible for it. He was glad of the opportunity of speaking of the pleasure and profit that that association, and the friendships he had made, had been to him. He had often been struck by the fact that the Italian naval constructors had always founded their designs on the basis of the strategy demanded by the physical and geographical features of their country. At the same time, in view of the fact that Italy was not a wealthy country, they had achieved quite remarkable results with the resources available to them. They had never been afraid to carry out what they thought were the best ideas, quite irrespective of what was being done elsewhere. In naval as in other matters there was frequently a tendency to follow a sort of fashion which happened to be set up, and he thought it a most valuable quality of the Italian naval authorities that they had never been afraid to think for themselves.

Signor Salvatore Orlando, President of the Italian Society of Naval Architects, regretted his inability to speak at any length owing to his imperfect knowledge of English, but said he would like to confirm the suggestion made by Sir William White that Italian naval work had been determined by physical and geographical requirements, by the fact that, although having such a great coast-line, Italy was not an island. He thought that the Italians, like the English, had a natural genius towards shipbuilding and navigation.

Admiral the Hon. Sir E. R. Fremantle thought that in its readiness to make experiments and new movements the Italian Navy had frequently made advances and given hints which were of great value to other navies. Sometimes it had made mistakes; but, on the whole, the world was very greatly indebted to it for the pioneer work it had done. Italian constructors had always been great believers in the value of experiment, which was, he thought, one of the reasons for their success.

Admiral Sir Reginald Custance said that he had not had an opportunity of hearing the paper read, but as he had been called upon, he would refer to a paragraph in it which he had noticed under the description of the Italia, in which it was stated that the principle of abolishing side armour was a failure on account of the unforeseen development of rapid-fire guns and high explosive projectiles. As it stood this paragraph was obviously not correct. If the principle referred to was right before the introduction of the quick-firing gun it must have been right after. Any changed conditions of gun-fire must apply equally to each party in a naval engagement.

Colonel G. Russo stated that the paper had been written at the invitation of the Institution, to whose proceedings he thought it an honour to contribute. He thanked Sir William White and others for the kind remarks they had made about Italy and Italian shipbuilding.

The President thought that the advances made and steps taken by Italy in certain directions showed that her developments were the joint work of the naval architect and the naval officer. The English naval officer had always taken a very close and keen interest in the doings of the Italian navy, and from his own career he remembered many incidents which illustrated that interest.

Progress in Naval Artillery.

The meeting then proceeded to the second paper, "Notes on Progress in Naval Artillery," by Sir Andrew Noble, which was read by its author. This paper, which we hope to reprint later, dealt with the gradual improvements both in guns and explosives which had taken place during the lifetime of its distinguished author. It was illustrated by wall diagrams dealing with old and modern artillery and with the properties of various types of explosives. These we shall also reproduce.

The discussion was opened by Rear-Admiral R. H. Bacon, who said that he was sure all present had listened to the paper with the greatest interest. All those who knew anything of the Navy would know that its members looked up to Sir Andrew Noble with a feeling which could only be described as one of veneration. To the naval officer the history of artillery was the history of Sir Andrew Noble.

Admiral the Hon. Sir E. R. Fremantle said he really knew nothing of the subject of the paper, but had found it of much interest. He thought the information and table with which it concluded giving data as to the amount of erosion due to different charges of much interest and importance.

Admiral Sir Archibald Douglas said that he looked upon Sir Andrew as the father of artillery, and what the Navy would have done without him he did not know. It owed the introductions of both the quick firing gun and cordite to Sir Andrew Noble.

Sir William White said that so far three naval officers had given their tribute to Sir Andrew Noble, and he would like to add to theirs one on behalf of the naval architects. There were four great names which stood out in the history of the development of artillery. They were Armstrong, Rendle, Vavasseur, and Noble.

Mr. Axel Welin said that all the previous speakers had been Englishmen, and that on behalf of Sweden he would like to add a word of thanks and appreciation for the great work which had been done by the author of the paper. The historical nature of the paper hardly gave a proper idea of the work which had been done by Sir Andrew Noble. Thousands of details had been worked out by Sir Andrew and his staff which had represented long years of work, and such details had by no means simply been left to the staff. Sir Andrew had himself taken a very close part in them all.

Vice-Admiral Luis Goni, of Chili, said that, as a representative from South America, he would like to add his tribute to the great work that had been done by Sir Andrew Noble. As long as thirty years ago they had had some of his guns in Chili, which had been of much service in an unfortunate war they had at that time; since then the progress due to Sir Andrew had been remarkable.

Sir Andrew Noble, in reply, said that he had now reached his eightieth year, and failing hearing, unfortunately, prevented him hearing very well the remarks which had been made on his paper. None the less, he thanked every one for their kind sentiments. He would like to mention that it was now sixty years ago since, on a voyage to the Cape of Good Hope, he first came to read the story of gunpowder. He was then so astonished by the varying reports that were given of the explosive pressure reached by it that he determined to investigate the matter for himself. He thought that since then he had found himself in an unusually favourable position for carrying out the work, and that anything he had done must be put down largely to good fortune.

The President, closing the discussion, said that those who were at the dinner on the previous evening would remember him saying that in Nature there were no rewards and penalties, only consequences. If this were true, he thought Sir Andrew Noble was one of the consequences. It was a pleasure to see Sir Andrew's amazing vitality, and he added his tribute to all that had been said before as to the wonderful work Sir Andrew had done.

Warship Building (1860 to 1910).

The next paper for consideration was that of Sir Philip Watts, K.C.B., on "Warship Building (1860 to 1910)." This paper, which was of considerable length, was taken as read, and there was no discussion on it.

Sir Philip, in his paper, gave a very comprehensive review of the development of each type of ship; but as machinery, armour, and artillery had been dealt with in other papers, there was little opportunity for dealing with the influences on ship design of contemporaneous progress in such work, so that there was not that wealth of deduction and analysis which we look for in contributions upon scientific questions from Sir Philip. Another deterrent was, no doubt, the determination of the Admiralty that official secrets regarding ships of the later types shall be scrupulously guarded, and obviously it would not have been courteous of Sir Philip to have entered upon any criticism of the ships of foreign Powers. Nevertheless, the paper is a most admirable *résumé* of the progress in size, engine-power, speed, and gun-power of the ships of practically all nations, up to the Neptune in the case of the British Navy, the Thuringen in the case of the German Navy, the Wyoming of the American Navy, and the Settsu of the Japanese Navy, and contemporary ships of other fleets. A similar *résumé* is given in the case of armoured cruisers, and Sir Philip established progress by indicating that when his late Majesty King Edward VII., then Prince of Wales, visited Canada in 1860, he made the passage in the Hero, a screw line-of-battleship of 91 guns and 2660 indicated horse-power, the time from Plymouth to St. John's being thirteen days under steam and sail; whereas, when His Majesty King George V. (when Prince of Wales) made the voyage to Canada in 1906, he went with the Indomitable, a ship of 17,250 tons, having eight 12-in. and sixteen 4-in. guns, machinery of 45,000 horse-power, and she made the return journey from Belleisle to Fastnet in three days, at an average speed of 25.13 knots. The later cruisers, torpedo craft, and submarine-boats were passed in review, the latest submarine vessels dealt with being the "D" class, of 595 tons displacement, with petroleum engines of 1200 horse-power, for driving the ship on the surface, and electric motors of 550 horse-power for propulsion when submerged. Sir Philip points out incidentally that, although it is not necessary for submarine vessels to be submerged to great depths, the U.S. Porpoise once accidentally touched bottom at a depth of 127½ ft. The great pressure prevented the ballast-tanks from being blown out by the air service, but after twenty minutes' hard pumping by the crew the boat rose unharmed to the surface. One of the earlier British boats once reached a depth of 78 ft. through too much water ballast being taken in. She was, however, brought to the surface undamaged except for a few leaky rivets. Since then one of the British "A" class has been submerged to a depth of 90 ft. Some interesting endurance trials have been undertaken at various times. In 1901 the French Narval was submerged for a twelve-hour test, but the crew suffered badly from the effects of the gas given off by the accumulators, which were not in a very satisfactory condition. In 1910 the Korrigan (France) and the Fulton (U.S.A.) both remained submerged for twelve hours, with no ill-effects to the crew, who came up fairly fresh at the end of these trials. Sir Philip Watts's paper is illustrated by a large number of diagrammatic elevations and plans to show the armour and disposition of the guns of all ships, but none of the ships of the British or German navies just laid down are included.

Armour for Ships.

The meeting then passed to the last paper, that on "Armour for Ships (1860 to 1910)," by Mr. Charles E. Ellis, which was read by the author. It was an historical paper, whose subject is obvious from its title. We hope to reprint it later.

The discussion was opened by Mr. C. H. Jordan, who said he had listened to the paper with great interest, but wished to point out that rolled armour was adopted on several of the early warships, including the Warrior. This was not altogether made clear in the early part of the paper.

Sir William White said that his connection with the armour question went back to 1864. He thought that the history of armour had shown that the manufacturers had always been willing to make expensive experiments and to take risks. Naturally they wished ultimately to be paid for such experiments, and he thought that on the whole they had been. The influence of the development of armour on naval architecture was enormous; as methods improved and thinner armour could be made to do the work of thicker, the process reacted on the size and arrangement of ships in all sorts of ways. He had now been out of direct touch with the question of armour for some nine years, and would rather like to know if Mr. Ellis could tell them anything of the development of the last few years.

Mr. C. E. Ellis, in reply, said that he would take note of the small point raised by Mr. Jordan. He was afraid the information asked for by Sir William White could not be given, for reasons which every one would understand. Before sitting down, he would like to express, for the manufacturers, their great indebtedness to the Admiralty for the assistance which had always been given them in experimental work dealing with armour.

Votes of Thanks.

This concluded the consideration on the technical papers, and the meeting terminated with votes of thanks to the Institutions of Civil Engineers and Mechanical Engineers for the loans of their halls, proposed by Sir John Thornycroft and seconded by Mr. Summers Hunter. The thanks of the

delegates were also expressed to the President and to the Institution by Maschinenbau-Oberingenieur F. Borowicka, of Austria-Hungary, and Mr. Stevenson Taylor, President of the American Society of Naval Architects. The thanks of the meeting were also passed to Mr. Dana, the Secretary, and his staff for the able way in which the arrangements for the Jubilee Meeting had been carried out.

River Excursion to the Port of London.

Upon the conclusion of the morning meetings on Friday a large number of delegates proceeded down the river, first with local steamers from Westminster to the Old Swan Pier, near Cannon-street Station, and thence by the saloon steamer Royal Sovereign, on which luncheon was served. The vessel made a trip down the river past the docks, so that the guests were able to see the extent of the harbour, and members of the reception committee explained the proposed developments under the new scheme of the Port of London Authority. The steamer went as far as Tilbury, where a special train awaited the company to take them back to Fenchurch-street Station.

Reception by His Majesty's Government.

On Friday evening, on the invitation of His Majesty's Government, a reception was given at the Savoy Hotel, and was very largely attended. The guests were received by the Right Hon. Walter Runciman, M.P., President of the Board of Education, and Mrs. Runciman, and the Right Hon. Reginald McKenna, M.P., First Lord of the Admiralty.

Visit to Windsor Castle.

The concluding function of the Congress was a visit paid to Windsor Castle "by command of His Majesty the King," on Saturday afternoon. The company, to the number of over 600, proceeded by special trains from Paddington to Windsor, and upon arriving at the Castle, were conducted first through the various rooms in the Upper Ward, where are located the State apartments and the King's private apartments, and later through the south wing, in which royal guests are accommodated. The company were entertained to tea and light refreshments in the gardens, and, owing to the excessive heat, the shade temperature reaching 86 deg., this part of the day was more appreciated even than the examination of the interesting features pointed out to the guests by the well-informed guides who took them in groups through the royal apartments. A photograph was taken of the gathering on the terrace, which will, no doubt, be cherished, especially by the foreign delegates and guests, as an appropriate souvenir of one of the most enjoyable international congresses ever held in this country.

INDUSTRIAL NOTES.

At the end of last week there was a distinct improvement in the aspect of affairs in connection with the dockers' and carters' strike in Manchester, for although business in Manchester and Salford was still greatly interfered with, there were no further disturbances. The grievances of both classes were under consideration by separate conferences, and it was stated that a provisional settlement had been reached in the case of the dockers and the Manchester Ship Canal Company. The offer of Mr. Askwith to try to promote peace negotiations in Glasgow was not accepted by the shipowners, who refused to recognise the men's union, although they have made concessions in wages. The employers in Leith have taken up the same position. The men on their side state that they will not consider any terms until the union is recognised. The presence of some 650 soldiers evidently had a controlling effect on the crowds at Salford, and consequently some amount of transport work was accomplished. A demonstration of about 2000 women took place in Salford on Friday last. They walked about 2 miles through the streets, hoping by their appearance to create sympathy with the dockers. They declared that they did not mind suffering, they only wanted the men not to give way. Of course, such demonstrations are meant to divert attention from the main points at issue, whatever the merits of these points may be. The dislocation of trade caused by the strike of seamen and firemen, followed by that of the dockers and carters, has been very costly. A rough estimate of the total loss at Hull is from 250,000*l.* to 500,000*l.* for a strike that lasted ten days, and flour advanced in price in the retailers' shops by from 60 to 80 per cent. At Grimsby the loss, though not so great, has been considerable, amounting, it is estimated, to about 1000*l.* Other ports have suffered correspondingly.

The beginning of this week, however, saw a settlement of the seamen, dockers, and carters' dispute, and on Monday morning it was known that the strikers had gained considerable concessions. The seamen and firemen have secured an advance of 10s. per month, and the shipowners have agreed that, in case of any dispute arising in future, they will meet the men and their representatives if they receive a reasonable notice. The crews, before embarkation, can have a doctor of their own choosing present when the medical examination takes place. With regard to the Federation ticket, no compulsion will be exercised on the men to take this out. The carters have got 25s. and 27s. per week respectively for one-horse men and two-horse men, instead of 27s. and 30s. per week, which they asked for, and they are to have 6d. an hour for all time worked before 7 o'clock a.m. Their trade union has also been recognised. The terms agreed to with the dockers are as follow:—(1) The minimum wage to be increased from 4s. 6d. to 5s. for a nine hours' day. Guarantees of a minimum of four hours when once a man has started work. (2) All men to receive 1s. 6d. as disappointment money if asked to work and then not allowed for some reason. Overtime rates from 6 p.m. to 8 a.m. to be increased to time and half. Double time for bank holidays or national holidays, and from Saturday midnight to Sunday midnight. (3) Increase from 5s. to 5s. 6d. for loading of general cargo. Increase from 4s. 6d. to 5s. for all shed men, casual checkers, and men discharging cargo. (4) The union is also to be recognised in cases where disputes arise, and the conditions of employment in many of the grades not mentioned above are to be greatly improved. The concessions made by the employers are very considerable, and the men are said to be well satisfied, and at once commenced to clear off arrears of work, but it is expected that at least a fortnight must elapse before the normal state of affairs is reached. The military and the extra police have been removed. The efforts of Mr. Askwith have been much appreciated.

The seamen's dispute in Rotterdam is settled, the men having decided to accept an increase of 5s. per month, conceded under certain conditions by the owners. The increase will not, however, take place till next year. In Amsterdam, mediation by the Dutch Minister of Agriculture and Commerce has been rejected by the shipowners, on the ground that a settlement brought about by this means would encourage men to consider that they had been justified in their methods of intimidation, and difficulties would be created.

The negotiations between the Midland Railway Company and the men employed in the goods department have, according to an official statement, resulted in a number of substantial improvements in the men's working conditions. The most important of these is the raising of the minimum wage of sidings porters from 16s. to 1*l.* per week, with a general increase of 1s. per week upon the maximum at various important stations. Horse-holders and point-holders at various centres are to have an increase of 1s. per week, and men are to be guaranteed a full day's pay for every period for which they are "booked on." An increase of 1s. per week has also been granted for under-shunters at St. Pancras, Bradford, Hendon, Somers Town, Sheffield, Cricklewood, Nottingham, Birmingham, Leicester, and some other centres. To goods shunters at various important sidings an eight-hour day is to be conceded during the summer months, and the gross hours of sidings porters are to be reduced from 12 to 10 hours per day. Work on Sundays, Good Friday, and Christmas Day is to be treated as overtime and paid for at greater rates.

The position in the Scandinavian labour market has not improved in the course of the week, and the prospects of amicable settlements have disappeared, both in Sweden and Norway. In the former country the masters accepted, but the men rejected, the proposal which was the outcome of the official mediator's endeavours, and the result is a lock-out, affecting 40,000 men within the building trades. The men held out for what was considered exorbitant pay, more especially in connection with piece-work; this pay has risen very materially for a number of years. Thus the hourly pay for a cement worker has risen from 35 or 40 öre to 64 öre during the last twenty years; that of carpenters from 25 or 30 öre to 55 öre during the same period; and for house-painters from 40 or 45 öre to 75 öre. The average pay of men in the building industry, for some length of time, has given cause for dissatisfaction, the reason being found in the frequent labour conflicts, in which respect the figures are exceptionally high, even without counting the four months' conflict in 1908, with a loss of 680,350 working days.

In Norway the miners appear to have almost unanimously rejected the masters' offer, and the lock-out consequently has come into operation as far as the first lot of 17,000 men are concerned. It has been stated that the large Sulitelma copper-mines in Northern Norway, which are owned by a Swedish company, are to be closed altogether; but this is not so. Owing to the large partial strike at the mines, it is not unlikely that the entire working will be closed for some time to come, and that a number of officials would thereby become superfluous.

A statement was made by Mr. Buxton in last Saturday's parliamentary papers that the total cost of the Labour Exchanges from the time the Labour Exchanges Act was passed to March 31, this year, in respect of salaries, travelling expenses, stationery, and the cost of buildings, was approximately 250,000*l.* The total includes capital expenditure in respect of premises.

A very interesting little emigration pamphlet has just been published by the Victorian Employers' Federation in Australia, giving particulars of the high wages ruling in trade and industry, and the scarcity of labour in the State. It is explained that the objects of the pamphlet are twofold. Firstly, by a statement of the actual facts to refute letters circulated in Great Britain by some of the local unions, reflecting on the wages paid out there, and alleging a scarcity of work; and, secondly, to encourage the emigration from Great Britain of suitable artisans with their families. It appears that very prosperous conditions now prevail in Victoria, and, indeed, all over Australia, and there seems to be a growing confidence in the political future—at any rate, to judge from the tone of the pamphlet. It is said that at the present time practically all manufacturing industries are undermanned in the State, and that, owing to the lack of labour, building operations are being limited, many Government contracts are unlet, and a great deal of work is either left undone or is being sent out of the State, and this in spite of the attractions of very high wages.

The immigration of rural workers and settlers from Great Britain is being encouraged by the Victorian Government, and the employers' federation maintains that artisan labour is being overlooked, although, as more new settlers are placed on the land, more workers will, no doubt, be required for manufacturing and other industries to supply the needs of an increasing population. As the country is opened up, the demand for artisan labour will, no doubt, continue to increase, and it is said that some British tradesmen who came to settle on the land found wages offered to artisans so high that they took up their trades again. In connection with Victorian industries, upwards of 15,782,648*l.* has been invested in machinery, land, and buildings; and, according to the statistics of 1909-10, there are now employed in these industries 97,355 hands, male and female. According to Government returns, there has in recent years been an average annual increase in the aggregate of wages paid amounting to 659,663*l.* As to wages, these, in all the main industries, are paid according to a scale determined by the wages boards, and there are about one hundred of these boards in operation. It is stated that the expense of living in Victoria is really very moderate, and compares favourably with any part of the world, both as to quality and cost. Bread costs from 5d. to 6d. per 4-lb. loaf; good tea ranges from 1s. to 1s. 6d. per pound; meat from 2d. to 7d. per pound; sugar, 3d. per pound; and old-age pensions are paid by the Government, the amount being 10s. per week, beginning at 65 years of age for men and 60 years of age for women. The rates of pay of the worker largely exceed those received by men in similar employment in Great Britain, and the hours as a rule are 48 per week, while in some trades they are down to 44 per week. Apprentices and improvers are said to be especially well treated, and the rates of pay in practice generally begin from 5s. to 10s. and 12s. per week, with half-yearly increases. There appears also to be a great demand for young people of both sexes in shops and factories, and also for female domestic service. There seems, therefore, to be many inducements to labour emigration to this State. The pamphlet contains a list of the Wages Board rates of wages for most trades, but we cannot include these here. Further information may be obtained on application to the Hon. Sir J. W. Taverner, Agent-General for Victoria, Melbourne-place, Strand, London, W.C.

The Royal Society of Arts.—At their meeting on Monday the Council of the Royal Society of Arts elected Lord Sanderson, G.C.B., Chairman for the year 1911-12. Lord Sanderson has been a member of the Society for over thirty years.

Acetylene as an Illuminant at the Coronation.—In connection with the illuminations at the recent Coronation a noteworthy feat was accomplished by the Thorn and Hoddle Acetylene Company, Limited, of 151, Victoria-street, S.W., which, at three days' notice, undertook the lighting of St. Edward's Tower and the whole of the west front of the Roman Catholic Cathedral at Westminster. The tower is 300 ft. high, and lights equivalent to 15,000 candle-power were fixed at its top.

THE "STOCK" OIL-FIRED CONVERTER AT DARLINGTON FORGE.

CONSTRUCTED BY MESSRS. THWAITES BROS., LIMITED, ENGINEERS, BRADFORD.

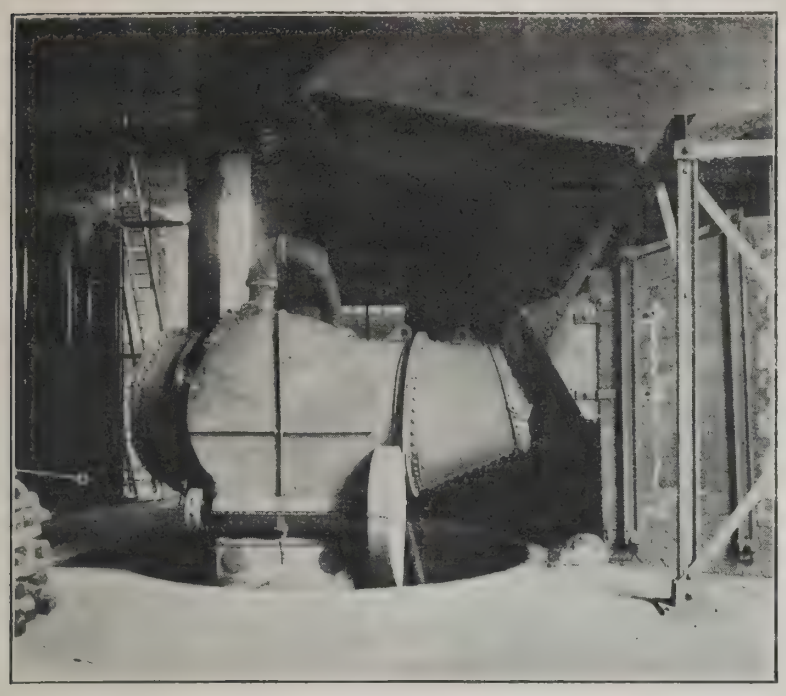


FIG. 1.

FIG. 2.

THROUGH the courtesy of the Darlington Forge Company, Limited, Darlington, we recently had the opportunity of inspecting a "Stock" oil-fired converter in operation at the firm's works, and were much struck with the simplicity of the plant and with the excellence of the steel castings turned out by it. The apparatus has now been in successful use for about twelve months at the Darlington Forge. It has been specially designed for the manufacture of all classes of steel, from soft-steel castings to special steels of the highest class. As will be seen from Figs. 1 and 2, above, the form of the vessel is very much like the ordinary Bessemer converter, so arranged that it can be tipped by gearing driven by electric motor, and also turned horizontally for charging and casting purposes. It is lined with ordinary silica firebrick, and is used not only for the conversion or blowing of iron, but also for melting the actual charge of iron and scrap by means of oil fuel, no separate cupola being required. The vessel is hung on trunnions, the bearings of which form part of the framing that revolves horizontally on the turntable shown. The trunnions work in roller bearings. The interior construction of the vessel permits of a large surface of metal being exposed to the action of the oil-burners, the section being oval. In front of the mouth of the converter are two hoods, one of which receives the hot gases of combustion during the melting of the charge (when the vessel is in a horizontal position) and leads them through a stove filled with iron pipes, through which air passes on its way to the converter. In this way the blast is heated up to about 300 deg. Cent. before it is used for blowing. When blowing the charge the vessel is vertical, and the gases are received by the other hood and conveyed by a chimney to the atmosphere. Before charging, the vessel is tipped to a horizontal position and is then turned through an angle of 90 deg. from the position it occupies when the melting is going on, in order that the mouth may project towards the charging-platform.

The charging (with about 3 tons of pig and scrap) is done by means of an ordinary peel, the operation being easily performed by three men in a little under 10 minutes. After being charged, the vessel is turned back through an angle of 90 deg. into the position necessary for melting, with the mouth pointing, as before stated, towards the air-heating chamber, which is a brickwork structure lined with firebrick. Fig. 1 shows it in this position. The air passing through the heater-pipes is supplied from a high-pressure Roots blower, the pressure being, when melting, about $\frac{3}{4}$ lb. per square inch, which is found sufficient for burning the oil, combustion being very perfect. The air is admitted in the side of the converter at two points on the side away from the heating-chamber, and at about one-third the height of the converter from the bottom, and at these two points the pipes that convey the oil are introduced. The time occupied by the melt with a 3-ton converter is about $1\frac{1}{2}$ hours.

In the converter which we saw at work there were two sets of oil-pipes, each set consisting of seven small steel tubes, each having an internal diameter of about $\frac{1}{16}$ in., and each set pointed through the centre of the tuyere where it was introduced. In this way the oil and the air are intimately mixed. We understand, however, that one set only of oil-pipes can be used if necessary. The oil used is the crudest petroleum available, costing about $2\frac{1}{2}$d. per gallon, and it can be easily stored in any large vessel, such as an old boiler. From this tank it is forced either by the blower or an air-compressor into a smaller tank, which contains a sufficient quantity of oil for from five to six meltings. In this service-tank is a coil through which hot air or steam circulates in order to regulate the viscosity of the oil. A small independently driven compressor is connected to this tank, which maintains a constant pressure of from 30 lb. to 35 lb. per square inch on the oil and forces the necessary quantity through a flexible pipe to the tubes in the tuyere-box. When the converter is cold, the gas and air are lighted by means of cotton-waste or similar substance; but when it has been heated up, this is not necessary, the temperature of the brick lining being of itself quite sufficient for the purpose.

TABLE I.—RESULTS OF TESTS ON SEVEN SAMPLES OF STEEL.

Test No.	DESCRIPTION.	ORIGINAL.		FRACTURED.		ULTIMATE STRESS.		CONTRACTION.	EXTENSION.		Appearance of Fracture. Bend, 1 In. Diameter.
		Size.	Area.	Size.	Area.	Total.	Per Sq. In. of Original Area.	Per Cent.	In.	Per Cent.	
		in.	sq. in.	in.	sq. in.	tons	tons		in.		
1	12 Roof-bars	0.798	0.50	0.540	0.229	13.7	27.4	54.3	3	30.0	180 deg. N.B. 1 sq. in.
2	4 Radial wheels	0.798	0.50	0.560	0.246	14.0	28.0	50.8	3	34.0	180 deg. N.B. 1 sq. in.
3	1 Forward bearing keep..	0.798	0.50	0.550	0.237	14.4	28.8	52.3	3	33.0	180 deg. N.B. 1 sq. in.
4	1 Forward bearing keep..	0.798	0.50	0.580	0.264	14.8	29.6	47.2	3	32.0	180 deg. N.B. 1 in. dia.
5	1 Aft bearing keep ..	0.798	0.50	0.550	0.237	15.0	30.0	52.3	3	32.0	180 deg. N.B. 1 in. dia.
6	4 Side frames	0.798	0.50	0.560	0.246	14.5	29.0	50.8	3	28.0	180 deg. N.B. 1 in. dia.
7	10 Platform supports ..	0.798	0.50	0.555	0.242	14.7	29.4	51.6	3	30.6	180 deg. N.B. 1 in. dia.

TABLE II.—*Analysis.*

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
Carbon	0.22	0.22	0.20	0.23	0 23	0.22	0.22
Manganese ..	0.607	0.540	0.600	0.567	0.540	0.607	0.540
Silicon	0.273	0.178	0.237	0.285	0.273	0.273	0.296
Sulphur	0.012	0.019	0.013	0.016	0.010	0.012	0.013
Phosphorus ..	0.020	0.024	0.018	0.029	0.020	0.020	0.025

When the melting process is completed, the oil-pipes are withdrawn, an operation that can be carried out in a few seconds. After this, the vessel is turned into a vertical position, and blowing commences, the pressure of air being about $3\frac{1}{2}$ lb. per sq. in. It will be understood from what we have said that the air does not enter the converter from the bottom, and pass up through the molten metal, as in the Bessemer converter, but is blown down on the top of the metal. The blowing operation occupies from 15 to 20 minutes, so that a complete blow, including the charging and melting, occupies about two hours. Blowing being completed, the vessel is turned into the horizontal position it had when charged, and the mixings are introduced, the molten metal being afterwards stirred in order to incorporate the mass. The steel is then poured into a ladle, and casting commences. As an actual example of what we saw the following may be of interest. Charging commenced at 11.7 a.m., the weight of the charge being 2 tons 10 cwt., and the charge was melted at 12.49 p.m. The quantity of oil used was 65 gallons. Blowing commenced at 12.51 p.m. and finished at $1.10\frac{1}{2}$ p.m. The weight of the mixings added was 2 cwt. 2 qrs. 7 lb., which was proportioned for a steel having a 0.25 per cent. of carbon. The temperature of the blast was 215 deg. Cent., and the consumption of electricity for the whole process was 60 units. The whole plant is very conveniently arranged and is very compact.

The chief advantages claimed for it are: (1) That no cupola plant is required for melting, and the loss of iron in the cupola is saved. (2) That, as liquid fuel is used exclusively for melting, all risks of picking up impurities during the process are avoided. (3) The high temperature of the melted charge allows of the use of pig irons low in silicon, or the use of higher percentages of scrap. (4) The metal is in such a state of extreme fluidity that it is possible to make the most difficult and intricate castings. (5) The amount of space occupied is comparatively small, due to the fact that the vessel can be turned in the horizontal plane, so that the arrangements for charging, blowing, and pouring can be provided in any convenient position; and (7) the comparatively small amount of power required.

From what we saw at the Darlington Forge these claims certainly appeared to be substantiated, and as regards the cleanness and delicacy of the castings produced, there did not seem to be anything left to be desired. As to the actual cost of the process, based on the production of 52 tons of steel per week, working single shift only, taking hematite at 60s. per

ton and electric power at ½d. per unit, and including depreciation and interest, royalty charges, general repairs and upkeep, lining ladles, &c.; this, we are informed, works out at 4*l.* 17s. per ton.

On the previous page, in Table I., are the results of seven tensile and bending tests of cast steel produced by this process, and analyses are given in Table II.

A carbon tool steel has also been made containing 0.83 per cent. carbon, 0.072 per cent. manganese, 0.011 per cent. silicon, 0.011 per cent. phosphorus, and 0.011 per cent. sulphur, which forges well, and has, we understand, proved very successful for chipping and calking chisels and pneumatic tools. The process has also been used for high-speed tool steel, containing 0.627 per cent. carbon, 0.198 per cent. manganese, 0.059 per cent. silicon, 0.002 per cent. phosphorus, and 0.007 per cent. sulphur. A very low carbon steel, suitable for seamless solid-drawn tubes, which stood all the Admiralty tests, has also been made, the percentage of carbon being 0.08, manganese 0.18, silicon 0.011, phosphorus 0.011, and sulphur 0.01. These analyses show that practically any class of steel can be satisfactorily produced. A remarkable feature of the castings is the absence of blow-holes and other defects.

As an example of the punishment the steel will stand, the following may be mentioned:—A steel wheel, about 4 ft. 9 in. in diameter, was dropped edgewise on a steel ingot from the following heights—5 ft., 10 ft., 15 ft., and 20 ft., without showing signs of fracture. A drop of 40 ft. on the rim broke one spoke. After this four more drops of 40 ft. on edge caused no further fracture either to the rim or the spokes, and the wheel was finally broken up by a steel 3-ton ball dropped ten times on the boss from a height of 40 ft.

Some remarkably small thin castings have been made, one of them a cup, shaped like a wine-glass, 5 in. high, the cup part being 2½ in. in diameter and rather more than $\frac{1}{16}$ in. thick, and the stem $\frac{3}{8}$ in. Another was a tumbler 4½ in. high, 2¾ in. in diameter at the top, and 2¼ in. in diameter at the bottom, and of about the same thickness as the cup; while another casting (the frame of a Clayton radiator), 32 in. long, with a thickness of flange round the holes ⅛ in., and a thickness of body of $\frac{3}{16}$ in., was quite solid and free from blows. The carbon in all these was practically 0.2 per cent. The Darlington Forge Company have also cast some large stop-valves and pipes from steel made by this process. The plant is constructed by Messrs. Thwaites Brothers, Limited, Bradford.

THE SCIENTIFIC STUDY OF NAVAL ARCHITECTURE IN GERMANY.*

By Geheimer Regierungsrat Professor FLAMM.

IT may sound strange if, in the land of ships—the land that has probably done the most towards the practical and scientific development of the whole domain of shipbuilding—I take upon myself to describe the aims of scientific study in Germany, and the methods which it is now adopting. If, however, we reflect that, on account of the exceptionally rapid and accurate exchange of ideas which now takes place between the civilised countries of the world, every successive generation, as it springs up, finds it easy to avail itself of the whole of the material which the past and present fellow-craftsmen of all countries have collected, we see that all nations are thereby enabled to attain a similar development from the same bases, and to make similar advances in the various domains of engineering.

Apart from small unimportant beginnings, the real nursery for scientific study in the various domains of naval architecture in Germany has been the institution now known as the Königliche Technische Hochschule zu Berlin, in Charlottenburg. Since 1904 the Königliche Technische Hochschule in Dantzic has likewise taken part in this work. The naval architectural departments of both these colleges have the same end in view—namely, the training of the young men who will later in life take a successful part in the building of the mercantile and naval fleets of Germany.

In view of the high degree of interest which the Charlottenburg technical college, as a whole, has often aroused abroad, and especially in England, it may not be out of place to give a brief account of the arrangement of the course of study in ship and marine-engine building in the institution in question. In accordance with the system adopted in all the technical colleges in Germany, it is a preliminary requirement for the admission of the students that they should have passed the matriculation examination of a gymnasium, realgymnasium, or oberrealschule (establishments with the classical, classico-modern, and modern tendencies respectively, met with in English secondary schools). As these schools comprise nine forms, it follows that candidates for admission to technical colleges must be between eighteen and nineteen years of age. Since a further qualification is a practical training of one year at a shipyard of recognised standing, the age of the candidate is increased by six months, often by a whole year. To this must be added the period of military service, which is required of every physically and mentally sound German citizen, but which, in the case of an educated man who has obtained his volunteer certificate, is restricted to one year. For those who contemplate a career in the higher ranks of the Imperial naval construction department, the period of practical work and the year of service are spent in naval establishments—that is to say, in an Imperial dockyard and on board a naval training-ship respectively, before the course of study at the technical college is entered upon.

It may thus be said that the course of study begins when the student is twenty-one, and that it has been preceded by a certain period of preparation in the practical work of shipbuilding or marine-engine building. It is with young men thus prepared that the colleges at Charlottenburg and Dantzic have to reckon. The course of instruction is arranged in the following manner:—Within the department for naval architecture a distinction is made, in the first instance, between the professions of naval architect and marine engineer. The course of instruction itself in almost all the subjects comprises lectures and tutorials, or "practices," the object here kept in view being, that what is taught in the former is put into practical shape in the latter. It is a general principle in the German technical colleges that, as far as possible, no lectures are to be delivered without the accompanying tutorials. This principle extends, not only to the main professional subject in each case, but also to the subsidiary subjects, such as pure mathematics, mechanics, physics, descriptive geometry, political economy, law and administration, &c. It is to be observed that this principle has been productive of very good results, and that its extensive application has raised very considerably the standard of the education provided.

In all the departments devoted to different professional branches the course is a four-year one. At the conclusion of the second year, the preliminary examination for the degree or diploma is held, the final examination being taken at the close of the fourth year. The first two years are principally devoted to the more general studies in mathematics and natural science subjects, although a beginning is made with the introductory lectures and tutorials in the main subjects at the outset of the first term. But whereas the general subjects at first take up much more of the student's time than the special ones, this proportion gradually alters as the course proceeds till it finally becomes reversed. Another feature of the arrangement of the studies is that the lectures are, as far as possible, delivered during the earlier terms, while the drawing-office work gradually assumes greater importance as the course proceeds. This is intended to give the student in his last year as broad a base as possible for designing and applying what he has learned from the lectures.

In following out these ideas, the preliminary examination at the end of the fourth term is principally confined to the subject of mathematics, mechanics, physics, descriptive geometry, and chemistry, the special subjects being represented by the general details of marine engines and ships, while the results of the tutorials which, together with the mathematical proficiency shown, form the basis for the admission of the student to the oral examination, comprise a considerable number of constructive applications to details of vessels, such as double bottoms, afterbodies with rudders, &c., three sets of lines with the corresponding calculations of displacement, several exercises in connection with the theory of shipbuilding, and, finally, the design and calculation of a number of parts of machinery.

The primary object of the course of instruction during the first two years is to give the student a general grounding on the broadest possible lines in mathematics and natural science subjects, and concurrently therewith to introduce him to the elements of his special subject, so that, after passing the preliminary examination, he may devote himself in a higher degree to the direct study of his profession during the last two years. In the course of these two years, then, the tutorials gradually take the place of the lectures, and the professional study proper is gone into in detail. The student of naval architecture is engaged in designing and working out the plans of merchant and war vessels, and in studying the arrangement and working of shipyards, while the marine engineering student is at work on marine boilers, reciprocating, turbine, and internal-combustion engines. In addition, auxiliary engines and propellers are thoroughly gone into. Students in each branch concern themselves with the other just so far that, in their respective parts of the work on one and the same vessel, they can completely understand one another, and give due consideration to each other's requirements. The domain of airship construction and aerial navigation, which is closely related to naval architecture, has been included in the province of the latter, and it may be of interest to mention that quite a number of the first designers and engineers who have specialised in airship construction were formerly students in the department of naval architecture.

A programme of the subjects taken during the two last years of the course is given in the syllabus of the final examination for the diploma. Among these are included:—

SHIPBUILDING.

(*a*) Mercantile Shipbuilding:—
- (i.) Designing of ships' lines.
- (ii.) Complete design for a merchant vessel.
- (iii.) Outline plans for a merchant ship.

(*b*) Warship building:—
- (i.) Design of a warship.
- (ii.) Principal details in connection with the design.
- (iii.) Design of a propeller with accompanying calculations.
- (iv.) Questions relating to shipyard arrangements and work.

MARINE ENGINEERING.

- (i.) Design for a marine reciprocating engine or for a steam-turbine, together with boiler installation for a merchant vessel or for a warship.
- (ii.) Design for a marine gas-engine.
- (iii.) Design for a ship's auxiliary engine.
- (iv.) Outline plans for a merchant vessel.

The oral examination includes questions on:

SHIPBUILDING.

- (i.) Theory of ship construction.
- (ii.) Design and construction of ships.
- (iii.) Lay out and working of shipyards.
- (iv.) Construction and arrangement of warships.
- (v.) Marine engine construction.
- (vi.) Fundamental principles of law and administration.

MARINE ENGINEERING.

- (i.) Power plants, machine-tools and machine construction.
- (ii.) Marine engine construction (reciprocating, turbines, interoal-combustion).
- (iii.) Boiler construction, auxiliary engines and accessories.
- (iv.) Shipbuilding (merchant vessels and warships).
- (v.) Electricity as applied to ships.
- (vi.) Administration and management of naval and private establishments.

The Tables of Studies, with the times devoted to each subject, are given on page 55.

One of the important aims of science as applied to naval architecture is directed to the keeping of the rules of the classification societies in general accordance with the latest advances in knowledge. This refers chiefly to the arrangement, scantlings, and riveting together of the structural part of the hulls of vessels, and to the application of the laws of mechanics, statics, and dynamics. A second aim is that the rules of these societies, which are gradually gaining in authority, shall be prevented from developing into crystallised and inelastic ordinances, which interfere with the scientific development of ship design. We should insist, in this as in every other branch of engineering, that each new structure shall be looked upon much more as a concrete entity than has hitherto been the case, and that any new ship's design shall be worked out in this spirit.

The system of tabulating, still so much practised, according to which the peculiarities of a new vessel are taken account of only by a few parenthetic clauses and special rules, is not the one and only right method. The endeavour should be, more than formerly, to have the individual demands of a new vessel recognised to a greater degree than hitherto, even though they represent departures from the actual rules of the classification societies, if only reasonable justification can be shown for such departures. In the rules for the tonnage measurement, freeboard, and arrangement of bulkheads, every vessel should be treated individually to a far greater extent than hitherto, so that her lines and other features, in which the design as such is embodied, shall form the basis for determination of the tonnage, freeboard, and relative unsinkability, the stability and structural strength at the same time receiving due consideration. The result of this would be that persons entrusted with the judging and supervision of designs of new vessels, and those who at a later stage watch over the carrying of the rules into effect, would not, as is now too often the case, be men devoid of scientific training, such as retired sea-captains or others of this stamp, but thoroughly qualified engineers, who have been successfully engaged for a term of years in practical work. Comparisons with the conditions obtaining in other technical branches, such as those in bridge-building, engine-building, and electro-technical engineering, prove the correctness of these ideas as applied to the construction of ships—the more so as the navies of all the principal nations already follow the path marked out as a matter of course, and with complete success.

There is one other point to which I must here draw attention. Both for instructional purposes and for scientific research work, suitable laboratories are nowadays of the very greatest value. In all branches of engineering there are many questions the solution of which by pure analytical methods is impossible, and which therefore can only be dealt with by practical experiment. To what excellent use in this way have not the existing testing laboratories in almost all countries been put. At the Technical College in Charlottenburg the Mechanical Engineering Section in particular has established numerous laboratories, and they have been of the utmost value both from the educational and from the industrial point of view. The distribution of these laboratories among the different sections of the college is as follows:—

Section for	Architecture	1
,,	Civil Engineering	1
,,	Mechanical Engineering	9
,,	Shipbuilding and Marine Engineering	—
,,	Chemistry and Metallurgy	8
,,	General Science	1

It will thus be seen that the Technical College at Charlottenburg now possesses twenty laboratories, which serve the purposes of the research work of the professors as well as those of instruction. A short time ago a project for the installation of a second laboratory for the civil engineering section for the investigation of hydraulic questions was unfortunately rejected by the Prussian House of Representatives. It is a remarkable circumstance that in the entire establishment the section for shipbuilding and engineering should be the only one which has no laboratory. It must be admitted that this is very much to be deplored, and that the course of instruction as well as the solution of engineering problems is immensely impeded thereby. It may readily be understood, therefore, that the naval architectural section is doing its best towards the early attainment of an establishment of this kind so as to close up the gap in its

* Paper read at the Jubilee meeting of the Institution of Naval Architects, July 6, 1911, and illustrated by cinematographic views.

TABLE OF STUDIES (CHARLOTTENBURG).

First Year's Course. For all Students.

Subject.	Number of Hours per Week. Winter.	Summer.
1. Experimental physics	4	4
2. Physics laboratory	4	4
3. Higher mathematics	8	8
4. Mechanics (I.)	6	6
5. Descriptive geometry (I. and II.)	8	8
6. Elements of machine design	6	6
7. Elements of ships		
8. Mechanical technology (I.) and metallurgy	2	2
9. Outline of experimental chemistry	2	2
10. Introductory to ditto	2	2
11. Ship drawing (I.)	2	2
12. Elements of political economy	4	4
13. Tutorial work in testing laboratory		1

Subject	Naval Architecture. Number of Hours per Week. Winter.	Summer.	Marine Engineering. Number of Hours per Week. Winter.	Summer.
Second Year's Course.				
14. Mechanics (II.)	6	6	6	6
15. Elements of machine design	10	8	10	8
16. Hoisting-machines		4		4
17. Naval architecture (theoretical)	2	6	2	6
18. Drawing of ships' lines (II.)	4	4	4	4
19. Ship designing	2		2	
20. Main features of ship construction	8	8	8	8
21. Marine boilers		2		2
22. Grapho-statics	4		4	
23. Mechanical technology (II.) and materials	4	4	4	4
24. Economic science (tutorial class)	2	2	2	2
25. Thermo-dynamics (I. and II.)			2	2
26. Mechanical laboratory			2½	2½
27. Electro-mechanics (I.)			4	4
Third Year's Course.				
27A. Warship construction	2	2	2	2
28. Design of warships		4		
29. Warships details	2	2	2	2
29A. Design of details (warships)		4		
30. Theoretical naval architecture	2		2	
31. Design and construction of ships (II.)	8	4	8	4
31A. Details of construction (merchant ships)	2			
32. Marine boilers	2	2	2	2
33. Auxiliary engines		2		2
34. Marine engines (reciprocating)	4	4	4	4
35. Marine gas-engines	2	2	2	2
36. Airship motors		2		2
37. Banking and business on the exchange	2	2	2	2
38. Commercial business	1	1	1	1
39. Banking and commerce (tutorials)	2	2	2	2
40. Finance		2		2
41. Ventilation and heating of ships	1		1	
42. Marine-engines (including turbines)			12	12
43. Internal-combustion engines and automobiles			2	4
44. Design of boilers				4
45. Design of marine steam-engines				4
46. Design of gas-engines for ships and airships				4
Fourth Year's Course.				
47. Design of warships	4			
48. Design of warship details	4			
49. Design and construction of ships (III.)	6	4	6	4
50. Turbines and propellers	2	2	2	2
51. Propeller design	4	4		
33. Auxiliary engines	2		6	4
52. Arrangement and management of shipyards	6	6	2	2
53. Shipyard management (tutorial class)	2	2		
54. Electrical equipment for ships	2	2	2	2
55. General and experimental electro-technics	2	2		
56. Applied dynamics	2	2	2	2
57. Strength of materials	2		2	
58. Hydraulics		2		2
41. Ventilation and heating of ships	1		1	
59. Testing of materials at the Lichterfelde testing establishment	4		4	
60. Design of turbines (marine)			4	4
61. Design of marine engines (reciprocating)			4	
63. Design of boilers			4	
64. Design of gas-engines for ships and air-ships			4	
65. Workshop plant			2	2
66. Electro-mechanics (II.)			2	2
67. Practical work in electrical laboratory			4	4
68. Design of internal-combustion engines			4	
69. Refrigeration machinery for ships				2

structure. What may be accomplished in such an establishment by the aid of a private grant is shown in my book on "The Screw Propeller and its Action on Water." It may not be uninteresting to outline some of the experiments made, and illustrate them by cinematograph views. The conclusions to which my researches have led are briefly these :—

1. The screw propeller in general exerts a sucking action upon the water, which lowers the surface of the latter.

2. The sternward-flowing stream preserves an approximately cylindrical form ; a propeller which draws together or heaps up the water does not exist. The water from the screw-propellers of canal-boats accordingly does not injuriously affect the beds of the channels ; this has been established by more than 4000 experimental runs made with model twin-screw vessels 23 ft. in length in a model canal-sectioned tank in the Royal experimenting establishment for hydraulic engineering and shipbuilding in Charlottenburg. In the case of a single-screw vessel, the observed effect on the bed of a channel was found to be entirely due to the interposition of the stern-post and rudder behind the propeller. The downward diversion of the water from the propeller and consequent action upon the bottom of the canal ceases at once when a pair of side-rudders are substituted for the single rudder at the centre-line. This latter fact was also demonstrated in the Charlottenburg establishment.

3. Axial thrust almost completely ceases as soon as the powerful suction effect brings air into the space about the screw-propeller. If the water above the propeller be covered over so that no air can get down beside the latter, exceedingly high efficiencies are obtained with blade-tips working close to the surface, this being quite impossible without such covering.

4. The axial thrust has its maximum value at the instant when cavitation begins.

5. The "thudding" effect of the propeller on the stern of a vessel is not the result of the projecting of masses of water against the hull, for no direct blow is thus delivered ; it may be that the smallness of the space in which the propeller has to work in the vicinity of the hull tends to produce a vacuum into which the water rushes in the intervals between the passage of successive blades. In so far as the vibrations of a vessel are due to propeller action, they are caused by the sucking down of a certain quantity of air by each successive blade in passing (accompanied by a loss of thrust) ; while the lower blades, which are meanwhile well immersed, produce a sudden and very pronounced displacement of the centre of pressure of the issuing stream, and a moment is set up which is very probably one of the causes of the vibration of the after body.

6. The loss of speed of turbine vessels in a heavy sea may also be similarly explained by the fact that the propellers are in the first place heavily loaded, so that the sucking action per unit of blade surface is at its maximum, and they are accordingly very likely to draw in air. Then, when the vessel pitches, a quantity of air is pretty sure to be drawn in during the passage of the blade near the surface of the water, whereby the thrust is almost destroyed, and the speed of the vessel is diminished.

If these ideas prove to be correct, it will be necessary in designing ships' propellers to pay more attention than hitherto to the form of the leading or suction surface, and, as in the case of the blades of aeroplane propellers, to have the smallest radius of curvature of this just behind the leading edge.

The stream of water which comes in contact with the convex side of the movable surface does not repel that side, but sucks it directly towards itself. If, then, the surface be held fast, the stream of water must be subjected to motion in the contrary direction and, in the case of a propeller blade, produces a thrust upon it.

My endeavours are directed to the establishment of a suitable naval architecture laboratory in which experiments may be made on this action of the screw propeller, and in which the gross and net amounts of work done by the latter, *i.e.*, its efficiency, may at the same time be determined. Further experiments will then be made to determine the effect on each other of several screw propellers arranged abreast, or one behind the other, and also the effect exercised on them by the rudder. We shall then know whether it is possible to design high-speed propellers of high efficiency, and our knowledge over a wide range of under-water phenomena will be available for further advances in this branch of engineering.

Students should take part in all inquiries of this kind, so that the results may benefit succeeding generations of engineers and enable them to play a leading part in the scientific progress of their time.

SOME FURTHER NOTES ON CAVITATION.*

By S. W. BARNABY, Member of Council.

ON the occasion of our last International Congress in 1897 I read a paper on "The Formation of Cavities in Water by Screw Propellers at High Speeds."† This was a restatement of the theory of cavitation which had been brought before the Institution of Civil Engineers by Sir John Thornycroft and myself two years previously. In order to prevent the formation of these cavities we proposed to limit the thrust per square inch of projected surface to about 11¼ lb. per square inch in the case of propellers having approximately the same shape of blade and pitch ratio, and the same depth of immersion as those of the destroyer Daring. It was explained that somewhat higher pressures than this could be allowed for screws of finer pitch ratio, or having deeper immersion, or for screws in which the shape of the blade departed from the ellipse, being made broad at the tips. At the time this limit of 11¼ lb. pressure per unit of surface was suggested the use of turbines for marine propulsion was not contemplated, and it has been found, as might have been expected, that the uniform turning moment obtained with a turbine enables a higher thrust to be used. In the case of a direct-driven propeller, where it is necessary to submit to some sacrifice of screw efficiency, in order that the turbine may run at a sufficiently high rate of revolutions for economical working, a thrust of about 13 lb. is accepted, and found to give a good compromise, although I believe that incipient cavitation is then present, causing an increase of slip, because the revolutions usually exceed by 2 or 3 per cent. the number which would be estimated from the tables based on model experiments.

It will be noticed that, in addition to this more uniform turning moment, all the conditions suggested in the paper referred to as likely to permit of the use of a higher thrust than 11¼ lb., are present in the turbine propeller as now made. For example, the tips of the blades usually have much greater immersion than in the screws driven by piston engines, because of their small diameter; also the pitch ratio is very fine ; and, lastly, the area is thrown as much as possible out towards the tips of the blades. I also pointed out some years ago* that the thrust of propellers driven by four-cycle explosion engines should not exceed 8 lb. to 9 lb. per square inch, because, unless a large number of cylinders are employed, the very irregular turning-moment of these engines causes cavitation to occur at lower thrusts than in the case of double-acting steam-engines.

I refer to this because some criticism has lately been expressed concerning the accepted theory of cavitation, on the ground that it had been proved that some propellers would stand a higher thrust than 11¼ lb. without cavitating, and that some cavitated at a much lower thrust. It is a mistake to suppose that 11¼ lb. was intended to apply to all cases. It has been suggested that the peripheral velocity of the propeller is a better criterion of the approach of cavitating conditions than thrust per unit area. I will give my reasons for not concurring with this view. The peripheral velocity at which cavitation commences is not by any means constant, but varies both with pitch ratio and "abscissa" value or slip ratio to a much greater extent than does thrust per square inch.

In Table I., page 56, are shown the cavitating speeds of three-bladed turbine-driven propellers, having a developed area of 0.74 disc area, assuming a limiting thrust of 13 lb. per square inch of projected area.

In Table II. I give the peripheral velocities of the same screws at these cavitating speeds, and it will be seen that they vary from 4,800 ft. to 17,280 ft. per minute.

I have drawn a thick line round those figures in the table which lie within the limits of usual turbine practice, that is, I include pitch ratios lying between 0.8 and 1.0 and "abscissa" values lying between 9 and 13. Within these circumscribed limits the peripheral velocities only vary from 10,550 ft. to 15,000 ft., and this probably explains why an impression has been formed that peripheral velocity is a safe guide in the design of turbine screws, an average value of about 12,000 ft. being recommended. This corresponds with an "abscissa value" of 11 and a pitch ratio of from 0.9 to 1.0, which are about the conditions usually aimed at, and so far it would be correct to design for this tip speed, provided the developed area of the blade was about that given in the table. But if the blades are made wider than this—if, say, they have a projected area of 0.75 disc area instead of a developed area of 0.74 disc area, which latter is the area ratio used in Tables I. and II.—then the peripheral velocities may be considerably increased.

In Table III. I have worked out the peripheral velocities for this projected surface ratio within the same limits of "abscissa value" and pitch ratio. They range from 11,600 ft. to 15,900 ft. per minute.†

The peripheral velocity of the wing screws of the destroyer Tartar, which had this projected area ratio of 0.75, was 14,850 ft. per minute. Very much lower velocities than these would have to be employed for propellers driven by geared turbines at lower revolutions, because, as will be seen from Table II., the permissible tip velocity decreases rapidly with increase of pitch ratio. On the other hand, a thrust of 13 lb. to 14 lb. would be equally suitable for direct-driven or geared propellers.

Commander C. W. Dyson, U.S.N., in a very interesting series of papers containing a large amount of valuable information on the trials of United States warships which he has contributed to the proceedings of the American Society of Naval Engineers, states that thrusts as high as 16 lb. per square inch of projected surface have in certain cases been recorded in turbine propellers giving a fair amount of efficiency. This is so much higher a thrust than I have ever known to be put through a screw with good results that I think it possible Commander Dyson may have a different way of calculating the thrust. In any case, it is not exactly measurable, and depends on the estimate which is made of the value of the propulsive coefficient and of the thrust deduction. He also states that the thrust per unit of projected area does not appear to be so important as the thrust per unit of disc area in affecting efficiency.

I think the explanation of the improvement in efficiency

* Paper read at the Jubilee Meeting of the Institution of Naval Architects, July 6, 1911.

† Transactions of the Institution of Naval Architects, vol. xxxix., page 139.

* "Marine Propellers," Fifth Edition, page 58.

† The assumptions made are 10 per cent. wake and 10 per cent. thrust deduction, 50 per cent. propulsive coefficient, 85 per cent. blade correction ; projected area = 0.75 disc area ; thrust, 13 lb. per square inch.

which he finds accompanying a reduced pressure per unit of disc area is that turbine propellers are nearly always made of two small a diameter for good efficiency in order to get high revolutions for the turbines, and the efficiency of the propeller would almost always be improved by increasing the diameter and reducing the revolutions, but at the expense of the combined efficiency of screw and turbine.

TABLE I.—*Cavitating Speeds of Three-Bladed Screws, Assuming* 13 *Lb. Thrust per Square Inch, and Developed Area* = 0.74 *Disc-Area.*

Pitch Ratio.	Knots.					
0.8	42.7	36.1	30.7	26.1	22.7	19.7
0.9	43.6	36.8	31 4	26.7	23.1	20.2
1.0	44.5	37.5	32 0	27 3	23.6	20.7
1.1	45.4	38.2	32.6	27.8	24 1	21.1
1.2	46 2	38.9	33.2	28.3	24.5	21.4
1.3	46.8	39.5	33.7	28.7	24.9	21.7
1.4	47.4	40 0	34.2	29.0	25.2	22.0
1.5	48.0	40.5	34.6	29.4	25.5	22.2
1.6	48.5	40.9	35.0	29.7	25 8	22.4
1.7	49.0	41.3	35.3	30.0	26.0	22.5
1.8	49.3	41.6	35.5	30.2	26 2	22.7
1.9	49 6	41.9	35.7	30 3	26.3	22.8
2.0	49.9	42.1	35.8	30.5	26.4	23.0
2.1	50.1	42.2	36.0	30.7	26.6	23.1
2.2	50.2	42.4	36.2	30.8	26.7	23.3
2.3	50.3	42.5	36.3	31.0	26.9	23.4
2.4	50.5	42.7	36.5	31.2	27.0	23 5
2.5	50.6	42.8	36.6	31.4	27.0	23.5
	7	9	11	13	15	17

Abscissa values.

TABLE II.—*Tip Velocities in Feet per Minute at Cavitating Speeds of Three-Bladed Screws, Assuming* 13 *Lb. Thrust per Square Inch, and Developed, Area* = 0.74 *Disc-Area.*

Pitch Ratio.						
0.8	17,280	15,000	13,450	12,300	11,370	10,580
0.9	15,720	13,800	12,450	11,350	10,490	9,760
1.0	14,500	12,820	11,590	10,550	9,720	9,100
1.1	13,500	12,000	10,800	9,850	9,000	8,500
1.2	12,650	11,250	10,150	9,250	8,500	8,000
1.3	11,900	10,580	9,600	8,720	8,060	7,560
1.4	11,280	10,030	9,100	8,260	7,690	7,170
1.5	10,700	9,550	8,650	7.850	7,320	6,800
1.6	10,190	9,100	8,250	7,500	7,000	6,500
1.7	9,700	8,700	7,890	7,170	6,710	6,210
1.8	9,300	8,350	7,550	6,880	6,440	6,000
1.9	8,900	8,000	7,250	6,610	6,200	5,770
2.0	8,550	7,700	6,950	6,370	5,950	5,570
2.1	8,220	7,400	6,680	6,150	5,750	5,400
2.2	7,900	7,180	6,450	5,950	5,570	5,230
2.3	7,650	6,920	6,250	5,790	5,400	5,070
2.4	7,380	6,690	6,090	5,640	5,230	4,930
2.5	7,150	6,460	5,950	5,520	5,100	4,800
	7	9	11	13	15	17

Abscissa values.

TABLE III.—*Tip Velocities in Feet per Minute at Cavitating Speeds of Three-Bladed Screws, Assuming* 13 *Lb. Thrust per Square Inch, and Projected Area* = 0.75 *Disc Area.*

Pitch Ratio.			
0.8	15,900	14,400	13,030
0.9	14,850	13,400	12,250
1.0	13,960	12,650	11,600
	9	11	13

Abscissa values.

Mr. D. W. Taylor, in the book he has just published on "Speed and Power of Ships," contends that the accepted theory of cavitation is inadequate, and that tip velocity and shape of blade section are the prime factors involved. There is no doubt that both have a very important influence on cavitation, and especially the latter. Mr. Taylor is so competent an experimenter and so high an authority on all matters connected with propulsion that one would hesitate to question any opinion he may express on any subject coming within the scope of tank inquiry; but it is well known that propellers cannot be made to cavitate in a tank under ordinary conditions, and very special means have to be taken to get the phenomenon to exhibit itself with model screws.

Mr. Parsons was able to observe it in a special tank with heated water having a vacuum over the surface, and it will be remembered that he confirmed generally the results I had obtained by calculation.

Mr. Taylor has not followed this method, but has made experiments with a special form of blade which cavitates freely in cold water, and with the pressure of the atmosphere upon the surface; but the instrument he used could hardly be called a propeller, because it is far outside the limits of all existing practice. The pitch ratio is as fine as 0.3, and the blades are unusually narrow and thick. Now, even at 0.6 pitch ratio the efficiency of a propeller has dropped from a maximum of 0.74 to 0.58, and no propeller has ever been made, so far as I know, with so low a pitch ratio as 0.3, because under such conditions it is simply churning the water. This model cavitates so vigorously that the thrust becomes negative above a moderate number of revolutions, and if used as a propeller it would only need to be driven fast enough to actually reverse the direction of the motion of the vessel.

Cavities first begin to appear at as low a tip speed as 3000 ft. per minute, and the thrust becomes negative at a tip speed of between 5000 and 6000 ft. With this special "cavitator" Mr. Taylor has been able to measure the pressure at different parts of the face and back of the blade by means of a very ingenious arrangement of pressure gauges, and he has found that there is a reduction of pressure at the leading edge of the driving face of his blade, and he expresses the opinion that cavitation is only injurious when it occurs at the driving face.

It seems to me that this conclusion has been arrived at somewhat hastily, and requires much further proof before it can be accepted. I think the reduction of pressure which was observed on the driving face was due to the abnormally fine pitch ratio in conjunction with a thick and narrow blade, and I do not think it is possible for cavities to form on the driving face with ordinary pitch angles and blades of normal section.

The photographs taken by Mr. Parsons of his propeller when cavitating, under conditions properly representing those found in practice, show most clearly that the cavities are at the back of the blade. (See Fig. 2, above.)

I thoroughly agree with Mr. Taylor that it is of the utmost importance that the blades should be very thin at the leading edge, and it may be even advantageous to make the edge thinner than will stand the water pressure unsupported, and to stiffen it with circumferential ribs, as he recommends; but I do not think he has made out a case in favour of taking tip velocity as a criterion in preference to pressure, because he has himself shown that cavitation will under special circumstances begin at as low a velocity as 3000 ft., and I have shown that in the case of the Tartar the tip velocity was as high as 14,850 ft., with good results. It will be observed that Mr. Taylor's cure for cavitation is the same as my own—namely, very wide blades—although he arrives at it by a different line of reasoning. He thinks that "face cavitation begins to spread slowly with increase of tip speed, so that the wider the blade the greater the area of the face whose thrust is not nullified by cavitation." As already stated, I doubt the existence of face cavitation on a properly-designed propeller, although it can evidently exist on an instrument specially designed to cavitate; and I still think that the great waste of power admittedly caused by cavitation is due to cavities at the back of the blade, and that these affect the efficiency, because at least half, and usually the major portion, of the thrust is due to the suction of the blade back, and this is lost as soon as the water breaks away from the back. Sir John Thornycroft has suggested to me that efficiency is also probably affected by the fact that when cavitating the propeller is working in a medium of less density, because the air bubbles extracted from the water forward of the screw form part of the stream passing through the screw's disc, as clearly shown by the spirals in the photographs (see Figs. 1 and 2), and thereby reduce its density.

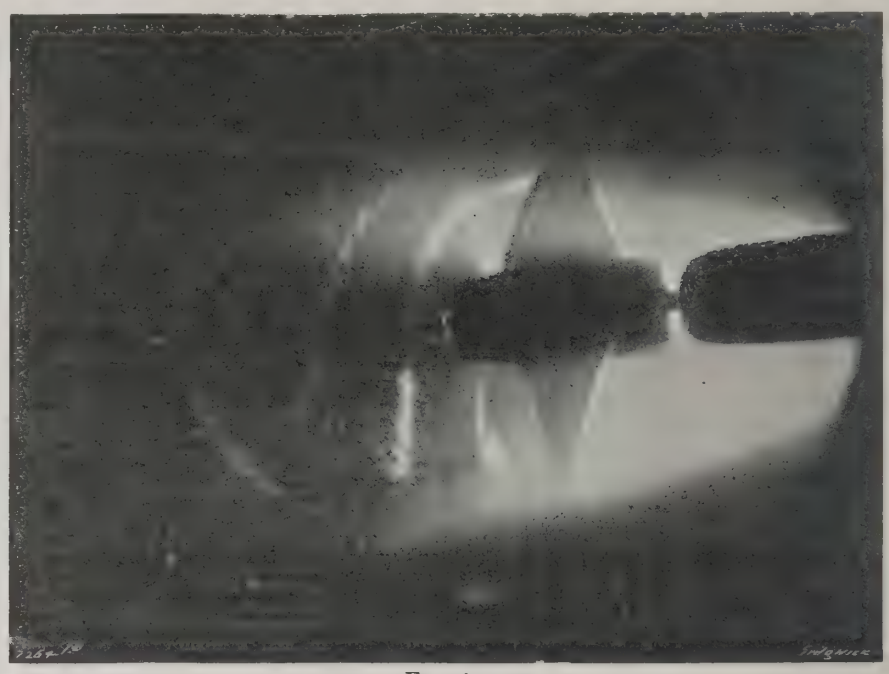


FIG. 1.

FIG. 2.

It may be objected that I bring forward no fresh proof that thrust is a safe guide, and that the tip velocities I have given in the tables are based on the assumption of a fixed limit of pressure. This is quite true, and perhaps further experiment only can settle the question. I must, however, say I have found it a very satisfactory method of fixing the blade area, and have seen no reason to doubt the soundness of the theory on which it is based.

I am glad to learn that Mr. Parsons is making a special tank of a much larger size than that with which he made his previous experiments, but arranged to work under the same conditions of hot water relieved of the atmospheric pressure, in which he will try models of actual propellers, and I think judgment should be reserved until the results he obtains are made known.

Fig. 1

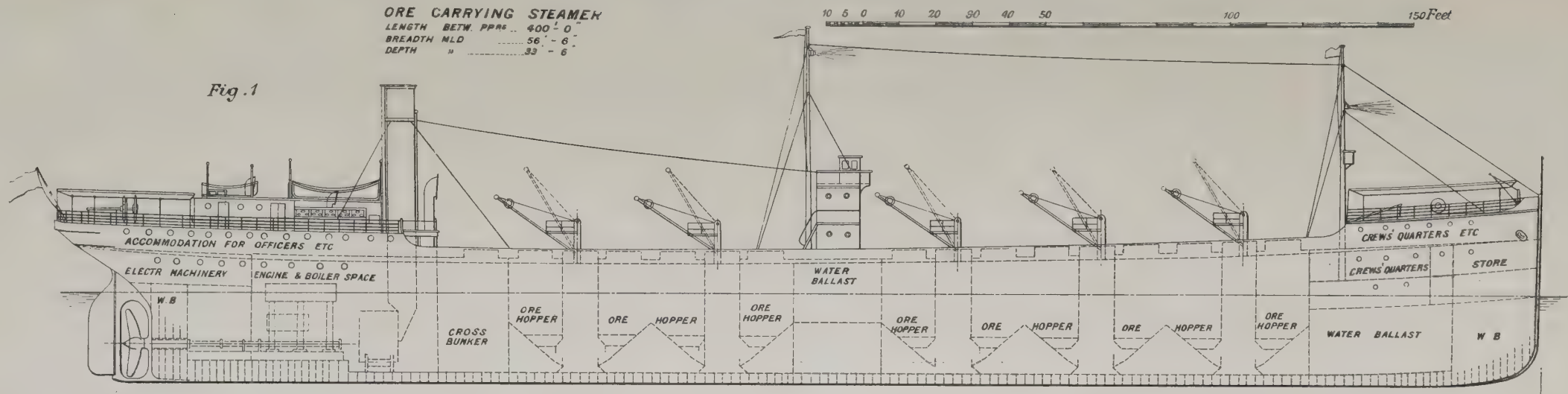


Fig. 2

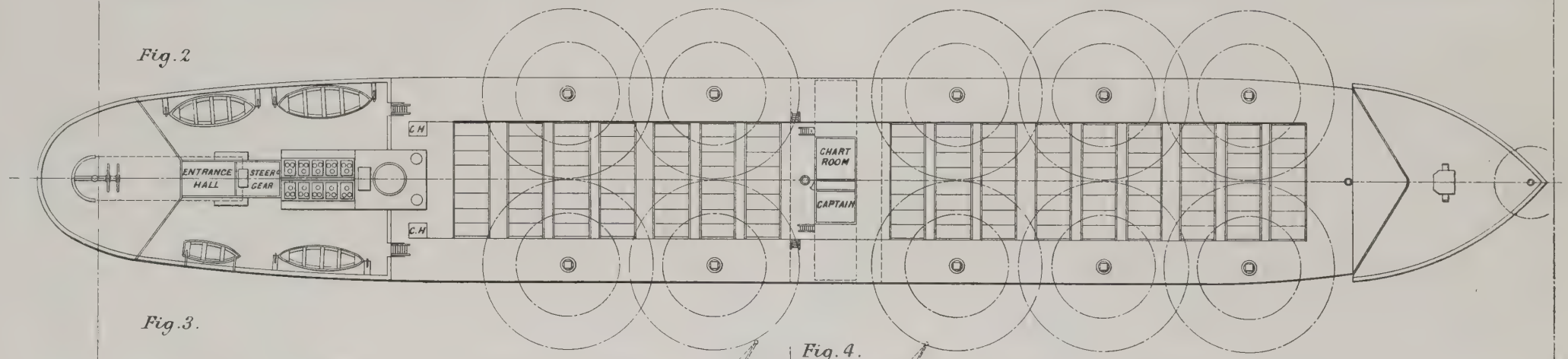


Fig. 3.

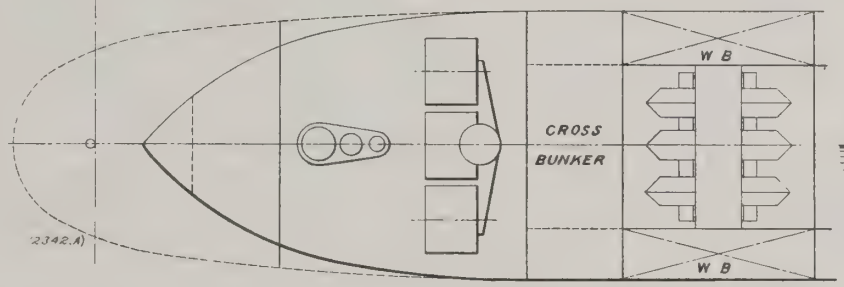
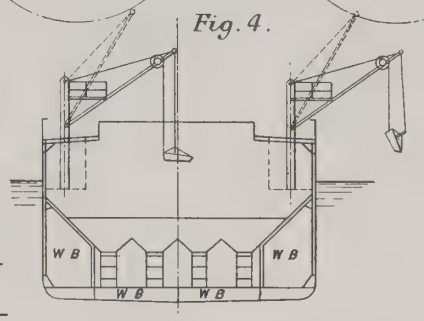
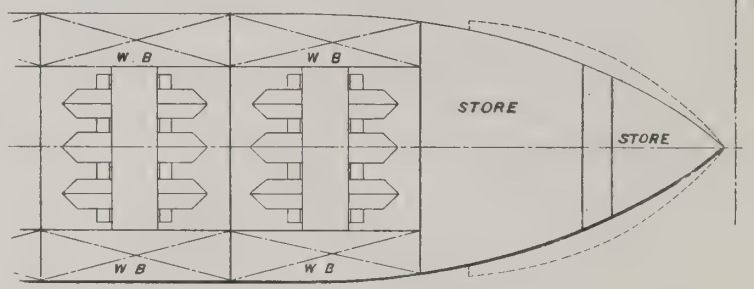


Fig. 4.





RECENT DEVELOPMENTS IN THE SEA TRANSPORTATION OF SWEDISH ORE.*

By J. JOHNSON, Member.

THE iron ore trade of Sweden having in later years grown into comparatively large proportions, it was found necessary, in order to keep pace with the increasing output of the mines, to facilitate the loading capacities at the shipping ports by means of suitable viaducts, enabling the ore to be shipped by utilising the force of gravity, with a minimum amount of manual labour.

The Port of Narvik, in Norway, over which most of the Swedish ore is now shipped, furnishes an example of the best facilities of its kind in Europe. The largest ships at present engaged in the ore trade can be loaded with reasonable despatch at this well-sheltered natural harbour.

Turning our attention, on the other hand, to the vessels employed in this trade, we find that these are nearly all ordinary tramp steamers, of which those that are specially built for the trade have as a distinguishing feature a special outfit of a large number of ordinary steam-winches, with accompanying masts, derricks, and gear of a very heavy description.

In the best-planned vessels of this kind the arrangement of hatches has enabled the cargo to be better distributed, in order to somewhat reduce the straining action on the ship's structure.

Special care has to be exercised in protecting watertight parts of the structure, such as ballast-tank tops and shaft-tunnels, from the falling of the heavy ore, when loading, by means of extra heavy ceiling, which in a comparatively short time is impregnated with the grit of the ore, and consequently adds an appreciable amount to the equipped weight of the vessel as well as to the cost of upkeep.

The discharging is still done chiefly by manual labour, the ore being shovelled into iron buckets of varying shapes, which, when filled, are hoisted by the winches in the usual way and emptied into shoots, lashed on the deck for the purpose. By means of the said shoots the ore is run into barges alongside the discharging vessel. This procedure is in vogue in most of the Continental ports, such as Emden and Rotterdam. In some of the British ports, receiving Swedish ore in

* Paper read at the Jubilee Meeting of the Institution of Naval Architects, July 6, 1911.

smaller quantities, the hoisting is effected by means of cranes on the wharfs. Shovelling iron ore by hand is extremely laborious, and it is plain that such a method of discharging is not in keeping with the improved facilities at the mines and at the best-equipped loading ports.

Naturally, one's attention is turned to the latest systems of discharging ore in the United States of America, where heavy and expensive staiths are fitted for the purpose and equipped with powerful clam-shell buckets, whereby the ore is handled effectively and with great despatch.

The main conditions of the American ore trade differ, however, considerably from the corresponding conditions in Europe. The American ore trade follows certain permanent interior routes, reducing the number of discharging ports to a few, whereas the number of European ports receiving ore is comparatively large. The consistency of the American ore is entirely different from that of the Swedish ore. Consequently, if any improvements are aimed at in the shape of mechanical devices for discharging iron ore of a stony nature and high specific gravity, such contrivances will have to be carried by the vessels themselves employed in the trade.

With a view of constructing a vessel for the purpose of carrying ore, specially fitted out with mechanical means of discharging, the Johnson-Welin system was devised a few years ago. By this system the ore is carried in bins or pockets of iron, built into the ship and placed athwartships, having sloping bottoms with suitable outlets.

The Trafikaktiebolaget Grängesberg - Oxelösund, of Stockholm, owners of the principal iron-mines in Sweden, decided to try this system, and in 1907 a temporary bin, holding about 130 tons, was fitted on board the s.s. Polcirkeln, belonging to a sub-company of the above-mentioned mining company. The results proved satisfactory, and in the following year the said company decided to build a vessel of about 8000 tons deadweight capacity to be fitted out with bins on the Johnson-Welin system.

By reference to Figs. 1 to 4, page 57, representing the general arrangement of a steamer designed in accordance with this system, it will be seen that the cargo hold is sub-divided by means of transverse bulkheads, forming alternately bins for the cargo and discharging shafts. The vertical bulkheads do not extend to the bottom of the hold, but terminate about 7 ft. from the tank top, and are connected to the sloping bottoms of the bins. These sloping bottoms have an inclination of 42 degrees from the horizon.

The ore is discharged from the bins through specially constructed shoots, having a closing arrangement, which can be manipulated by one man. Figs. 5 and 6 show the mechanical principle of this closing arrangement, which is quite simple, and has been found to work very satisfactorily. The door A consists merely of an iron plate, stayed by two horizontal stiffening bars. This door is raised by means of a lever C, having an adjustable counterweight E. The shaft F conveys this motion to the other side. The upper edge of the door A is held in position and guided by links D. The fulcrum F of the levers C and the point of suspension of the links D are in such positions that in opening the outlet the door A move outwards, thus relieving the pressure of the ore.

CLOSING ARRANGEMENT FOR ORE SPOUT

Fig. 5.

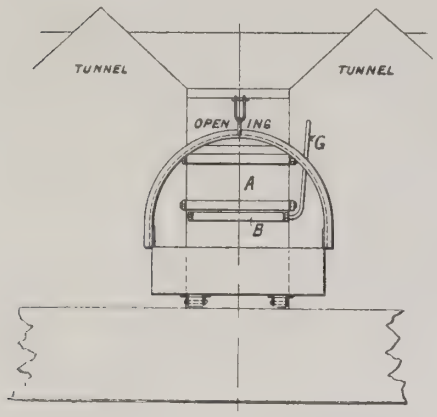


Fig. 6.

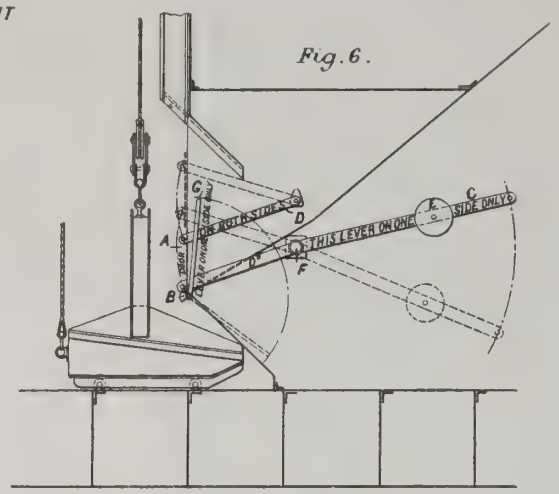
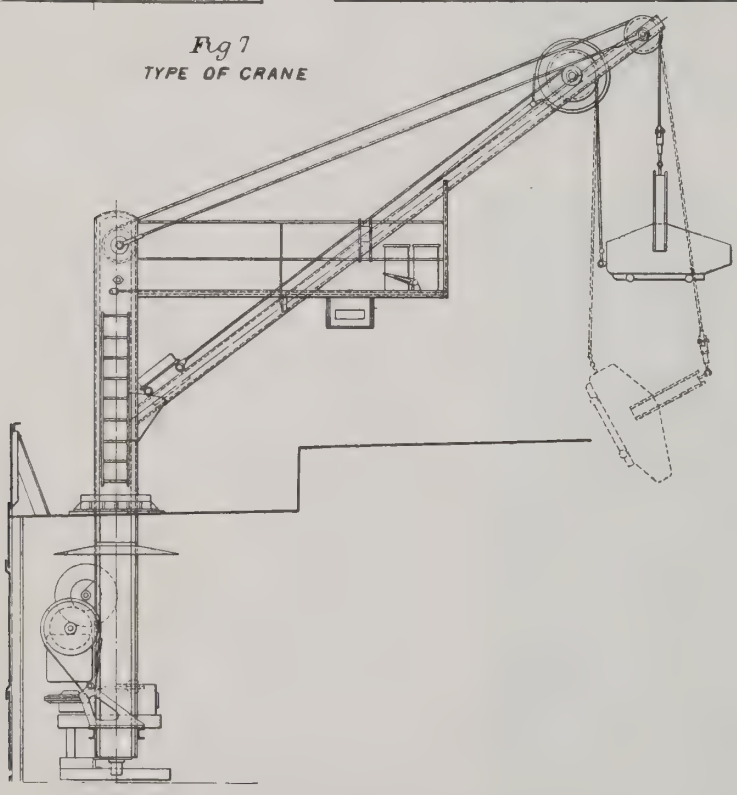


Fig 7
TYPE OF CRANE



At the bottom of the shoot an angle-iron lip B is fitted, actuated by a lever G; this lip B serves the purpose of stopping the outflow of smaller particles of ore if the door A cannot be entirely closed. The design of the vessel in this case embodies wing tanks for carrying water ballast, and the tops of these wing tanks, as will be seen from the section in Fig. 4, page 57, are sloping, in order to convey the ore to the wing outlet shoots. No wood ceiling is required in the holds, with the exception of protective wood cleading on the sloping sides of the wing ballast tanks in way of the cargo bins.

In working out the preliminary design, it was decided that cranes should be used for lifting the cargo out of the holds, and it was further decided to adopt electrical transmission of power for driving the cranes.

The decision to use cranes for the hoisting of the cargo was an outcome of the necessity of dispensing entirely with all hands on deck, except the crane-driver, and the design of these cranes must therefore embody several special features, not usual in ships' cranes. In the first instance the crane-driver must not stand at the rear of the crane, but on a platform in front, where he can look down into the hold when the crane is swung inboard, and be in an equally advantageous position to overlook the emptying of the bucket when the crane is swung outboard.

It was further decided that the tilting of the ore discharging buckets must be effected by the crane-driver, without any assistance whatever from men on the deck or on the receiving barges, and, in order to carry this out, it was arranged to suspend the buckets by means of two ropes, one hoisting and one tipping rope, these ropes to be wound on separate drums of equal circumferential speeds, and when the bucket is to be emptied the brake is put on the tippling rope, leaving the bucket suspended by that rope in an incline position, at any required height.

Fig. 7 shows the design of crane ultimately adopted in conformity with the above-mentioned requirements. The crane builders in this case adopted an independent drum for the tipping rope, actuated automatically by a counterweight, which travels on the jib of the crane. The hoisting, slewing, and tipping is all done by one man on the platform of the crane, and the electric transmission of power lends itself admirably to the smooth and effective working, which has been a noted feature in the cranes of the two vessels built on this system.

During the coldest winter months the ore, on its way from the mines, is sometimes mixed with ice and snow and is apt to freeze together in the holds of the vessels, thus rendering the discharging very difficult.

Steam heating pipes were therefore fitted in the holds under the bottoms of the ore bins for preventing this freezing, which arrangement has proved satisfactory.

Two vessels have been built on this system, the s.s. Vollrath Tham, of 8000 tons carrying capacity, in 1909, and the s.s. Sir Ernest Cassel, of 10,800 tons, in 1910. The contracts for building both these vessels were entrusted to the well-known firm of Messrs. R. and W. Hawthorn, Leslie, and Co., of Hebburn-on-Tyne.

In both these steamers the electric generating plant for power and light is situated aft in the engine-room 'tween decks, each vessel having a very complete outfit, comprising two duplicate compound engines, each coupled direct to a multipolar compound-wound generator, and one lighting set.

In the Vollrath Tham ten electric cranes are fitted, each having a lifting capacity of 2½ tons at a speed of 75 ft. per minute. In the Sir Ernest Cassel twelve cranes are fitted, each having a lifting capacity of 3½ tons at a speed of 75 ft. per minute. In this vessel the crane construction admits of changing the radius, thus enabling the cargo to be discharged into barges or on railway wagons at varying distances up to 20 ft. from the ship's side. All the mechanism of the cranes is below deck in watertight compartments. The time used in discharging each of these two vessels is about 36 hours with all cranes working. The primary object in view has, however, not been so much the reduction of time of discharging as the diminishing of manual labour.

In Continental ports, where the ore is discharged with ordinary winches into barges, twelve men are considered necessary at each hatch:—One man at the hoisting winch, one man at the slewing winch, two men on deck directing the winch men and manipulating the tilting of the buckets, and eight men in the hold. Thus, in an ordinary vessel of the same loading capacity as the Vollrath Tham using steam-winches, 120 men would, as a rule, be employed, taking about 40 hours for discharging. In the Vollrath Tham 20 men are sufficient.

The same ratio holds good in the Sir Ernest Cassel, that is, 24 men do the same work as 144 men discharging by hand and with ordinary steam winches, in the latter case using, of course, considerably more exertion.

The Vollrath Tham and Sir Ernest Cassel, have, during continuous service, fulfilled all expectations of their owners, designers, and builders. The vessels have been built to the British Corporation Class, and it is a great pleasure to record the enthusiasm and skill displayed during the construction by the classification society, the builders, and sub-contractors.

THE HISTORY OF THE INSTITUTION OF NAVAL ARCHITECTS AND OF SCIENTIFIC EDUCATION IN NAVAL ARCHITECTURE.*

By Sir WILLIAM H. WHITE, K.C.B., F.R.S., LL.D., D.Sc., D.Eng., Hon. Vice-President.

(*Concluded from page* 15.)

As was natural, the admission of marine engineers to membership in 1869 led to reconsideration of the title borne by the Institution. The desirability, or otherwise, of indicating explicitly in its title that the Institution is a common centre for both marine engineers and naval architects having been considered, it was unanimously decided to continue in use the title under which the Institution had risen from small beginnings, to a place in the front rank of technical societies. For more than twenty years there has also been in existence an Institute of Marine Engineers, whose membership chiefly consists of men charged with great and increasing responsibilities incidental to the management of the complex machinery in modern steamships, so that the question of title may be regarded as unlikely ever to be raised again, and there is obviously no reason for raising it.

Enlarged experience, of course, may lead to further modification of the rules, but as they stand they represent the matured views of the Council. They have been embodied in the Charter of Incorporation, which has been granted recently to the Institution by His Majesty in Council, and which forms a fitting recognition of the work done for the British Empire and the profession represented in our society during the first half-century of its existence.

The office of treasurer to the Institution is of consider-

* Paper read at the Jubilee Meeting of the Institution of Naval Architects, July 4, 1911.

able importance; and during the somewhat protracted period when the finances were not very flourishing, it was no sinecure. An eminent Thames shipbuilder, Mr. Samuda, served in that capacity from 1860 to 1885, and was succeeded by Mr. H. Green, then head of another famous firm of shipbuilders and shipowners. Mr. Morgan—one of the Chief Constructors at the Admiralty and an original member of the Institution, as well as a student of the second School of Naval Architecture—served from 1891 to 1903, when ill-health compelled him to resign. Dr. Elgar was elected as treasurer in 1903, and continued in that office until his sudden death in January, 1909. Full acknowledgment of the long and faithful service which Dr. Elgar had rendered to the Institution was made in the Transactions for 1909. His splendid generosity, both during his life and at his death, will ever be kept in memory, making him the greatest benefactor to the Institution who has yet appeared. An admirable successor to Dr. Elgar was found in Mr. Dixon, Chairman of Lloyd's Register of Shipping, but death again brought loss to the Institution speedily, and the present treasurer, Mr. Charles Ellis, was then elected by the Council. In his hands the finance of the Institution is well cared for, and its condition has long been satisfactory. Much of the success attained has undoubtedly been due to the ability and energy displayed by the secretaries to the Institution, of whom there have been six during the half century of its existence. Allusion has already been made to the work done by Sir Edward Reed in the preliminary arrangements connected with the organisation and start of the Institution. This work he did as honorary secretary. To no man ought more grateful acknowledgment be recorded than to him for the establishment of this society. But it is proper to associate with that acknowledgment due recognition of the valuable assistance rendered by others at that stage, and especially by Mr. Scott Russell and Sir Nathaniel Barnaby. The latter is naturally reticent in regard to his own work at the beginning; his unceasing devotion to the interests of the Institution is too well known to need any detailed comment. In regard to Mr. Scott Russell, Sir Nathaniel Barnaby permits me to use the following extract from a note written at my request for information in regard to the initial stages of our organisation:—

"The formation of such an Institution had been talked about by members of the first school of naval architecture, and then by Dr. Woolley and members of his school. It needed someone familiar with the working of other great technical associations to bring such mere wishes to a living issue. In Mr. Scott Russell a leader was found, and a most capable leader he was."

Sir Edward Reed served as the official secretary and editor of the Transactions from the first meetings of the Institution up to April, 1862, when increasing professional engagements and official responsibilities caused him to resign. Provision for performing the secretarial duties was then placed in the hands of an executive committee consisting of Dr. Woolley and Mr. Scott Russell, who soon after appointed an assistant secretary. By special resolution of the Council the services of Sir Edward Reed were suitably acknowledged, and he was elected a Member of Council, so that his further help in the conduct of the affairs of the Institution was ensured, and for many years was generously rendered. In 1864 Mr. C. W. Merrifield, F.R.S. (Principal of the Royal School of Naval Architecture and Marine Engineering) became acting-secretary, and from 1867 to 1875 he served as honorary secretary. From 1871 to 1874 Mr. Merrifield was aided in the secretarial duties by an able assistant-secretary, Mr. Adrian Vizetely, who had been one of the few comparatively British private students at the Royal School of Naval Architecture. On the death of Mr. Vizetely, Mr. Adam Woolley succeeded him as assistant-secretary, and in the following year was appointed secretary on the occasion of Mr. Merrifield's retirement. As one of his old students, and having had intimate personal knowledge of the great services which Mr. Merrifield quietly and without reward rendered to the Institution at a time when its finances were in an unsatisfactory state, I desire to place on record this simple acknowledgment of what we owe to him. Mr. Woolley resigned in 1878, and Mr. (now Sir) George Holmes was appointed secretary. He held office for 23 years, and greatly aided the remarkable developments of the Institution which took place during that period. His resignation was consequent on appointment to the Chairmanship of the Board of Public Works in Ireland. Our great indebtedness to him was recognised by the presentation of an address, accompanied by more substantial tokens of the high appreciation by all classes of what were well described as "invaluable services as Secretary of the Institution." Sir George Holmes was also appointed an honorary member, and still maintains an active interest in the welfare of the Institution he served so long and well.

It is unnecessary to dwell upon the work which has been done since his appointment in 1901 by our present secretary, Mr. R. W. Dana. Like his predecessor, Mr. Dana has been trained as an engineer; he is a member of the Institution of Civil Engineers, and relinquished active practice to take up this position. Possession of professional qualifications such as these are of great advantage to the Institution, whose Transactions are edited by the secretary, and to these qualifications are added personal qualities which have enabled Mr. Dana to succeed in the necessarily difficult task of following so efficient a predecessor. It is to be hoped that his service with the Institution will be as long as that of Sir George Holmes, and that it will be associated with equally great developments in members and prosperity.

Qualifications of Professional Members.

Before dealing with the growth of the Institution, it may be of interest to describe briefly the conditions which have been laid down from time to time for the admission of professional members. The corresponding conditions for associates have already been stated, and have remained unchanged from the commencement.

According to the original constitution the class of members was to "consist exclusively of naval architects," although the founders recognised that there were then "comparatively few naval architects in this country." In the statement made by the secretary at the preliminary meeting the following passage occurs:—

"Many of our shipbuilders are not naval architects; consequently the members will not be numerous for some years to come."

With wise prescience it was added: "One of the earliest and best effects [of the Institution] will doubtless be the stimulation of shipbuilders to a great improvement in their mode of training young men, and this will react in favour of the Institution by increasing the number of persons eligible for membership."

This prediction was not fulfilled as speedily as was hoped for, notwithstanding vigorous action taken at an early date by the Institution to encourage the education of naval architects; but it has come true increasingly in later days, and now gives the best assurance we possess of continued and increasing prosperity for the Institution. As the years have passed the professional education of naval architects has been continuously and greatly improved, and the Council has steadily raised the standard of qualification for admission to the class of members. Notwithstanding this action the growth of numbers in that class has been both great and comparatively rapid, and this is a matter for satisfaction.

The names of eminent marine engineers appeared amongst the little group of founders, and in the first roll of the Institution. These men concurred both in the title selected for the Institution and in the restriction of membership to naval architects, and took their place contentedly in the class of associates. In that list were included representatives of many other branches of engineering, but the prominent part taken by marine engineers in the promotion of the scheme was good evidence of their intimate association with naval architecture. In fact, some of these gentlemen — Scott Russell, for example — practised in both marine engineering and shipbuilding. It was natural, therefore—indeed, was almost inevitable — that both these two closely allied branches should be represented before long in the class of members. This step was taken in 1869; its wisdom has been demonstrated by subsequent events. Since that date "marine engineers conversant with naval architecture" have been admitted to membership, after their claims have been approved by the Council at successive general meetings of the Institution. Actual election, of course, rests with the members. The present rules also provide that a candidate who "has been regularly educated by apprenticeship or pupilage, or in a technical school as a civil or mechanical engineer, and has been subsequently professionally employed for at least seven years in some public or private shipbuilding yard or marine engine works," may be admitted to membership if his claim is approved by the Council, and he is recommended for election. Formerly the lower limit of age for membership was twenty-five years; it is now thirty years.

In 1899 a class of associate members was established. It is intended to provide for admission to the Institution of naval architects and marine engineers who are less than thirty years of age, subject to the conditions that their professional training has been of a satisfactory character, and that they are actively engaged in professional work. This class also provides for properly trained men who are over thirty, but still occupy positions which do not involve such a degree of responsibility as is required for full membership. In 1910 there were 169 associate members on the roll of the Institution; in future that number will become much larger. Many men who originally entered the Institution as associate members have since been transferred to full membership.

Another modification of the original constitution was made in 1905 by the establishment of a student class into which are admitted young men between eighteen and twenty-five years of age who are serving as articled pupils, apprentices, or students in naval architecture or marine engineering. Before attaining the age of twenty-six years students as a rule apply for transfer to the class of associate members, and usually have that transfer approved unless their training is considered by the Council to be inadequate. Experience gained during the last six years shows that the student class will in future become a good recruiting ground for members.

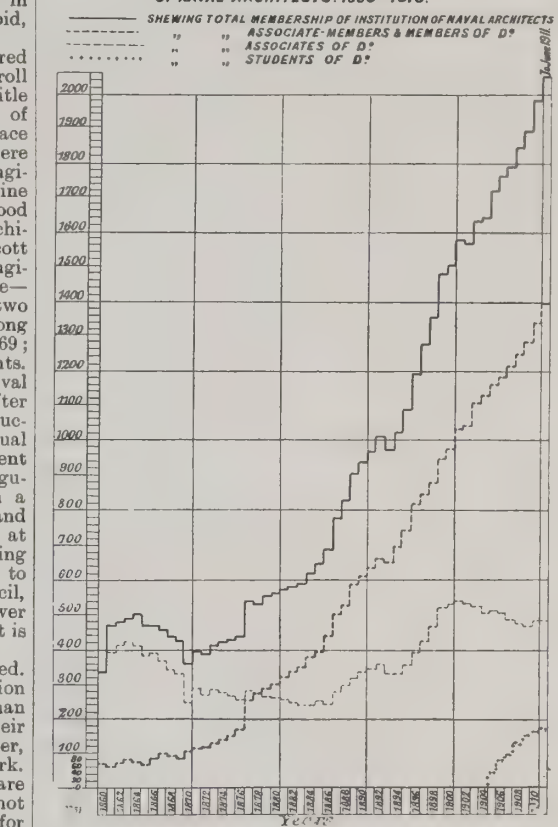
At present the special committee appointed by the Council has under consideration the desirability or otherwise of amending in some respects the professional qualifications which shall be required in future for the admission of members and associate members, especially in view of the great developments made during recent years in the specialised branches of engineering whose products form so important a part of the equipment of modern steamships. In these and other ways the Council makes a constant endeavour to promote the true interests of the Institution and to secure a high standard of qualification amongst those admitted thereto.

Growth of the Institution.

Attention will next be directed to the development of the Institution since its foundation in regard to numbers on the roll. The facts are diagrammatically represented in the annexed chart. The first list of names published in the first volume of the Transactions showed a total of 324; it did not distinguish between members and associates. Classification was commenced in 1861; there were then enrolled 10 honorary members and honorary associates, 65 members and 390 associates. The members' list embraced almost all the leading officials in the shipbuilding department of the Admiralty, as well as a considerable number of the leading private shipbuilders, and the principal surveyors of Lloyd's Register of Shipping. In the list of associates stood the names of a large number of men who were eminent for public services, of distinguished officers in the Royal Navy, of leading engineers, shipowners, yachtsmen, and others interested in ships and shipping. These lists are well worth study; they furnish ample evidence of wide-spread sympathy and support given to the Institution by representatives of many departments of public life and work at this early stage of its existence.

The list for 1864 showed a total of 492, of whom 75 were members. During the next six years there was a serious falling-off in the number of associates, which was only 240 in 1870 as against 409 in 1863. The total number on the roll in 1870 was 351, only 27 more than in 1860, although the members had increased to 103, or nearly 60 per cent. in the ten years. This increase in the professional class continued slowly, and by 1876 there were 168 members but only 249 associates. Probably an explanation is to be found in the fact that the great excitement of the period 1860-65 in connection with discussions connected with the ironclad reconstruction was followed by a period of reaction and that the Institution was settling down to no less important but less attractive technical work which had been the main purpose for

CHART SHEWING MEMBERSHIP OF THE INSTITUTION OF NAVAL ARCHITECTS. 1860 - 1910.



which it was established. Falling off in numbers also involved lessened financial resources, and this could be ill afforded.

In 1877 the first summer meeting of the Institution was held at Glasgow, the invitation having been given by the local authorities of that city and district as well as by the principal firms of shipbuilders and engineers on the Clyde. This meeting was necessarily experimental, but it proved to be a complete success. The ebb-tide in the affairs of the Institution was turned; the immediate effects were an addition of fully 50 per cent. to the list of members, and 10 per cent. to that of associates. The total names on the roll rose to 537, the previous maximum (attained in 1864) having been 492. It was thus made evident that the prosperity of the Institution might be increased by holding similar meetings in the great centres of shipbuilding and shipping, and so extending public knowledge of the work and objects of the Institution. Those of us who took part in the first of these meetings can never forget what the Institution owes to our friends on the Clyde, and in particular to the late Mr. William Denny, who had recently been elected to the Council, and took a conspicuous part in organising the arrangements.

The Glasgow meeting was succeeded by nine years of steady growth in membership, and a progressive diminution in the number of associates kept the total numbers down—in 1885 that total was 642, the associates being 241 and members 390. A summer meeting at Liverpool next year was most successful, but it left the associate class untouched. No considerable increase in numbers occurred until 1887, when a summer meeting was held in Newcastle-on-Tyne and Sunderland. On that occasion the list of members was increased by 63, and that of associates by 27. The personal influence of Lord Ravensworth (then President) in the district no doubt contributed to this satisfactory result; but, undoubtedly, the main cause of increase was that better knowledge of the Institution which followed upon its visit to the North-East Coast. Since then many other summer meetings have been held—at Glasgow twice

(1888 and 1901), Cardiff (1893), Southampton (1894), Newcastle-on-Tyne (1899), Belfast and Dublin (1893). In nearly all cases an increase of membership has followed upon these meetings. In the first twenty-five years of the history of the Institution the total number first enrolled was not quite doubled; the number on the roll in 1885 was more than doubled in 1898. The total membership is now (June, 1911) 2047, of whom 480 are associates; 1401 members and associate-members, and 166 are students. Obviously the associate class needs large additions to strengthen this branch of membership.

Relations to Kindred Societies.

When this Institution was founded there were only one or two local associations of shipbuilders existing in the United Kingdom. Of these that in Glasgow was the most important. It has since been merged in the Institution of Engineers and Shipbuilders in Scotland, and has joined in the friendly greetings we have received when our visits to Glasgow have been made. In later years there has been a considerable increase in local associations formed for the study and advancement of shipbuilding and marine engineering. When that local development began fears were expressed lest the Institution of Naval Architects should suffer from consequent competition. My own opinion has always been that the real effect would be in a contrary direction, and it has been my pleasure to assist in the formation of local societies which are now flourishing. Experience has since demonstrated conclusively that there is room and scope for all the associations. Local societies can and do meet more frequently than the parent institution; they afford excellent opportunities for an interchange of information and for discussion; their Transactions already form valuable supplements to those of the Institution of Naval Architects. Our Institution can still secure an adequate, and often has a redundant, supply of excellent papers. Relations of the most cordial character have always existed, and still exist, between our Institution and these local associations, which have been our generous and kindly hosts whenever summer meetings have been held at British seaports. In many instances membership of local associations is a prelude to membership of the Institution of Naval Architects; in other cases membership of the Institution of Naval Architects has been supplemented by membership of local associations; not a few presidents of local associations have also served on the Council of the central Institution. There is, in short, no conflict, but rather a community of interests and mutual help in the effort to advance knowledge of science and practice amongst shipbuilders and marine engineers.

The relations existing between the Institution of Naval Architects and foreign societies of a kindred nature are also most friendly. This was to be expected in view of the facts that these foreign societies have been modelled largely on lines laid down for this Institution, and that they have benefited by our longer experience. Amongst their chief organisers and founders have been prominent gentlemen who were previously valued members of this Institution, which may, therefore, be fairly described as the "parent" institution, in relation to those which have been established during the last twenty-five years. First, in 1888, came the Association Technique Maritime with its seat in Paris. Its first president was our distinguished honorary member, the late M. de Bussy; its second the late M. Daymard, who for many years previously had been an active and much respected member with us. The name of its present president, M. Emile Bertin, has long been on our list; for fifteen years it has stood amongst our honorary members. The invitation to visit France in 1895, and the complete success of the Paris meetings that year, were largely due to M. Bertin, and his services to the Institution will not soon be forgotten.

In 1893 the American Society of Naval Architects and Marine Engineers was incorporated at New York, avowedly to undertake in the United States work similar in character to that which had been done in this country by the Institution of Naval Architects for more than thirty years. Amongst the prime movers in this enterprise, of which the success has been great, were found naval architects and marine engineers who were members of our Institution, some of whom had received their professional education in Great Britain.

The Schiffbautechnische Gesellschaft was founded in Berlin in 1899. Its president, Professor Busley, and many of the members of the society are also members of this Institution. Japan and Sweden have each established a Society of Naval Architects, in which members of this Institution take a leading part. Italy has a similar society, of which the president (Signor Orlando) and many of his colleagues have long been valued members of this Institution. It is no exaggeration, therefore, to claim that the influence of our Institution on the foundation and organisation of these societies has been great, and the fact has been repeatedly acknowledged. This important portion of our work lies outside the scheme which our founders constructed, but it is no discredit to them that they did not foresee its possibility. By establishing and maintaining cordial relations with foreign kindred societies the Institution of Naval Architects has undoubtedly furthered the more rapid advancement of scientific methods in connection with shipbuilding and marine engineering throughout the world, and has itself been greatly benefited by the addition to its roll of many distinguished foreign members and associates. Their presence and collaboration have been and always will be highly esteemed.

The list of meetings abroad is not a long one. All these gatherings have proved most pleasant and successful; and the institution owes much to gentlemen who have undertaken the responsibility for their organisation. The first was held at Paris in 1895; the second at Hamburg and Berlin in 1896; the third at Düsseldorf in 1902, when it took the form of a joint meeting with the German society. The last foreign meeting was held at Bordeaux in 1907 in connection with an international exhibition and a congress of naval architects, in the organisation of which M. Bertin took the leading part. Kindred societies of all countries were represented on that occasion, and our president (the Earl of Glasgow) was appointed to be president of the congress.

This international side of the work of the Institution received one of its most successful illustrations when the congress of 1897 was held in London. Delegates from all the principal maritime countries attended, as they are doing on this occasion, and the programme of papers was of exceptional interest. His Majesty King Edward VII. (then Prince of Wales) honoured the Institution by becoming president of the congress, and receiving our guests from abroad, Her Majesty Queen Victoria graciously invited members of the congress to Windsor, and personally welcomed the foreign delegates. Now that the celebration of the Jubilee of the Institution has been undertaken, we desire to emphasise once more its international character by giving a hearty welcome to foreign friends and professional colleagues; as well as by including in the record of progress in shipbuilding and marine engineering, not merely the history of what has been accomplished in the United Kingdom, but of what has been done throughout the world during the memorable half-century over which the existence of our Institution has extended. The programme of papers to be read and discussed indicates that this intention has been fulfilled; the volume in which these contributions will be collected will, undoubtedly, be not merely interesting historically, but valuable to all maritime nations.

The Education of Naval Architects.*

One of the main objects in the minds of the founders of this Institution was the provision, as soon as possible, of adequate arrangements for the scientific as well as the practical training of young men desirous of becoming naval architects and marine engineers. It was their desire to remove the reproach that no school of naval architecture and marine engineering existed in the United Kingdom, although it was the country which held the lead in shipowning and shipbuilding. At the preliminary meetings this subject received attention, and no long time elapsed before definite action was taken to bring the subject before the Government. At the meetings in March, 1863, Mr. Scott Russell read a paper which represented not merely his own view, but those of his colleagues on the Council. No better advocate could have been found for pleading the cause; the object of technical education was one in which Mr. Scott Russell had done valuable pioneer work, his own reputation as an experimentalist in some branches of scientific research was considerable; and—as the builder of the Great Eastern and a man whose influence had been great on the design of the Warrior—he was able to command the attention of the Government as well as that of his fellow shipbuilders. The action taken by the Institution was both well considered and prompt. A committee was formed, representations were made to the Government, and the movement was greatly aided by Lord Hampton and by Sir Edward Reed (who had been appointed Chief Constructor of the Royal Navy). Before the year 1864 ended the Royal School of Naval Architecture and Marine Engineering had been organised, the Admiralty and the Education Department having joined in the arrangement of its courses of study and the selection of the teaching staff. That school continued to carry on its work at South Kensington until 1873. During that period 119 students were under instruction. Of these, 95 students—53 naval architects and 42 marine engineers—completed their training. Fourteen students came from foreign countries, and 24 were British private students. The Institution of Naval Architects watched over its child with great solicitude, every annual report containing references to its progress. Prominent members of the Institution gave their services as lecturers and teachers, and in that list appeared names which will always be esteemed great in the history of ships and shipbuilding. Sir George Airy, the Astronomer Royal, lectured on the errors and corrections of compasses in iron ships; Mr. William Froude on stability and oscillations. Professor Rankine on strength of materials and propulsion of ships; Dr. Percy on metallurgy; Scott Russell on fluid resistance and the wave-line theory for ship forms; Sir Edward Reed and his principal assistants in the Admiralty on subjects connected with ship design and construction; and distinguished officers of the Royal Navy on questions of naval armaments and tactics. Dr. Woolley, who had been principal of the second British School of Naval Architecture, was appointed to supervise the courses of studies, and acted as chief examiner. Mr. Merrifield (already mentioned) was the first principal; with him were associated an excellent staff of teachers, which included some of the most brilliant younger graduates of Cambridge University, as well as members of the constructive and engineering staff at the Admiralty, and practical shipbuilders and marine engineers of large experience. It is not possible for me to speak impartially of an Institution where I was taught my profession, and afterwards became a teacher myself; it would be out of place for me to say much about the results attained. These results speak for themselves, for the men who were trained at South Kensington are now nearing the end of their professional careers; their work is chiefly done, and its results are known. In its whole career it is probable that the Institution of Naval Architects has done no more important piece of work than that involved in the establishment, organisation, and development of this third British School of Naval Architecture. In a certain sense the effort may be thought to have been made too soon. The amount of support which the school received from private British shipbuilders and engineers must undoubtedly have disappointed the expectations of its founders, and to that extent been "before its time." On the other hand, the establishment of this school removed the long-standing reproach that the United Kingdom absolutely neglected the scientific education of its naval architects and marine engineers. Moreover, when its doors were closed, those of the Royal Naval College were opened, and in that splendid educational establishment, from that time onward, the lamp of scientific instruction in shipbuilding and engineering has been kept steadily burning. This later work has been done under the patronage of the Admiralty, and primarily for its purposes; but it has also been made available for the teaching of private students who were properly qualified to gain admission, and not a few of those educated there for the service of the Admiralty are now holding positions of great responsibility in private firms.

Some years elapsed before any other institution in Great Britain provided advanced courses of instruction in naval architecture and marine engineering, but the advantages of such instruction were being more and more realised in the interval, and the time was ripe for action when Mrs. John Elder generously provided the means for establishing a Professorship of Naval Architecture in the University of Glasgow. Dr. Elgar was appointed to this Chair in 1884, and organised the courses of study with the ability which his training at South Kensington and subsequent professional career had led his friends to anticipate would be displayed. His successors at Glasgow, the late Professor Jenkin and Professor Biles, both received their training under the Admiralty, and have fully justified its merits in their subsequent work. The Glasgow classes have been well filled, and have attracted many students from abroad, as well as from the United Kingdom, and it had become evident that larger provision for the education of young naval architects and marine engineers were required before further steps were taken to secure it at English Universities. Fortunately, this want has now been met, and professorships of naval architecture have been established at Newcastle-on-Tyne and Liverpool. The former is due to the joint action of the authorities of Armstrong College and of the leading private firms on the North-East Coast; the second to the generosity of Mr. Alexander Elder. In these cases, also, the two Professors—Welch and Abell—received their training at the Royal Naval College. For many years it was my endeavour to secure the establishment of these two Chairs, and the fulfilment of that hope, although long deferred, has been most gratifying. It is certain, however, that unless there had been a growth of belief in the advantages attaching to this higher instruction amongst shipbuilders, shipowners, and marine engineers in this country, these results would never have been obtained, and that growth has undoubtedly originated from the seeds sown by this Institution nearly fifty years ago.

The Institution has watched with sympathetic interest all these recent educational developments, and meanwhile has been at work in other directions. Scholarships have been established in aid of young men whose means are limited. One of these was founded by subscriptions from the members in order to perpetuate the memory and services to the Institution of the late Mr. Martell (Chief Surveyor of Lloyd's Register of Shipping). Another was founded by the generosity of the late Dr. Elgar, and bears his name. A third is due to the action of our respected Vice-President, Mr. Alfred Yarrow. It is reasonable to suppose also that the example and influence of action taken by the Institution may have had some effect on the minds of the Chairman and Committee of Lloyd's Register of Shipping, who have established a considerable number of scholarships for the benefit of students of naval architecture and marine engineering at the universities above named. Successive chairmen of that committee have been vice-presidents of the Institution, the names of many members of the committee are on our roll, and the professional staff are very largely represented in our membership. While fully recognising that the generous deed is entirely due to the committee, the Institution may feel that it is not entirely disconnected therefrom.

Public Work Done by the Institution.

Immediately after its foundation the Institution of Naval Architects began work of a public character in relation to shipping. It continues to do this work either by means of special committees appointed by the Council, or through representatives and delegates nominated by the Council, as members of committees appointed by Government departments or public bodies. Lord Hampton was of great service in bringing into prominence the fact that important work of this nature was undertaken by the Institution, and his presidential addresses were full of allusions to the subject. Questions relating to the lading and stability of merchant ships engaged attention from the Institution long before the Load-Line Committee, appointed by the Board of Trade in 1884, under the chairmanship of Sir Edward Reed, began an inquiry which eventually led to regulations that are now international in their application. The basis of that settlement was found in proposals which had been previously placed before the Institution by Mr. Martell, and freely discussed by members and associates, shipowners naturally holding strong opinions on the subject.

The Board of Trade, through its Marine Department, has again and again availed itself of the services of the Institution, asking for opinions on important points or requesting the nomination of representatives on com

* For further details on this subject see the address given by the writer as Chairman of the Royal Society of Arts on November 18, 1908.

mittees, special and standing. At present the Institution is thus represented on the advisory committee which deals with questions affecting shipping interests, as well as on another committee of longer standing, which advises on technical details of ships and machinery. Members of the Institution have served on special committees which have dealt with tonnage laws and other important matters affecting the mercantile marine.

Lloyd's Register of Shipping has also sought the aid of the Institution, which has long had representatives on the Technical Sub-Committee of Lloyd's, and quite recently has been invited to appoint representatives on the General Committee.

The British Corporation has requested and received similar assistance from the Institution.

Its position in the front rank of technical societies has been recognised in many other ways. The Institution of Naval Architects is one of the five societies represented on the Engineering Standards Committee: the chairmanship of a most important committee (that of steel sections) has been held by one of our representatives, Mr. Archibald Denny. The Institution is also represented on the Executive Committee of the National Physical Laboratory, as well as the Special Committee appointed to supervise the operations of the National Experimental Tank, which has been added to the equipment of the laboratory by the splendid generosity of our Vice-President, Mr. Yarrow. The official opening of that tank to-morrow is one of the most important and interesting events in our programme, and will constitute a fitting memorial of the Jubilee. The provision of a maintenance fund for that tank is another public duty which has been undertaken by the members of this Institution, and there is no doubt but that it will be fulfilled.

The Institution is represented on the Courts of the Universities of Liverpool, Bristol, and Sheffield, and upon the Governing Body of the Imperial College of Science and Technology in London. Members of the Institution are serving at the present time on the Special Committee appointed to consider reports on the establishment of a Science Museum in London. These are but examples of the public services which have been rendered since the Institution was founded, and which have grown in importance with its growth.

Perhaps the strongest evidence of the value attached to the national work done by the Institution may be found in the fact that for a very long period the Admiralty has made an annual grant in aid of that work This grant was first made when the financial condition of the Institution was a cause for anxiety to the Council, and aid was then of greater relative value than it has been in later years, when financial difficulties have disappeared. As a recognition by the Government of the public duties performed by the Institution the continuance of the grant is highly esteemed.

The Transactions of the Institution.

Every one will agree that important as other departments of its work have been and still are, the most important is represented by the fifty-two volumes of its Transactions.

These volumes contain a detailed record of progress in the science and practice of shipbuilding and marine engineering during the period they cover. Reference has already been made to the paper in which Dr. Woolley ably summarised the condition of the mathematical theory of naval architecture in 1860. Another stock-taking of scientific knowledge was attempted by Sir Edward Reed when the International Congress of 1897 was held in London, and his paper showed that, in many branches of naval architecture, considerable advances had taken place since 1860; especially in those branches relating to the stability and oscillations of ships, fluid resistance, and propulsion of ships, the mechanical theory of propellers, and investigations of the structural strength of ships. Since 1897 progress has continued, and is still continuing. The later volumes contain full records of the most recent additions to the vast treasury of information gathered in preceding Transactions, and they are in no sense inferior to their predecessors. At the outset Sir Edward Reed remarked that one of the most important factors in the success of the Institution would be the contribution of original papers in sufficient numbers. Fears on that head were speedily dispelled; from the first the supply of papers of excellent quality were in excess of requirements. In later years—even with an increasing demand for contributions of a similar kind from local societies—the supply to the parent Institution has been in excess of what could be read and adequately discussed within the limits of time available.

The Institution, in fact, offers unrivalled attractions for the authors of papers, and especially for the originators of new ideas or experimentalists in new directions; because of its larger membership, cosmopolitan character, and high reputation as the best means of making known to the shipping world new methods and discoveries in the domain of naval architecture and marine engineering Our Transactions contain numerous original communications by distinguished men, whose contributions mark epochs in the history of ship design and construction; and who have chosen our Institution as the most suitable place for publication of successive steps in invention and research. Theory and practice both find adequate representation; and illuminating discussions, as well as independent and differing views on particular subjects expressed by high authorities, add greatly to the value of the record.

The first volume of the Transactions struck a high note which has been since well maintained. In addition to Dr. Woolley's paper on the theory of naval architecture, this volume contained contributions from Sir George Airy on compass correction in iron ships, from Scott Russell on the wave-line principle of ship construction, and from Mr. Barnes on experiments to determine the height of the centre of gravity of ships. Iron shipbuilding was discussed by high authorities like Sir William Fairbairn and Grantham. John White, of Cowes, described the diagonal system of wood shipbuilding, with which most remarkable results were obtained in the combination of lightness and strength. Sir Nathaniel Barnaby wrote on mechanical invention in its relation to the improvement of naval architecture. Mr. Moorsom dealt with tonnage legislation of ships. Mr. Robert Murray described means and appliances for economising fuel in steamships. Mr. Lennox read a paper on chain cables. This was an excellent start, representing all sides of the work which the Institution was founded to perform.

In Volume II. of the Transactions, prolonged discussions on ironclad ships were recorded, these discussions continued over several years, and had immense public interest and value at a critical time. Mr. William Froude contributed a paper on the rolling of ships, which introduced a new view of the causes influencing the behaviour of ships at sea, and gave clearer guidance to naval architects in their treatment of the conflicting qualities of stiffness and steadiness in new designs for ships. Papers on the methods of making the calculations for the stability of ships were also read. That by Mr. Barnes formed the first of the long series of such investigations contained in subsequent Transactions. Next year a feature was developed which has since become common in our proceedings. A paper like that by Mr. Froude on the rolling of ships could not possibly be mastered when it was read or immediately discussed: it required careful study before the real meaning and value could be understood, or doubtful points and limitations discovered. In 1862, therefore, as was natural, a number of papers appeared dealing with this subject from different points of view, and, as a result, knowledge was advanced. Later on Professor Rankine began a series of contributions which were of the greatest value in connection with the oscillations of ships; and still later came experimental and analytical investigations by Mr. William Froude, Mr. R. E. Froude, and others, with the final result that the fullest discussion extant of this branch of naval architecture is to be found in our Transactions.

The same claim may be made for the treatment in these volumes of the important subject of stability, both on the theoretical and the practical sides, and for all classes of ships. A great mass of authentic data has been accumulated; the effects of variations in form, type, and lading investigated, methods of calculation described, and attention drawn to the valuable help obtainable by the use of integrating machines, in the production of which Dr. Amsler took the lead when the need for them was made clear by discussions in this Institution.

In the Transactions also may be found the epoch-making communications of William Froude, relating to his system of experiments on models of ships and propellers; contributions from Wm. Froude, Rankine, R. E. Froude, Cotterill, Greenhill, and other authorities on the mathematical theory of propellers, and the causes chiefly influencing their efficiency; records of experimental research on water-resistance to the motions of ships and speed trial data for actual ships.

Questions of the greatest importance to the mercantile marine, such as rules for classification, legislation for load-lines, tonnage measurements, watertight subdivision, corrosion and fouling, stowage of cargoes, loading and discharging appliances, anchors and cables, refrigerating apparatus, steering gears, docks, harbours and ports, fire protection, masts and spars, boat lowering, and endless other items have all been made the subject of papers and discussions.

If one desires to obtain accurate information as to improvement in shipbuilding materials, the substitution of iron for wood, the construction of composite ships, the introduction of mild steel, the use of stronger qualities of steel, the advantages or disadvantages of various kinds of material, the Transactions offer the greatest facilities.

Similarly, one turns to them for information in regard to systems of construction, structural arrangements, methods of riveting and combining parts of the structures of ships; and one never turns in vain. Methods of approximating to the principal stresses which may come upon various parts of the structures of ships, and deciding on the upper limits of stress which experience shows may be accepted in practice, as well as the determination of local stresses, and of the best methods of meeting them, are also to be found in these volumes.

Scientific analysis and practical experience are herein associated, and always with advantageous results. All classes of vessels receive consideration, ranging from the lifeboat up to the great ocean-going passenger steamship or the monster battleship; ice-breakers, railway ferry steamers, telegraph-laying steamers, steam and sailing yachts, torpedo vessels, submarines, and others; all have come under review, or been made the subject of discussion. Nothing that floats is too small or too great to receive attention from the Institution and a place in the Transactions.

In the Transactions are also to be traced in detail, authentic records of the remarkable progress made during the last half-century in marine engineering, increase in steam pressure, improvements in steam generation in propelling and auxiliary machinery, in fuel economy, in systems of propulsion and propellers. The stories of the development of the reciprocating engine, the introduction and disuse of water-jet propellers, and the triumph of the steam-turbine, are all told as they happened. Recently the application of the internal-combustion engine to ship propulsion has been debated, and its history is being written. Liquid fuel for the use of steamships was discussed in this Institution forty years ago; and, now that it is coming into more general use, the economic results are being investigated by competent authorities. The relative merits of cylindrical and water-tube boilers, of different types of superheaters and condensers, of various systems for the transmission of power, come under review. No one can peruse these pages and fail to be impressed with the remarkable growth of scientific method, accurate observation, systematic research, and thorough analysis; as applied to the design, construction, and performances of ships, marine engines, and boilers. Related problems such as the vibration of steamships, the balancing of engines, the influence of rate of revolution, and numbers or positions of propellers upon vibration—have all received attention. The aggregate result of these advances in knowledge are to be seen in the increase of speed, the practical supersession of the sailing ship by the steamship, the cheapening of sea transport, and the greater regularity and comfort of sea travel, with all the consequent benefits to humanity at large.

This brief and imperfect review of the outstanding features in our Transactions cannot be concluded without a reference to the intimate connection which has existed between the proceedings of the Institution and the contemporaneous development of the Royal Navy. Here from the commencement have been held debates on warship construction far more valuable than any discussions in Parliament could possibly be on such highly technical subjects. Here naval officers and naval architects have met and conferred or disputed. From the very outset the Institution was chosen as the place whereat the constructive policy of the Admiralty for the time being should be explained and discussed. All through the periods of office of Sir Edward Reed, Sir Nathaniel Barnaby, and myself, as the responsible designers of ships of the Royal Navy, this policy was continued. It was at our meetings that the relative merits of broadside and turret armaments were championed by Reed and Cowper Coles, and descriptions have been given by men responsible for the designs of new types while they were building. Here the controversies of the past were centred, and to a large extent were settled, in all probability to the great advantage of the nation. These controversies need not be revived, but they can still be studied in the Transactions, and the student finds that in warship design, as elsewhere, history often repeats itself. In these pages can be found records of the long battle between ordnance and armour, of the great improvements made in each, and the consequential effects on designs. In recent years all this has been changed, and, as many of us think, unfortunately changed, when regard is had to the undoubted benefits which have flowed from open discussion in the past. For many years now the Institution has had no official communications made to it, such as were formerly the rule, respecting the designs for new British warships. It is hoped that before long there may be a reversion to earlier and well-proven practice. In the past some things have always been left unsaid in papers contributed by officials. It is not suggested that in future there should be disclosures of information that would be indiscreet or improper any more than there has been in the past. As one familiar with the events of the last forty-five years in our proceedings, I cannot recall one occasion where the public interests have suffered in consequence of the papers read and discussed in which warship design and construction formed the subject.

Looking back upon work which has been done by the Institution, it may be claimed that the intentions of its promoters, on the whole have been well fulfilled; in some respects they have been surpassed. The meetings of the Institution have afforded exceptional opportunities for the discussion of questions affecting the science and practice of naval architecture and marine engineering; the construction of warships and of merchant ships; the shipbuilding policy of Great Britain; the safety of life and property at sea; the introduction of new materials of construction and structural arrangements; the development of experimental methods of research; the introduction of new methods of ship calculations and design; and the discussion of new inventions of various kinds. Before the Institution was founded, naval science had no home in England; its treasures lay scattered far and wide in the form of memoirs and papers contained in the Proceedings of the Royal Society or in other publications. Everything worthy of preservation now naturally finds its way to the Transactions, and through them to naval architects, marine engineers, and others interested in these subjects throughout the world. All movements sensibly affecting shipping now leave their record in the papers and discussions; from this point of view the Transactions have already attained and will maintain a high historical value. Every great movement may be said to have been chronicled for fifty years, and the history of the progress of the theory of naval architecture is also to be found therein.

Sanguine as were the founders, it seems unlikely that any of them could have anticipated such a growth in numbers, standing, and recognised usefulness as has taken place. Most of those to whose courage and devotion the establishment of the Institution was due have passed away; others, who have done their best to promote its interest and further its operations for many years, will soon come to the end of an active participation in its affairs. It may, however, be asserted confidently that the Institution we all love so well will live and flourish, because it has become a centre of association and friendly help for all who are interested in ships—the home of naval architects and marine engineers of all maritime countries, as well as of shipowners and seamen.

Growth of Bristol—In 1897 the rateable value of Bristol was 1,153,311*l.*; in 1910 the total had grown to 1,845,161*l.*

SHIPPING ON THE GREAT LAKES.*

By FRANK E. KIRBY, Vice-President Soc. N.A. and M.E., and A. P. RANKIN, Member.

THE object of this paper is to describe and illustrate, without touching on the technical side of the subject, the water-borne commerce of the Great Lakes of America. The writers offer it apologetically, realising the futility of attempting to cover in detail so large a subject in a paper of necessarily restricted length, but they trust that by indicating some of the outstanding facts in this development their efforts may not be without some interest.

In beginning it may not be out of place to give briefly a *résumé* of the physical features regarding the Great Lakes, together with their connecting navigable channels and principal ports. Also, although the object will be to avoid statistics as far as possible, it will be necessary to submit sufficient of these for an intelligent realisation of the volume of the trade, together with its rapid increase. Consisting of a series of inland seas, known as Lakes Superior, Michigan, Huron, Erie, and Ontario, reaching east and west 1000 miles, and half that distance north and south, with a water surface of over 90,000 square miles and a drainage basin of 275,000 square miles, connected throughout by navigable channels and discharging through the St. Lawrence River into the Atlantic Ocean, they may be justly considered, from their magnitude, the great area of the region drained by them, and their beneficial effect on the climate, one of the most important physical features of the North American Continent.

Lake Superior, the most westerly of the group, is 602 ft. above mean sea level, while Lake Ontario on the east is elevated only 247 ft. Between Lakes Superior and Erie, however, the fall is somewhat less than 30 ft., so that almost the entire descent is below Lake Erie, or in the Niagara and St. Lawrence Rivers. The difference in level between Lakes Superior and Huron is about 21ft., the natural channel being the St. Mary's River. The St. Mary's Rapids have a drop of 18 ft. in about three-fourths of a mile, and navigation at this point is accomplished by means of the Sault Ste. Marie (or commonly the "Soo") canals, of which there are two, one in United States and one in Canadian territory, the former having two locks, side by side, while the latter has a single lock. In all cases the total lift of 18 ft. is overcome in one lock. The older of the United States locks, known as the "Weitzel," was built in 1870-81, and is 515 ft long, 80 ft. wide in the chamber, narrowing to 60 ft. at the gates with 17 ft. of water over the sills.

The latest, or "Poe" lock was built in 1887-96, and is 800 ft. long, 100 ft. wide, with 22 ft. of water over the sills. The Canadian lock is 900 ft. long, 60 ft. wide throughout, and was built in 1888-95. Either of these locks can be filled or emptied in seven or eight minutes, and the gates opened or closed in two minutes. A third United States lock is under construction at the present time, on completion of which it is proposed to rebuild and deepen the "Poe" lock, and a fourth lock is contemplated. Since 1881 no tolls have been levied, both canals being free for use by ships of all nations. The average time in making a lockage is about 30 minutes, but generally two, and frequently as many as five, boats are put through at once.

The navigable channel through the St. Mary's River has been improved, by dredging and cutting, until the available depth is in the neighbourhood of 20 ft.

Lakes Michigan and Huron connect through the Straits of Mackinac and have a common level. The connection between Lake Huron and Lake Erie is through the St. Clair River, Lake St. Clair, and the Detroit River, the difference of levels, 8 ft. in about 90 miles, causing an average current of 1½ miles per hour, increasing to 2½ at the narrow channels. By an amount of work and at an expense difficult to realise these channels have been deepened and improved, until 20 ft. of water is available throughout at normal lake levels.

The Welland Canal, which is built entirely in Canadian territory, connects Lake Erie with Lake Ontario, overcoming the Rapids and Falls of Niagara. The canal is 26¾ miles long, the total lift being 326¾ ft., accomplished in 25 locks, each 270 ft. long, 45 ft. wide, with 14 ft. of water available. It is the intention, however, to confine this paper to the commerce of the Great Lakes above Niagara Falls, as the comparatively small dimensions of the Welland and lower canal locks make Buffalo the eastern terminal of the great bulk of the lake traffic, which is handled in ships of much greater dimensions. Between Lake Ontario and Montreal, however, there are six canals, and 21 lockages are necessary, the dimensions of lock and depth of water given for the Welland Canal being available throughout.

The sailing distance from Buffalo, at the eastern extremity of Lake Erie, to Duluth, the western limit of Lake Superior, is 980 miles, and from Buffalo to Chicago, at the southern end of Lake Michigan, 885 miles, while from the lower end of Lake Ontario to Duluth is 1175 miles.

Navigation on the Great Lakes opens about the middle of April and closes early in December, leaving a navigation season of eight months. During the four winter months the rivers and harbours are ice-bound, and navigation entirely ceases, except in the case of car and other ferries.

The international boundary line divides Lakes Ontario, Erie, Huron, and Superior, passing midway through the connecting channels, and leaving Lake Michigan entirely in United States territory.

It is not the intention to attempt anything like a historical description of the early navigation and development of the commerce on the Great Lakes, but generally to describe it as it now exists, referring, of necessity, to the small beginnings by way of contrast, and to illustrate the rapid advance that has taken place.

The chief reason for the growth of this commerce is the proximity of great natural resources to the districts tributary to the lakes, the bulkiness of the products making water transportation specially valuable. This condition naturally existing, what had to be artificially provided was the means of cheap transportation by water, which in turn necessitated deep waterways, so that large ships could be utilised, special types of ships to handle the different kinds of cargoes, and adequate facilities for handling the same. The gradual advance along these lines constitutes the real story of the growth of the commerce of the Great Lakes, the deepened and improved waterways always in the van, the ships of increased dimensions following closely, and the cargo handling apparatus keeping pace with their structural arrangements, and often, indeed, causing radical changes to be made in their design.

Probably the simplest way to a realisation of the volume of this commerce is a study of the statistics covering the tonnage passing given points in the navigable channels. That through the Sault Ste. Marie canals represents the Lake Superior traffic, and accurate records are kept at this point. This represents about two-thirds of the Detroit River tonnage, the remaining third being mostly traffic to and from Lake Michigan ports. The following tables show the amount of tonnage passing these points during the navigation season of 1910 :—

East and West-Bound Commerce Passing both American and Canadian Canals at Sault Ste. Marie, Michigan, and Ontario, for the Season of 1910.

East Bound.

Articles.	U.S. Canal.	Canadian Canal.	Total.	Total Sh. Tons.
Copper, short tons	121,438	26,632	148,070	148,070
Grain, bushels	14,943,137	24,300,195	39,243,332	821,492
Building stone, short tons	9,335	300	9,635	9,635
Flour, barrels	4,856,746	2,718,933	7,575,679	757,568
Iron ore, short tons	13,075,362	28,525,024	41,600,386	41,600,386
Pig-iron, short tons	40,340	8,650	48,990	48,990
Lumber, M. ft. B.M.	558,607	44,494	603,101	986,482
Wheat, bushels	17,505,949	68,754,025	86,259,974	2,587,799
General Merchandise, short tons	96,337	76,950	173,287	173,287

West Bound.

Coal, hard, short tons	1,109,533	549,311	1,658,844	1,658,844
Coal soft, short tons	8,319,072	3,535,811	11,854,883	11,854,883
Flour, barrels	10	1,100	1,110	111
Grain, bushels	2,153	..	2,153	34
Manufactured iron, short tons	226,611	169,068	395,679	395,679
Iron ore, short tons	..	3,248	3,248	3,248
Salt, barrels	390,191	138,419	528,610	78,448
General Merchandise, short tons	611,209	627,053	1,238,262	1,238,262

Summary.

Vessel passages, number	12,927	7,972	20,899	
Registered tonnage, net	26,506,986	23,349,137	49,856,123	
Freight—				
East-bound, short tons	15,602,673	31,351,036	47,133,709	
West-bound, short tons	10,324,988	4,904,521	15,229,509	
Total freight, short tons	25,927,661	36,435,557	62,363,218	

The volume and increase of traffic in the Detroit River is illustrated by the table given below, covering the years 1902 to 1910 :—

Year.	No. of Passages.	Net Registered Tons.	Freight Tons. Estimated.	Estimated Value.
				dols.
1902	33,000	39,328,659	44,260,506	440,834,640
1903	33,113	37,453,796	46,817,245	471,917,830
1904	29,472	33,049,984	42,792,326	453,598,656
1905	35,599	45,912,622	55,508,360	522,888,751
1906	35,128	50,673,897	63,808,571	662,971,053
1907	34,149	53,959,769	71,226,895	697,311,302
1908	27,883	40,628,350	54,086,750	614,425,480
1909	32,296	54,668,846	67,789,369	732,803,079
1910	33,638	58,821,282	73,526,602	771,294,055

On the lakes, iron ore is reckoned in tons of 2240 lb., commonly known as the "gross" ton, while for coal and other merchandise the short or "net" ton of 2000 lb. is used. To simplify the tables all weights are given as short tons, while elsewhere, where necessary, the tons will be qualified by the terms above. This, in 1910, averaged about 225 tons passing this point for every minute of the navigation season.

An examination of the table of statistics covering tonnage passing through the "Soo" locks will show that the bulk of the cargoes carried consisted of a comparatively few articles. Thus, of the 62,363,218 tons passing east and west, 41,603,634, or over 66 per cent. of the whole, is iron ore. Coal contributes 13,513,727 tons, or nearly 22 per cent., grain and flour accounts for 3,345,512 tons, or 5½ per cent., these three articles making over 93 per cent. of the total, and it thus becomes an easier problem to specialise the ships, docks, and cargo-handling apparatus. The ships engaged in this great commerce may be roughly, but with sufficient exactness, divided into four classes as follows :—

1. Coarse or bulk freighters, including all steamers engaged in carrying iron ore, coal, or grain in bulk.

2. "Package freighters," covering steamers carrying general merchandise in holds and on main deck, handled generally through side gangways.

3. Passenger steamers.

4. Car ferries, used in the transportation of railroad cars across the rivers and lakes.

Bulk Freighters.—The development of the freighter on the lakes is so interwoven in its history with the improvement of the waterways and the perfecting of the cargo-handling apparatus, that it would be impossible to follow one without tracing also the simultaneous advance of the others. A somewhat superficial review, however, touching only on the most important steps, must suffice to lead up to the bulk freighter of the Great Lakes as she exists to-day. This type of ship is engaged exclusively in the carrying of iron ore, coal, and grain. The ore trade is entirely down the lakes, or east bound, the principal shipping ports being Duluth, Superior, Two Harbors, Ashland, and Marquette on Lake Superior, and Escanaba on Lake Michigan. Of the 42,620,201 tons carried during the navigation season of 1910, 34,012,897 tons were received at Lake Erie ports, the balance being delivered to those of Lake Michigan.

The grain traffic, also east bound, amounted in 1910 to 245,171,763 bushels, the principal shipping ports for United States grain being Duluth, Superior, Chicago, and Milwaukee, the receiving ports being Erie and Buffalo, from where it is shipped by the Erie Canal railroads for distribution and export. Port Arthur and Fort William, Ontario, are the storage and shipping points for the grain from the Canadian North-West, most of which is carried to the seaboard for export between September and December. The larger steamers transfer to the railways at Georgian Bay ports, while those of Welland Canal dimensions cover the entire route from the head of the lakes to Montreal.

The coal trade, being all west bound, forms a convenient return cargo for steamers which are not exclusively engaged in the ore trade. It ranks second in volume, and during the navigation season of 1910, 18,406,469 tons of bituminous and 4,170,813 tons of anthracite coal were shipped west from Lake Erie ports.

Freight rates between Lake Erie and Lake Superior ports during 1910 were as follows :—

Coal	31 cents per ton.
Grain	1⅓ cents per bushel.
Iron ore	70 cents per ton.
General merchandise	2.00 dols. per ton.

From the ore rate above 15 cents per ton must be deducted for unloading charges, which are borne by the vessel's owner.

The iron-ore trade is, of course, the most important, and the relation of the lakes to the mining and transportation of the ore has done more to establish the position of the United States in the iron and steel trade of the world than any other fact. Three-quarters of the ore used in the furnaces of the United States comes from the Lake Superior region, a thousand miles removed from the available coke and limestone supply, and but for the lake transportation it would be impossible to economically assemble them, the traffic, at rates profitable to the steamers, offering no attraction to the railways; in fact, without this great water route the Lake Superior ore deposits could never have been developed.

Iron ore was first discovered in the Lake Superior district in 1844, about 14 miles from what is now Marquette, and, at first, attempts were made to manufacture iron in the locality of the deposits, and several forges were established in the years 1848-50, but financially the results proved disastrous. The difficulties of transportation to the lake, the long trip to the mills in Pennsylvania, made the cost of the blooms so high that it was impossible for the industry to continue. In 1850, 10 tons of iron ore were sent to New Castle, Pennsylvania, for experimental purposes, but it was not until 1853 that the idea of manufacturing iron in the Lake Superior district was abandoned, and definite steps taken toward shipping the ore to the lower lakes.

In the early shipments the ore was laboriously hauled to the lake, wheeled on board small sailing vessels, and at the "Soo" had to be unloaded, carried over the portage of about a mile, and below St. Mary's Falls was again loaded upon vessels, and so carried to the Lower Lakes. Meanwhile, a canal around the rapids at Sault Ste. Marie was under construction, work being commenced in 1852, and on June 18, 1855, the canal was opened for traffic. The steamer North Star, passing up through the canal on the 20th, was the first to reach Marquette, and the brig Columbia carried the first ore cargo, consisting of 132 tons, through the canal on August 17, 1855, and in all 1,447 tons were shipped that year. The first ship canal at Sault Ste. Marie was 5,700 ft. long, 100 ft. wide at the water surface, 64 ft. wide at the bottom, and the depth of water was 13 ft. The locks were two in number, 350 ft. long, 70 ft. wide, with 11½ ft. of water over the sills, and each had a lift of 9 ft.

In 1857 the first steam railroad from the mines to Marquette was finished. It was not until 1862 that any of the mining companies found themselves on a paying basis, but meantime they had joined together in building, at Marquette, a wooden dock with elevated pockets on trestle work, to facilitate the loading of the ore. Primitive as the structure was, it represented in principle the great loading docks of to-day, embodying the universal method of loading through spouts from elevated pockets, filled by cars from above.

For the first few years almost all the ore shipments were made on small sailing vessels, on which, owing to their construction, with the ordinary hatchways, this method of loading could be used. The few steamers of those days all carried passengers, and were in no way adapted for the transportation of ore. As the channels

* Paper read at the Jubilee Meeting of the Institution of Naval Architects, July 6, 1911.

were not lighted navigation through them ceased at nightfall, and the custom was for the schooners to be towed through the rivers, numbers of tugs finding steady and profitable employment in this connection. In the sixties this was the general method of ore transportation on the lakes, and in 1860 115,401 tons of iron ore represented the year's business in that commodity.

At this time the method of unloading ore at the Lake Erie ports was an exceedingly slow and laborious one. The work was usually done by contract, the means employed to elevate the cargo from the hold being tubs, operated by blocks and tackle with horses as the motive power, and wheelbarrows then served to convey it ashore. To unload a 400-ton cargo in two days was accounted excellent work. In 1867 small portable engines were substituted for the horses, and at once the unloading time was cut in two. Up to this time ore was not the most important trade on the lakes; grain, then, and for many subsequent years, holding that position. In 1866 grain receipts in Buffalo were 1,500,000 tons, while the total ore delivered at all Lake Erie ports represented only 278,796 tons. For some years as the traffic increased the system was adopted of towing sailing vessels, five and six in line, the entire distance from the loading docks on Lake Superior to Lake Erie. The year 1869 marks an important change in the business of ore carrying in the introduction of the steamer and consort. In that year the steamer R. J. Hackett was built at Cleveland, Ohio, being, as the term is now generally understood, the first bulk freighter on the Great Lakes. She was of wood, 211 ft. long, and 33 ft. beam, the propelling machinery being placed aft. Her hold was continuous, and her hatches spaced 24 ft. centres, influenced, no doubt, by the design of the early loading docks on Lake Superior. She had a carrying capacity of about 1,200 tons, the draught being, of course, fixed by the 11½ ft. of water at the "Soo" locks. The following year the Forest City, of approximately the same dimensions, was built as a consort to the Hackett, and the two vessels were operated together. Although intended to be always in tow of the steamer, she was rigged with sufficient canvas to care for herself in case of being dropped through stress of weather. This method of transporting ore by means of steamers and consorts became rapidly popular, and continued as the prevailing practice for almost twenty years thereafter.

In 1874 the steamer V. H. Ketchum was launched at Marine City, Mich., and being 20 ft. longer than anything afloat on the lakes at that time was considered a monster. She was of wood, 233 ft. long, 41 ft. beam, and 24 ft. deep.

About this time the demand became general and insistent for a deeper channel throughout the Lake System. Draughts of 13 ft. and over were possible at some of the principal lake ports, yet the draught of ore-laden vessels was regulated by the depth of water at the "Soo" locks, viz., 11½ ft. A 16-ft. channel throughout was decided upon, the first step toward which being an increase in the depth of the St. Mary's Fall's Canal from 12 ft. to 16 ft., and the construction of a new lock 515 ft. long and 80 ft. wide, to provide for the whole 18 ft. difference of level in one lift. This new lock, the "Weitzel," was completed in 1881, but it was 1884 before the 16-ft. channel was available throughout. In the meantime a large fleet of vessels had been built of dimensions to utilise to best advantage the increased facilities, and the principal ports had been deepened to suit. At this time the growth of the ore-carrying trade had been notable, shipments having increased from 300,000 tons in 1866 to 2,300,000 in 1884. In 1882 a departure from the use of wood in shipbuilding was made by the construction at Cleveland, Ohio, of the steamer Onoko, the first iron bulk freighter built on the lakes, and for a time the largest dead-weight carrier, her dimensions being 287 ft. in length, with a beam of 38 ft. With the development along other lines the ore-loading docks at the Lake Superior ports had been gradually and consistently enlarged to keep pace with the requirements. The construction of these docks has always influenced the arrangements of the ships in one way. The loading spouts were originally placed at 12 ft. centres, and on account of this the early boats were built with their hatches spaced 24 ft. centres in order that each alternate spout could be used without shifting. The early docks were invariably of timber, with the base of the pockets only 20 ft. above water, this giving sufficient incline for the flow of the ore. Concrete and steel, however, enter largely into the construction of the modern ore-loading dock, and Fig. 1, Plate X., shows the Duluth and Iron Range Company's dock, No. 6, at Two Harbors, Minn. This dock is 40 ft. from waterline to bottom of pockets, and 73 ft. high to railroad track, and has storage capacity for 43,246 tons. The steamer shown under the loading spouts is 569 ft. long over all, and on October 10, 1909, was loaded with 10,111 tons of ore in 39 minutes.

In unloading, however, no material advance had been made, the portable engine, buckets, and wheelbarrows prevailing as late as 1880. The first real improvement was introduced at Cleveland by the building, in 1882, of a cable-way machine designed by Alex. E. Brown, which marks the beginning of the speedy development of the material-handling machinery on the lakes. It consisted of a number of cables, each supported on two fixed piers, one at the dock face and the other some 300 ft. back. On each cable ran a one-ton ore bucket, controlled in its movements from a central station. The buckets were filled by hand in the hold, the machine lifting out, depositing the ore on the storage pile or directly into cars, and returning the empty bucket to the hold without further hand labour. Although an infinite improvement over the old method, the limitations of a machine with fixed piers was soon realised, in that it could cover only a limited storage pile, and it soon gave place to the type carrying a rigid bridge structure instead of the cable, the piers being mounted on wheels and movable along the length of the dock. This type was brought to great perfection by the Brown Hoisting Machinery Company of Cleveland, and became the almost universal standard, their capacity being largely limited by the speed of filling the buckets. Fig. 2, Plate X., shows the highest development of this class of machine, superseded now by the "grab-bucket" type.

Steel was first introduced in the construction of bulk freighters on the lakes in the building of the Spokane in 1886, and this speedily became the only material used. When in 1884 the 16-ft. channel became available, a great many steamers of 1500 to 1900 tons net register, with a carrying capacity of about double that amount were in use. In 1888 iron ore became the leading article of commerce on the lakes, a position which it has retained uninterruptedly since, and from that time the vessels built for that trade were greater in number and larger in tonnage than those for any other. In constructive features they were yet practically the same as the Hackett and Forest City. Steel had been substituted for wood, the double bottom had been added, but the internal arrangements remained substantially the same.

The demand for deeper waterways on the lakes has been unceasing, and the 16-ft. channel was no more than completed when it was realised that it was totally inadequate to the demands of the commerce, and measures were taken towards increasing it. The improvements included the further deepening of the St. Mary's Canal to 25 ft. and the building of a new lock, 800 ft. long and 100 ft. wide, with 22 ft. of water over the sills. This, the present "Poe" lock, was built on the site occupied by the first lock, and was opened for traffic in 1896. Simultaneously, the work on the Canadian Canal and lock had been carried on, it being completed the year previous. The channels through the connecting rivers were also improved by deepening, straightening, and making safer for night navigation, and the effect of this new 20-ft. channel was immediately felt in increased ship dimensions. In 1896 more than half the tonnage in bulk freighters built exceeded 2000 tons net register, while six years previously not a single vessel of this tonnage was in service.

The first of the 400 ft. class, built in 1895, marked a departure from ordinary construction in the wide spacing of her main deck beams. This was the steamer Victory, 400 ft. long over all, 48 ft. beam, and 28 ft. deep. Her carrying capacity was 5200 tons on 18 ft. draught, and at that time she represented the highest development of the bulk freighter. It is evident that with the class of bulk cargoes carried in these ships intermediate decks are unnecessary, the cargo being carried entirely on the "tank top" or inner bottom. Up to the time of the introduction of the hopper-type ship the so-called main-deck beams, on which, however, no deck was laid, and hold stanchions, were invariably installed for structural reasons. On the Victory the arrangement was simplified by spacing these beams 8 ft. apart. In 1897 steamers of 475 ft. in length appeared, and about this time were built the last of the "consorts," owners realising that the highest economy in operation was reached by the single steamer of large carrying capacity and comparatively low power.

In 1899 there was installed at Conneaut, Ohio, a new type of ore-unloading machine, the "Hulett," operating a self-filling or "grab" bucket, which marked a point of radical change, both in the design of unloading machinery and in the internal arrangements of the ships. Up to this time the ore had been handled in one-ton buckets, the size found most satisfactory for hand filling, but with the new mechanical buckets the capacity seemed to be limited only by the clear space available in the hold. Since the introduction of the grab bucket two types of machines have been developed, one in which the bucket is suspended by the operating ropes, and the other in which the bucket is mounted on the lower end of a vertical rotating leg operated by an oscillating beam.

Fig. 3, Plate XI., represents one of the former type built by the Brown Hoisting Machinery Company, of Cleveland, Ohio, this machine being arranged to deliver directly into cars. On July 21, 1910, a machine of this type, using six 5-ton grab buckets, unloaded 9681 gross tons of ore from the steamer Matthew Andrews in 5 hours and 58 minutes, or at the rate of 353.2 tons per hour for each bucket.

Fig. 4, Plate XI., illustrates a "Hulett" type machine, built by the Wellman-Seaver-Morgan Company, of Cleveland, Ohio. Operating four 15-ton grab buckets, this machine unloaded from the steamer Thomas F. Cole, on August 5, 1910, 11,131 gross tons of ore in 4 hours and 30 minutes, or at the rate of 618 tons per hour per bucket.

In 1900 the first "500-ft." steamers appeared, but during the two or three years following the dimensions dropped back slightly. In 1902 the steamer James H. Hoyt was built, with her nineteen hatches spaced 12 ft. centres, making it possible to use loading spouts in all hatches simultaneously, and allowing greater freedom in the hold. This created new records for both loading and unloading.

Two years later, in 1904, was witnessed the most radical change ever made in the construction of lake freighters. A steamer was built 60 ft. longer than any other vessel on the lakes, and differing materially in construction from the existing type. This steamer was the Augustus B. Wolvin, 560 ft. long, 56 ft. beam, and 32 ft. deep. She had 33 hatches, spaced 12 ft. centres, and her hold construction was novel, beams and stanchions being omitted entirely and compensating strength secured by heavy plate arch-girders under the spar deck, between hatches. Instead of the usual practice of running the "tank top" or inner bottom out to the ship side, it was carried up to the edge of the main-deck stringer, the sloping sides forming the hold into a long, continuous hopper, as shown on Fig. 5, Plate XI. The space thus formed on each side, between the hopper sides and skin of ship, added materially to the capacity for water ballast, the cargo was concentrated within the reach of the unloading machines, and all obstructions to the working of them removed from the hold. The success of the type was instantaneous, and since that time every bulk freighter on the lakes has been built on some modification of this design.

Fig. 6, Plate XI., shows the type of hopper hold now generally adopted, and illustrates how the grab buckets may be turned, after passing through the hatches, to clean up the ore close to the vertical sides of the hopper.

Considerable work has been done on the older-type steamers in the re-arrangement of the main-deck beams and grouping of the stanchions, and, latterly, vessels of the earlier type have been entirely changed to the arch or girder construction, for the fact is obvious that for the economical handling of ore by present-day unloading machinery the hold must be entirely free.

The bulk freighter of the Great Lakes to-day, while not a thing of beauty from the marine architect's point of view, is, nevertheless, a most efficient, economical, and capacious carrying machine, excellently suited to the requirements of the business she was intended for and is engaged in. Ordinary practice and accepted formulæ have affected her design but little. Extraordinary conditions had to be met, and the result has been the evolution of a type of ship peculiar to the conditions of the trade in which she was to operate. She represents no compromise design, but is planned with a single purpose in view, no thought being given to the possibility of her ever engaging in business of any other nature. Under present conditions she is still unhampered as to length, and two steamers 617 ft. long are at present under construction. As, however, a width of 60 ft. or over prevents the use of all the "Soo" locks except the "Poe," the possibility of serious delay through the derangement of this lock has to some extent governed the beam of the ships, and 58 ft. has been generally adopted as the maximum up to date, although several steamers of 60 ft. beam are in use. The great length, in comparison to the limited depth available, makes the question of longitudinal strength an all-important one, while the extreme athwartship width of the hatches complicates the problem somewhat. The speed of loading ore precludes the possibility of taking the steamer under the loading spouts with any considerable amount of water ballast, as it is impracticable to discharge it as fast as the ore is run in. Therefore, to get the necessary slope of the spouts to insure the proper running of the ore, with the ship in a light condition, the hatches are made about two-thirds the beam of the ship in width. The full lines, square middle body, bluff bow, and practically flat bottom, the extreme forward position of the navigating bridge, the long sweep of deck, clear of spars and pierced by hatches from end to end, the hopper hold, free from cross-beams and stanchions, and spanned by the deep spar-deck girders, the arrangement of the steel hatch covers, and method of removing and replacing them, the absence on board of all cargo-handling machinery, the large capacity for water ballast, the compactness, simplicity, and economy of the propelling machinery, together with its comparatively low power, the labour-saving devices, the consequent small crew required, and the superior accommodation provided for them, together with the almost entire absence of wood in the construction, are a few of the striking characteristics of the bulk freighter of to-day.

The following are the principal dimensions of one of the "600-footers," common enough now on the lakes to constitute her a typical example of the latest practice:—

Length over all, feet	600
Length between perpendiculars, feet	580
Beam moulded, feet	58
Depth moulded, feet	32
Carrying capacity in gross tons at 19 ft. draught	10,400
Displacement in gross tons at 19 ft. draught	15,350
Block coefficient, per cent.	86
Length of cargo-hold, feet	440
Width of cargo-hold at bottom, feet	36
Capacity for water ballast, gross tons	8,000
Number of hatches	36
Clear opening of hatches, feet	36 by 9
Number of crew	25
Type of propelling-engine: Triple-expansion jet-condensing.	
Diameter of cylinders and stroke, 25 in., 39 in., and 65 in. by 42 in.	
Revolutions per minute	85
Indicated horse-power	2,000
Number of boilers	2
Type and size in feet: Cylindrical, 16 ft. by 11½ ft.	
Working pressure, lbs.	180
Loaded speed, miles	11½

Fig. 7, Plate XII., shows, as an exception to the general rule, a freighter carrying her own unloading machinery. Two of this class are in use on the lakes carrying crushed limestone, and by an arrangement of hopper hold, travelling scrapers, and elevators, the cargo is delivered on the dock entirely without hand labour.

Package Freighters.—General merchandise, outside of shipments made in bulk, and known as "package freight," forms a very considerable trade on the Great Lakes, amounting annually to over 7,000,000 tons, which is handled almost entirely in steamers of greater speed than the bulk freighters, built expressly for the traffic, and owned and operated by, and in connection with, the great railway systems. Single-screw vessels of the

double-deck type are used, and, although many of the earlier steamers had their machinery amidships, the later types, in common with the prevailing practice on lake screw steamers, have their engines and boilers aft. They are divided into two classes, those carrying freight only, in which type the boilers are frequently placed on the main deck, in order to increase the hold capacity, and those carrying passengers in addition. Unlike the bulk freighter, with its almost universal triple-expansion engine, the quadruple finds most favour on this class of ship. The package freighters carry their own cargo-handling machinery, the cargo being worked generally through the side gangways, and entirely so in the case of the passenger steamer, where the accommodation does not allow of hatches through the spar deck. The apparatus is peculiar to this class of steamer, and consists of a line-shaft, running the entire length of the 'tween deck cargo space, driven at a constant speed by an independent engine, and carrying a number of compressed-paper pulleys. Abreast each hatch two hoisting drums are placed, one end of each being formed into a smooth cast-iron wheel corresponding in position to the friction-wheels on the line-shaft. The drum-shafts, carried in eccentric bearings, are so arranged that the operator can, by means of a lever, cause the drum-wheel to come in contact with the revolving paper friction, or by a reverse motion bring it into contact with a stationary brake-block. In practice this proves to be a fast, efficient, and silent method of handling mixed cargoes of this class.

Passenger Steamers.—The passenger steamers on the Great Lakes abound in such profusion and represent so many differing types that a very general description of a few of the most notable must suffice in this paper. As indicating the enormous volume of the passenger business, statistics show that 16,000,000 persons annually are carried. The passenger season proper lasts only from the early part of June until the middle of September, but during this time the steamers are crowded to their utmost capacity. The development of the passenger steamer has been more gradual than that of the other classes of steamers referred to, and the types do not represent any radical departure from usual and accepted American practice, the chief characteristics being regularity of service and excellence of the accommodation provided.

The only exclusively passenger steamers on the lakes are those of the Northern Steamship Company, and Fig. 8, Plate XII., represents the North West, one of their two "through" steamers between Buffalo and Duluth. These steamers are 386 ft. long, 44 ft. beam, and 25 ft. deep, of the twin-screw type, and are most luxurious in their appointments.

The steamers engaged on Lake Erie, in the night service between Cleveland and Detroit, illustrate the growth of the paddle-wheel type in the three steamers which have been successively engaged on this route, and have each borne the name City of Cleveland. The first of these, now known as the State of Ohio, is 225 ft. long; she was built in 1880, and fitted with fifty-six state-rooms. The City of St. Ignace, 272 ft. in length, was built in 1886, with the number of state-rooms increased to 185, while Fig. 9 illustrates the present City of Cleveland, which was built in 1908. She is 402 ft. long, 54 ft. beam of hull, 92 ft. beam over all, and has 342 state-rooms. Her engines are of the inclined three-cylinder compound type, of 7000 indicated horse-power. In addition to her large passenger capacity, she is arranged for 1000 tons of general merchandise, stowed on the forward main deck.

A steamer is now under construction for this service 472 ft. long, 50 ft. beam, 94 ft. wide over all, which will have 436 state-rooms, and 9000 indicated horse-power in her propelling machinery.

The City of Erie, one of the night steamers between Buffalo and Cleveland, represents the highest development on the lakes of the paddle-steamer with engines of the "beam" type, which, although for many years the favourite design for this class of steamer, has now given way entirely to the three-crank inclined type. She is 324 ft. long, and has a compound engine of 6000 indicated horse-power, the high-pressure cylinder being 52 in. in diameter by 95 in. stroke, and the low-pressure cylinder 80 in. in diameter and 144 in. stroke, both acting on a single beam.

Car-Ferries.—The car-ferries of the Great Lakes, all of which are owned and operated by the railway companies, are divided into two classes—those for river service, and those specially constructed for cross-lake traffic. The earliest ones are of the former type, introduced in the 'seventies to supersede the then existing slow and costly method of unloading merchandise from the train, ferrying across the rivers, and re-loading on the other side. This class of ferry is peculiar on the lakes to the rivers connecting Lake Huron and Lake Erie, where bridging has never been considered feasible, and tunnelling is only a matter of recent accomplishment, and for many years the entire railroad business across the Detroit River, between Detroit and Windsor, and that of the St. Clair River, between Port Huron and Sarnia, was carried by means of them, and it is estimated that in 1907 some 26,000,000 tons were transported across in this manner, as well as from 25 to 30 passenger trains per day.

Ten ferries were employed continuously, and, although, since the opening of the Michigan Central Railway tunnel under the Detroit River four of these have been withdrawn from the service, the remaining business is still very considerable. Operating always in still water, these river-car ferries are built with low freeboard and flat clear decks, the propelling machinery, in the case of the screw-boats, being entirely under the car-deck, and well out in the wings in the paddle type, in which there is no cross-shaft, the wheels being independent and driven by separate engines. All the river ferries are "double-enders," fitted with two to four tracks, and can accommodate from eighteen to twenty-four freight cars. These are loaded from connecting shore tracks, an "apron," or hinged section, of the dock being fitted at the end of the loading slip to provide for the fluctuation of the water-level. Regular service is maintained all the year round, the steamers being specially constructed for ice-crushing during the severe winter weather.

Fig. 10 shows one of the earlier type of river car-ferries, propelled by paddle-wheels, transporting a passenger train and breaking her way through the ice on the Detroit River. The later types of these vessels are fitted with two propellers at each end.

The principal routes of the lake car-ferries are across Lake Michigan, the Straits of Mackinac and Lake Erie. On the former about thirteen of these ferries are in operation, the Père Maquette Railway making connections between Ludington, Mich., and several ports on the Wisconsin side, while the Ann Arbor Railway operates a fleet from Frankfort, Mich., to cross-lake ports, the routes varying from 60 to 90 miles in length. These are powerful twin-screw steamers, averaging 350 ft. long, with capacity for thirty loaded freight-cars carried on tracks laid on the main deck. The sides are carried up some 18 ft. to a shelter-deck covering the entire ship, except a small portion aft where the stern is left open for the loading and unloading. Passenger cars are not carried on these ferries, accommodation for passengers being provided above the shelter deck.

Across the Straits of Mackinac two car-ferries have been operated since 1888, carrying both passenger and freight trains between Mackinaw City and St. Ignace, a distance of 7 miles. On account of the difficulty in keeping this service open during the winter months, owing to the "ice packs" which occur in the Straits, these steamers are fitted, in addition to the usual propeller aft, with one at the bow, driven by an independent engine, to assist in breaking out a channel. During the summer months the forward one is not operated, the engine being disconnected and the propeller allowed to revolve freely.

The Lake Erie car ferries are exclusively used in transporting Ohio and Pennsylvania coal to Canada, several routes being operated. The largest of these steamers have a capacity for thirty coal-cars of 50 tons capacity each.

SHIPPING ON THE GREAT LAKES.

Fig. 9. Northern Steamship Company's Passenger Steamer "City of Cleveland."

Fig. 10. Passenger Train-Ferry on Detroit River.

TANK TESTS ON MODELS OF SUBMARINES.

By Mason S. Chace, Member

*Results of Experimental Tank Tests on Models of Submarines.**

The model tests, the results of which are here recorded form a part of a series of a number of models of submarines tested at the United States Experimental Model Basin, Navy Yard, Washington, D.C., for the author. This paper presents the results of tests of four models, all derived from the same parent form. These tests comprise speed and power tests of the four models; also an experimental determination of the stream-lines, or lines of flow, around one of the models.

* Paper read at the Jubilee Meeting of the Institution of Naval Architects, July 5, 1911.

SHIPPING ON THE GREAT LAKES.

(*For Description, see Page* 62.)

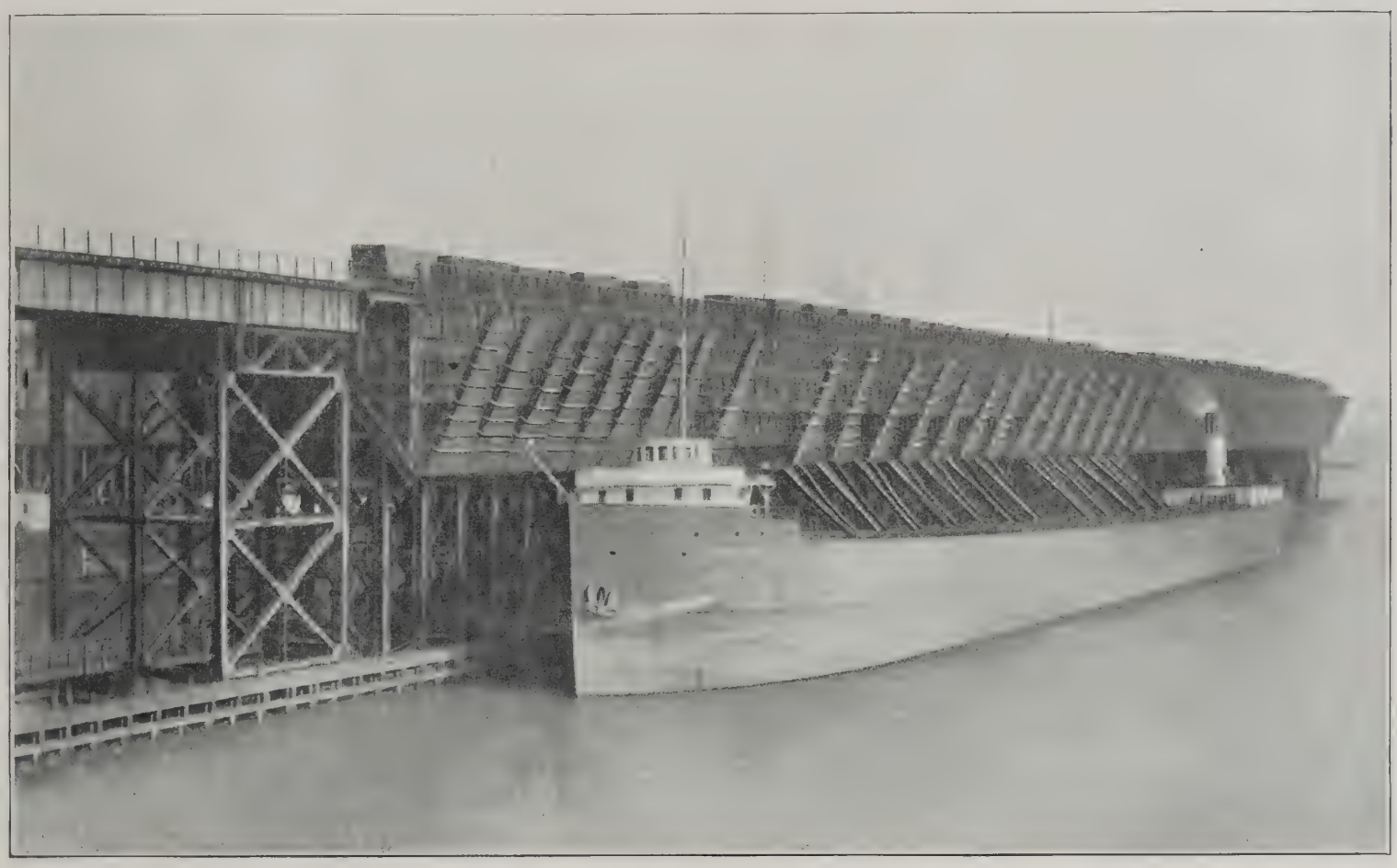


Fig. 1. The Duluth and Iron Range Company's No. 6 Dock, Two Harbours, Minnesota.

Fig. 2. Travelling Gantry Conveyors, Unloading Iron Ore at Menomina Dock, Ashtabula, Ohio.

(*To face Page* 64.)

SHIPPING ON THE GREAT LAKES.

(*For Description, see Page* 62.)

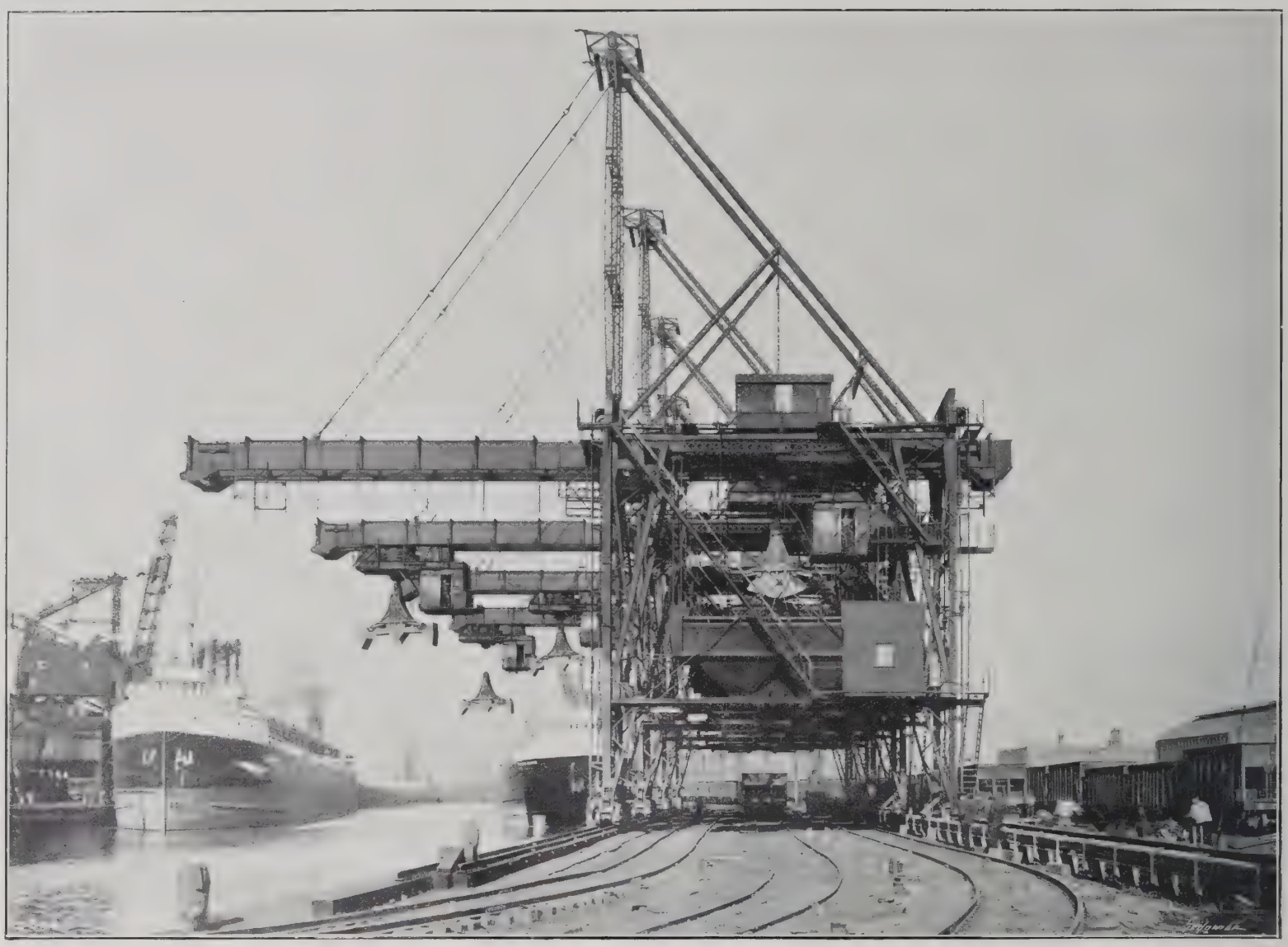


FIG. 3. HULETT GRAB-BUCKET MACHINES AT THE N.Y., P., AND O. DOCK, CLEVELAND, OHIO.

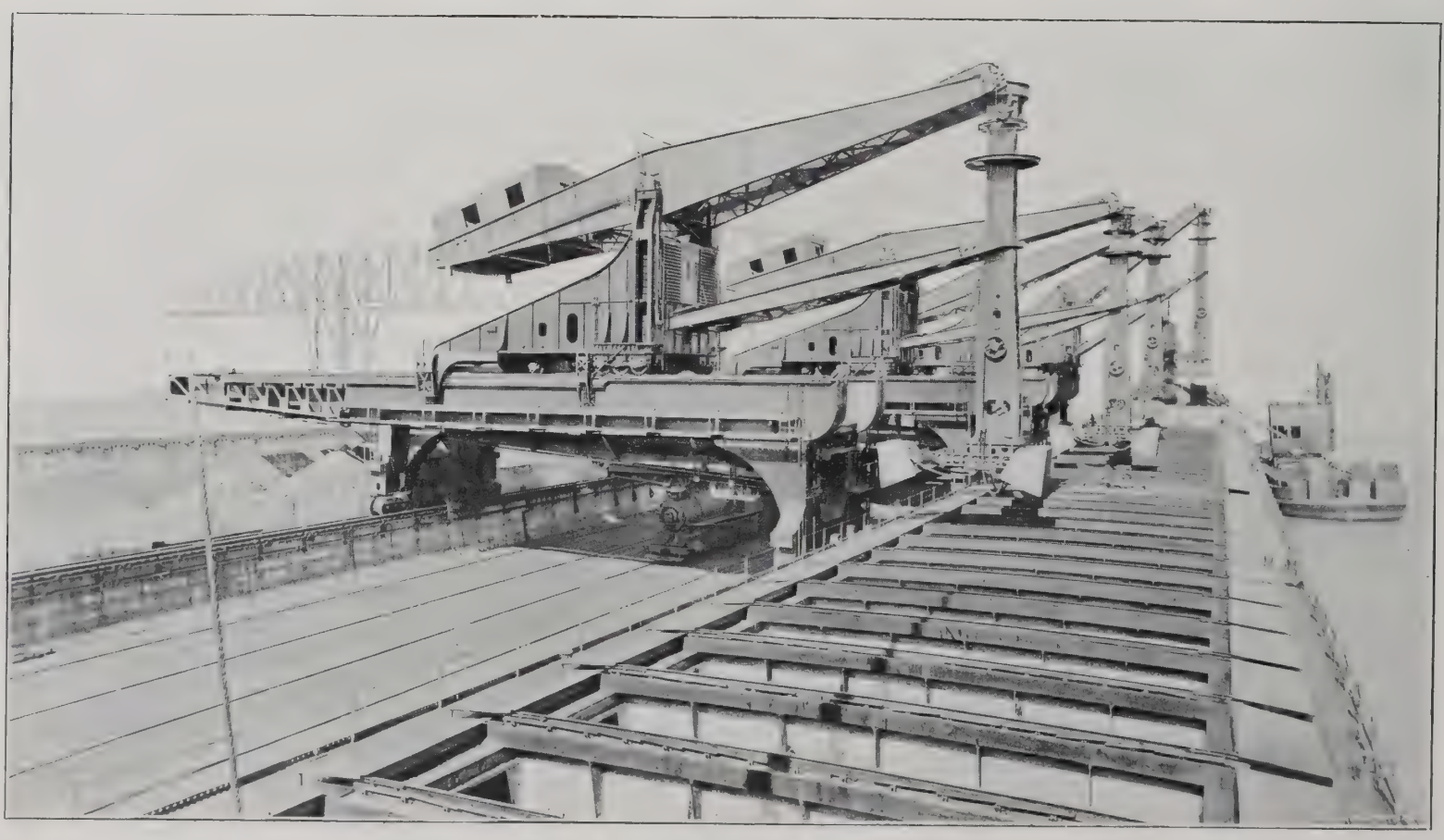


FIG. 4. HULETT OSCILLATING-BEAM GRAB-BUCKET MACHINES.

SHIPPING ON THE GREAT LAKES.

(*For Description, see Page* 62.)

FIG. 5. HOLD OF THE "AUGUSTUS B. WOLVIN."

FIG. 6. TYPICAL HOLD OF MODERN BULK-FREIGHT STEAMER.

FIG. 7. BULK-FREIGHT STEAMER WITH UNLOADING GEAR.

FIG. 8. NORTHERN STEAMSHIP COMPANY'S PASSENGER STEAMER "NORTH-WEST."

RESULTS OF EXPERIMENTAL TANK TESTS ON MODELS OF SUBMARINES.

(*For Description, see Page* 64.)

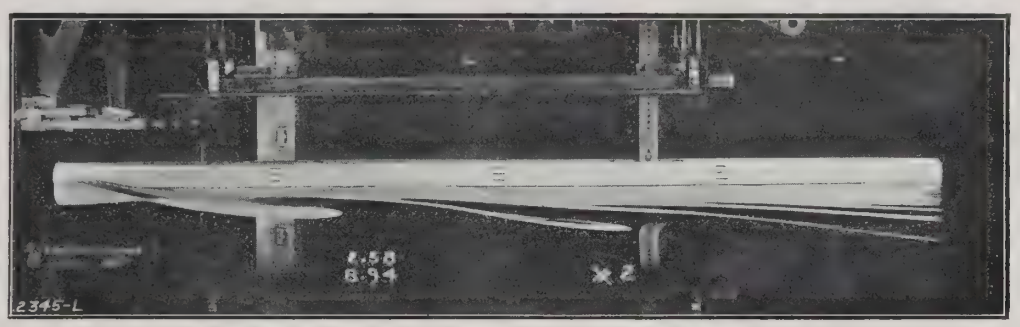


FIG. 6. Speed of model, 2.58 knots; speed of ship, 8.94 knots.

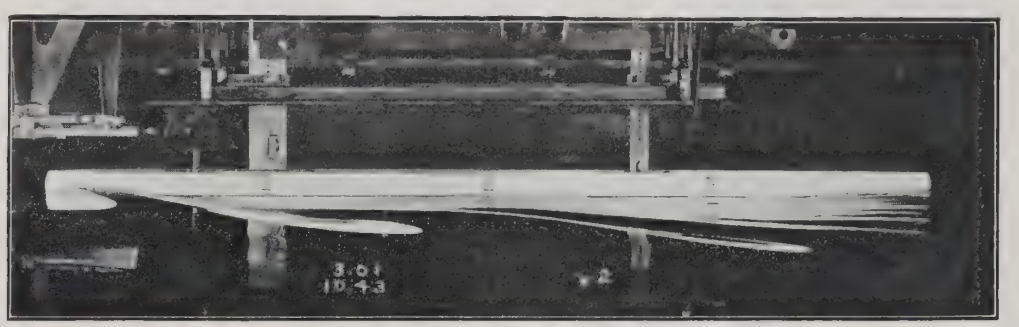


FIG. 7. Speed of model, 3.01 knots; speed of ship, 10.43 knots.

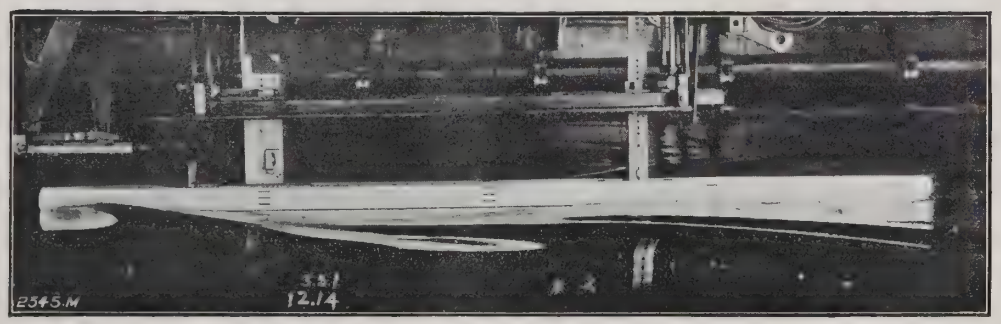


FIG. 8. Speed of model, 3.51 knots; speed of ship, 12.14 knots.

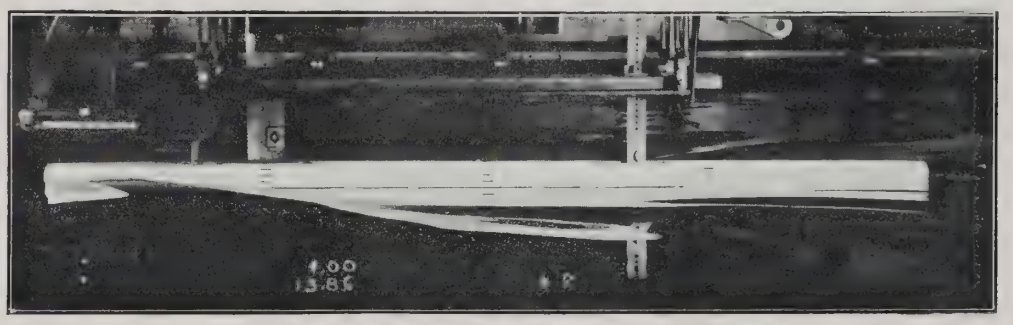


FIG. 9. Speed of model, 4.00 knots; speed of ship, 13.86 knots.

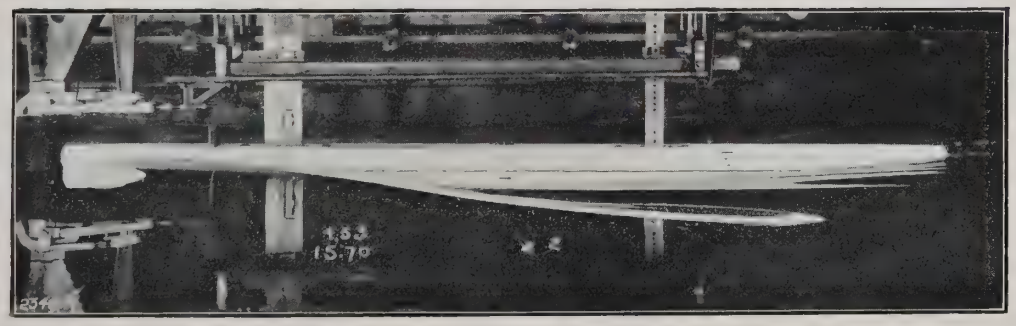


FIG. 10. Speed of model, 4.53 knots; speed of ship, 15.70 knots.

FIG. 11. Speed of model, 5.10 knots; speed of ship, 17.67 knots.

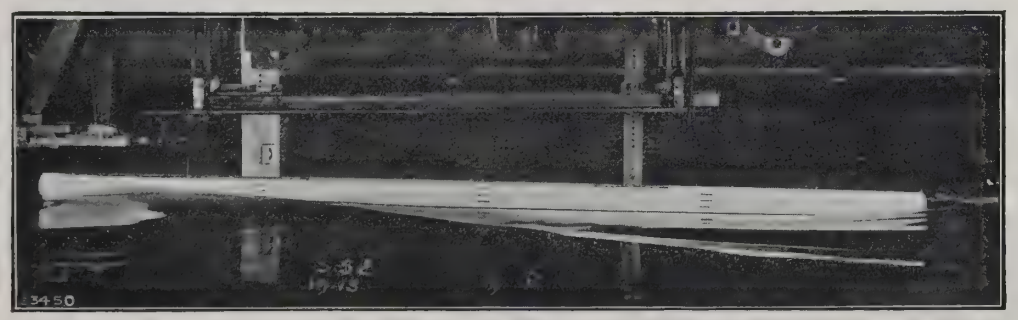


FIG. 12. Speed of model, 5.52 knots; speed of ship, 19.13 knots.

FIG. 13. Speed of model, 6.05 knots; speed of ship, 20.96 knots.

FIGS. 6 TO 13. WAVE PROFILES OF MODEL NO. 2 AT VARIOUS SPEEDS.

TANK TESTS ON MODELS OF SUBMARINES.

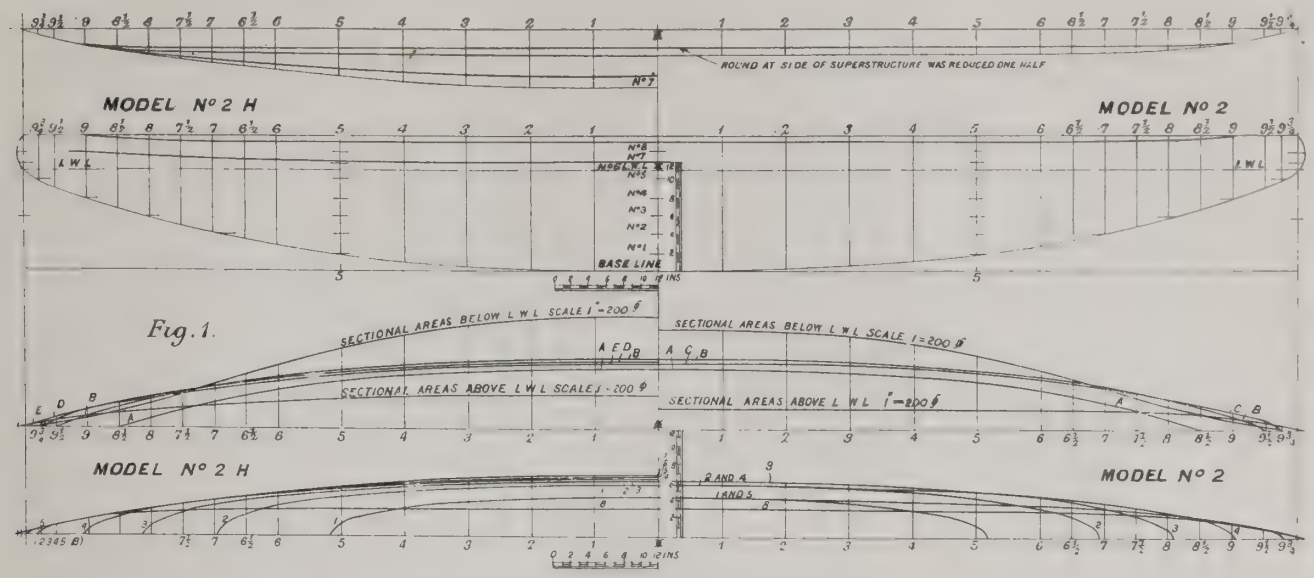

MODEL Nº 2 H
MODEL Nº 2
ROUND AT SIDE OF SUPERSTRUCTURE WAS REDUCED ONE HALF
L W L
BASE LINE
SECTIONAL AREAS BELOW L W L SCALE 1"=200 ☐"
SECTIONAL AREAS ABOVE L W L SCALE 1"=200 ☐"
A E D B
A C B
E D B
A
C B
2 AND 4
LANDS
(1 2 3 4 5 B)

Fig. 1.

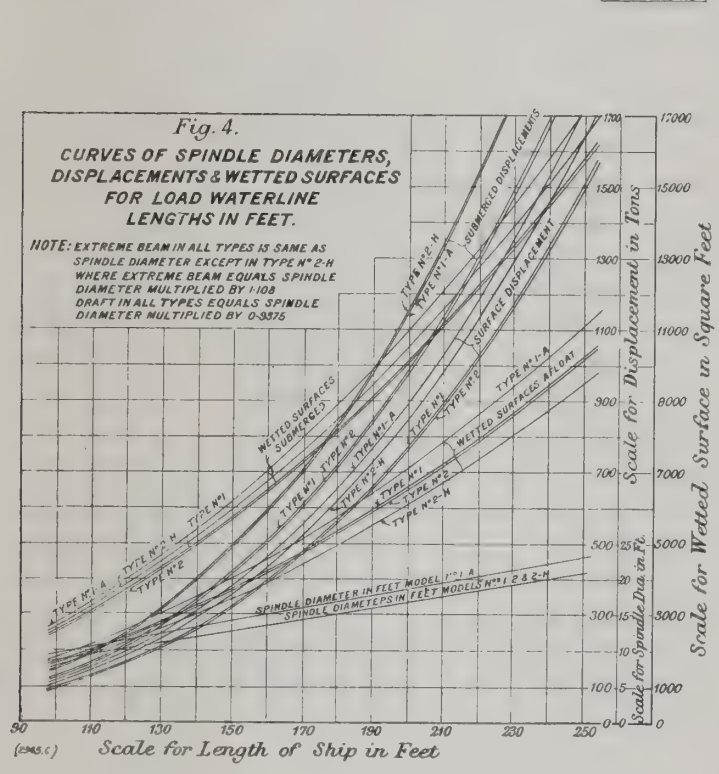

CURVES OF SPINDLE DIAMETERS, DISPLACEMENTS & WETTED SURFACES FOR LOAD WATERLINE LENGTHS IN FEET.
NOTE: EXTREME BEAM IN ALL TYPES IS SAME AS SPINDLE DIAMETER EXCEPT IN TYPE Nº 2-H WHERE EXTREME BEAM EQUALS SPINDLE DIAMETER MULTIPLIED BY 1·108
DRAFT IN ALL TYPES EQUALS SPINDLE DIAMETER MULTIPLIED BY 0·9375
SUBMERGED DISPLACEMENTS
SURFACE DISPLACEMENT
WETTED SURFACES SUBMERGED
WETTED SURFACES AFLOAT
SPINDLE DIAMETERS IN FEET MODELS Nos 1 2 & 2-H
SPINDLE DIAMETERS IN FEET MODEL 1·A
Scale for Displacement in Tons
Scale for Wetted Surface in Square Feet
Scale for Spindle Dia in Ft.
Scale for Length of Ship in Feet

Fig. 4.

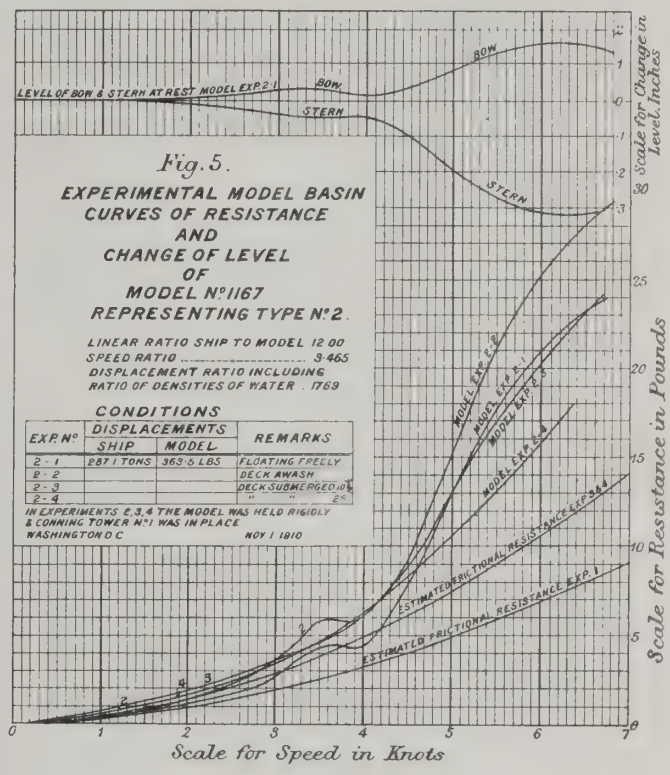

LEVEL OF BOW & STERN AT REST MODEL EXP 2·1
BOW
STERN
Scale for Change in Level. Inches
MODEL EXP 2·1
MODEL EXP 2·2
MODEL EXP 2·3
MODEL EXP 2·4
ESTIMATED FRICTIONAL RESISTANCE EXP 2·4
ESTIMATED FRICTIONAL RESISTANCE EXP 2·1
Scale for Resistance in Pounds
Scale for Speed in Knots

Fig. 5.

EXPERIMENTAL MODEL BASIN
CURVES OF RESISTANCE
AND
CHANGE OF LEVEL
OF
MODEL Nº 1167
REPRESENTING TYPE Nº 2.

LINEAR RATIO SHIP TO MODEL 12·00
SPEED RATIO ..... 3·465
DISPLACEMENT RATIO INCLUDING RATIO OF DENSITIES OF WATER . 1·769

CONDITIONS

EXP. Nº	DISPLACEMENTS		REMARKS
	SHIP	MODEL	
2 - 1	287·1 TONS	363·5 LBS	FLOATING FREELY
2 - 2			DECK AWASH
2 - 3			DECK SUBMERGED 0·6
2 - 4			" " 2·5

IN EXPERIMENTS 2, 3, 4 THE MODEL WAS HELD RIGIDLY & CONNING TOWER Nº 1 WAS IN PLACE
WASHINGTON D C NOV 1 1910

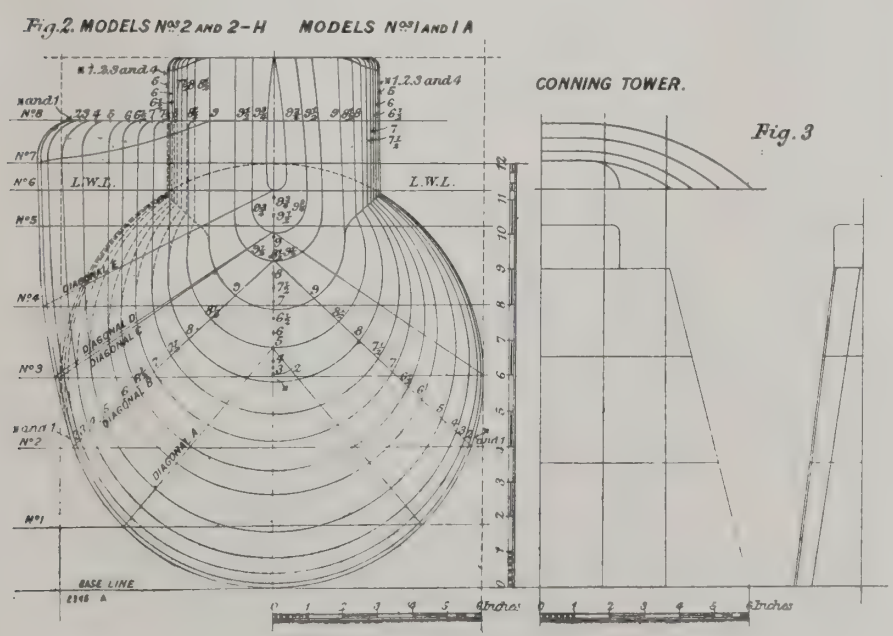


Fig. 2. MODELS Nos 2 AND 2-H MODELS Nos 1 AND 1 A

Fig. 3

Description of the Models.—These models are of a simple, elementary form, with the bow and stern exactly alike, and of canoe shape. All four models have a uniform spindle diameter of 12 in. Figs. 1 and 2 show the combined body-plan of all models, and the form of conning-tower used in the tests is given in Fig. 3. The sheer and half-breadth plans, also the diagonals and curves of sectional areas for models Nos. 2 and 2 H, are given in Fig. 1 and 2.

Model No. 1, the parent form, has circular cross-sections. All models, with the exception of model No. 1 A, have a length on the load water-line of 12 ft., and a parallel middle body 14.4 in. long.

Model No. 1 A was derived from Model No. 1 by the removal of this parallel middle body and a consequent reduction of the load water-line length to 129.6 in.

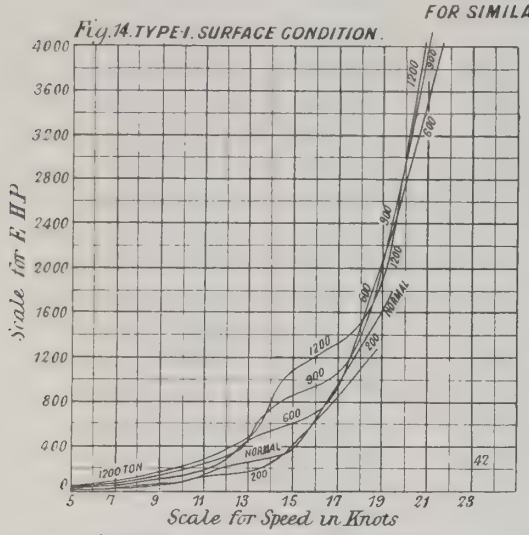
Model No. 2 was derived from model No. 1 by slightly fining the ends on about one quarter of the length from each end, and changing the shape of the end sections from circular to oval.

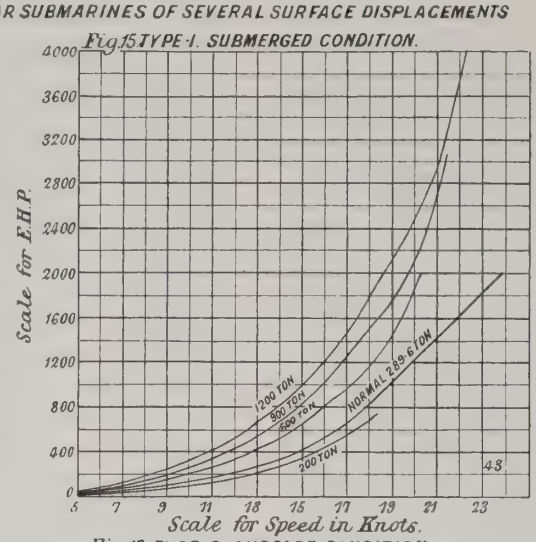
Model No. 2 H was derived from Model No. 2 by hipping out amidships, above the axis of the spindle, and fairing in with the original form.

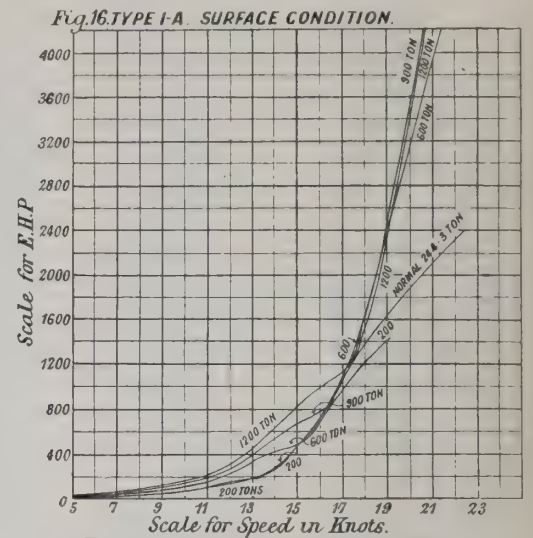
The principal dimensions and characteristics of these models are given in the table which follows (see page 69). This table is prepared on the assumption that the models represent full-sized vessels, on the scale of 1 in. equals a foot, and all figures in the table are for such full-sized vessels floating, or submerged, in sea-water. The displacement and wetted surface of the conning-tower appear at the bottom of the table. The figures pertaining to the conning-tower are not included in others given in the table.

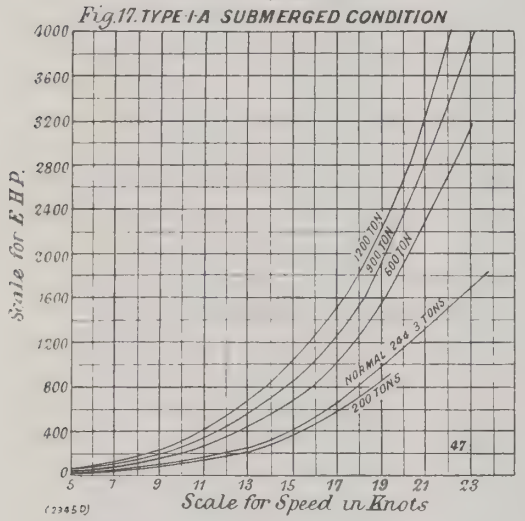
The principal dimensions and elements of the types which these models represent are shown on Fig. 4,

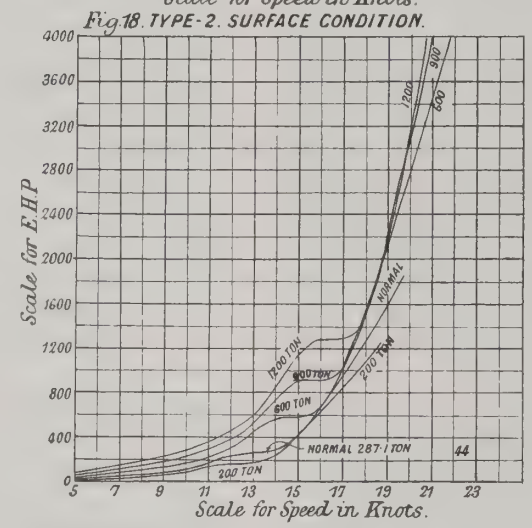
CURVES FOR EFFECTIVE HORSE-POWER
FOR SIMILAR SUBMARINES OF SEVERAL SURFACE DISPLACEMENTS

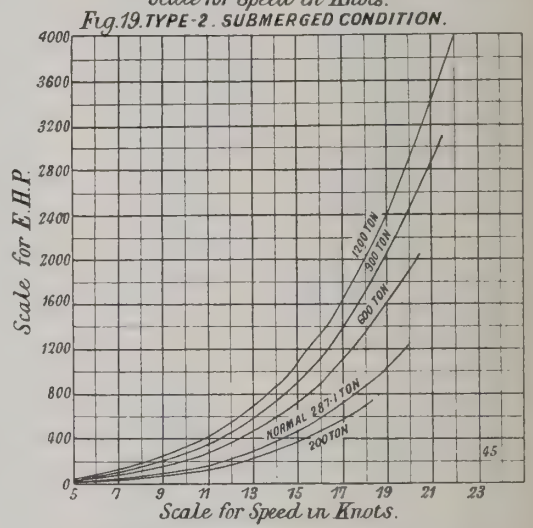












transmitted to the models by means of a vertical towing-bar, fitted with a roller, which bore on the forward vertical face of the towing-box in the model at a point slightly below the load water-line, when the models were at rest. The vertical distance separating the point of application of the pull of the carriage and the line of resistance of the models probably has more of an effect on the trim, at different speeds, in the case of models of submarines, with their comparatively small longitudinal stability, than it does in the case of models of ships of ordinary form.

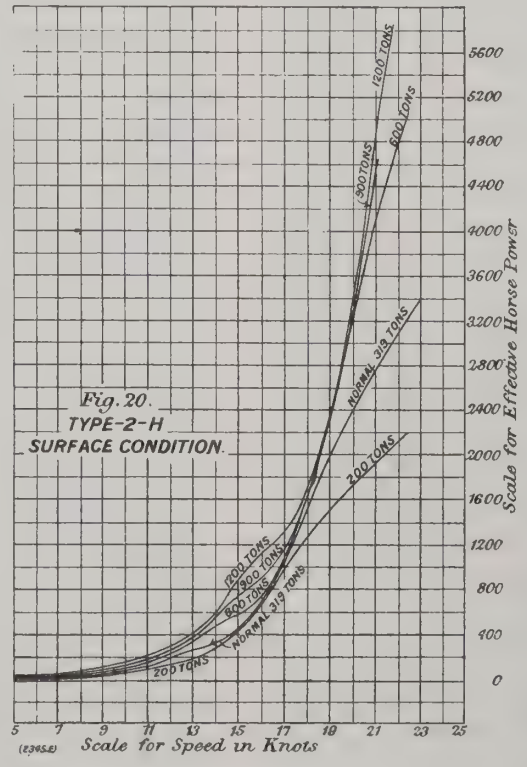
When towed awash, or submerged, the models were held rigidly in a horizontal position, at the required depth, by two vertical fins. After the completion of each series of submerged runs, the fins were run to determine the fin-resistance. The resistance of the model was obtained by deducting the fin-resistance from the total resistance of model and fins. The resistance of the fins, when run alone, and when run in conjunction with the model, is probably not the same; also the model resistance, submerged, when held horizontal may not correspond exactly with that of the full-size vessel, running submerged, at a corresponding speed, in its position of equilibrium. The curves of model resistance, submerged, show that within the limits of these experiments the submerged resistance diminishes with an increase of submergence. Even when the top of the spindle-hull is submerged to a depth of 2.4 diameters, all effects of surface disturbances are not eliminated.

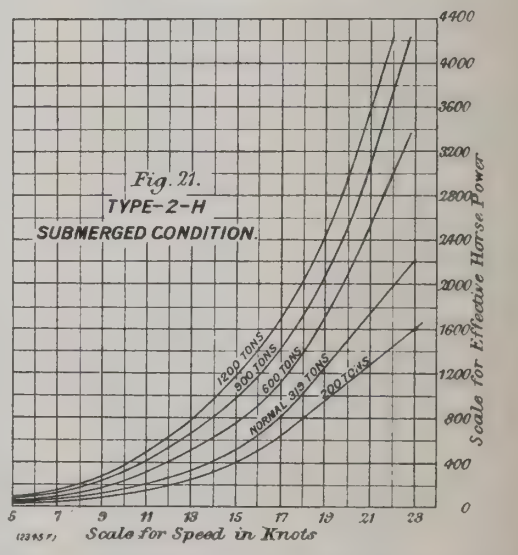
The resistance of the conning-tower, as obtained from model tank tests, is likely to be underestimated rather than given its true value, in per cent. of the total resistance, running submerged, owing to the presence of the fins in line with the conning-tower.

These models were tested without appendages, so in using curves of effective horse-power developed from the results of these tests to power full-sized vessels, with appendages, due allowance must be made for the added resistance of the appendages. The resistance due to appendages of submarines, such as keels, rudders, struts, shafting, torpedo-tube projections, &c., in excess of the bare hull resistance, can generally be closely estimated from the results of model tank tests, but it is sometimes found to be in excess of what the model tests indicate. This may be due to the presence of eddies, in the case of the full-size vessel, which do not exist for the model. It is often found difficult to obtain consistent results when it is attempted to separate the appendage resistance up into its component parts. The total resistance, due to all appendages, can generally be closely estimated in per cent. of the bare hull resistance, or allowed for in the choice of a propulsive coefficient, from known data regarding similar submarines.

The curves of model resistance, in Fig. 5, show a well-defined hump, for surface running, and also for running with the top of the superstructure awash, at a model speed of 3.5 knots, or a value of $\frac{V}{\sqrt{L}}$ equal to about 1. This hump is followed by a hollow, at a speed of 4 knots, beyond which the curve rises rapidly. The hollow in the curve of resistance occurs at a "critical" speed in so far as a change of trim is concerned. The curves of level, at the top of Fig. 5, show that beyond the speed of 4 knots the bow rises and the stern settles rapidly. Referring to the photographs, Figs. 6 to 13, Plate XIII., which show the wave profiles at various speeds, it may be noted that at the speed of 3.51 knots, corresponding to the hump, the hollow of the bow wave is forward of amidships, and that at the speed of 4 knots it is nearly amidships, with the second wave-crest at the stern. At the higher speeds this hollow moves aft, and the second crest passes astern.

All four models, even when driven at much higher





speeds, in proportion to the lengths, than could be attained by full-sized submarines, exhibited a marked tendency to trim by the stern, or "squat." This quality is desirable, in the case of submarines, for a tendency to "root" might become dangerous, owing to the comparatively small longitudinal stability, low freeboard, and small emerged displacement of such vessels.

Speed and Power-Curves for Full-Sized Vessels—Curves of effective horse-power for surface and submerged running, developed from the curves of model resistance, are shown in Figs. 14 to 21, inclusive. Each diagram gives curves of effective horse-power for similar full-sized vessels, of several surface displacements from 200 tons to 1200 tons. For convenience in making comparisons the results of the curves of effective horse-power are put in the form of contours of effective horse-power, plotted on speeds and displacements. Figs. 22 to 25, page 67,

TANK TESTS ON MODELS OF SUBMARINES.

CONTOURS OF EFFECTIVE HORSE-POWER.

Fig. 22. TYPE 1-SURFACE.

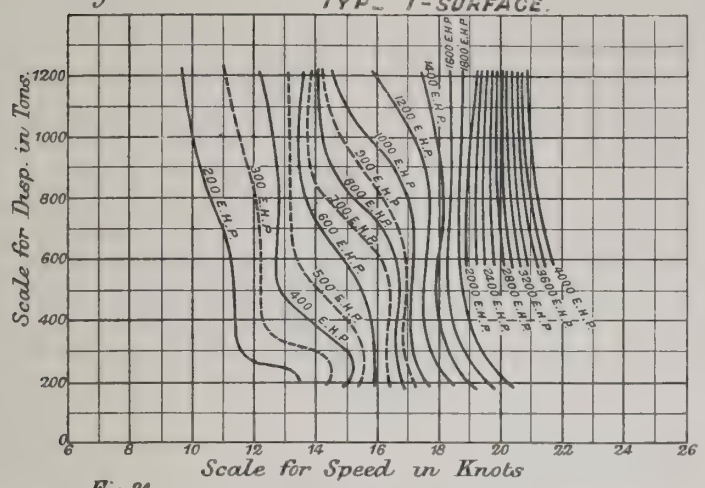


Fig. 23. TYPE 1-A-SURFACE

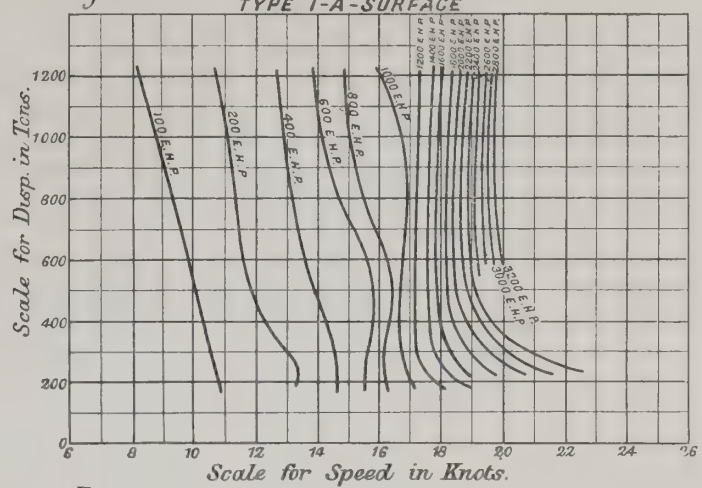


Fig. 24. TYPE 2-SURFACE.

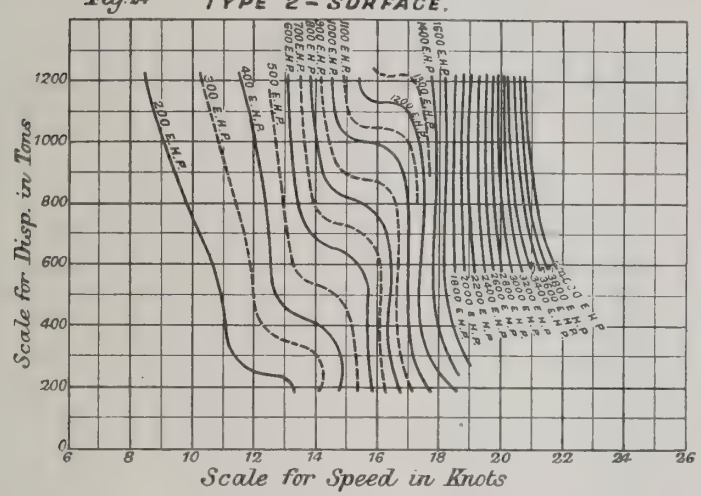
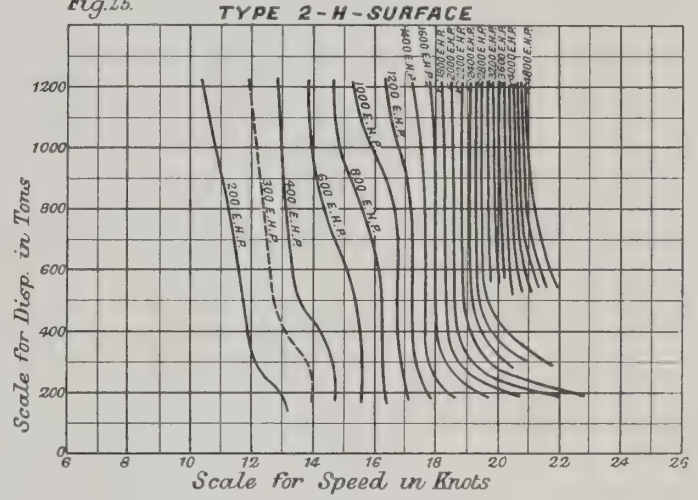


Fig. 25. TYPE 2-H-SURFACE



CONTOURS OF EFFECTIVE HORSE POWER

Fig. 26. TYPE 1-SUBMERGED

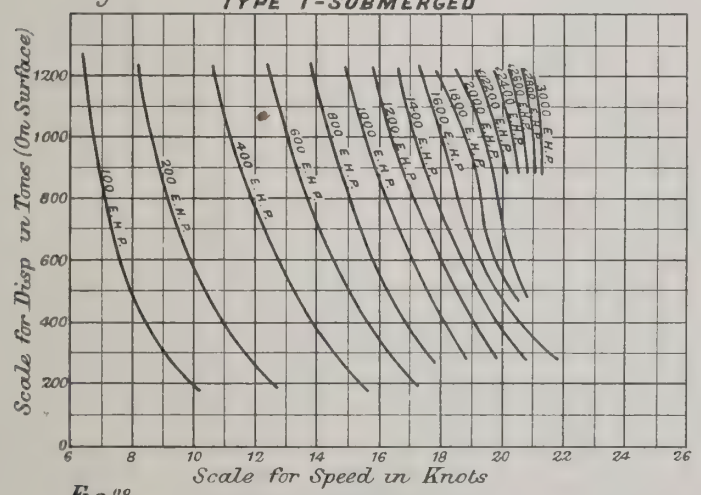


Fig. 27. TYPE 1-A-SUBMERGED

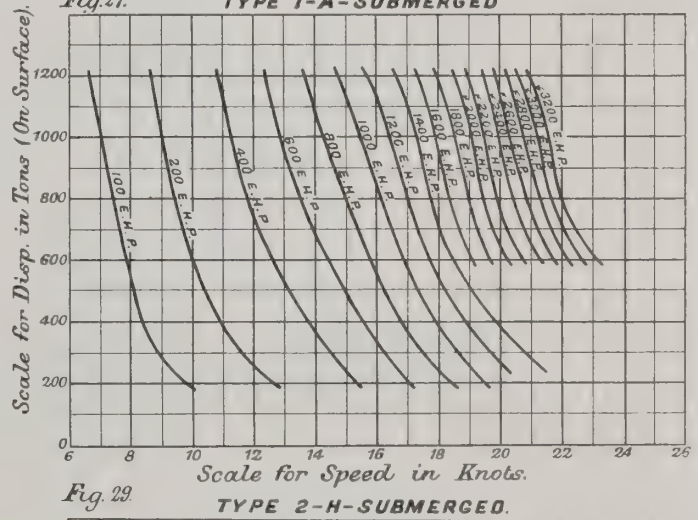
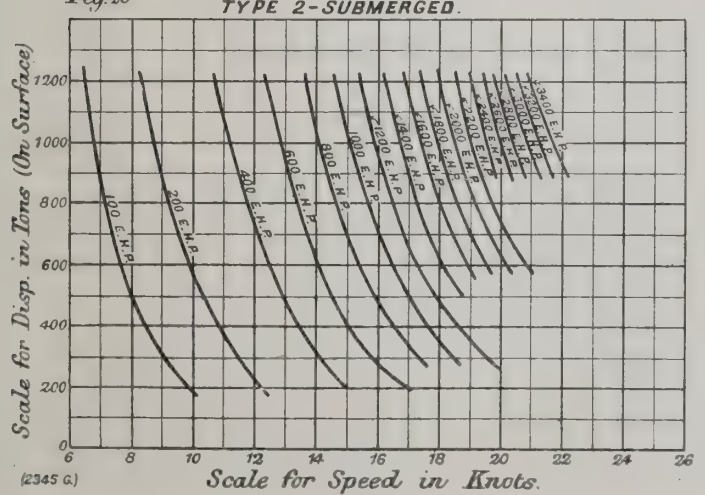
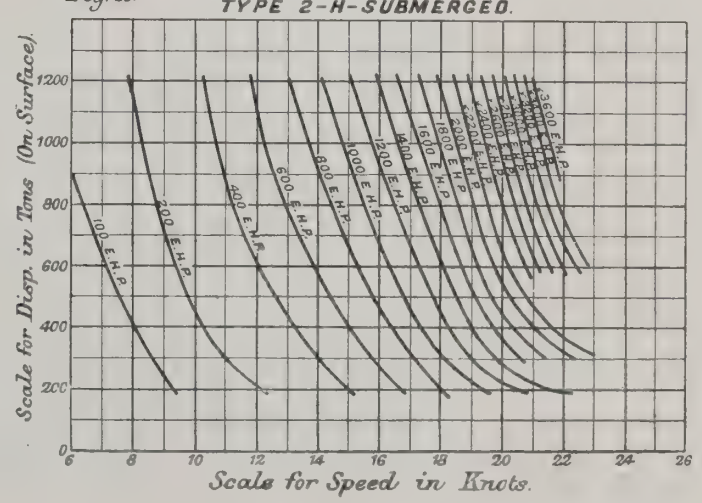


Fig. 28. TYPE 2-SUBMERGED.



(2345 G)

Fig. 29. TYPE 2-H-SUBMERGED.



shows the contours of effective horse-power for surface running, and Figs. 26 to 29, page 67, for submerged running.

Curves of residuary resistance in pounds per ton of displacement, plotted on values of $\frac{V}{\sqrt{L}}$ applicable to vessels of any size, are shown in Fig. 30 for the four types, under surface and submerged conditions.

The curves of effective horse-power all rise rapidly beyond a value of $\frac{V}{\sqrt{L}}$ equal to about 1.25, they also cross and re-cross at different speeds, showing that at these speeds vessels of different lengths and displacements take the same power to drive. At the high speeds the contours of effective horse-power, particularly for surface running, approach and become nearly vertical. While large submarines, suitable for high speeds, would probably not be designed by increasing all dimensions in the same proportion, these curves can be used in making different speeds, and made the humps and hollows of the curves of resistance come at lower speeds.

The removal of the parallel middle body from type No. 1 to produce type No. 1 A has effected a reduction in length of 14.4 ft., a reduction in the ratio of length to beam of from 12 to 10.8, and a reduction in the total displacement, submerged, of 54.5 tons, but a material increase in the displacement-length coefficients. These changes have resulted in a reduction of the longitudinal coefficient, surface condition, from 0.64 to 0.60.

A comparison of the curves of effective horse-power of the two types shows that a vessel of type No. 1 A requires materially less power to drive, surface running, than a vessel of the same displacement type No. 1, until speeds where $\frac{V}{\sqrt{L}} = 1.2$ are reached. For a speed such that $\frac{V}{\sqrt{L}} = 1$, surface running, the residuary resistance of type No. 1 A is only one-half of that of type No. 1. For $\frac{V}{\sqrt{L}} =$ even in so far as the use of model tests are concerned. The speed problem is a much more complicated one, in the case of submarines, than in that of any other type of ship, as submarines are designed for both surface and submerged running, and a choice of factors favourable in one condition may be extremely unfavourable in the other. While the percentage of the displacement which can be assigned to propulsion, in the case of submarines, is smaller than in that of surface torpedo-boats, the weight so assigned must be divided between two power systems, one for surface running and the other for running submerged. All systems at present in use for submerged propulsion are extremely inefficient.

To-day the question of how to best increase the speed of submarines is the most important one connected with their future development, particularly as a further menace to the battleship, whose operations are practically restricted to the high seas, owing largely to what the submarine can now do, and ignoring the great possibilities of the future use of aerial craft, especially in connection with coast defence.

Increased speed, particularly surface speed, combined with increased radius, is required of the sea-going submarine. This means increased dimensions, even if important improvements are made in the power systems to be

Fig. 30.

CURVES OF RESIDUARY RESISTANCE IN POUNDS PER TON OF DISPLACEMENT FOR THE SEVERAL TYPES OF SUBMARINES FLOATING & SUBMERGED.

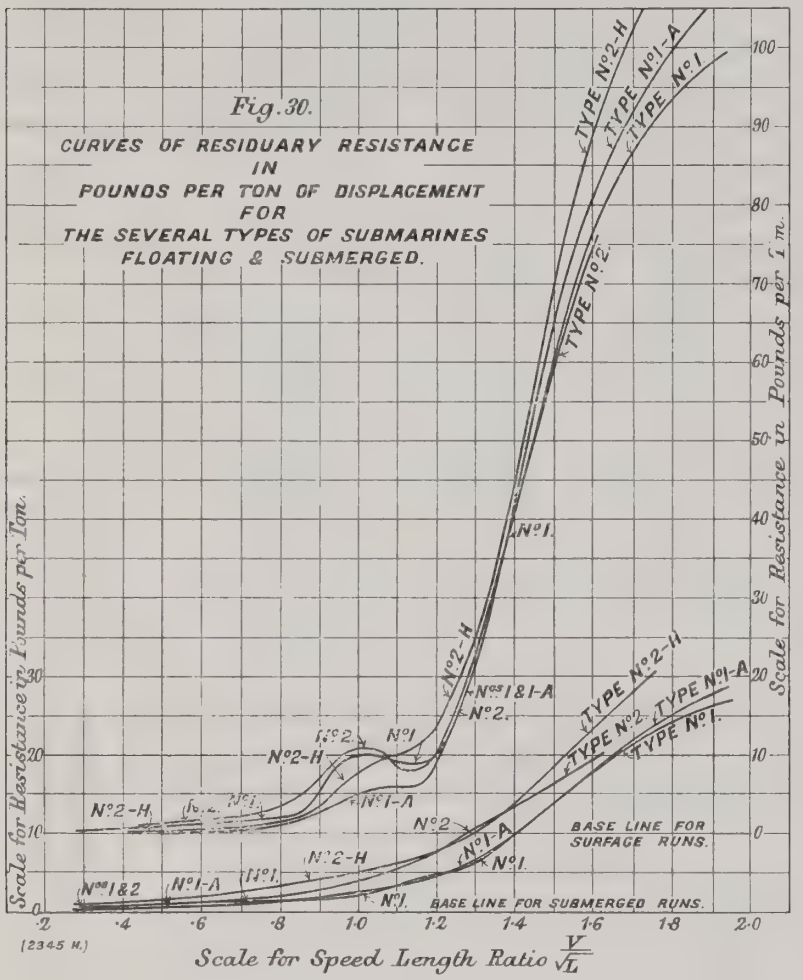


Fig. 31. EXPERIMENTAL MODEL BASIN LINES OF FLOW OVER. MODEL 1167 TYPE No 2

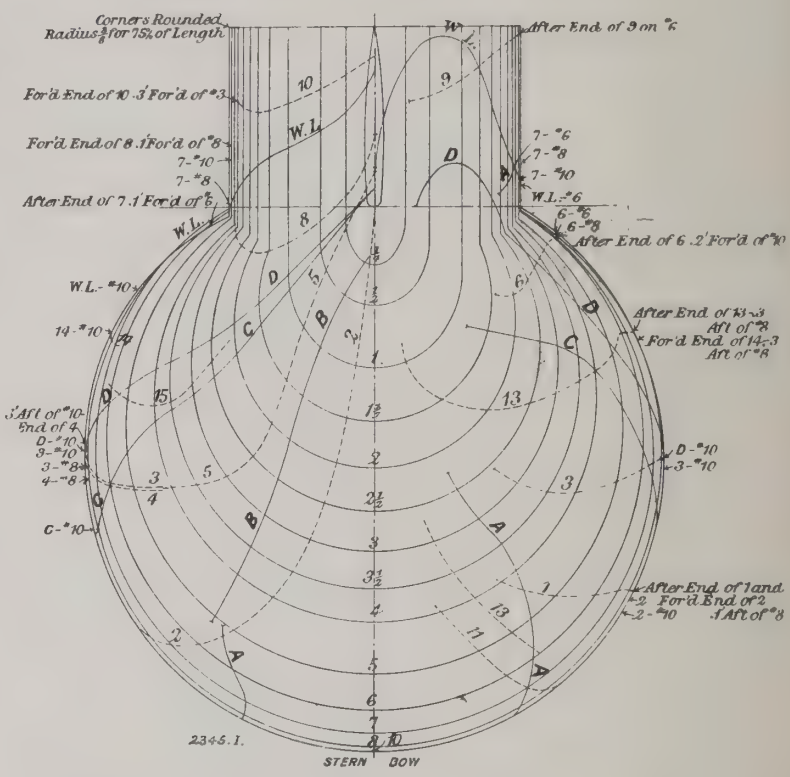
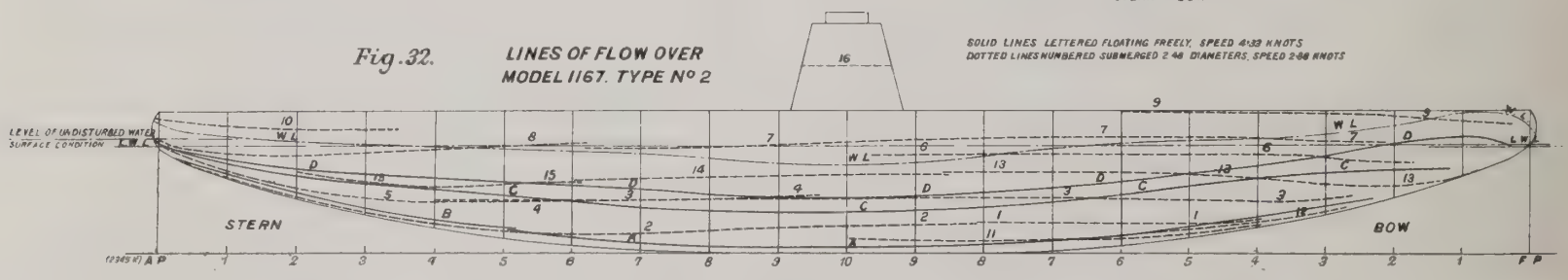

Corners Rounded Radius 1/8 for 75% of Length
After End of 9 on 7
For'd End of 10 .3 For'd of 3
For'd End of 8 .1 For'd of 8
After End of 7 .1 For'd of 6
After End of 6 .2 For'd of 10
W.L.
STERN
BOW
2345.1.

Fig. 32. *LINES OF FLOW OVER MODEL 1167. TYPE No 2*


SOLID LINES LETTERED FLOATING FREELY. SPEED 4·33 KNOTS
DOTTED LINES NUMBERED SUBMERGED 2·46 DIAMETERS. SPEED 2·66 KNOTS
LEVEL OF UNDISTURBED WATER SURFACE CONDITION
STERN
BOW
(2345 M.) AP
FP

comparisons, and in a preliminary investigation of speed possibilities.

Comparisons and Observations.—In comparing the results of the tests, let us first consider the type represented by models No. 1 and No. 2. The variation made in model No. 1 to obtain model No. 2 was quite small, consisting only of a reduction in the total displacement, submerged, of 3.2 tons, or less than 1 per cent., which reduction was made by fining the ends. This fining process was apparently not beneficial from the point of view of resistance. Inspection of the curves of effective horse-power, Figs. 14, 15, 18, and 19, on page 66, shows that for both surface and submerged running, except in the "hollows" of the curves (surface condition) which cannot be utilised, and at very low speeds, the finer model No. 2 takes more power to drive than No. 1, until very high values of $\frac{V}{\sqrt{L}}$ are reached. The wetted surfaces for the two models are practically the same. The curves of residuary resistance, on Fig. 30, show the difference in the residuary resistance of No. 1 and No. 2, for different values of $\frac{V}{\sqrt{L}}$. A possible explanation of these results is that fining No. 1 to produce No. 2 has shortened the wave-making length of No. 2, and brought about the interference of the bow and stern wave systems at lower about 1.2 the residuary resistance curves coincide, and for a value of $\frac{V}{\sqrt{L}}$ greater than 1.3 the residuary resistance of type No. 1 is less than that of type No. 1 A. For submerged running the two types take practically the same power, and the curves of residuary resistance cross and re-cross.

While type No. 2 H was derived from type No. 2, by hipping out amidships, we will briefly compare the power necessary to drive vessels of the same surface displacements of type No. 1 A and type No. 2 H, as these types have the same ratio of length to beam, and the displacement length coefficients are about the same. The wetted surface per ton of displacement for type No. 2 H is less than for type No. 1 A.

For surface running, type No. 1 A generally takes slightly less power than type No. 2 H. The residuary resistance in pounds per ton of displacement is less for type No. 1 A, at all speeds, surface or submerged, than it is for type No. 2 H. The power required, when submerged, is greater for type No. 2 H than for type No. 1 A, owing to the increase in the submerged displacement for the same surface of displacement.

We would have to go beyond the limits of this paper to give due consideration to all of the various factors which enter into the speed problem in the design of submarines, adopted in the future. Sea-going submarines of a surface speed of 20 knots, combined with a submerged speed of 10 knots, have already been proposed as an immediate future development.

We may note, from an inspection of the curves of effective horse-power for type No. 2, Figs. 18 and 19, page 66, that a vessel of this type, bare hull, with a surface displacement of 1200 tons, a submerged displacement of 1536 tons, and a length load water-line of 232 ft., would require 330 E.H.-P., or, roughly, 660 indicated horse power, to attain a submerged speed of 10 knots, and 3140 E.H.-P., or, roughly, 6280 indicated horse-power, for a surface speed of 20 knots. A vessel of the same displacement designed for these particular speeds could be made more economical.

Experimental Determination of Stream-Lines for Surface and Submerged Running, Model No. 2.—The same method of investigation was followed as has been successfully used at the model basin* in the case of the models of ordinary types of ships, other than submarines.

The surface of the model is coated with a mixture of glue and sesqui-chloride of iron, which is allowed to dry

* See "An Experimental Investigation of Stream-Lines Around Ships' Models," by Naval Constructor D. W. Taylor, U.S.N., Transactions of the Society of Naval Architects and Marine Engineers, 1908

on for about twenty-four hours before the model is put into the water and towed. While the model is under way, a strong solution of pyrogallic acid is ejected from holes bored through the model from the opposite side. It mingles with the water, and flows aft as part of it. The acid which comes in contact with the coating of chloride of iron forms ink, and leaves a black streak on the model, which marks the line of flow past the hole. This streak widens, and becomes indistinct as it passes aft, but its centre can be accurately located for a distance of 2 ft. or 3 ft. abaft the hole. The model is taken out of the water after each run, and the centre of the streak traced as far as possible, and then a new hole is made from which to eject acid on the new run.

TABLE I.

Dimensions and Elements.	Type No. 1.	Type No. 1 A.	Type No. 2.	Type No. 2 H.
Length over all .. .. ft.	145.58	131.18	145.58	145.58
Length between perpendiculars, same as length on L.W.L. .. .. .. ft.	144.00	129.60	144.00	144.00
Beam, extreme .. .. ,,	12.00	12.00	12.00	13.33
Beam, at L.W.L. .. ,,	6.00	6.00	6.00	13.29
Ratio of length on L.W.L. to extreme beam	12.00	10 80	12.00	10.80
Draught, extreme, to L.W.L. ft.	11.25	11.25	11.25	11.25
Freeboard, L.W.L. to top of superstructure .. ft.	3.75	3.75	3.75	3.75
Depth, total, keel to top of superstructure .. ft.	15	15	15	15
Ratio of length on L.W.L. to total depth	9.60	8.64	9.60	9.60
Ratio of beam on L.W.L. to draught	0.53	0.53	0.53	1.18
Displacement, immersed to L.W.L. .. .. long tons	289.6	244.3	287.1	319.0
Displacement, emerged above L.W.L. .. .. long tons	81.2	72.0	80.5	114.7
Displacement, total, submerged .. .. long tons	370.8	316.3	367.6	433.7
Emerged displacement in per cent. of total displacement, submerged .. per cent.	21.9	22.8	21.9	26.4
Emerged displacement in per cent. of total displacement, immersed to L.W.L. p.c	28.0	29.5	28.0	39.0
Displacement - length coefficients, $\left(\frac{D}{\frac{L}{100}}\right)^3$ for the two conditions :—				
Floating at L.W.L. ..	97.0	112 2	96.1	106.8
Submerged	124.2	145.3	123.1	145.2
Midship section area to L.W.L. sq. ft.	110.1	110.1	110.1	125.0
Midship section coefficient to L.W.L.	0.816	0.816	0.816	0.836
Midship section area to top of superstructure .. sq. ft.	132.5	132.5	132.5	161.5
Midship section coefficient to top of superstructure ..	0.736	0.736	0.736	0.808
Longitudinal coefficient to L.W.L.	0.64	0.60	0.63	0.62
Longitudinal coefficient to top of superstructure ..	0.68	0.64	0.67	0.65
Wetted surface to L.W.L. sq. ft.	3421.00	2996.00	3393.00	3155.00
Wetted surface total submerged .. .. sq. ft.	5271.00	4623.00	5237.00	5467.00
Wetted surface per ton of displacement, to L.W.L. sq. ft.	11.8	12.3	11.8	9.9
Wetted surface per ton of displacement submerged sq ft.	14.2	14.6	14.2	12.6
Displacement of conning tower long tons	..	5.4		
Wetted surface of ,, sq. ft.	..	205.00		

In some cases the first holes used were near the stern, so that the lines of flow at the stern could be sharply defined before the model coating in that vicinity became darkened. Some of the lines of flow were traced for only a part of the length of the model. It was necessary to re-coat the model several times during the course of the experiments, and although, during each run, two or three holes were used at a time for the ejection of acid, the process was a slow one.

In the determination of the stream-lines for surface running the model was towed at 4.33 knots, corresponding to a speed of 15 knots for the full-sized ship. The resulting stream-lines, also the wave profile, are shown by the full-lettered lines on Figs. 31 and 32, page 68. These stream-lines, for surface running, have the same general characteristics as might be expected from a study of the results of similar tests made with ships' models, already referred to.

The water from forward, starting from near the surface, flows downwards, and tends to pass, or actually passes, under the model amidships, and then flows up aft. The water which follows the line A first diverges from the centre-line, and then approaches it as it comes amidships. From amidships aft this water passes first outward and upward, and then again approaches the centre-line as it passes upward and aft. Changes in direction of the stream-lines and changes in the form of the wave profile correspond, and the direction of the stream-lines is apparently influenced to a considerable depth by the form of the waves.

In determining the stream-lines for submerged running the model was towed at 2.9 knots, corresponding to a speed of 10 knots for the full-sized ship. The top of the spindle hull was submerged to a depth of 2.4 diameters. The model was probably not deeply enough submerged to eliminate all possibility that the stream-lines would be affected by surface disturbances. The resulting stream-lines are shown by the dotted, numbered lines on Figs. 31 and 32. The marked difference between the general direction of the stream-lines in the surface and submerged conditions is notable.

In the submerged condition, water starting from forward near the top of the model takes first an upward course, and then a nearly horizontal one as it flows towards amidships. Forward water, further below the top of the model, starts to flow downward, and then changes its course to a horizontal one long before the middle of the model is reached. Well aft the nearly horizontal stream-lines turn sharply upward as they approach the centre line. While a knowledge of the direction of flow of the water in contact with the hull is useful in fixing on the location of various hull appendages, such as keels, struts, rudders, torpedo-tube projections, &c., it is evidently much more difficult to locate appendages in a way not to seriously interfere with the direction of this flow, in the case of submarines, where the stream-lines have a double direction of flow, than it is with ordinary ships. The possible effect of the direction of the stream-line flow, submerged, on the stability of motion, submerged, of submarines of various forms and dispositions of submerging rudders, and different appendages, brings up many interesting questions.

FIFTY YEARS' DEVELOPMENTS IN MERCANTILE SHIP CONSTRUCTION.*

By S. J. P. THEARLE, D.Sc., Chief Ship Surveyor to Lloyd's Register, Member of Council.

FIFTY years ago, when the Institution of Naval Architects came into existence, some of the ships of the mercantile marine were being built of iron and some of wood, while a smaller proportion of new vessels were of composite construction. Iron as a material for ships had distinctly established itself, and yet wood as a material had not wholly given place to it. There were still many builders, and indeed many owners, who maintained a preference for the older material, while the wishes of those who desired to combine the structural advantages arising from the use of iron with the freedom from fouling due to a copper-sheathed bottom when on a long voyage under sail, were satisfied by the composite system. The s.s. Himalaya, built at the Thames Iron Works in 1853, and acquired by the Admiralty for transport service during the Crimean War and for many years afterwards, is an instance of an excellent iron vessel built prior to the Institution's birth. An examination of this old vessel, still doing duty as a coal-hulk at Devonport, will show that even so far back as 58 years ago, our foremost iron shipbuilders could design and build a good ship, notwithstanding the limitations due to the comparatively primitive state of the rolled-iron industry of that date. The dimensions of the Himalaya were 340 ft. by 46 ft. by 21 ft. 4 in., which were those of a very large vessel at that time, her displacement being 4690 tons.

But, large as was the Himalaya compared with the average mercantile vessel of 1853 (for she was originally built for the P. and O. Company), she was dwarfed into comparative insignificance by the Great Eastern, built at Millwall by Mr. Scott Russell in 1857. As will be remembered, the dimensions of this vessel were as follow: — 679 ft. 6 in. by 82 ft. 8 in. by 31 ft. 6 in., and when they are compared with those of the largest mercantile steamers existing in 1893, viz., the s.s. Campania and Lucania, which were then built for the Cunard Company, it will be admitted that the Great Eastern of 18,915 tons register was as one born out of due time. Had there been no Great Eastern to take into previous account, a consideration of the progress of mercantile shipbuilding in the fifty years of the Institution's existence would have shown a gradual development throughout. But, with such a vessel already in existence, the earlier years would seem rather to have been a period of decadence, were it not for the fact that, great as was Scott Russell's vessel as a specimen of shipbuilding, she was not a success as a commercial venture, nor was she adapted to profit-making; which is, after all, the only safe criterion by which to judge the merits of a mercantile vessel. The Great Eastern showed possibilities in iron ship construction, having regard to the materials available at the time for the purpose, and she further showed what should be avoided. It is only fitting that an Institution which owes its existence largely to the energy, foresight, and scientific ardour of Scott Russell, should now, in the fifty-first year of its age, bear public testimony to the genius of that great man, and if we cannot set down the name of the Great Eastern in the list of commercially successful vessels, yet we are able to recognise in that noble specimen of naval architecture a piece of work which, having regard to the time and circumstances of its production, is still without rival.

In the year 1860 the mercantile marine of the United Kingdom consisted of 27,663 vessels, of 4,658,687 tons net register, of which by far the greater part was of wood. The exact separate tonnages of wood, iron, and composite vessels of that date are, however, not now available. Of the total tonnage in 1860, 25,663 vessels, of 4,204,360 tons net, were propelled by means of sails, and 2000 vessels, of 454,327 tons net, were steamers.

At the end of December, 1909, the merchant shipping of the United Kingdom consisted of 21,189 vessels, of 11,585,878 tons net, or 18,402,201 tons gross register. Of these, 11,797 vessels, measuring 10,284,818 tons net, or 16,994,732 tons gross, were steamers, and there were 9392 sailing vessels, of 1,301,060 tons net, or 1,407,469 tons gross register.

From these figures it will be seen that there were 6474 more vessels in our mercantile marine in 1860 than there were in 1909, but the net tonnage in the latter year was 11,585,878 as compared with 4,658,687 tons in the former year, showing an increase in the 49 years of 6,927,191 tons net register.

* Paper read at the Jubilee Meeting of the Institution of Naval Architects, July 6, 1911.

But this does not adequately indicate the growth of the mercantile marine in that time. To realise better the expansion which had taken place, it should be noted that the growth in steamer tonnage was from 454,327 tons to 10,284,818 tons, while the reduction of sailing tonnage was from 4,204,360 tons to 1,391,060 tons.

It is usual to compute that a ton of steamer tonnage is at least equal to 3 tons of sailing tonnage as far as regards cargo-carrying capability in any stated time, say, for instance, one year; this is due to the greater speed with which the steamer performs her voyage, and the greater despatch she gets at her port of loading or discharge. In point of fact, the ratio is even greater than 3 to 1, and is a continually increasing one. But taking it at 3 to 1, it would appear that the ratio of cargo-carrying capability of the British mercantile marine in 1909, compared with that of 1860, is as 32,155,514 to 5,567,341, or nearly as 6 to 1. Considering that a ton of steamer capacity is so much more now than it was in 1860, the actual ratio is even still greater than this.

Not only has the total tonnage grown enormously in the fifty years, but the average size of ship has also grown at perhaps an even greater rate. The average tonnage of the sailing vessels of the Mercantile Marine of 1860 was 164 tons, and that of the steamers was 227 tons. A vessel of 1000 tons was then considered a large one, the Great Eastern notwithstanding.

As was stated in a paper contributed by the writer to this Institution in 1907, the average tonnages of the cargo steamers afloat in 1870, 1880, 1890, and 1900 were respectively about 870 tons, 1330 tons, 1500 tons, and 1900 tons. In the year 1911 the average tonnage is about 2,300 tons. In the same paper the average gross tonnages of the cargo steamers built in the years 1870, 1880, 1890, and 1900 were stated to be respectively 1050 tons, 1580 tons, 2150 tons, and 3000 tons. The average gross tonnage of the cargo steamers built in 1910 was rather more than 3000 tons.

In 1860 the length of an average cargo steamer, as then being built, was under 200 ft., but by 1911 it had reached to from 350 ft. to 400 ft.

The form of midship section which prevailed in 1860 is shown by Figs. 1, 2, and 3, page 70, which represent respectively iron and composite sailing vessels and a cargo steamer. Fig. 4 shows a steel passenger steamer of the year 1883, and by referring thereto it will be seen that, although the section was fuller than in 1860, it still had a fair rise of floor, and a well-rounded bilge. The midship sections shown by Figs. 5 and 6 indicate the extreme flatness of floor and the squareness at bilge which is now a common feature in ocean steamers.

Rules had been prepared and published by Lloyd's Register for the building and classification of iron ships about 1855, and as might have been expected, produced as they were at a time when wood construction largely predominated, the classification of iron vessels under these rules was expressed in terms of years. Indeed, it was not until 1863 that the term of years criterion of a vessel's insurable qualities was discontinued, and its place taken by the letter designations $\frac{A}{A}$ $\frac{A}{B}$ and $\frac{A}{C}$, which expressed in a comparative manner the relation borne to a ship of the first class. In the year 1867 this mode of designation and comparison was superseded by the numerical one 100 A, 95 A, 90 A, 85 A, and 80 A; and up to the present time 100 A represents the highest classification of an iron or a steel vessel in Lloyd's Register.

By the year 1860 iron mercantile ship construction had assumed a definite character, and as regards sailing ships and the great bulk of steamship tonnage, there was not much evolutionary change visible for nearly twenty years after, except as regards the question of size and the proportion borne by iron vessels to the total number built, which was all the time an increasing one.

The frame of an iron ship was still, as it had been from the first, formed of an angle iron and a reversed angle riveted back to back, from the upper turn of the bilge to the gunwale, and riveted respectively to the lower and upper edges of a floor-plate below the upper turn of bilge. Beams were formed at first of plates with double half-round irons on the lower edge and double angles on the upper edge, and this was the kind of beam fitted in the Himalaya. When progress in rolled iron manufacture had reached a more advanced stage, a bulb-plate took the place of the double bars of half-round section, and later on the Butterly Company produced a rolled section equivalent to the bulb-plate and the double angles. Keelsons were of many different forms, ranging from the "box" keelson, which was inaccessible, and consequently could not be kept painted and clean, to the ⊤ shaped keelson formed of a plate with double ⊥ angles on upper and lower edges which still survives in the exceptional cases where the vessel has not a cellular double bottom. There were from an early date continuous centre-line keelsons having floors united to them, and intercostal centre-line keelsons associated with continuous floors. There were centre-through-plate keelsons associated with bar keels and continuous vertical keelson-plates associated with flat-plate keels. Indeed, the possible varieties of centre keelson have not been much, if at all, amplified since the early sixties of last century, as illustrated in Lloyd's Rules of that period. Similarly as regards side keelsons, also bilge and side stringers, there was not much difference in practice for many years. The midship section shown by Fig. 1 is in most respects typical of the iron sailing vessel of 1860, but the ordinary keelson arrangement of that time is better shown by Fig. 2, which represents a composite sailing vessel of about the year 1867, while Fig. 3 is representative of the comparatively few mercantile steamers being built in the early sixties, and more

FIFTY YEARS' DEVELOPMENTS IN MERCANTILE SHIP CONSTRUCTION.

(*For Description, see Page 69.*)

Fig. 1.
MIDSHIP SECTION OF AN IRON SAILING VESSEL OF ABOUT 1860

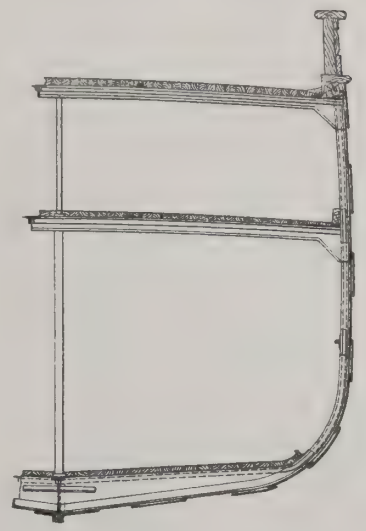


Fig. 3.
MIDSHIP SECTION OF AN IRON SCREW STEAMER OF ABOUT 1860

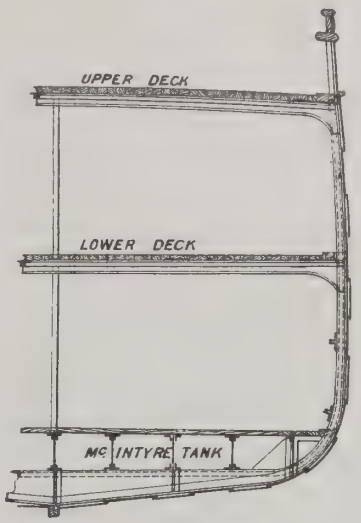


Fig. 4. MIDSHIP SECTION OF A PASSENGER AND CARGO STEAMER OF ABOUT 1883

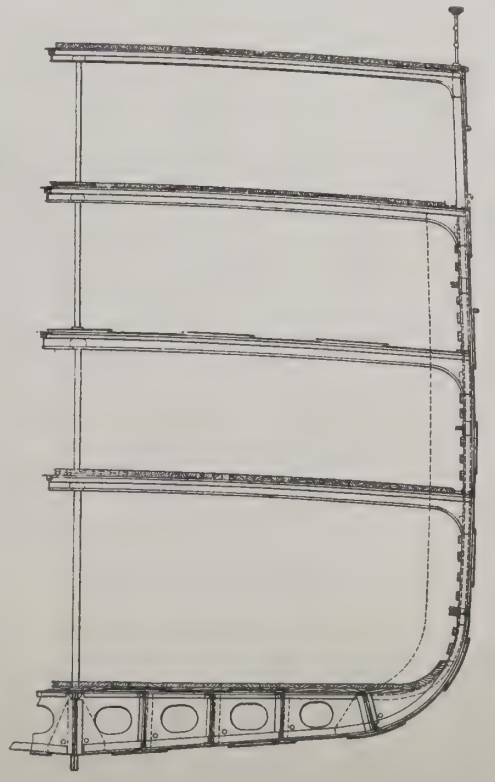


Fig. 2.
MIDSHIP SECTION OF A COMPOSITE SAILING VESSEL ABOUT 1867

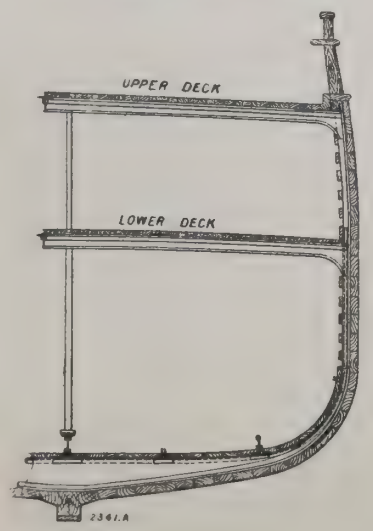


Fig. 5 MIDSHIP SECTION OF A MODERN CARGO STEAMER HAVING WIDELY SPACED PILLARS AND FITTED WITH STRONG LONGITUDINAL GIRDERS AT THEIR HEADS 1909

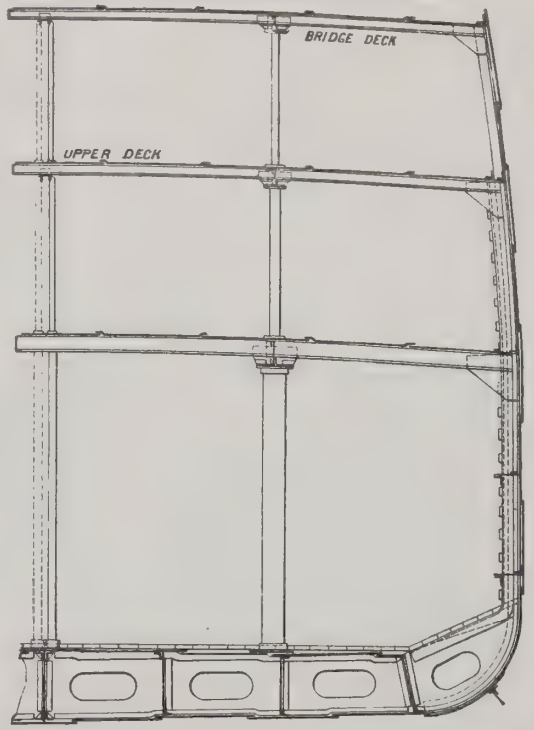


Fig. 6. MIDSHIP SECTION OF A TURRET DECK STEAMER 1905

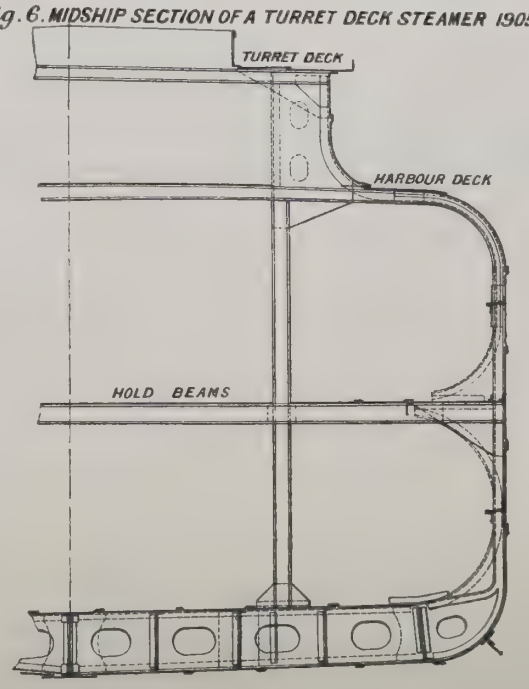


Fig. 7.
MIDSHIP SECTION OF A TRUNK DECK STEAMER 1907

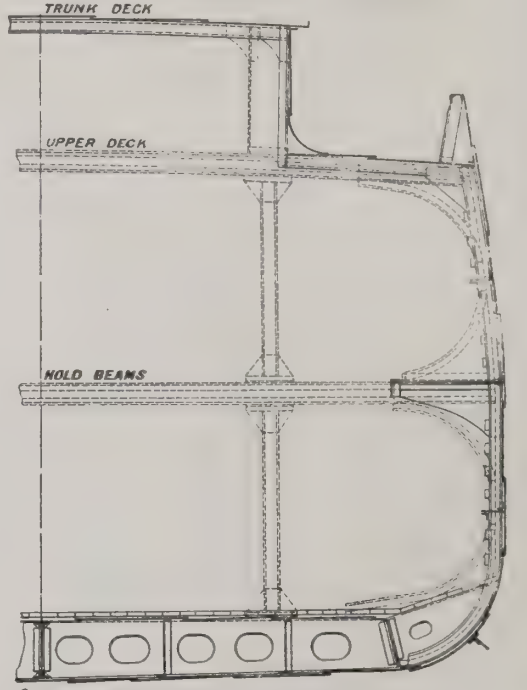
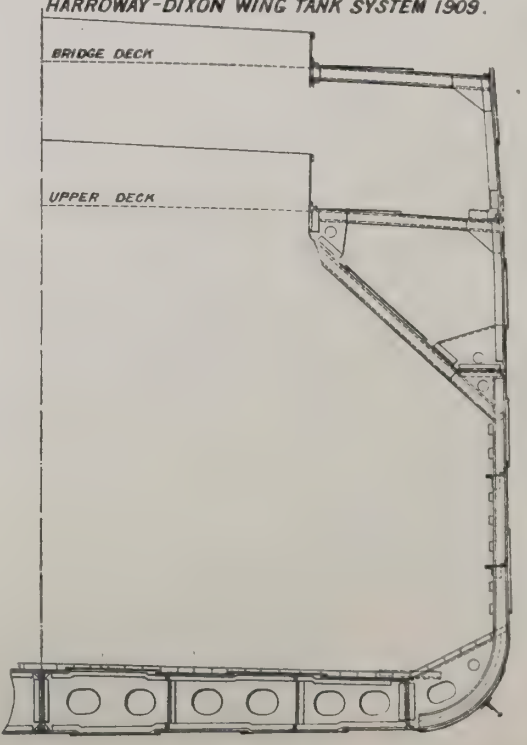


Fig. 8. MIDSHIP SECTION OF STEAMER BUILT ON THE HARROWAY-DIXON WING TANK SYSTEM 1909.



especially those intended for the coast trade between Newcastle and London.

It was at about that time that water-ballast tanks began to form a part of the bottom structure of steam colliers, and Fig. 3, page 70, shows a midship section of one of these vessels fitted with the McIntyre double bottom The story of the John Bowes, and the other early steam colliers, has often been told, and the McIntyre tank was long ago described in the Transactions of this Institution. This is not the occasion to repeat what has already been so well said on the subject, but it is necessary to at least make a passing allusion to it in such a paper as the present. Moreover, it should be recorded that, inasmuch as the cellular double bottom is to a large extent an evolutionary development of the McIntyre tank, so the early steam colliers were to that extent the progenitors of the typical mercantile steamer of to-day. It was not, however, until about the year 1880 that the cellular double bottom in anything like its present form appeared in

Fig. 9. MIDSHIP SECTION OF A STEAMER WITH Mc GLASHAN SIDE TANKS 1901.

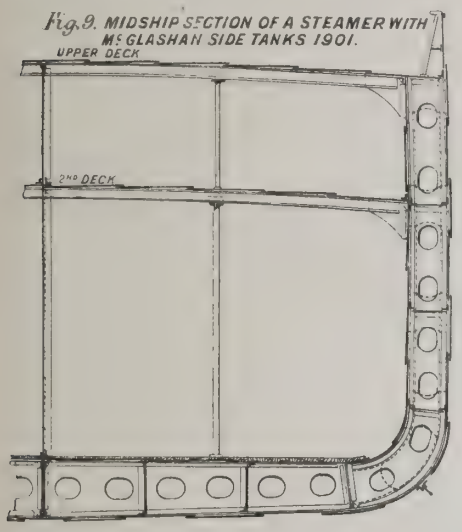


Fig. 10. MIDSHIP SECTION OF STEAMER BUILT ON THE "ISHERWOOD" SYSTEM 1909.

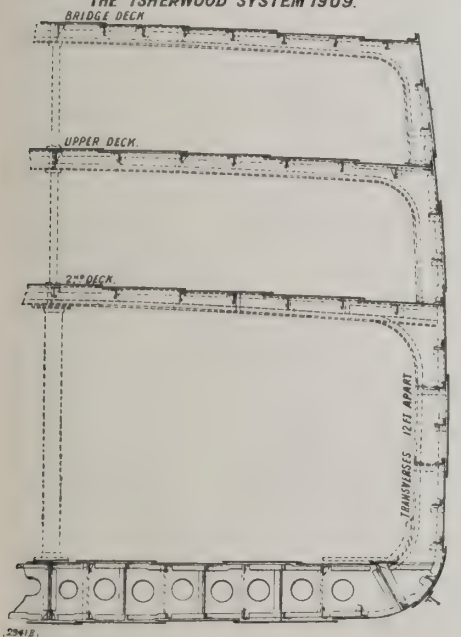


Fig. 11. MIDSHIP SECTION OF A MODERN ATLANTIC LINER 1907
762'0" × 88'0" × 57'1"

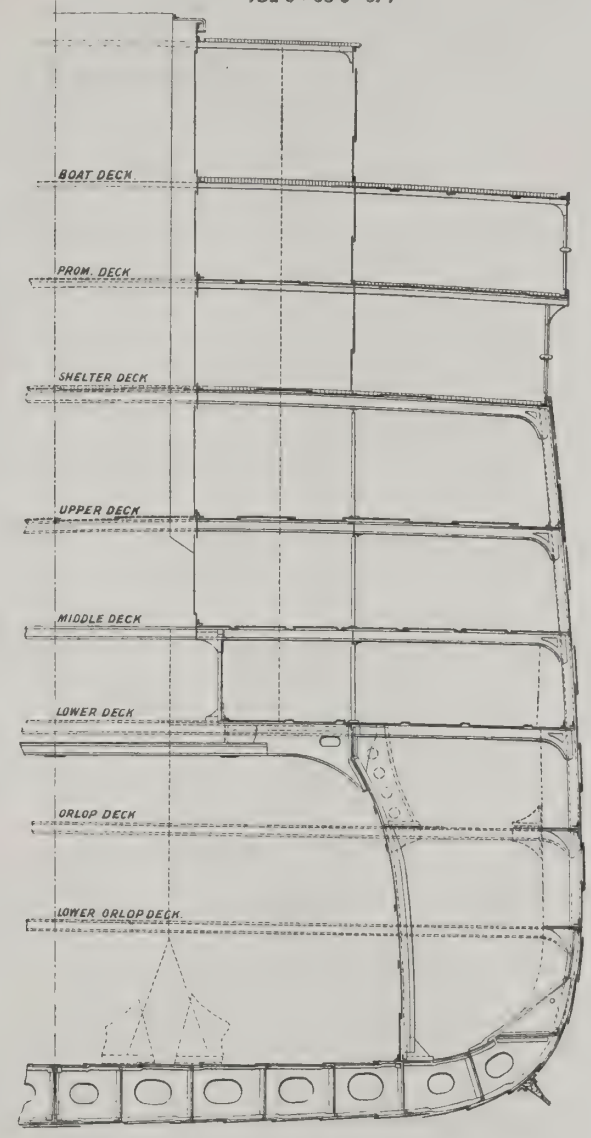


Fig. 12.
MIDSHIP SECTION OF AN ATLANTIC LINER 1893.
601'0" × 65'2" × 37'8"

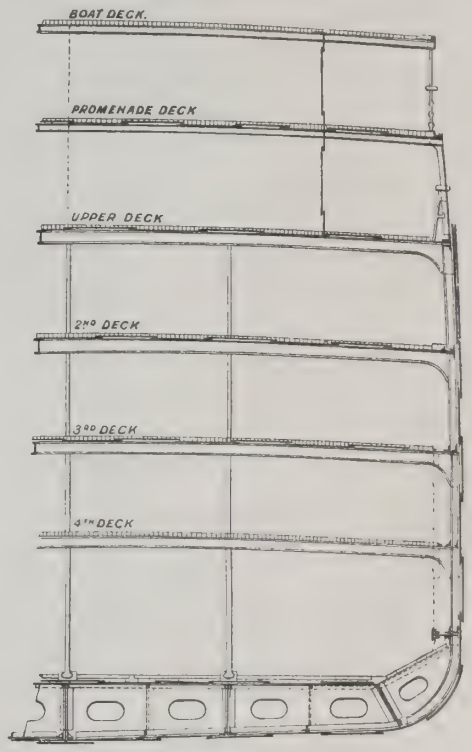
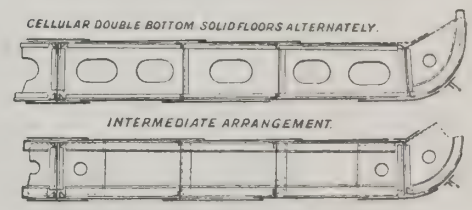


Fig. 13. RECENTLY ADOPTED CELLULAR DOUBLE BOTTOM ARRANGEMENTS 1909.



ships of the mercantile marine, although an arrangement somewhat like it had been adopted some years earlier in the armoured ships of the Royal Navy, but without the characteristic feature of the margin-plate at each bilge with its frame attachments, which then, and now (with but little modification), is peculiar to the mercantile steamer. Fig. 4, page 70, shows the midship section of a steel passenger steamer of 1883, and, as will be seen, it has a double bottom fitted with floors at alternate frames.

By the year 1887 cellular double bottoms were becoming very general in both cargo and passenger steamers, and yet as late as 1889 the two largest and fastest vessels in the Atlantic passenger trade were constructed without double bottoms and with ordinary floors and shaped keelsons standing upon them. A few years later, and only vessels built for carrying petroleum in bulk, and some of the smallest cargo steamers in the coasting trade, were being built in that way. Such is still the case to-day.

The modes of combining the materials in cellular double bottoms have, however, changed very much since the latter were first introduced into the mercantile marine. For some years it was sought to subordinate transverse to longitudinal strength in the bottom framing by making the side longitudinal girders continuous, and by fitting the floors intercostally between the girders. This was doubtless largely, if not wholly, due to the prevalence of a similar practice as regards the longitudinal frames of both the bottoms and sides of war vessels. Sometimes one longitudinal girder on each side was continuous and the others intercostal, thereby limiting the number of pieces composing a floor to two on each side of the middle line. In cases where the floors on each side were fitted in one piece they were spaced at alternate frames only, and these were associated with a greater number of longitudinal girders fitted intercostally in lengths of two frame spaces; brackets being associated with the intermediate frame and reverse angles. Such an arrangement is not unusual in vessels still being built, and it is shown by Fig. 4.

Gradually it began to be realised that with both outer and inner bottom plating, associated with a continuous centre girder, continuous margin-plates, and well-fitted intercostal side girders, there was ample longitudinal strength in the bottom. Moreover, the fact that continuous floors associated with intercostal side girders was found to be an arrangement admitting of more rapid and cheaper construction than any of the others, served at length to make it the most commonly adopted, and such is the case to-day. The midship section shown by Fig. 5 has a cellular double bottom framed in this way.

During the past year or two the question of double-bottom construction has received much attention from shipbuilders. It has been suggested that the strength of a cellular double bottom is in most cases in excess of the requirements arising from stresses at sea, and even from ordinary dry-docking. The necessity for carrying a certain quantity of water ballast has, it cannot be doubted, had more to do with fixing the depth of the floors and girders than strength requirements, and so it has happened that various arrangements have been devised for diminishing the weight of material in the double bottom without reducing its water-ballast capacity. Time will show whether any or all these arrangements will prove sufficient in the different circumstances which may arise, but it is believed that some of them, more especially that shown in Fig. 13, will be found to give satisfactory results. For the most part these designs consist in associating the ordinary floor arrangements spaced at two or three intervals apart, with intermediate combinations of strong bulb-angle frames and reversed frames having plate-brackets at their extremities. Longitudinal girders are fitted on each side of the middle line in number determined by the spacing of the floors and the breadth of the vessel.

Particular reference is made to this growth of double-bottom construction within the past fifty years, because the bottom has probably undergone at least as great a change as any other part of the vessel, and especially has this been the case during recent years

In recording recent developments in the structure of mercantile vessels, mention ought to be made of the rapidly-growing tendency during recent years to omit angle side-stringers in holds and to compensate for their omission by increasing the thickness of shell-plating. Not only does this detract in no degree from the strength of the structure, but it has the advantage of cheapening production and of affording greater facilities for cleaning the inside of the vessel after discharging a cargo. It should also be recorded that there is a growing disposition to increase the frame spacing of vessels under proper conditions of size of frames and thickness of shell-plating. The joggling of either plate-edges or frames in order to avoid fitting packing between the frames and shell-plating is now becoming a common practice at all our ports, and the same principle is applied also to steel decks and to inner bottom plating.

In considering the question of deck beams, one has at the same time to deal with that of pillaring, for the two are largely interdependent. In 1860 the pillaring of an iron ship followed the same principle as had up to then been the practice in vessels of wood. A pillar was placed under the middle of the length of every beam throughout the greater part of an iron vessel's length (see Figs. 1 and 2), and under alternate beams at the extremities of the vessel, where the beams were much shorter than at amidships. Pillars were also placed at the sides of hatchways in number proportionate to the length of the hatchway. Vessels were not so broad at that time as to require more than the middle line row to the beams clear of the hatchways. Subsequently, as vessels became broader, a row of quarter pillars was introduced on each side of the vessel, these being generally placed under alternate beams.

The time had not then arrived for shipowners to order ships to be designed without any hold obstructions such as pillars occasion.

The first step in a progressive direction was made when tubular pillars were introduced. These are, however, so expensive that even to-day the smaller sizes are but rarely used. Then came the "massed pillaring" arrangement, in which support to the deck is afforded by a few

very strong pillars placed under longitudinal girders which, in association with additionally strong hatch-end beams, distribute the localised support over the entire deck (see Fig. 5). This arrangement admits of many modifications and adaptations. The fewer the pillars the larger they must be, and the stronger must be the distributing girders; while the more numerous the pillars the smaller they may be, and strong girders are less necessary. The extreme case is that in which the only pillars are the bulkheads, and in which certain of the beams are made very strong, of arched form, and so associated with longitudinal girders and brackets at the bulkheads as to throw the entire weight of the deck on the bulkheads and the sides of the vessel. Great changes have been made during recent years in regard to this matter of beams and pillaring. Beams are now for the most part fitted at every frame. They are usually of bulb-angle or channel section when iron or steel decks are laid, and are connected to the sides of the vessel by bracket-knees. Beams of "Butterfly" section or built with bulb-plates and double-angle mountings, such as were formerly so common, are now not often used, and only when beams are fitted to alternate frames. Similarly "turned" and "slabbed" beam-knees are become practically things of the past. The contrast between the beam formed with a plate, double-angle mountings and double - cope - irons on the lower edge, as was fitted in the Hima- laya, and the rolled-beam sections as used to- day is very great, and so is that between the round-bar iron pillars and the built pillar, as shown in Figs. 1 and 5 respectively.

The stiffening of water-tight bulkheads has undergone many changes during these fifty years. In 1860 the only stiffening to water-tight bulkheads, other than that afforded by the several decks, consisted of angle-bars of reverse-frame size spaced about 30 in. apart. It must, of course, be borne in mind that there were usually more decks in a steamer of the small tonnages then being built than would be the case to-day. Nevertheless the bulk- head stiffening was usually very inadequate for resisting the pressure due to a hold being filled with water.

The influence of the Bulkhead Committee of 1891 is to be seen in the practice of to-day. But before the Bulk- head Committee sat, the Committee of Lloyd's Register had increased the stiffening requirements by making the vertical stiffeners of frame - angle size and by fitting horizontal stiffeners 4 ft. apart in addition. To this was subsequently added deep vertical webs at the middle line and on each side, in number determined by the breadth of the vessel, and this was supplemented by semi-box beam-stiffeners, where decks were not laid on the beams, and by fitting brackets to the heels of the vertical stiffeners and to the extremities of the horizontal stiffeners.

The general practice to-day is to use vertical stiffening only, and this is frequently formed by flanging the edges of the bulkhead plates, which for this purpose are arranged vertically. The stiffening of the bulkhead in the way of each 'tween deck and in the holds is governed by both the depth from the top of the bulkhead and by the height of the 'tween decks, or depth of hold, as the case may be. The stiffening of a transverse water-tight bulkhead, as now built in a mercantile steamer, is a reasonable one and in marked contrast with that of fifty years ago.

For some years after iron ships were first built they were fitted with wood decks, which covered only stringers and tie-plates—for iron decks were then unknown. With increase in size grew the necessity for providing strength in excess of that which was obtainable through stringers and tie-plates. At length iron decks were found to be a necessity, but, at first, they were covered with a wood deck flat. Ultimately the wood sheathing was discarded, except in passenger vessels and those intended for certain special trades; and to-day it is more usual to find un- sheathed steel decks than any other arrangement in cargo steamers. Of late years various preparations, of which the material known as "Lito silo" may be taken as a sample, have been extensively used to protect iron and steel decks from corrosion, and at the same time to afford the other advantages associated with a wood sheathing. Recent years have witnessed many impor- tant departures in steel ship construction. The first of these to claim attention is the turret steamer, shown in section by Fig. 6, page 70. These vessels were intro- duced by Messrs. Doxford and Co., of Sunderland, who have built a great many of them for many different owners, although of late the demand for them seems to have fallen off. Among the advantages of the turret system is that of a larger dead-weight carrying capacity than that of the normal type of steamer upon the same registered tonnage. It is also said of them that they are very sea- kindly in their behaviour. The "trunk" steamers shown by Fig. 7, page 70, were introduced by Messrs. Ropner, of Stockton-on-Tees, and are chiefly used for the convey- ance of ore, grain, and other bulk cargoes. Descriptions of vessels so distinct in character, and differing so much from the normal type, as are the "turret" and "trunk" steamers, would, it is thought, best proceed from those to whose design they are due, and it is much to be desired that Messrs. Doxford and Messrs. Ropner would favour this Institution in such a manner. The cantilever frame wing-tank steamer of Messrs. Sir Raylton Dixon and Co., shown in midship section by Fig. 8, has been described by Mr. Waynman Dixon before the Institution of Civil Engineers, but it is regretted that the Institu- tion of Naval Architects contains no record in its Trans- actions of a type of vessel which is not only structurally interesting, but which has the advantage of affording means for suitable immersion in a ballasted condition without an attendant excess of stability. The same may be said of McGlashan's side - tank steamer shown by Fig. 9, page 71.

Probably the most interesting of all the recent develop- ments in ship design is that of Mr. Isherwood, which is described in the Transactions of 1908,* and shown by Fig. 10. Upwards of ninety of these vessels, repre- senting about 356,000 tons gross, have been ordered by different companies, and forty of them have been built and are at sea. The experience so far obtained regarding their structural efficiency has been generally satisfactory. Such a distinct departure from previous shipbuilding practice must, of course, for some little time to come, partake of an experimental character, and one must be prepared to learn by "trial and error" regarding this as of all other modes of ship construction.

To do full justice to the subject of this paper, some further reference should be made to the composite system of construction, which between the years 1860 and 1870 seemed likely to wholly take the place of iron con- struction for sailing vessels. It was, indeed, favoured by some for steamships also. Fig. 2, page 70, shows the midship section of a composite sailing vessel, such as was being built in 1867. The system combined the strength of iron framework partially plated, with the advantages of a wooden skin to receive copper sheathing, and thereby avoid the fouling of bottom which was experienced in iron vessels. The sailing speed of iron vessels was con- siderably reduced, more especially on the homeward voyage, by reason of this tendency of an iron bottom to become rapidly foul in sea-water. The idea of a compo- site system of construction was probably due to the high freights obtained for prompt delivery of the early tea crop. The performances of the composite tea clippers will long be remembered, and even their names will not be forgotten. Very soon composite vessels were built for the Australian and East India trades also, and about the year 1867 there was a very considerable tonnage of composite sailing vessels being built in the United Kingdom in vessels of about 800 to 1,000 tons register. The system was, however, an expensive one to build, and it was soon found that the vessels were liable to special forms of deterioration, chiefly associated with galvanic action, which made their maintenance costly. The open- ing of the Suez Canal gave a new impetus to steam navigation, and within a few years afterwards composite vessels almost wholly ceased to be built for the mercantile marine.

The proportion of the sailing carrying trade performed by wooden vessels continued to be considerable for nearly twenty years after this Institution came into being. The writer of this paper found abundant occupation in the survey of wooden mercantile vessels, even up to 1200 tons register, between the years 1876 and 1880, and it may be said with perfect truth that never were wood vessels built so strongly nor so durably as when the time came for the building of them to practically cease altogether.

So far as we have gone, attention has been given only to the changes which have occurred in the material and the details of the construction of mercantile vessels in the course of fifty years. This does not by any means cover all the ground. On the contrary, it is doubtful whether the changes which have occurred in the outline design of steamers have not been at least as considerable as those relating to the details of construction.

In a former paper, already alluded to, the evolution of the cargo steamer was considered, and consequently it does not appear to be desirable to again go over the ground then traversed. Reference is invited to the paper referred to so far as regards the progress made in the design of tramp steamers in the course of fifty years and of the various stages through which those changes occurred. It is, however, necessary to give some atten- tion to the enormous strides made in the design and con- struction of passenger steamers, and more especially those engaged in the North Atlantic trade.

Neglecting the case of the Great Eastern as of one born out of due time, we see a growth of from 340 ft. to 850 ft. in length during that time, and in tonnage from 2960 tons to about 32,000 tons. In 1860 the fastest steamers in the passenger trade had no greater speed than 12½ knots; whereas to-day there are two vessels which are capable of averaging nearly 26 knots on a voyage from New York to Queenstown. (Fig. 11, page 71). The number of passengers carried in one of our largest steamers in 1860 did not exceed about 250, whereas to-day no less a number than 2600 can be con- veyed in one vessel between Liverpool and New York. To show the advances made in only fourteen years —viz., from 1893 to 1907—Figs. 11 and 12 may be advantageously compared. Fifty years ago passengers were for the most part berthed on one or more decks below an upper deck, whereas to-day a large part of the passenger accommodation is provided in roomy, well- lighted, and airy cabins situated above the upper deck. A comparison of the luxury attending steamer travel to-day with the conditions which prevailed in 1860 would demonstrate more clearly than in any other way to the "man in the steeet" the enormous strides in passenger steamship design which have been made in the interval. And to it all there have been added greater strength of structure, greater security against the ordinary perils of the seas, and greater regularity of performance.

Much of this development has been due to the substitu- tion of mild steel for iron, and even to the use of high tenacity steel for those parts of the structure subjected to the principal tensile stresses. How much of it is due to the improvements made in the marine steam-engine, and more particularly to the application of the steam- turbine to marine propulsion, I leave my engineering friends to say. Every advance in steel manufacture and in the rolling of plates and sectional material has been conducive to more efficient structural combination, and therefrom to stronger and better ships. The naval architect has received help from many sources, to all of which he bows in grateful recognition. The ocean pas- senger finds himself conveyed in faster and safer vessels than were conceivable when this Institution came into existence, and under conditions of comfort, and even luxury, which are unsurpassed in the best hotels. Such are some of the principal features which serve to indicate the progress of the past fifty years in mercantile ship construction. But finality has not yet been reached, nor is it likely to be in the near future, even if at any time. While these remarks are being put upon paper, the writer is daily, in the course of his official duties, being confronted with something new, which, if not always worthy of being described as progressive, is yet indicative of the restlessness of the age, and of the continual search which is being made for that which shall render existing tonnage obsolete. It is only in that way that progress is made, and while it undoubtedly happens that every step made is not a step forward, yet it must be remembered that without movement progress is impossible, and that he who never makes mistakes possibly never makes anything.

* Transactions of the Institution of Naval Architects, vol. l., page 115. ENGINEERING, vol. lxxxv., page 830.

THE COPPER MARKET.—In their report, dated July 3, Messrs. James Lewis and Son state that there has been a good demand for copper during the past month, both American and European consumers buying freely, in- fluenced by the improvement in the statistical position, increasing consumption in the United States, and the greatly increased consumption of and export from Europe. Standard copper advanced from 55*l.* 2s. 6d. for cash, on the 1st ult., to 57*l.* 10s. on the 26th, when 58*l.* 2s. 6d. was paid for three months prompt, and the price subsequently receded to 56*l.* 12s. 6d. on the 29th, but recovered next day to 57*l.* On the 3rd inst. the closing values were 56*l.* 12s. 6d. cash, and 57*l.* 3s. 9d. three months, on disturbing political news. The month's sales amounted to 24,000 tons. American electrolytic sells at 12⅜ cents per lb., large quantities having been sold for export to Europe. Shipments from the United States during the past month amounted to 30,074 tons. The imports were 11,234 tons, and deliveries 15,319 tons greater than during the same period of last year.

COMPETITIVE DESIGNS FOR PLAN OF NEW CAPITAL CITY OF AUSTRALIA.—We have been privileged to see the maps, plans, conditions, and other information on this subject, which have just been received from Mel- bourne. The competition is, we believe, the most impor- tant one of the kind hitherto presented to architects, engineers, and town-planners, intensified as it is by the fact that it is for the only capital city, with the excep- tion of Washington, planned from the outset on virgin ground. The maps include particulars resulting from a close survey of the site, and are on a scale of 400 ft. to 1 in., with contour levels 5 ft. apart vertically. These contour lines, of course, stand first in importance, and form the chief guide to the design. Besides this there are geological maps and a report, meterological and other information, as well as two landscape drawings printed in colour. We understand that the Commonwealth Government look forward to getting the best possible design from among those architects, &c., who propose to compete, especially as town-planning has recently been a very live subject, more particularly in this country.

SIR ROBERT HADFIELD AT SHEFFIELD.—Sheffield, both from a practical and an academic standpoint, owes much to Sir Robert Hadfield, F.R.S., who has recently returned to this country after an absence necessitated by too com- plete a devotion to the gospel of the strenuous life. His enforced divorce from business has been utilised by him in making a journey round the world, and the observa- tions made on this have served as the text of two speeches recently delivered by him at public gatherings in Sheffield. At the first of these, held at the university, he expressed his acknowledgments for the honorary degree of Doctor of Metallurgy conferred on him by that corporation, an honour which he must appreciate the more in view of the great importance of the Sheffield Metallurgical School. From his speech Sir Robert had evidently returned more and more convinced of the prime importance of quality in manufactured goods, and this, we believe, is particu- larly true in the case of the export trade to new countries. An interesting point raised by Sir Robert was that he thought he had found evidence in the course of his travels that the production of steel by the fusion process was practised in the East 2000 years ago, and he is now having analysed and examined some tools from Ceylon dating back 1500 to 2000 years. He further noted that, on crossing the Pacific to the United States, his steamer took with it the first load of Chinese pig iron to be ex- ported. China, he stated, had the largest iron ore resources yet discovered, so that this initial shipment may mark the inauguration of a new era. The second speech to which we have referred was delivered to a party gathering, and this dealt, to some extent, with matters as to which opinions will always differ, since, in politics, the data from which conclusions are drawn are necessarily incomplete, and every man, in drawing his deductions, unconsciously includes what, to use a mathematical ex- pression, may be called certain "concealed co-ordinates," and, further, the average politician, unlike the scientist, is much more concerned in what may be said than in what should be said. One interesting statement in this speech was that the natural productions of America have now an annual value of 2000 millions sterling, a circum- stance which, as Sir Robert pointed out, greatly reduces the danger of experiments affecting the body politic, since the results of even a disastrous failure would be cancelled by the harvesting of a single good crop.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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NOTICE OF MEETING.

THE INSTITUTION OF MECHANICAL ENGINEERS.—On Monday, July 24, the Summer Meeting will commence with alternative excursions from Basel to Zurich, visiting on the way (*a*) Rheinfelden and Laufenburg, (*b*) Baden, including the works of Messrs. Brown, Boveri, and Co., (*c*) Rheinfelden, or (*d*) Wangen-on-the-Aare and Baden, including the works of Messrs. Brown, Boveri, and Co. On Tuesday, July 25, at 10 a.m., the President, Colonel P. E. Huber, or the Vice-President, Mr. E. Sulzer-Ziegler, of the Verein Schweizerischer Maschinen Industrieller, will welcome the President, Council, and Members of the Institution in the Aula of the Swiss Polytechnikum, after which papers will be read and discussed. The following papers have been offered for reading and discussion:—"Electric Traction in Switzerland," by Mr. E. Huber-Stockar; "Results of Experiments with Francis Turbines and Tangential (Pelton) Turbines," by Professor Dr. Franz Prásil; "Some New Types of Dynamometers," by Dr. A. Amsler; "Rack-Railway Locomotives of Switzerland," by Mr. T. Weber and Mr. S. Abt. "High-Pressure Water-Power Works," by Mr. L. Zodel; "Steam-Turbines," by Mr. H. Zoelly; "Modern Diesel Oil-Engines," by Mr. F. Schubeler. On Tuesday afternoon alternative visits have been arranged to the works of Messrs. Escher Wyss and Co., or the Oerlikon Machine Works, while an excursion on Lake Zurich has also been arranged at the invitation of the Verein Schweizerische Machinen Industrieller. In the evening, the Institution dinner will be held in the Tonhalle. On Wednesday, July 26, at 9 30 a.m., the meeting will be continued in the Aula, and papers will be read and discussed. In the afternoon there will be alternative excursions (*a*) to Winterthur, to the works of Messrs. Sulzer Brothers, and the Swiss Locomotive and Machine Company; (*b*) to Schaffhausen, (*c*) to Beznau. On Thursday, July 27, alternative whole-day excursions have been arranged to Glarus or Braunwald. On Saturday, July 29, Members will travel to Lucerne, *viâ* the Rigi-Kulm, this concluding the official arrangements.

ENGINEERING.

FRIDAY, JULY 14, 1911.

THE DIRECTOR OF NAVAL CONSTRUCTION.

THE announcement by the First Lord of the Admiralty of the impending retirement of Sir Philip Watts, K.C.B., from the post of Director of Naval Construction at the Admiralty is one of first importance in view of the great responsibilities attaching to the office and of the consequent necessity of securing a successor possessing the highest qualities to carry out the various and exacting duties. Sir Philip's demission of the position has not come as a surprise. It was known to many that for some time he has been contemplating the prospect of relief from the heavy task continuously imposed upon the Chief of the Constructive Department of the Navy, and the utilisation of his ability and experience in less onerous work. It is true that he has not held the office for as many years as some of his predecessors. The late Sir Edward Reed, K.C.B., was Chief Constructor of the Navy for only about seven years, but Sir Nathaniel Barnaby held that position, and the same post under the new designation of Director of Naval Construction, for about fifteen years; Sir William White, K.C.B., was in office for over sixteen years; and now Sir Philip Watts is retiring before the completion of his tenth year; but he has continued in harness until a later age, and it may also be said that he has made vaster changes and incurred greater responsibilities than those incurred within the same number of years in any period in the history of the Navy.

We have no intention of reviewing Sir Philip's work and its influence on naval architecture generally. That would be premature, for it is not yet completed. It is worth recalling, however, that, according to the Navy Estimates, Parliament has voted for shipbuilding, repairs, and maintenance of hull and machinery of ships of the Navy since he took office in February, 1903, a total of 168,700,000*l.*, excluding the cost of ordnance. That is a fair measure of the financial responsibility of the department. It would be easy to prove that efficiency in the fullest sense of that word has been achieved in the expenditure of this money so far as it depended on the department over which Sir Philip has presided. Warship design, it has often been said, is a combination of conflicting considerations. The strategist and the tactician lay down these considerations, so far as they affect offence and defence, which include speed as a matter of course, and it then becomes the duty of the naval constructor and the engineer to embody these so far as is possible within limits of dimensions and cost, which may or may not be reasonable. The advances made in any period of naval development cannot therefore be attributed to any one official at the Admiralty, but it cannot be forgotten that the ships designed for foreign Powers by Sir Philip, when at Elswick, were remarkable for those qualities of gun-power and speed which have been outstanding features of the recent additions to the British fighting fleet. The unification of calibre in guns was dictated by considerations of gun-control in battle practice; but the application of the principle devolved upon Sir Philip's department, with the difficulty of finding accommodation for magazines in positions dictated by the need for all-round fire, and of ensuring structural strength to withstand the stress consequent upon the greater muzzle energy of volley firing. It was quite consistent with fact, therefore, when the First Lord said, in announcing the impending retirement of the Director of Naval Construction, that Sir Philip "must bear upon his broad shoulders all the praise or all the blame which is to be associated with the name 'Dreadnought,'" but that he "would be comforted by the fact that, whatever else might be said of that type of ship, it is a type which has been much copied." A higher compliment can scarcely be paid, and with this remark we leave for the present Sir Philip's great services to the Navy and to the nation.

It is pertinent, however, to direct attention to the future, and to the qualifications which the Admiralty must seek for in the new Director of Naval Construction. Of the idea, once entertained, of deputing the duties and responsibilities to a Directorate composed of representatives of various departments at Whitehall, little has been heard lately. The idea cannot be commended, since devolution of responsibility is dangerous. A capable masterful mind is far more efficient from the creative standpoint when acting with undivided power and responsibility than when trammelled by colleagues equal in all things except ability, and therefore either acquiescent without attempting criticism, or critical without attempting original constructive design. At present the Board lays down the qualities of ships dictated by strategical and tactical considerations; the work of embodying these in ship design falls upon departments over which preside, and for which responsibility is accepted by, the Director of Naval Construction, the Engineer-in-Chief of the Fleet, the Director of Naval Ordnance, &c. This delimitation of work has continued since 1875 with unalloyed success, from the points of view of hull, engine, gunnery design, economy in cost, and efficiency in service. These have been years of great advance, alike in the qualities of individual ships, in the fighting efficiency and preparedness for war of vast fleets, and in the rapidity with which each step of possible opponents has been checkmated by the new ships. These are the true standards of test of the organisation at the Admiralty, and there is no evidence available to prove the need for any change.

The public and the profession are therefore very properly considering the qualifications for this important post, and the men available and capable of filling it. There may be gain in discussing the former subject; but we refrain from reflecting upon the latter, since the *rôle* of prophet is ever unprofitable. So far the struggle between nations has been confined to the peaceful victories in ship design, and, so far as finances allowed, to predominance in number. For years, too, we have enjoyed the flattery which comes from imitation; but it cannot be disparaging to the ability of the present or future officers of the Navy or Admiralty to say that the fact that we lead in construction and others follow may not always ensure victory in warfare, whether it come soon or is long deferred, especially as the advance of scientific education, begetting originality in conception, combined with increasing experience, encourages our friends in other countries to proceed on new lines, divergent in significant respects from those pursued by the British Navy. Of this fact there were ominous indications in the proceedings at the International Congress in London last week, the report of which is concluded in this issue. British methods are copied not merely as "fashions," but in large measure because of confidence in our prescience, resource, and experience. Such copying is not only complimentary, but satisfactory, since we lead, so long as it continues. With advancing education and increasing experience in the case of all foreign navies must come confidence and the determination no longer to follow. There is thus greater need in the future than in the past that the Director of Naval Construction should, above all else, be a man capable of original work, and of courage to evolve, and to enforce the acceptance of, new departures which are justified by their efficiency. In other words, our rate of acceleration in improvement must be increased, however difficult it may be in

view of the great achievements of the past, if we are to continue to maintain our supremacy so far as *matériel* is concerned.

It follows that work in a groove must be avoided, but it is certainly not a corollary that any one who has assisted Sir Philip in the past would, if elected as his successor, fail to show the originality and courage desiderated. It would be universally accepted as fair that the claims for promotion of existing members of the Royal Corps of Naval Constructors should first be considered, not alone because of their co-operation with the present and past holders of the office and of their right to reward for past services, but also because they have experience of the work and of the administration. Discrimination by the authorities responsible for the appointment must, however, necessarily begin with the generally accepted fact that experience of, and full acquaintance and long contact with, existing conditions tend to narrow the mental perception of blemishes and of the need of change. Another point upon which the public will have more cause to insist than those in authority is that there should be the highest independence of character. The post of Director of Naval Construction is one calling not only for high ability, but for courage and forcefulness in all technical matters. We have been fortunate in the past, but there have been occasions which have shown that this quality is requisite. British ships, in comparison with some ships designed and built by British firms for foreign navies, have often had their fighting efficiency depreciated by the fittings insisted upon by executive officers against the better judgment of designers ; and not infrequently, too, these have been needlessly multiplied in exposed positions, with the risk of disseminating destruction as a consequence of the action of explosive shells.

There are one or two distinguished naval architects not in the Admiralty service whose claims must be considered. It is essential that in such a case there should have been intimate practical contact with recent warship work, not only in the building of ships for the British Navy from the designs of Sir Philip Watts, but in the designing and construction of ships for foreign navies. Initiative, resource, and courage in the enforcing of new ideas can only be cultivated by practice. It is true that formerly nearly all our foreign clients for warships were disinclined to accept any departure from British Admiralty practice, and that the scope for originality was thus limited. One or two Powers still adopt the same attitude ; but most of them seek now the best that can be guaranteed by responsible firms, so that men possessing the qualities desiderated are obtainable from without the Admiralty. It is significant that Sir William White and Sir Philip Watts "stepped up higher" from one of our prominent naval construction firms, and the eyes of the public are naturally directed towards the men who are at the head of the designing and constructional staffs of such firms. There can be no question of the excellent and original work done with remarkable efficiency by Mr. J. R. Perrett, of Sir W. G. Armstrong, Whitworth, and Co., Limited, and Mr. T. G. Owens, of Messrs. Vickers, Limited, both of whom have been responsible in all respects for the design of the foreign ships built by the respective firms, and for the realisation of the results in those ships. These are the firms who have done more naval work for foreign navies than any other concerns in the world, and it is natural that the names of the officials solely responsible for their results should take precedence in the mind of the public as well as of the Board of Admiralty. The Admiralty must weigh well all the qualities of every available warship designer —experience, originative faculty, force of character, and administrative ability—and secure his services, irrespective of cost and of influence opposed to him, for the claims of naval efficiency should be held superior to all other considerations.

INTERNAL-COMBUSTION ENGINES FOR ELECTRIC POWER-STATIONS.

THE history of the development of electric generating stations in this country could almost be divided into a series of definite phases, or ages, each characterised by a different form of prime mover. Indeed, the history of electric generators could almost be similarly divided, since up to the latest developments of the steam-turbine, the electrical end of a generating set represented a form which had come into existence merely owing to the demand created by the development of its engine end. The phases into which electric generating stations could be divided might be known as the belt or rope-driven age, the direct-coupled high-speed-engine age, and the steam-turbine age. This classification is, of course, an approximate one only, and intermediate stages and individual cases have at all times cropped up which have interfered with its simplicity. None the less, this division into ages is a fair representation of facts, especially in this country, where, owing to so large a proportion of the electrical stations being under municipal control, there has been a great tendency towards definite lines of practice at particular times—a tendency towards what can best be described as the fashion of the moment. This tendency is natural enough, and is, indeed, inevitable, since it is no part of the business of a municipality to indulge in engineering experiments, but it is more than doubtful if it is in the best interests of engineering progress.

A tendency at any particular time towards uniformity of practice in generating-station design carries with it at least two evils. The first of these is illustrated frequently enough in the present steam-turbine age. If the type of prime mover to be adopted in any particular case is to be determined merely in terms of conformity with ruling practice, many examples will be found in which such conformity has resulted in the installation of unsuitable plant, or, at any rate, plant which was not the most suitable. Such examples are found at the present time in the form of steam-turbines of small capacity, having no advantages over reciprocating engines, and some disadvantage as compared with them, installed in some cases on quite a small scale in reciprocating stations, and having no justification beyond the fact that at the moment it is the fashion to instal turbines. The second evil is that a fashion in terms of any particular type of prime mover is likely to render the introduction of any new or improved form a matter of greater difficulty than need be. It may appear that the fact of the rapid advance of steam-turbines, and the supersession of direct-coupled high-speed engines by them, goes to show that this evil is small or non-existent ; but we think that an examination of the facts of the case will show this deduction to be unsound. Although in a way steam-turbines have superseded high-speed engines as the fashionable prime mover, they have not superseded them in the way that metallic filament incandescent lamps have superseded carbon filament lamps. The coming of the steam-turbine in generating-station practice was not properly an example of a new form taking the place of an older, since the extent of the work to be done increased so greatly at about the time of the introduction of the turbine. The general adoption of turbines was undoubtedly greatly assisted by the fact that they displayed such aptitude for driving the large electrical units which the rapid extension of the field and scale of supply rendered necessary. If the mission of turbines had merely been the taking over of work on the same scale as it was being carried out by reciprocating engines, it is doubtful if they would have made the rapid advance which has been seen.

During the last few years a new type of prime mover for generating-station use has come into the field in the form of the internal-combustion engine. A considerable number of installations of this class have already been put down and have proved successful. These have taken the form both of gas-engines and Diesel engines, and although the whole subject is still one around which a large amount of discussion revolves, it is by this time quite certain that either of these types is capable of forming the basis of successful plants. None the less the extent to which internal-combustion engines are used in generating stations is still very small as compared with steam plants. This is particularly the case as regards municipal stations, which, as we said, tend to illustrate, more than others, the fashionable practice of the moment. There are, however, several municipal stations both of the gas-engine and the Diesel-engine types, and the fact that the Incorporated Municipal Electrical Association devoted two papers to the question of internal-combustion-engine stations at their Sixteenth Annual Convention, which was held at Brighton the week before last, shows that municipal engineers in general are realising the importance of the matter.

It is an interesting speculation as to whether the next decade will see the beginning of an internal-combustion-engine age in generating-station design, in the sense that the present is the turbine age. Many gas-engine and Diesel-engine enthusiasts would undoubtedly say that it will, but, personally, we certainly have no intention of committing ourselves to any such prophecy. It will be remembered that Mr. Ferranti, whose prescience in some matters has been remarkable, decided against gas-engines in the large central generating-station scheme which he sketched in his presidential address to the Institute of Electrical Engineers. None the less, it must be remembered that this scheme was but a sketch intended rather to illustrate an idea than to stand for detailed practice. It is, of course, impossible for anyone to lay down the law as to the future line of development of any branch of engineering, and although non-believers in the internal-combustion engine may point out that the gas-engine is of much older standing than the steam-turbine, in the modern sense, and that the latter's relatively greater progress is proof of its superiority for generating-station use, they do not really make any case against the former. Their argument is a parallel one to that which might have been advanced to Sir Charles Parsons twenty-seven years ago, when it might have been pointed out to him that the inferiority of the turbine to the reciprocating engine was definitely established by the fact that it had been in existence since the days of Hero, and had been surpassed in every way by the reciprocating engine.

Although quite a good deal has by now been done in this country with gas-driven generating-stations, none the less the number of such stations is as yet insufficient for there to be any great amount of data available to enable them to be compared with steam stations. The local conditions and management of different stations varies so much that a large number of examples are necessary before it is possible to draw any general conclusion which may be considered fairly applicable to a particular type of plant. This fact, of course, militates against the rapid spread of new methods unless they show such remarkable advantages in the examples existing that it is impossible to ignore them. There are several large gas-driven stations now at work in this country, but they are mostly situated at private works or collieries, and in many cases the local conditions are specially favourable, so that the average municipal engineer probably feels that both the extent and conditions of the present practice are not such as to justify him in adopting a similar type of plant for his own use. An additional hindrance to the spread of the gas-engine for generating-station work lies in the obvious fact that it cannot be adapted to an existing steam station in the simple way that a turbine can be put down in a reciprocating-engine station. It involves a radical change of method.

If internal-combustion engines have an inherent and absolute superiority over steam-engines, they will ultimately come into extensive use and will take their proper place even in municipal stations ; but the process of change, especially at the present stage, must be a slow one. The hopes of the gas and Diesel engine makers, as far as municipal work is concerned, must at present be turned mainly towards the smaller stations, in which the new problems to be faced are not so great, on which there are more data available, and in which, in case of unsuccess, the capital loss will not be so serious. Diesel engines, in particular, have of late made remarkable progress, and it is certain that no one building a new generating station of moderate power is, at the present day, justified in neglecting the very serious consideration of them. We hardly think the large gas-engine can be said to have yet attained a similar position. In the mere matter of capital expenditure, for instance, there is not enough extended experience available for any generally accepted figures to be extant. In the two papers read at Brighton some estimated figures for gas plants were given. Mr. R. M. Carr, the chief electrical engineer of Leek, where there is a gas-driven station, and who was speaking in favour of that type, gave in his paper a curve of capital cost for plant and machinery which suggested that for a 2000-kw. station the expenditure per kilowatt installed would be about 22*l.* ; while Mr. H. L. Howard, the chief electrical engineer of Barking, which has a Diesel-engine station, gave a corresponding figure of 15*l.* for a 10,000-kw. station. These figures were obviously not strictly comparable, but Mr. Carr's curve suggested that the cost of gas plant is not going to greatly fall per kilowatt installed, after a capacity of above 1600

kilowatts has been reached, and in any case it is obvious that the difference between the figures is too great for them both to be right. The truth is, of course, that there is no right in the matter. Figures of this sort are based on assumptions, which there is not yet sufficiently extended experience to enable one to make correctly for a general case which must be held to represent the mean of a large number of special cases, every actual example being a special case.

THE INTERNATIONAL RUBBER EXHIBITION.

THE chief novelties in the machinery exhibits at the Rubber Exhibition, which will remain open at the Agricultural Hall, Islington, until this evening, July 14, were noticed in our issue of June 30. We will to-day deal, in the first instance, with the more chemical side of the rubber problems, its synthetic preparation, the reclamation of rubber, and rubber substitutes, and then describe some further machines—testing-machines in particular.

The exhibits of synthetic rubber are not of a kind to alarm rubber-planters. Artificial rubber may some day oust the natural product, as synthetic indigo is replacing the natural dye. So far, however, artificial rubber can hardly compete in price with the material which various kinds of plants furnish. The problem of the synthesis of rubber is generally understood to involve two tasks: the preparation of isoprene, and the conversion of isoprene into rubber. Isoprene is a colourless, very mobile liquid, highly volatile, and distinguished by a peculiar, unpleasant smell; the boiling point is 33.5 deg. Cent., and the density 0.67. Some isoprene is obtained when natural rubber is submitted to destructive distillation. That some distillation product of rubber, subsequently identified as isoprene, changed, when treated with hydrochloric acid, into a substance having all the essential qualities of caoutchouc, was observed by Bouchardat in the fifties, as we pointed out in an article on artificial rubber last year.* Isoprene still remains the material on which many distinguished chemists rely in their endeavours to prepare rubber. Isoprene has the formula C_5H_8, and the constitution $CH_2 = C - CH = CH_2$; it is also known as

$$CH_3$$

methyl divinyl. Under certain conditions it polymerises into a very tough and stable elastic solid, which is supposed to consist of an unknown number of double molecules of isoprene $(C_{10}H_{16})n$; whether this latter hydrocarbon forms an open chain, such as we have just indicated for isoprene, or a closed chain or ring compound, is still unsettled. [Polymerisation signifies that several equal molecules have united to a complex compound.] Now rubber undoubtedly contains a hydrocarbon of the above formula $(C_{10}H_{16})n$ as its most characteristic constituent, and the polymerisation of isoprene into this compound has certainly been effected in various ways. It is customary to call the resulting product, which looks very much like rubber, synthetic rubber, and to say that it must be rubber. That seems to be a very wide assumption. In the first instance we do not know the value of the n. Further, in the latex of the rubber tree the elastic substance is suspended in very small globules; the membranes of these globules contain proteins; resins and certain salts are likewise present; they remain in the rubber, and they may all be essential; that is to say, the peculiar properties of rubber need not depend alone upon the properties of the hydrocarbon. It is not quite immaterial what substance (acetic acid, mineral acids, carbon dioxide, and smoke) is used for coagulating the latex, and recent researches on the reclaiming of rubber tend to show that the different properties which the more or less vulcanised rubber assumes at different stages of these processes must partly be ascribed, not to chemical reactions in the ordinary sense, but to various degrees of polymerisation. Passing to the practical aspect of the problems, we should say that the purification of isoprene and its separation from other compounds which are produced at the same time, is very difficult, and that the conversion of the isoprene into rubber is very incomplete, again owing to the formation of other compounds.

The two exhibitors of synthetic rubber are the Caoutchouc Syndicate, Limited, of 14 to 16, Cockspur-street, S.W., and the Silberrad Research Laboratories, of Buckhurst Hill, Essex. Dr. A. Heinemann, of the Caoutchouc Syndicate, explains that he starts either from oil of turpentine (as most scientists have done, and as the Elberfelder Farbenfabriken do in their Fritz Hofmann process), or from some carbohydrate, starch, sugar, sawdust. The oil of turpentine is broken up by heat in contact with finely divided silver or copper at a comparatively low temperature; at a higher temperature diisoprene would form instead of isoprene. The starch is boiled with acids to yield laevulinic acid ($C_5H_8O_3$), which, distilled with phosphorus trisulphide or other sulphur compounds, or with flowers of sulphur, passes into thiotolene; the latter is reduced by hydrogen or water-gas to isoprene. The impure isoprene (density, 0.684) is heated with some additional substance up to 105 deg. Cent. at a pressure of from 5 to 8 atmospheres for several days. The liquid turns viscous, as the specimens exhibited show; when poured out it forms a sticky colourless mass, which darkens when slowly dried (for days), and changes more and more into something like sheet rubber. The additional substance just mentioned may be ozone or some albuminoid; when ozone is used, the heating is only carried to 40 deg. Cent.

Dr. Silberrad is more reticent. He does not state what is his raw material nor explain his process, but he shows a small piece of compact rubber and the intermediate products, and claims to be able to produce isoprene at about 8½d. per lb., while Dr. Heinemann would do it for less than half that money and hopes to supply rubber at something like 6d. per lb.—which figure probably refers to the cost of raw materials.

As long as rubber is not manufactured by the ton, the reclaiming and re-forming processes deserve full attention, which they will indeed retain. The reclaiming of waste rubber—*i.e.*, old vulcanised rubber—is done by chemical agents, which, it is generally asserted, remove part of the sulphur, if not all of it; the re-forming processes merely grind up the material, cleaned from grease, and compress the more or less soft particles. The mass is subsequently heated at or above vulcanising temperature, while the high pressure is kept on. Only soft waste is applicable for reclamation; hard rubber, ebonite, is ground up and is re-used merely as filling material, but its sulphur content probably helps to vulcanise the fresh rubber to which it is added. The reclaiming is effected by means of alkali or acid, or with the aid of heavy oils or resinous compounds, or of volatile sulphur solvents. Reclaiming processes were first introduced in the United States, where fifty large works are now in existence. Several of these works apply acid processes (Mitchel), against which the objection is sometimes raised that acid, even in traces, is apt to corrode the rubber in which it is left, or to change its degree of polymerisation, so that a subsequent treatment with alkali and with steam is required; oils are added to the product during rolling. The alkali process of Marks, introduced about 1900 by the North-Western Rubber Company, of Manchester, treats the rubber with moderately concentrated alkali (caustic soda, as a rule), under a pressure sufficient to destroy the textile fibre; traces of alkali are not so injurious to the rubber as acid.

The North-Western Rubber Company, which owns the largest works of this kind, at Litherland, Liverpool (general superintendent, Dr. J. Torrey), has a fine show of its products in the Exhibition. Alkaline processes are also used, we believe, by the Russian Prowodnik Company, of St. Petersburg, which is well represented by Messrs. J. Lang, of 37, Fenchurch-street, by the British Recovered Rubber Company, of Clayton, Manchester (established 1872), in their "Amazon" brands, and by the Rubber Regenerating Company, of Trafford Park, Manchester. The Premier Re-Forming Company, of Walthamstow, E., exhibit various products—buffers, tiles, screw-stoppers, and inner rubber tubes for tyres.

The solvent process of Messrs. Max Fränkel and Runge, of Spandau, near Berlin, deserves a detailed notice. It is due to Dr. P. Alexander, who explains the process with the aid of specimens taken from the various stages. The works were established ten years ago, and the process is recommended for materials, old tyres, &c., which contain much mineral and textile matter. The material is disintegrated and treated for several hours under pressure with certain hydrocarbons, which dissolve the vulcanised rubber as such; the mineral and textile matters are not attacked, and are allowed to settle. The viscous solution could be mixed with acetone or alcohol in order to precipitate the rubber and thus to separate it from the oils and other organic matter, &c.; the recovery of the solvent would be too difficult, however, and these substances are left in the solution, which, on distilling the solvent off, appears as a black or grey (according to the original colour) sticky mass, which is dried and then rolled into sheets. That this regenerated product is really rubber, though vulcanised, Dr. Alexander proves by the nitrosite reaction and other reactions. If the solution in hydrocarbon is treated with a little concentrated alkali, an "artificial latex" of vulcanised rubber results, which contains some alkali and will mix with water (the real latex does not), and which can be coagulated just like ordinary latex; the precipitate is gelatinous, however, and will redissolve in water. Dr. Alexander considers that the alkali effects a depolymerisation, and that changes in character which rubber undergoes during its manufacturing processes, which make it hard or plastic, according to temperature and other conditions, are partly due to successive polymerisations and depolymerisations. His regenerated rubber is of decidedly superior appearance, and can be worked into tubing, coils, &c., without any addition of fresh rubber (which is customary with most other processes, at least for certain purposes).

What science can achieve is shown by the United Malaysian Rubber Company, of Pinner's Hall, Austin Friars, E.C. Their raw material is rubber from the jelutong trees of Borneo; the stuff looks poor, and is crumbly like cheese, or very sticky and hardly elastic at all; yet a good rubber is produced from it, in addition to resin and resin oils. Rubber substitutes of all kinds, white amber, and dark products prepared from oil, as well as all kinds of mineral matters, are exhibited by Mr. Alfred Smith, of Clayton, Manchester, Messrs. Typke and King, of 16, Mincing-lane, and others.

The M.R., mineral rubber, exhibited by Messrs. Alden and Co., of Liverpool and London, and by the Canadian Mineral Rubber Company, of Toronto, Chicago, and 34, Nichols-lane, E.C. (Pioneer M.R.), is obtained from gilsonite, a brittle natural hydrocarbon occurring in Utah; the resulting product is soft, melts (or softens completely) at 280 deg. Fahr., and leaves no ashes. The Canadian Company has used it as a substitute for rubber and asphaltum since 1898. Recent antiseptic coagulants for rubber are exhibited by the Elias Pure Rubber Process Company, of 9 and 10, St. Mary-at-Hill, E.C., as a dry powder, which is dissolved in water, and by the Purub Company, of Berlin, S.W., 68. The "purub" is the invention of Dr. Sandmann, and consists essentially of hydrofluoric acid, which he originally used for preserving fruit; the acid is bound by the salts of the fruit or rubber and thus rendered harmless; $\frac{1}{16}$ oz. of the purub, which is supplied in lead bottles, is reckoned per gallon of latex.

Of special products we may mention the 20,000-volt gloves (seamless rubber, lined with sockinette) and boots for electricians, of the Harburg and Vienna India-Rubber Works, of Harburg-on-the-Elbe, and the "polarit" goods (for acid and oil works), the "polarit" jointing material for superheated steam, the imitation leather, and the solid tyres of Messrs. Polack, of Waltershausen, and of the Polack Tyre and Rubber Company, of 32, Basinghall-street, E.C.; one of their 5-ton lorries for the Great Central Railway had covered 25,814 miles and looked still in fair condition. In the tyres of Messrs. S. Herz, of Berlin, and of 15, Dowgate-hill, E.C., the fabric is woven to shape in one piece, which is saturated with rubber solution and applied in continuous layers without joints.

The Royal Prussian Materialprüfungsamt, of Gross Lichterfelde, near Berlin, display an interesting collection of their rubber-testing machinery in the German Section, one of the most instructive and comprehensive, though not the most attractive section of the Exhibition. In view of the importance which is attached to mechanical rubber-testing, Professor Martens, director of the Prüfungsamt, recently presented a memoir on the subject to the Prussian Academy of Sciences, in which he drew attention to a book on "Kautschuk und seine Prüfung," published by his colleagues, Hinrichsen and Memmler; copies of these publications are on view. Several of the machines have been built to the designs of Professors Martens and Dalén, by Mr.

* See ENGINEERING, May 13, 1910, page 617.

Louis Schopper, of Leipzig, whose stand adjoins that of the "Amt."

As it was found that rubber specimens of the shape of test-bars, with or without wider ends, which broke near the heads, where they were gripped, and also the 8-shaped samples (used in cement testing) were not suitable, Professor Dalén introduced cylindrical rings, 44.6 mm. internal diameter, and 6.4 mm. in thickness, for these tests. The rings are stamped out of sheets by special machines fitted with ring knives, or cut on the lathe; they are stretched over two rollers; the upper roller turns in ball-bearings, the lower is rotated by toothed gearing, so that the rubber ring travels while under test, and is evenly strained. The two rollers just mentioned are attached to the upper portion of a column apparatus, which stands on two feet set at an angle. In their general construction these machines resemble the renowned textile-testing machines of Mr. Schopper, which may be worked by hand, electric motor, or by hydraulic pressure. The rubber-testing machine in question is joined through a Martens valve to the water main; it requires a pressure of about 40 lb. to the square inch; the pressure forces the piston, to which the lower roller is fixed, down into the barrel which forms part of the stand. The stress is indicated by a lever moving over an arc which is provided with teeth on its inside; the lever is gripped at the moment that rupture takes place. The extent to which the rubber ring stretches (it may be ten times its diameter) is shown by a pointer moving over another arc. When the test is not carried to the breaking point, the permanent set which the ring has taken is measured on a simple small machine, in which the lower roller is under a constant load. The elongation depends, to a considerable extent, upon the vulcanisation, of course, and the "Amt" therefore has its own vulcanising plant. Vulcanised rods are apt to develop transverse cracks under load tests, and it is owing to these cracks that they do not stretch at a uniform rate, but periodically at an accelerated rate.

Fatigue tests are conducted, with four rings simultaneously in a horizontally-arranged machine, in which the stress is alternately increased and diminished, until the specimen gives way; the machine then stops and marks the number of stress applications. In another machine, a modification of a paper-testing machine, the strip or sheet of rubber is alternately pulled to right and left and folded over. In another machine, again, balls 30 mm. in diameter are run under a heavy load in a V-groove; this very characteristic test determines the wear of the rubber. Another machine serves a similar purpose; a rubber ring is suspended over a lower roller, against which an upper loaded roller is pressed; the pulleys revolve until the ring is worn through. The rubber rolls for typewriting machines are tested with the aid of an electro-magnetic hammer.

As regards strength tests of balloon fabrics, there is no generally-accepted practice so far. German military men would like to have sample strips 1 metre in width; others call for tests of part of the actual finished structure, with all its seams, &c., or demand bursting tests of especially prepared cylindrical specimens; these specimens are expensive, and a great deal would depend upon their finish. The Prüfungsamt prefers to use strips 50 mm. in width for the strength tests, and circular sheet samples for the bursting and most of the other tests. The discs are of areas of 0.01, 0.02, 0.03, 0.05, 0.1, 0.3 square metre, and are held by planed cast-iron clamps and rubber. Permeability and heat-transference tests are also made at the Prüfungsamt by apparatus due to Heyn and Bauer; in the latter the stretched sheets are exposed to radiations, and the temperature is determined in the space behind the sheets by means of thermo-couples.

We stated already that Mr. Louis Schopper, of Leipzig, represented in this country by Messrs. John Griffin and Sons, of Kingsway, W.C., shows his rubber-testing and also textile-testing machines; it is the only group exhibit of its kind in the Hall. Some apparatus, viscosimeters, and small centrifugal apparatus for rubber analysis, are also to be found on the stand of the chemical laboratories of Dr. R. Henriques's Successors, Dr. E. Marckwald and Dr. F. Frank, of Berlin, S.W., 68.

With regard to the rubber-washing machine of Messrs. Werner, Pfleiderer, and Perkins, of Peterborough, which was mentioned in our first notice, we should like to add that the machine does not turn out the rubber in the form of sheets, but in the form of a coarse-grained dough. The rolls are not keyed to the shaft, but cast on them, and are deeply corrugated; when in operation the two rolls of a machine remain at a fixed distance apart, and any particles of wood, pebbles, &c., in the rubber would not be splintered or broken, but squeezed into the slots and would drop out or be caught on the ledges. The two rolls carry the rubber down between them, round, and up again. The rolls exhibited by the Auto-Electric Vacuum Drying Syndicate, of 709, Salisbury House, Finsbury Circus, E.C., are supplied plain, fluted or grooved, solid, or chambered for heating, by Messrs. Bever, Dorling, and Co., of Bradford. The electric-vacuum drying-stoves of the firm consist of glass shelves heated by coils which are pushed over horizontal rods arranged between the shelves; the temperature is controlled by means of thermostats. The vacuum drying and evaporating apparatus of Mr. Emil Passburg, of Berlin, exhibited by Mr. James Livingston, of 30, Great St. Helens, E.C., are made stationary and rotary, and are heated with exhaust steam, gas, oil, or electricity.

The automatic rubber-thread-cutting machine of Messrs. J. and P. Hill, Ordnance Works, Sheffield, is provided with a disc knife which runs at 1500 revolutions per minute in a cast-iron case, into which water is forced. The rubber to be cut is carried on a drum of canary-wood wrapped with a shell of cheap rubber 0.5 in. in thickness, to cut into, over which the rubber sheeting is wound to a thickness of 2 in. The knife makes a cut and is then withdrawn and advanced, so as to cut strips from $\frac{1}{16}$ in. to $\frac{3}{4}$ in. in width. The drum can be run at 90, 150, and 210 revolutions.

A small novelty is the exhibit of the steel studs for rubber tyres of Messrs. Haedge and Richter, of Hanover, represented by Mr. A. C. Jacobs, of 11, Abercorn-place, Maida Vale, W.; the studs consist of specially hardened heads and one or several soft shanks, with washers of various shapes; a riveting-machine for these studs is also on view.

We reserve descriptions of some machines of the Harburg Eisen und Bronze Werke, A.-G., of Harburg-on-the-Elbe, an hydraulic autoclave for vulcanising tyres, &c., the four-piston pump for this autoclave (pressure up to 300 atmospheres), and a three-high calender.

The Exhibition is well stocked and arranged. International conferences of planters, manufacturers, chemists, &c., were held in connection with it during the first fortnight. The arrangements made for the conferences cannot be praised; excellent papers were read and discussed, but a preliminary programme was not issued, and sometimes the lecturers themselves did not know till the very morning when their turn would come.

THE WORKING OF THE BOILER EXPLOSIONS ACTS.

THE annual report for the year ended June 30, 1910, on the working of the Boiler Explosions Acts, 1882 and 1890, has just been issued by the Board of Trade. During the period named, 98 preliminary inquiries and 5 formal investigations were held under the provisions of the Acts. Of the 103 explosions thus dealt with, 43 resulted in loss of life or personal injury, 14 persons being killed and 62 injured. The 14 deaths were caused by 11 explosions, of which 4 occurred on land and 7 on ships.

For the previous 27 years the average number of explosions, and the average number of persons killed and injured, were 69.3, 27.1, and 57.9 respectively. It will therefore be seen that the number of explosions dealt with in the year under review again shows an increase above the average. The number of persons injured, however, is only slightly above the average, while the number of persons killed is only about one-half of the average for the period named. The report states: "It is so far satisfactory to note that the increase is not in the number of serious explosions, and there is reason to believe that during the past year a larger proportion of the minor explosions which occurred were brought to the notice of the Board of Trade than in previous years." In four out of the five cases in which formal investigations were held, the Courts found that persons who had been connected with the boilers were to blame for the explosions, and they made orders for the payment of costs in three of these cases, the total sum ordered to be paid amounting to 83*l*.

Of the 103 explosions reported on, 60 occurred on land, and 43 on board ship. By the former 4 deaths and 42 cases of personal injury, and by the latter 10 deaths and 20 cases of personal injury were caused. In 38 cases the boilers, &c., had been inspected or insured by Lloyd's underwriters, the Board of Trade, or marine insurance companies, and in 19 cases by boiler insurance or inspection companies or associations. In the 46 remaining cases the boilers, &c., were under no special system of inspection or insurance. Appendices B, C, and D, added to the report by Sir R. Ellis Cunliffe, Solicitor to the Board of Trade, give some further information. Appendix B gives the causes of the explosions as follow:—

Deterioration or corrosion	26
Defective design or undue working pressure	32
Water-hammer action	9
Defective workmanship, material, or construction...	16
Ignorance or neglect of attendants	8
Miscellaneous	12
	103

The 103 explosions are classified as having arisen from the following types of boilers, &c.:—

Horizontal multitubular	16
Vertical	6
Lancashire...	2
Locomotive	3
Water-tube	9
Tubes in steam-ovens	15
Heating apparatus	3
Steam-pipes, stop-valve chests, &c.	30
Miscellaneous	19
	103

Appendix C gives the following list of boilers, &c., which exploded, and regarding which formal investigations were conducted by the Board of Trade:—

Steam-chest	1
Vertical boilers	2
Locomotive boiler	1
Still	1

These explosions resulted in the death of three persons and injuries to ten others. The report adds: "The causes of these explosions have been clearly ascertained, and in no case has the explosion been attributable to unavoidable accident."

Appendix D, reproduced in the following table, gives the total number of explosions dealt with since the passing of the Acts, the number of lives lost, and the number of persons injured.

Year.	Number of Explosions.	Number of Lives Lost.	Number of Persons Injured.
1882-83	45	35	33
1883-84	41	18	62
1884-85	43	40	62
1885-86	57	33	79
1886-87	37	24	44
1887-88	61	31	52
1888-89	67	33	79
1889-90	77	21	76
1890 91	72	32	61
1891-92	88	23	82
1892-93	72	20	37
1893-94	104	24	54
1894-95	114	43	86
1895-96	79	25	48
1896-97	80	27	75
1897-98	84	37	46
1898-99	68	36	67
1899-1900	59	24	65
1900-1	72	33	60
1901-2	68	30	55
1902-3	69	22	67
1903-4	60	19	45
1904-5	57	14	40
1905-6	54	25	21
1906-7	77	28	65
1907-8	73	23	50
1908-9	93	12	53
1909-10	103	14	62
Totals ..	1974	746	1625
Average of 28 years ..	70.5	26.6	58.0

A large proportion of the explosions referred to in the report were of a very simple character, such as those arising from tubes in bakers' ovens, of which 15 cases are given. It is satisfactory to note that the number of serious explosions is by no means on the increase, and it is to be hoped that we are within appreciable distance of their practical extinction. The investigation by the Board of Trade of all accidents, whether serious or of a minor character, and the circulation of information respecting the causes and means of prevention, must tend to the attainment of greater security in working.

NOTES.

THE GREAT BALTIC MOTOR-BOAT RACE.

THE great international motor-boat race across the Baltic started from the Swedish naval port of Karlskrona on the evening of June 28, bound for the Island of Bornholm. Of the fourteen boats entered only seven put in an appearance at the start; the first boat was off at 8 o'clock, and the rest at two minutes' intervals. They were :— Bolinder VIII., Tatjana, Alba, Avance, Hermes, Penta IV., and White Horse. Two torpedo-boats accompanied the motor-boats as far as the Kalmar Sound; the course of the competing boats was round the Island of Bornholm and back to the Swedish port of Kalmar, which had to be touched, and from thence to the Varholm fortification in the Stockholm Skärgard. The weather was unsettled and the sea very rough. The Bolinder VIII., which started as No. 1, went ahead at such a speed that the torpedo-boats lost sight of her half-an-hour after they got into the open sea, Hermes being second. At 4.30 A.M., June 29, the Hammeren rock in Bornholm was sighted from one of the torpedo-boats (with the speed of which the heavy sea had seriously interfered), whilst the Hermes was 3 to 4 miles ahead. Bolinder VIII. sought shelter in an East Coast port in Bornholm; the Hermes passed Nerö (Bornholm) at 8 A.M., and was then carrying sails. The Tatjana collided with some floating timber and had to seek refuge at Bornholm. The Hermes reached Kalmar at 6.43 P.M. on June 29, starting at 7.23.30. Bolinder VIII. reached Kalmar at 6.49, on the same day, starting again at 7.34. The Avance reached Kalmar at 9.20.30, leaving again at 9.25. *En route* for Varholm the Bolinder VIII., however, easily beat the Hermes, arriving at the winning-post at 12.36.45 P.M. on the Friday. Her skipper, Lieutenant Isberg, had himself been at the wheel during the whole of the 40 hours' trip, with the exception of a couple of hours' rest. The crossing of the Baltic to Bornholm had been very rough, with fog and a strong westerly gale, the seas incessantly washing over the deck. The average speed had been rather more than 11 knots; the motor had worked very satisfactorily, and the boat, in spite of its long and narrow build, had behaved very well in the rough sea; sails had only been used for a short time. The Hermes reached Varholm at 3.38.40, and Avance at 6.34.14, its owner having ordered dinner to be ready by 6 o'clock. The Hermes was the only one of the competing boats which had gone direct round the Island of Borholm, and she had not taken in a single sea; sails had been used during the latter part of the trip, when the speed was 13 to 14 knots. The Avance, from Bornholm to Varholm, had not taken in a single wave on her deck. The other three boats (the Tatjana being disabled) had all sought shelter at Bornholm, starting again in a body at 9.15 P.M., Thursday, reaching Kalmar on Friday afternoon, Alba at 1.32, Penta at 2, and White Horse at 5.40. They were expected to reach Varholm on Saturday forenoon.

INSURANCE AGAINST NON-EMPLOYMENT IN FINLAND.

A special committee in Finland has just finished its labours and drawn up a proposal for insurance against non-employment—a matter which is at present to the fore in most countries. The Finnish proposal provides for the establishment of non-employment funds, from which aid can be rendered to the members in cases of need. Such funds may be formed for the whole country or for certain districts, and also for societies and unions of societies, provided that the funds in question are kept entirely apart from the other objects of the societies. Any labourer who complies with the regulations of the non-employment funds can become a member. Such funds, however, when formed within a society or a union, need only receive as members such men as are otherwise eligible. The limits as regards age are put at 18 and 60 years. The members can only belong to one non-employment fund subsidised with public money, and the subscriptions paid by members are to be so calculated that they, jointly with the State aid, will suffice to provide for the obligations of the fund. Non-payment of subscriptions within the prescribed time entails exclusion and forfeiture of payments already made. The non-employment funds can grant their members day money, house-rent, and travelling money. A member is not entitled to support unless he has been paying for six months and his non-employment exceeds six days, with fifteen days as a limit. The assistance must not exceed a maximum of two-thirds of the average pay of the member, though not less than 50 penni or more than 3 marks Finnish. Day money during twelve consecutive months must not exceed an aggregate of ninety days. Members who for three years have drawn the highest permissible support can receive no further aid until another twelve months has elapsed. The non-employment fund must not render aid to members who join in a strike, or to sick or disabled members, or to members who without proper cause have left work, or with proper cause have been discharged from work, or to members who, without the sanction of the fund-board, refuse to accept suitable work for which suitable payment is offered. The Imperial Senate, on being petitioned, will grant the non-employment funds a State subsidy of half the fund's management expenses and one third of the aid the fund has paid to its members who during the last two years have been resident in Finland. In case aid has been paid to a member in a place where there is a municipal bureau for finding work, the man shall show that the said bureau has been unable to find work for him during the time he has received aid. State aid is not to be paid to non-employment funds with fewer members than fifty. State aid can, under certain circumstances, be withdrawn.

UNPRECEDENTED ACTIVITY IN SHIPBUILDING.

Lloyd's return of vessels under construction in the United Kingdom shows that there are at present in various stages 560 vessels, the tonnage of which exceeds that at any previous period since such figures were collected by Lloyd's. The number and total of merchant ships is 496 vessels, of 1,476,394 tons, 102,000 tons more than at the beginning of April, and 358,000 tons more than a year ago. The previous record total, which was returned in September, 1901, was 62,000 tons less than at this time. The recovery from "bottom," touched in the autumn of 1908, has been exceedingly rapid. For some time in 1908-09 the total merchant tonnage in progress fluctuated between about 730,000 and 900,000 tons. The upward movement began in September, 1909, and, with the exception of a slight check at the end of 1910, due to the lock-out, it has continued since, the recovery in twenty-four months being from 750,000 tons to 1,450,000 tons. When to this is added the tonnage of warships in course of construction the total becomes still more remarkable, being 1,891,934 tons This total is 922,000 tons more than was the case in July, 1909, while the improvement, as compared with a year ago, is nearly 400,000 tons. The figures are made up as follow :—

	July, 1911.	July, 1910.	July, 1909.
	tons	tons	tons
Merchant steamers ..	1,466,989	1,115,484	739,991
Merchant sailing ships ..	9,405	3,103	5,714
Total merchant ships ..	1,476,394	1,118,587	745,705
H.M. ships in dockyards ..	111,140	96,080	84,370
H.M. ships in private yards	271,350	239,193	89,980
Foreign warships	33,050	43,250	49,600
Total	1,891,934	1,497,110	969,655

While practically all districts have profited, the greater increases, so far as merchant work is concerned, are recorded for the Clyde, Tyne, and Wear. Barrow, however, is mostly concerned with warship work, and a very considerable proportion of it is credited to that port. The Liverpool total of merchant ships is much less owing to the completion of the large contract for refrigerator ships for Nelson's Line, but the laying down of the battleship Audacious more than compensates for the falling-off in merchant work. At Glasgow there are 103 vessels, of 332,892 tons, in course of construction. This is nearly 50,000 tons more than three months ago, and 104,000 tons more than a year ago. In the case of Greenock the improvement is almost as great, for the fifty-eight vessels, of 241,770 tons, now building represent 19,000 tons more than three months ago and 61,000 tons more than a year ago. On the Tyne the total is 5000 tons greater than in April last, and 52,000 tons more than in June, 1910, there being 67 vessels now on the stocks, making up a total of 246,504 tons. At Sunderland there are 54 vessels, of 195,104 tons, in progress; this is 38,300 tons more than three months ago, and 87,000 tons more than twelve months ago. Middlesbrough, however, has not fared so well, the total being 10,000 tons and 16,000 tons higher than in March last and in July of last year respectively. Fifty-one vessels are being built, and these make up 86,649 tons. The condition at Hartlepool has not changed much in the past few months; the addition, as compared with July of last year, is only between 4000 and 5000 tons. The number of vessels being built is 17, with a collective tonnage of 69,506 tons. These figures for the respective districts do not include the warship work, and it may be said that not for many years have so many large fighting ships been in course of construction. There are in all 12 ranging from 22,500 to 26,500 tons, the latter being the displacement tonnage of the cruiser Queen Mary, building at Palmer's works at Jarrow-on-Tyne.

THE GROSVENOR-ROAD PUMPING-STATION OF THE LONDON HYDRAULIC POWER COMPANY.

ON Wednesday, the 12th inst., at the invitation of the chairman and directors, an opportunity was afforded of inspecting the London Hydraulic Power Company's new pumping-station in the Grosvenor-road, S.W. This station is very complete and well laid out, and includes a river frontage, though the site is intersected by the Grosvenor-road. The whole of the station, with the exception of the coal-unloading wharf, is, in fact, on the side of the road remote from the river. At present the plant includes five engines, each capable of delivering at the rate of about 28,000 gallons per minute, at a pressure of 800 lb. per square inch, together, of course, with the necessary boilers and accessory plant. Nearest to Grosvenor-road stands the coal-store, and next to this comes the boiler-house. Contiguous to the boiler-house stands the engine-house, and beyond this the settling-basins. The latter consist of six reservoirs of an aggregate capacity of 2¼ million gallons. They are approximately 100 ft. by 38 ft., and are constructed on the Hennebique ferro-concrete system. The compartments are filled from the river by 20-in. pipes, laid at about half-tide level. Wash-out pipes, 14 in. in diameter, are laid below the bottom of the reservoirs, and are used to carry away the sediment after each emptying.

After time has been allowed for settlement, the water is drawn off by the circulating pumps on the main engines, passed through the condensers, and delivered to an unfiltered-water tank above the coal-store. From this tank the water is passed through spherical filters of the Pulsometer Engineering Company. There are sixteen of these filters, situated in two rows of eight, over the coal-store, but below the unfiltered-water tank, from which the water is fed to the filters by gravity. Of the sixteen filters two are kept as stand-bys, and one of the remainder is always being cleaned. The filtering medium is crushed quartz. Each filter can deal with 4500 gallons per hour. Hydraulic blowers are used for cleaning them. From the filters the water passes by gravity into a filtered-water tank over the boiler-house. Both the filtered and unfiltered-water tanks have a capacity of 300,000 gallons. They are built of cast-iron plates, with stringers, &c.

The main engines are of the triple-expansion surface-condensing inverted direct-pumping type, working at a steam pressure of 180 lb. per square inch. From the main engine-pumps the water passes to two accumulators, of which the ram crossheads carry about 150 tons load. In the engine-house are also two auxiliary vertical direct-acting pumps for supplementing the engine circulating-pumps in delivering water to the unfiltered-water tank. A recorder, by Messrs. W. H. Bailey and Co., Limited, also in the engine-house, records automatically the speed of the engines. Outside the boiler-house is a water-softener, on the Desrumaux system, capable of dealing with 1000 gallons per hour. The feed-water, after passing through filters, is measured by "Lea" recorders. At present there are four Babcock and Wilcox water-tube boilers installed, each capable of evaporating 6000 lb. of water per hour at 180 lb. to 200 lb. pressure, and superheating to 100deg. to 120deg. Fahr. The boilers are fitted with chain-grate stokers with hopper feed, the stokers being driven by Pelton motors. Two economisers are arranged in the flue, the scraper gear for these being driven by hydraulic motor. There are two hydraulic direct-acting horizontal feed-pumps for supplying the boilers, each capable of delivering 2000 gallons of water per hour against boiler pressure.

The coal-store is arranged for a capacity of 1000 tons in six compartments. Coal is conveyed to it from the wharf by a conveyor running under the Grosvenor-road, and from it to the boiler-house, also by conveyor. Coal can, in fact, be taken direct to the hoppers over the boilers or discharged into one of the six compartments of the store and conveyed thence subsequently

to the boilers by a conveyor. The ashes from the boilers are likewise handled mechanically and discharged at the wharf either into wagons or barges, passing on the way under the Grosvenor-road. The plant at the wharf includes an hydraulic coaling-crane with a grab bucket discharging into a hopper to which is fitted an automatic coal-weigher with both indicating and recording gear. The intakes and the discharge of the wash-out pipes are in front of the wharf, and the pipes pass thence to the reservoirs along a large subway and pipe-trench.

In the whole station, steam is used only in the main engines; all other plant is hydraulically driven. The drainage from the boiler-house is lifted from a sump to the sewer intercepting-chamber by two automatic hydraulic ejectors. The station supplies three distribution mains, two of 8-in. bore and one of 6-in. bore, automatic control-valves being placed in the subway to isolate the system in case of accident.

During Wednesday afternoon demonstrations were given of two interesting applications of hydraulic power. One of these consisted of an adaptation of this form of power to vacuum cleaning. With an exceedingly simple fitting a vacuum of 30 in. can be almost instantaneously produced, but it is found best to work with one not exceeding 25 in., in order to keep the pipes dry. At this vacuum the dust is drawn up through thick carpets, so that the covering and floor are both cleaned, and the dust is immediately disposed of down the waste-pipe. We understand that many large business houses and places of entertainment now employ this system. The second application of which a demonstration was given was of its use for fire service. By means of an hydraulic injector, working in conjunction with a tank supply, a jet at about 75 lb. pressure, capable of reaching to a height of about 120 ft., can be produced.

In addition to the workshop in which the tools are driven by a Pelton motor, and to the engineering features of the station above described, there are well-arranged stores, offices, and mess-room. The station gives one the impression of being well arranged, though the site must have been no easy one to deal with. The main engines and hydraulic plant are by the Hydraulic Engineering Company, Limited, Chester.

A CRUISER FOR THE TRAINING OF CHINESE OFFICERS.

MESSRS. VICKERS, LIMITED, launch to-day (Friday) from their Naval Construction Works, Barrow-in-Furness, a cruiser named Ying-Swei, for the Chinese Navy, for the training of officers and men in connection with modern munitions of naval warfare, and therefore a forerunner of that new navy which will be built within the next few years for China.

While having all the fighting capacity possible in a ship of the draught (13 ft.) and of the limited displacement (2400 tons) prescribed by the Chinese authorities to meet certain harbour conditions, she excels in the comprehensive character of the provisions introduced for training purposes. Messrs. Vickers, Limited, are responsible for the design, which, like the plans for many of the later warships built by the company, have been prepared by Mr. T. G. Owens, the naval constructor and a director of the company. The special features of the design are:—(1) The great variety in the size of the guns fitted—6-in., 4-in., 14-pounders, 3-pounders, and 1¼-pounders—all introduced primarily for instructional purposes; but incidentally making the cruiser a formidable fighting ship. (2) The different types of boilers on board—cylindrical and water-tube—so that the Chinese stokers may acquire experience. (3) The adoption of alternative systems of auxiliary machinery as far as is consistent with efficiency, for the education of Chinese officers and crew. (4) The unusually large quantity of ammunition carried; 160 rounds for each of the two 6-in. guns, 200 rounds for each of the four 4-in. guns, and 1000 rounds for each of the smaller guns, which permits of extensive battle practice, and confers the advantage of the maintenance of a long engagement in war. (5) The embodying of an unusually thick protective deck—1½ in.—in such a light cruiser. (6) The ensurance of a speed of 20 knots under easy steaming conditions and without exacting that care and organisation in the stokehold which come only with prolonged experience. The principal dimensions of the ship are as follow:—

Length between perpendiculars ...	330 ft.
Breadth, moulded	39 ft. 6 in.
Depth ,, ...	23 ft. 9 in.
Mean draught	13 ft.
Displacement (about)	2500 tons
Speed (about)	20 knots

The armament consists of two 6-in. quick-firing guns, one carried on the forecastle deck, and the other on the poop deck; four 4-in. quick-firing guns, placed on the upper deck—two at the aft end of the forecastle, and two at the fore end of the poop, at the sides of the ship; two 14-pounder quick-firing guns—one on each end of the upper deck amidships; six 3-pounder quick-firing guns—three carried on each side of the upper deck in the waist, and two 1¼-pounder quick-firing guns placed on the bridge. Two-18-in. revolving deck torpedo-tubes are carried, one on each side of the upper deck aft. The guns and torpedo-tubes are controlled in accordance with the latest practice. Accommodation is provided for 230 officers and men and 40 cadets.

The propelling machinery is of the Parsons turbine type, with three lines of shafting, and one propeller on each shaft. The turbines are arranged in one engine-room. The high-pressure ahead turbine is on the centre shaft, and a low-pressure ahead on each wing shaft. The wing shafts are arranged for working astern, a reversing turbine being incorporated in each of the two low-pressure turbine-casings.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, July 5.

THE low prices prevailing for coke have finally started furnace and foundry companies to heavy buying. Contracts were placed last week for several months' output, covering deliveries to the end of the current year, the later buyers having to agree to a 10 cents per ton advance. The curtailment of production since April 15 prevented any accumulation of stocks, and this assisted makers in advancing prices. One Pittsburg concern contracted for 9000 tons per month for six months; another furnace company took 50,000 tons for July and August delivery, and 50,000 tons for delivery after September 1. All other coke-consuming interests are in the market this week, making themselves safe. A great many idle ovens will soon be started up.

The car-builders are in sight of much new business. Inquiries have been received within the past few days for 12,000 cars from the trunk lines, exclusive of passenger coaches, of which 800 are for the National Railways of Mexico. Several systems have presented inquiries for rails during the past few days. The inquiries cover a little over 100,000 tons. This sudden improvement in demand has stimulated confidence in further progress. Prices, which have been weakening, have developed a stronger tone. The weak factor in the situation continues to be the large volume of idle capacity. On the other hand, the strong factor is the urgent necessities for iron and steel construction material, which are becoming more and more urgent. Tariff possibilities are pretty well discounted. Reciprocity discussions have lost interest, and threaten to wind up as a political issue; but it will be a losing one, as the general sentiment of the people is in favour of it, and of the extension of the principle to other countries if conditions ever become favourable.

THE ROAD BOARD'S EXPERIMENTS IN KENT.

UNDER the able direction of Mr. H. P. Maybury, M. Inst. C.E., the county of Kent has in recent years become nearly as famous for the efforts made to adapt its roads to modern traffic requirements as it has long been for the charm of its landscapes. Whilst in other portions of the kingdom the advent of the motor-car, and the consequent impossibility of ignoring longer the bad condition and construction of most of our highways, merely led to violent protests against the car and its users, in Kent steps were quickly taken to discover effective methods of combating the nuisance resulting from the simultaneous use on the roadways of "percussive" traction, such as that of draught animals, and of mechanically-propelled vehicles fitted with soft tyres. The debt which road surveyors have thus incurred to Mr. Maybury and his progressive county council is now about to be further increased, since, with the assistance of the Road Board, arrangements have now been completed for a comparative test, under practically identical conditions, of most of the improved methods of road construction so far introduced.

The stretch of road selected for the test is a 1½-mile section between New Eltham and Sidcup, on the London-to-Maidstone road. The recorded traffic along this stretch of road is very heavy, being about 180,000 tons per yard of width per annum, or 500 tons per yard width per day of 24 hours. In a 14-day census 4516 motor vehicles passed over the road, and 6361 horse-drawn ones. Included in the motor vehicles were 22 traction-engines, which hauled 44 trailers, 1829 motor-cars and vans, 1468 motor-omnibuses, 122 steel-tyred motor-lorries, and 236 motor-lorries with rubber tyres. The stretch of road selected is slightly undulating, and is unshaded by trees save in one or two places. In all 23 kinds of road-surfaces are to be tested, each of which will be laid on an area of 1000 to 1200 square yards.

Sockets are to be fixed in groups of three across each section, which will serve as reference marks for testing the rate of wear. The Road Board have appointed Mr. F. W. Greig, of 20, Alma-road, Sidcup, to act as resident engineer during the progress of the test, which will, of necessity, extend over some years. The twenty-three materials to be laid are:—(1) Ordinary water-bound granite macadam, laid by the Kent County Council. (2) The same, painted with tar. (3) Single "pitch-grouted" macadam, laid by the Kent County Council to the Road Board's Specification No. 3. (4) Double pitch-grouted macadam, laid to the Road Board's Specification No. 4. (5) "Durax" armoured paving, laid by the "Durax" Dustless Roads, Limited, of 20, Victoria-street, S.W. This consists of granite cubes grouted with coal-tar pitch tempered with creosote or tar, to which is afterwards added 30 per cent. of fine dried sand. (6) Granite macadam, laid by "Plascom" (1909), Limited, of Fawdry-street, Wolverhampton, with a binder of a bituminous character. (7) "Cormastik," laid by the British Cork Asphalt Company, Limited, of 85, London Wall, E.C. "Cormastik" consists of a mixture of granite or basalt chippings with sharp Thames sand, powdered Sicilian rock asphalt and Portland cement, with a binding of Cuban natural asphalt. (8) Tar-macadam, laid by Messrs. Chittenden and Simmons, Limited, the aggregate consisting of Kentish rag, with prepared tar and pitch as the binding medium, the two being mixed hot in a rotary mixer. (9) and (10) Tar-slag macadam, laid by Messrs. Constable, Hart, and Co., Limited, Clarence House, London, E.C. (11) "Tarmac," laid by Tarmac, Limited, of Etlingshall, Wolverhampton. (12) "Roadoleum" asphalt, laid by Mr. W. H. Stansbury, of 37, Moorfields, Liverpool; in this case the aggregate is Penmaenmaur diabase, broken to sizes between 1¾ in. and ⅜ in. The binder is a pure bituminous asphalt marketed by the Anglo-American Oil Company. (13) "Rocmac," laid by Rocmac, Limited, of Central Bank Chambers, Leeds; this consists of the usual Kent County Council aggregate, with "silicate-saccharate-carbonate" as the binding material. (14) Tar-macadam, laid by the Taroads Syndicate, Limited, of 9, Victoria-street, S.W. (15) and (16) Tarmacadam, laid by Messrs. Bristowe and Co., Limited, of 20, Tothill-street, S.W. (17) "Roadamant," laid by the Roadamant Company, Limited, 65, London Wall, E.C. Roadamant consists of refined Trinidad bitumen, natural rock asphalt, stone chippings, and the "roadamant" mixture. (18) "Lithomac" asphalt paving, laid by the Limmer Asphalt Paving Company, Limited, of Caxton House, S.W. This paving consists of crushed granite, sharp sand, and pure limestone, blended with bitumen. (19) "Pitchmac," laid by the Taroads Syndicate, Limited, of 9, Victoria-street, S.W. This is pitch grouted macadam. (20) Natural asphalt matrix, laid by the Val de Travers Asphalt Paving Company, Limited, Hamilton House, London, E.C. This consists of the Kent County Council aggregate, with a binder consisting of Trinidad Lake bitumen, and the natural rock asphalt. (21) "Asphalt macadam," laid by the Val de Travers Asphalt Paving Company, and consisting of natural rock asphalt broken into rectangular pieces and laid without any addition. (22) Trinidad asphalt macadam (3 in. thick), laid by the Trinidad Lake Asphalt Paving Company, Limited, of Townmead-road, London, S.W. In this case the aggregate consists of Channel Island granite bonded with prepared Trinidad Lake bitumen. (23) Trinidad asphalt macadam (4 in. thick), laid by the firm already mentioned. The contract cost of construction per square yard varies from 1s. 9d. up to 7s. 6d., the cheapest being, of course, ordinary water-bound macadam. Tarring the surface costs 1½d. per square yard. The contractors, however, in the case of some of the more costly systems of road construction give free maintenance for several years, whilst others claim that the cost of maintenance is very small. Taking this into account, the total cost of the improved pavements at the end of six years ranges from 9d. up to 19.5d. per square yard; but, so far as the higher figures are concerned, the contractors are in some cases prepared to maintain the surface free for ten years.

The data obtained in this series of experiments should prove of the greatest value, but, unfortunately, some years must elapse before a fair comparison can be made between the competing systems. It would be an immense advantage were any short-time method available for adequately testing them in the laboratory, but the attempt to find a solution to the problem of devising such tests seems hopeless.

THE GERMAN WIRE INDUSTRY.—The convention between German manufacturers of wire and kindred goods, the formation of which was beset by many difficulties, has collapsed, and ceased its functions at the end of June, the members being now free to contract for sales for delivery. This result is regretted by many of its members, as the convention worked fairly satisfactory. The stumbling-block in the way of a renewal of the union was the absolute refusal of several works to submit to any limitation as to production. This, on the other hand, was insisted upon, as far as the large manufacturers were concerned, as a mere price agreement handicaps certain works. Of late there had also been certain price reductions which were at variance with the agreement. The cessation of the convention will probably have an unfavourable effect upon the works which make wire rods.

DOCTORS AND THE MOTOR-CAR.—The motor-car has proved of the greatest utility to medical men, making possible a large increase in radius, as well as considerably augmenting the amount of work possible in a given time, but it is a first essential that the cars should be not only reliable, but easily repaired. Fortunately some cars are now so simple in their construction that the doctors find the work of overhauling and repairing them an enjoyable recreation. We have recently had a report from a practitioner who has himself driven a Wolseley car for close on 50,000 miles, and has just had a motor dismantled. It was the first time that the cylinder had been taken out, and it was found that the deposit on the piston-head was trifling (less than 1 oz.) and that there was scarcely any on the cylinder-head. The piston-rings were all bright, and so were the exhaust-valves, although they had never been ground in, and there was no pitting. There was a little lateral play at both ends of the connecting-rods, but no up-and-down play.

ST. PAUL'S BRIDGE.

TO THE EDITOR OF ENGINEERING.

SIR,—Presuming that the Committee will deal with the question in an exhaustive manner, within their reference, at least, may I mention one or two points on which a pronouncement would be acceptable.

They refer to the high-level character of the proposed bridge. Would not the proposed viaduct over Queen Victoria-street mean the spoiling of one beautiful new street in the making of another?

And, in view of the probability of thoroughfares on the foreshores (the north particularly), between London Bridge and Blackfriars Bridge, would not a co-ordinating alternative be preferable to a repetition of the awkward arrangement on the Embankment at Waterloo Bridge?

In the event of the former, Is an arrangement not possible whereby the existing Southwark Bridge might be dispensed with? and would not the appearance of the river be improved by its removal?

The latter queries refer to a contingency which ought to be taken account of. Reference to it also bears out the force of the contention expressed in your columns last week, that the whole question ought to be viewed in a much wider aspect and delayed to fit in with a larger scheme.

Yours truly,
O.B.I.T.

London, July 10, 1911.

THE EDUCATION AND TRAINING OF ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the report of the discussion at the Conference on the Education and Training of Engineers, which appeared in your journal of the 30th ult., your reporter, in condensing my remarks on specialised entrance examinations, rather missed the point which I endeavoured to bring out, and that is, a boy who passes from a secondary school to an engineering college, and who after a time prepares to matriculate and work for a degree at the London University, ordinarily goes through a very disconnected course in mathematics, for at the secondary school he, in most cases, is taught *pure* mathematics, then at the college *practical* mathematics, and when he commences to prepare for his university examinations he has to again take up pure mathematics. In other words, this is a most wasteful sandwich system, as the change-over in the college from practical to pure invariably leads to his general work receiving a serious set-back; and, no doubt, this has not a little to do with the smallness of the proportion of university matriculated students there are in the leading colleges of the London district. The only satisfactory way I can see of straightening out this unfortunate condition of things is to get the authorities of the secondary schools to arrange for boys who intend to become engineers to receive instruction in *practical* mathematics during, say, the two years before leaving; and, at the other end, to arrange for a further continuity of study by inducing the university authorities to allow engineering students to matriculate and graduate without being obliged to sit in *pure* mathematics; for most engineering colleges have for years wisely realised that mathematics, instead of being an abstract discipline, should become the means of applying truths to the every-day affairs of the world we live in. As to the range of this work, it is safe to say that the excellent syllabus of the Board of Education in practical mathematics covers all the mathematics the engineer is likely to require in ordinary practice.

Yours truly,
HENRY SPOONER.

The Polytechnic, Regent-street, July 12, 1911.

TO THE EDITOR OF ENGINEERING.

SIR,—Recent speakers on the subject of the training of engineers have developed quite a habit of uttering warnings against specialisation; in one instance holding up as an example to be avoided the case of a modern university which has advanced so far as to give a degree in motor-car engineering and to appoint a professor in this subject. The standing of the speakers gives their utterances great weight, and at first sight it would appear that this university is moving on wrong lines; but further consideration shows that these warnings may be quite unnecessary; may, in fact, exert a harmful influence in helping to continue that type of education which produces the bookish-engineering graduate scorned by the practical man.

There is some confusion in the use of the word "specialisation" in this connection. The study of some limited field of engineering knowledge—for example, the heat treatment of metals—is specialisation; and the student would be well advised not to follow such a course to the exclusion of other studies. But the study of some one branch of engineering is not specialisation in this sense; it may be better termed "selection." Such specialisation or selection is to be strongly advocated as sound, educationally and economically.

The student generally devotes the first two years of his college course to the study of mathematics and the fundamental laws of chemistry and physics; afterwards he studies their applications to the problems of engineering under such groupings as strength of materials, heat engines, &c. There is danger here that the student may become a mere theorist, for the teacher unconsciously tends to teach his subject as a subject complete within itself, withdrawing more and more from actual practice as introducing difficulties foreign to his subject. The laboratory work becomes unreal, exercises are so arranged as to illustrate some particular point, and in the end, to take an example, the student may come to think that the theory of heat engines is a series of beautiful abstractions, but has little to do with the actual steam or petrol engine.

If, instead of studying engineering principles in general, the student concentrates on some particular branch, he at once becomes conscious of the need of general and systematic information. The effect is to broaden the field of study and yet to simplify, because the necessity and interdependence of each branch of study is realised. If motor-car engineering is selected, the principles studied, as strength of materials, become of some importance; the student begins to appreciate his ignorance of chemistry and the properties of gases and fluids; he feels the influence of modern developments in steels and alloys. He realises to what extent his theory of heat engines affects design as compared with popular demand, price, and other factors. In short, concentration has broadened his outlook and unified his knowledge. Economically the necessity of concentration is great. The idea that the student leaves college equally ready to take work in a shipyard, tool-room, or on irrigation work, assumes the existence of employers with the willingness and leisure to teach the beginners. This is a mistake. The student will have to teach himself, and his work will be the easier to the extent he has already prepared himself.

Yours truly,
W. MORGAN.

LAUNCH OF SPECIAL-TYPE DESTROYER.—H.M.S. Acheron, a torpedo-boat destroyer of the special type included in the 1910-1911 programme, and built to the design of Messrs. John I. Thornycroft and Company, Limited, was launched recently from this firm's Woolston Works, Southampton. The following are the particulars of the vessel:—Length, 251 ft. 9 in. between perpendiculars; breadth, 26 ft. 4 in. The propelling machinery consists of a twin set of turbines of the Parsons type, designed to give a speed of 29 knots, steam being supplied by three large water-tube boilers fired by oil fuel. The armament consists of two 4 in. and two 12-pounder guns, and the vessel also carries two torpedo tubes. It is noteworthy that this is the first to be launched of the six special destroyers ordered in the Admiralty programme of last year, and the vessel is also the first destroyer to be fitted with a two-shaft arrangement of turbine machinery. Messrs. Thornycroft have a sister vessel, H.M.S. Ariel, on the stocks, which is also in a forward state of completion, and will be ready for launching very shortly.

THE UNITED STATES BATTLESHIP "UTAH."—The battleship Utah, built for the United States Navy by the New York Shipbuilding Company at Camden, New Jersey, and fitted with Parsons turbines, has just completed her speed trials with satisfactory results. The vessel is 510 ft. long, 88¼ ft. beam, and at 28½ ft. draught displaces 21,825 tons. Her armament includes ten 12-in. and sixteen 5-in. guns, besides smaller machine-guns. The designed horse-power of the main turbines was 28,000 shaft horse-power, and this, it was anticipated, would give a speed of 20¾ knots. The measured-mile progressive speed tests included twenty runs in all over the measured distance of the Rocklands course—three runs at 10 knots, 12 knots, 19 knots, and 20¾ knots, with five at the highest possible speed, followed by three at 16½ knots. The actual speeds on these progressive runs were 10.556 knots, 12.015 knots, 19.049 knots, 21.228 knots, and 16.799 knots. The full speed was thus 21.228 knots, and was attained with the turbines running at 309 revolutions per minute, and developing 28,477 shaft horse-power. The Utah is practically finished, only 1.6 per cent. of the work remaining to be done, and she will probably go into commission about August 16.

PERSONAL.—The business of "Acer," Limited, cylinder-grinding specialists, of Hanwell, has been transferred to larger and more suitable premises at Leaborne Works, Harrow. The company has recently prepared for distribution a revised price-list.—The Electric and Ordnance Accessories Company, Limited, Cheston-road, Aston, Birmingham, is now represented, so far as its electric manufactures are concerned, in and round the city of Sheffield, for a radius of 10 miles, by Mr. H. E. Ridley, 104, Marlcliffe-road, Sheffield. The agency for the Vickers centrifugal fans will remain, as before, in the hands of Mr. J. Crawford, Manchester.—Messrs. Jno. Hy. Andrew and Co., Limited, Toledo Steel Works, Sheffield, have appointed Messrs. Bernard Holland and Co, 17, Victoria-street, S.W., to act for them in London and district, so far as the British Government Departments, railway companies, engineers, shipbuilders, contractors, &c., are concerned, the arrangement hitherto existing between Messrs. Campbell, Macmaster, and Co., 11 and 12, Clements-lane, E.C., and themselves having expired.—It is publicly announced that, in consequence of the death of the late Sir John Aird, the businesses of Messrs. John Aird and Sons and the Westminster Construction Company, Limited (of which the late Sir John Aird was chairman from its formation in 1899), have been amalgamated, and will in future be carried on under the registered style and title of "Airds, Limited." There will be little change in the management or staff. The chairman of Airds, Limited, is the present Sir John Aird, and the managing director Mr. Malcolm R. Aird.—We are informed by Messrs. J. Wardell and Co, manufacturing agents and merchants, that, on the 12th inst., they removed their offices to Westminster Chambers—namely No. 3, Victoria-street, Westminster, S.W. Their telephone number and telegraphic address will be as before.—Messrs. John Williams and Co., iron and steel manufacturers, Wishaw, Scotland, have appointed Mr. H. B. Sparrow, 65, Fenchurch-street, E.C., their sole agent in London.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was firm, but quite idle. Quotations for Cleveland warrants were nominally higher at 46s. 5d. cash, 46s. 8d. one month, and 47s. 1½d. three months sellers. In the afternoon a good tone again prevailed, and 3000 tons of Cleveland warrants were done at 46s. 5d. and 46s. 6d. cash, 46s. 7½d. one month, and from 47s. 1½d. to 47s. 2½d. three months. At the close sellers quoted 46s. 6d. cash, 46s. 9d. one month, and 47s. 2½d. three months. On Friday morning the market was quiet but strong, and Cleveland warrants improved in value. The turnover was 2500 tons at 46s. 7d. cash and 46s. 10d. one month, and closing sellers' prices were 46s. 7½d. cash, 46s. 10½d. one month, and 47s. 4½d. three months. Buyers of hematite offered 60s. 10½d. cash and 61s. 9d. three months, and sellers quoted 62s. three months. In the afternoon Cleveland warrants continued to improve, and 2000 tons changed hands at 46s. 11½d. and 47s. one month, and at the close the quotations were 46s. 9½d. cash, 47s. one month, and 47s. 6d. three months sellers. On Monday morning the tone was strong, and 3000 tons of Cleveland warrants were dealt in at 47s. and 47s. 1d. cash, 47s. 1d. fourteen days, and 47s. 1½d. eleven days. Closing prices were up to 47s. 0½d. cash, 47s. 3½d. one month, and 47s. 9d. three months. Hematite was also strong, and 2000 tons changed hands at 61s. 3d. and 61s. 2d. cash, and 62s. three months. The cash closing quotation was 61s. 3d. sellers and 61s. 1d. buyers. In the afternoon the market maintained its good tone, and 2500 tons of Cleveland warrants were done at 47s. 0½d. cash, and 47s. 9d. three months. At the close there were sellers at 47s. 1d. cash, 47s. 4d. one month, and 47s. 9½d. three months. Hematite was firm, and 500 tons were dealt in at 62s. 2d. three months, with sellers over, and buyers at 62s. 1d. For the cash position buyers offered 61s. 2d., and sellers quoted 61s. 3d. On Tuesday morning prices fell away a little, and the dealings consisted of 2000 tons of Cleveland warrants at 47s. and 46s. 10½d. cash, and 47s. 2d. and 47s. 1½d. one month. Closing sellers quoted 46s. 11d. cash, 47s. 2d. one month, and 47s. 8d. three months. An easier tone again prevailed in the afternoon, when Cleveland warrants to the amount of 7500 tons were put through at from 46s. 10d. to 46s. 8½d. to 46s. 9d. cash, and at 47s. one month. Sellers' closing quotations were down to 46s. 9d. cash, 47s. one month, and 47s. 6d. three months. When the market opened to-day (Wednesday), the tone improved, and 1500 tons of Cleveland warrants were put through at 46s. 11d. cash, 47s. 2d. and 47s. 1½d. one month. At the close there were sellers at 46s. 11d. cash, 47s. 2d. one month, and 47s. 7½d. three months. In the afternoon the market was firm, and Cleveland warrants were the turn harder. The turnover amounted to 3000 tons at 47s. twelve days, 47s. 3d. August 23, and 47s. 8d. three months, and closing sellers quoted 46s. 11d. cash, 47s. 2½d. one month, and 47s. 8d. three months. Cash sellers of hematite quoted 61s. 6d. The following are the market quotations for makers' (No. 1) iron:—Clyde, 60s. 6d.; Calder and Gartsherrie, 61s.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 64s.; Shotts (at Leith), 62s.; and Carron (at Grangemouth), 63s.

Sulphate of Ammonia.—The demand for sulphate of ammonia has again become stronger, and the price has advanced. The current quotation is now 13*l.* 12s. 6d. per ton for prompt lots, Glasgow or Leith, which is 5s. up from last week, and 15s. above the lowest point touched this year.

Scotch Steel Trade.—As is usual, the approach of the annual Fair Holidays has made the Scotch steel-makers rather busier, and there is some pressure to get orders hurried out before the works close on Friday at noon. Specifications for ship-plates have been plentiful during the past week, and the demand for boiler-plates has also been very good, but, on the other hand, no improvement has been shown in the demand for angles. Fresh business continues scarce, but contracts on hand are sufficient to keep the various establishments employed for some time. Light steel and sectional material are in fairly good request, and makers are being kept fairly busy this week. The majority of the steel works will resume after the holidays, on Monday morning, the 24th inst.

Malleable-Iron Trade.—In the malleable-iron trade business has been more active this week, but the tone of the trade has not improved. New orders are not very numerous, despite the fact that bars are still being offered on the basis of 6*l.* per ton, less 5 per cent. The holidays will be practically the same as those in the steel trade.

Scotch Pig-Iron Trade.—The local demand for the ordinary qualities of Scotch pig iron has lately been very moderate, and that from the South has not quite come up to expectations. There is a little more doing in export orders, but in this connection also there is room for improvement. Deliveries generally are more satisfactory this week on account of the approaching holidays. The demand for Scotch hematite is still very poor, and the price is nominally 65s. per ton.

INDIAN WATER-WORKS.—The proposals of the municipality of Cawnpore for the extension of the city waterworks have been approved by the Government of the United Provinces. The scheme includes a large multiple filtration plant for dealing with the water of the Ganges. The filters will have a capacity of 7,000,000 gallons per 24 hours. The consulting engineers are Messrs. H. Chabal, E.C.P, of Paris, and Walter Clemence, M.I. Mech. E., London.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Engineering Competition.—Although having more work in progress than at the same time last year, it was stated at the recent annual meeting of Messrs. Davy Brothers, Limited, engineers, Sheffield, that the financial result was short of expectations. Stress was laid upon the fact that in engineering, as in other big branches of trade, modern conditions are very much against big profits. The company was busily engaged last year, but the return for the work done was upon a much lower level of value. Amongst the factors pointed to as explaining this condition of affairs were low selling prices, increased cost of raw materials, keen foreign competition, and difficulties in foreign markets. However, the managing director of the company went so far as to give a hopeful expression of opinion upon the future.

South Yorkshire Coal Trade.—The labour unrest in the shipping world, which, of course, particularly affects the coal market, has had a considerable influence upon the position of affairs, which the coal trade still feels. The congestions at sidings and the accumulations of stock at collieries have both upset normal working. Manufacturing inquiries have been good, and are likely to be better when all the works have completed stocktaking. There has not been much underselling, prices remaining very steady. The majority of gas-coal consumers have fixed up their contracts and some are already taking additional supplies. The demand for slacks is quite as large as the collieries can cope with, and some qualities are higher priced. Stronger quotations are also made for coking smalls. The house-coal market remains quiet, and there is little buying, even of lots favourably offered. Most collieries are working half-time, and have considerable stocks on hand. Prices are firm and a good number of contracts have been arranged at current figures. Recent Change quotations are: Best branch hand-picked, 13s. to 14s.; Barnsley best Silkstone, 11s. to 12s.; Silkstone, 9s. to 10s.; Derbyshire house, 8s. to 9s.; large nuts, 7s. 3d. to 9s.; small nuts, 5s. 6d. to 6s. 6d.; Derbyshire brights, 10s. to 11s.; Yorkshire hards, 8s. 3d. to 9s. 6d.; Derbyshire, 8s. to 9s.; washed nuts, 7s. 9d. to 8s. 9d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. to 5s.; smalls, 1s. 6d. to 2s. 6d.

Iron and Steel.—The quietness in the iron market, usual at the period of the half-yearly stocktakings, has extended over into the present week. It remains to be seen what sort of effect the quarterly meeting at Birmingham will have upon the situation. Prices of hematites have been easier, particularly East Coast, and it is stated that in some instances buyers have obtained substantial advantages. The West Coast qualities remain about the same. The market for common irons shows little change, but competition has brought about a weakening of prices. Some undercutting by Derbyshire makers has placed Lincolnshire producers at a disadvantage. Competition continues to run high also in the billet trade. The home makers can, of course, do nothing to avert the influx of cheap Continental material, and consumers, in these days of cut profits, naturally favour the cheaper article. Bar iron makers remain fairly employed, with a somewhat better outlook. The position, however, does not warrant any alteration in the standing quotations. Steel-makers are favoured by the low price of tungsten, although this material has been a little firmer on the week. There is a good deal of uneasiness in the local steel trades upon the possible effects of the Government's insurance proposals. The present aspect of the steel trades is good, if business is not evenly distributed. The heavy branches show the most pronounced activity, and big quantities of armour-plate and gun-forgings are being turned out by the three East End houses. In some directions inquiries are hardly satisfactory, but the great majority of the makers have well-filled order-books, particularly the manufacturers of special steels. The foreign demand for this class of work has extended so much in recent years that what might almost be termed the monopoly of a few local firms has disappeared. First one manufacturer and then another has turned his attention to this branch until competition is now very keen, and profits are not so easily obtained as heretofore. In twist-drills and various kinds of mining tools and special steels, engineers' and shipbuilders' tools, and all kinds of high-speed steels, the inquiry continues to grow. Complaints are met with that the prices of many finished articles are not commensurate with the increased cost of raw materials.

WATERPROOFING CEMENT.—Messrs. Kerner, Greenwood, and Co., timber and builders' merchants, King's Lynn, have, we understand, now acquired sole control of the well-known waterproofing powder "Solita." They have registered it under the name of "Pudlo," considering it a better name, and in future it will be known by this name. They have prepared for distribution a little booklet on the subject, and will also answer any inquiry regarding the material. "Pudlo" is a white powder, which, when mixed with cement, makes it waterproof. The method of mixing and applying is as follows:—The cement is spread upon the floor, out of the wind, and the "Pudlo" is sprinkled over it through a fine sieve, is then shovelled well into the cement, the process being repeated until about 5 lb. in weight of "Pudlo" is mixed with about 100 lb. in weight of cement. Sand and water are then added to the cement in the usual way, the result being that the mixture is made absolutely waterproof. Messrs. Kerner, Greenwood and Co. have been selling this product for some considerable time, and have, they say, thoroughly tested the material. The British Government have, we understand, tried it for keeping heads of water back in fortifications.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The pig-iron market is steady, and, on the whole, the situation is satisfactory for this time of year, which is usually a quiet season. Prospects are regarded as fairly bright, and most traders predict that the autumn will be characterised by considerable briskness. There are certainly grounds for taking a hopeful view of the future. Favourable reports continue to come to hand from the United States, and they should have some beneficial influence on the market. The most gratifying feature of the position, however, is the fact that the output of pig iron is well taken up, and as the season advances the make should be considerably more than fully absorbed, so that if production is not increased substantial reductions in stocks may be announced shortly. No. 3 g.m.b. Cleveland pig is steady at 47s. f.o.b.; whilst No. 1 is 50s. 3d.; No. 4 foundry and No. 4 forge each 46s. 6d.; and mottled and white iron each 46s. 3d.—all for early delivery. A rather better feeling in East-Coast hematite pig is reported. There are one or two inquiries in the market, but so far as can be ascertained, they do not appear to have, as yet, resulted in business. Mixed numbers can still be obtained from both makers and merchants at 61s. 6d., and that is the general market quotation. Business in foreign ore is at a standstill. Rubio, of 50 per cent. quality, is quoted 19s. to 20s. ex-ship Tees, and other descriptions of foreign ore are in the usual proportion. There is a fairly heavy demand for coke for local use, and requirements are met by a very full supply. Average blast-furnace qualities stand at 14s. 6d. delivered here.

Blastfurnacemen's Wages.—The average net selling price of No. 3 Cleveland pig iron for the three months ending June 30 last has been certified at 49s. 0.16d. per ton, as compared with 49s. 6 86d. for the first quarter of the year. There was, therefore, a reduction in price of 6.70d. per ton in the second quarter of the year. This means a reduction in blastfurnacemen's wages in the North of England of 0.50 (half of one) per cent., and brings wages from 21.75 per cent. above the standard to 21.25 per cent. above the standard.

Cleveland Miners' Wages.—At the quarterly meeting of the Cleveland Ironstone mine-owners and the miners' representatives, held at Middlesbrough this week, the owners stated that they regarded 26¼ per cent. as the standard of the wages that should be paid during the ensuing three months, against 27½ per cent., which had prevailed during the past quarter. A further meeting will be held on the 24th inst.

Trade Statistics.—The quarterly returns of the Middlesbrough Chamber of Commerce show that at the end of June of 79 furnaces built within the port of Middlesbrough 54 were in operation. The estimated output for the second quarter of the year is given at 580,000 tons, of which 380,000 tons was Cleveland pig iron, and 200,000 tons hematite, spiegel, basic, and other special irons. For the previous three months the total make was given at 600,000 tons, and for the second quarter of last year at 570,000 tons. The imports of foreign iron ore into Middlesbrough last quarter totalled only 436,926 tons, as compared with 549,742 tons for the previous three months, and 558,748 tons for the second quarter of 1910. The total value of goods other than coal and coke exported to foreign and colonial destinations from Middlesbrough during last quarter amounted to 2,122,575*l.*, and for the half-year to 4,225,793*l.*, being an increase for the quarter as compared with the corresponding time last year of 474*l.*, and an increase for the half-year as compared with the first half of last year of 295,120*l.*

Manufactured Iron and Steel.—There is not much new to report concerning the various branches of the manufactured iron and steel industries. New orders come slowly to hand, but producers of most descriptions have good contracts made, and values all round are well maintained. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 15s.; iron ship-plates, 6*l.* 12s. 6d.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron girder-plates, 6*l.* 17s. 6d.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; and steel joists, 6*l.* 7s. 6d.—all less the customary 2½ per cent. discount. Cast-iron railway chairs are 3*l.* 12s. 6d.; cast-iron columns, 6*l.* 10s.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; and steel railway sleepers, 6*l.* 10s.—all net cash at works. Iron and steel galvanised corrugated sheets, 24-gauge, in bundles, are 10*l.* 12s. 6d. to 10*l.* 15s. f.o.b.—less the usual 4 per cent.

CONTRACTS.—We understand that the Midland Railway-Carriage and Wagon Company, Limited, have accepted the tender of Messrs. Belliss and Morcom, Limited, for the equipment of the central power generating-station at their new works at Washwood Heath, Birmingham, to the specifications of Messrs. D. and A. Home-Morton, MM. Inst. C.E., MM.I. Mech. E., consulting engineers, Glasgow and Birmingham.—The Mirrlees Watson Company, Limited, Glasgow, have recently booked a large number of orders for surface-condensing plants and jet-condensing plants, complete, also for accessory machinery for same, both for this country and abroad, several items being repeat orders.—Messrs. Fraser and Chalmers, Limited, inform us that they have this week booked an important order for two turbines and blowers for the Stanton Iron-Works Company, Stanton, near Nottingham, to work in conjunction with existing reciprocating engines in connection with their extensive blast-furnaces.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has ruled quiet. Colliery owners have shown no disposition to reduce prices for the best or second Admiralty coal for shipment before the August holidays; for other descriptions, however, slight concessions have occasionally been made for prompt loading. The best large steam coal has made 18s. 6d. to 19s. per ton; secondary descriptions have ranged from 16s. to 17s. 9d.; best bunker smalls from 10s. to 10s. 6d., and cargo smalls from 8s. 3d. to 8s. 9d. per ton. House coal has shown scarcely any change; the best ordinary descriptions have been quoted at 14s. 6d. to 16s. 6d. per ton, No. 3 Rhondda large at 17s. to 17s. 6d., and smalls at 10s. 6d. to 10s. 9d. per ton. No. 2 Rhondda large has brought 11s. 9d. to 12s. 3d., and smalls 8s. to 8s. 3d. per ton. Foundry coke has been quoted at 18s. to 20s. 6d. per ton, and furnace ditto at 16s. to 17s. per ton. As regards iron ore, Rubio has been making 18s. 6d. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Dowlais.—The Dowlais works have been well employed. The Goat Mill has been engaged on heavy sections of steel rails and tin-bar, and the Big Mill has been turning out fish-plates to accompany the heavy rails run off at the Goat Mill, as well as light railway *matériel* for pit-top use, curves, angles, &c.

South Wales Coal.—The shipments of coal—foreign and coastwise—from the six principal South Welsh ports—Cardiff, Newport, Swansea, Port Talbot, Neath, and Llanelly—in the first half of this year were as follows:—Cardiff—foreign, 7,992,922 tons; coastwise, 1,309,322 tons; total, 9,302,244 tons. Newport—foreign, 2,286,486 tons; coastwise, 355,764 tons; total, 2,642,250 tons. Swansea—foreign, 1,405,391 tons; coastwise, 136,383 tons; total, 1,541,774 tons. Port Talbot—foreign, 800,325 tons; coastwise, 70,061 tons; total, 870,386 tons. Neath—foreign (estimated), 80,000 tons; coastwise (estimated), 90,000 tons; total, 170,000 tons. Llanelly—foreign, 79,806 tons; coastwise, 24,958 tons; total, 104,764 tons. The aggregate shipments for the six months were, accordingly, 14,631,418 tons.

South Wales Mining Students.—A party of about thirty South Wales mining students left Cardiff on Saturday for the coal and iron mines of Silesia. The arrangements for this, the eighth tour of a Continental coal-field, were made through the officials of the Glamorgan County Council, assisted by Herr Williger, a Silesian engineer.

SIXTH CONGRESS OF THE INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS, NEW YORK AND WASHINGTON, U.S.A.—The sixth Congress of the above Association will be held at New York and Washington in the beginning of September, 1912, under the auspices of the American Society for Testing Materials. Professor H. M. Howe, President of the Association, will act as President of the Congress, and Professor E. Marburg, of Philadelphia, as Secretary. The Congress will be divided into the Sections A, Metals; B, Concrete, Cement, Stone; C, Miscellaneous. The manuscripts of papers to be presented at the Congress must be sent in to the head office of the Association, Nordbahnstrasse 50, Vienna II., not later than January 1, 1912. Members desirous of taking part in the Congress are requested to notify their intention as soon as possible to the representative of the Association for Great Britain, Mr. G. C. Lloyd, Secretary of the Iron and Steel Institute, 28, Victoria-street, London, S.W.

EIGHTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY, WASHINGTON AND NEW YORK, U.S.A.—The Eighth International Congress of Applied Chemistry will be held in Washington and New York, U.S.A., from September 4 to 13, 1912, under the patronage of the President of the United States. The Hon. President of the Congress is Professor Edward W. Morley, Sc.D., Ph.D., LL.D.; the President is Mr. William H. Nichols, Sc.D., LL.D., and the secretary Dr. Bernhard C. Hesse, 25, Broad-street, New York City. The Congress is divided into twenty-four sections and sub-sections. Papers will be accepted for reading and discussion in all the sections, preference being given to those specially adapted for international discussion. They must be sent in not later than July 1, 1912. A preliminary pamphlet has been issued, and may be obtained from the hon. secretary of the British Organising Committee, Mr. Charles G. Cresswell, Society of Chemical Industry, Palace Chambers, Westminster, S.W.

ADMIRAL TOGO'S VISIT TO MESSRS. VICKERS' WORKS.—Admiral Togo, accompanied by his suite and the naval and some other members of the Japanese Embassy, left London on Saturday, the 8th inst., for Barrow-in-Furness, to visit the naval construction works of Messrs. Vickers, Limited. Mr. Albert Vickers, the chairman, and Sir Trevor Dawson, managing director of the company, also accompanied him. The works at Barrow have special attractions for Admiral Togo. It was there that the Vickers Company designed and built his flagship during the late war, the Mikasa, while later the Katori was completed for the navy of the Mikado. At present there is in course of construction at Vickers' works an armoured cruiser which is expected to surpass in all fighting qualities any warship yet laid down. This vessel, with which considerable progress has been made, has been designed by Mr. T. G. Owens, the naval constructor and director of the company. On Monday Admiral Togo inspected the vessel and her turbine and ordnance machinery, and was also present at gun trials at the company's range at Eskmeals, on the Cumberland coast.

THE PHYSICAL SOCIETY OF LONDON.

AT the meeting of the Physical Society of London, held on June 9, 1911, at the Imperial College of Science, Professor H. L. Callendar, F.R.S., in the chair, a paper on "*The Lüders Lines on Mild Steel*" was read by Mr. W. Mason.

Previous investigations have shown that Lüders' lines on specimens of mild steel and wrought iron, strained in tension, are inclined at about 50 deg. to the axis of pull. For tests in compression the information available is not precise, and though the angle of the lines with the direction of the compression is commonly understood to be about 40 deg., some doubt has been thrown on this point.

The author had found previously that the lines are well developed on the surface of mild-steel tubes. Since it was easy to obtain a compressive stress of practically uniform distribution in tubes under end pressure, while at the same time a hoop tensile stress could be induced by internal fluid pressure, the author confined his attention to the lines on tubular specimens. These were of mild steel, either hot or cold drawn, and most of them were annealed. They varied in bore from 2½ in. to 3 in., and in thickness of wall from about 0.08 in. to 0.125 in. Four sets of tubes were tested under end-loading, simultaneously (for the most part) with internal water-pressure, these loadings being so arranged as to give at the yield-point ratios of the longitudinal compressive stress to hoop tensile stress ranging from 0.25 to ∞.

The Luders lines on the outer surface appeared at the yield-point indicated by the extensometer—*i.e.*, their appearance coincided with the commencement of the large "yield" strain. In all cases where there were lines on the inner and outer surfaces of a tube, an inner and outer line, and also the ends of these lines, were found to be radially opposite, showing that the lines were traces of surfaces or canals of disturbance which passed through the tube-wall, and indicating, moreover, that the disturbance spread spirally onwards, and not outwardly from a line initially formed on the more severely stressed inner surface.

The inclination α of the lines to the axis of the tube was found to vary in the following way for tubes under end load and internal pressure:—

$$\text{For } \frac{\text{longitudinal stress}}{\text{hoop stress}} = 0.25,\ \alpha = 42 \text{ deg. (about)}.$$
$$\text{,, ,, ,, } = 1,\ \alpha = 45 \text{ deg. (about)}.$$
$$\text{,, longitudinal ,, stress only, } \alpha = 50 \text{ deg. (about)}.$$

For values between 0.25 and 1, and between 1 and ∞, α became progressively larger.

Some tests of tubes under external water pressure and longitudinal tension gave results similar to those above mentioned. The directions of the lines with respect to the axes of like stress were practically the same, though the inclinations to the axes of the tubes were now complementary to the values of α quoted above.

The conclusion is drawn that the Lüders surfaces have the same or approximately the same inclination to an axis of simple pull or simple push. With stresses of opposite sign at right angles to each other the lines and surfaces are more inclined to the stress of greater intensity, and with equal intensities the surfaces are at about 45 deg. The author suggests that if a shear stress of given intensity be the only condition for that spreading of plastic strain which commences at the yield-point, then there is no reason why there should be any variation in the angle of the Lüders lines and surfaces. The variation suggests that not only the maximum shear stress—*i.e.*, the half difference of the greatest and least principal stresses—but also the magnitudes of the principal stresses, are factors in producing the yielding condition in mild steel.

Dr. Chree said Lüders' lines seemed to possess a double interest. If their first existence coincided in time with the ending of linearity in the stress-strain relation, their presence intimated that the ordinary mathematical equations had ceased to apply. In this connection their utility would be greater if the stress function supposed to determine the elastic limit were greatest at a point or small area visible to the eye, instead of, as in the present case, over the whole inner surface of a cylinder. The phenomenon seemed, however, also interesting in itself. The nature of the change in the material and the mode of propagation of the altered volume would be more easily studied if the altered material could be recognised in sections of the cylinders.

Professor Coker asked whether the lines were a surface phenomenon produced by the stresses in the oxide.

Professor C. A. M. Smith pointed out that slipping in the material takes place in a definite manner, even after quite a long time, and that the lines might be due to this.

Mr. E. H. Rayner pointed out that the elastic constants in the two directions would probably be different, and that the compression might put on shear, resulting in lines only appearing in one direction.

Dr. A. Russell asked the author if his results threw any light upon the phenomena obtained when wires are drawn.

Mr. Maclachlan asked the author if he had ever tried polishing the surface of his tubes. His own experiments made on the compression of solids showed that the lines were not always spirals, but approximated to a section of the cylinder made by a plane inclined at 45 deg.

The author, in reply, stated that he did not know whether the lines occurred at the elastic limit, or just after. The lines were not a surface phenomenon, as they were obviously related to the bend in the stress-strain diagram. Mr. Rayner's difficulty was got over by reversing the stresses. The lines were not due to massive slipping, but to the propagation of a disturbance.

A paper on "*A New Method of Harmonic Analysis by Averaging Selected Ordinates*" was read by Professor S. P. Thompson.

Assume with Fourier that the curve representing any periodic single-valued function of x may be expressed by the harmonic series

$$y = A_1 \sin x + A_2 \sin 2x + A_3 \sin 3x + \ldots + B_1 \cos x + B_2 \cos 2x + B_3 \cos 3x.$$

Then to find the coefficient of any term, A_n or B_n, it suffices—subject to a limitation stated below—to measure off on the curve $2n$ equidistant ordinates over one period; that is, spaced at successive intervals apart of π/n. Then, having reversed the sign of every alternate ordinate, the simple algebraic mean of them gives the coefficient sought. For cosine-coefficients the first ordinate must be taken at the origin; while for sine-coefficients the first ordinate must be taken at a point $\frac{1}{2}\frac{\pi}{n}$ from the origin. In symbols this is—

$$A_n = \frac{1}{2n}\left\{ \begin{array}{c} y_{\frac{1}{2}\pi/n} - y_{\frac{3}{2}\pi/n} + y_{\frac{5}{2}\pi/n} - y_{\frac{7}{2}\pi/n} + \ldots \\ - y_{\frac{4n-1}{2}\pi/n} \end{array} \right\};$$

$$B_n = \frac{1}{2n}\left\{ \begin{array}{c} y_0 - y_{\pi/n} + y_{2\pi/n} - y_{3\pi/n} + \ldots \\ - y_{(2n-1)\pi/n} \end{array} \right\}.$$

The limitation is that if, in finding the nth harmonic, there be present also the 3nth, or the 5nth, or the 7nth, &c., these will be included in the average found by the process, and must, if present, be separately determined and eliminated.

The process is much facilitated by the use of templates of transparent celluloid having equispaced vertical lines engraved upon them. They are laid down on the curve, and the values of the selected ordinates are thus readily measured off. For analysis of valve motions, of alternating-current curves, of tidal observations, and diurnal magnetic variations, the method presents certain advantages, as it requires no multiplication of ordinates by sines or cosines.

The President commented upon the extreme ease with which the method adapted itself to the analysis of experimental curves.

Dr. Russell remarked that the method can be usefully employed in interpolation as well as in harmonic analysis. In this connection he gave a brief *résumé* of Gauss's extension of Lagrange's interpolation formula. He also pointed out certain cases in which Fourier's analysis fails to be of practical use.

Sir G. H. Darwin communicated the following remarks:—In 1874 Mr. Archibald Smith published, in the Admiralty Scientific Manual on "Deviations of the Compass," schedules whereby the multiplications in the usually accepted process are simple. This same arrangement has been in use for the harmonic analysis of tides since 1870; and in his "Manual of Tidal Observations," Major Baird gave multiplication tables for the sines of 15, 45, 60, 75 deg., which render this part of the work so easy that avoidance of all multiplication hardly seems necessary. In 1884, in "Tables and Formulæ to Facilitate the Computation of Harmonic Coefficients," General Sir Richard Strachey gave rules which reduce the multiplications still further. In both these schemes Professor Thompson's principle is used for some of the higher harmonics. Smith's and Strachey's schedules are arranged for 24 hourly values, but they may be equally well used for 12 ordinates. Schedules for the use of any other number of ordinates would have to be prepared specially, and in such cases Professor Thompson's rules might prove very convenient.

A "*Demonstration of the Subjective Nature of the Difference Tone*" was given by Professor S. P. Thompson.

Two tuning-forks of frequencies 3328 and 3584 were sounded loudly. On striking the second the difference tone was heard, but while the notes from the two forks seemed to come in a definite direction from an external source, the difference tone seemed to be located in the ear itself.

A demonstration of "*Spinning-Tops and Gyroscopic Apparatus*" was given by Sir George Greenhill.

A 52-in. Otto bicycle-wheel was shown mounted on an axle with ball bearings, and spun by hand with the point in a small cup, to serve as a spinning-top visible to a large audience.

The gyroscopic apparatus is made of an ordinary 28-in. bicycle-wheel, the axle screwed into a stalk of a short length of rifle barrel, suspended from a lug on a bicycle hub; the hub is fastened to an iron bracket, which is bolted to the underside of a beam or sleeper, large enough to absorb vibration, and resting on two step-ladders. The wheel is spun by hand, and the axle is projected to obtain any desired gyroscopic motion, undulating, looped, or with cusps.

The wheel can be detached by unscrewing the pin through the lug, and can then be used like the large wheel as a spinning-top, or as the "Top on the top of a Top" described in "Maxwell's Life."

If the wheel be put out of balance by a bar through the spoke and the axle be held, it will serve as a pendulum, making oscillations however large, or complete revolutions; and the effect may be investigated of varying the angle of the axle with the vertical.

"*A Model Illustrating the Passage of a Light Wave Through Quartz*," constructed by Professor H. N. Allen, of Poona, was described by Dr. H. S. Allen.

If a crystal is so cut, and a wave sent through it in such a way as to avoid separation of the two component waves by double refraction, it is easy to construct models showing how a vibration gradually alters in form as it passes through the crystal. The model exhibited illustrates the passage of a wave originally plane polarised through a crystal which rotates the plane of polarisation of light sent along its axis (quartz). The direction of propagation is oblique to the axis of the crystal. It is assumed that the crystal has been cut so that the surface of incidence is perpendicular to the direction of propagation of the wave. As the wave progresses the linear vibration opens out into a counter-clockwise elliptical one, while the major axis of this ellipse rotates in the counter-clockwise direction. The minimum ratio between the axes is reached when the retardation is half-a-period. A retardation of a whole period gives a linear vibration again, and so on. If the model is cut by a series of parallel planes the sections give the form of the elliptic vibration as the wave travels through the crystal. The instantaneous wave forms can be drawn on the surface of the model.

A paper on "*The Measurement of Contact Differences of Potential*," by Professor A. Anderson and Mr. J. E. Bowen, was taken as read.

The paper describes two methods of measuring the contact differences of potential of pairs of metals. The first, or deflection, method depends on the property which a radioactive source has of destroying a field of electrostatic force in air, and the second, or null, method on the possibility of determining by means of such a source whether such a field exists between two plates at zero potential. Measurements were made on 10 different metals, and it was found that both methods gave practically the same results provided that the time which was allowed to elapse between the two measurements was sufficiently small. The addition law was verified.

A paper entitled "*A Short Table of Circular and Hyperbolic Functions for Complex Values of the Argument*," by Mr. A. Johnstone, was also taken as read.

FOREIGN ENGINEERING PROJECTS.

WE give below a list of colonial and foreign engineering projects, for several of which tenders are asked. Further data concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C.

Canada: H.M. Trade Commissioner for Canada reports that estimates are being prepared for water-works extensions at a town in Ontario, at a probable cost of 1,000,000 dols. (about 205,000*l.*). The Imperial trade correspondent at Toronto (Mr. F. W. Field) reports that a company, with a capital of 10,000,000 dols. (about 2,055,000*l.*), has been granted a charter to manufacture all kinds of sales books, cheque books, wooden wares, paper wares, registers, &c. A company has been formed with a capital of 3,500,000 dols. (about 718,000*l.*) for the purpose of manufacturing railway locomotives and rolling-stock and also all kinds of steam, gasoline, oil, and other engines. A company has been incorporated, with a capital of 2,000,000 dols. (about 411,000*l.*), for producing and refining petroleum and its products, and for mining metals, ores, and minerals. It is also granted the right to manufacture soap, candles, perfumery, and toilet articles. With reference to the notice on page 44 ante, relative to a call for tenders for the construction of a breakwater, and of wharves, the dredging of a channel and basin, and the construction of a dry dock and ship-repairing plant of the first class at St. John Harbour East (Courtenay Bay), H.M. Trade Commissioner for Canada has forwarded a copy of the specifications, form of tender, &c., which may be seen by British firms at the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall street, London, E.C. Tenders will be received by the Secretary, Department of Public Works, Ottawa, up to 4 p.m. on August 10.

Spain: The *Gaceta de Madrid* of June 24 notifies that the "Sociedad Anónima Tranvía de Orihuela à Crevillente" has applied to the General Directorate of Public Works for a concession for the construction and working of a steam tramway from Orihuela to Crevillente. It is proposed that two years be allowed for the completion of the line. The initial rolling-stock will comprise four locomotives, four first class and ten second-class coaches, four covered and eight uncovered wagons.

Sweden: The British Vice-Consul at Nyköping (Mr. A. Helander) reports that tenders are invited by the Swedish State Railways Administration for the construction of a new line between Enstaberga (outside Nyköping) and Aby (outside Norrköping). Tenders should be marked "Anbud a anläggande af järnväg mellan Enstaberga och Aby, Registratorns Byra," Stockholm, where they will be received up to noon on August 15. The new line, which is to be opened for traffic not later than September 1, 1915, will pass through mountains, and considerable blasting operations will be necessary. Copies of the drawings, specifications, &c. (in Swedish) can be obtained by British firms through the British Vice-Consulate, Nyköping, on payment of the sum of 3*l.*, the greater part of which will be returned upon receipt of a *bonâ-fide* tender.

Italy: Referring to the notice on page 739 of our last volume relative to the construction of a breakwater and kindred works in Catania Harbour, the *Gazzetta Ufficiale* (Rome) of June 26 notifies that, as no award has been made in respect of this contract, tenders are again invited, and will be opened on July 24 simultaneously at the Ministero dei Lavori Pubblici, Rome, and at the Prefettura di Catania, Catania. The upset price is put at 2,450,000 lire (98,000*l.*), and a deposit of 120,000 lire (4800*l.*) will be required to qualify any tender. Although this contract will doubtless be awarded to an Italian firm, nevertheless the carrying out of the work may involve the purchase of some materials out of Italy.

ROAD LOCOMOTIVES.—The value of the road locomotives exported from the United Kingdom in April was 42,496*l.*, as compared with 40,157*l.* in April, 1910, and 29,968*l.* in April, 1909.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

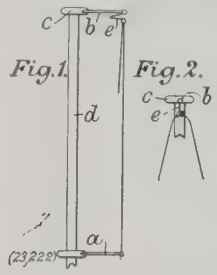
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

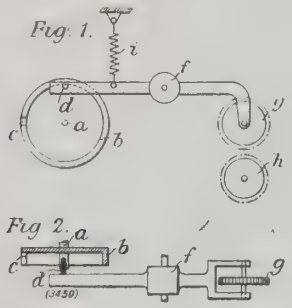
ELECTRICAL APPARATUS.

23,222/10. G. Ludecke and the Imperial Lamp Works (Brimsdown), Limited, Brimsdown. Electric Lamps. [5 *Figs.*] October 7, 1910.—The invention consists in providing, in connection with the rigid upper supporting arms for the filament, secondary supports of thin wire bent to an acute angle and each of the arms of which is equally inclined to the filament, the arrangement being such that contractions or



vibrations of the filament are compensated for by movement of the arms. The rigid lower supporting arms *a* and rigid upper supporting arms *b* are connected to the beads *c* of the central glass stem *d*. To the arms *b* the secondary supports *e* of thin wire are connected. In order to prevent too sharp bending of the filament, the secondary supports *e* are provided with a small spiral of two or more windings through which the filament is passed as shown in Fig. 2. (*Accepted May* 3, 1911.)

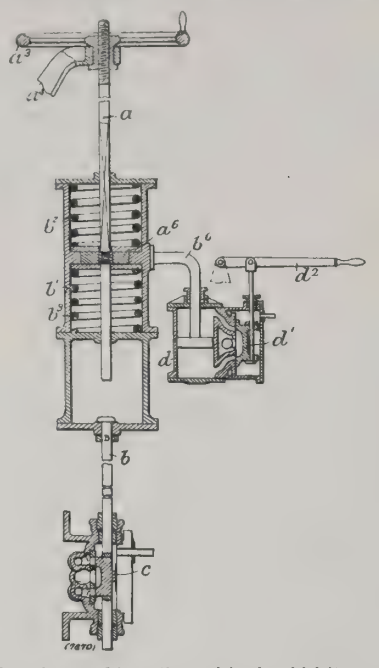
3450/11. Firm H. Aron Elektrizitatszahlerfabrik, G.m.b.H., Charlottenburg, Germany. Prepayment Electric Meters. [2 *Figs.*] April 6, 1910.—In a prepayment electric meter, according to this invention, a normally inoperative coupling between the prepayment mechanism and the meter switch is rendered operative only after a part of the meter has rotated through a determined angle or distance, through which period current can pass through the meter without prepayment, whereupon further current can be obtained only after prepayment by the insertion of a coin in the ordinary way. *a* is the axle of a counting-wheel of the meter. On this axle is mounted a disc *b* having a slot *c*. A pin *d* carried by a lever *f* bears against the inner edge of the disc *b*. A spring *i* has a constant tendency to pull the end of the lever *f* in an upward direction. The disc *b* is driven by the axle of the meter and turns round gradually until the slot *c* comes opposite or in front of the pin *d*. The spring *i* is now free to pull the lever *f* upwards, and thus causes



the pin *d* to pass up and through the slot *c*. By this means the other end of the lever *f*, which carries the toothed wheel *g*, is moved down into engagement with a toothed wheel *h*. The toothed wheel *g* is permanently connected to the axle *a* of the meter by mechanism (not shown). The toothed wheel *h* belongs to the prepayment mechanism of the meter. When the wheels *g* and *h* have been brought into engagement with each other, as above described, the meter works in the same manner as an ordinary prepayment meter; that is to say, it opens its switch automatically to cut off the current when the amount of electricity determined by the previously inserted coin has passed through. When the switch is opened and the current cut off, no further current can be taken by the consumer until after he shall have inserted another coin into the meter. The two toothed wheels *g* and *h* remain in engagement with each other, because the pin *d* is kept out of the disc *b* by the action of the spring *i*. (*Accepted May* 10, 1911.)

GUNS AND EXPLOSIVES.

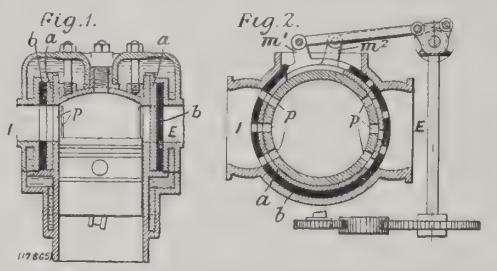
7870/10. R. H. S. Bacon and F. Duncan, Coventry. Ordnance-Training Gear. [2 *Figs.*] April 1, 1910.—In training control gear for ordnance, according to this invention, a supplementary hand-controlled valve is provided by means of which the turntable may be caused to rotate rapidly in either direction, as required, without disturbing the position at which the main controlling hand-wheel is set. The training control valve-spindle *a* has at one end a screw-thread, on which is mounted a nut forming the boss of a hand-wheel a^3 mounted in a bearing a^4. The spindle is arranged to move axially, but is prevented from rotating; rotation of the hand-wheel traverses the valve on its seat. The valve-spindle is in two portions, *a* and *b*; the end of one portion *a* is provided with a disc a^6, and the other *b* is attached to a cylinder b^1, in which the disc a^6 can move axially. Between the ends of the cylinder and the disc springs b^2, b^3 are inserted, either of which is strong enough to overcome the frictional resistance of the valve, and suitable centering stops are provided to determine the mid-position of the disc in the cylinder. It is, therefore, obvious that on rotating the hand-wheel a^3, the valve spindle *a*, *b*, cylinder b^1, disc a^6, and springs b^2, b^3 move as one piece. By means of a crosshead b^6 the cylinder b^1 is attached to the piston of a double hydraulic cylinder *d* controlled by a valve d^1 actuated by a lever d^2. The valve and ports are so arranged that when the valve is in its mid-position both ends of the cylinder are put to exhaust. When pressure is admitted to one or other end of the cylinder *d* by moving the lever d^2 the training



control-valve *c* is moved from the position in which it may be situated to one or other extreme end of its stroke, thereby causing the turntable to rotate at maximum speed either in the same or opposite direction to which it was rotating. On the supplementary lever d^2 being centred, the hydraulic cylinder is put to exhaust, and the compressed spring b^2 or b^3 extends and returns the training control-valve *c* to its original position. (*Accepted May* 10, 1911.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

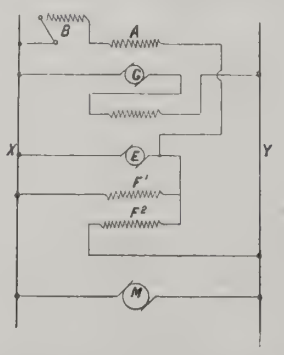
17,865/10. J. Hay, London. Internal-Combustion Engines. [5 *Figs.*] July 27, 1910.—In an internal-combustion engine, according to this invention, two cylindrical valves are placed outside the upper portion of the cylinder and have ports cut in them. The valves are oscillated and control ports in the cylinder wall. *a*, *b* are the two valves, the valve *a* being the inner one and sliding on the outside of the upper portion of the cylinder.



In the upper portion of the cylinder, ports *p* are cut and lead to the inlet-passage I and to the exhaust-passage E. Similar ports are cut in the valves *a*, *b*, the relative positions of these ports being determined by the required timing of the inlet and exhaust functions. The valves are operated from the crank-shaft through the medium of the half-speed shaft through arms m^1, m^2. (*Accepted May* 10, 1911.)

LIFTING AND HAULING APPLIANCES.

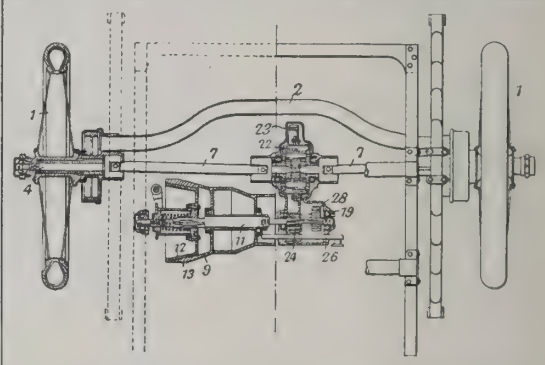
29,728/10. Crompton and Co., Limited, J. C. Macfarlane, and H. Burge, Chelmsford, and A. Williams, London. Electrically-Operated Driving Systems. [1 *Fig.*] December 21, 1910.—In electrically-operated hauling or winding machinery, or electrically-operated rolling-mills, wherein wide variations in torque and speed occur, while the demand for power from the supply is restricted, and in which current is supplied to the working motor from a direct-current generator provided with a variable field separate excitation so that it is



capable of delivering current at a variable voltage, there is employed on the working motor a field winding which is connected between the positive brush of the generator and the positive brush of the exciter. G represents a direct-current generator provided with a variable field excitation A and a hand-controlled resistance B, so that it is capable of delivering its current at any desired voltage. E is an exciter direct coupled to the generator, and developing exciting current at a constant voltage. X and Y are supply conductors connected to the brushes of the generator G, and leading current to the motor M. The field of the motor is provided with a winding F^1, excited directly from the brushes of the exciter E. A second winding F^2 is provided, and is connected from the positive brush of the exciter or from the positive pole of the supply to the conductor Y. (*Accepted May* 10, 1911.)

MOTOR ROAD VEHICLES.

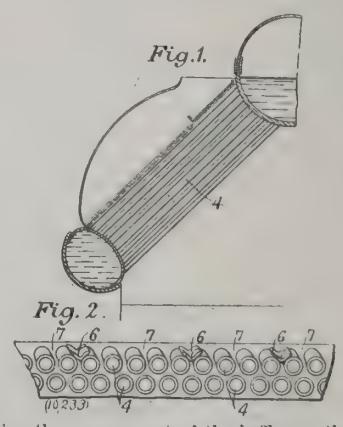
11,196/10. C. H. Dent, Tamworth, and Dent Motors, Limited, Birmingham. Transmission Gear. [4 *Figs.*] May 6, 1910.—This invention relates to motor road-vehicles in which the rotation of the engine is transmitted to the driving gear by means of a single belt and a pair of variable-speed cones, drums, or pulleys. The rear wheels 1 of the vehicle are rotatably supported at the outer ends of a curved transverse bridge-piece or rigid axle 2, and are driven from the outer members of a bevel differential gear, or from the sun-wheel of a planetary differential gear, by means of transmission shafts 7, which are connected by Cardan joints to the said members and to short axles 4 secured to the hubs of the rear wheels 1. The rear cone, which preferably consists of a pulley provided with three speed or belt surfaces and arranged with its largest diameter outwards, is located on one side of the centre line of the vehicle, while the differential and reversing gearing, and in the majority of cases the reducing gearing, is arranged on the other side of the said centre line and as near as possible to the latter. The rear cone is loosely mounted on its shaft 11, but is adapted to be connected to and freed therefrom by any suitable construction of clutch. The clutch preferably consists of a cone 12 which is mounted on a squared or castellated part of the shaft 11 and is constantly pressed by a spring into engagement with a coned surface 13 formed in the interior of the outer end of the rear cone.



The outer end of the shaft 11 is mounted in a bearing supported by one of the side members of the frame or chassis of the vehicle, while the inner end of the shaft is mounted in a bearing or bearings provided in a box or casing 19 which is supported from one or more of the transverse members of the frame or chassis of the vehicle. The rear of this box or casing is made of such size as to accommodate a cage 22 containing the differential gear and a large toothed wheel 23 secured to the exterior of the said cage, while its front end is made of such size and shape as to receive and support the mechanism by which the large toothed wheel 23, and therefore the cage, is rotated in either direction. This mechanism preferably consists of a pinion 24 slidably mounted on the inner end of the shaft 11, a fork embracing the pinion and secured to a spindle 26 slidably mounted in the box or casing 22, and a reversing shaft provided with a wheel 28 adapted to be engaged by the pinion 24 and with a pinion, not shown, always in mesh with the large wheel 23. When the cone 12 is in engagement with the cone surface 13 of the rear cone, the drive is transmitted at a reduced speed to the wheels 1, which will be rotated either in a forward or in a backward direction, the direction of rotation being determined by the position of the pinion 24; that is to say, whether the pinion 24 is in engagement with the large toothed wheel 23 or with the wheel 28. Further, when the cone 12 is disengaged from the rear cone, the latter will rotate without transmitting the drive to the wheels 1. (*Accepted May* 10, 1911.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

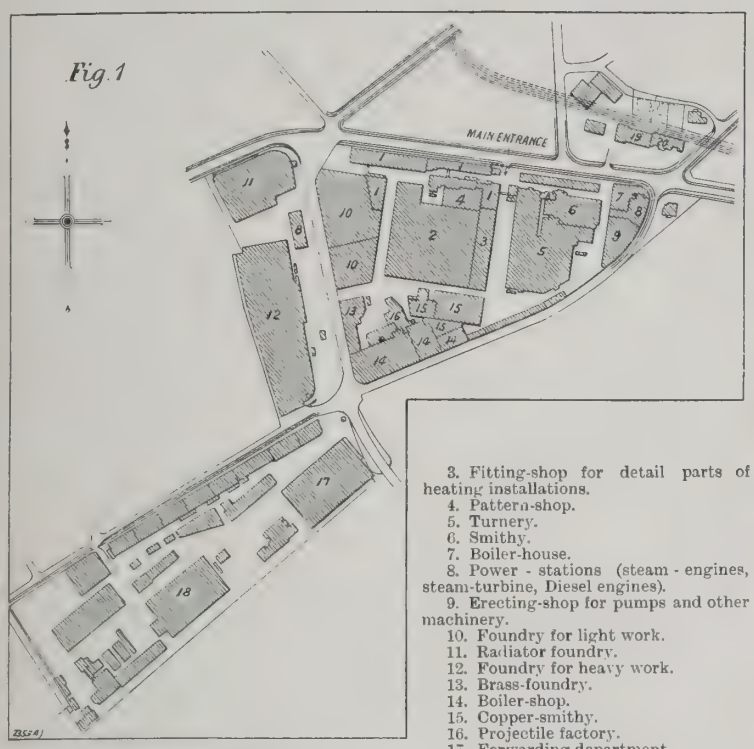
10,233/10. A. F. Yarrow, Blanefield. Water-Tube Boilers. [8 *Figs.*] April 26, 1910.—In water-tube boilers uniformity of distribution of the heated gases over the surfaces of the water-tubes is secured by adjusting, by means of baffles, preferably removable or displaceable, on the uptake side of the banks of water-tubes, the space for the passage of the furnace gases between the water-tubes, so as to present a substantially uniform resistance to the passage of these gases over all paths which they can take in passing from the combustion space to the uptake. This result may be attained in a number of ways, one of which is illustrated in the drawings, Fig. 1 being a part transverse section of a water-tube boiler of the Yarrow type, fitted with removable baffles, and Fig. 1*a* a perspective view on an enlarged



scale, showing the arrangement of the baffles on the outermost row of one bank of water-tubes. As therein shown, angle-bars 6 or other suitable rolled sections are placed between adjacent tubes of the outermost row of tubes 4, spaces being left between the tubes for the passage of the gases as shown at 7. The distribution of the angle-bars 6 is so varied as to present a greater obstruction to the flow of the gases along the shorter paths than along the longer paths, so as to equalise as much as possible the resistance to flow along all paths. Thus, towards the centre of the bank of tubes, the angle-bars may be placed so that between successive angle-bars there will be two or three vacant inter-spaces 7, while towards the ends of the boiler the angle-bars are spaced more widely, thereby leaving a greater cross-section of free space for the flow of the gases. (*Accepted May* 3, 1911.)

WORKS OF MESSRS. SULZER BROTHERS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 83.)



1. Commercial and technical offices.
2. Erecting-shop for Diesel engines and for refrigerating plant.
3. Fitting-shop for detail parts of heating installations.
4. Pattern-shop.
5. Turnery.
6. Smithy.
7. Boiler-house.
8. Power - stations (steam - engines, steam-turbine, Diesel engines).
9. Erecting-shop for pumps and other machinery.
10. Foundry for light work.
11. Radiator foundry.
12. Foundry for heavy work.
13. Brass-foundry.
14. Boiler-shop.
15. Copper-smithy.
16. Projectile factory.
17. Forwarding department.
18. Shipbuilding yard.
19 and 20. Workmen's library, canteen, baths, and school for crafts.

Fig. 1. Plan of Messrs. Sulzer Brothers' Works at Winterthur.

Fig. 4. Foundry for Light Work, showing Cupolas.

Fig. 2. Bird's-Eye View of Messrs. Sulzer Brothers' Works at Winterthur and Ludwigshafen.

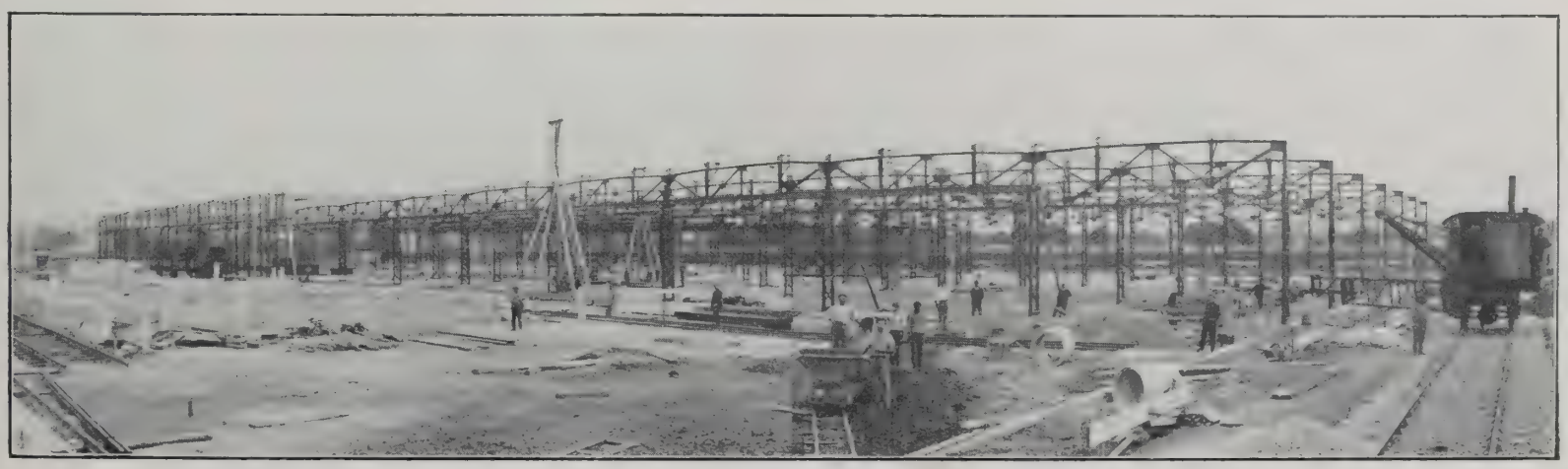


Fig. 3. New Fitting and Erecting-Shops for Heating Installations at Ober-Winterthur.

(*To face Page* 82.)

THE WORKS OF MESSRS. SULZER BROTHERS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page 83.*)

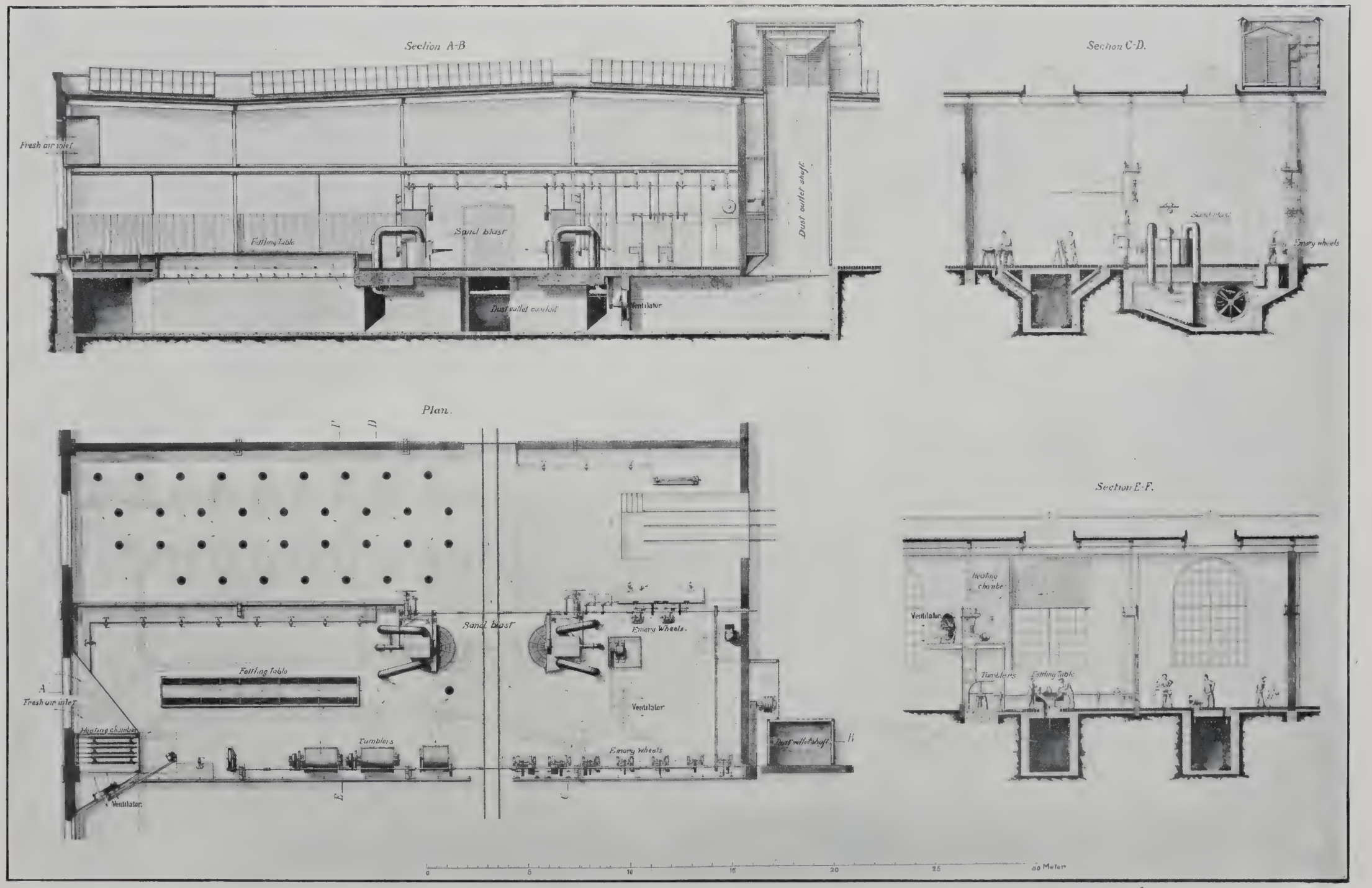


FIG. 10. VENTILATING, HEATING, DUST-REMOVING, AND FETTLING INSTALLATION IN CONNECTION WITH FOUNDRY FOR LIGHT WORK.

THE WORKS OF MESSRS. SULZER BROTHERS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 83.)

FIG. 11. VIEW IN RADIATOR FOUNDRY.

FIG. 12. BRASS FOUNDRY, SHOWING DRYING-STOVE.

FIG. 13. VIEW IN BRASS FOUNDRY.

FIG. 14. VIEW IN BRASS FOUNDRY.

THE WORKS OF MESSRS. SULZER BROTHERS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 83.)

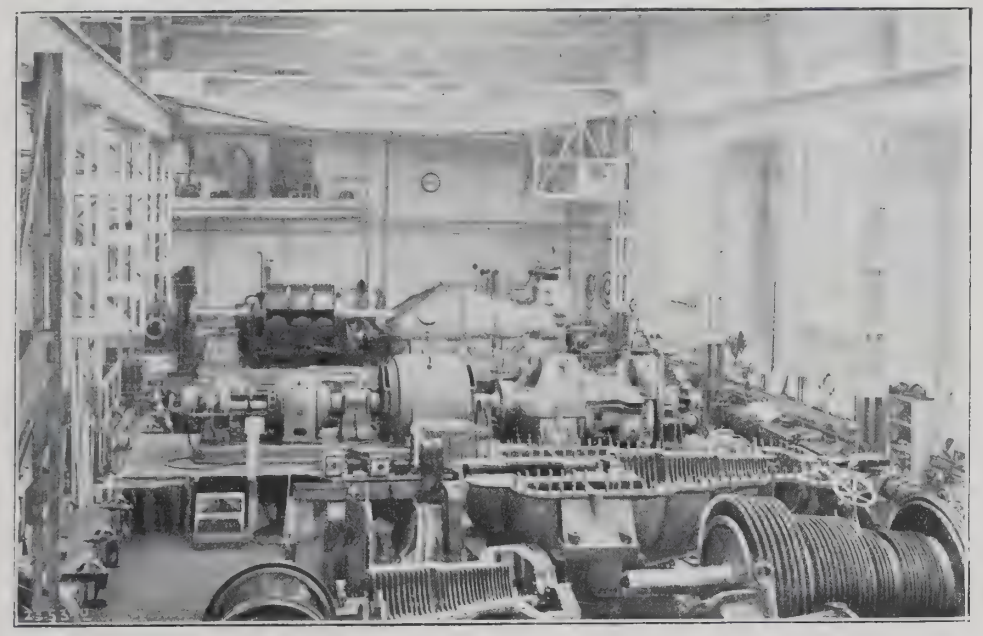


FIG. 15. STEAM-TURBINE ERECTING-SHOP. IN THE BACKGROUND, A 10,000-HORSE-POWER SULZER STEAM-TURBINE.

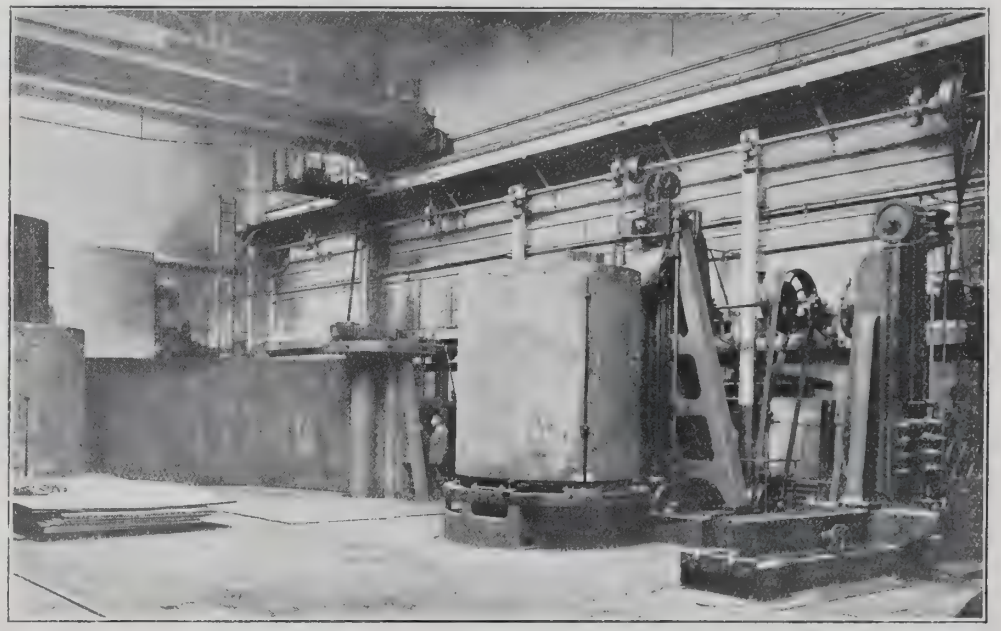


FIG. 16. BOILER-PLATE BENDING AND MACHINING-SHOP.

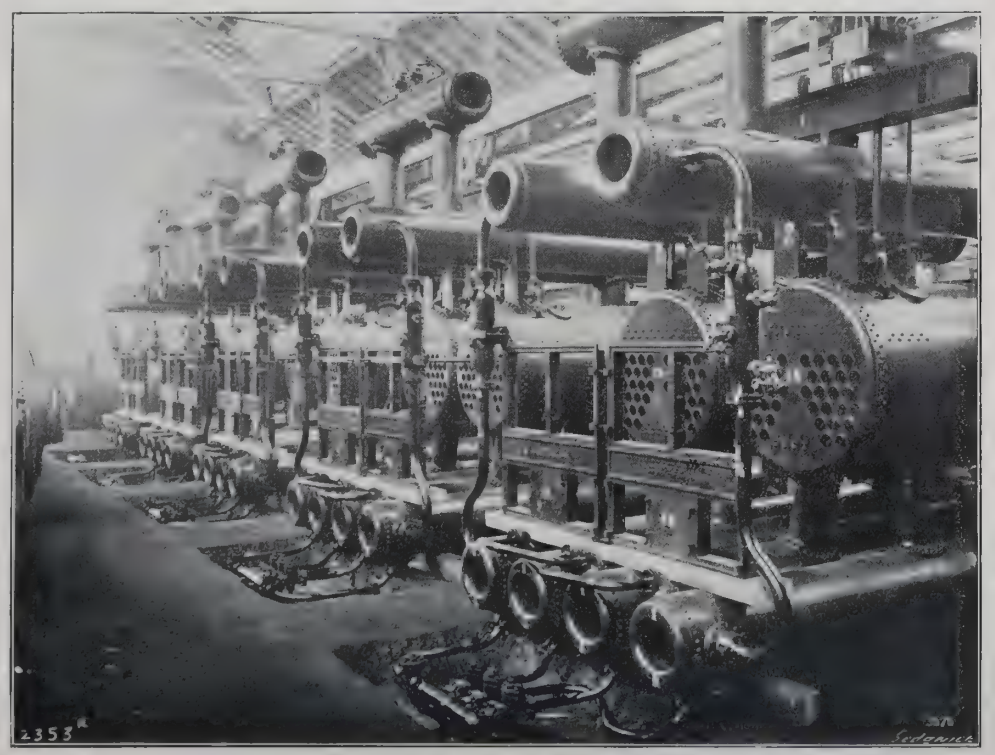


FIG. 17. VIEW IN BOILER-SHOP.

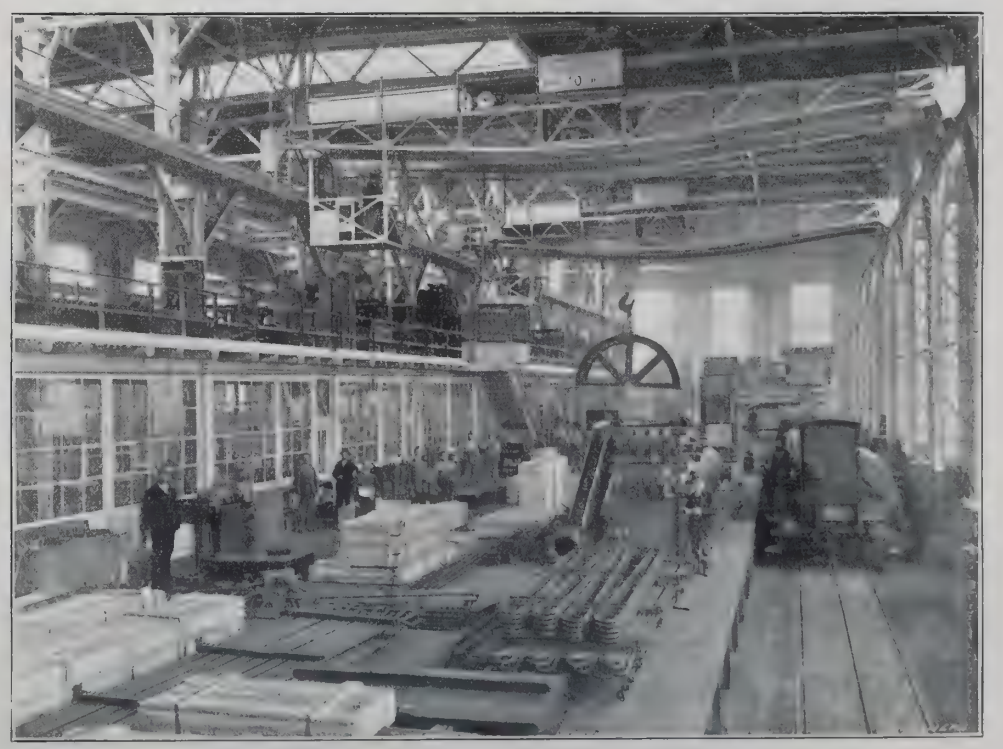


FIG. 18. VIEW INSIDE DELIVERY BAY.

WORKS OF MESSRS. SULZER BROTHERS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 83.)

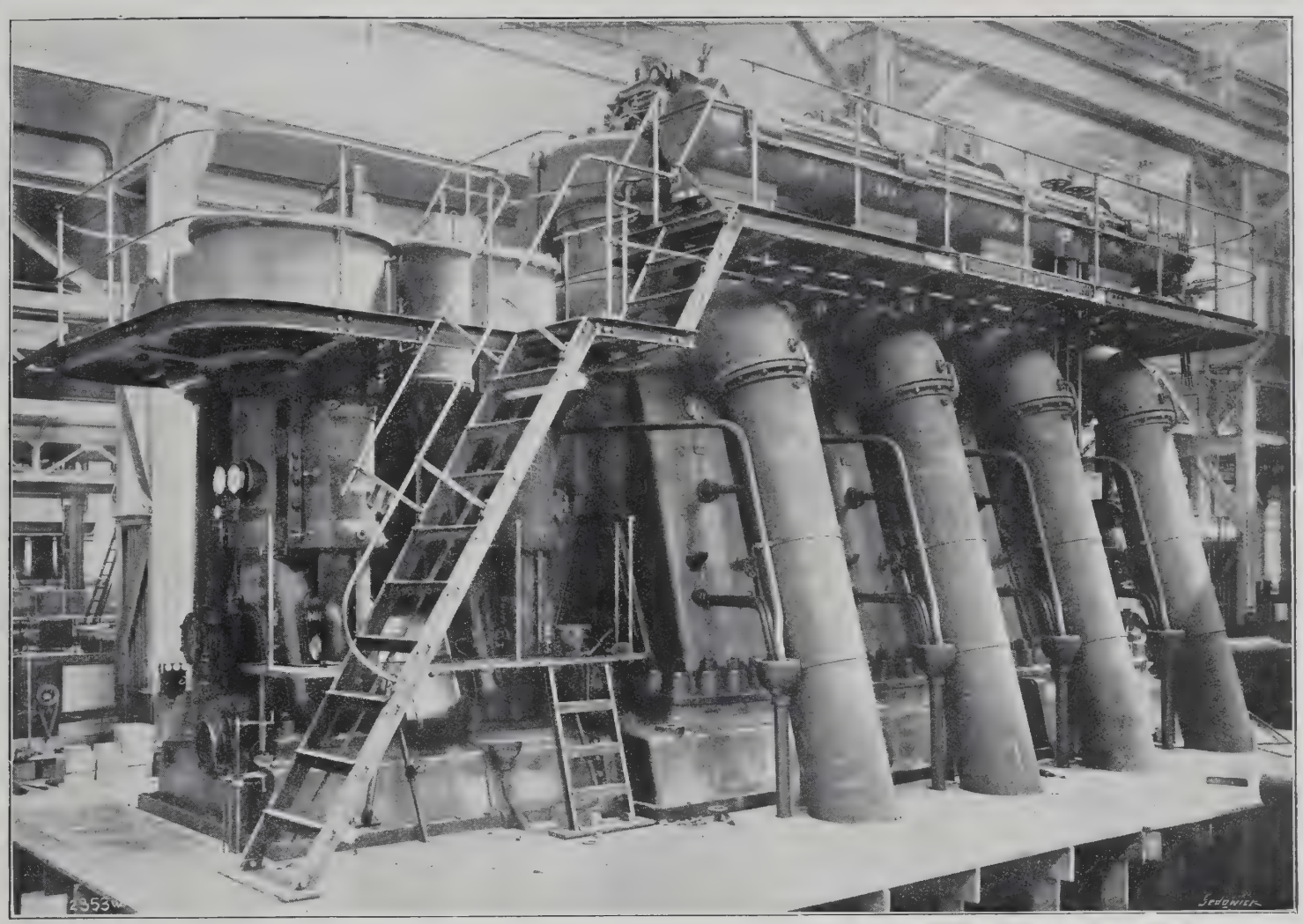


Fig. 19. 2400-Horse-Power Stationary Diesel Two-Cycle Engine in the Fitting and Erecting-Shop.

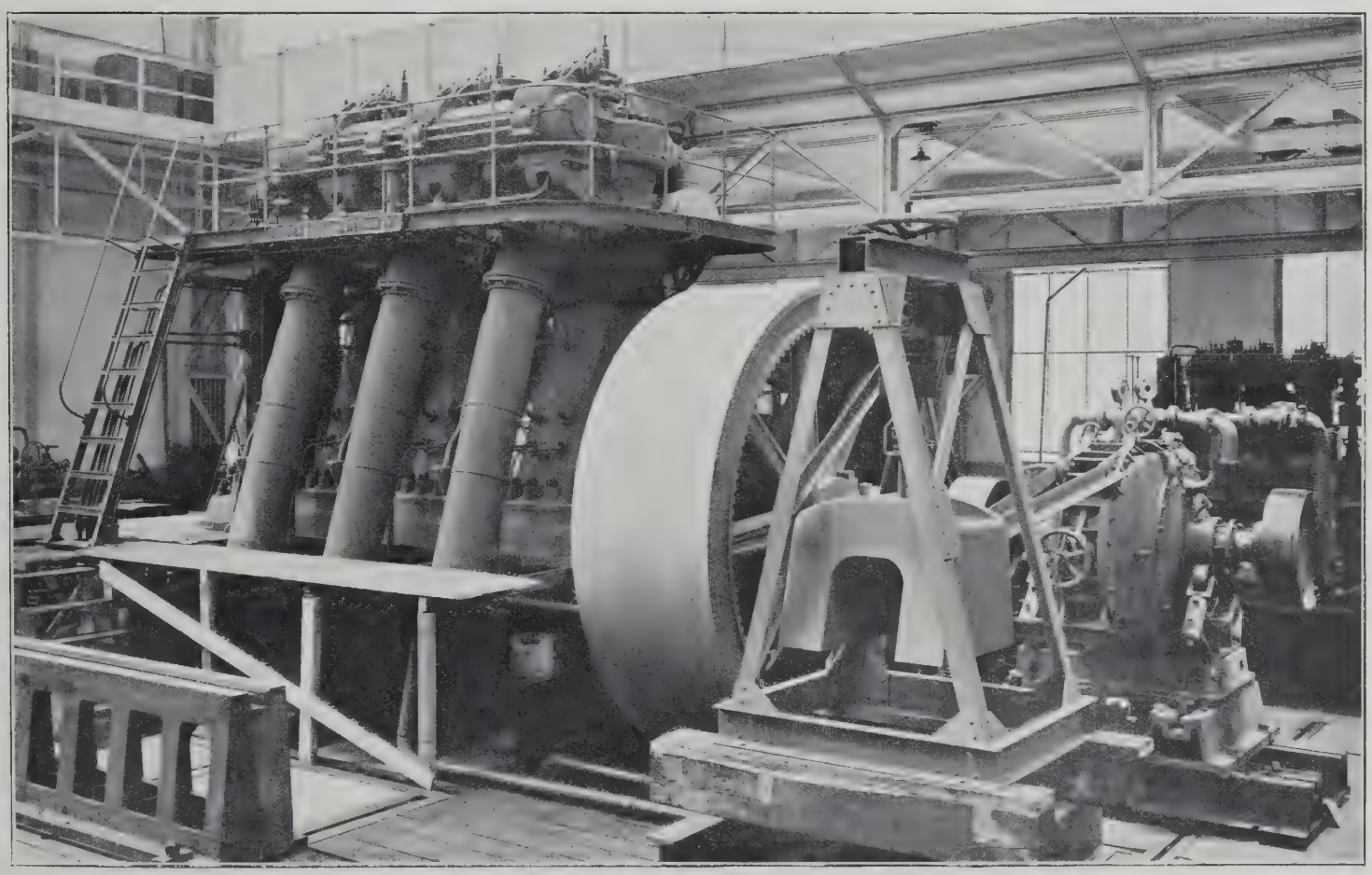


Fig. 20. Testing a Two-Cycle Diesel Engine in the Fitting and Erecting-Shop.

WORKS OF MESSRS. SULZER BROTHERS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 83.)

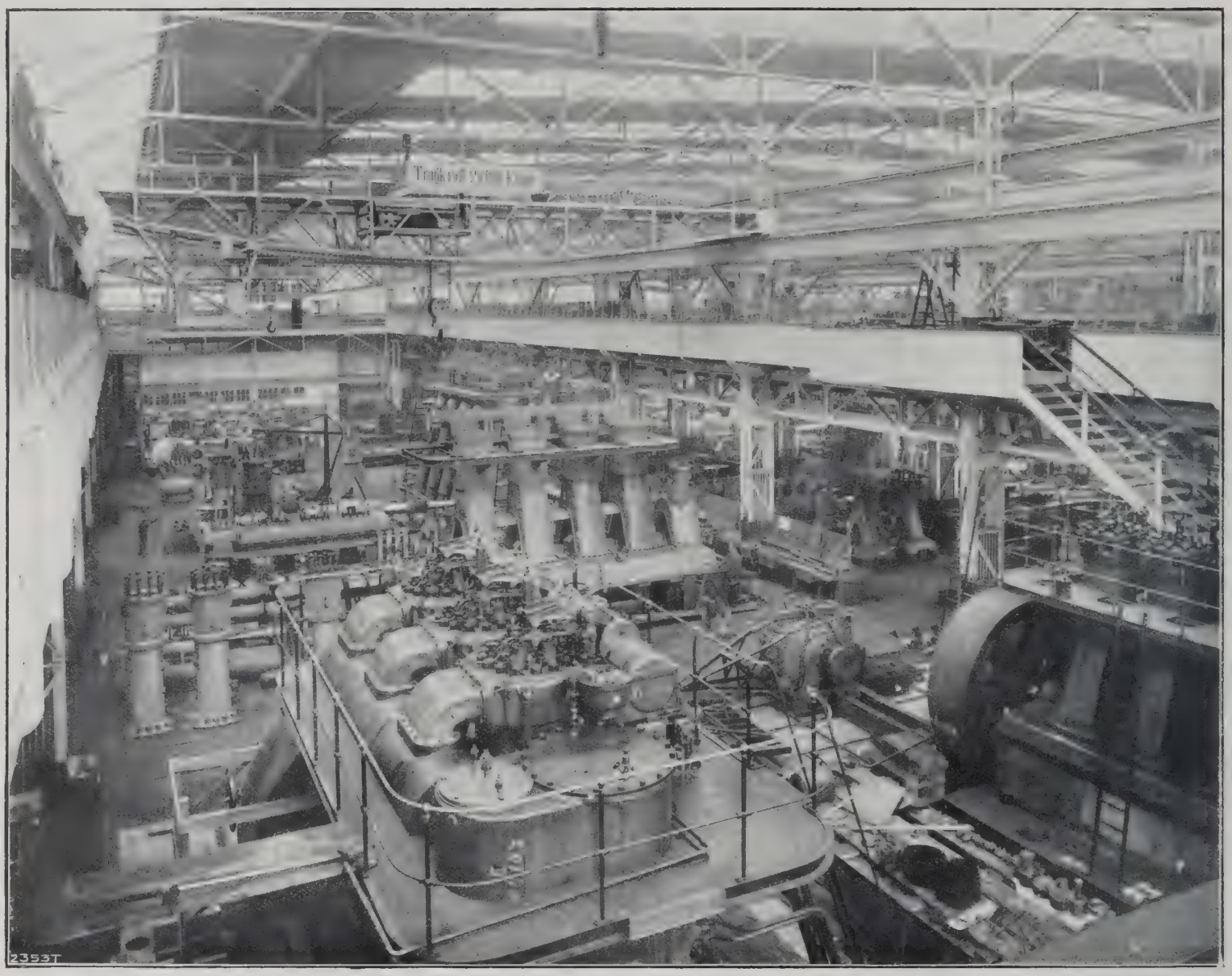


Fig. 21. Fitting and Erecting-Shop, showing Portion of Erecting-Bay for Stationary Diesel Engines.

Fig. 23. Water Turbine-Wheel Cast in One Piece in Foundry for Heavy Work.

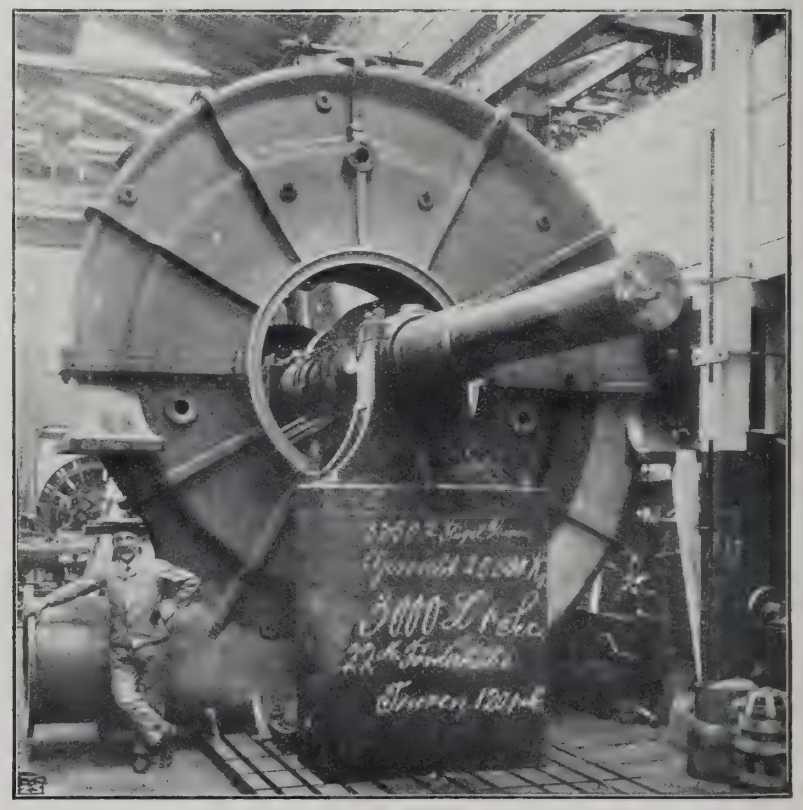


Fig. 24. Centrifugal Pumps for Egypt on Lathe at Winterthur.

(*To face Page* 83.)

THE WORKS OF MESSRS. SULZER BROTHERS, WINTERTHUR.

On Wednesday next, the 26th inst., a number of the members who are taking part in the meeting of the Institution of Mechanical Engineers at Zurich, will make an excursion to Winterthur to visit the works of Messrs. Sulzer Brothers. The history of this large Swiss engineering establishment is an interesting one; it is, briefly, as follows. The first member of the Sulzer family who turned his attention to industrial pursuits was Solomon Sulzer, who was born in January, 1757. Solomon Sulzer had studied theology and was on the point of accepting an appointment as pastor in a township in close proximity to Zurich, when he decided to abandon this position and to follow what was, after all, his real calling—the trade of a brass-founder. At that time, in the latter part of the eighteenth century, an intelligent craftsman had established a business at Schaffhausen; this craftsman had started the manufacture of brass castings, and had in the course of a very short period become a dangerous competitor to the coppersmiths of the district. Young Sulzer had heard many reports concerning this brass-founder and his successes. He called on him at his shop at Schaffhausen, purchased his secret for 500 florins, equal to about 50*l*., learned the trade, and came to Winterthur, where he established himself as a tradesman.

This appears now a most simple matter; young Sulzer, however, did not find it so. He not only experienced in the usual way that "all commencements are difficult" in themselves, but in his case he had to deal with local prejudice. In the mind of the inhabitants he was introducing a secret trade, and was looked upon with suspicion. He was only allowed to put down his plant—a very small one, as might be expected—close to the town ditch, and the fight was an uphill one. He first manufactured by casting a large number of small articles which until then had been made in the copper-smithy. He gradually increased his installation, and added to it a small turnery and a small fitting-shop. The business was commencing to prosper when the French Revolution broke out; this stopped all trade for many a year, and Solomon Sulzer left his son in charge of the plant and went to Lorraine in 1806, to earn a livelihood until better times supervened, but he died there in 1807. He was succeeded in the Winterthur business by his said son, Jacob Sulzer, who was followed by his two sons, the first brothers Sulzer, who in turn were followed by Messrs. H. Sulzer-Steiner, A. Sulzer-Grossmann, E. Sulzer-Ziegler, and J. Sulzer-Imhoof. The present owners of the works are the two last-named gentlemen, with Messrs. Carl Sulzer-Schmid, Albert, Robert, and Hans Sulzer, and Richard Ernst.

The first brass foundry, as it was taken over in 1807 by the son of the founder, occupied an area of only 54 sq. m. (590 sq. ft.), and one cast only, a very small one, was made per week. From these small beginnings has sprung up the huge establishment with which we have now to deal. We do not propose to detail the various developments undertaken by the succeeding generations of Sulzers—this would make too heavy demands on our space—nor do we propose to enter into the particulars of the part played in these developments by the late Mr. Charles Brown and other collaborators of the owners. We shall only state that whereas in the early days two foundrymen and two labourers formed the whole staff, the blowing-engine being driven by a mule on casting days, the staff now numbers 4000 men at Winterthur, of which 1400 are occupied in the foundries. The total staff, including the Ludwigshafen Works, amounts to 5500. The Ludwigshafen Works were put down in 1881. The works at Winterthur now cover an area of 70,000 sq. m. (83,700 sq. yards); those at Ludwigshafen an area of over 30,000 sq. m. (35,800 sq. yards).

The Winterthur Works are shown in the plan, Fig. 1, on Plate XIV., a reference to the various departments being annexed. We also illustrate these works in the view, Fig. 2, on the same plate, which also shows Messrs. Sulzer's Ludwigshafen establishment. Fig. 3, also on Plate XIV., shows an extension in course of completion at Ober-Winterthur, as stated further on.

When the Winterthur works were first put down on the site they now occupy—in the year 1834—the proprietors little expected that they would require such a marked extension. The extension has been gradual, but during the last ten years, more especially, the business to be coped with in the various departments throughout the works has increased to such a degree that Messrs. Sulzer have been repeatedly compelled in this later period to enlarge their plant. It so occurred that at the different epochs separating each periodical extension made with a view to meet the increase in demand, the plant became inadequate for a short time, and manufacture had to be decentralised until it could be centralised again on the completion of a new extension or transformation. In this way the owners built, in 1910, the new erecting-shop [illegible] Diesel engines, together with other shops, a[illegible] they are now occupied in reorganising their old [illegible]shops so as to still better adapt them to the va[illegible]us processes of manufacture of their different sp[illegible]ialities.

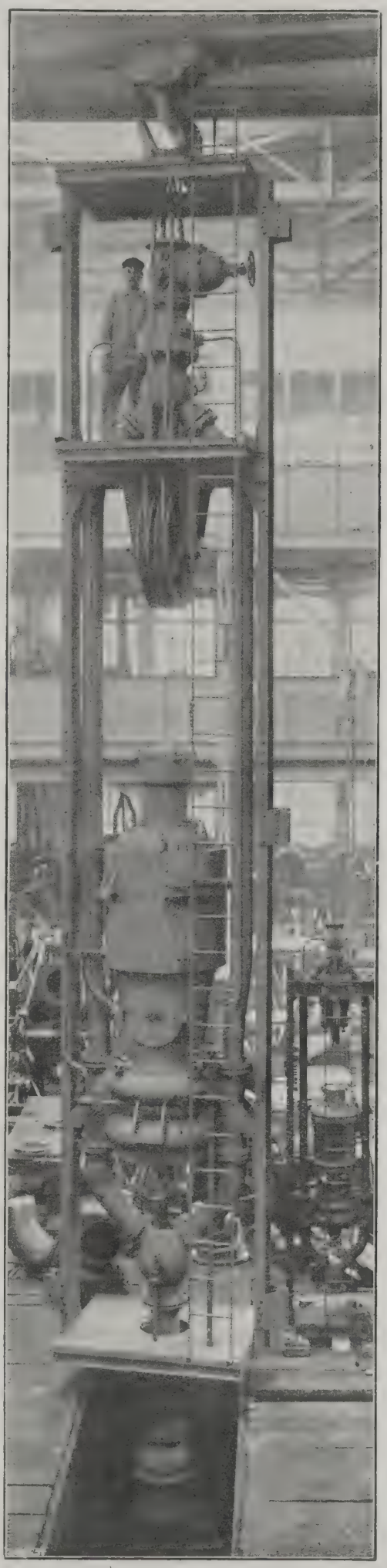


FIG. 22. SINKING PUMP BEING ERECTED.

The works as they now stand were commenced in 1834 by the putting down of a foundry. There are now, as will be seen in the plan, Fig. 1, three cast-iron foundries; these cover a total area of 28,500 sq. m. (34,000 sq. yards). Their annual output amounts to 20,000 tons of castings, and they employ, as stated above, 1400 men. In many engineering works, both in this country and on the Continent, the foundry is frequently considered as a very secondary shop, and, in [illegible]veral instances, no very special care seems to have been given to its installation. At Messrs. Sulzer's Works, on the contrary, the foundry has always, from the very commencement, been looked upon as forming

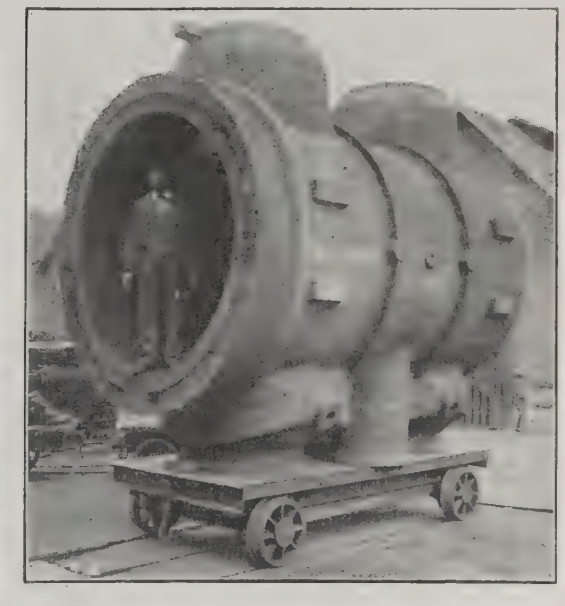


FIG. 25. LOW-PRESSURE CYLINDER FOR A 6000-HORSE-POWER STEAM-ENGINE FOR MOABIT POWER-STATION, BERLIN.

the principal shop. The foundry, as it were, forms a separate and privileged part of the establishment. It has its own special organisation, and is not under the supervision of a works manager, but under that of one of the Brothers Sulzer, and this has always been the case. The present partner who has charge of the foundry department is Mr. Albert Sulzer, who succeeded to the senior partner of the preceding generation, Mr. Sulzer-Grossmann; the latter managed it during forty-three years—from 1867 to 1910. The work in the foundry has always been carried out on the best scientific methods. The chemical and physical laboratories, besides the analyses and research work they make concerning all the material used throughout the shops—nickel-steel, other alloys, paints, lubricants, and so forth—are very fully occupied in testing the raw materials used in the manufacture of the different castings, and also specimens of the casts. Most of the coal and pig iron used by Messrs. Sulzer comes from this country. They turn also to account various grades of scrap and briquettes made of the chips collected from the fitting and machine-shops.

In Winterthur and the neighbourhood, Messrs. Sulzer's works have always been, and are still, known and referred to as the "Giesserei," the foundry.

The foundry for light work, shown in the views, Figs. 4 and 5, on Plates XIV. and XV., was put down in 1873, and enlarged in 1894. It is built of iron and glass exclusively, and is admirably lighted and ventilated. It covers an area of 6300 sq. m. (67,800 sq. ft.), and is divided into four

bays, served by sixteen overhead electric travelling cranes, ranging from 1 to 15 tons. Most of the work is done by moulding-machines. It contains five cupolas of Sulzer design and construction, with fore-hearth, each cupola having a capacity of from 3 to 6 tons per hour. A complete system of railway tracks run throughout the shops, and special frame cars, which can be seen in the view, Fig. 4, are used for the rapid removal of castings and machinery parts. An annexe to the foundry contains the core-making and the sand-mixing machinery. This latter is on two floors, the upper one containing the mixers, the grinding-machines, and also a series of magnetic separators. The fettling-shop consists of two special annexes which communicate with the hand-moulding section, and contains two fettling-tables, three fettling-drums, sand-blast apparatus, emery and sand wheels. All the dust from the fettling-tables and apparatus is exhausted by vacuum.

The foundry for heavy castings covers, including the fettling-shop, the drying-ovens, and the sand-mixing plant, an area of over 7200 sq. m. (77,500 sq. ft.). Special care has, as we have stated, been taken to ensure perfect lighting and ventilation of the shop. It is served by 18 overhead travelling-cranes, worked electrically, and ranging from 5 to 25 tons; two 2-ton hand travellers; one electric 2-ton jib-crane; two 2-ton lifts; and 24 different hand-cranes of 1, 2, and 3 tons capacity. It contains five large cupolas, with fore-hearths, each cupola having a capacity of 5 to 9 tons per hour; the fore-hearth connected to each cupola has a capacity of from 8 to 10 tons. The sand and loam-mixing machinery is on the south side of the foundry, and is of the most approved type. There are six casting-pits up to 6 m. (19 ft.) in diameter, and of various depths. The drying-ovens are fourteen in number, distributed throughout the foundry, and mostly used for drying cores. The moulds themselves are dried by portable fires, supplied with air-blast in the usual way. The largest piece cast weighs 40 tons. The foundry for heavy castings is illustrated in the views, Figs. 6 to 8, on Plate XV. The fettling-shop is in the rear of the cupolas, and, as will be seen from Fig. 9, on Plate XVI., is most carefully designed with a view to the removal of all dust. The latter is received in a number of grated openings on the floor level, connected to an underground gallery which ends in a common dust-collector. The sand removed from the castings is carried out by an hydraulic lift. Fig. 10, on Plate XVII., illustrates a similar installation in connection with the foundry for light work.

Messrs. Sulzer Brothers manufacture in very large numbers complete heating plants for dwelling houses and all classes of buildings; these require a very large quantity of castings, such as radiators and other parts. The manufacture of all these castings is centralised in a separate shop, shown in the plan, Fig. 1, which is served by sixteen cranes of 12 cwt. to 4 tons. These details of heating plant being a speciality which is quite distinct from the others with which the firm deals, the section of the works devoted to it forms a department to itself. A view in the radiator foundry is given in Fig. 11, on Plate XVIII.

The brass foundry is shown in Figs. 12 to 14, on Plate XVIII. It has two characteristic features. In the first place, it occupies the upper storey of a two-storey building; it is further, we believe, the largest brass foundry on the Continent to belong to an engineering works which does not make a speciality of the supply of brass castings as such. Messrs. Sulzer use a very large quantity of brass-work of different grades in their various manufactures, especially, perhaps, for their pumps, and they have always endeavoured to remain completely independent of outside sources, and to be able to undertake absolutely all responsibility for the whole of the work they supply; in this they have hitherto fully succeeded. The brass-foundry building covers an area of 900 sq. m. (9700 sq. ft.). The ground floor and the first floor are set apart for sand-mixing, offices, and stores. The second floor, forming the foundry, contains four Piat-Baumann crucible furnaces, two of 4 cwt. and two of 6 cwt., and two other smaller furnaces. The floor of the foundry is occupied by the moulding frames; an adjoining room is set apart for fettling, and in this, as in the cast-iron foundries, the dust is exhausted by vacuum. Access is had to the foundry by steps; it is also served by an hydraulic lift. This arrangement is conductive to the saving of floor-space. The foundry being on the top of the building, it is possible to utilise the floors below, whereas the gases from the foundry would make it impossible to erect offices and stores above it. The arrangement has further made it possible to have the foundry in a central position, close to all the other shops to which its products have to be distributed. Our views, Figs. 12 to 14, show the upper floor above the ground floor, occupied by the foundry.

Before describing the other shops we may refer here to the power-stations in the works. These stations are three in number, distributed as shown in the plan, Fig. 1, Plate XIV. At the present time electricity is used almost exclusively for power transmission. Formerly it was used only for lighting, and in 1878 small dynamos were put down throughout the works as they then stood for supplying current to arc-lamps. The first generating-station for power was built in 1894; this supplied 250 horse-power to hoisting apparatus and ventilating-fans, there being at that time twenty-eight electric motors in the various shops. A second station was put down in 1895. Connected to the three main stations there are three sub-stations for light and power; the capacity of the total plant for power and lighting is 2900 horse-power. The generating-station near the smithy contains a 400 horse-power vertical compound steam-engine running at 100 revolutions; this drives by belting a part of the lathes in the turnery. The vertical steam-engine in question was exhibited by Messrs. Sulzer at the Paris Exhibition of 1889; we described it at the time (ENGINEERING, vol. xlviii., page 488). The main generating-station is close to the boiler-shop. This contains a 1300-horse-power 1500-revolution Sulzer steam-turbine, direct-coupled to a Brown-Boveri three-phase generator which supplies a 3000-volt 50-period current; this high-tension current is transformed down to 200 volts in part in the generating-station itself and in part in one of the sub-stations. The same generating-station contains also a 600 to 800 horse-power horizontal steam-engine running at a speed of 150 revolutions, being an old compound engine which has lately been transformed for experimental purposes into a uniflow steam-engine. This horizontal engine is direct-coupled to a 200-volt 50-period electric generator.

We may mention here that the current which Messrs. Sulzer can now generate at their works in their three stations is in excess of their requirements, and experiments have repeatedly been made with the horizontal engine just mentioned. The last-named generating-station is, in fact, used at the present time also as a testing-room for steam consumption and so forth. A few years ago these two generating-stations became inadequate, and the constant development of the works rendered necessary a further supply of power. In the meantime, Messrs. Sulzer having improved the design and construction of Diesel engines, they decided to build a third station and to equip it with these motors. This third station is close to the foundry for heavy castings, and lies opposite to the second one. It contains a 350-horse-power and a 150-horse-power motor, both four-cycle, and direct-coupled to 200-volt three-phase fly wheel generators. The larger Diesel engine has a speed of 140 revolutions, and the smaller one a speed of 180 revolutions.

The steam supply is ensured by three boiler-rooms containing in all nineteen steam-boilers. The boiler-room in close proximity to the station containing the turbine and uniflow engine has eight boilers, with automatic stoking and automatic coal delivery, two being water-tube boilers, one a Garbe tubular boiler, the five others being Cornish boilers. A boiler-room near the boiler-shop contains a boiler having 340 sq. m. (3660 sq. ft.) heating surface. The one near the large foundry contains a boiler having 210 sq. m. (2260 sq. ft.) heating surface. The steam that can be raised in these three boiler-rooms is more than sufficient for the present requirements, and gives an ample margin for further extensions.

Near the main boiler-house and power-station is the smithy. This measures 41 m. (134 ft.) in length and 26 m. (85 ft.) in width, and contains eight steam-hammers, varying in power from 5 cwt. to $3\frac{1}{2}$ tons, served by open fires and by nine revolving cranes. The heaviest forgings turned out weigh from 5 to 6 tons. The smithy is an accessory shop, since a large number of forgings of special shapes, or of weights exceeding the above maximum, are obtained from outside sources, either rough machined or simply in the forged state.

Close to the smithy is the turnery; the heavier machines are on the ground floor, and the lighter on the upper floor. As early as in the 'fifties and 'sixties of last century Messrs. Sulzer were able to design and to build for their own exclusive use quite a number of machine and other tools of different types for special classes of work, and this placed them quite early in the day in a favourable position for the manufacture of any given class of plant or machinery. They were thus easily able to maintain in their own hands a monopoly for the products in question. Not only so, but the reputation which Messrs. Sulzer have since acquired in reference to the high finish of their engines and various machines can in a very great measure be traced to the fact that they very early built in their own works the appliances to manufacture them. They continue to work on the same lines, and still design and build any special machine-tool they may from time to time require for the carrying out of particular work. The turnery contains an excellent plant of modern machinery; the building itself, however, is one of the oldest in the works.

Adjoining the power-station, which contains the turbine and horizontal engine, is the pump-testing room for testing all pumps up to those having exceptionally large deliveries. The pump-delivery measuring-tank can be fitted with a series of changeable outflow discs, a method which was introduced by Messrs. Sulzer, and which is now generally followed.

Near this testing department is the former delivery bay, which has since been transformed into an erecting-shop for pumps and steam-turbines. It is illustrated in Fig. 15, on Plate XIX., which shows a 10,000-horse-power Sulzer turbine in the background.

From this shop, which is located at the extreme eastern end of the works, the centre of the establishment is reached through the turnery and a small fitting and erecting-shop for parts forming heating installations, adjoining which the large fitting, erecting, and testing-shop for Diesel engines, ammonia-compressors, pumps, and other machines, has been built. The department for the construction of heating installations (the parts forming which are cast in the separate foundry, called the radiator foundry, already dealt with) is one of the very busy departments at Messrs. Sulzer's works. For these installations they are now putting down at Ober-Winterthur, a distance of about three miles, a special building to maintain the fitting and erecting of radiators as distinct as possible from their other manufactures. This new building, above referred to, and the framework of which is illustrated in Fig. 3, on Plate XIV., will be complete in itself, and will contain its own power-station. It will comprise, besides a large wood dépôt, a wood-drying plant, frame-saws, and the briquetting-presses for briquetting the chips for use in the foundry cupolas.

The boiler works, located to the south of the engineering shop, consists of the copper-smithy, the tube and pipe-bending shops, and the large boiler-shop proper, which runs parallel to the Swiss Federal Railways. Fig. 16, on Plate XIX., is a view inside the boiler-plate-bending and machining-shop, and Fig. 17, on the same plate, illustrates a number of boilers erected in the works, and ready for delivery. The boiler-shop communicates with the plate-bending, flanging, and drilling-shop. The plates are bent by vertical rolls. Autogenous welding is used extensively. Messrs. Sulzer build their boilers complete with every fitting and accessory without exception, and are thus able to readily undertake all the required guarantees and responsibility. All the brass fittings proceed from their brass foundry. The firm have been known for years past almost exclusively in connection with their steam-engines with their special valve distribution, but their boilers have been, and are still, much more extensively distributed over the world than even their engines have been, and they have always proved, at least, quite as satisfactory in every respect as the latter.

In connection with this portion of Messrs. Sulzer's Winterthur establishment, it is interesting to notice that the works also have been fully busy since 1860 with the manufacture in the usual way of shrapnel shell for use by the Swiss Artillery Corps. The shells are finished ready for firing by the Swiss arsenal at Thun. One of the early Sulzer Brothers spent several months in the late 'fifties of last century at Woolwich Arsenal, and there decided to take over this speciality at Winterthur; since then the Winterthur Works have supplied the Swiss artillery with shrapnel shell at different intervals.

In Fig. 18, on Plate XIX., we illustrate the

delivery bay. This delivery department, as alluded to above, was formerly in another part of the works, but was transferred to its present position a few years ago. It is a model of its kind and has invariably excited the admiration of visitors. An annexe to this forms the radiator dépôt and contains a very large number of these ready for delivery. A large number of buildings and sheds, not numbered in the plan, Fig. 1, placed at convenient sites, contain the various stores and dépôts.

The large fitting and erecting-shop, which we illustrate in the views, Figs. 19 to 21, on Plates XX. and XXI., is built of armoured concrete. It measures 80 m. (262 ft.) in length, and 72 m. (236 ft.) in width. Taken cross-wise, from east to west, it is divided into four smaller bays, having galleries at top, and three large glazed bays, there being a smaller bay between the left-hand and the central one, and also between the central and the right-hand one. This is an

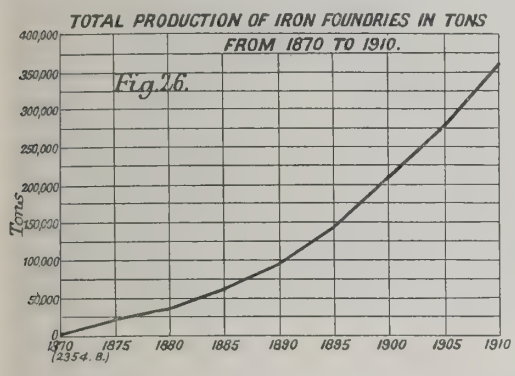
All the engines are tested on the beds in the shop on which they have been erected; they are made to run for eight days consecutively. The power is recorded by a Heenan and Froude hydraulic brake. The exhaust gases are led to silencers and to pipes placed outside the west wall of the shop, the pipes being led up to the roof. Messrs. Sulzer have already built, including the 16,060 horse-power above given, a total of about 140,000 horse-power to the present day.

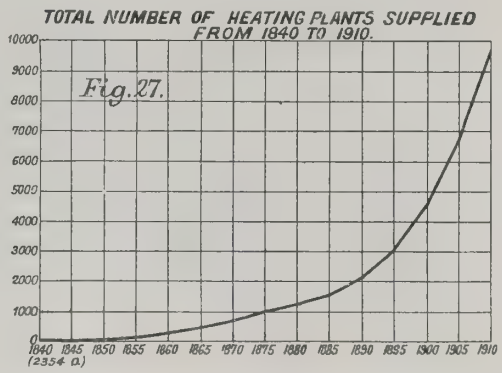
Close to the delivery bay is the shipbuilding shop, used at the present time—in the temporary absence of contracts for passenger and other steamers for navigation on the lakes—for working up plates and section work. The plates and frames forming the ships' hulls are bolted together at the Winterthur Works, then riveted up in the Navigation Companies' slips on the lake shores.

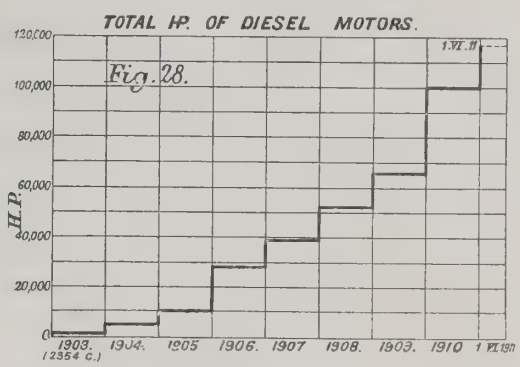
In proximity to this shop is a testing station in

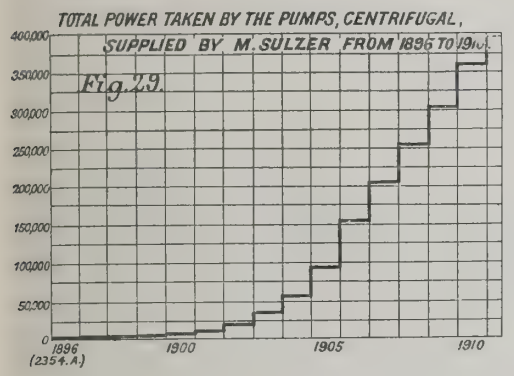
low-pressure cylinder for a 6000-horse-power steam-engine for a current-generating station.

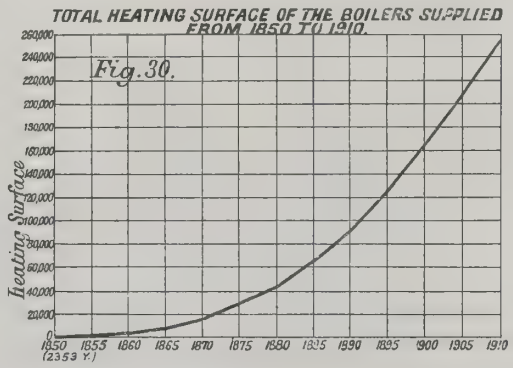
The curves, Figs. 26 to 32, on the present page, illustrate better than any description the gradual development of the works at different periods. These curves show the total production of the iron foundries in tons from 1870 to 1910; the total number of heating plants supplied from 1840 to 1910; the total horse-power of Diesel engines built from 1903 to June 1, 1911; the total power required by the pumps supplied from 1896 to June 1, 1911; the total heating surface of the boilers built from 1850 to 1910; the total horse-power of the steam-engines built from 1855 to 1910; and the number of workmen and staff from the earlier days, 1834, down to 1910. The whole of these curves, it will be noticed, rise constantly, although every year of the time they cover cannot have been equally prosperous all round. They give

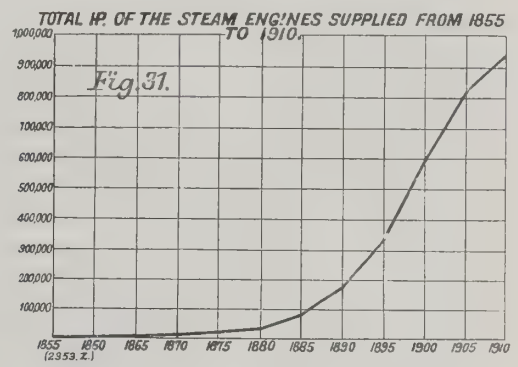






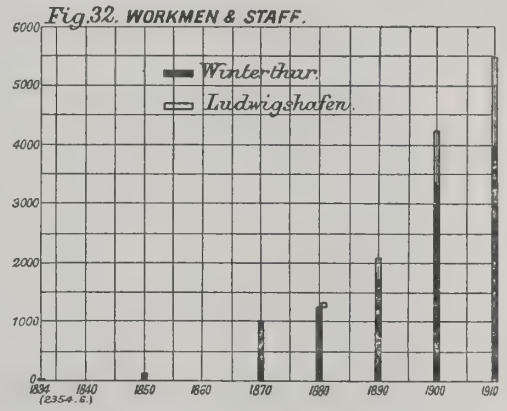






admirable shop, most carefully lighted and ventilated; it is heated during the winter months. An idea of its height is afforded by the view, Fig. 22, on page 83, which represents a sinking pump in course of erection. The galleries over the four smaller bays are served by lifts; access is also had to them by double sets of stairways. They are set apart for bench-work, small machining-work, assembling detail parts for Diesel engines, and for erecting small engines and pumps. Under the first, left-hand, or east, glazed large bay are large machine-tools, crank-shaft lathes, plate lathes, transportable machine-tools, a large planing and milling-machine capable of machining pieces measuring 15 m. (50 ft.) in length and over 2 m. (6 ft. 6 in.) in diameter, and weighing up to 30 tons. Under the adjoining smaller bay the pumps are erected, and the larger parts and mechanical details for the Diesel engines are fitted together. The large central glazed bay forms the erecting-shop for large stationary Diesel engines and pumps. In the smaller bay, separating the central bay from the right-hand, third, or west, glazed bay are erected the Diesel marine motors. The third large glazed bay, like the centre one, forms an erecting-shop for large stationary Diesel engines. The last small bay under the gallery is the erecting-shop for high-speed Diesel engines. Each of the three large bays, with glazed roof, is served by a 30-ton and a 20-ton overhead electric travelling-crane. The four smaller bays under the gallery have two 5-ton electric travellers each; in some a 15-ton traveller is substituted for a 5-ton one. At the present time Messrs. Sulzer have in this building in course of erection, or in process of testing, the following Diesel engines:—

Stationary:	Thirty-four engines, for a total of 11,460 horse-power	Total: 16,060 horse-power.
Marine:	Ten engines, for a total of 4600 horse-power	



which Messrs. Sulzer propose to carry out a series of exhaustive tests with a Diesel locomotive on which they have been working since 1905. We understand that they are making excellent progress in this direction, and we hope to be able to deal further with the subject later on.

The firm have also worked most actively at the development of Diesel engines for marine purposes, and have already built a good number of these for sea-going boats, including submarines; they have in hand at the present time a set of Diesel engines for an ocean steamer. They are proceeding with their experiments in this direction without remission, and are at the present time carrying out a complete series of experiments with a 2000-horse-power two-cycle cylinder with a view to battleship propulsion.

Fig. 23, on Plate XXI., which represents a water turbine-wheel cast in one piece by Messrs. Sulzer Brothers, gives an idea of their skill in foundry work. Fig. 24, on the same plate, shows a heavy centrifugal-pump casing weighing 25 tons on the lathe in their turnery. Fig. 25, on page 83, is a

an unmistakable indication of a perfect organisation, of a thrifty management, and of a satisfactory reserve fund.

The men employed at Messrs. Sulzer's works are almost all on piecework, only a few being on day-work. They are paid fortnightly. The shop methods are very generally on the "American system." A special office settles the piecework prices; the men are satisfied, and work with a will; in fact, we have hardly ever come across a better and a more contented-looking set of artisans. The reason why there is no labour problem at these works is that the owners were years ago able to solve the almost insoluble problem which consists in taking a fatherly care of the men while remaining their master. They have also and for many years taken care to train the men's sons, both practically and technically, in the trades for which the boys felt a special vocation, and have thus and for many years developed their own staff. Like a few other Swiss works, they exclude absolutely workmen of several other nationalities, and thereby they continue year in and year out to live in peace.

The school for the boys is just outside the works; this was the original shop and offices, first built in 1834. Special interest attaches to this building. At one time it had been decided to do away with it to make room for necessary extensions. Considering, however, that it formed, as it were, the old stem on which had grown the works as they now stand, and in which a preceding generation of Sulzers had expended their energies, it was removed and rebuilt, stone by stone, unaltered, on the site it now occupies. To it Messrs. Sulzer have added a canteen, a reading-room, and baths for the men. A proof of the men's standard is afforded by the fact that the library and reading-room are exceedingly well attended. Dwellings have been built for the men. Each man who has been employed at the works for a period of at least ten

years receives one week's holiday every year, his wages being paid him during the time. Life insurance and invalidity funds have been established for many years, and work most satisfactorily.

The very complete and accurate account-keeping, with which a separate statistical bureau is entrusted, makes it possible for the owners and their staff to obtain at any time an exact idea of the progress of the work being carried out in every department. Each machine-tool has its own account, and the work carried out with it is credited to it for amortisation. A standardising bureau sees that, when this is in the least degree possible, all pieces have to be manufactured to standards, for which patterns, jigs, &c., are available.

This thorough organisation in every detail; the total absence of unnecessary staff and "fausses manœuvres" which, unfortunately for them, are to be met in so many other establishments; the regard which the men feel, and very justly so, for the owners, have made it possible for the latter to compete with success in every part of the world with the works of other nations eminently more favoured from the point of view of raw material and other physical facilities. Nor do the firm confine their activity to the specialities already referred to, for they also take a strong interest in important civil engineering works, a fact of which their share in the construction of the Simplon Tunnel affords a striking example.

THE WORKS OF MESSRS. ESCHER WYSS AND CO., ZURICH.

THE works of Messrs. Escher Wyss and Co., at Zurich, which will be visited by the members of the Institution of Mechanical Engineers on Tuesday next, the 25th inst., may be said to constitute the cradle of the Swiss mechanical engineering industry. They were founded as early as 1805, by Hans Kaspar Escher. Like many young men who have made for themselves in later years a name in the metallurgical and engineering world, H. K. Escher was destined by his parents for a different career; it had been decided in the family circle that he should be a merchant. He entered commercial life, but this for him was drudgery, and he soon left it to devote his energies to architecture. Owing, however, to the unrest which generally reigned in the early years of the 19th century, architecture could hardly be made to pay, and there was "nothing doing" in that profession.

It was during a period of slackness in his architectural work that H. K. Escher had his attention called specially to mechanics. Switzerland had long been known for some of her hand-made light textile fabrics. The report had reached Escher that there were then working in this country a number of cotton-spinning machines which were greatly successful, so much so in fact that their manufacture and their use were kept absolute secrets. He immediately saw the advantages which would be derived by the construction of such machinery in Switzerland. He came to this country, where he managed to see the machinery in question, he got out drawings of similar machines from memory, and returned to Zurich, where, in 1805, he built the Neumühle works on the Limmat, the river formed by the outflow from Zurich lake. These works were able to put their first mechanically-spun yarn on the market in the commencement of 1807. The Escher Wyss Co., founded in 1805, primarily for spinning, very shortly afterwards added to their work the building of the machines for outside buyers, and gradually the company was transformed from a spinning concern into one engaged in the manufacture of spinning machinery. Their engineering specialities, however, gradually increased in number, and included, as the years went by, the construction of water-wheels, transmission gear, steam and water-heating installations, machine-tools, grinding-mills, stationary steam-engines, and steamers complete. H. K. Escher died in August, 1859, and the works management was continued by members of his family and others who had been his collaborators in the earlier days of the company, or who had joined it subsequently. In 1889, the concern was transformed into a share company. In the meantime the business of the firm had increased to such an extent that new premises had to be taken, there being no space available at Neumühle to allow for expansion. A tract of land was selected in the north-western part of the city, on which the first shops of the present works were built in 1895.

The general arrangement of the works is shown in the plan, Fig. 1, annexed. They are admirably laid out, the various shops and offices covering an area of 35,000 sq. m. (41,800 sq. yards) of the total site, which has an area of 90,000 sq. m. (107,000 sq. yards). One of the principal specialities of the company at the present time is the construction

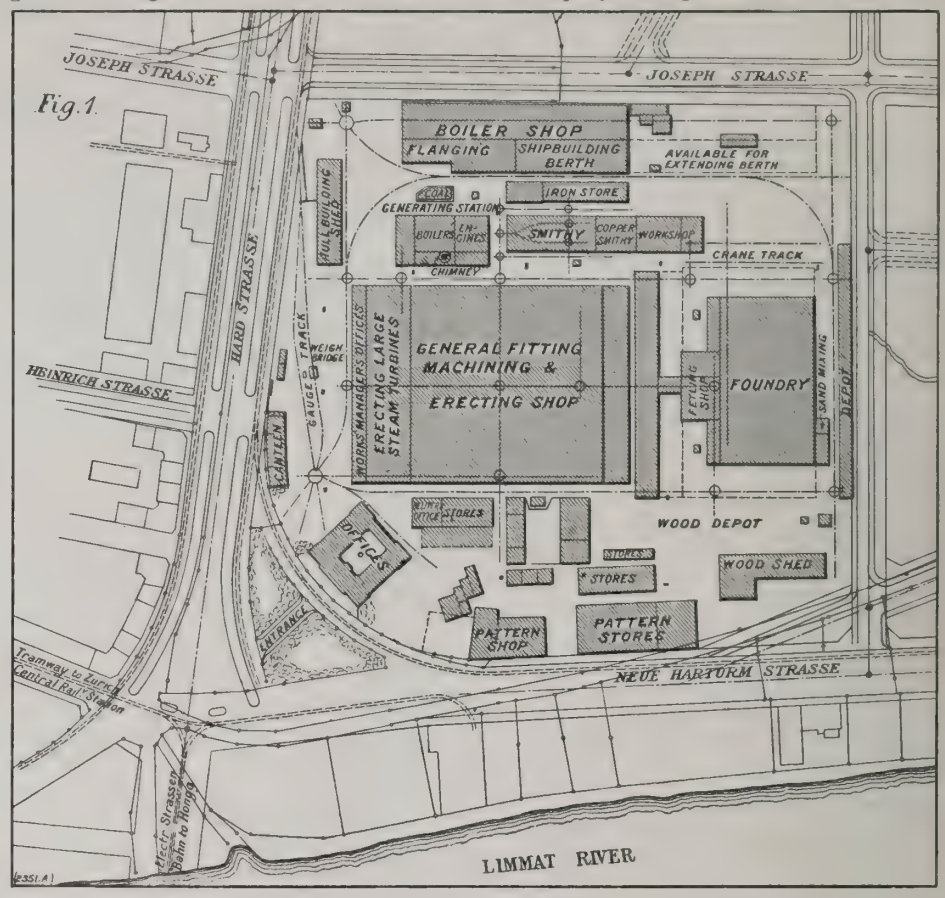


FIG. 1. PLAN OF WORKS.

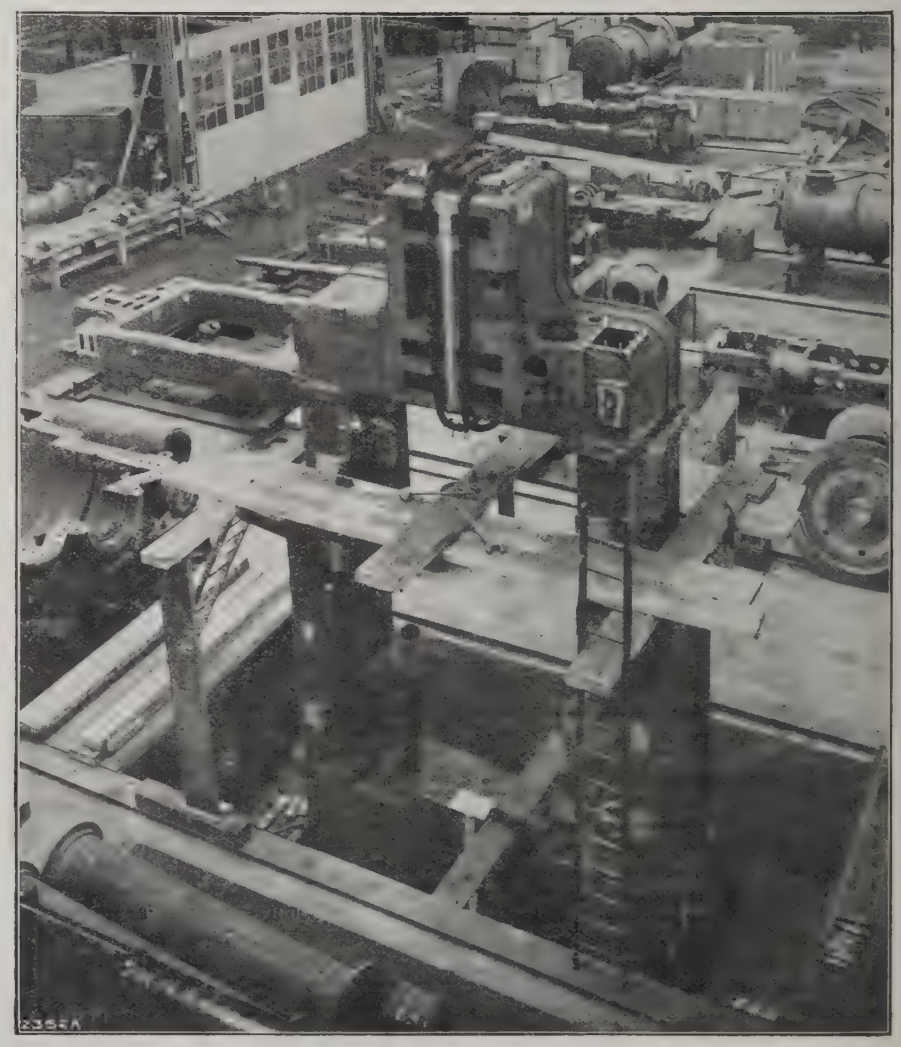


FIG. 26. VIEW SHOWING METHOD OF ASSEMBLING BED-PLATES VERTICALLY.

of water-turbines and water-power installations complete, of which they have built a very large number of all powers, for all purposes, working

under the most varied conditions, and under heads up to 910 m. (2986 ft.). Up to June last they had either built or had in course of construction :—

2611 tangential wheels, for 994,229 effective horse-power,
2282 Francis turbines, for 1,008,682 effective horse-power.
Total 4893 water-turbine plants, for 2,002,911 effective horse-power, and
5200 m. (over 32 miles) of high-pressure conduits.

They also build the Zoelly steam-turbine for all powers, ranging from 10 to 10,000 horse-power, and have supplied among other large units :—

One 7500 horse-power, 1000 revolutions, for the Central Station, Reisholz (Germany) ;
One 7500 horse-power, 1500 revolutions, for the Centrale Electrique de l'Escaut ;
One 5000 horse-power, 1400 revolutions, for the Charbonnage Grand Hornu (Belgium) ;
One 8500 horse-power, 1500 revolutions, for the Hydro-Electrica Española, Madrid.

The firm also design and build refrigerating machinery and installations, paper-making machines, steamers for lake navigation, steam-driven motor-boats complete, pumps and pumping installations complete, and Zoelly turbo-compressors. We will now proceed to give a brief description of the works.

The pattern-shop, in close proximity to the offices, is a two-storey building 40 m. (130 ft.) in length and 22 m. (72 ft.) in breadth, equipped with the necessary wood-working machinery, the wood chips and sawdust being exhausted from each machine. Close to this is a three-storey building, measuring 65 m. by 26 m. (213 ft. by 85 ft.), containing the pattern stores.

The foundry, which is illustrated in Figs. 2 and 3, on Plate XXII., is a clean, healthy shop, well equipped, and from which the smoke and gases are carefully exhausted. It is 88 m. (288 ft.) in width and 34 m. (111 ft.) in length, divided into seven bays, an annexe containing the brass foundry, another the sand-mixing plant, and still another the necessary appliances for the manufacture of cores. On leaving the foundry, and on their way to the machinery and erecting building, the finished castings pass through the fettling-shop. The brass foundry measures 37 m. by 7 m. (120 ft. by 23 ft.) The whole of the foundry installation covers an area of 5680 sq. m. (6800 sq. yards). The cast-iron foundry is served by twelve overhead electric travellers of powers ranging from 5 to 20 tons. It contains three cupolas, having a capacity of 3, 4, and 5 tons per hour. Most of the work is cast in sand, but the foundry is fully equipped for casting in loam ; the largest pieces, for water-turbines, are mostly so cast, and weigh up to 20 tons. The brass foundry contains eight Baumann crucibles, and can exceptionally manufacture pieces weighing up to $2\frac{1}{2}$ tons.

The machine and erecting-shop for steam-turbines and water-wheels occupies the centre of the works and is a magnificent shop. It is illustrated in Figs. 4 to 24, on Plates XXII. to XXVII., and is 145 m. (575 ft.) in width and 104 m. (340 ft.) in length, divided into fifteen bays, as follows :—One of 8 m. (26 ft.), one of 23 m. (75 ft.), six of 13 m. (42 ft.), six of 4 m. (13 ft.), and two of 6 m. (19 ft.). The whole of the bays are served by eighteen overhead electric travelling-cranes, of power ranging from 5 to 30 tons. The largest, 23 m. (75 ft.), bay contains four travellers, two of 10 tons, running on a track situated at a height of 7.5 m. (24 ft. 7 ins.) above the shop level, and two of 20 and 30 tons, on a track at a height of 10.5 m. (34 ft. 5 ins.) above the same level, and therefore above the smaller ones. Normal and narrow-gauge railway tracks run throughout the building from all the other shops ; railway wagons can be loaded for the delivery of finished machinery by the overhead travelling cranes in the different bays. A marked feature of this building is the method followed for heating it during the winter months, when the outside temperature remains for many weeks together below freezing point. The heating installation consists of eleven hot-water boilers, which supply hot water through pipes which are fitted vertically, parallel with several of the columns supporting the various bays, or through a system of radiators, which are mounted inside the built-up stanchions in the centre bays (see Figs. 8, 9, 10, and 13, on Plates XXIII. and XXIV.). The heating of the shops commences with the setting in of winter and continues night and day without interruption until spring ; it costs the company 30,000 francs (1200*l.*) every winter.

The large machine-tools are driven electrically by separate motors ; the medium-size and smaller ones are driven electrically in sets by belt transmission. There are, so to speak, no specialised machines ; they are employed indifferently on water-turbine or steam-turbine parts, or for machining the elements of other plants manufactured by the firm. There are several large and powerful tools, among which we may mention a vertical boring and turning machine capable of taking pieces up to 2.6 m. (8 ft. 6 in.) high and 4 5 m. (14 ft. 9 in.) in diameter, and next to it a similar machine taking pieces having the same height and up to 6 m. (19 ft. 8 in.) in diameter. Close to these, and distributed over the shops, are twelve marking-out tables. The work coming from the foundry, in a straight line through the fettling-shop, is delivered to these marking-out tables, whence it proceeds to the machining department, to that machine suitable for the work which happens to be free to take it, thence it passes to the erecting bay. This large shop may be considered as

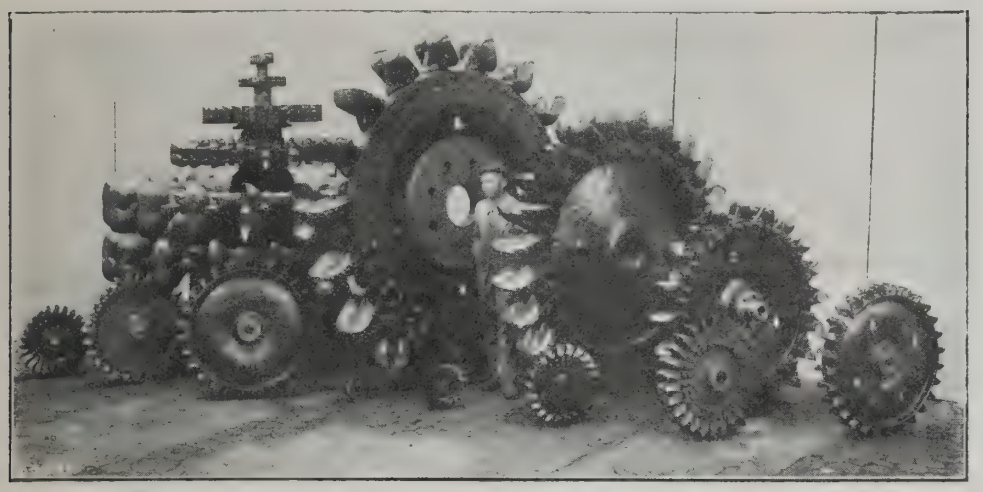


FIG. 27. PELTON WHEELS.

FIG. 28. PADDLE-STEAMER LOADED FOR TRANSIT.

FIG. 29. MOTOR-BOAT LOADED FOR TRANSIT.

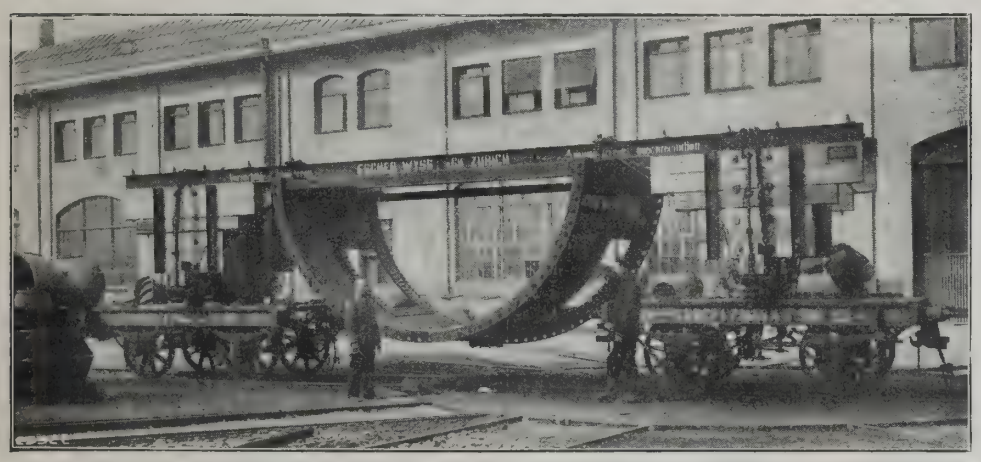


FIG. 30. HALF-CASING FOR WATER-TURBINE.

divided into two parts by the railway track through its centre; on one side are located the machine-tools, while on the other side is the erecting department for the various machines and installations built by the firm. The large bay contains at the present time in course of completion and testing under steam the following large steam-turbine units: one of 8400 horse-power at 1500 revolutions, one of 5000 horse-power at 1500 revolutions, one of 3000 horse-power at 1500 revolutions, and one of 7300 horse-power at 1500 revolutions, besides a large number of smaller turbines.

The steam-turbines are erected on heavy framework built over a number of separate masonry pits, several of which are provided with live steam flexible connections for supplying steam to any turbine under test. The pits are also provided with the necessary connections with the condensing plant, with lubricating pipes, and all the necessary apparatus.

The water-turbines are erected in the same bay, when space is available, and also in two of the parallel bays. Messrs. Escher Wyss and Co. have lately completed and delivered two 13,000 horse-power 225 revolutions 160-ton turbines to work under a head of 33 m. (108 ft.). They have in course of construction for the Laufenburg, Switzerland, hydro-electric generating station, four water-turbines of 5000 horse-power each, for an 8 m. (26 ft. 3 in.) head; six 12,500 horse-power units for Japan, for a head of 120 m. (393 ft.); six 12,000 horse-power units, also for Japan, for a 320 m. (1050 ft.) head; besides a number of other smaller units. They have also recently booked a contract from the Rio de Janeiro Tramway, Light, and Power Company for two water-turbines each of 19,000 horse-power, for a head of 266 m. (872 ft.). These will be the largest water-turbines yet built in Europe. Escher Wyss water-turbines are now working in practically every country of the world.

A portion of the main engineering building is set apart for a tool shop; the company generally manufacture all their special tools, most of which are of high-speed steel or with high-speed steel insets.

The boiler-shop, flanging-shop, and ship-construction berth, measures 120 m. (393 ft.) in length, 36 m. (118 ft.) in width, and is served by three overhead electric travelling cranes, two of 15 tons and one of 5 tons. Fig. 25, on Plate XXVII, is a view in the boiler-plate-bending shop. The shipbuilding berth is closed on the outside by a movable partition to allow for extension. Messrs. Escher Wyss and Co. have at the present time on order two passenger steamers for Lake Constance and Lake Neuchatel. The principal dimensions of these steamers are the following :—

—	Length.	Beam.	Power of Steam-Engines.
			h.-p.
Lake Constance	53.5 m. (175 ft.)	6.3 m. (20 ft)	700
Lake Neuchatel	46 m. (150 ft.)	6 m. (19 ft.)	350

Their hulls will be bolted up on the shipbuilding berth at the Zurich works, then taken to pieces for riveting on the slipways belonging to the Lake Navigation Companies, where the steamers will be launched, engined, and fitted up. At the present time the berth is occupied by a barge, which Messrs. Escher Wyss and Co. are building for a contractor for service on one of the Swiss lakes. It is built in two longitudinal parts, which are taken apart for delivery by rail, the two parts will be finally riveted up together on the spot. The barge is propelled by a screw, driven by a 15 horse-power petrol motor. In the boiler-shop proper are several large boilers in course of completion, including a tubular boiler for a passenger steamer for Belgrade, Servia, for which the firm are also building the 700-horse-power steam-engine; several condenser-shells, &c. A large hydraulic riveting-machine, which is capable of taking pieces up to 3.5 m. (11 ft. 6 in.) in diameter and 10 m. (32 ft. 10 in.) high, completes the installation.

The smithy is 48 m. (157 ft.) in length and 18 m. (59 ft.) in width; it contains five steam-hammers of from 2 to 30 cwt. served by the necessary open fires and revolving-jib cranes. The copper-smiths' shop, which adjoins the smithy, deals with the bending of pipes of various diameters required in the different installations built by the company.

A good view in the turbine-erecting bay is afforded by Fig. 26, on page 86, which shows their method of erecting bed-plates for turbine sets vertically in one of their turbine-erecting and testing pits. Fig. 27, on the same page, shows a number of Pelton wheels manufactured by the firm.

Messrs. Escher Wyss build a large number of motor-boats complete, fitted with a multitubular-boiler arranged to burn coal, oil fuel, or wood, and supplying steam to miniature marine-engines, which they build, of powers ranging up to 100 horse-power. They have several small shops set apart for this, and have at the present time in course of construction for Brazil, a steam-driven yacht, the hull of which is built of galvanised-steel sheets. She is 20 m. (65 ft. 7 in.) long, 2.5 m. (8 ft. 2 in.) beam, and 1.1 m. (3 ft. 7 in.) deep, and with wood-firing will reach a speed of 24 km. (14.9 statute miles), with 50 horse-power. Fig. 28, on page 87, shows a small steam paddle-boat, 59 ft. long, in three sections, ready for delivery. Fig. 29, on the same page, illustrates a 25-horse-power steam-launch for a Swiss lake.

Fig. 30, also on page 87, shows the manner followed for delivering the housings for large water-turbines.

There are distributed over the works and in convenient situations a number of store rooms and dépôts, as shown on the plan, Fig. 1.

The current-generating station is parallel with the main central building and in a line with the smithy. Messrs. Escher Wyss and Co. own at Bremgarten, on the Reuss, at a distance of about 12 miles from Zurich, a 1500 horse-power hydro-electric station, from which they take 900 horse-power in the form of three-phase current at 5000 volts, the remainder being sold to other firms. The 5000-volt three-phase current is transformed down to 200-volt three-phase at the Zurich works station for power. This station contains three steam-boilers, having a total heating surface of 620 sq. m. (6600 sq. ft.), and provided with superheaters and economisers. They supply steam to three engines, two being vertical, of 250 and 350 horse-power, and one horizontal, of 450 horse-power, thus aggregating 1050 horse-power, coupled to the electric generators. The electric lighting throughout the works is by continuous current, generated by the 350 horse-power vertical-engine set. The boilers supply the steam and superheated steam to the turbines undergoing their steam tests in the erecting-shop above referred to. They are fed with water from a well sunk in close proximity. The draught is obtained by a brick chimney 40 m. (130 ft.) high, provided at about the middle of its height with a water-tank having a capacity of 50 cubic metres (11,000 gallons), into which the water from the well is pumped for delivery to various parts of the works and offices. The steam-engines in the works' generating station act as a stand-by and run more generally during the winter months, when there is not sufficient water at the Bremgarten hydro-electric station. Two small locomotives are used for hauling cars to and from the various shops.

We have stated above that Messrs. Escher Wyss and Co. have built water-power stations for heads up to 910 m. (2986 ft.). A recent installation of theirs of considerable importance is that of the Adamello, on the Austro-Italian frontier, in which the water from the lake of Arno is utilised in a generating-station at a place called Isola. Further extensions of the system are contemplated. The power-house at Isola has been designed for seven sets of 6500 horse-power each, consisting of Pelton wheels 2.750 m. (9 ft.) in diameter, coupled to 12,000-volt three-phase generators.

The Zurich works employ 2000 engineers, clerks, and men. Messrs. Escher Wyss and Co. also own works at Ravensburg, in Germany, which employ 300 men in the construction of water-turbines, paper-making plant, and transmission gearing.

THE PORT OF DAKAR.—The French authorities are showing much energy in the development of Dakar, the capital of the French possessions in Western Africa. Large sums have in the course of the last two years been expended upon harbour works, and the entrance is now protected by two piers carried a considerable distance out to sea. The dry dock, which has entailed an expenditure of about 125,000*l.*, can accommodate vessels up to 16,000 tons capacity, and is practically the only dock on the West Coast of Africa. During the last eight years an aggregate of about 2,000,000*l.* has been expended in public works of different nature, and a still larger sum is available for further undertakings, canals, waterworks, &c.

LITERATURE.

Bridge Engineering—Roof Trusses: A Manual of Practical Instruction in the Calculation and Design of Steel Truss and Girder Bridges, for Railroads and Highways, including Analysis and Design of Roof Trusses and other Details of Mill Building Construction. By FRANK C. DUFOUR, C.E.; Assistant Professor of Structural Engineering, University of Illinois. Chicago: American School of Correspondence; London: Crosby Lockwood and Son. [Price 12s. 6d. net.]

THIS book, primarily designed for the use of students of the American School of Correspondence, is not to be regarded, it may be presumed, as complete in itself, since it is intended for the use of those who are to profit also by assistance rendered by the school. It is to be expected, therefore, that the treatment should be somewhat less convincing than in the case of a work entirely self-contained. This proves to be the fact, yet though the statement of principles is somewhat bald, and in some cases not free from obscurity, and no sort of demonstration of those principles is, as a rule, vouchsafed, the methods are so fully detailed that the student may hope by diligent application and much thinking, to arrive at a sound understanding of the reasons underlying the processes developed; but for the unaided reader it will hardly be an easy book. Those having some knowledge of the subject, being less dependent upon extraneous help, may find the book useful as a means of recovering lost knowledge, or of supplementing that already mastered.

Of some 250 pages devoted to bridge engineering, about one-half are allotted to the determination of stresses in framed structures, by usual algebraic methods, graphic solutions being in no case resorted to. Various cases of loading are dealt with, and the solution of maximum web and chord stresses for concentrated wheel loads is given in considerable detail for the simpler forms of trusses and for plate girder-spans. Wind effects are treated at some length, both with respect to through and portal bracing, in an instructive manner. The latter part of the space devoted to bridge engineering is used to give practical expression to the teaching of the earlier part, by dealing with detail design and methods of construction in steel. This portion is perhaps more satisfactory than that which precedes it; there is much information of value in design, and though presenting nothing very new, yet, by collecting useful matter from diverse sources, the author renders no little service to the student. Examples of a plate girder bridge and of a through Pratt truss-span are worked out at length. Before dismissing this section of the book it may not be improper to note that the title is a little too inclusive, having regard to the fact that a small part only of the whole science of bridge engineering is treated, and some idea of the limitations of this part will be gathered from the fact that though treating of steel construction wholly, the flexure of beams and trusses is nowhere touched upon

The second section of the book, of nearly 100 pages, dealing with roof trusses, contains much information of a very practical kind, and is perhaps on the whole superior to that dealing with bridges. A collection of formulæ for the weights of roof trusses, by various authorities, is displayed, giving, however, very divergent results. With respect to these formulæ it may be said that Merriman's, though simple, appears to be, in its results, most conformable to British practice, while Bryan's seems to be incorrectly given in this connection, as it yields weights sufficient, indeed more than sufficient, to include both the truss and all other steel-work of one bay. The loads to be supported by roof trusses, recommended for adoption, are in excess of those commonly assumed in this country, due, no doubt, to differences of climatic conditions as to a great part. The calculation of inclined rafters, as given in one of the examples, in which no notice is taken of the effect of inclination upon the bending effort of vertical loads, is hardly satisfactory.

With respect to the very usual practice of computing stresses in ordinary roof trusses by assuming an inclusive distributed and vertical load, instead of determining such stresses correctly for the various conditions of loading, the author, commenting upon it, approves the usage for spans up to 100 ft., though it is doubtful if it can wisely be adopted beyond 60 ft., at about which width differences in the approximate and the true stress values, and the sections resulting, begin to be appreciable. Reversal of stress in some members, due to wind striking the

THE WORKS OF MESSRS. ESCHER WYSS AND CO., ZURICH, SWITZERLAND.

(*For Description, see Page* 86.)

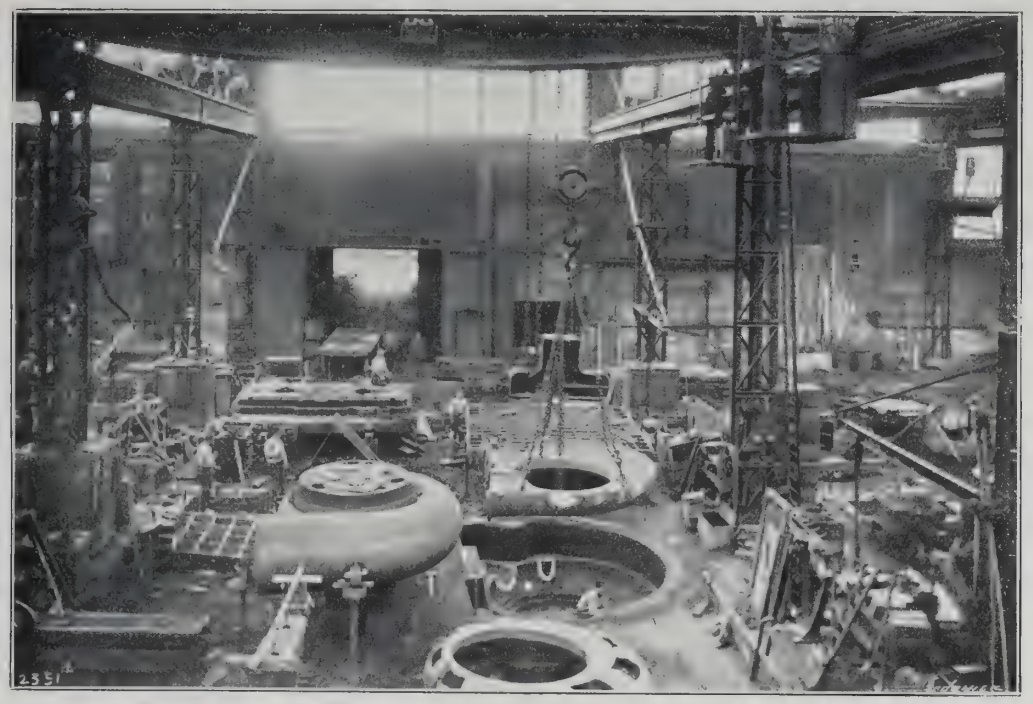


FIG. 2. VIEW IN FOUNDRY.

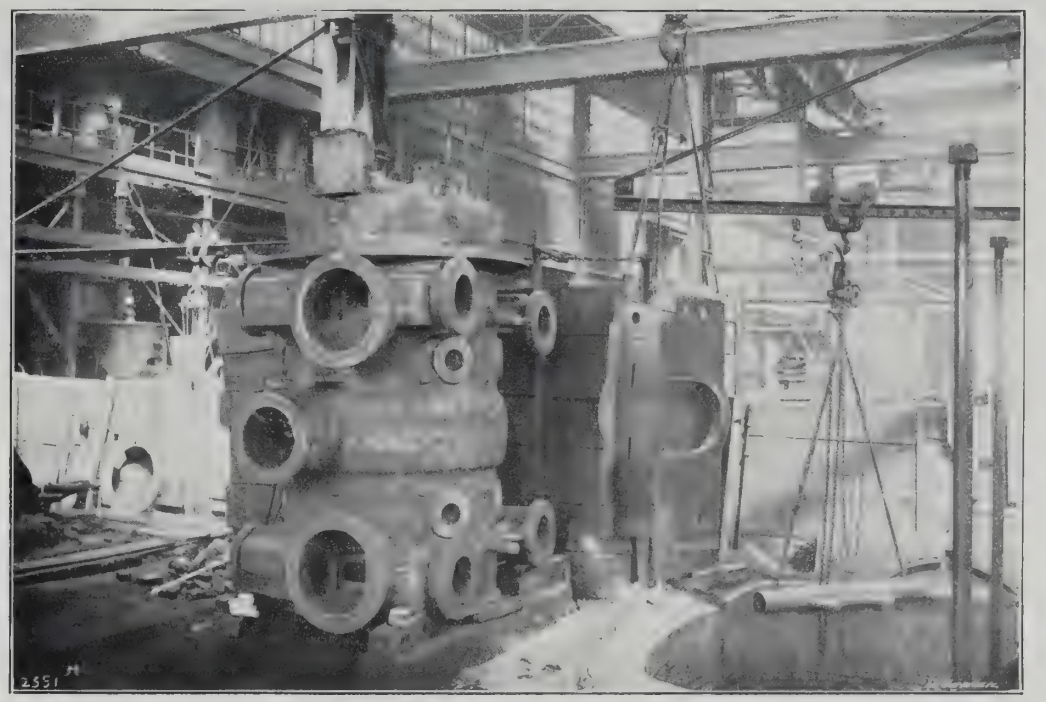


FIG. 3. VIEW IN FOUNDRY.

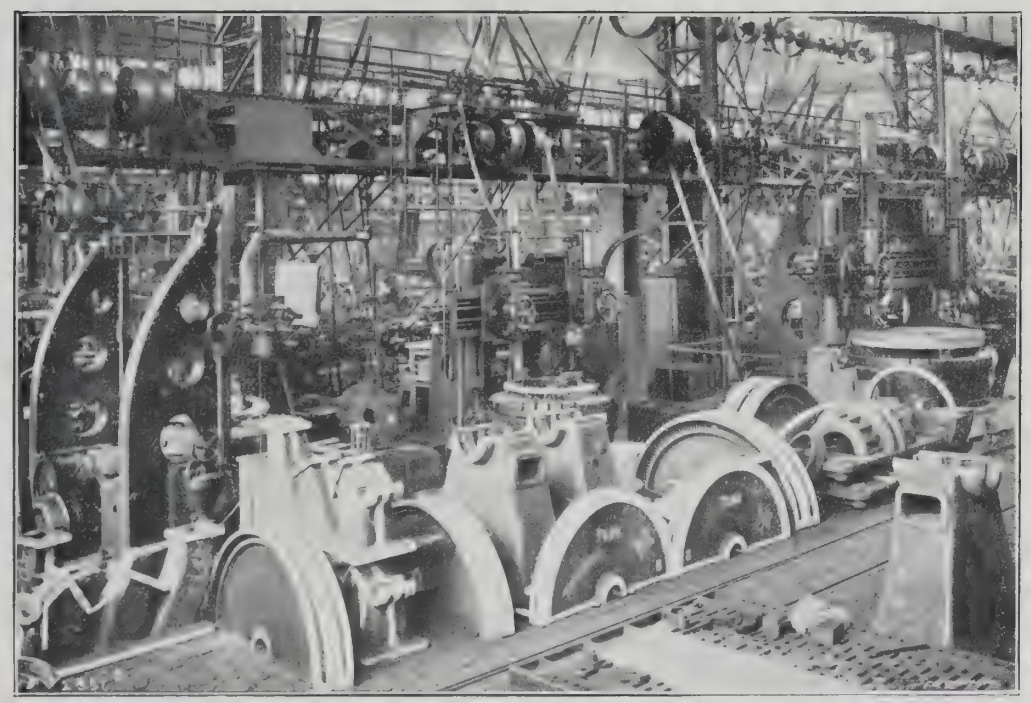


FIG. 4. VIEW IN A BAY OF THE MACHINE AND ERECTING-SHOP.

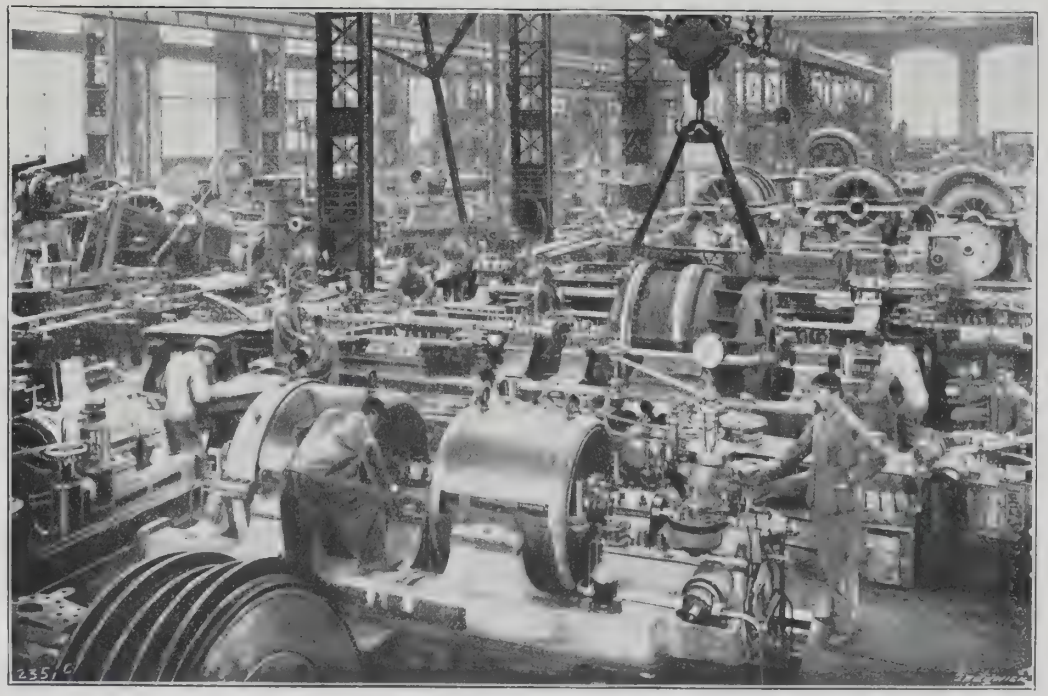


FIG. 5. ERECTING-BAY FOR STEAM-TURBINES.

(*To face Page* 88.)

THE WORKS OF MESSRS. ESCHER WYSS AND CO., ZURICH, SWITZERLAND.

(*For Description, see Page* 86.)

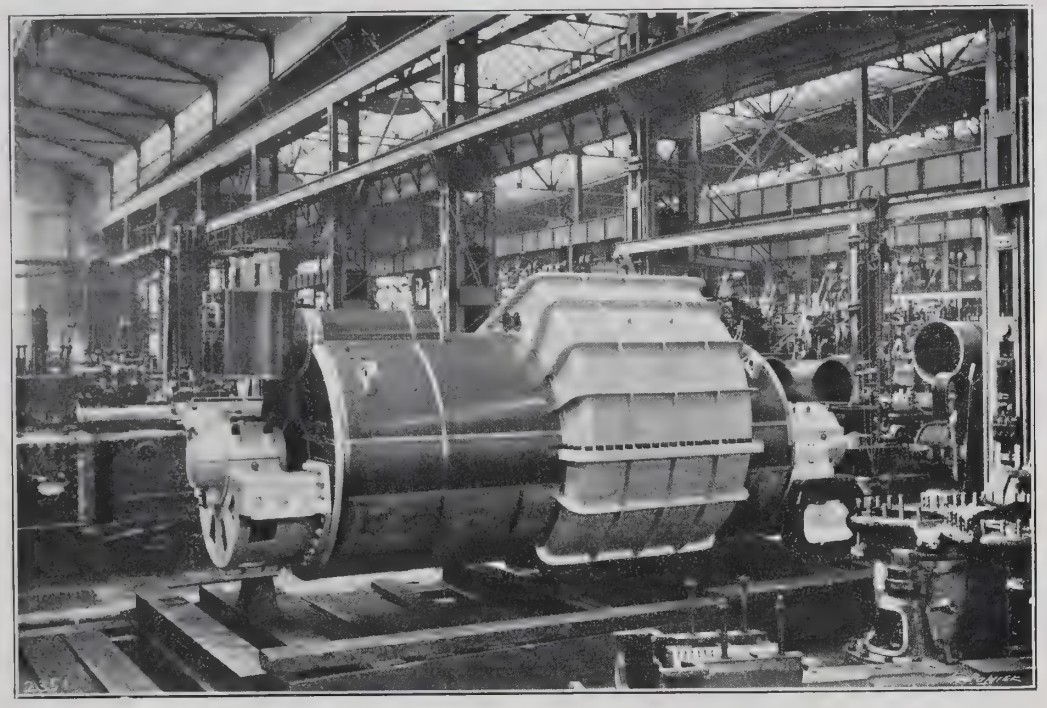


FIG. 14. STEAM-TURBINE FOR A TORPEDO-BOAT; 7000 H.-P.; SPEED, 680 REVOLUTIONS.

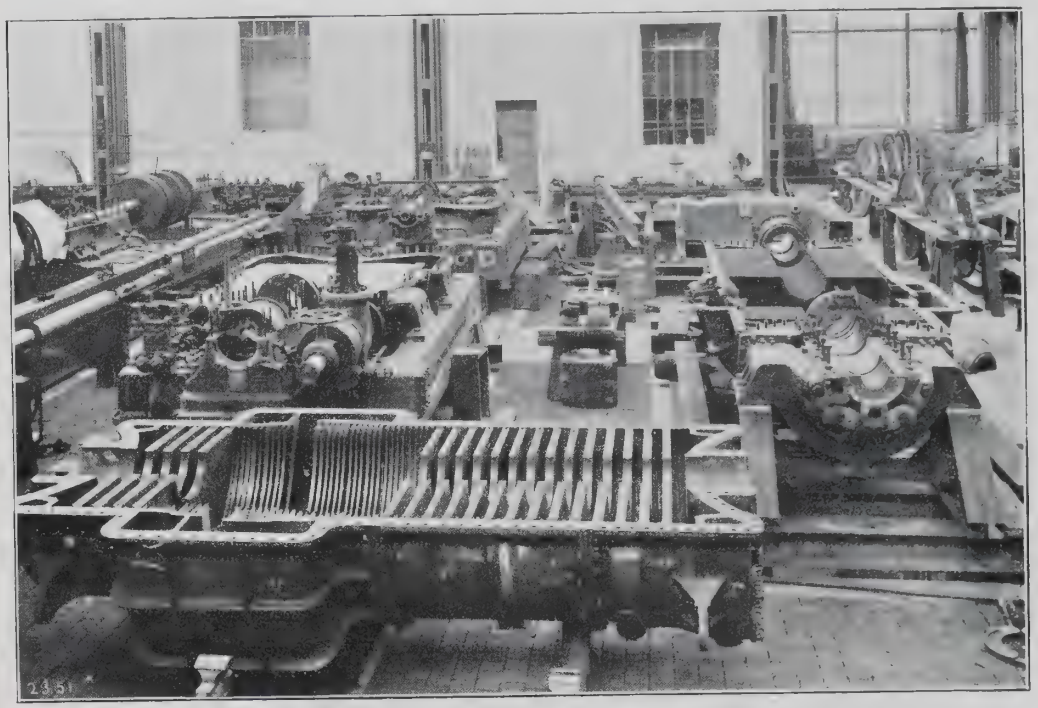


FIG. 15. ERECTING-BAY FOR MARINE TURBINES.

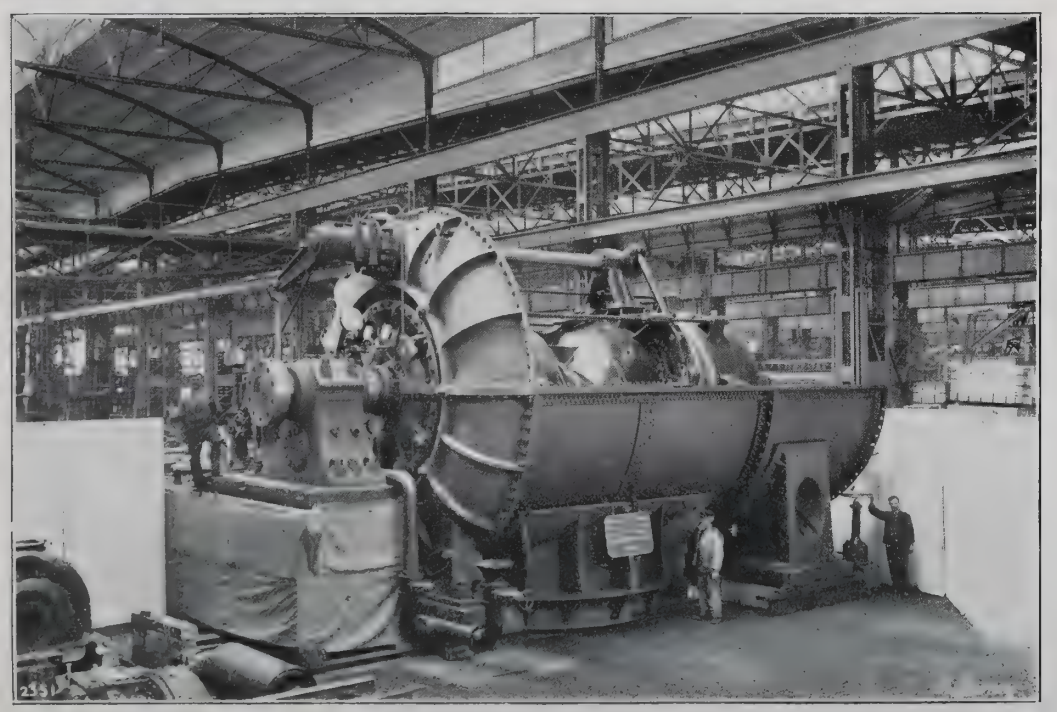


FIG. 16. 13,000-H.-P. DOUBLE FRANCIS TURBINE IN COURSE OF ERECTION.

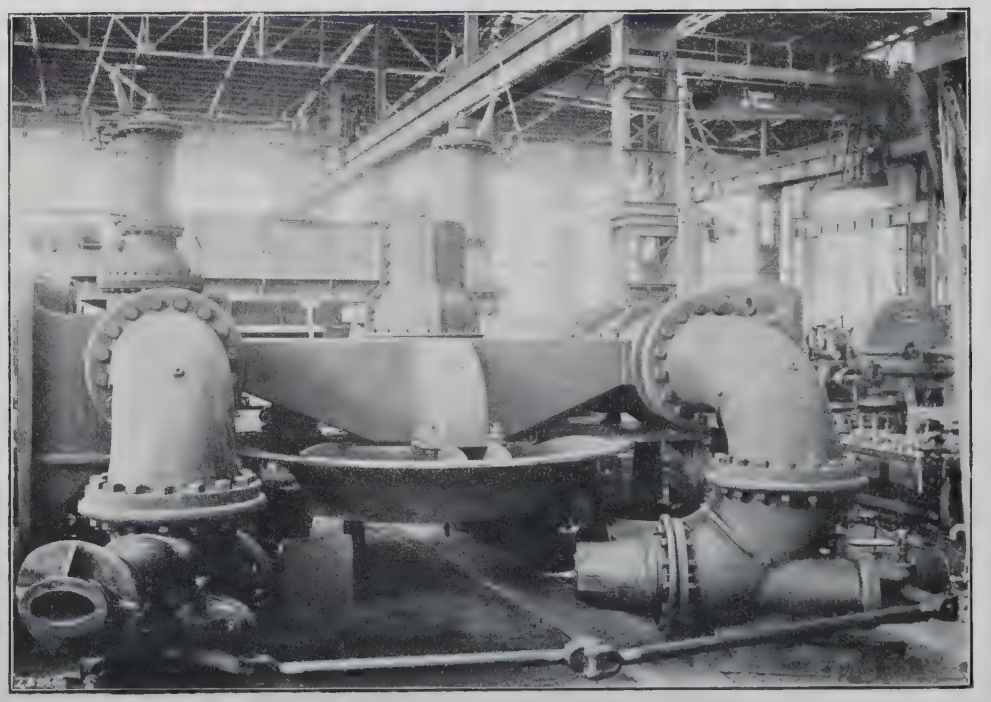


FIG. 17. 11,000-H.-P. WATER-TURBINE IN COURSE OF ERECTION; SPEED, 300 REVOLUTIONS; HEAD, 800 FT.

THE WORKS OF MESSRS. ESCHER WYSS AND CO., ZURICH, SWITZERLAND.

(*For Description, see Page* 86.)

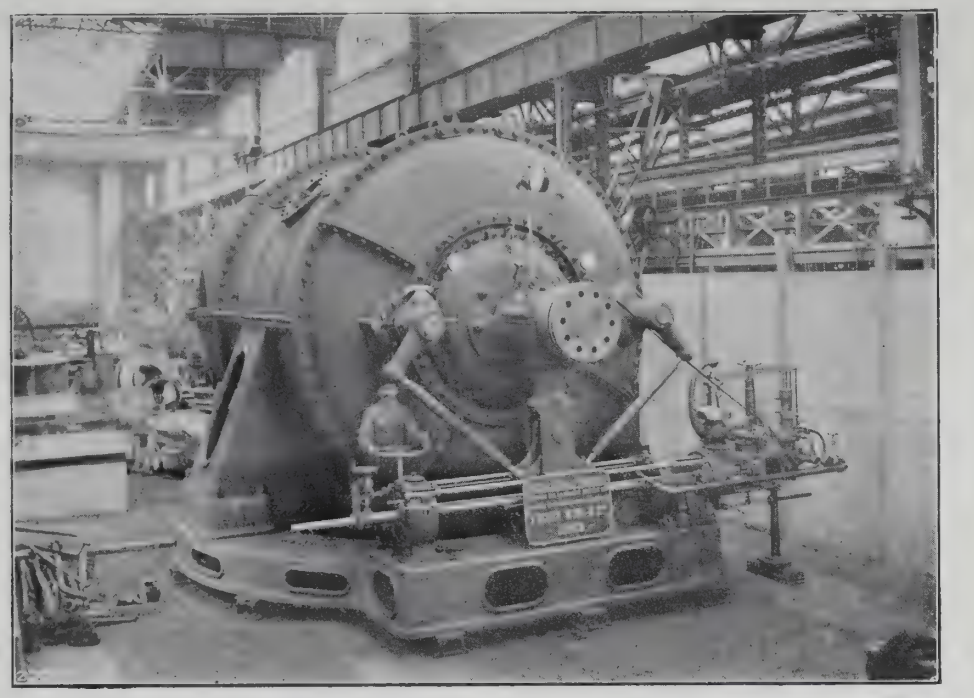


FIG. 18. 4500-H.-P. WATER-TURBINE IN COURSE OF ERECTION; SPEED, 180 REVOLUTIONS; HEAD, 684 FT.

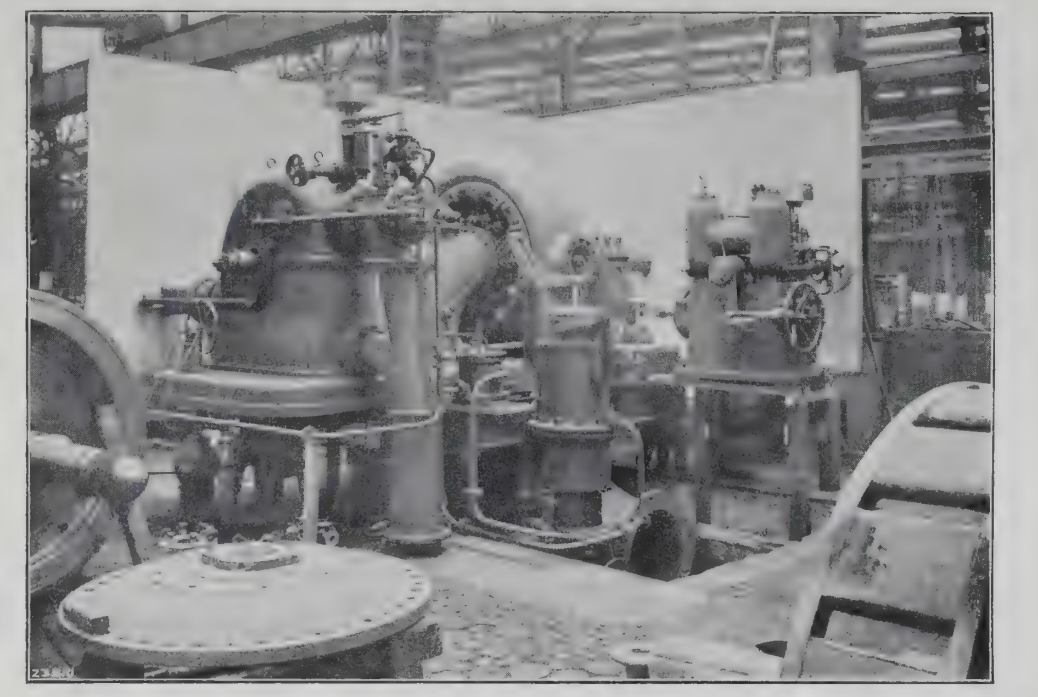


FIG. 19. 4000-H.-P. WATER-TURBINE IN COURSE OF ERECTION SPEED, 1000 REVOLUTIONS; HEAD, 440 FT.

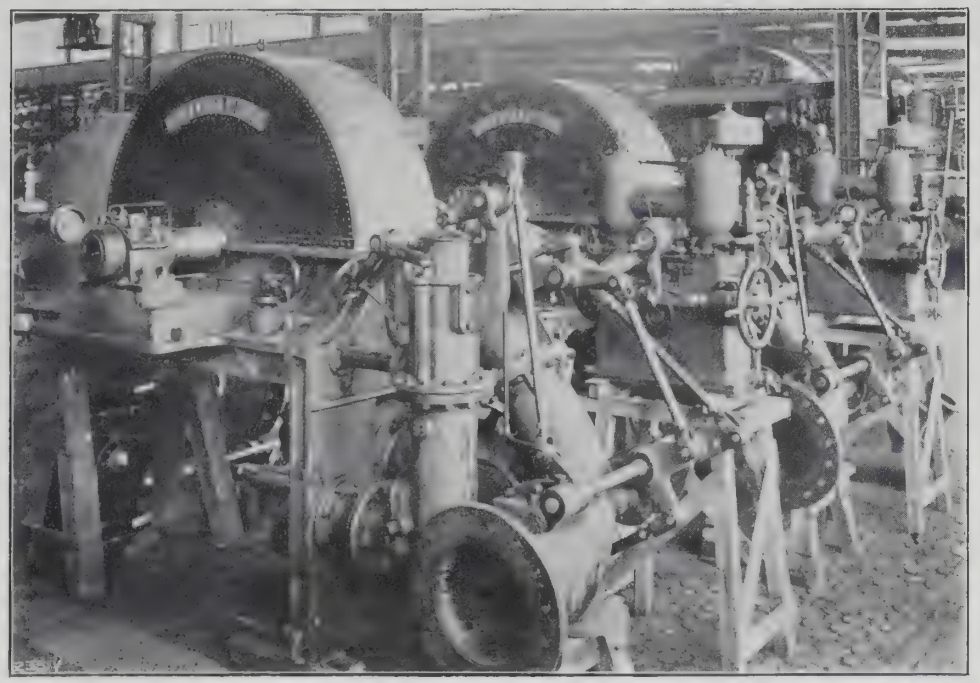


FIG. 20 4500-H.-P. WATER-TURBINES IN COURSE OF ERECTION; SPEED, 375 REVOLUTIONS; HEAD, 880 FT.

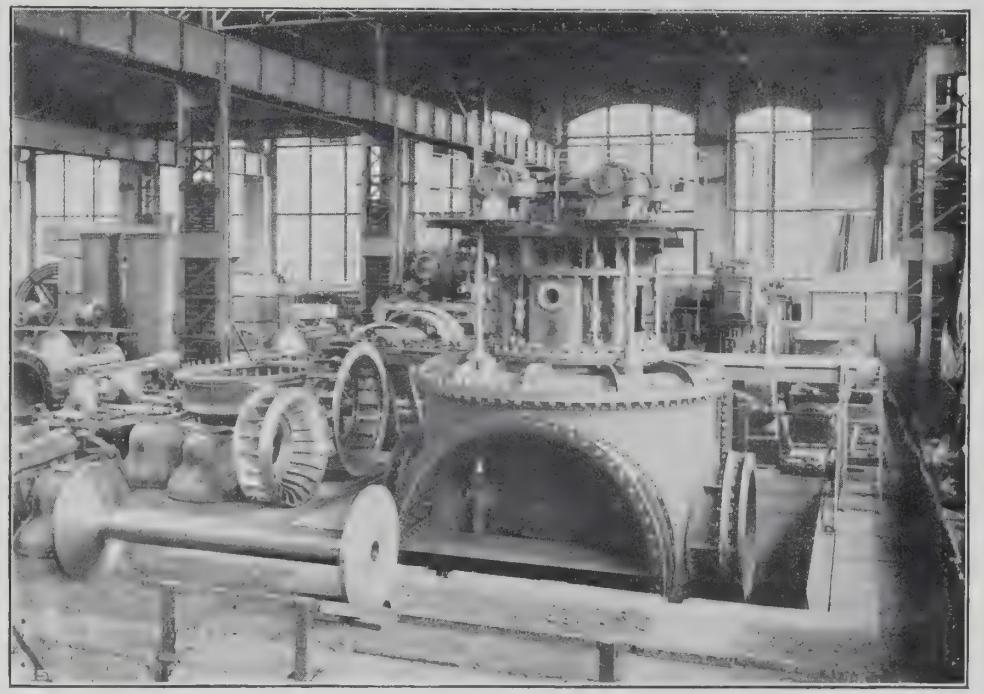


FIG. 21. 10,250-H.-P. WATER-TURBINES IN COURSE OF ERECTION; SPEED, 250 REVOLUTIONS; HEAD, 121 FT.

THE WORKS OF MESSRS. ESCHER WYSS AND CO., ZURICH, SWITZERLAND.

(*For Description, see Page* 86.)

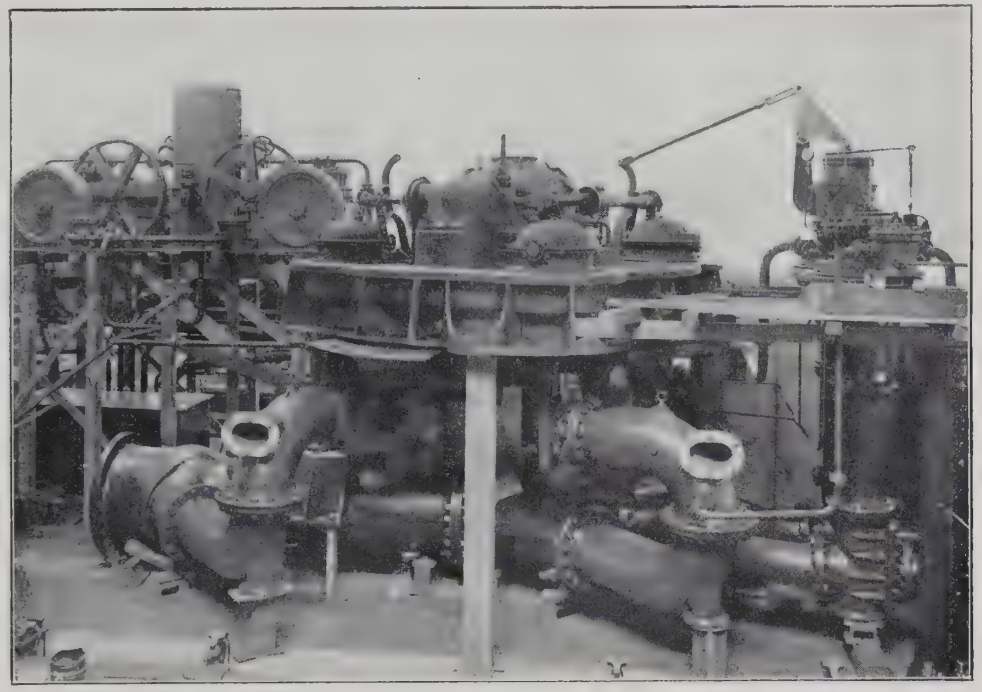


FIG. 22. 16,000-H.-P. WATER-TURBINES IN COURSE OF ERECTION; SPEED, 375 REVOLUTIONS; HEAD, 950 FT.

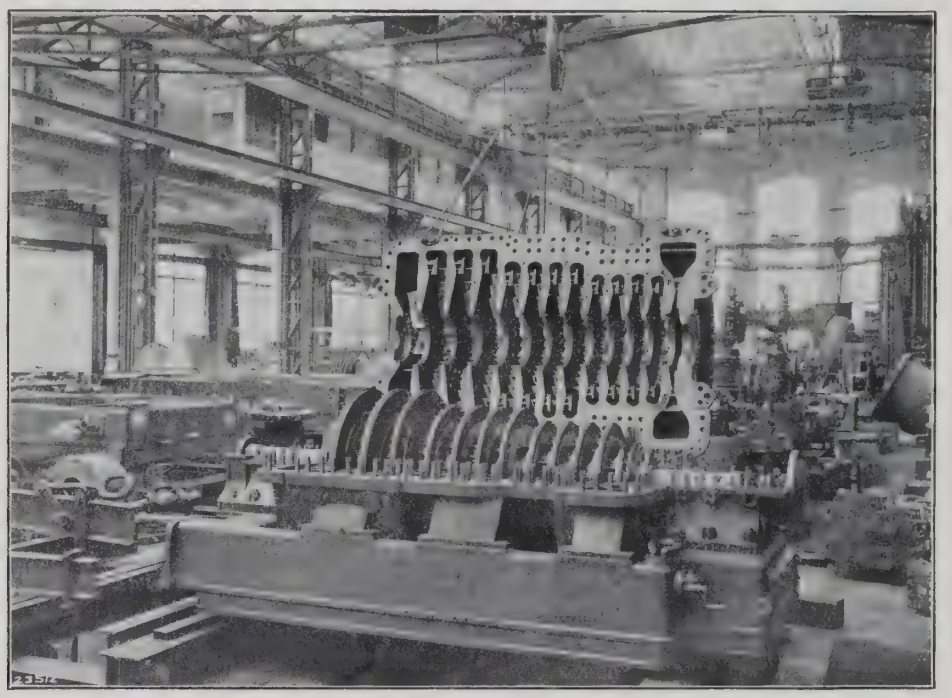


FIG. 23. ROTARY AIR-COMPRESSOR IN COURSE OF ERECTION.

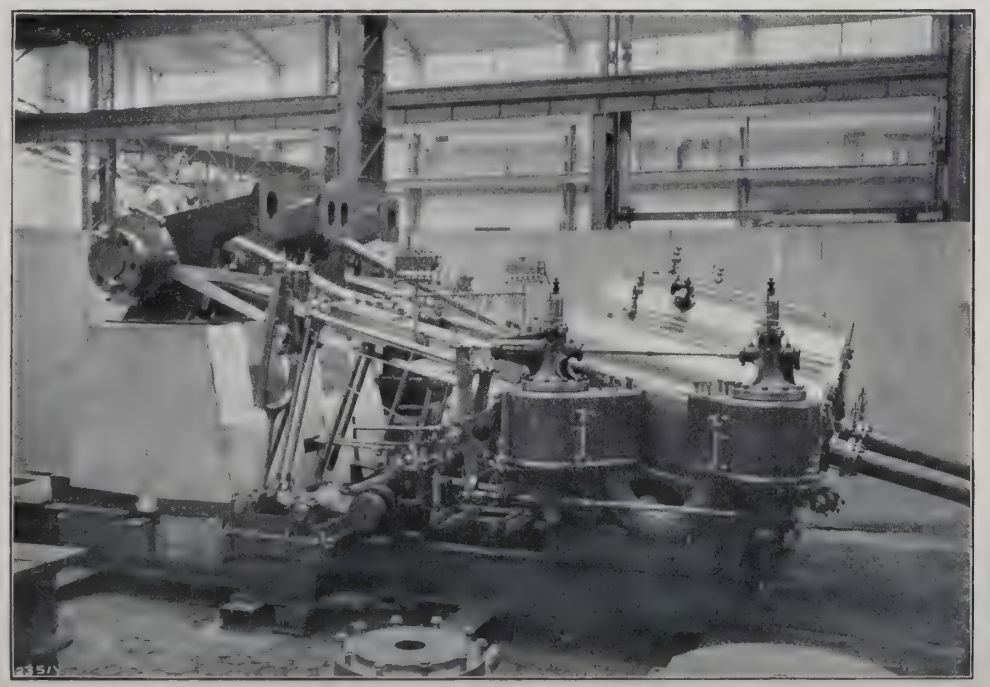


FIG. 24. MARINE ENGINE FOR SWISS LAKE STEAMER.

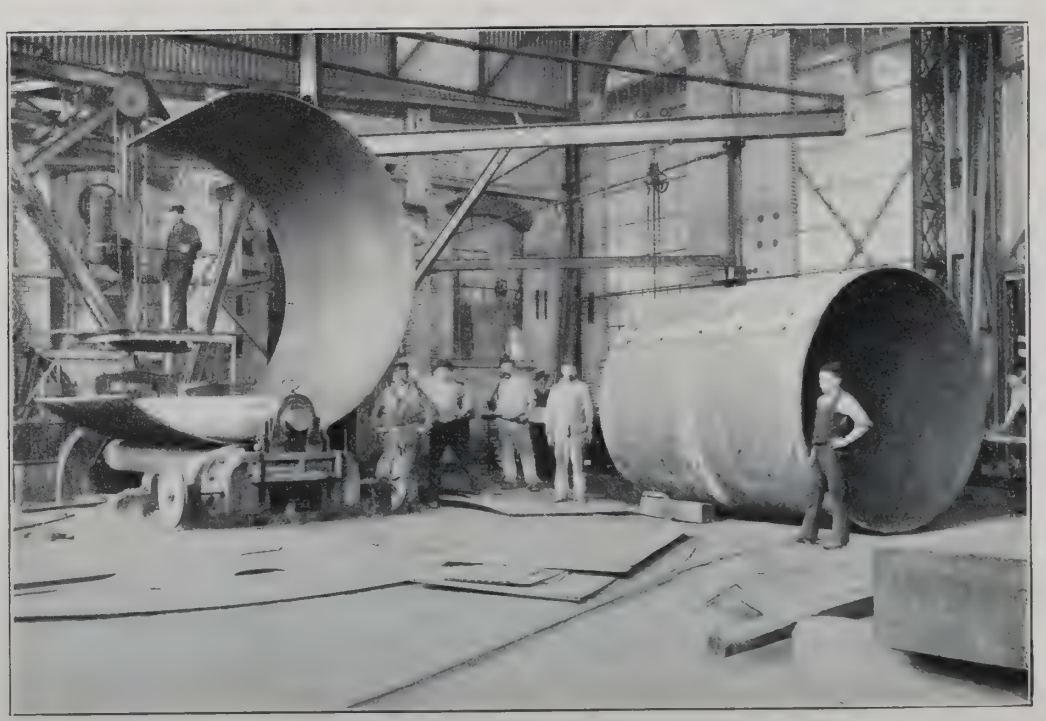


FIG. 25. VIEW IN BOILER-PLATE-BENDING SHOP.

THE SWISS LOCOMOTIVE AND ENGINEERING WORKS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 89.)

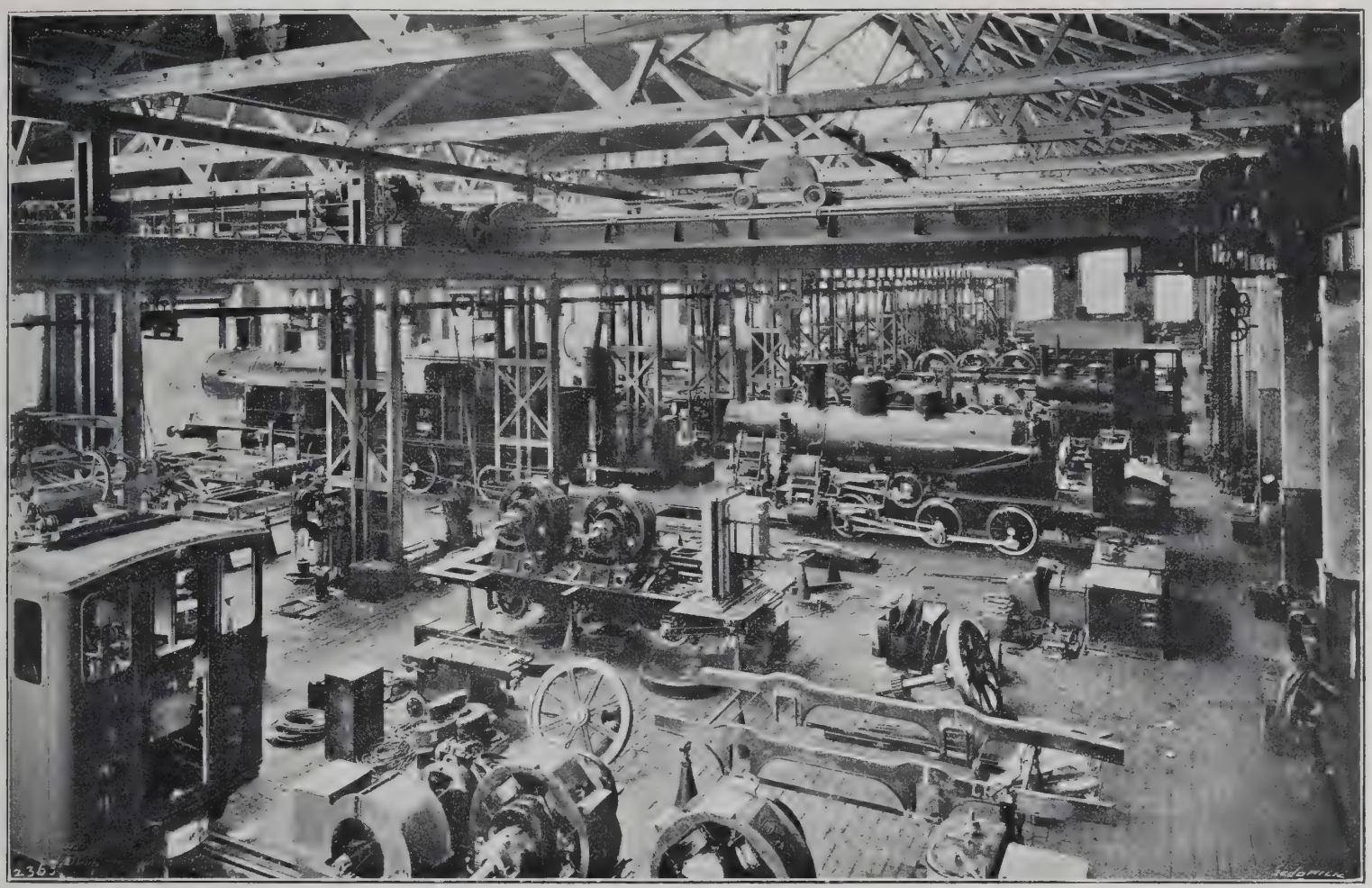


FIG. 3. LOCOMOTIVE-ERECTING SHOP.

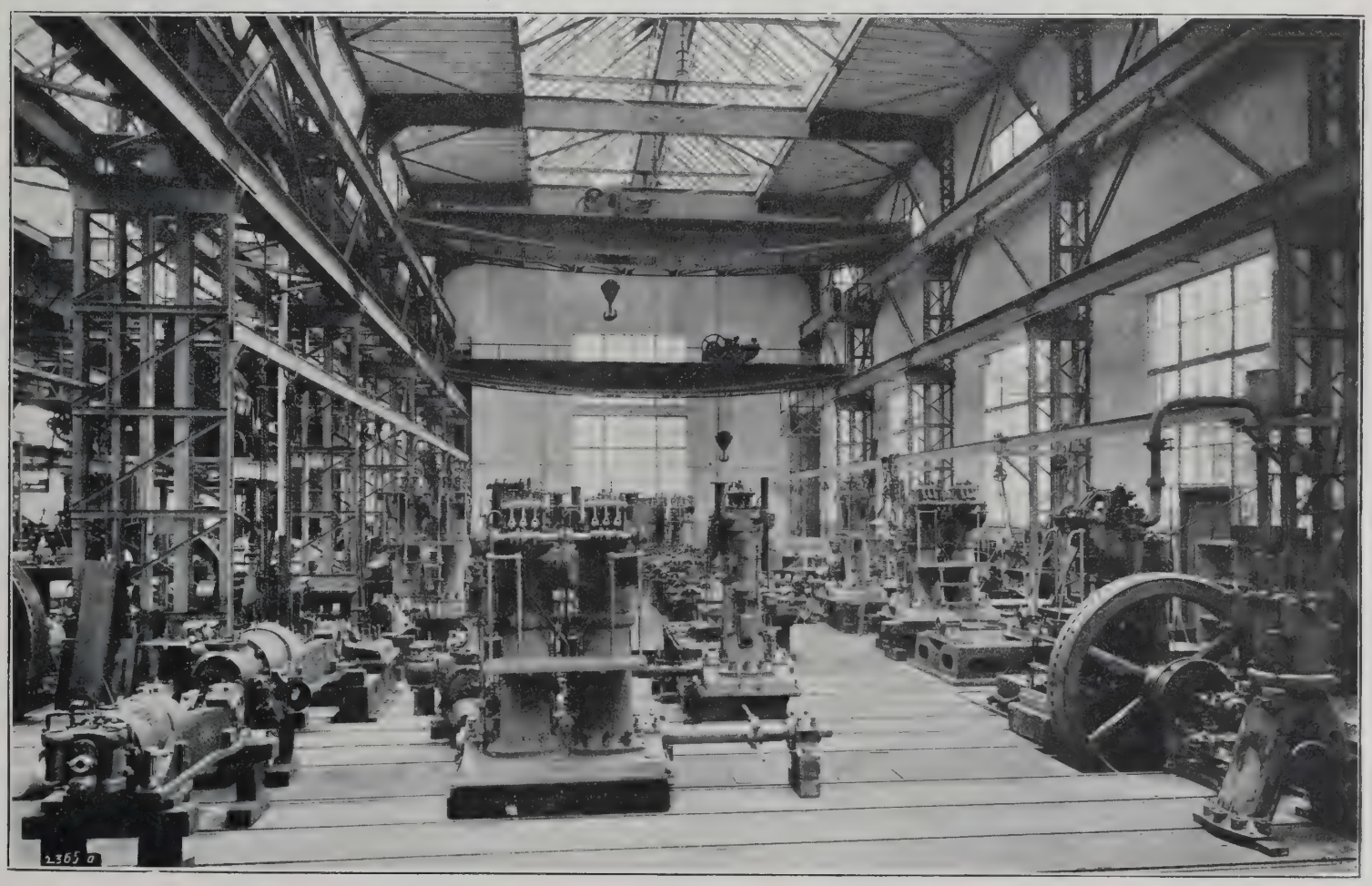


FIG. 4. ERECTING AND TESTING-SHOP FOR DIESEL ENGINES.

THE SWISS LOCOMOTIVE AND ENGINEERING WORKS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 89.)

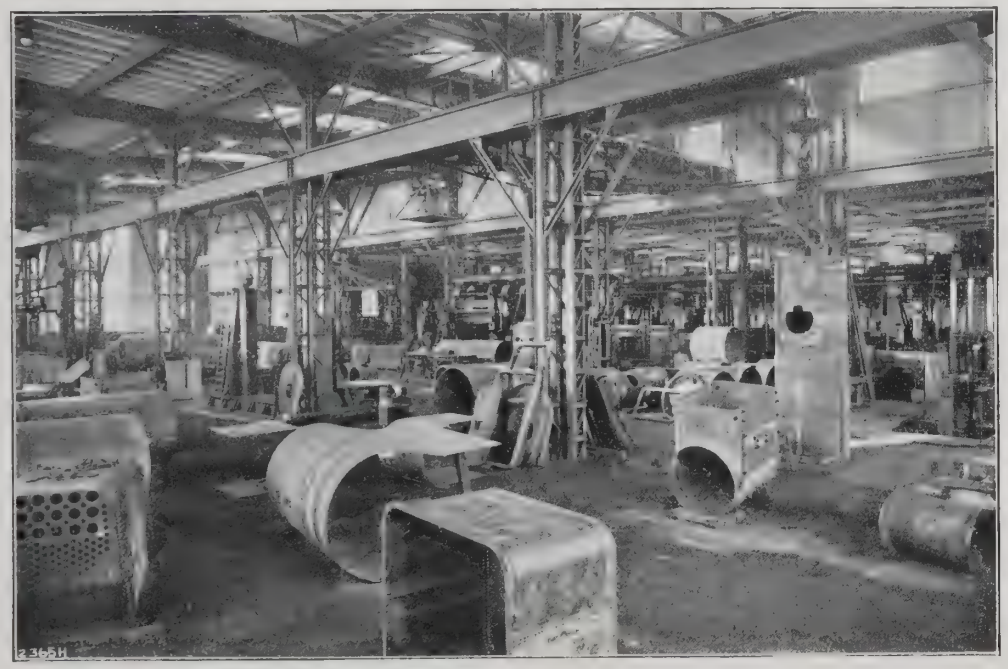


FIG. 5. LOCOMOTIVE BOILER-SHOP.

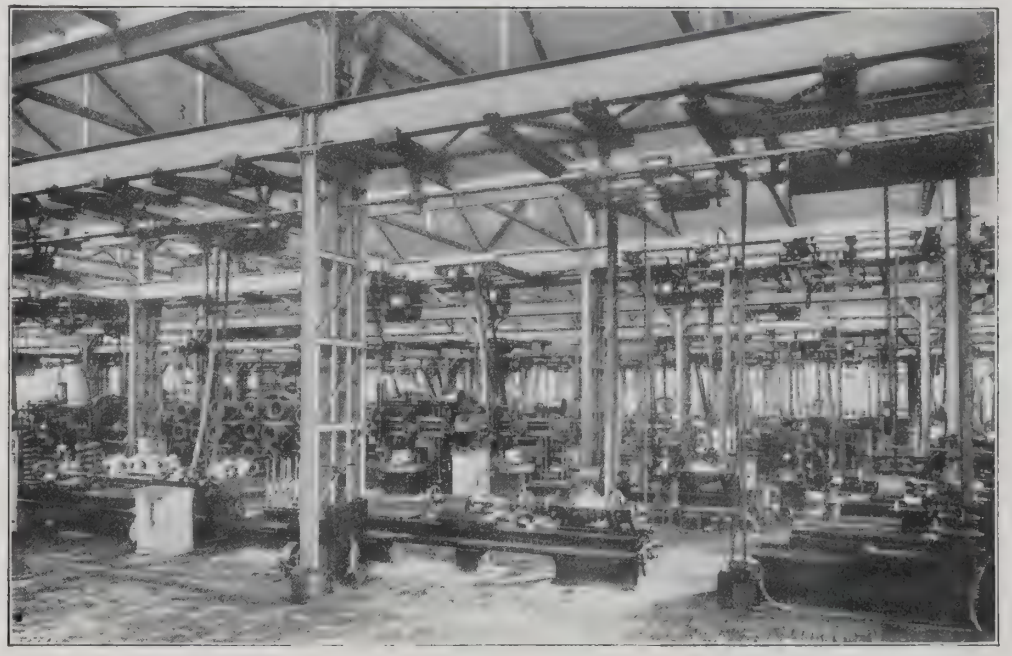


FIG. 6. VIEW IN TURNING-SHOP.

FIG. 7. GAS-ENGINE ERECTING-SHOP.

FIG. 8. VIEW IN TURNING AND FITTING-SHOP.

roof on one side, may also become a serious matter if the vertical load convention be too light-heartedly adopted. The treatment of stresses in the main members is indeed of a somewhat perfunctory character. The many short cuts to stress amounts, though undeniably helpful in practical design, are not such as to develop in the student a mastery of the subject. Some cases of difficulty have, however, received particular attention, as in the case of roof trusses connected by knee-braces to wall stanchions, for which the stresses are investigated at length. The details of roof construction and roof coverings are exceptionally full and instructive, and should prove of the greatest utility.

As a whole, this book has much to recommend it. It will be most useful to those who are already well advanced in this branch of study, or to those others who are well tutored while working through the volume. The illustrations are good.

BOOKS RECEIVED.

Lehrbuch der Elementaren Praktischen Geometrie (Vermessungskunde). Band I. *Feldmessen und Nivellieren, des Lehrbuchs der Vermessungskunde Besonders für Bauingenieure.* Von Dr. E. HAMMER. Leipzig and Berlin: B. G. Teubner. [Price 22 marks, unbound; 24 marks, bound.]

The Production of Malleable Castings: A Practical Treatise on the Processes Involved in the Manufacture of Malleable Cast Iron. By RICHARD MOLDENKE. Cleveland, Ohio: The Penton Publishing Company. [Price 3.00 dols., express prepaid.]

The Design of Channels for Irrigation or Drainage. Compiled by ROBERT BURTON BUCKLEY, C.S.I. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 2s. net.]

Lehrbuch des Maschinenbaues. Herausgegeben von KARL ESSELBORN. Erste Band. Leipzig: Wilhelm Engelmann. [Price 20 marks.]

Imperial Telegraphic Communication. By CHARLES BRIGHT, F.R.S.E., M. Inst. C.E. London: P. S. King and Son. [Price 3s. 6d. net.]

Notes on Plate-Girder Design. By CLARENCE W. HUDSON, C.E., Mem. Am. Soc. C.E. New York: John Wiley and Sons; London: Chapman and Hall, Limited.

Kinetic Theory of Engineering Structures, dealing with Stresses, Deformations and Work, for the Use of Students and Practitioners in Civil Engineering. By DAVID A. MOLITOR, B.G.E., C.E. New York and London: McGraw-Hill Book Company. [Price 21s. net, post free.]

The Temperature Entropy Diagram. By CHARLES W. BERRY. New York: John Wiley and Sons; London: Chapman and Hall, Limited.

Income-Tax; How to Make the Return and Prepare Accounts in Support; How to Recover Excess Paid, or Obtain Reduction; with Settled Cases. By F. B. LEEMING. London: Effingham Wilson. [Price 2s. 6d. net.]

British and Foreign Building Stones. By JOHN WATSON. Cambridge: University Press. [Price 3s. net.]

Moxly's Theory of the Tides, with a Chapter of Extracts from Moxly's Original Work. By J. J. RUTHVEN. Revised and enlarged edition. London: J. D. Potter.

Die Kaiserbrücke in Breslau. Von Dr.-Ing. TRAUER. Leipzig: Wilhelm Engelmann. [Price 2 marks.]

Royaume de Belgique: Ministere de l'Industrie et du Travail. Office du Travail. Rapports Annuels de l'Inspection du Travail. 15me Année (1909). Brussels: J. Lebègue et Cie. [Price 4 francs.]

The Student's Lyall: The Principles and Methods of Geology as Applied to the Investigation of the Past History of the Earth and its Inhabitants. Edited by JOHN W. JUDD, C.B., LL.D., F.R.S. *With Historical Introduction.* Second edition, revised and enlarged. London: John Murray. [Price 7s. 6d. net.]

The Propagation of Electric Currents in Telephone and Telegraph Conductors. By J. A. FLEMING, M.A., D.Sc., F.R.S. London: Constable and Co., Limited. [Price 8s. 6d. net.]

The Compulsory Working of Letters Patent in its Imperial and Economic Aspects. By F. W. BENEY, London: William Clowes and Sons, Limited. [Price 3d.]

Bateaux Sous-Marins à grande vitesse sous l'eau. Par C. DEL PROPOSTO. *Avec un Projet,* par M. C. LAURENTI. Paris: Augustin Challamel.

Das englische Eisenbahnwesen. Von JOHANN FRAHM. Berlin: Julius Springer. [Price 20 marks.]

Cours de Mécanique, rédigé conformément aux nouveaux programmes des Ecoles Nationales d'Arts et Metiers. Par L. GUILLOT. Tome Deuxième. *Mécanique Spéciale des Fluides, Hydraulique, Thermodynamique, Air Comprimé.* Paris: Ch. Beranger.

An Introduction to Bacteriological and Enzyme Chemistry. By GILBERT J. FOWLER, D.Sc., F.I.C. London: Edward Arnold. [Price 7s. 6d. net.]

Bird-Flight as the Basis of Aviation: A Contribution towards a System of Aviation. By OTTO LILIENTHAL. With a biographical introduction and addendum by GUSTAV LILIENTHAL. Translated from the Second Edition by A. W. ISENTHAL, A.M.I.E.E. London: Longmans, Green, and Co. [Price 9s. net.]

BROUGHTON DYE WORKS, SALFORD BOILER EXPLOSION.—We are informed that the formal investigation ordered by the Board of Trade to be held in this matter is fixed for hearing in the Town Hall, Broughton, Salford, Lancs., on Tuesday, the 25th inst., at 11 a.m.

THE SWISS LOCOMOTIVE AND ENGINEERING WORKS, WINTERTHUR.

IN the late 'sixties of last century, an important development took place in the Swiss railways; the railway companies increased the number of their lines, strengthened their permanent way, and planned further extensions of their systems, for which they obtained, very generally, the assistance of the towns and districts traversed. At that same period, various classes of steam-engines and other machinery were being built in the country, and Swiss machinery users were gradually becoming more and more independent of outside sources for the prime movers they required. In respect of locomotives, however, they were absolutely dependent upon foreign works, no home works having as yet laid themselves out for their manufacture. The development referred to in railway construction led to the formation of the Schweizerische Locomotiv- und Maschinenfabrik; this was established in 1871, at Winterthur, with a share capital of 1,200,000 francs (48,000*l.*) and a debenture capital of 600,000 francs (24,000*l.*), the object in view being the construction of locomotives, and also of other types of engines. The works were opened on July 1, 1873. In the commencement, the company had to fight against very great odds. In the first place, the capital was far too low, considering the programme it had set to itself; the cost of the buildings and plant exceeded the figures calculated, owing to a rapid increase in the cost of material and labour; the boom in trade and industry which followed upon the Franco-German war was of much shorter duration than had been expected; stagnation in business rapidly supervened and prices fell all round owing to over production. The new enterprise in its early days was practically unable to withstand the competition of the German locomotive builders; these were long-established firms, favourably located both in regard to the supply of materials and the delivery of finished products, eager for an extension of their business and under the fostering care of the German State. Another factor which greatly handicapped the new Winterthur locomotive works was the very low duty paid on foreign locomotives on their entrance into Switzerland, compared with the duty charged by other neighbouring countries.

The company passed through several crises before the 'eighties, when it was established upon a firm basis, with a share capital of 8,000,000 francs (320,000*l.*), and a debenture capital of 3,000,000 francs (120,000*l.*). Since that time the Swiss Locomotive and Engineering Works has prospered; all the large Swiss railway systems, the secondary railways, and the mountain lines have gradually contracted more and more with this company, which now supplies the greater part of their requirements in the matter of locomotives. Not only is this the case, but the firm has become a serious competitor to the locomotive works of other countries, and an idea of its activity is afforded by the fact that it has built and supplied to date, besides a total of 1470 locomotives for the Swiss railways, 607 to other European countries, including 157 to Italy, 103 to France, 92 to Germany, and six to this country; and, further, 113 to distant lands. The company builds locomotives of all types and powers; it has also made a speciality of the construction of rack-railway engines, and has likewise built a comparatively large number of electric locomotives.

The company took in hand, in 1886, the construction of internal-combustion engines, since which time it has greatly increased its production in gas oil, petrol, and alcohol motors. It commenced with town-gas motors, it then dealt with producer-gas installations complete, and has added to these, in comparatively recent times, the Diesel engines, which it builds of powers ranging from 20 to several hundred horse-power, under an agreement with Messrs. Sulzer Brothers, whose works are adjoining.

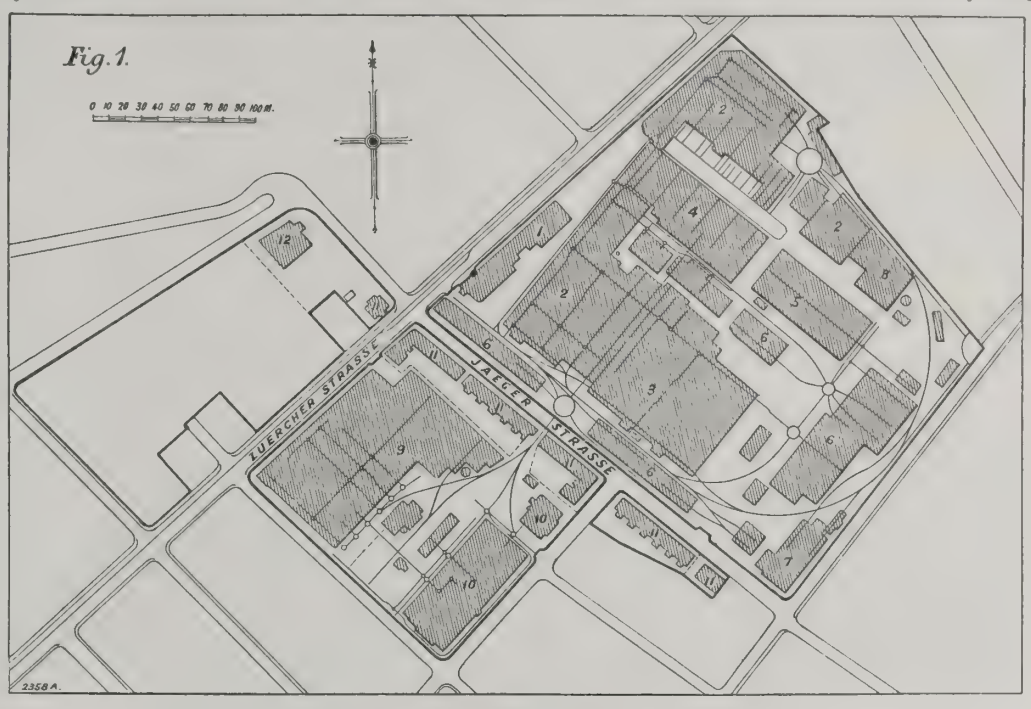


FIG. 1. PLAN OF SWISS LOCOMOTIVE WORKS.

At the present day, the works, which will be visited by members of the Institution of Mechanical Engineers on Wednesday next, the 26th inst., give employment to 1500 men. They cover an area of 89,462 sq. m. (over 100,000 sq. yards), and their arrangement is shown by the plan, Fig. 1, annexed. The references to this plan are as follow:—

1. Offices.
2. Locomotive fitting-shops.
3. Tender and boiler-shops.
4. Locomotive - erecting shops.
5. Smithy.
6. Stores.
7. Delivery department.
8. Generating - station for light and power.
9. Internal - combustion-engine shops.
10. Foundries.
11. Dwellings for fire brigade.
12. Workmen's club and canteen.

The works are divided into two main parts by the Jaeger Strasse, the portion to the east containing the offices and the shops for the construction of locomotives, locomobiles, stationary engines, and boiler work; the portion to the west being set apart for the construction of internal-combustion engines. Fig. 2, page 90, is a general view of the works; Figs. 3 and 4, on Plate XXVIII., are views in the locomotive-erecting shop, and in the erecting and testing-shop for internal-combustion engines, the two principal shops on either side of the works.

Dealing first with the locomotive section, the stores for raw material and other products required throughout the works are contained in two large buildings, measuring 60 m. (197 ft.) in length and 9 m. (29 ft.) in width, close to the entrance and parallel with the Jaeger Strasse. The fitting and machine-shop for all the mechanical parts required in the construction of locomotives, marked 2 on the plan, contains a great variety of machine-tools, driven by belting from overhead shafts, the grinding-machines being provided with exhausting apparatus for carrying away the dust. The side closer to the offices is occupied by fitters' benches. A great proportion of the machine-tools in this department are semi-automatic, and are arranged in sets, each set being supervised by one man. The tool-shop and tool-stores is in the centre of

this machine-shop; it contains all the tools, gauges, and jigs used throughout the works, among which are several very fine sets of milling-cutters. This shop is driven by a 170-horse-power horizontal steam-engine, which drives the overhead transmission shafts by belting. The shop is in direct communication with the tool-manufacturing departments, which consist of a smithy and an installation for hardening and tempering the different tools, which are manufactured of carbon, high-speed, and other quality steels. The hardening and tempering installation was designed and built by the company, and is considered the best-equipped installation for this class of work in the whole of Switzerland. All the furnaces in this installation are heated by producer-gas, and a temperature up to 1300 deg. Cent. can be reached. Close to this is the building set apart for case-hardening motion links and blocks, this containing three furnaces, which are heated either with coke or with producer-gas.

Adjoining the fitting and machining-shop is the tender and locomotive-boiler shop, which covers an area of 4800 sq. m. (51,700 sq. ft.). It is shown in the view, Fig. 5, on Plate XXIX.; it is divided into five bays; of these, there are two newer bays on the south-east end of the shop, east end of the works is well equipped. It contains the following sets:—(1) A 400-horse-power double-acting horizontal tandem producer-gas engine, driving a 300-kw. 400-volt three-phase alternator. (2) A 300-horse-power double-acting horizontal single-cylinder producer-gas engine, driving by belting a 200-kw. 400-volt three-phase alternator. (3) A 200-horse-power single-acting horizontal tandem producer-gas engine, driving by belting a 150 kw. 400-volt three-phase alternator. (4) A 150-horse-power single-acting horizontal double-cylinder producer-gas engine, driving by belting a 100-kw. 400-volt alternator. These four engine sets supply current for power purposes throughout the works. Besides these there are:—Two 100-horse-power single-acting horizontal single-cylinder producer-gas engines, driving by belting a 75-kw. 120-volt continuous-current dynamo for lighting.

The whole of the above engines are supplied with gas from a battery of six Dowson pressure-producers, three of which are being replaced by suction-gas producers. This producer-gas power-station for power and light was commenced about fifteen years ago; it has gradually been increased to meet the growing needs of the works. It is interesting inasmuch as it affords an illustration of the different types of gas-engines built during the period in question, and of the progress made in their construction.

The locomotive frames are machined and built up in a separate shop adjoining the electric power-station; this shop is divided into two bays, and contains in the centre a number of machines for dealing with frame-plates. Each bay is served by a 10-ton overhead electric travelling-crane. Power for driving the machinery is supplied by a 50-horse-power crude-oil engine (Winterthur system), which drives the machine-tools in the shop by an overhead shaft; close to this engine on the floor level and driven by a belt from the overhead shaft is an alternating-current generator, which acts as a stand-by.

The locomotive-erecting shop, marked 4 on the plan, Fig. 1, is divided longitudinally into two bays, served by 20-ton and 30-ton overhead electric travelling-cranes. There are in this shop in course of construction at the present time locomotives for the Swiss railways, for the Paris-Orleans Railway Company, for the Northern of France Railway Company, for the Santa Fé (Argentine) railways, and a number of trucks for electric mountain railways. Outside this shop and parallel with it is the traverser-track for carrying the locomotives to the painting-shop. A shop for manufacturing the small fittings and containing the copper-smithy communicates with the locomotive-erecting shop.

The above is a brief description of the locomotive section of the works, which contains besides all the requisite store-houses, dépôts, &c., located at convenient sites. As above stated, the Jaeger Strasse separates this department from the internal-combustion engine section. The latter is bounded on the street end by a series of forty dwellings, marked 11 on the plan, Fig. 1, each dwelling being let to a family. These dwellings are let at low annual rentals to foremen and workmen employed in the various shops, who elect to serve on the works' fire-brigade. These dwellings are very neat, and are most carefully kept. When a vacancy occurs in any one of them—and a vacancy rarely occurs except through the death of the occupant—numerous applicants are forthcoming for the vacant dwelling notwithstanding the exigencies of the fire-service, or rather the ties necessarily associated with this service, for fires occur, fortunately, but very seldom.

This section of the works may be said to consist of two main departments: the foundries and the fitting and erecting-shop for the internal-combustion engines. The brass foundry, a building measuring 20 m. (65 ft.) in length and 20 m. in width, contains two Piat-Baumann crucible furnaces, each of

FIG. 2. GENERAL VIEW OF THE SWISS LOCOMOTIVE AND ENGINEERING WORKS, WINTERTHUR.

65 m. (213 ft.) in length and 30 m. (98 ft.) in width, served one by a 25-ton overhead electric travelling-crane, and the other by a 15-ton similar crane, these two newer bays being set apart for the assembling of locomotive boilers and fire-boxes. The boiler-shop contains all the necessary machines for working up the plates which enter in the construction of locomotive engines, including hydraulic riveting machines, the newest of which can take plates 7 m. (23 ft.) in length and 3 m. (9 ft. 10 in.) in diameter. Pneumatic riveters are also used to a very large extent. Motive power is supplied to the boiler shop from an adjoining room, which contains a 100-horse-power four-cycle crude-oil engine (Winterthur system), which drives the machine shaft by a steel belt transmission. The room also contains two hydraulic pumps working at a pressure of 100 atmospheres (1400 lb. per sq. in.), which supply the accumulator for working the hydraulic riveting machines, stamping presses, and so forth. Oxy-acetylene blow-pipes are used extensively for cutting out openings in boiler and furnace plates.

The smithy, marked 5 in the plan, Fig. 1, is a building 70 m. (230 ft.) in length and 30 m. (98 ft.) wide, divided into a central bay and two side bays, and containing a 1.5-ton hammer, served by a reheating furnace, with a hand-crane close by. There are also eight smaller hammers, served by two other furnaces, and forty-two open fires.

The electric power-station in the extreme north-a total capacity of 4 cwt., and one ordinary melting furnace. The fettling-shop is adjoining.

The cast-iron foundry is a well-lighted building 80 m. (262 ft.) in length and 35 m. (114 ft.) wide, divided into three bays, the main central bay being served by two overhead electric travellers of 15 tons, and the other bays by eleven cranes of different sizes. The foundry employs two hundred men, and is principally occupied with the manufacture of castings used in the construction of internal-combustion engines. All the work is cast in sand; the weight of the largest piece cast is 24 tons. There are three cupolas, one having a capacity of 5.5 tons, and the two others a capacity of 3.5 tons each per hour; the foundry contains also three drying-stoves, and a number of portable drying-fires supplied with blast from special fans. The largest pieces are cast in the central bay, the smaller work and accessory foundry work being carried out in the side bays.

The newest shop in the whole installation is that marked 9 in the plan, Fig. 1, which is set apart exclusively for the machining, fitting, and erecting of internal-combustion engines. The company commenced building producer-gas engines and plant complete in 1895; previously they had made a speciality of the construction of town-gas engines, having commenced building these, as above stated, in 1886, concurrently with locomotives, which latter have always formed their principal speciality. In

this shop the "American methods" of working are followed, and every detail of the engines is standardised. The various machine-tools are driven from six electric-motors in the shop, supplied with current from the works' generating-station above described; should this current supply fail through any cause, current would be supplied to the motors from the municipal current generating station. There is also a 100-horse-power two-cylinder vertical gas-engine for driving the machine-tools. Overhead belt transmission is resorted to generally for this. The machine-tools are of the most approved types.

This fitting and erecting-shop, views inside which are afforded by Figs. 6 to 8, on Plate XXIX., is covered by a saw-tooth roof and is divided crosswise into ten bays, served by fifteen overhead electric travelling-cranes ranging in power from 3 to 25 tons. One side of the building is made with a gallery, which contains the hand-fitting benches. The tool-store is in the centre, as is also the dépôt of working drawings for all detail parts, the drawings being delivered out to the men as required, and against a check. A room underground is set apart as a stores for manufactured parts and for accessories and fittings purchased from the outside.

The works build both gas and Diesel engines on order, or for stock, and they are always able to give quick delivery. They have at the present time in course of construction about 160 engines of different types, which include:—(1) One and two-cylinder horizontal Diesel engines; one to four-cylinder vertical Diesel engines, ranging from 25 to 300 horse-power. (2) Town and producer-gas engines, horizontal, single-acting, with one or two cylinders, from 6 to 300 horse-power; and vertical, from 70 to 600 horse-power. (3) Current sizes of petrol and oil-engines (4) A series of small crude-oil "Winterthur" engines of 5 to 20 horse-power. (5) Different sizes of gas-producers for the corresponding engines.

All the engines are tested on the bed upon which they have been erected; a special building contains the producer-gas plant for testing the producer-gas engines. The Diesel engines are tested regularly during ten consecutive hours after erection and previous to taking down for delivery. A very complete chemical laboratory is equipped for analyses; analyses and tests of coal for use in the producers are the most numerous.

This very brief description of the Swiss Locomotive and Engineering Works Company would be incomplete without a passing reference to the workmen's club and canteen—or "casino," as it is called—marked 12 in the plan, Fig. 1, and illustrated in the views, Figs. 9 and 10, annexed. This is admirably equipped with reading-rooms, dining-rooms, a kitchen with two large coppers for making coffee, to serve out to the men in the works during the summer months.

The building contains under the floor level 50 cells for douche baths, which the men use against payment of 1d., for which they receive a piece of soap and the use of a towel. There are, besides, three bath-rooms, the price for using which is 3d. Several of the upper rooms are equipped for use by the doctor, who calls regularly twice a week for consultation. Surrounding the casino, as shown in plan, Fig. 1, is a tract of land which is let out to the men for allotment gardens. During the last ten years benevolent institutions, pension and invalidity funds, have been founded by the company in favour of their men.

FIG. 9. EXTERIOR VIEW OF CASINO.

FIG. 10. INTERIOR VIEW OF CASINO.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, July 12.

THE weather has been exceptionally oppressive for over a week, resulting in some stoppages in mills and partial stagnation in some lines of trade. A number of blast-furnaces have blown out because of slow distribution, and this has to some extent lessened coke consumption. General trade is up to the summer average. The month's output of pig iron made from anthracite and coke was 1,787,566 tons. The daily rate of production was 59,585 tons, the lowest since January. The total output of pig iron for the half-year was 11,630,054 tons, as against 12,319,807 tons last half of last year, a decline of 5 per cent. The repairing season is now on, and rolling-mills will gradually resume. Prices in all crude and finished products are unchanged. Very few buyers care to extend deliveries beyond the end of the third quarter. The spread of railroad construction in the North-West calls for corresponding machine-shop facilities, and this is reflected in a better inquiry for shop tools and equipment, as well as for electrical equipment. Water-power is being secured in various sections of the United States and Canada, and plans are being perfected for the erection of electrical plants for the generation and transmission of power for varying distances.

The demand for structural material for railroad and general construction purposes is improving, the June aggregate being 128,000 tons; the May aggregate, 180,000 tons; and the April aggregate, 90,000 tons. The next encouraging demand is for agricultural steel. Usually implement manufacturers buy in May or June for a year ahead, but this year they have delayed until July, and their orders are helping to give a stronger tone to the agricultural steel industry. Other branches are dragging along with a demand pretty near normal for the time of year. Twelve thousand workmen are still on strike at the Baldwin Locomotive Works in this city. The company is booking orders freely, evidently anticipating an early resumption. The intense heat all over the agricultural States has not as yet done any harm to crops.

THE BRITISH ASSOCIATION.—The British Association will this year assemble at Portsmouth on August 30, and the meeting will last the customary week and one day, concluding on the following Wednesday. It will be the first time that Portsmouth entertains the Association; Sir William Ramsay will preside. It is expected that general discussions will again be encouraged. The Engineering Section G will have a joint discussion on "Mechanical Flight" with Section A, Mathematics and Physics; a similar discussion was held last year; this year the subject is to be opened by Mr. A. E. Berriman. In its own deliberations Section G, under the presidency of Professor J. H. Biles, will discuss the Advantages of Superheated-Steam-Engines (Captain H. Riall Sankey), of Suction-Gas Plants (Mr. Tookey), and of Diesel Engines (Mr. C. Day); the names in brackets are those of the gentlemen who are to open the discussions. As regards sh pping, papers will be presented by Mr. G. K. B. Elphinstone, on the "Gyro-Compass;" by Mr. B. P. Haigh, on "Electrical Steering;" by Mr. H. A. Moor, on "Electrical Driving of Ships' Propellers;" and by Mr. J. H. Rosenthal, on "Marine Engines for Burning Crude Oils." Mr. Digby will describe the vibrograph; Mr. Worby Beaumont will speak on the origin and production of corrugation on tramway rails; and Dr. J. S. Owens will discuss smoke abatement. Radiotelegraphy will also be dealt with; Captain Sankey is expected to exhibit a portable radiotelegraphy equipment, and Professor T. W. Howe will show some novel experiments on radiotelegraphy. In accordance with our custom, we shall publish further particulars of the arrangements made for the British Association in the week preceding the opening of the meeting.

INDUSTRIAL NOTES.

THE monthly report of the Amalgamated Tool-Makers for July shows an increase of 975 in the membership since June, 1910. The number of unemployed for June last was the same as in the corresponding month of last year—namely, 81—and the reserve funds stood at 22,500*l.*, against 16,500*l.*—an increase of 6000*l.* The total membership now stands at 5184.

The return for the four weeks ending July 1 shows a total membership of 3171 in the Associated Blacksmiths and Ironworkers' Society, against 3187 for the previous month, or a decrease of 16. The income for the four weeks in June last was 737*l.* 10s. 5½d., and the expenditure 532*l.* 7s. 2½d., a net gain of 205*l.* 3s. 3d. The outlay for the four weeks for benefits and management came to 3s. 8d. per member. The amount of the expenditure was made up as follows:—Unemployment benefit, 51*l.* 17s. 7d.; superannuation benefit, 167*l.* 5s. 10d.; sick benefit, 132*l.* 6s. 9½d.; funeral benefit, 29*l.*; management outlays and grants, 160*l.* 17s. Wages have been advanced 3s. per week in the Clan Line repairing shops, in the Glasgow Co-operative Baking Society ½d. per hour, and in the Clyde Trust and Messrs. A. W. Smith's ¼d. per hour, but trouble seems to threaten with the Belfast employers, who have declined to grant a conference. The trade in the shipbuilding industry continues good, and there is a good demand for labour, while on the engineering side of the industry work is plentiful; altogether the outlook is said to be promising.

According to the monthly report of the United Society of Boilermakers and Iron and Steel Shipbuilders for July, the number of members signing the book at the end of June was 2017, as against 1486 at the end of May last. There were 941 members on the sick fund, compared with 1210 at the end of May, and 2124 on superannuation, compared with 2400 in the previous month. The expenses for June amounted to 6956*l.* 8s. 5d., against 6054*l.* 15s. for May, or an increase for June of 901*l.* 13s. 5d. There were, however, five weeks' expenses in June against four in May.

According to the Board of Trade *Labour Gazette*, issued on July 17, the state of the labour market in June was as follows:—

Employment continued good, but was not quite so good generally as in May. There was a slight improvement in the pottery trade and at iron and steel works, but in most other industries, except mining, employment declined slightly. Some trades were adversely affected by the woolcombing and shipping disputes.

As compared with a year ago, nearly all the principal industries showed an improvement. There was, however, a considerable decline at blast-furnaces and in the lace and jute trades.

In the 394 trade unions, with a net membership of 758,666, making returns, 22,895, or 3.0 per cent., were returned as unemployed at the end of June, 1911, compared with 2.5 per cent. at the end of May, 1911, and 3.7 per cent. at the end of June, 1910.

Returns from firms employing 450,221 workpeople in the week ended June 17, 1911, showed a decrease of 2.3 per cent. in the amount of wages paid compared with a month ago, and an increase of 2.8 per cent. compared with a year ago.

With one exception all the changes in wages reported as taking effect in June were increases, and affected 27,400 workpeople, of whom 21,600 were employed in engineering works on the North-East Coast. The only decrease affected 190,000 coal-miners in South Wales and Monmouthshire, but its effect was more than sufficient to counterbalance that of all the increases reported, with the result that the net effect of the changes during the month was a decrease of 840*l.* per week.

The most important disputes in progress during the month were those involving about 65,000* seamen, firemen, dock labourers, and other transport workers at various ports in the United Kingdom, 19,000 woolcombers, &c., at Bradford, 12,000 coal-miners in the Rhondda Valley, 1700 coal-miners at South Shields, 1400 coal-miners at Wigan, 800 builders' labourers at Nottingham, 400 carpenters and joiners at Burnley, and 500 railway surfacemen in the Glasgow district. The new disputes beginning in June, 1911, numbered 36, and the total number of workpeople involved in all disputes in progress during the month was 116,334, or 79,466 more than in the previous month, and 99,868 more than in June, 1910. The time lost during the month by these workpeople amounted to 1,214,100 working days, or 690,300 more than in May, 1911, and 1,057,900 more than in June, 1910.

Cases reported under the Conciliation Act affected seamen, firemen, dock labourers, and other transport workers at various ports, steel-workers in Scotland, steel-melters at West Hartlepool, building trades' operatives at Southampton, shoddy and mungo workers at Ossett, and matting weavers in East London. Settlements in the form of agreements or awards were made in certain cases of the seamen, &c., the steel-melters at West Hartlepool, and the shoddy and mungo workers at Ossett.

* This is the estimated number affected up to the end of June.

Trade-Union Employment Returns for June.

Trade-union percentages of unemployed.

Trade.	Membership of Unions Reporting.	Percentage Unemployed at End of June, 1911.	Increase (+) or Decrease (−) in Percentage Unemployed as Compared with a	
			Month ago.	Year ago.
Building	57,419	4.2	+ 0.6	− 2.6
Coal-mining*	153,855	0.8	..	+ 0.2
Engineering	178,398	3.1	+ 0.3	− 1.3
Shipbuilding	57,231	3.8	+ 1.1	− 3.8
Other metal	45,351	2.6	− 0.4	− 1.3
Textiles*	119,927	3.7	+ 1.4	+ 1.2
Paper, printing, and bookbinding	61,677	5.4	+ 0.5	+ 0.6
Furnishing and woodworking	34,881	3.0	+ 0.8	− 1.1
Miscellaneous	49,927	3.1	− 0.1	+ 0.2
Total	758,666	3.0	+ 0.5	− 0.7

* In addition to the ordinary short time which occurs in all trades, it should be noted that in the mining and textile industries a contraction in the demand for labour is more generally met by a reduction in the time worked per week by a large number of workpeople than by the discharge of a smaller number.

On Wednesday last a development in connection with the seamen's strike at Cardiff took place, for it was resolved by 5000 dockers that they would support the seamen's demand that their union should be recognised. It is the object of the malcontents to block every ship in Cardiff. The Shipping Federation has again been challenged by Mr. Havelock Wilson, who threatened that he will call 50,000 men out in the Port of London next Monday if a conference is not granted by the Federation. There is much unrest, and riots have taken place.

The North-Eastern Railway men held a demonstration on Sunday last at the Town Moor, Newcastle-on-Tyne, between 4000 and 5000 men taking part in a procession. The demonstration was organised as a protest against the employment of non-union men in the ranks of labour, and was arranged by representatives of the Amalgamated Society of Railway Servants, and by members of the General Railway Workers' Union. Representatives of the Northumberland Miners' Union were also present. Protests were raised against the non-unionists reaping the benefits of trade-unionism, and yet remaining outside organised labour. The General Railway Workers' Union passed a resolution dealing with the dispute over the programme which has been under consideration by the representatives of the railway company at York. This resolution was as follows:—"We desire to inform the general secretary of the railway company that, unless the programme is fully discussed by July 19, voting papers will be issued to all members of the union to ascertain their present position with regard to it, and to take such steps as may be necessary."

The railway workers at Hull also held a meeting on Sunday last, and carried the following resolution:—"That this meeting of railway workers is of the opinion that the time has now arrived when every man must be a member of his own union, and pledges itself that, when the date is fixed, no one will work after that date with non-union men."

Negotiations between masters and men in the engineering trades have resulted in an increase of wages of 1s. per week at Blackburn, with the promise of a further 1s. in March, 1912, should the textile industry be maintained at its present satisfactory state. Excluding the shipyards at Belfast, the employers have now agreed to an immediate increase of 1s., and another 1s. in January next. The men have confirmed the agreement in each case. At Leeds and Aberdeen disputes are still outstanding. The agreements for the regulation of wages in the engineering trade are binding for a comparatively long time.

It was officially announced on Monday last that the vote taken in the ballot of Northumberland miners for and against a strike to abolish the three-shift system showed that a two-thirds majority was in favour of a strike. It is stated that the Miners' Federation of Great Britain will consider the Northumbrian miners' request for a national stoppage in order to enforce their wish. The outlook appears very gloomy. It will be remembered that at the beginning of last year, when the Eight Hours Act came into force, the employers at several of the collieries found it necessary to institute the three-shift system, and there was great opposition to it, chiefly on account of the effect it had on the domestic arrangements of the colliers and on their social life. The men, however, agreed to give the system a trial. There has since been much negotiation with the coal-owners, but with no result. The attempt to secure a minimum wage of 30 per cent. above the standard has failed, and the Northumberland Conciliation Board has consequently terminated. The employers state that increasing working costs make it impossible to accede to the men's request for an increase in this respect.

According to the semi-monthly report of the American Association of Commerce and Trade, the German workmen's insurance system, which has been in operation since 1884, has grown into a very large system of co-operative relief. It is, however, very complex and full of abstracts of law. The system is threefold, embracing: (1) Invalidity insurance, (2) sickness insurance, and (3) accident insurance. The first of these provides an annuity for those who are unable to make a living, if this incapacity is caused by a bodily or mental defect, chronic sickness, or natural decay of the physical powers and old age. It covers all persons over sixteen years of age who are working for salaries or wages in the following occupations:—Workmen, apprentices, domestic servants, sailors, and employees of the textile and tobacco home industry, commercial and technical employees and teachers, provided their yearly income does not exceed 50*l.* Employers and employees contribute to it in equal parts, the Government adding a fixed sum to each allowance paid, and the contributions are paid weekly on a fixed scale, the amount depending on the salary of the insured person. These weekly contributions vary from 1½d. for a yearly income of about 17*l.* to 4½d. for a yearly income of about 55*l.*, and the contributions are made by stamps, which are affixed to a card, the stamps being provided by the employer, who is responsible for the contributions being paid regularly, and who is entitled to deduct half of the value of the stamps from the salary or wages of the insured. Old-age pensions are payable on the completion of the seventieth year of the insured, provided he has made a certain number of payments.

Sickness insurance includes workmen employed for salaries and wages in mines, quarries, factories, smelting works, shipbuilding yards, transport by land and inland waterways, building handicrafts, commercial and professional offices, and the Post Office, Army, and Navy departments. The mercantile marine, agriculture, and forestry, however, are not included. The payments are made by the employers and employees in the proportion of one-third to two-thirds respectively, and vary from 2 to 4 per cent. of the salary of the insured. The insured are entitled to medical attendance, drugs, and treatment, whether unable for work or not; in the former case, sick-pay commences from the third day of illness. In the case of women pay continues for six weeks after confinement. All insured get funeral expenses. Sick-pay is not less than half the average rate of wages, but does not exceed 1 dol. a day, and is payable for twenty-six weeks, which, under special conditions, may be extended to one year.

Accident insurance applies to the same classes as sickness insurance, but includes also agriculture and forestry, divided into the following classes:—Industry and transportation, agriculture and forestry, building and construction, and the mercantile marine. Persons employed in shops and offices, as well as domestic servants, are not included. The employers provide the whole of the funds, the amount being based on salaries and wages paid. Compensation does not begin until after the expiration of a period of thirteen weeks from the time of the accident, during which time compensation for sickness insurance is paid. Accident payments include medical treatment, drugs, and appliances—an allowance, in case of complete incapacity to work, at the rate of two-thirds of the wages previously earned, and funeral expenses according to a fixed scale. The latest German Government reports give the following figures, which show the number of insured persons with the amount of expenditure and receipts in 1908:—

	Insurance against		
	Sickness.	Accident.	Invalidity.
Insured persons .. No.	13,189,600	23,674,000	15,226,000
Indemnity cases .. ,,	5,701,180	1,008,677	1 [illegible]8,749
Total receipts .. marks	365,994,100	207,550,500	285,882 100
Receipts from employers marks	114,913,900	181,596,600	92,211,200
Receipts from employed marks	236,220,200	..	92,211 200
Total expenditure .. ,,	350,544,100	183,818,700	200,339,100
Indemnity .. .. ,,	331,049,900	157,884,700	181,473,800
Administration .. ,,	19,494,200	25,934,000	18,862,300
Total assets .. .. ,,	267,708,400	326,601,500	1,[illegible]8,610,000
Average indemnity per case .. .. .. marks	58.07	158	165
Proportionate charge for insured .. marks	26.55	7.75	15.50

THE ROYAL AGRICULTURAL SOCIETY'S SHOW: ERRATUM.—A misprint has crept into our article on page 5 *ante*, column 2, in our description of Messrs. Davy, Paxman, and Co.'s engine. The maximum power this engine can develop is 90 brake horse-power, and not 30, as we stated.

PROGRESS IN NAVAL ARTILLERY.*

By Sir ANDREW NOBLE, Bart., K.C.B., LL.D., F.R.S., Hon. Vice-President.

WHEN I was asked by the Council to write a paper on the progress which artillery has made during my lifetime, I must confess to having been a little unwilling, as I thought I had already said quite enough on the subject to tire my naval and military friends; and, as regards the subject, I remembered a conversation I once had with a very eminent scientific friend, who, when I was expressing my regret that we could not expect to live to see the solution of the difficult question we were discussing, replied that I ought to be content, because the progress of the world during my lifetime exceeded in importance all that had been done in the ages which had preceded us. His remark was, I think, perfectly true, and it certainly applies to artillery, both as regards the guns and the propellants and explosives employed. When I joined Her Majesty's Service, now about 64 years ago, no appreciable advance had been made in artillery during 500 years, either in gunpowder or its mode of manufacture, and but little, except in size, and that not very great, in the guns themselves.

To give you an idea of how slow was the increase of power in guns from the time of the Armada, I may mention that the armament of Nelson's flagship, the Victory, which consisted of 102 guns, included sixty 42, 32, and 24-pounders; forty 12-pounders, and two 68-pounder carronades; the weight of the heaviest gun being 75 cwt. The armament of the Duke of Wellington, commissioned just before the Crimean War, consisted of 131 guns, there being seventy-two 8-in. and 32-pounders on the lower and middle decks, thirty-eight 32-pounders on the main deck, and twenty short 32-pounders and one 68-pounder pivot gun on the upper deck. Taking the most powerful gun, the 68-pounder, the maximum velocity realised with the Service charge was a little under 1600 foot-seconds, and the maximum energy 1170 foot tons. I have alluded to the small advance made in the construction of guns during 500 years. The guns of Her Majesty's ship the Duke of Wellington were merely blocks of cast iron, and the machining to which they were subjected consisted only in the formation of the bore and the drilling of the vent. The carriages on which they were mounted were equally rude; they were made entirely of wood, generally in the later days of teak and mahogany; they were carried on wooden trucks, the rear trucks being frequently replaced by a wooden chock. The recoil was controlled by the friction of large wooden axles and big wedges under the trucks, and was finally brought up by the breechings by which the carriage was attached to the vessel's side. The elevation was given by quoins, and hand-spikes were used either for training or elevating. For running-out, blocks and tackle were generally employed. To work with any degree of smartness these rude weapons, a very strong gun's crew was necessary; indeed, the gun was practically surrounded by its crew, which numbered fourteen or fifteen men. The much more powerful modern 6 in. gun is served by three or four men.

In the year 1858, the first great step in artillery progress was made. In that year the Committee on Rifled Cannon, of which I was secretary, was appointed, and experiments with the various guns submitted to them were made, but the superiority in accuracy of the gun submitted by the late Lord Armstrong was so conspicuous, and the details, as regards projectiles, fuses, &c., were so superior, that the Committee unanimously recommended the adoption of his system. With regard to range, accuracy, and penetrative power, the superiority of the rifled guns was so great that it was evident to nearly all naval and artillery officers that the days of smooth-bored guns were numbered. But the point which occasioned most surprise was the extraordinary increase in accuracy. The Rifled Cannon Committee fired forty rounds from the smooth-bored field gun of the Service, and a similar number from the Armstrong rifled field gun. I used the method of least squares to determine the relative accuracy of the two guns, and found that, with the rifled gun, at a range of a little more than 1000 yards, half the shot fell in a rectangle of about 23 yards long by 1 yard wide, while with the smooth-bored field gun the similar rectangle was about 145 yards long by 10 yards broad. You will however, more readily appreciate the difference, if I show a diagram giving the comparative areas of the rectangles to which I have referred. (Fig. 1.)

The great success which had attended the application of rifling to the smaller nature of guns led to the immediate construction of rifled guns. But the additional complications of breech-loaders were looked on with dislike by the older officers, and this feeling lasted a considerable time, leading to the abandonment for some years of the construction of breech-loading guns. It led also to England being, for a considerable time, behind the principal Continental nations, owing to her refusal to adopt improvements until (which will never happen) finality was reached. It is curious to look back fifty years and compare what were then considered impossibilities with the realities which are in existence at the present time. To illustrate the distrust and doubt with which novelties were regarded, I may mention that I was secretary to a committee of naval and artillery officers on plates and guns, and at their meetings there was discussed the weight and calibre of a gun intended to be the heavy gun for both land and sea service. The artillery officers preferred a gun weighing 7 tons, but the naval officers were doubtful whether so heavy a gun could be carried on board ship. The point was finally compromised by making the gun 6½ tons—I need not point out to you that our ships are now carrying guns more than ten times as heavy as the weight then considered impossible. Twenty of these guns, known as the Somerset gun, were constructed, but the advisability of adopting rifling was then considered so doubtful by the authorities that it was ordered that the bore should be large enough to carry a smooth-bore shell of nearly the same weight as the rifled shell. The guns, when completed, were practically useless, and few of them were ever put on board ship. In the days to which I refer, the older officers could hardly be got to look with patience on any appliance to which they were not accustomed, and which could not be made or repaired on board ship, but there is now a very great change in this respect. Too much praise cannot be given to the naval officers of the present day for the ability and zeal they have shown in mastering, and their skill in using, the various and, in some cases, the complicated machines committed to their charge.

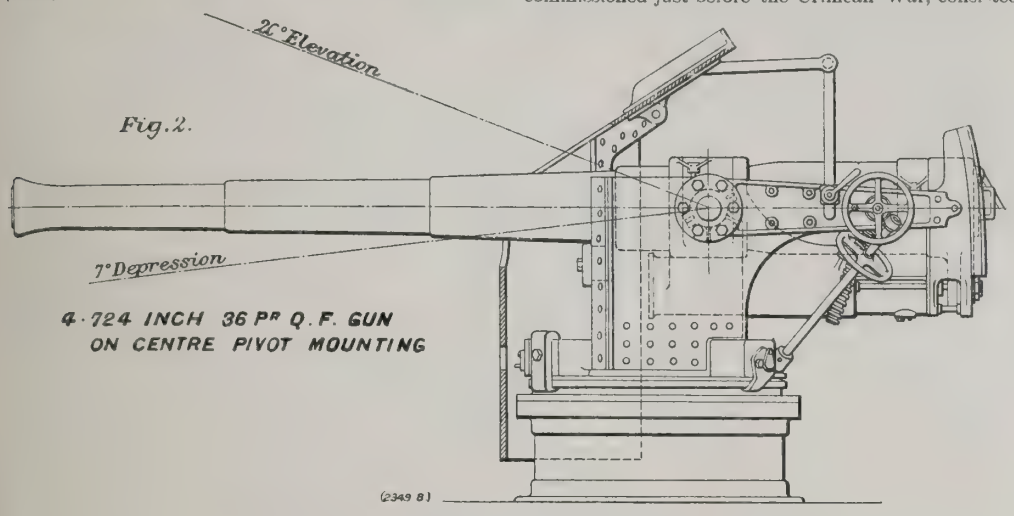
I need hardly point out that the battle between guns and armour rendered it most important that the velocities of rifled guns, which at the outset were very low, should be increased. The first step in this direction was made by the Committee on Explosives, who, by their experiments, showed that with improved forms of powder the velocities, which originally had generally run between 1200 ft. and 1350 ft. a second, were in the same guns raised to 1600 ft. a second, the increase in velocity being at the same time accompanied by a very considerable reduction of maximum chamber pressure. But the most important step was made by my firm, who, acting on certain experiments made at Elswick, and which were reported in a paper communicated to the Royal Society, made, in 1877, 6-in. and 8-in. breech and muzzle-loading guns, with which, while the maximum pressure remained the same, the velocities of the projectiles were, at a single bound, raised from 1600 foot-seconds to 2100 foot-seconds, thereby increasing the energies by nearly 75 per cent., and necessitating a reconstruction of guns and their mountings. At the same time, from the increase in the length of the guns which the high energies then introduced demanded, a return to breech-loading, from the retrograde change to muzzle-loading, which some years before had been adopted, was also necessitated. I need hardly say that since that date the weight and power of heavy guns have been enormously increased. We have now 12-in. guns of a weight of 68 tons and with a velocity of over 3000 foot-seconds and an energy of 58,600 foot-tons, that is, an energy forty-five times greater than that of the most powerful gun when I entered Her Majesty's service; while 14-in. guns are being made which, with a very moderate velocity, will be capable of piercing 15 in. of K.C. armour at ranges between 7000 and 8000 yards.

Turning now to quick-firing guns, I shall consider the guns in connection with their mountings, as these last, when rapidity of fire is considered, are nearly as important as the guns. Early in 1887 the gun and mounting I now show you (Fig. 2) were submitted for trial on board H.M.S. Handy. The gun was the first mounted on the Elswick cradle, having the recoil-press and spring-box beneath the cradle. The weight of the gun and mounting was taken on the balls under the pivot, the mounting and shield being carefully balanced. The

COMPARISON OF ACCURACY.

Fig. 1.

Fig. 2.



COMPARISON BETWEEN A 6 INCH 32 PR OLD GUN AND A 6 INCH B.L. NEW GUN.

Fig. 3.

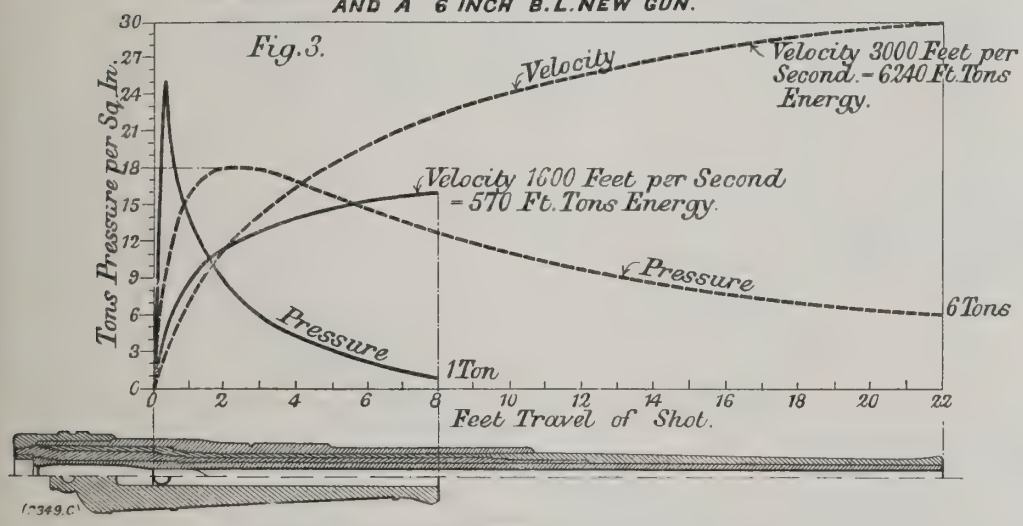


TABLE I.—OLDER EXPLOSIVES.

Amide	Powder B	Powder D	Powder A	Pebble	R.L.G.	F.G.	Mining Powder	C. & H. No. 6	Powder C	Spanish Powder	Cocoa
Volumes of Gas.											
400	315	282	254	278	274	263	360	241	347	234	198
Units of Heat.											
832	715	745	800	721	726	788	517	764	525	767	837
Energy of Explosive.											
332,800	225,225	210,000	203,200	200,438	198,924	194,094	186,120	184,124	182,175	179,478	165,726

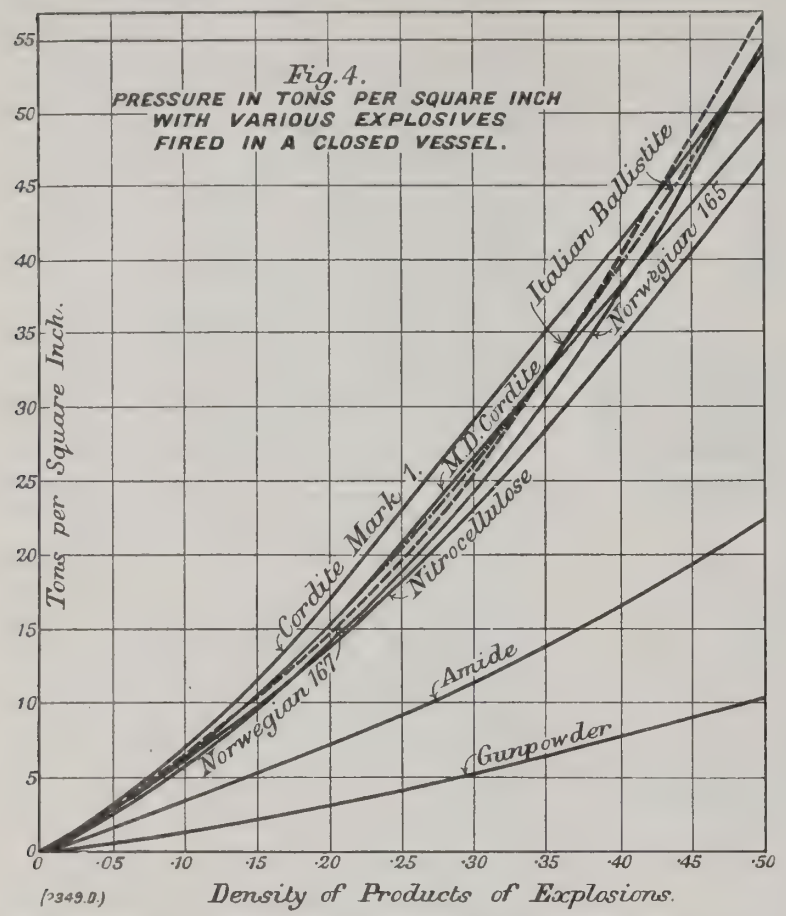
TABLE II.—MODERN EXPLOSIVES.

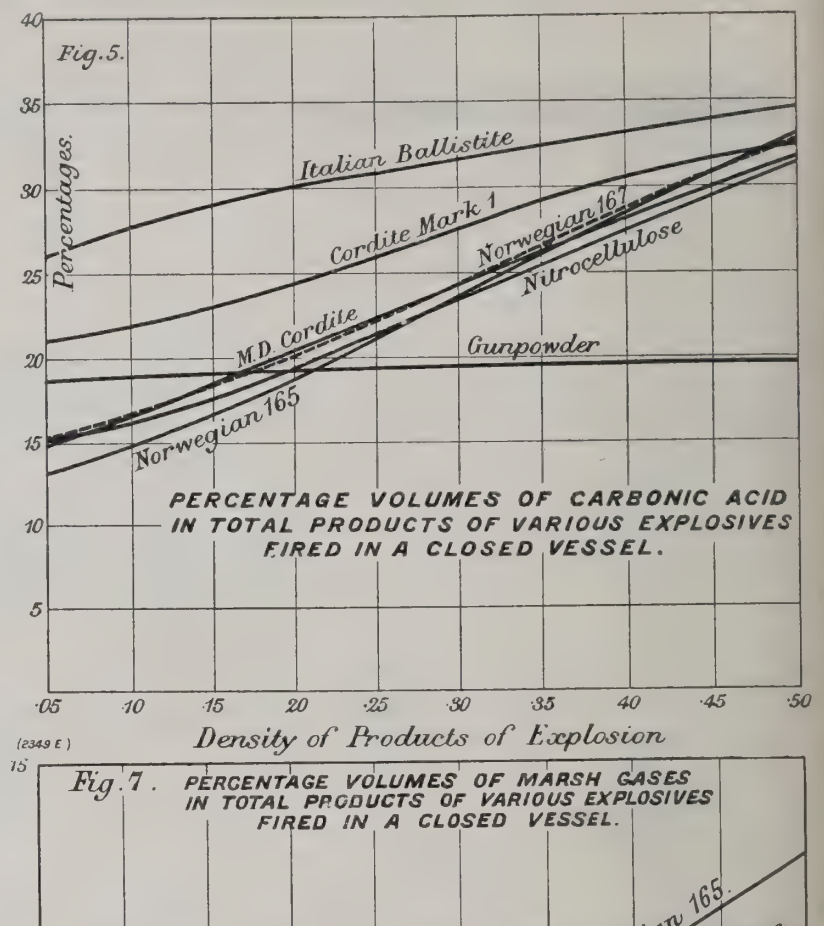
Cordite Mark I	Italian Ballistite	M.D. Cordite	Norwegian 167	Nitro-Cellulose	Norwegian 165	Blanche Nouvelle	Lyddite
Volumes of Gas.							
875.5	810.5	913 5	899.9	934	909.9	822	960.4
Units of Heat.							
1246	1305	1030	1005.5	924	935.5	1003	856 3
Energy of Explosive.							
1,090,873	1 057.703	940,905	904,850	863,016	851,212	824,466	822,390

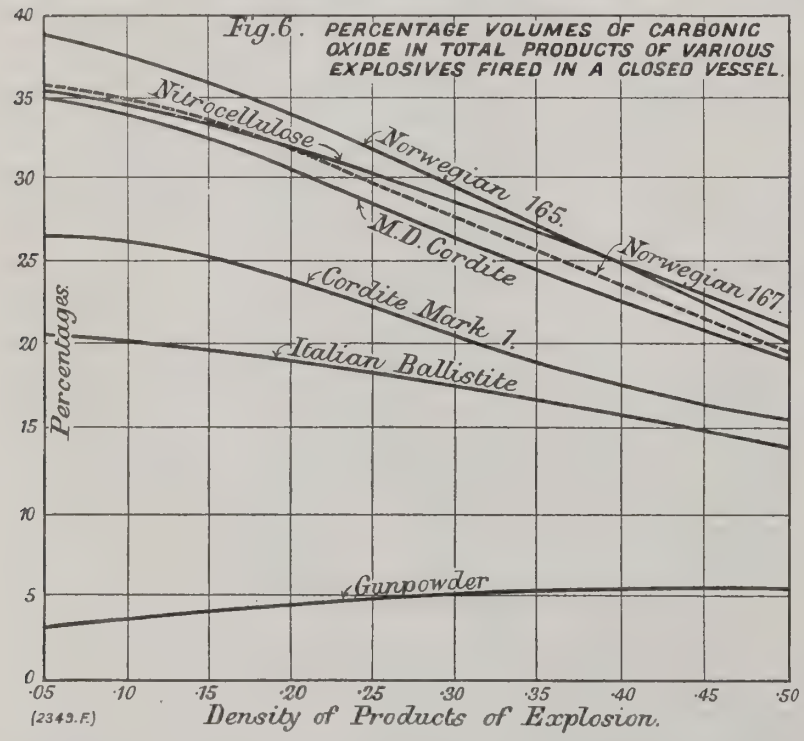
* Paper read at the Jubilee Meeting of the Institution of Naval Architects, July 5, 1911.

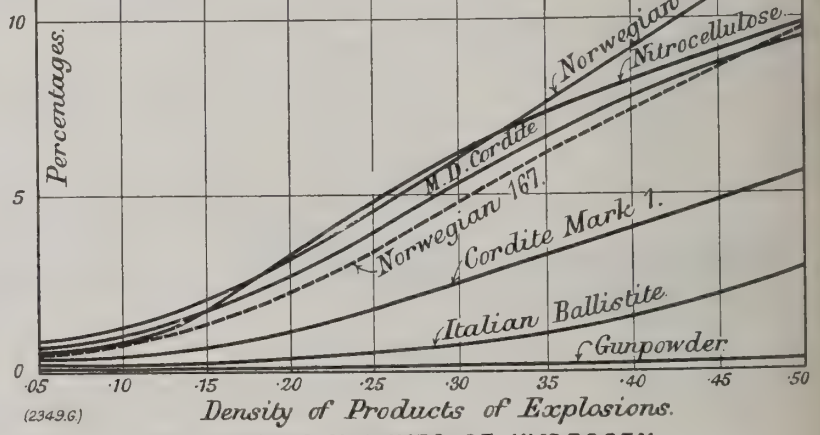
whole weight of the gun and mounting was under 5 tons, and the gun could be trained easily by the shoulder. The sights were on the cradle and did not recoil with the gun. A single man could with ease train, work the elevating gear, lay and fire by means of an electric pistol. With this gun and mounting a very accuracy, of the modern gun are even more remarkable.

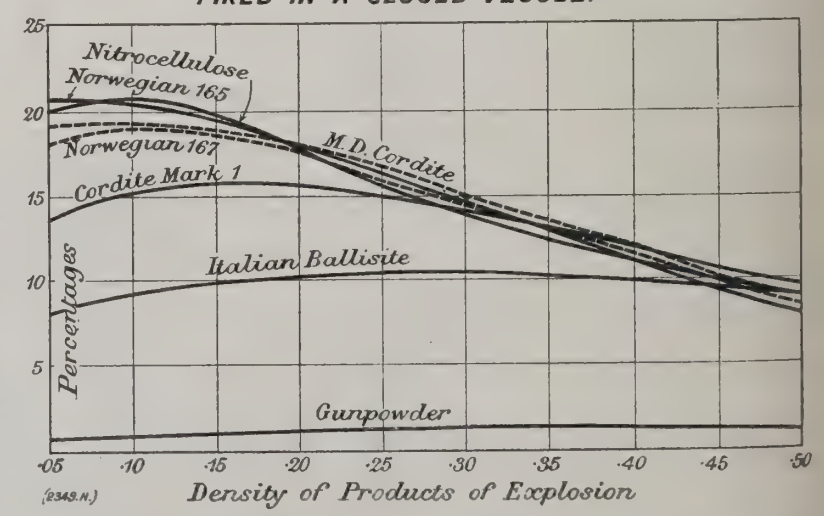
In what I have hitherto said I have referred chiefly to guns and the energies they were capable of developing; but, if the increase in the dimensions and power of the guns is remarkable, the increased power of the pro- 10,000 atmospheres. But the experiments which, for a long time, were taken by many to be tolerably reliable, were those of Count Rumford, who, in 1797, communicated to the Royal Society the results of two series of experiments, from one of which he deduced that the maximum pressure was, at a density of unity, about 190











great advance in rapidity of fire was obtained. At the trial above mentioned ten rounds were fired in 47½ seconds, and later as many as fifteen rounds per minute were obtained. I may mention an interesting incident connected with this trial. The gunboat Mastiff was sent the same day, and was ordered to fire ten rounds from the Service 5-in. breech-loading gun as rapidly as possible. The time taken for the ten rounds was 6 min. 16 sec., so that the quick-firing gun fired its ten rounds before the then Service gun fired its second shot.

On the diagram I now show you (Fig. 3) are placed side by side sections of the 6.3-in. smooth-bored gun of 1850, and of the 6-in. 100-pounder of the present day. The diagrams show the pressures and velocities of the two guns. The velocity and energy given by the 32-pounder smooth-bored gun are about 1600 ft. per second and 570 foot-tons respectively. The corresponding figures for the 6-in. are about 3000 ft. per second and 6240 foot-tons energy, but the rapidity of fire, the range and pellants is quite as much so. During more than fifty years I have made very many hundreds of experiments, and completely examined eighteen different propellants, determining, for most of them, the changes in transformation which take place when the propellant is fired at different densities. And first, as regards gun-powder and the pressure produced by its explosion, I do not know any physical fact as to which, for many years, so wide a difference of opinion prevailed. Robins, the Father of Gunnery, put the pressure developed at a density of unity at 1000 atmospheres, or 6.6 tons per sq. in., while Hutton put it at 2000 atmospheres, and Daniel Bernoulli, who was nearest the truth, made it tons per sq. in. This, however, he considered to be much below the truth, and he finally believed the pressure per square inch to be 662 tons. This latter pressure never seems to have been accepted, but in my own time Piobert accepted as tolerably correct Rumford's first series, and fixed the tension of gunpowder at the density of unity at

150 tons on the square inch, while Cavalli, in 1867, made the tension 158 tons per sq. in. On the other hand, text-books used at the Royal Military Academy, Woolwich, so late as 1870, placed the tension as low as 2200 atmospheres, or 14 tons on the square inch.

Referring to the high estimates I have mentioned, it is curious that as no such pressures were obtained in guns, this being attributed to slow combustion, no attention was paid by the eminent men I have mentioned to Robins's remark that the powder he employed must have all been exploded before the projectile was much removed from its seat, as, were it not so, a much greater energy would be realised when the weight of the shot was doubled, trebled, &c., but he had found that there was no very material increase. I myself, nearly a century and a-half later, repeated Robins's experiments with means at my disposal far greater and more accurate than anything he could have employed, and these experiments entirely corrobated the accuracy of his views.

The long series of experiments I made, and described in a paper, published by the Royal Society, by myself and my friend the late Sir F. Abel, set at rest the question of the pressures and temperature of fired gunpowder, as I was able with several varieties of powder to obtain the pressures and to examine the solid and gaseous products of combustion at all densities from 0.05 up to that of unity, the products being entirely confined after explosions, and the pressure at a density of unity was found to be about 42 tons per sq. in. The decomposition of these powders was affected by the pressure under which they were exploded, but only very slightly, and much less than was the case with the more modern explosives of which I shall have presently to speak.

I have alluded to the long period during which gunpowder remained unchanged, and it was only shortly before it was its fate to be replaced by modern explosives that any attempt was made to improve it The first step in this direction was made by Major Rodman, U.S.A., who not only appreciated the importance of the size and density of the grains in diminishing excessive pressure, but invented a most ingenious instrument for determining the pressure of the exploded gases. Before the adoption of the pebble, P 2, and prismatic powders, which were due to the labours of the first Explosion Committee, the chamber pressures indicated were very high, and occasionally ran exceptionally high, but these exceptional pressures did not exist at the same instant throughout the chamber, but were due to waves passing backwards and forwards between the end of the chamber and the base of the projectile. Some of these wave pressures have been observed 50 per cent. higher than the pressures due to powder exploded in a close vessel at the density of unity, that is approximately in its own space.

But I must turn to modern explosives. Of these I have examined pretty completely eight varieties (nine if I include Amide powder, the energy of which is about 60 per cent. higher than that of the old powder. If we compare the potential energies of the old powders of the Service I examined, these varied from 200,438 units in the case of pebble powder to 194,094 units with that known as F.G. The comparative energies of other old powders are, as you will see from the tables on page 93, some a little higher, others somewhat lower, but, with the exception of the Amide powder, there is no very great difference in the energy developed, and but little in the decomposition which takes place when exploded at different densities.

TABLE III.—*Erosions.—Cubic cm.*

TOTAL EROSIONS. (Curve Readings.)

	Cordite Mark 1.	M.D. Cordite.	Tubular Ballistite. Lot 165.	Tubular Smokeless No. 2.
1 *Round of Full Charge* (4 *Lb.* 10 *Oz.*, 2098 *Grammes*) *per Bolt; Density*, 0.206.				
	28.50	18.10	12.10	11.80
4 *Rounds of ¾ Charge* (3 *Lb.* 7½ *Oz.*, 1574 *Grammes*) *per Bolt; Density*, 0.155.				
1	22.00	14 20	7.75	9.20
2	39.85	25.50	14.45	16.20
3	58.20	35.80	20.45	22.43
4	77.30	45.70	25.90	28.45
16 *Rounds of ½ Charge* (2 *Lb.* 5 *Oz.*, 1049 *Grammes*) *per Bolt; Density*, 0.103.				
1	13.30	9.37	4.34	5.30
2	24.15	17.34	8.14	9.97
3	33.67	24.29	11.56	14.18
4	42.71	30.53	14.68	18.06
5	51.70	36.27	17.54	21.67
6	60.92	41.65	20.17	25.04
7	70.52	46.78	22.61	28.20
8	80.43	51.70	24.86	31.18
9	90.57	56.44	26.95	34.00
10	100.90	61.03	28.89	36.66
11	111.40	65.49	30.69	39.19
12	122.00*	69.84	32 37	41.60
13	132.80*	74.09	33.94	43.90
14	143.70*	78.25	35.40	46.09
15	154.80*	82.34	36.75	48.17
16	166.00*	86.36	38.00	50.15

The erosion belt used for half-charges of Cordite Mark 1 was burned through on one side at the eleventh round, and could not be used again.

* These figures are the estimated continuation of Cordite Mark 1.

The case is very different with the modern propellants. With gunpowder the products of combustion, when cool, are about 43 per cent. by weight gaseous and 57 per cent. solid, and they include seven gases, the same number of salts, and two elements. With modern propellants the products are only six—five gases, and water, the amount of which in the different explosives varies from about 12 to 20 per cent. of the total weight. With gunpowder, as I have said, there is, with increased density of charge, but little difference in the decomposition, and the quantity and nature of the products differ but little. The case is, as I shall shortly show you, widely different with high explosives.

Table I. gives the volumes of gas, units of heat and energy of the older explosives. Table II. also gives the same details of the modern explosives I have examined, and you will note that the energies vary from nearly 5½ times to 4¼ times as great as that of gunpowder, cordite developing the highest energy. With gunpowder, as I have said, there is, with increased density of charge, but little difference in decomposition, the percentage and nature of the products of explosion differing but little. With high explosives the case is widely different; but, before going into details, it will be as well to give you an idea of the differences of pressure between the old powders and the modern propellants at the same density. Fig. 4 is a diagram which exhibits up to the density of 0.5 the pressures of gunpowder and of several modern propellants. You will observe that at the density of 0.5 the pressures of the modern propellants are about five times as great as that of gunpowder; but I need not say we do not allow these pressures to be developed in guns, the maximum in that case being about 20 tons on the square inch.

The pressure of gunpowder at the density of unity, as I have said, is about 42 tons per square inch. I have made more than one effort to obtain the pressure of cordite at the same density, but have not been perfectly successful, as my gauges were always crushed upon the piston by the high pressure. I know, however, the pressure to be considerably above 100 tons, and believe the true pressure at the density of unity to lie somewhere between 108 and 115 tons on the square inch. Unlike gunpowder, the decomposition of modern explosives differs greatly with the pressure under which they are exploded. The quantities of the nitrogen and water formed are not much affected, but with increased density considerably larger percentages of carbonic acid and marsh gas are formed. As an illustration, in the case of Norwegian Ballistite, in passing from a density of 0.05 to that of 0.5, the carbonic acid is increased from 13.40 per cent. to 33.4 per cent., the carbonic oxide being decreased from 38.5 per cent. to 19.5 per cent. Similarly, with the same explosive at the same densities, the marsh gas is increased from 0.4 per cent. to 12.55 per cent., the hydrogen being decreased from 20.6 per cent. to 7.4 per cent.

The rapid increase in the amount of carbonic acid and marsh gas at the higher densities, accounts at once both for the decrement in the volume of the total gases formed by the explosion, and for the very much greater heat developed at the higher density. Thus, in passing from density 0.05 to density 0.5, the volume of the gases per gramme falls from 959 to 780 volumes, while the temperature of explosion is increased by about 1500 deg. Cent. Although there are great variations in the percentages of the gases to which I have referred, the same general law as to increment or decrement of volume with increase of density is followed in all the explosives with which I have experimented.

Thus, in the diagram giving the percentage volumes of carbonic anhydride, Fig. 5, you will note that, with increasing density, the percentage of CO_2 steadily increases, and is in marked contrast to gunpowder, where the CO_2 can hardly be said to alter at all. I may point out also that with increase of density the differences in the volume of carbonic oxide in all the propellants examined steadily decrease as the densities increase, and are not great at the density of 0.5. As a matter of course, the volumes of carbonic oxide decrease as those of carbonic anhydride increase, and I exhibit a diagram (Fig. 6) showing the percentages of this gas up to the same density. As regards gunpowder, the increase in density causes but little change in the percentage of carbonic oxide, even up to the density of unity, and, unlike the modern explosives, the changes appear to be in a great measure independent of the density.

Turning now to marsh gas and hydrogen, the variations in their percentage at different densities are very striking. These variations also are more easily appreciated by means of diagrams, and, as before, I give you curves showing the volumes of each gas at the different densities (Fig. 7). Commencing with marsh gas, you will see that at the density of 0.05 the percentage is, with all the propellants, exceedingly small, the largest being under half a per cent. The increments, you will note, are very variable with the different propellants; the Italian Ballistite being only at a density of 0.5 about 2½ per cent., while one of the Norwegian Ballistites reaches over 12½ per cent. With the old gunpowder, the percentage of marsh gas is, as you see, almost infinitesimal, and is nearly constant. On the other hand, the differences in the percentage of hydrogen at the low densities (Fig. 8) are very large, varying from about 8 per cent. to nearly 21 per cent., while at the density of 0.5 the differences nearly disappear, being considerably under 2 per cent. You will observe also that with gunpowder the percentage of hydrogen is, as in the case of marsh gas, exceedingly small, being very uniform, and only about 1 per cent.

The only other point to which I shall draw your attention is the question of erosion. As erosion increases at so rapid a rate with increase of calibre, it becomes of importance in the larger guns to have the length as great as possible, as by so doing the amount of the charge is very greatly decreased. I may add that I think erroneous opinions as to the decrease in erosion due to the decrease in charge have been entertained, and I conclude my paper by giving you Table III., showing the erosions due to full, half, and quarter-charges of different propellants.

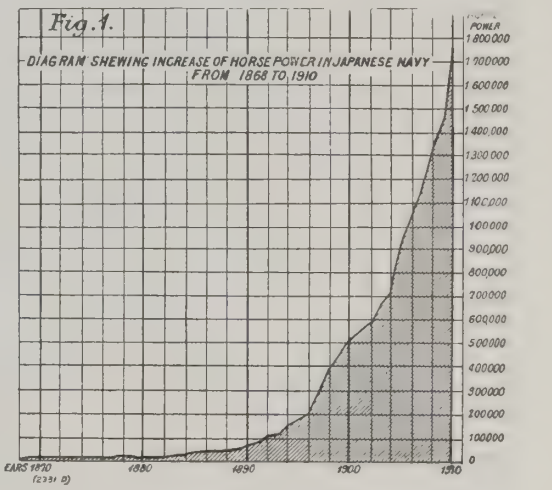
PROGRESS OF NAVAL ENGINEERING IN JAPAN.*

By Engineer Rear-Admiral TERUGORO FUJII, I.J.N., Member.

THE increase of horse-power in the Japanese Navy has become somewhat remarkable since 1896, as will be seen from Fig. 1. The total horse-power and number of ships built or building will be gathered from Table I., and it will be seen that nearly 28 per cent. of the total indicated horse-power of our warship machinery comes from Great Britain.

In the following remarks I intend to give a brief account of the evolution of ship machinery, with reference to Table II., page 96, and the drawings given.

Boilers.—The gunboat Chiyoda Gata, the first steam-driven ship built in Japan (1863), was equipped with three low-pressure cylindrical boilers of the locomotive type. Subsequently, either locomotive or return-tube boilers were adopted for every ship launched before 1899. In 1900 the Normand type was installed in the despatch boat Chihaya; and next year the high-type cylindrical boilers of the Itsukushima and Matsushima were replaced by Belleville boilers; and those of the Hashidate by Miyabara boilers, invented by our Admiral Miyabara, this being the first time that this boiler was used on a warship. Then in 1902 the locomotive and low-type cylindrical boilers on the Chiyoda, as well as the Yayeyama, were replaced by boilers of Belleville and Niclausse types respectively. These afforded us opportunity for very important investigations with regard to water-tube boilers; and on a training cruise for our naval cadets to Australia and back, the Miyabara boiler fitted in the Hashidate proved very satis-



factory. This fact was also confirmed by the experience of rough usage during the late war. Since that time, the Japanese authorities have decided to adopt the same for nearly all ships of new construction in Japan; and, in fact, the Tsukuba, Ibuki, and Satsuma have already given good results on their trials with this type of boiler on board. Also the first-class battleships Kawachi and Settsu, now under construction, are to be equipped with Miyabara boilers of double-ended type. Figs. 2 and 3, page 96, show the boiler for the cruiser Tsukuba. As may be seen from the drawings, the construction of the Miyabara boiler is comparatively simple, having horizontal water and steam drums, with slightly-curved tubes connecting them. From the nature of its construction, this type is very elastic and contains a comparatively large quantity of water; moreover, the water circulation being always efficient, it gives no trouble from leakage.

TABLE I.

Class.	Where Built.	Number of Ships.	Total H.-P.
Warships	Home	45	573,617
	Great Britain	47	376,540
	Elsewhere	32	254,652
	Total	124	1,204,809
Destroyers	Home	45	306,000
	Great Britain	16	95,050
	Elsewhere	5	23,000
	Total	66	424,050
Torpedo-boats	Home	58	77,029
	Great Britain	10	19,217
	Elsewhere	25	39,804
	Total	93	136,050
Submarines	Home	6	3,400
	Great Britain	2	1,200
	Elsewhere	5	1,500
	Total	13	6,100
	Grand total	296	1,771,009

On the other hand, in 1903, another type was tried for the third-class cruiser Otowa, and, its results being very satisfactory, this type was used for 28 destroyers constructed in the year 1904. Figs. 4 and 5, page 96, show the boiler of the destroyer Ayanami. We named this boiler "Navy Type," as it is an express type specially used

* Paper read at the Jubilee Meeting of the Institution of Naval Architects, July 6, 1911.

TABLE II.—List of Machinery for Warships Built or Building in Japan, 1860-1911.

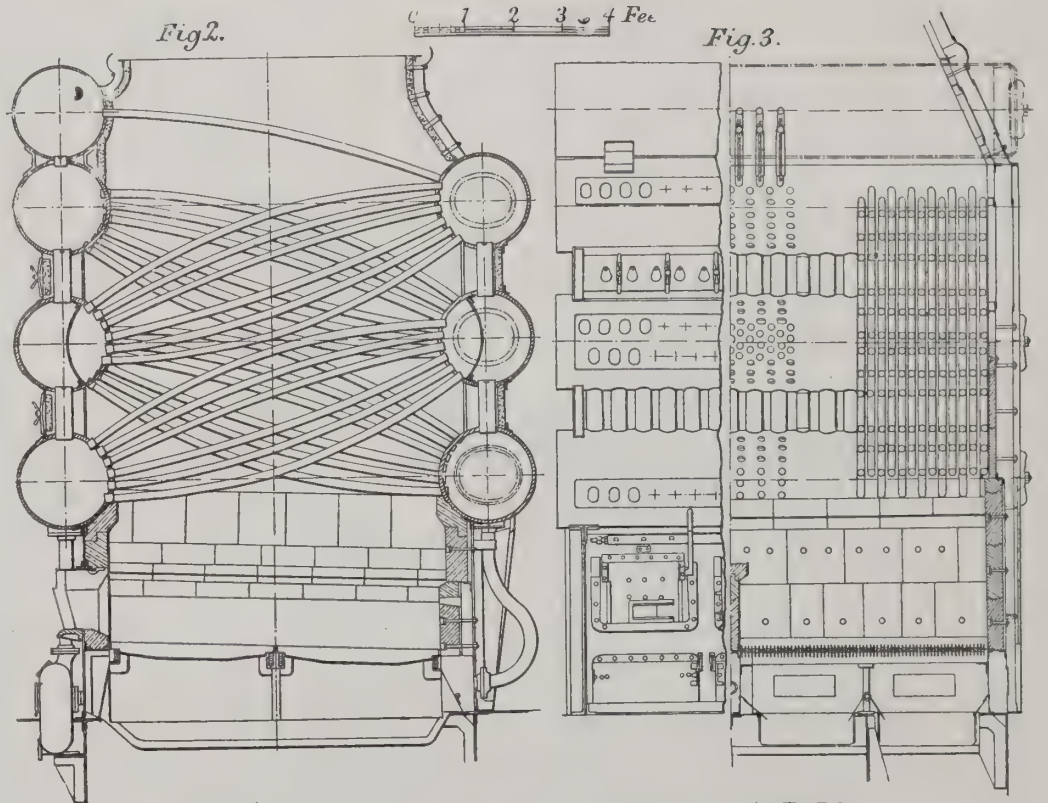
Class.	Names.	Date of Launch.	Horse-Power.	Type of Engine.	Diameter of Cylinders.	Stroke.	Number of Propellers.	Type of Boiler.	Number of Boilers.
					in.	in.			
Gunboat	Chiyodagata ..	1862	60	Horizontal direct-acting	15¾ × 2	15¾	1	Cylindrical	3
Sloop	Seiki	1875	443	Horizontal three-cylinder compound	37⅝ × 3	23⅝	1	,,	2
Imperial yacht ..	Jingei	1876	1,400	Diagonal direct-acting	58½ × 2	63	(Paddle)	,,	4
Sloop	Amagi	1877	720	Horizontal three-cylinder compound	37⅝ × 3	23⅝	1	,,	2
Gunboat	Banjo	1878	659	Horizontal direct-acting	38 × 2	25.2	1	,,	4
Corvette	Kaimon ..	1882	1,267	Horizontal return-acting compound	44 × 74	30	1	,,	4
Ditto ..	Tenriu	1883	1,267	Ditto	44 × 74	30	1	,,	4
Ditto ..	Katsuragi ..	1885	1,622	Ditto	48½ × 80	30	1	,,	6
Ditto ..	Yamato ..	1885	1,622	Ditto	48½ × 80	30	1	,,	6
Ditto ..	Musashi ..	1886	1,622	Ditto	48½ × 80	30	1	,,	6
Gunboat	Maya	1886	963	Horizontal direct-acting compound	27 × 50.4	16	2	,,	2
Ditto ..	Atago	1887	963	Ditto	27 × 50.4	16	2	,,	2
Ditto ..	Chokai	1887	963	Ditto	27 × 50.4	16	2	,,	2
Ditto ..	Akagi	1888	963	Ditto	27 × 50.4	16	2	,,	2
Cruiser	Takao	1888	2,332	Ditto	35 × 68	32	2	,,	5
Despatch-boat ..	Yayeyama ..	1889	5,400	Horizontal direct-acting triple-expansion	31 × 46 × 68	28	2	,,	6*
Cruiser	Hashidate ..	1891	5,400	Ditto	15.3×24.4×56.7	39.4	2	,,	6†
Gunboat	Oshima ..	1891	1,216	Vertical direct-acting triple-expansion	11 ×19⅛ ×31⅛	15¾	2	,,	2
Cruiser	Akitsushima ..	1892	8,516	Horizontal direct-acting triple-expansion	32½ ×47½ ×75¾	35	2	,,	4
Ditto ..	Suma	1895	8,500	Vertical direct-acting triple-expansion	32.3×48.8×74.8	28.3	2	,,	8
Despatch-boat ..	Miyako	1896	6,130	Ditto	27⅜×40⅜×59⅜	27⅜	2	,,	7
Cruiser	Akashi ..	1897	8,000	Ditto	32.3×48.8 ×74.8	29.5	2	,,	9
Despatch-boat ..	Chihaya ..	1900	6,000	Ditto	27 × 40½ × 60	27	2	Normand	4
Cruiser	Niitaka ..	1902	9,500	Ditto	29½×44½× (49½×2)	30	2	Niclausse	16
Ditto ..	Tsushima ..	1902	9,500	Ditto	29½×44½× (49½×2)	30	2	,,	16
Gunboat	Uji	1903	1,000	Ditto	11 × 17½ × 28	18	2	Navy type	2
Cruiser	Otowa	1903	9,141	Ditto	29½×44½× (49½×2)	30	2	,,	10
Armoured cruiser	Tsukuba ..	1905	23,260	Ditto	41 × 64 × (70×2)	39	2	Miyabara	20
Ditto	Ikoma	1906	22,670	Ditto	41 × 64 × (70×2)	39	2	,,	20
Battleship	Satsuma ..	1906	18,507	Vertical direct-acting triple-expansion	37 × 59 × (66 × 2)	48	2	Miyabara	20
Ditto ..	Aki	1907	24,000	Curtis turbine	Dia. of pitch circle	144	2	,,	15
Armoured cruiser	Kurama ..	1907	22,500	Vertical direct-acting triple-expansion	41 × 64 × (70 × 2)	39	2	,,	28
Cruiser	Tone	1907	15,000	Vertical direct-acting triple-expansion	35 × 52 × (59 × 2)	33	2	,,	16
Despatch	Yodo	1907	6,500	Vertical direct-acting triple-expansion	22 × 34 × (38½×2)	24	2	,,	4
Armoured cruiser	Ibuki	1907	27,111	Curtis turbine	Dia. of pitch circle	144	2	,,	18
Despatch	Mogami ..	1908	8,000	Parsons turbine	Dia. of drum of turbine: H.-P. 3 ft. 5 in.; L.-P. 4 ft. 3 in.; astern 3 ft. 6 in.		3	,,	6
Battleship	Kawachi ..	Building	25,000	Curtis turbine	Dia. of pitch circle, 144 in.		2	,,	16
Ditto ..	Settsu	,,	25,000	Ditto	Ditto		2	,,	16
Cruiser	Hirato	,,	22,500	Ditto	Dia. of pitch circle, 108 in.		2	Navy type	16
Ditto ..	Yahagi	,,	22,500	Ditto	Ditto		2	,,	16
Ditto ..	Tsukuma ..	,,	22,500	Parsons turbine	One H.-P. cruising, one L.-P. cruising, two H.-P., two L.-P., and two astern		4	,,	12
Gunboat	..	,,	1,400	Vertical direct-acting compound	14 × 26	14	3	,,	2
Armoured cruiser	"A"	,,	64,000	Improved Parsons turbine	(Details not settled)		4	,,	36
Ditto ..	"B"	,,	64,000	Ditto			4	,,	36
Ditto ..	"C"	,,	64,000	Curtis turbine			4	,,	36
Total (above) ..	45	..	573,617						
Destroyers (total)	45	..	306,000						
Torpedo-boats (total)	58	..	77,020						
Submarine-boats (total)	6	..	3,400						
Grand total ..	154	..	960,046						

* Replaced with eight Niclausse boilers in 1904.

† Replaced with eight Miyabara boilers in 1901.

for our navy. This type is very similar to that of the Yarrow boiler, but the tube has a certain curvature instead of being straight, which gives sufficient elasticity for expansion and contraction of all parts. This curvature also gives much more space for cleaning the boiler, and effective heating is insured by the insertion of proper baffle-plates. Table III., page 97, shows the result of evaporative tests of Miyabara and "Navy Type" boilers, from which may be seen the gain in boiler power due to utilisation of oil-fuel.

Reciprocating Engines.—The Chiyodo Gata was installed with a horizontal-geared direct-acting engine of



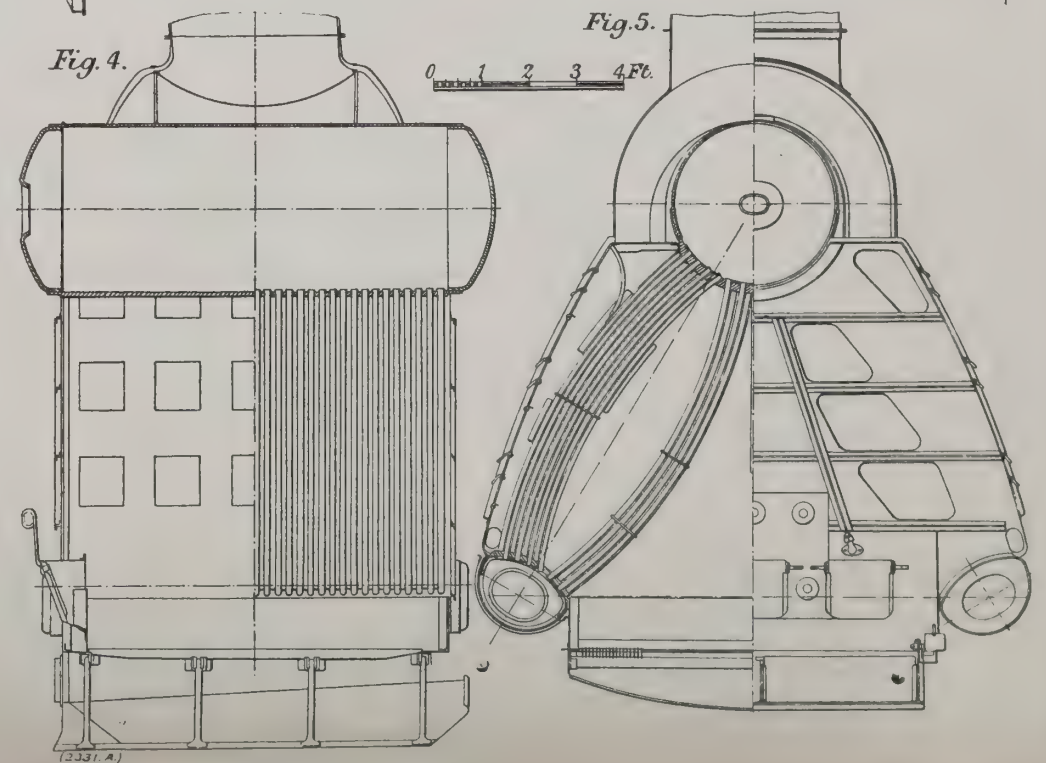


TABLE III.—RESULT OF EVAPORATIVE TESTS OF "MIYABARA" AND NAVY-TYPE BOILERS.

	"KURAMA" (FIRST-CLASS CRUISER).														"AYANAMI" (DESTROYER).											
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.
Type of boiler	Miyabara	Miyabara	Miyabara	Miyabara	Miyabara	Miyabara	Miyabara	Miyabara	Miyabara	Miyabara	Miyabara	Miyabara	Miyabara	Miyabara	Navy type	Navy type	Navy type	Navy type	Navy type	Navy type	Navy type	Navy type	Navy type	Navy type	Navy type	Navy type	Navy type
Kinds of trial	Coal only	Coal only	Coal only	Coal only	Coal and oil mixed	Coal and oil mixed	Coal and oil mixed	Coal and oil mixed	Coal and oil mixed	Coal and oil mixed	Oil only	Oil only	Oil only	Oil only	Coal only	Coal only	Coal only	Coal only	Coal and oil mixed	Coal and oil mixed	Coal and oil mixed	Coal and oil mixed	Coal and oil mixed	Coal and oil mixed	Oil only	Oil only	Oil only
Duration of trial .. hrs	3	3	8	3	2	2	2	2	2	2	2	2	2	2	3	3	3	3	2	2	3	2	3	3	2	3	3
Grate area (G.S.) .. sq. ft.	53.906	53.906	53.906	53.906	53.906	53.906	53.906	53.906	53.906	53.906	53.906	53.906	53.906	53.906	55	55	55	55	55	55	55	55	55	55	55	55	55
Heating surface (H.S.) „	1911.77	1911.77	1911.77	1911.77	1911.77	1911.77	1911.77	1911.77	1911.77	1911.77	191 .77	1911.77	1911.77	1911.77	2703.58	2703 58	2703.58	2703.58	2703.58	2703.58	2703.58	2703.58	2703.58	2703.58	2703 58	2703.58	2703.58
Ratio of $\frac{H.S.}{G.S.}$	35.466	35.466	35.466	35.466	35.466	35.466	35.466	35.466	35 466	35.466	35.466	35.466	35.466	35.466	49.15	49.15	49.15	49.15	49.15	49.15	49.15	49.15	49.15	49.15	49.15	49.15	49.15
Barometer .. .. in.	29 990	29.818	30.123	29.990	30.038	29 965	29.830	30.088	30.099	30.138	30.363	30.155	29.418	30.137	30.156	3 .23	30 094	30 169	30.237	29.830	30.204	30 00	29.91	29.85	30.00	29.875	30.09
Boiler pressure .. lb.	233.84	233.95	235 88	233 00	234.00	234.23	235.58	237.46	235.93	231.15	235.35	234 96	234.46	239 15	249.03	249.7	249 68	249.95	249.68	250.70	251.62	249.24	249.9	250 8	248.9	248.51	250.2
Total fuel burnt per square foot of grate per hour lb	17.721	29.535	37.411	44.302	19.458	24.467	29.225	37.235	44.382	49 172	17.77	25.868	29.187	37.585	20.00	40.00	50.00	58.00	16 182	27.4364	33 563	38.6449	47.455	53.0303	10.64	12.182	19.788
Total fuel burnt per square foot of heating surface per hour .. .. .. lb.	0.4997	0.8328	1.0548	1.2492	0.5486	0.6899	0.8241	1.0473	1.2514	1.3865	0.5010	0.7294	0 8314	1.0598	0.4069	0.8137	1.0172	1.1799	0.3292	0.5581	0.6827	0.7862	0.9654	1.0812	0.2164	0.2478	0 4026
Quantity of ash and clinker during the trial .. lb.	210.729	373.959	767.966	285.714	108.057	130.58	128.111	139.332	193.546	177.798	..	..	..	..	203	173	235	192	69	61	121	64	111	139	..	..	..
Kind of fuel	British anthracite coal	British anthracite coal	British anthracite coal	British anthracite coal	British anthracite coal & heavy oil	British anthracite coal & heavy oil	British anthracite coal & heavy oil	British anthracite coal & heavy oil	British anthracite coal & heavy oil	British anthracite coal & heavy oil	Heavy oil	Heavy oil	Heavy oil	Heavy oil	British anthracite coal	British anthracite coal	B itish anthracite coal	British anthracite coal	British anthracite coal & heavy oil	British anthracite coal & heavy oil	British anthracite coal & h avy oi	British anthracite coal & heavy oil	British anthracite coal & heavy oil	British anthracite coal & heavy oil	Heavy oil	Heavy oil	Heavy oil
Temperature of feed water deg. F	75 05	75.00	73.33	74.63	76 08	77.15	74.46	76.15	77.08	74.00	44.00	56.0	58.00	56.00	51.00	53.05	53.00	53.00	64.00	54.00	61.514	64.08	60.00	56.00	65 00	48 00	66.00
Temperature of atmosphere { Outside of boiler-room deg. F.	79.68	85.37	83.16	80.95	85.46	81.54	86.08	83.54	79.77	77.77	49.35	48 31	67.54	52.08	55.16	55.22	54 86	62.00	63.40	59.00	55.00	74.00	56.10	49 20	71.44	46.16	69.90
Temperature of atmosphere { Inside of boiler room deg. F.	91.47	91.16	89.84	92.37	75.81	91 62	99.73	91.15	91.27	82 92	63.92	69 92	85.77	69.12	79.65	77.80	75.35	78.05	78.00	83.70	78 11	86.96	82.30	74.95	59.56	78 40	83.48
Water evaporated from and at 212 deg. Fahr. per pound of fuel .. .. lb	10. 439	9.2646	9.1603	8.2293	12.3431	11.9717	11.579	10.9101	9.8303	9.7556	12.5866	13.0862	13.3874	13.1130	3105	7.4971	7 712	6.6913	9.7686	11.3332	10 691	11.5764	10 5864	9 7266	11.9636	11.094	12 9851
Water evaporated from and at 212 deg. Fahr. per square foot of heating surface lb.	5.2162	7.7150	9.6627	10.2300	6.7714	8.2603	9.5421	11.4748	12.3022	13.526	6.3066	9 5449	11.1309	13 8909	3.7881	6 1009	7.8442	7.8951	3.2148	6.3257	7 295	9.1019	10.1217	10.4849	2.5887	2.7493	5,2272

NOTE.—Evaporative power of British coal in Japan is generally reduced 10 per cent. (average) lower than when the test is made in Britain.

TABLE IV.—RESULT OF TRIALS OF H.I.J.M.S. "IBUKI."

DATE.	Kinds of Trial.	Duration of Trial in Hours.	Revolution per Min.	S.H.-P.	NUMBER OF NOZZLES ON EACH STAGE.														STEAM PRESSURE (IN POUNDS AND INCHES).															
					STARBOARD.							PORT.							Boilers	Main Steam in Engine-Room.		Chest of Turbine.		1st Stage.		2nd Stage.		3rd Stage.		4th Stage.	
			Mean.	Total.	1st	2nd	3rd	4th	5th	6th	7th	1st	2nd	3rd	4th	5th	6th	7th		Starboard.	Port.	Starboard	Port.	Starboard.	Port.	Starboard.	Port.	Starboard.	Port.	Starboard.	Port.				
1909																																		
Aug. 12	Full power	6	250.2	27,111	20	64	96	96	256	256	256	20	64	96	96	256	256	256	269.6	252.1	251.4	244.4	233.9	71.40	67.20	39.70	40 00	12.00	12 40	- 1.92	0.38				
„ 7	¾ „	6	236.6	21,094	16	64	96	96	256	256	256	16	64	96	96	256	256	256	261.8	246.3	247.3	242.6	235.6	54.50	49.40	29.00	29.30	+ 13.50	+ 13.60	- 6.50	- 5.80				
July 31	½ „	24	216.7	16,027	13	56	96	96	237	237	237	13	56	96	96	237	237	237	253.5	244 3	239.8	234.2	232 8	47.90	41 90	20.10	21.0	+ 3 70	+ 5.10	- 9.80	- 9 00				
„ 26	¾ „	6	188.4	9.842	9	64	96	96	256	256	256	9	64	96	96	256	256	256	250.4	239.7	235.2	231 9	228.2	23.50	19.10	8.90	9.40	- 5.10	- 5.50	- 17.80	- 16.70				
„ 24	½ „	8	152.2	5,254	5	64	96	96	256	256	256	5	64	96	96	256	256	256	244.9	227.2	229.4	220.0	219 5	8.50	7.20	- 3.80	- 0.60	- 15.60	- 14 80	- 22.50	- 23 00				

TABLE IV.—(*continued*).

DATE.	Kinds of Trial.	STEAM PRESSURE (IN POUNDS AND INCHES).								Barometer in Inches.	TEMPERATURE (DEG. FAHR.).					BOILER.			WATER RATE OF MAIN ENGINE PER S.H.-P.		MAIN CONDENSER.		MAIN ENGINE.		
		5th Stage.		6th Stage.		7th Stage.		Vacuum in Main Condenser in Inches.			Superheat after Passing Regulating Valves.		Main Condenser.			Number of Boilers.		S.H.-P. per Square Foot of Grate.	Not Corrected to Contract Conditions (per Hour).	Corrected to Contract Conditions (per Hour).	Condensed Water per Sq. Ft. of Cooling Surface per Hour in Lbs	Circulating Sea Water per Pound of Steam in Lbs.	Bucket Speed in Feet per Second.	Steam Velocity in Feet per Second. (1st Stage.)	Efficiency of Turbine. Per Cent.
								Top.		Bottom.			Sea Water.												
		Starboard.	Port.	Starboard.	Port.	Starboard.	Port.	Starboard	Port.	Starboard	Port.		Starboard.	Port.	Inlet.	Outlet.	Condensed Water.	Feed Water after Passing through Feed Heater.	Double-Ended.	Single-Ended.								
1909																											
Aug. 12	Full power	- 15.68	- 15.41	- 22 84	- 22.55	- 25.79	- 25.64	26.20	26.47	28 33	28 52	29.995	21.8	22.9	74.6	97.7	90.9	131 11	10	8	16.45	15.050	13.77	11.505	44.293	157.3	2142.5	52.45
„ 7	¾ „	- 18.10	- 18.40	- 24.00	- 23.90	- 26.40	- 26.70	26.90	26.90	28.10	28.40	29.990	15.0	10.3	71 2	91.4	86.0	132.75	10	8	12.80	15.686	14.76	9.099	39.635	147.7	2330.0	48.95
July 3	½ „	- 19 80	- 19 80	- 24.90	- 24.80	- 26.80	- 26 90	27.20	27.00	28.00	27.80	29.900	6.8	3.9	75.0	93.4	8 .5	131.6	10	8	9 72	16.505	15.62	7.253	41.113	136.2	2379.0	46.30
„ 26	¾ „	- 23.90	- 23.80	- 26.80	- 26.70	- 27 80	27 90	28 10	27.50	28.60	28 40	30.300	1.3	2.0	73.2	90.8	86.7	136.8	5	8	9 23	18 652	17.75	5.038	30 056	118.4	2640.0	40.70
„ 24	½ „	26.90	25.90	- 27.70	- 27.60	- 28.16	- 28.30	28.30	27.75	28.46	28.17	30.320	3 1	4.3	78.2	92.3	88.7	145.2	5	0	9.05	21 074	20.57	3 0e5	30.946	95.6	2943.0	35.10

TABLE V.—*Manœuvring Trials of H.I.J.M.S. "Ibuki"*

Kinds of Trial.	Date.	Ahead.*		Astern.		B/A	Steam Pressure in Lb	
		Revolutions per Minute.	Shaft Horse-Power (A).	Revolutions per Minute.	Shaft Horse-Power (B).		Ahead.	Astern.
	1909.					p.c.		
Inertia	July 17	110	2,200	80.6	1,845	83.7	200.0	150 0
	„ 17	150	5,000	78.9	2,837	56.7	250.0	225.0
	„ 17	175	7,800	94.7	3,941	50.5	225.0	172 0
	„ 17	190	10,200	98.5	4,488	44.0	200 0	188.0
	„ 19	218	14,750	109 6	5,460	37.0	231.0	218.5
Astern	„ 19	200	10,322	133.7	4,291	41.6	232 5	210.0
	„ 19	120	2,700	108.0	2,585	95.5	224.0	200 0
	„ 19	85	1,200	76.4	748	62.3	225.5	200.0
	Aug. 7	239	20,612	196.8	12, 265	59.5	241 0	208 5

* The horse-power mentioned here is decided by the number of revolutions counted before the order to go astern.

60 horse-power, to drive a single-screw propeller, which was really the first marine engine ever built by Japanese hands.

In 1875 a return connecting-rod compound engine of 443 horse-power was installed in the wooden gunboat Seiki; while in the Jingei, an imperial yacht, a diagonal direct-acting engine of 1490 horse-power was tried to drive her paddle-wheels. Then for a decade or so, either horizontal direct-acting or return connecting-rod types were used. In 1890 a vertical triple-expansion engine, developing 1200 horse-power, was installed in the Oshima, and a vertical triple-expansion engine of 8500 horse-power, in the protected cruiser Suma. As a consequence of this increase in horse power in 1902, vertical four-cylinder triple-expansion engines of 9500 horse-power were installed in the cruiser Niitaka. In 1906 two sets of vertical four-cylinder triple-expansion engines of 22,000 designed

horse-power were built for the first-class cruisers Tsukuba and Ikoma; also the same type of engine, developing 18,500 horse-power, was installed in the first-class battleship Satsuma. These engines are all fitted with forced lubrication system, which has given very satisfactory results.

Steam-Turbine.—The prominent success of the Parsons turbine having undoubtedly encouraged marine engineers in all countries to try the turbine system for naval work, our authorities decided to try one set of Parsons' turbines of 8000 brake horse-power for the despatch-boat Mogami in 1907. Later in the same year we adopted two sets of seven-stage Curtis turbines for the Aki and the Ibuki, as their size, weight, revolution, steam consumption, and cost, made it desirable to replace the reciprocating engines with which they were originally designed.

An improvement has been made for all Curtis turbines of new design, on a part of the drum and second-stage stern-wheel, to counterbalance the propeller thrust by means of steam-thrust, so that the thrust-shaft and collar may be made comparatively short.

The result of the steam consumption trial for the Ibuki is shown in Table IV., page 97. With regard to her manœuvring, we found it fairly good as compared with that of ships fitted with reciprocating engines. Table V. gives the results of trials.

Cost of Propelling Machinery.—The cost of propelling machinery for the gunboats Atago and Takao varies from 50 yen to 55 yen* per horse-power, and that of twenty-eight destroyers, built in 1902, was found to be 35 yen. In the case of the armoured cruiser Tsukuba and the Ibuku, the cost was 98 yen and 95 yen respectively, the latter being equipped with Curtis turbines, while that of the first-class battleship Satsuma was nearly 115 yen per horse-power. Generally speaking, the cost of propelling machinery in Japan seems slightly less than it is in Europe and America. This is probably due to the lower wages of workmen, notwithstanding the higher price of imported materials. Though the wages in Japan are still much lower than those of Europe or America, they are constantly getting higher, and during the last fifteen years the pay of workmen has increased from 32 sen (8d.) to 66 sen (1s. 4d.) per day of about 10 hours' work.

Personnel.—The number of officers and men belonging to the Engineering Corps of our navy at the end of 1910 was as shown in Table VI. And the total number of workmen engaged in marine engineering in the Imperial Dockyards at the end of the same year was summarised as being 9200. Of these, 3300 men were employed at Yokosuka, 2300 men at Kure, 1900 men at Sasebo, and 1300 men at the Maidzuru Dockyard, and the remainder at various other places.

Effect of War on Machinery.—It is gratifying to mention that the machinery of our squadrons had not shown any defects such as to affect the action of our fleet during the whole course of the recent war, and it may be worth mentioning that some of the warships were continuously under steam for over 2000 hours. The only noticeable trouble which our engineers experienced was the leakage of both main and auxiliary condenser-tubes. Also, I may add, that the spare parts of auxiliary machinery were found indispensable, they having been used very often.

Fig. 6.

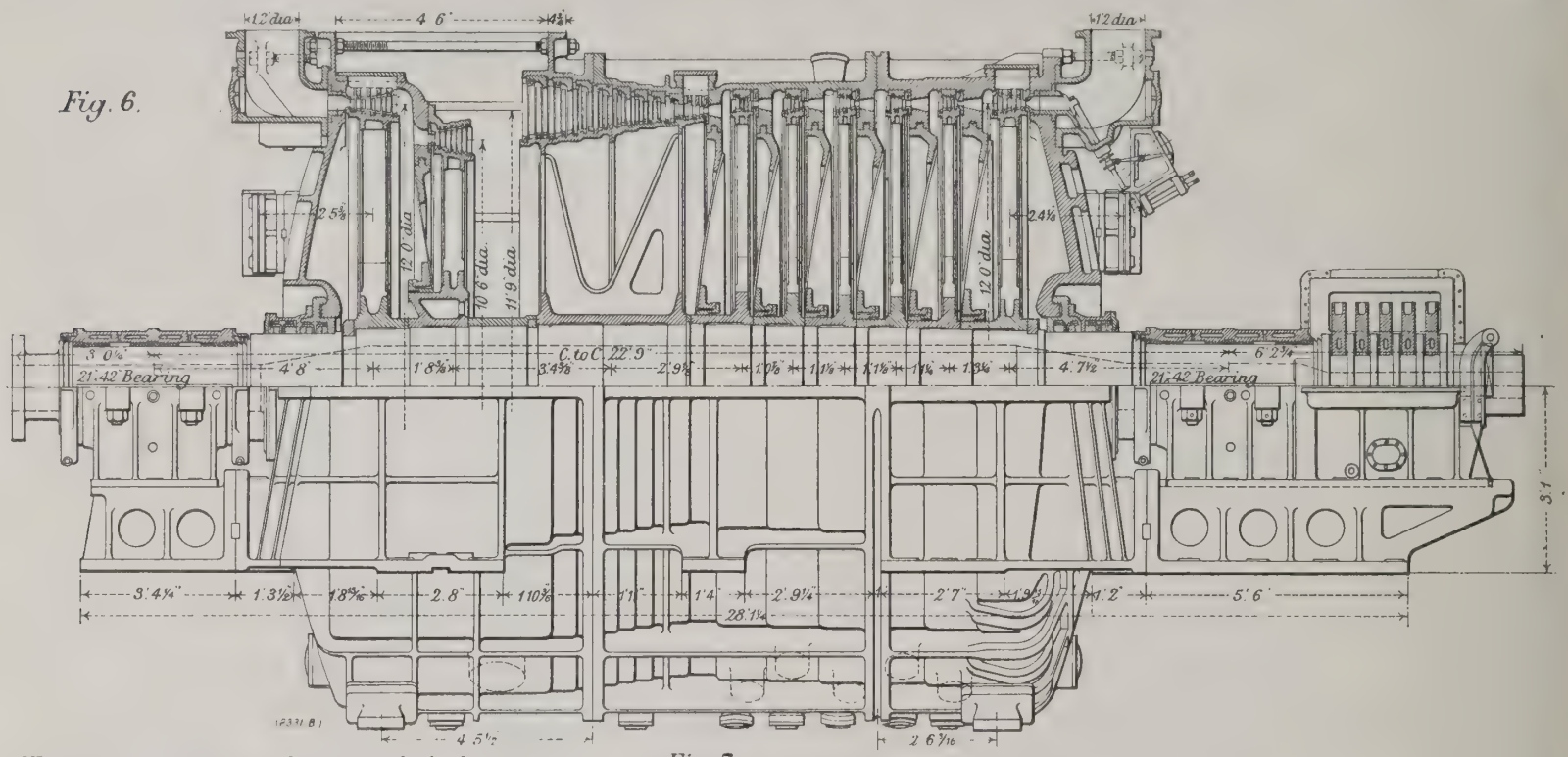
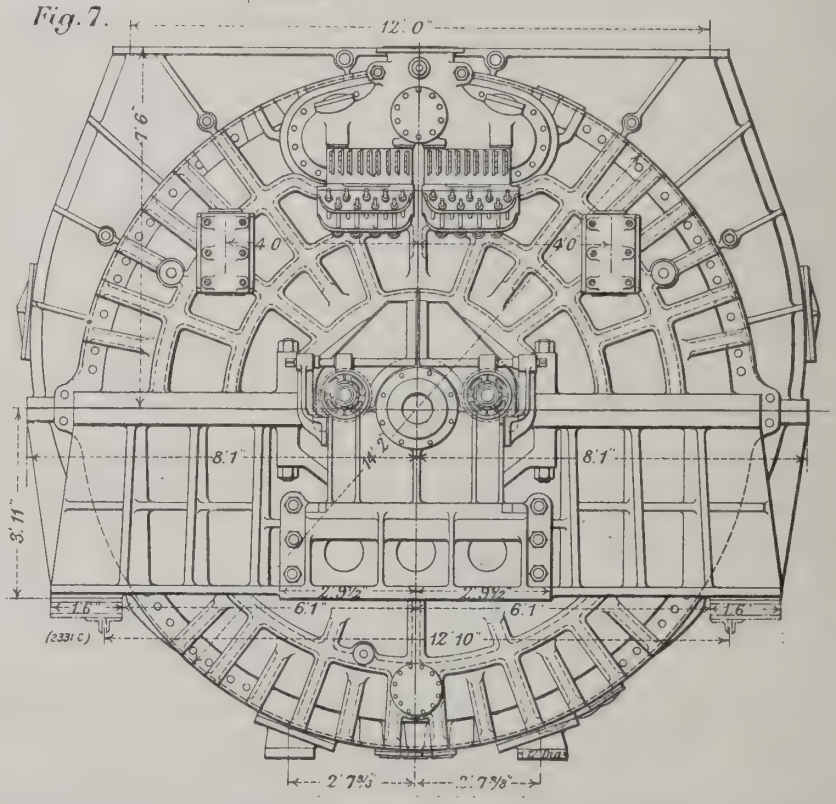


Fig. 7.



We, moreover, propose to adopt 25,000 brake horse-power Curtis turbines for two of the first-class battleships, Kawachi and Settsu, and 22,500 brake horse-power Curtis turbine sets for two out of three scout cruisers. For the remaining scout one set of Parsons turbines of the same power will be used, and two sets of the Parsons type of 20,500 horse-power for two destroyers. Also the latest improved Parsons turbines of 64,000 brake horse-power are to be installed for three first-class armoured cruisers, one to be built in England and the remainder at home; and a Curtis turbine installation of same power is to be equipped in another first-class armoured cruiser which will be built at home.

TABLE VI.—*The Engineering Corps of the Japanese Navy.*

Those in Charge of Construction and Repairs.				All other in Charge of Ships, &c., except the Preceding.		Total.
Engineer-rear-admiral	2	Inspector-general of naval construction	1	Engineer-rear-admiral	7	10
Engineer-captain	6	Inspector of naval construction	2	Engineer-captain	22	30
Engineer-commander	9	Chief naval constructor, 1st class	1	Engineer-commander	40	49
Engineer-lieut.-commander	10	Chief naval constructor, 2nd class	10	Engineer-lieut.-commander	56	77
Engineer-lieutenant	4	Naval constructor	7	Engineer-lieutenant	202	213
Engineer-sub-lieut., 1st class	—	Assistant naval constructor, 1st class	3	Engineer-sub-lieut., 1st class	109	112
Engineer-sub-lieut., 2nd class	—	Assistant naval constructor, 2nd class	—	Engineer. sub-lieut., 2nd class	53	53
	—	—	—	Midshipman	61	61
—	—	Civil officials	15	—	—	15
Total ..	31	—	39	—	550	620

Engineer warrant officers	132
Engineer petty officers and men ..	14,460
Total	14,592

Figs. 6 and 7, above, show the fifteen-stage Curtis turbine for the battleships Kawachi and Settsu. The diameter of the turbine is 12 ft. at its pitch circle for these battleships and cruiser, and it is designed for 27,000 brake horse-power at 270 revolutions for the seven-stage, and 25,000 brake horse-power at 245 revolutions per minute for the fifteen-stage turbine. The latter consists of six ahead wheels and one ahead drum carrying nine stages, and two reverse wheels.

Regarding the machinery of destroyers and torpedo-boats, from which we naturally expected some trouble, they proved perfectly serviceable, not having shown any serious defects.

In conclusion, I may add that in attaining our present efficiency in naval engineering, we owe a great deal to the advice and help given by the British, many of our naval engineers having been educated in Great Britain.

1 yen = 2s. approximately.

BOW WORKS, STRATFORD: BOILER EXPLOSION.—We are informed that the formal investigation ordered by the Board of Trade to be held in this matter is fixed for hearing in the Town Hall, Broadway, Stratford, Essex, on Wednesday, August 2, at 11 a.m.

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ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" can be supplied direct from the Publisher post free, for twelve months, at the following rates, payable in advance:—

For the United Kingdom	£1	9	2
For Canada—			
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Thick ,,	£1	16	0 ($8.75)
For all other places abroad—			
Thin paper copies	£1	16	0
Thick ,,	£2	0	6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

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With Eight One-Page Plates of the WORKS OF MESSRS. SULZER BROTHERS, WINTERTHUR, SWITZERLAND; Six One-Page Plates of the WORKS OF MESSRS. ESCHER WYSS AND CO., ZURICH, SWITZERLAND; and Two One-Page Plates of the SWISS LOCOMOTIVE AND ENGINEERING WORKS, WINTERTHUR, SWITZERLAND.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Saturday afternoon, July 22, at 3 o'clock, visit to the recently-completed Walton Reservoir Pumping-Station, &c., of the Metropolitan Water Board.

THE INSTITUTION OF MECHANICAL ENGINEERS.—On Monday, July 24, the Summer Meeting will commence with alternative excursions from Basel to Zurich, visiting on the way (*a*) Rheinfelden and Laufenburg, (*b*) Baden, including the works of Messrs. Brown, Boveri, and Co, (*c*) Rheinfelden, or (*d*) Wangen-on-the-Aare and Baden, including the works of Messrs. Brown, Boveri, and Co. On Tuesday, July 25, at 10 a.m., the President, Colonel P. E. Huber, or the Vice-President, Mr. E. Sulzer-Ziegler, of the Verein Schweizerischer Maschinen Industrieller, will welcome the President, Council, and Members of the Institution in the Aula of the Swiss Polytechnikum, after which papers will be read and discussed. The following papers have been offered for reading and discussion:—"Electric Traction in Switzerland," by Mr. E. Huber-Stockar; "Results of Experiments with Francis Turbines and Tangential (Pelton) Turbines," by Professor Dr. Franz Prásil; "Some New Types of Dynamometers," by Dr. A. Amsler; "Rack-Railway Locomotives of Switzerland," by Mr. T. Weber and Mr. S. Abt. "High-Pressure Water-Power Works," by Mr. L. Zodel; "Steam-Turbines," by Mr. H. Zoelly; "Modern Diesel Oil-Engines," by Mr. F. Schubeler. On Tuesday afternoon alternative visits have been arranged to the works of Messrs. Escher Wyss and Co., or the Oerlikon Machine Works, while an excursion on Lake Zurich has also been arranged at the invitation of the Verein Schweizerische Machinen Industrieller. In the evening, the Institution dinner will be held in the Tonhalle. On Wednesday, July 26, at 9 30 a.m., the meeting will be continued in the Aula, and papers will be read and discussed. In the afternoon there will be alternative excursions (*a*) to Winterthur, to the works of Messrs. Sulzer Brothers, and the Swiss Locomotive and Engineering Company; (*b*) to Schaffhausen, (*c*) to Beznau. On Thursday, July 27, alternative whole-day excursions have been arranged to Glarus or Braunwald. On Saturday, July 29, Members will travel to Lucerne, *viâ* the Rigi-Kulm, this concluding the official arrangements.

NOTICE.

Our issue of July 28 will be a Double Number, price 1s., post free 1s. 0½d., and will contain the Title and Index to Vol. XCI.

ENGINEERING.

FRIDAY, JULY 21, 1911.

THE AMENDMENT OF THE INSURANCE BILL.

IT will be conceded that the old adage, "Give them an inch and they will take an ell," is not an inaccurate commentary upon the proceedings in the House of Commons in connection with the amendment in Committee of the Insurance Bill. Demands are being made upon all sides for the extension of benefits provided. It must, however, be placed to the credit of the Chancellor of the Exchequer that he has discovered, although not too early, that the cost must be carefully counted, and thus the concessions sought are being met in a critical mood. Indeed, he found it necessary on Wednesday night to warn his friends that success on their part in forcing concessions might seal the fate of the Bill. The detailed consideration of the Bill further establishes anew the complicated nature of the scheme, the many interests involved, and the necessity that every detail should be rigorously scrutinised. The progress made, while it appears slow, is therefore satisfactory, and it is to be hoped that no attempt will be made to limit analysis or to minimise the importance of reviewing adequately all sides of every provision. The consideration of the first section of the Bill, dealing with the contributions, has been completed in Committee. Several amendments have been made, but it must be recognised, even by those most anxious for the early enactment of the project, that this section, as well as those already, and yet to be, modified, must be subjected to further analysis upon the report stage, to ensure that degree of permanence which can only come in the event of the scheme being not only comprehensive and lucidly laid down, but equitable to every interest involved.

Largely to meet the well-organised opposition of the medical profession, the scope, so far as voluntary contributors are concerned, has been limited. Originally anyone engaged in employment could insure himself, although there were limitations to the extent to which employers were called upon to contribute. Now only those engaged in employment and having an income not exceeding 160*l.* per annum can secure benefit from insurance against ill-health. Again, in connection with Clause 4 a change having far-reaching effects has been made, under which agricultural labourers, seamen, nurses, clerks, and others, who already enjoy sick benefit as part of the conditions of their employment, may have their contributions reduced to the extent of 1d. per week from the workman and a corresponding sum from the employer, sureties being demanded that sick benefit is provided by the employer. It will be noted that while only four classes of employees are mentioned, there is little limit to the scope in this matter, and railway servants and many others who may come within the terms of the amended clause can seek similar advantages. It will always be open, however, to the employer to weigh carefully the alternative of discontinuing the sick benefit as part of the conditions of service, instead of securing the deduction of 1d. per week from the amount payable by him under the normal condition of invalidity insurance. In other words, the question is, does the remission of 4s. 4d. per annum from the employer's payments exceed the possible sickness benefit at present incurred under the agreement with the workman? Provided the workman has not reached the time of life when the period of invalidity tends to increase, the employer may secure an advantage; but here, as with so much of our recent legislation, the tendency will be for the employer to supersede, by young and healthy workers, employees as they reach that age when ill-health becomes more frequent, so that there is once again an incentive to eliminate the less fit, and to encourage the operation of the doctrine of the "survival of the fittest." Thus the scheme, instead of being a preventive of unemployment and hardship, may act the other way.

A consideration of the benefits payable under the Bill is now in progress, and already one or two modifications have been made which tend to increase the scope and financial burden of the scheme. In Clause 8 the benefits of "sanatoria and other institutions" has been altered to "sanatoria and otherwise," which meets the objection, reasonably made, that too much reliance is placed on sanatoria, involving enormous capital cost. Consideration was given to the question as to whether the wives and children of the injured were to secure the benefits in this connection, and the promise was made that, provided the local authorities paid half the cost involved in extending the advantages of treatment in sanatoria to dependants, the Treasury would meet the remaining moiety of the cost. Under Clause 45 of the Act, the County Health Committees are called upon to contribute the excess charges for medical benefits administered by local authorities, and it is contended that under this provision power may be given to the local authorities to pay half the cost of treating the dependants in sanatoria The result will be greatly to increase the burden upon such authorities and to augment rates, and there is probability of a very keen contest regarding the subject. Another concession made is that an employed married woman shall receive not only the maternity benefit of 30s. on her own behalf, but a corresponding sum in respect of her husband's insurance, making 3*l.* for maternity instead of 30s. The representatives of labour in the House sought to have this increased sum paid in case of maternity irrespective of any other consideration, even in the case of unmarried mothers; but this was resisted. Originally sickness benefit was to begin in the case of insured persons at 21 years of age; but now members of approved societies are to secure benefit from 16 years of age, provided that they contribute materially to the support of relatives. On the tenth clause an amendment allows medical, sanatoria, and maternity benefits to a man even if his payments are in arrears up to a period of twenty-six weeks. Again, it was proposed to relieve a contributor, who falls into arrears through unemployment, from liability to make good the arrears of the contributions which would have been paid by his employers had he been in work, the State to bear the burden; but this was resisted, the Chancellor of the Exchequer threatening that if the amendment were carried it would defeat the Bill. On the division the Government had a majority of only 47, and then the Committee agreed to Mr. Lloyd George's alternative to allow the approved society to pay the arrears of its defaulting member.

Most of these amendments only affect employers indirectly, although they increase the general burden of taxation; but Clause 11, considered during an all-night sitting on Wednesday by a House containing only one-fifth to one-fourth of the Members, demanded more scrupulous examination, because it involves a very serious amendment of the Workmen's Compensation Act, and will be pernicious in its incidence. When the Workmen's Compensation Act of 1906 was under consideration, it was stated that certain insurance companies induced workmen to accept a lump sum of money in discharge of their claims for compensation for injury, and the result was, in many cases, a loss to the work-

man, in respect that, owing to the advantage of receiving the lump sum when money was much needed, he did not always consider whether it would equal the allowance under the Act of half the weekly wage until complete recovery. The Legislature, therefore, inserted a special provision in the 1906 Act to meet such cases. This arrangement allowed the employer and the workman to come to an agreement for the payment of a sum in lieu of the usual weekly allowance, the interests of the workman being at the same time adequately safeguarded, as it was provided that a memorandum of such agreement had to be lodged with the Registrar of the County Court, and only if he were satistied as to its *bonâ fides* could it be recorded. The County Court Judge had still the power, upon application made, to remove it from the register within six months on proof of fraud, undue influence, or any other improper action. This arrangement has proved satisfactory in the fullest sense. From two-thirds to three-quarters of compensation cases are thus dealt with in an amicable spirit by employers and their workmen. Of recent years there has been a growing custom on the part of workmen to seek for compensation for a week or ten days at the time of the settlement. The sum, however, is not large, and the employers frequently agree to pay it although not under a legal obligation to do so. The result has been an absence of that friction inevitable where legal proceedings are taken, and the promotion of a kindlier feeling between master and man.

Clause 11 of the Insurance Bill provides that if the compensation for accident is less in amount per week than the benefit payable under the insurance scheme, the difference must be paid out of the insurance fund. The Labour Party opposed this clause, and were willing to relinquish other advantages under the clause, desiring that the sickness benefit should be paid in all cases without regard to compensation for injury. Thus in the case of the mechanic the compensation for injury might be anything up to 20s., being half-pay, with the addition of 10s. per week for thirteen weeks under the insurance scheme, while the labourer might easily get 20s. per week in all—equal to his weekly wage. Obviously there would, in such case, be no incentive to recovery. This part of the clause was approved amid threats by Labourists of defeating the whole Bill—namely, that compensation for injury or sick benefit should be paid, the lowest amount being 10s. per week. Thus the labourer getting as compensation for accident 8s. or 9s., being half-pay, would get 2s. or 1s. from the benefit fund. In respect of the sub-sections of the clause a keen fight was waged. The insurance authorities under the Bill should be informed as to what is being paid to the workman by his employer ; and it is provided in the Bill, paragraph *d*, that such notification must be made by the employer within three days. This period is too short. Again, it is right that the Commissioners should be safeguarded in the case of an agreement under the Compensation Act for the payment of a lump sum in lieu of weekly allowance. If the sum were inadequate, the workman might ultimately come upon the sickness fund. Hitherto the payment of a lump sum has been an effective antidote to malingering, as, with the compensation lump sum to his credit, there was a strong inducement for the workman to resume his weekly earnings at the earliest possible moment. If, after receiving the lump sum, he could, by prolonging sickness, receive 10s. per week from the insurance fund, there might be a tendency to protract the period of invalidity. It must be conceded, however, that the provision of the Compensation Act ensures a perfectly equitable arrangement, in view especially of the possible revision by the county court in the event of prolonged illness ; and it would seem, therefore, as if further safeguard were unnecessary. Paragraph *c* of Clause 11, however, introduces an important amendment of the Workmen's Compensation Act, as it is laid down that no agreement to terminate weekly payments of compensation for accident by the handing of a lump sum by the employer to the workman shall be valid unless by the previous consent of the "approved society," meaning in many industries the approval of the trade union. The sum, too, is to be paid into court, and the registrar has power to determine whether the sum is adequate.

It will at once be recognised that we have here a method of strengthening the power of the trade union against the masters. They can scarcely be recognised as disinterested parties, and yet all the powers of arbitrators are conferred upon them. Moreover, paragraph *e* provides that if an injured person does not take proceedings against his employer for compensation when he has the right to do so, the "approved society" may take proceedings in his stead. Originally there was the greater injustice in this, as the society was in no way responsible for the costs involved, while invested with high privileges ; but now the societies are to be responsible for the costs.

The Legislature ought in every way to promote the interests of industry, and these can only be advanced by encouraging friendly intercourse and the recognition of mutual responsibility by co-operation and consultation. To increase the difficulties of amicable agreement, either by making agreement between the parties dependent on sanction by the trade union, or by giving the trade union power to force a workman to take legal proceedings, must be inimical to that co-operation between master and man essential to the peaceful pursuit of industry. Apart from this, there is the undoubted fact that resort to legal procedure involves delay and increased costs. The disadvantages are intensified when it is remembered that while the legal process continues the workman's invalidity is prolonged, often without regard to his capacity to work, and the cost to industry is thereby greatly augmented. It has been estimated, upon the most careful consideration of the effect of this proposal—that "approved societies" must sanction the agreements referred to—that the result will be an increase on the existing premiums for insurance against accident to the extent of 10 per cent. When it is recalled that the average premium for engineers is about 25s. per cent. of the annual wage, and for shipbuilders 50s. per cent., it will be recognised that we have here a considerable increase in the burden cast upon industry, apart from its pernicious effects. On the report stage a vigorous resistance must be made to the objectionable features of this clause.

These considerations lead to the general conclusion that in this, as in every other provision of the insurance scheme, industry will be handicapped. It is true that, as we have repeatedly stated, the scheme is approved from the ethical point of view, but every care should be exercised in order to minimise, as far as is consistent with the ethics of the case, the possible injury to industry. It has been urged that the charge for this national insurance scheme will fall on production, but it has not yet been brought home to every one that the inevitable consequence is that increased cost of production will reduce our strength in competition in the markets of the world. Again, the charge in other directions must fall directly upon the people. For health insurance alone the amount to be collected for next year, 1912-13, is estimated at 18½ millions sterling, and even within four years this will be increased to 23,310,000*l*. Of this something like 10 millions sterling must be paid by employers. In the case of municipalities the charge will be very considerable. The Finance Committee of the London County Council, for instance, have estimated that the total cost to the rates in connection with the tramway, education, and other services will be 12,000*l*. Obviously, this must all involve increased difficulty in maintaining our position against foreign competition. The result may be to aggravate the unemployment problem, and here we must once again enter a strong plea against the injustice, firstly, of including in one measure provisions which necessarily increase the difficulties of finding employment ; and, secondly, of imposing upon one branch of industry alone heavy charges to provide benefit for those who are unemployed. Why, it is asked, should the building and engineering trades be singled out for penalty in this respect? The engineering and building trades, like others, exist for promoting the welfare of the community by providing employment. As a matter of fact, unemployment in those trades has never become acute except in periods of widespread depression. Moreover, the trade unions in these industries are all-powerful, and have in the past recognised their duty to provide against the unemployment of their members. There has thus been cultivated that independence which should be the most cherished characteristic of all, and particularly of working men ; and any scheme which militates against the development of this trait should be opposed. The unemployment part of the Insurance Bill, however cannot be considered by the House for some time, so that we shall have other opportunities for a careful examination of the details of the scheme. Here we content ourselves with entering the plea that the Legislature should make it their special function so to scrutinise every detail of the scheme of insurance as to provide not only in connection with consumption, zymotic and other diseases, but also as regards unemployment, remedies which will be thoroughly preventive rather than palliative.

RAILLESS OVERHEAD ELECTRIC TRACTION.

THE recent openings of railless electric services in Leeds and Bradford, and the application to Parliament this year for the necessary powers to apply the principle to several other towns in the United Kingdom, are drawing attention to a system which has had considerable success on the continent of Europe. We learn that municipalities or companies at the following localities are among the promoters of schemes of railless traction :—Aberdare, Brighton, Chiswick, Halifax, Northampton, Newcastle-on-Tyne, and Rotherham. Schemes at Croydon, Malvern, Macclesfield, Matlock, and Oldham have failed to get their powers or have been withdrawn.

The free-driving car, from whatever source its power may be derived, unfettered laterally in its progress, has obviously many advantages over the rail-bound tramcar, especially when the streets to be traversed are narrow and tortuous. In many of such streets the progress of the tramcar is often impeded by tradesmen's carts standing at the kerb, or is blocked by slow-moving wagons, which have to clear the rails to allow the car to proceed at its normal speed. If the dead-weight of accumulators and the cost of their upkeep could be got rid of, we should have in the electric motor-bus an ideal vehicle for public service where the streets are not wide and straight, and for places where the amount of traffic is insufficient to justify the laying down of an expensive permanent-way.

By the various railless overhead systems, the economical application of power from a central station, enjoyed by the electric tramway, is attained without its lateral inflexibility, while the electric car thus driven is stated to have many advantages over the ordinary internal-combustion engine-driven vehicle, which is its real rival. The electric motor is capable of severe temporary overloads, and, producing its maximum torque at low speeds, it dispenses with the friction-clutch and gears of variable ratio of the petrol-car, which necessarily impair efficiency and entail extra expenditure for maintenance, especially in tyre renewals. Omnibuses and cars driven by steam share, to a great extent, these advantages ; but for various reasons they have not, so far, been able to compete successfully with the petrol-driven vehicle. It is the various disabilities of the petrol vehicle, no doubt, as well as success in Germany, which have brought about the movement in England in favour of the road omnibus electrically operated direct from a central source.

The several plans for effecting the connection between the laterally free-moving car and the trolley-wire may be divided into two main ones : that in which this is done by a flexible cable of positive and negative wires, and that in which connection is made by a pair of rigid hinged poles, in each case making contact each to each, with the positive and negative trolley-wires, there being no rail, as in the tramway, for the return current. The Cedes-Stoll patents, which have been at work from two to four or five years in Austria, Hungary, Bohemia, and Styria, are representative of the flexible connection arrangement, while the Railless Electric Traction Company, Limited, London, have adopted the rigid-pole system, and have equipped with it both the Leeds and Bradford services.

In the flexible system the trolley-wires are hung at the same level, and upon these runs the current-collector in the form of a small truck, with two small grooved wheels on each side of it. One of these pairs of wheels runs on the positive wire, and the opposite pair on the negative wire, and the corresponding wires in the cable are suspended from the centre of the truck between the two trolley-wires. Here also, at the centre of the truck, is suspended a weighted pendulum which keeps the wheels well pressed down on the wires. Derailment, or "dewirement," as it may be called, is also provided against by a double-hook arrangement fixed to the axle of each truck-wheel, inside and outside of the latter, embracing the wire

beneath, on which it runs. It is stated that the device provided in each car to replace the truck, if any of its wheels should leave the wires, is rarely brought into requisition. The motion of the omnibus draws the truck with it on the wires. Where there is only a single pair of wires, a condition which prevails in most of the lines in operation, and when two cars running in opposite directions meet, the drivers interchange the trolley conduits in a moment or two by means of detachable contact-boxes within reach of their seats. The conducting cable can be lengthened to follow the car by means of two appliances—an upper sliding knot tied to the pendulum weight and stretched by means of a spring in the latter, and a cable-roller on the car, which can roll or let out through the action of a spiral spring. In Southern Germany, and in the outskirts of Vienna where there is a successful trackless service, the trolley-wires are fixed at a high elevation, so that the lateral pull on the collector-truck is never excessive.

The average capital expenditure on the eight lines installed on this system in Austria, Hungary, Bohemia, &c., has been about 2250*l.* per mile, and the total cost of working is stated to range from about 4.16d. to 5.28d. per car-mile, the car capacity being from eighteen to twenty-four passengers. The cost of current per kilowatt-hour ranges from 1½d. to 3d. The important sub-division of the above represented by tyre-renewal cost, is not given separately in the working statistics, but the life is estimated on one of the lines, the Kalksburg, at from 31,000 to 34,000 car-miles. It is, however, difficult to believe that the former figure of working cost could be reproduced in this country. If we subtract 2d. for tyres and 1½d. for current, there is very little left for wages and depreciation.

The Cedes-Stoll firm employ a combined 20-horse-power motor and wheel The cable transmitting the current passes through the interior of the axle. The field magnets of the motor are fixed by means of keys on the axle itself. The wheel is mounted as an ordinary motor, on ball-bearings, the cover serving to close the motor hermetically, as well as to fix it on the axle. The chassis is made of pressed steel, and is supported on the axles by springs, and the brakes act in the usual manner on the back wheels, which are the drivers.

The rigid-pole system is advocated, on the ground of its greater adaptability to the extension of, and use over, present tramway systems, the overhead equipment of the railless extensions being capable of easy conversion to that for ordinary tramways, if, and when, the increase of traffic should warrant this action. Further, the arrangements of the poles are such that, with the addition of the negative trolley-wire, the railless vehicles can make use of the ordinary overhead wires on the tramway, either for additional service over that portion, or as a means of reaching a central garage, if required.

These conditions require that the trolley-heads should be of the usual under-running type, and to accommodate this arrangement to the lateral movements of a railless car the London company, to which we have referred, has designed a special trolley base. In this, besides the usual raising springs, there are additional springs working in a horizontal plane and controlling the pivot of the trolley base in such a manner as to relieve the trolley-wheel of excessive side-pressure against the trolley-wire, even when the car is running at some distance from the wires. With this attachment, the head travels freely under the wires with little side-pressure, at whatever angle the poles may be trailing. The trolley-heads are of standard type, and the two poles are so connected at the base that they always remain parallel to each other, and at the same time are able to accommodate themselves to irregularities in the height and spacing of the overhead wires. The use of standard tramway trolley-heads permits of the use also of standard tramway overhead fittings, and thereby insures complete freedom for crossings, junctions and inter-running between tramcars and railless cars operating in the same town. In running over any portion of a route in which a tramway exists, the negative wire is not indispensable, as by the system now being described there is an alternative by which the negative trolley may be put out of action and the return provided for by a skate hinged to the chassis and running upon the rail.

The Leeds and Bradford services, which were both started on June 20, are on the Railless Electric Traction Company's R.E.T. system, and are practically identical, the former line being over 4 miles, and the latter 1¼ miles long. The general type of overhead construction is that of 18-ft. brackets sustaining the wires. The rigid poles are 17 ft. long, and allow a lateral divergence of 16 ft. each way, arranged to suit the maximum width of the roads used. The cars, the wheels of which are of the usual motor-omnibus type, carry twenty-eight passengers, and weigh 3 tons 12 cwt. empty and about 5 tons when full. A maximum speed of 20 miles per hour is attainable, but the municipal regulations limit this to 12 miles per hour. The Leeds cars have an entrance in front, to the left of the driver, and there is no conductor. At Bradford a conductor is employed, and the entrance is at the rear. There is a 20-brake-horse-power motor for each driving rear wheel, and the current is delivered at 525 volts. These rear wheels are braked mechanically. The car can turn on a radius of 12 ft. on the inner wheels.

Besides the services already mentioned, trackless lines have been at work at Gravenbruck, in Westphalia, since 1903; in Monheim-Langenfeld, near Cologne, and in Vierchedal, Westphalia, from 1904; in Wurzen und Grossbauchlitz, in Saxony, and Lyons Charbonnières, in France, from 1905; in Ahrweiler, in Rhenish Prussia, from 1906; and in Mulhausen, since 1907. A few of these are for goods traffic only, and in many of the smaller German services there is no conductor, the driver collecting the fares. There is also the Intelvi valley line in Italy, worked by the Italian Trackless Trolley Company of Milan. This is nearly 6 miles long with heavy grades. The three-phase current is supplied by the Volta Supply Company, converted to 600-volt direct current. There is only one pair of wires, and the cars, which carry eighteen to twenty passengers, weigh 3½ tons empty. The working expenses are said to be 5.64d. per car mile, including 1.8d. for tyre renewals.

As yet, there is only one trackless trolley service in America. This connects Bungalow Town with the Los Angeles-Pacific Railway in California. It is 1½ miles long, working on a 25-ft. road, with grades running up to 1 in 8⅓. The collectors are fixed to rigid poles, and are formed of under-running shoes sliding against the wires. The weight of the car is about 1½ ton carrying sixteen passengers, and it cost about 520*l.* It is worked by one man.

It will be seen that there is a very limited experience in this country of trackless trolley service. This, as far as it goes, is favourable, and is embodied in the evidence given before the Parliamentary Committee, which inquired into the proposed scheme for Chiswick. Mr. J. B. Hamilton and Mr. C. J. Spencer, general managers of the Leeds City and Bradford City Tramways respectively, stated, about a fortnight later than the opening of these services, that the working was satisfactory, and Mr. Spencer had been asked, in consequence, to report on three or four new routes to which the system was applicable. The engineer of one of the municipalities promoting lines now before Parliament, informs us that, after going carefully into results elsewhere, he has come to the conclusion that, owing to the smaller capacity of the vehicles and the cost of tyre renewal, the working expenses of trackless services per passenger mile are not expected to be very different from those of the same unit in connection with an ordinary electric tramway under similar conditions. The advantages, he said, lay in the enormous reduction in first cost and, consequently, in the interest thereon, the rapidity of installation, and, therefore, the early earning power, and finally, the lesser obstruction to traffic, due to the flexibility in working the cars.

THE COMPRESSION OF LIQUIDS AT HIGH PRESSURES.

WHEN investigating, in 1907, the behaviour of carbon under high pressure, the Hon. C. A. Parsons, F.R.S. (now the Hon. Sir C. A. Parsons, K.C.B.), observed very considerable volumetric compression, and at the same time he found that the apparatus was suitable for the direct measurement of the compressibility of water and other liquids at very high pressures. Last May Sir Charles presented to the Royal Society an account of his recent experiments, which he had resumed in conjunction with Mr. S. S. Cook, B.A., and with the further assistance of Mr. Robert Howe. Pressures were carried up to 40 tons per square inch, or more than 6000 atmospheres, while Amagat, in his experiments on the compressibility of water and ether at different temperatures, made about twenty years ago, only went up to 3000 atmospheres. Amagat's compressibility figures, which were higher than had been expected, are confirmed by these new determinations, which are of considerable interest.

The apparatus consisted of a steel mould about 4-in. bore and 12-in. external diameter, with a plunger working in it. The whole was placed under a heavy hydraulic press capable of exerting a pressure of 2000 tons, with a main ram 29 in. in diameter, and a lifting ram 6 in. in diameter. The mould was constructed of gun-steel, having an elastic limit of 40 tons per square inch; the apparatus was afterwards modified. Water in the experiments was supplied to the upper side of the ram at pressures up to 2000 lb. per square inch by a three-throw hydraulic pump driven by an electric motor. The pressure on the ram was recorded by a Bourdon gauge, and the depression of the liquid in the mould measured with the aid of a pair of multiplying calipers, inserted between the top of the mould and a projecting collar on the plunger. One of the outer arms of the calipers moved over a graduated scale attached to the other arm, and readings of this scale were, for safety sake, taken through a telescope outside the armoured building in which the press was set up. A cup-leather backed by a thin-edged cup of brass, made an effective packing for the plunger in the mould.

This cup introduced a compressible element into the apparatus, but, of course, its bulk was very small compared with that of the water. This and some of the several other sources of error inherent to the experiments could have been eliminated if the apparatus could have been worked first with the mould filled with an incompressible fluid. As such a fluid is not known, a steel cylinder was prepared of half the volume of the liquid, and of a smaller diameter than the bore of the mould. In the first experiment the steel was inserted in the mould, which was then filled with distilled water up to the 2000 cub. cm. mark. In a second experiment the 2000 cub. cm. space was entirely filled with water, the steel cylinder having been removed. Since the volumetric compression of the water in the first experiment was only half that of the second experiment, the constant error of the apparatus could be determined by subtracting the compression reading of the second experiment from twice that of the first—assuming the inserted steel cylinder itself to be incompressible. Now steel is not incompressible, of course; but the compressibility of steel at ordinary pressures, as deduced from the modulus of rigidity and Young's modulus, is only 0.78×10^{-6} per atmosphere, a small percentage of the compressibility of water, and this allowance was made in determining the compression of the liquid.

When 2000 cub. cm. of distilled water were compressed at 18 deg. Cent., the volume decreased steadily down to about 1650 cub. cm. at 6600 atmospheres, and increased again as the pressure was reduced. When the pressures were plotted on the abscissa, and the volumes on the ordinates, the 2000 cub. cm. being marked at the top corner, and smaller volumes lower down, the volume-curve was slightly concave, descending for increasing pressures, and ascending again in a parallel branch slightly below the first curve when the pressures were reduced. Thus a very regular loop was obtained, the (small) breadth of which would correspond to twice the pressure that would be required to overcome the friction of the working parts of the press and of the packing. Heavy cylinder oil gave a very similar loop. Acheson graphite, of density 2.23, with 2.75 per cent. of ash, gave a wider and less regular loop. It had been thought that graphite would behave like a fluid at very high pressure, but the curve indicated an increasing degree of consolidation with increasing pressure, and the stress was apparently not the same in all directions. On opening up the mould, the graphite was removed in biscuit-like fragments, which often separated along a conical surface at about 45 deg. to the axis. The bulk compression of the graphite could not accurately be determined from these experiments; but it was afterwards found, by immersing 1400 grammes of graphite in 1300 grammes of water, to be 6.5×10^{-6} in atmospheric units.

When the experiments with liquids were repeated under the same conditions, the second curve for increasing pressures was always found to be a little

below the first curve for increasing pressure. As no trace of leakage could be detected, the persistent phenomenon was ascribed to temperature variation. The work done during compression was transformed into heat and rendered the compressed substance a little hotter than its surroundings; at the end of the cycle the substance would have lost some of its heat, and would thus start a second cycle colder than during the first. In order to measure the heat effect, a heavy cylinder oil was compressed to 6300 atmospheres and kept for two hours under this pressure, during which time the heat of compression would leak away. The pressure was then suddenly released, and the level of the liquid in the mould was found to be 0.2 in. lower than at the beginning of the experiment, indicating a total reduction in volume of 2 per cent. Further, 2000 cub. cm. of thin machine oil were kept under high pressure, in an external temperature of 11.5 deg. Cent.; the apparatus was then opened (which occupied a quarter of an hour, however), and the temperature at the moment of release was estimated to have been 24.5 deg. Cent. The resulting loss of heat was evidently in excess of that due to the work done upon the piston during expansion, and it was calculated that the work done by expansion was equivalent to not more than 7.5 heat-units per pound, leaving 10.5 units per pound to be accounted for by internal forces.

These experiments demonstrated the need of discriminating between adiabatic and isothermal compressions, and the research was continued, with the further object of determining the amount of heat developed from the internal forces during compression, and absorbed by the same agency during expansion. As various attempts made to measure the instantaneous temperatures of the liquids in the mould by electrical methods failed, the apparatus was modified. An accumulator was installed to put on or to release pressure almost instantaneously; the packing was made rapidly removable, so that a quick-reading mercury thermometer could be inserted after release, and the mould was provided with a water-jacket. For isothermal compression the pressure remained applied sufficiently long to let the liquid acquire the temperature of the jacket; for adiabatic compression the pressure was raised in a few seconds; it was not raised above 4500 or 5000 atmospheres at the outside, however, so that the observers were now able to remain inside the armoured building.

The experiments on water were then taken up again, and it resulted that the adiabatic compression was only 3 per cent. less than the isothermal. With other substances the difference proved greater, owing to their lower specific heats, and apparently also to their higher internal forces. By increasing the pressure from one atmosphere up to 4500 atmospheres, water at 4 deg. Cent., Messrs. Parsons and Cook ascertained, was compressed to 87 per cent. of its original volume, or to 90.2 per cent. at 3000 atmospheres, while Amagat had found 89.8 per cent. for 3000 atmospheres at 0 deg. Cent.

In order to measure the influence of temperature upon the compressibility, water was compressed adiabatically at various temperatures, and readings were taken at 600 atmospheres, and immediately afterwards (a few seconds later) at 4500 atmospheres. In agreement with Amagat the compressibility was found reduced with increase of temperature, which would signify that the coefficient of heat expansion of water is slightly greater at high pressures than at atmospheric pressure.

Similar experiments with pure ether at 35 deg. Cent. yielded an isothermal compression to 80 per cent. of its original volume by a pressure of 4000 atmospheres, again in fair agreement with Amagat (within 4 per cent.). Neither for water nor for ether did the curves definitely indicate the existence of a limiting value to the compression.

A paraffin oil of a flash-point of 131 deg. Fahr., and of density 0.812 at 0 deg. Cent., indicated an isothermal compression to 84.5 per cent. of its original volume at 34 deg. Cent. by a pressure of 4500 atmospheres. Thus paraffin oil is more compressible than water, and ether still more so. The memoir by Sir C. A. Parsons contains also, as we stated already, the data for deducing the average values of the molecular forces from the heat lost during the adiabatic expansion. These internal forces are very great. The results of the research are summarised in the following two tables. In the first, compressibility is expressed in atmospheric units; that is to say, as the ratio of the decrease of volume per atmosphere of pressure to the volume of liquid. The second table gives the equivalents of the molecular forces in atmospheres.

I.—*Isothermal Coefficients of Compressibility.*

Substance.	Temperature.	Pressures in Atmospheres.	Compressibility.
	deg. Cent.		
Water	4	1	50 × 10−6
		2000	25 × 10−6
		4000	22.5 × 10−6
Ether	35	1	165 × 10−6
		1000	64 × 10−6
		2000	42.5 × 10−6
		4500	18 × 10−6
Paraffin oil ..	34	1	87 × 10−6
		2000	34 × 10−6
		4500	17 × 10−6

II.—*Molecular Forces in Atmospheres.*

	Atmospheres.
Water (for gauge pressures between 0 and 4550 atmospheres)	2150
Ether (for gauge pressures between 0 and 4000 atmospheres)	2440
Paraffin oil (for gauge pressures between 0 and 4600 atmospheres)	2920

THE ALKALI WORKS REPORT FOR 1910.

THE forty-seventh report of the Chief Inspector of Alkali Works for the year 1910 is signed by Mr. W. S. Curphey, formerly Inspector in Scotland, Mr. Forbes Carpenter, who had been Chief Inspector for fifteen years, having retired in 1910 after twenty-eight years of distinguished service in the department. The number of works registered in 1910 under the Alkali Works Regulation Act of 1906 was 1266 in England, Wales, and Ireland, against 1263 in 1909; the works in Scotland bring the total up to 1434 works. Excluding Scotland, 5868 visits were paid to works, and 6184 tests were made. Proceedings against owners of works for undue escape of noxious gases were not taken in any case; serious warning was issued in one instance, and one case of alleged damage to crops and vegetation, investigated by Mr. H. Porter, F.I.C., was not traced to any contravention of the Act. The question of the acid gases evolved from the calcination of sulphide ores and regulus smelting is, however, demanding serious attention.

The alkali and wet copper works did not cause noteworthy trouble in spite of their great activity; in the salt-cake furnaces further perfection was attained in the regulation of the draught, which had already been much improved. Of the cement works more than half are situated in the estuary of the Thames. There were altogether 53 such works in 1910, against 61 in 1908, but the introduction of modern methods, and especially of the rotary kiln, has once more placed this industry on a sound basis in its original home on the Thames. The south-eastern district, under Mr. Napier Sutton, F.I.C., contained, in 1900, 58 works, with 1639 kilns, mostly of the chamber type, including 270 open kilns and 10 Schneider kilns, at that time a novelty in this country. Foreign competition then forced on the abandonment of obsolete methods, and the rotary kiln and slurry washing were introduced; the number of works was, by 1910, reduced to 32, with 993 kilns. Rotary kilns, 57 in number, were installed at 11 works in 1910, and the present tendency is in favour of long kilns (200 ft. and more in length), in which production and combustion are improved; the "dry" or "semi-dry" method of mixing (briquettes of chalk and gault with only 16 per cent. of moisture being burnt in continuous Schneider kilns) has also been adopted. As regards smelting works, Mr. S. E. Linder, B.Sc., has worked out a new method of estimating the total and volatile sulphur in tin ores.

Great activity prevailed in the manufacture of sulphuric acid owing to the increase in coke-oven works provided with tar and ammonia recovery plant, and also in tin-plate works. To meet the increased demand, many plants were enlarged, new works built, and the "intensive" system was more widely adopted. In discussing these features, Mr. Curphey draws attention to the remarkable researches on the chemistry of the lead chamber, published in February, 1911, in the Journal of the Society of Chemical Industry, by Dr. Raschig. Kessler concentration plants remained widely in use. The number of sulphate and muriate of ammonia processes and gas liquor processes under inspection in 1910 was 600, an increase of nine over the preceding year. The total amount of ammonia recovered in the United Kingdom was 367,587 tons of sulphate, against 349,143 tons in 1909; it is customary to express the ammonia in terms of sulphate, although some of it is gained as chloride and nitrate. This total of 1910 was made up by 167,200 tons from gas works, 20,139 tons from iron works, 59,113 tons from shale works, 92,665 tons (against 82,886 tons in 1909) from coke-ovens, and 27,850 tons from producer-gas and carbonising works. Had it not been for strikes the increase over 1909 would probably have been greater still. As regards novel processes, the "direct" process sends the hot gases, with or without cooling, from the coke-oven direct to the sulphate-house, where they are freed from tar-fog, an exhauster drawing them through the tar-arresters and forcing them through the sulphuric acid of a saturator; the gases are then burned. Liquor thus only condenses in the connections between the ovens and the tar-arresters, and in so small a quantity that no effluent need leave the works. A similar process has also been adopted in some gas works; thus the storage of liquor and the loss of ammonia incurred during storage (up to 5 per cent. in 24 hours, according to Mr. J. T. Sheard) are avoided. Some particulars of a small new plant, erected by Mr. G. Wilton, are given by Mr. E. Jackson, F.I.C., the inspector of the South Midland and Norfolk district, and other notes by Dr. A. C. Fryer, F.I.C., inspector of the South and South-West district of England. The trial working of the Walther Feld process for the elimination of sulphuretted hydrogen from crude coal gas, mentioned in last year's report, had been discontinued.

Passing to chlorine works, mention (without details) is made of a mechanical process for producing bleach; the burned lime is prepared without causing any dust trouble. The tin-plate flux works were very busy, owing to the extended use of tin plate for packing purposes; yet progress was effected in reducing the escape of muriatic acid and of metallic fumes. Some furnaces were, however, worked at too high a temperature or with too strong a draught, leading to losses of tin through oxidation. The "thick metal" or "slime," a brittle, crystalline tin, which has a pasty consistency when fused, contains, according to Dr. Fryer, up to 12 per cent. of iron, and appears to be an alloy of about the same density as tin, which separates by a process of incipient crystallisation; it is found in the bottoms of the tinning sets, and does not contain any zinc. With respect to the absorption of the sulphuretted hydrogen of sulphide works in lime-purifiers, which is not always satisfactory, Mr. Linder contributes a memorandum on the oxidation of the sulphuretted hydrogen (in presence of air, but absence of carbon dioxide) by means of manganese dioxide. The arsenic works gave no special trouble, but the zinc fumes from zinc works required much attention.

Mr. J. W. Young, B.Sc., inspector in Scotland, paid 606 visits and made 412 tests. He reports two preventable fatal accidents in sulphuric acid works. An electrician making repairs in explosive works succumbed to corrosive fumes in spite of the heroic efforts of one of the men, Kenneth McNab, to rescue him.

On the whole a good understanding continued to prevail between manufacturers and inspectors.

NOTES.

OIL-ENGINES FOR WARSHIP PROPULSION.

WE have, on former occasions, indicated the probability of the Admiralty ordering oil-engines for a thorough practical test of their suitability for warship propulsion, and we noted some time ago that two or three of the torpedo-boat-building firms had been invited to submit designs, either for a destroyer to be propelled solely by internal-combustion engines, or by oil-engines in association with turbines supplied with steam from oil-fired boilers. The designs have been under consideration, and it is probable that of the twenty vessels of this class provided for under the Navy Estimates two will have internal-combustion engines. One has already been ordered from Messrs. J. I. Thornycroft and Co., Limited, of Southampton, and in this case it is intended to have a combination system of engines, an arrangement which is the more convenient as the same oil is used as fuel in the boilers and in the internal-combustion engines. This arrangement enables the normal cruising speed to be attained with the internal-combustion engines alone working. The advantage is that a hig

economy will be attained at low speed, so that the radius of action of the destroyer at cruising speed will be practically doubled, and will exceed 4000 miles. The adoption of oil fuel for the boilers and for the turbines for driving the wing-shafts will still enable full speed, when required, to be attained within a very short time of the lighting up of the boilers. The hull, as well as the machinery, is entirely the design of Messrs. Thornycroft, who, as is well known, have very considerable experience of torpedo-boat work, and have already built many Diesel engines, not only for land, but for marine work. The many problems in detail which must be solved before success is achieved could not have been placed in better hands. Although this is a limited application of the internal-combustion engine for warship propulsion, there is every probability of complete data being obtained to establish the suitability of this prime mover for larger vessels and for greater powers.

The Importance of Export for the German Iron Industry.

For some months the question of the relative importance of foreign markets and the home market, as far as the iron industry is concerned, has been attracting a considerable amount of attention in different quarters in Germany; but it is a difficult problem to solve, the more so because the value of work done on material imported and exported in various stages of manufacture is difficult to appraise. Nor is it, on the other hand, correct, as far as some branches of the iron industry are concerned, to compare the German export with the entire production, and to state the result to be, perhaps, 5 or 10 per cent. of the aggregate production of, say, pig iron and manufactured iron. It is overlooked that of the 90 or 88 per cent. which, in the meantime, remains in the country, a further 5 or 10 per cent. is subsequently exported in a more finished state. Of the German pig-iron production in 1910, which amounted to

—	German Pig-Iron Production.	Imports of Iron, Iron Goods, and Machinery.	Value of Imports.	Exports of Iron, Iron Goods, and Machinery.
	tons	tons	marks	tons
1907	13,045,800	902,200	203,000,000	3,784,300
1908	11,813,500	634,700	150,000,000	4,094,200
1909	12,917,700	527,000	137,000,000	4,375,600
1910	14,793,300	629,700	154,700,000	5,269,100

—	Value of the above German Exports.	Percentage of German Exports in Weight to Germany's Pig Iron Productions.	The Percentage of Imports of Iron Goods and Machinery to the Exports of the Same.
	marks.	per cent.	per cent.
1907	1,178,000,000	27.6	17.3
1908	1,136,000,000	34.7	13.2
1909	1,108,000,000	34.0	12.4
1910	1,314,000,000	35.6	11.8

an aggregate of 14,800,000 tons, there were only exported about 800,000 tons, or some 5.5 per cent. The rest—that is, 94.5 per cent.—of the German pig-iron production was, however, principally worked into steel, and in this shape there were exported, during 1910, 500,000 tons of half-finished goods, 500,000 tons of shape iron, 500,000 tons of bar and hoop iron, 400,000 tons of plate, 400,000 tons of wire, and 700,000 tons of railway material. Leaving out of consideration that it requires more than 1 ton of pig iron to make 1 ton of manufactured steel, the above-mentioned specialities alone represent an export of 3,000,000 tons of the 14,000,000 tons of pig iron, which leaves only 75 per cent. of the German pig iron as remaining within the country. This figure, however, is still much too high, as engine construction, the electrical industry, and the manufacture of smaller articles, which all show a material export surplus, naturally absorb further quantities of iron for this export. The truth is that about half of the German iron and iron goods production is exported. The German home market will for the future only prove capable of comparatively unimportant development as far as iron consumption is concerned. When the home market showed considerable development, and this was the case over a long period, foreign competition was forced more and more into the background. This has reduced the entire import of foreign iron, iron goods, and machinery down to about 6 per cent. of the home production. The inland demand for raw material increases to a great extent only because the manufactured articles meet with a larger sale for export. The German consumption of pig iron could not have increased so largely in 1910 had not the export of girders, bar iron, half-finished goods, wire, pipes, railway material (40 per cent.), machinery (20 per cent.), &c., increased so largely. The accompanying table for the last four years shows the movement in export and import.

The Financial and Economic Annual of Japan.

The eleventh Financial and Economic Annual issued by the Finance Department of the Government of Japan, just come to hand, maintains the reputation of the issues which have preceded it for the completeness and systematic order of the information given in its pages with regard to the financial and economic conditions of Japan, and it forms an invaluable compendium for those who are interested in the affairs of that country. These are not by any means confined to students of politics, as there are now large numbers of investors in this country who have a financial interest in the condition of Japan. Such persons will find very complete information regarding present conditions and recent developments, but we rather value the publication as a contribution to industrial and commercial history, which is of the greatest interest to those who study the evolution now in progress in the Far East, and promising in time profoundly to affect economic conditions in other parts of the world. There can be no doubt that the centre of importance of the world's trade and industry is gradually moving in the direction of the Pacific area, and the peoples of the West should keep themselves informed not only of the developments which have taken place, but also of the tendencies of the economic forces now at work. As with former issues, engineers will find the "Annual" of special value not only for the information which it contains, but also for the graphical methods employed to illustrate its mass of statistics. In the Japanese colleges the teachers of science do not confine themselves to abstract analytical methods, but freely use graphical methods, combined, when possible, with experiment, with the result that the students have a firm grasp of the problems which they are studying. The same system has been adopted as far as possible to statistical and industrial subjects, and the book before us might well be taken as a model for some of our Government publications. We cannot, of course, enter into a detailed description of its contents, our object being chiefly to direct attention to it, and as the Japanese Government sends it freely to public institutions in this country, there is no difficulty in obtaining the use of a copy. Naturally a large part of the "Annual" is taken up with financial subjects, and full details are given of the national finances, the foreign loans, the banking system, and the methods of taxation. Many of our readers, however, will find the information with regard to industrial developments and engineering works the most interesting part of the book. It gives a very good idea of the rapid progress which has been made in Japan in every department of agriculture, industry, and commerce. It is satisfactory to find that, while they are developing industries of Western origin, the Japanese are doing a great deal to improve their oldest industry—namely, agriculture; and we have little hesitation in saying that in many respects the Japanese farmers could give many lessons to the farmers of this country, who are very slow to move out of the rut of antiquated practice. In almost every department of industry the Japanese have made great progress, and we commend the statistics in the "Annual" to the attention of manufacturers in this country. The section dealing with the means of communication—namely, railways, shipping, telegraphs, telephones, post office, &c.—we commend to the attention of our engineering readers, as it will give some idea of the great developments which have taken place almost within a generation. The section relating to railways and tramways opens with the statement:—"In order to unify the arrangements of transportation in our country, and promote its economic advantages, the Government recognised the necessity of nationalising all private railways intended for public transportation with the exception of small local lines." This sentence shows that the Japanese are evolving a national system, not only of railways, but also of all the necessities of national life, and a study of their work in this direction would serve as an example, and probably in some cases as a warning.

THE LATE MR. JAMES S. DIXON, LL.D.

We regret to have to record the death, at his residence, Fairleigh, Bothwell, of Mr. James S. Dixon, LL.D., the eminent mining engineer, and founder of the Chair of Mining in Glasgow University.

Dr. Dixon was born in Glasgow. In 1850, while he was still a child, his father removed his residence to Hamilton, and he was one of the first daily travellers by rail from that town to Glasgow. Dr. Dixon received his education at Hamilton Academy and Glasgow University, where he studied mining engineering. After gaining practical experience in mining, he became lessee, in 1872, of the Bent Colliery. Great trouble was being experienced in the Hamilton district with the inrush of water into the mines; but Dr. Dixon had made an exhaustive study of the subject, and was able to adopt measures by which the difficulty was overcome, when the working of the coal-field could be safely prosecuted. He subsequently acquired the coal-fields under the Hamilton Palace grounds, and both collieries were worked by a company with remarkable success, Dr. Dixon being managing owner.

Dr. Dixon very early in his career won a high reputation as a mining engineer. He was a member of the Royal Commission on the coal supplies of Great Britain, and his report on the available resources of Scotland is the standard authority on the subject. He took a warm interest in the formation of the Mining Institute of Scotland, of which he was twice president. He has also been President of the Institution of Mining Engineers of Great Britain. In recognition of the enlightened interest he had always taken in the education and technical training of mining engineers, and of his gifts to the university, Dr. Dixon received from the University of Glasgow in April, 1906, the honorary degree of Doctor of Laws.

It was not to the University of Glasgow alone and to those connected with the important industry in which he was engaged that Dr. Dixon proved a generous benefactor. In the beginning of 1907 he purchased from the representatives of the Duke of Hamilton an area of land, extending to about 9 acres, lying between the public park and Bothwell-road, valued at about 3000*l.*, and made it over as a park to the burgh of Hamilton.

In the autumn of the same year Dr. Andrew Carnegie went to Hamilton to open the free library provided through Dr. Dixon's liberality for the burgh, and was presented with the freedom of the burgh. A similar honour was at the same time bestowed upon Dr. Dixon, who signalised the event by presenting to the Town Council a further sum of 1000*l.*, which he subsequently increased by 500*l.* for the enclosing and laying out of the park. Dr. Dixon also provided for the restoration of the old parish church of Bothwell. Dr. Dixon took no prominent part in public affairs. In politics he was a Unionist, and on the death of Sir William Rattigan, in 1900, he was pressed to contest North-East Lanarkshire at the by-election which followed; but he declined the honour. Dr. Dixon was a Justice of the Peace and an Income-Tax Commissioner for the Middle Ward of Lanarkshire. He was also associated as a director with the Broxburn Oil Company and with the Edinburgh Collieries Company. He was chairman of the Broxburn Company for a period, but relinquished the office last year on account of the state of his health.

Dr. Dixon was also a liberal supporter of all wise and well-considered charitable effort. In this department of work he was cordially seconded by Mrs. Dixon (by whom he is survived), who was untiring in her efforts to alleviate sickness and suffering among the poor and afflicted, and many a desolate home was gladdened by the timely practical help which came from Fairleigh House.

The First Austrian "Dreadnought."—The first Austrian Dreadnought was launched recently from a private yard at Trieste. The vessel was named Viribus Unitis, in accordance with the Emperor's wish. She is built entirely of material produced in the home country, and by native workmen, the cost amounting to about 60,000,000 kr. Austr. (3,333,000*l.*). Her displacement is 20,000 tons, and the principal armament will be twelve 30.5-centimetre guns, in four revolving-turrets, twelve 15-centimetre quick-firing guns, twenty-two smaller guns, and four submarine torpedo-firing tubes. She will be engined with Parsons turbines, and the designed speed is 21 knots. The ship has been in course of construction for eleven months, and will be completely finished by the end of 1912. The crew will be about a thousand men. A sister-ship, at the same yard, will be ready for launching in October, and a third will be commenced on the slip vacated by the Viribus Unitis. The fourth Austro-Hungarian Dreadnought will be commenced at Fiume in the course of the present year. Three fast cruisers, of 3500 tons, and some torpedo-boats have been contracted for abroad.

1350-BRAKE-HORSE-POWER GAS-ENGINE.

THE illustrations on page 106 show a 1350-brake-horse-power gas-engine constructed by Messrs. Galloways, Limited, of Knott Mill Iron Works, Manchester, to the designs of Messrs. Ehrhardt and Sehmer, for whose engines Messrs. Galloways have the sole British manufacturing license. The engine is intended to drive an 800-kw. alternator on a seven-days-a-week day-and-night service. It will run in parallel with two similar engines, built by Messrs. Ehrhardt and Sehmer, which have been running successfully, on Mond gas, for five years and one year respectively. It represents the designers' latest practice, and includes a number of new features which were not embodied in the Ehrhardt and Sehmer engines which we have previously illustrated.

The engine is of the double-acting four-cycle type, and has two cylinders in tandem. Its general construction is well shown in Fig. 1, and it is unnecessary to deal at any length with many of its details, as these are but characteristic of modern practice. Its principal particulars are as follow :—

Diameter of each cylinder	37.4 in.
Stroke ,, ...	43.3 ,,
Revolutions per minute	105
Maximum brake horse-power ...	1350
Weight of engine	160 tons
,, flywheel	50 ,,
Total weight	210 ,,

The heaviest single part is the bed-plate, which weighs 28½ tons. The engine is, of course, water-cooled throughout, the connection to the piston-rod and pistons being made through two rocking-pipes which attach to the centre crosshead, as will be seen in Fig. 1. A slight modification in connection with the water service has, however, been introduced, as compared with earlier designs, in that the exhaust-valves are no longer cooled. The valve chambers are jacketed, but it has been found an unnecessary refinement to cool the valves themselves, and considerable simplification has resulted from the omission of the arrangements which were previously used for this purpose.

The valve gear is driven from a side-shaft geared down by spiral gear from the crank-shaft. This side-shaft cannot be seen in Fig. 1, but it may be said that it is divided into two parts, which are connected by spur gearing. The two parts run at the same speed, and the object of the gearing is in the main to get the part of the side-shaft which carries the valve cams into the most convenient position for the arrangement of the connecting-links to the valves. A single cam is used for the operation of each pair of inlet and exhaust-valves. The control of the engine is carried out entirely on the throttle. Down to about half-load the gas alone is throttled, the compression remaining approximately constant, while below half-load the gas and air are throttled together. This prevents very weak mixtures, with the possibility of mis-fires at small loads. The gas-admission valve is carried on the same spindle with the main admission-valve, and is flexibly connected to it, so that, even in the event of the two seatings being unequally worn, the valves close tightly and prevent waste of gas or back-firing.

The feature to which we wish to draw special attention in the engine is the built-up cylinder arrangement, which has been designed to eliminate casting and heat expansion stresses. This is illustrated both in Fig. 1 and in Figs. 2 and 3, which show a half and a complete cylinder respectively. The essential feature of the arrangement is that each cylinder is made in two parts, and that in each of these parts the cylinder proper —*i.e.*, the inner working part—is connected to the barrel forming the outer jacket at the outer end only. There are no ports or webs connecting the two barrels, so that, both during casting and later, when the cylinder is in position on the engine, there is no restriction to any slight movement which may be necessary to allow for expansion or contraction. The two parts are bolted together, as shown in Fig. 3, to form the complete cylinder, and an internal wearing liner of hard metal is fitted. This is maintained in position by an outer rib, as will be seen in Fig. 1. The continuity of the water-jacket is made up by fitting two sheet-iron half-cylinders round the opening left at the centre. These are shown in section in Fig. 1, and it will be seen that the lower one of the two carries two of the water-service pipes. The elasticity of the whole arrangement is maintained by arranging that these half-cylinders shall simply clamp over the cylinder proper, the water-joints being made by rubber rings in V-grooves, as will be seen in Figs. 1 and 2. An incidental advantage of the arrangement is that by removing the half-cylinders very ready access for cleaning may be had to the interior of the jackets. This feature will be readily appreciated from Figs. 2 and 3.

Additional arrangements in connection with expansion are made in the engine by bolting down the front end of the cylinder only, and arranging that the back end shall be capable of sliding and taking up a position free from strain. Cast-iron sliding-blocks are fitted into the foundations in connection with this feature. They will be seen in Fig. 1. The remaining details of the engine will be seen from Fig. 1, but it may be said that metallic packing is fitted throughout, and that the cylinder covers are so arranged that, if necessary, they may be packed up so as to alter the amount of compression. This latter point is intended to adapt the engine for working with any type of gas.

THE EDUCATION AND TRAINING OF ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—Will you kindly permit a correction in the report of what I said at the recent educational conference held at the Institution of Civil Engineers. It was the Royal Geographical Society which drew up a syllabus of geography (not "geology") for public schools and secondary schools. This met with universal commendation and equally universal neglect:—the commendation, because no course of geographical study could be more educative; the neglect, because the required foundation is not laid in the preparatory schools.

The latter statement applies to most subject-matter of study in these schools, other than "classics."

There are four main reasons why the general education of our sons in preparatory schools is so markedly defective:—

1. Eighty per cent. of the scholarships offered by the public schools are for proficiency in Latin and Greek, for which reason the whole course of study is laid out to suit a small minority of boys.

2. The masters have had no training in their profession as teachers, hence most of the teaching is dry and lifeless.

3. Parents do not, as a rule, know what to demand of the schools, and acquiesce in a system which results in a large percentage of boys being untrained in English, modern languages, mathematics, and science.

The net result is that in a very large number of cases the years from eight to fourteen are practically wasted.

Yours faithfully,
STANLEY DE BRATH, M. Inst. C.E.

East Grinstead, July 14, 1911.

ARMOUR FOR SHIPS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the report of the proceedings of the recent International Congress of Naval Architects, contained in your publication of July 14, it is stated on page 51 that, in opening the discussion on the paper read by Mr. Charles E. Ellis on "Armour for Ships (1860 to 1910)," I said "rolled armour was adopted on several of the early warships, including the Warrior." This, however, as regards that vessel, is exactly the reverse of what I said; for I stated that the whole of her armour-plating was, to my personal knowledge, made under the steam-hammer.

I shall be obliged, therefore, if you will kindly afford me space for this correction.

Yours faithfully,
CHAS. H. JORDAN.

Luanza, 39, Westmount-road, Eltham,
July 18, 1911.

PRESENTATION OF THE ROYAL SOCIETY OF ARTS ALBERT MEDAL TO SIR CHARLES PARSONS. — The Council of the Royal Society of Arts attended at Clarence House on Friday, the 14th inst., when His Royal Highness the Duke of Connaught, K.G., President of the Society, presented its Albert Medal to the Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S., "for his experimental researches into the laws governing the efficient action of steam in engines of the turbine type, and for his invention of the reaction type of steam-turbine and its practical application to the generation of electricity and other purposes."

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—A new department has been formed in the faculty of engineering, to deal with heating and ventilating engineering, the lecturer being Mr. Arthur H. Barker, B.A., B.Sc., Wh.Sc. The course is intended for students having a sound elementary knowledge of mathematical science, and intending to specialise in the practice of heating and ventilation. At the end of the second term a tour in Germany will be arranged to inspect important installations there. The tour will be under the guidance of the lecturer, to whom application for further particulars should be made.

THE POST OFFICE AND AUTOMATIC TELEPHONE EXCHANGES.—As a result of visits to America by the engineer-in-chief and other officers of the Post Office, it has been decided to instal two trial automatic telephone exchanges in this country. These will each be equipped with about 500 lines at the outset, and will be situated at Epsom and Caterham respectively. The Epsom system will be on the Strowger principle, while that at Caterham will be of the Lorimer type. The Strowger gear is that which was described in detail on pages 166 and 203 of our eighty-ninth volume. In addition to these two exchanges an automatic system is also to be installed for the service between the official departments at St. Martin's-le-Grand. It is expected that the Epsom and Caterham plants will be working within the next six or eight months; so that it should be possible to form an idea of their suitability for English conditions within twelve months from now. Consideration is also being given by the Post Office officials to semi-automatic telephone systems, but no announcement is as yet forthcoming as to any definite steps having been taken in connection with them.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a steady tone, but prices were inclined to get easier. A good business, consisting of 12,500 tons of Cleveland warrants, was put through at 46s. 10½d. and 46s. 10d. cash, 47s. and 46s. 11d. twelve days, 46s. 11½d. twenty-seven days, and 47s. 1½d. and 47s. one month. At the close sellers quoted 46s. 10½d. cash, 47s. 1½d. one month, and 47s. 7d. three months. There was no afternoon session, the market being closed for the annual Fair Holidays. When business was resumed on Tuesday morning a strong tone prevailed, but dealings were limited to 1000 tons of Cleveland warrants at 47s. 10d. and 47s. 9½d. three months. Closing prices were firm at 47s. 1d. cash, 47s. 4d. one month, and 47s. 9½d. three months sellers. The afternoon session was steady, and 4000 tons of Cleveland warrants changed hands at 47s. 3d. one month and 47s. 9d. and 47s. 9½d. three months. Closing sellers quoted 47s. 1d. cash, 47s. 4d. one month, and 47s. 10d. three months. When the market opened to-day (Wednesday) there was a dull tone, and business was quiet. The turnover consisted of one Cleveland warrant at 47s. 3½d. one month, with sellers over at that figure, and at 47s. 0½d. cash and 47s. 9½d. three months. There were buyers of hematite at 61s. 3d. cash and 61s. 6d. one month, but no sellers were in evidence. In the afternoon there was again little life in the market, and prices were steady. The business consisted of 1000 tons of Cleveland warrants at 47s. cash and 47s. 3d. one month, and closing sellers were unchanged at 47s. 0½d. cash, 47s. 3½d. one month, and 47s. 9½d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde, 60s. 6d.; Calder and Gartsherrie, 61s.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 64s.; Shotts (at Leith), 62s.; and Carron (at Grangemouth), 63s.

Scotch Steel Trade.—There is practically nothing to report in connection with the Scotch steel trade this week, but it is stated that the booking of new business has not yet shown much evidence of improving. The so-called half-year, which ends at the Fair holidays, has not been a very satisfactory one for steel makers, owing to several causes, the principal one being the trouble with the shipyard workers last year. It always takes some time to get over the effects of strikes and locks-out, but steel-makers are confident that the worst is now past, and that very shortly there will be a renewed demand for material, as shipbuilders' order-books are at present very well filled. During the period mentioned, the output of the plate mills has been fairly good; but, on the other hand, angle-makers have suffered from a scarcity of orders. Black sheets have been in excellent demand, largely for shipment, and, with prices firm, the outlook is good.

Malleable-Iron Trade.—The mallable-iron trade of Scotland has passed through a very trying time during the past six months, and hand-to-mouth conditions have generally been the rule since this year began. The reduced prices which came into vogue some time ago did not tend to improve matters, and the immediate outlook is far from reassuring. The current figure, based on 6*l.* per ton, less 5 per cent., for crown bars, leaves practically no margin, and, except that works are being kept moving, there seems little sense in accepting orders on these terms.

Scotch Pig-Iron Trade.—The Scotch pig-iron trade will be in full swing again next week, and makers are looking forward to an increased demand. Inquiries in circuit point to this, and the prospects for the next few months are considered to be quite bright. With regard to hematite, however, little can be said, as recently there has been an absence of demand. The price is nominally 64s. per ton for delivery on to the end of the year, but less would be accepted for some orders for prompt delivery.

Scotch Imports of Iron and Steel.—The quantities of iron and steel manufactures which were imported at Aberdeen, Dundee, Glasgow, Grangemouth, and Leith, from the Continent and the United States of America, during the first six months of this year, are given in the following table, and the figures are also given for the corresponding period of last year:—

	1911.			
	Ex. Continent.		Ex. U.S.A.	
	Tons.	Value. £	Tons.	Value. £
Iron bars, &c. ..	10,398	64,693	10	140
Steel bars, &c. ..	14,443	87,380	22	200
Hoops and strips	1,923	13,979	1717	22,716
Plates and sheets	9,241	67,194	684	4,970
Totals ..	36,005	233,246	2433	28,026
	1910.			
Iron bars, &c. ..	4,304	27,102		
Steel bars, &c. ..	6,983	45,454		
Hoops and strips	1,093	8,662	1751	21,012
Plates and sheets	3,602	31,227	907	6,409
Totals ..	15,982	112,445	2658	27,421

At Glasgow, Grangemouth, and Leith, during the past six months, the imports of steel sheet, bars, slabs, and billets, amounted to 55,636 tons, valued at 292,654*l.*, as against 44,055 tons, valued at 224,316*l.*, for the corresponding six months of last year.

ENGINEERING SCHOLARSHIPS.—Engineering students' attention is drawn to the Works Engineering Scholarships offered by the Daimler Company, Limited, Coventry. Five of these scholarships, giving a remission of a premium of 100*l.*, together with other advantages, are awarded in September next. Entries are accepted up to the end of July.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Returns.—The decrease in the quantity of coal dealt with through the port of Hull during June, as compared with June of last year, represents the larger part of the decrease on the half-year just concluded as against the first half of 1910. The comparative figures for the half-years are: 3,088,032 tons, 1911; and 3,298,800 tons, 1910—a falling off of over 200,000 tons. The monthly tonnages were 552,496 tons and 627,376 tons respectively—a drop of nearly 75,000 tons. It is notable that the reduction in foreign exports on the six months is nearly 200,000 tons. This loss of trade is accounted for by considerable declines in business with Russia, Germany, Holland, and Sweden, or practically the Baltic trade. The largest colliery output, that of Denaby and Cadeby, shows a decrease on the month of over 20,000 tons.

South Yorkshire Coal Trade.—The hard-coal market has been considerably affected by the shipping disturbances. Accumulating supplies have caused congestion of the sidings, and the pits have had a difficulty in clearing their stocks. During the past few days the position has improved, and this brightening of the outlook has kept prices steady. The tonnage going for shipment is expected to be much increased during the coming week. Gas coals are about the same. The reduction of colliery outputs has placed slacks in a better position, and, in fact, it is somewhat difficult to meet calls for these coals. Coking smalls are also scarce. The house-coal trade is exceptionally quiet. The extremely hot weather has further reduced the normal summer demand, and the determination of owners to keep up prices checks business. Practically nothing was done in this branch on the local Exchange at the week end. Usually at this period contracts are being arranged in large numbers, but so far very little has been done in this direction. Inquiries at pits are much smaller than normal, and the increase in stocks has become an important matter. Short-time working is the general rule. London orders are very small. Latest 'Change quotations are: Best branch hand-picked, 13s. to 14s.; Barnsley best Silkstone, 11s. to 12s.; Silkstone, 9s. to 10s.; Derbyshire house, 8s. to 9s.; large nuts, 7s. 3d. to 9s.; small nuts, 5s. 6d. to 6s. 6d.; Derbyshire brights, 10s. to 11s.; Yorkshire hards, 8s. 3d. to 9s. 6d.; Derbyshire, 8s. to 9s.; washed nuts, 7s. 9d. to 8s. 9d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. to 5s.; smalls, 1s. 6d. to 2s. 6d.

Iron and Steel.—The benefit to the iron trade expected to accrue from the quarterly meeting at Birmingham has not been realised. The general impression received at that gathering was that prices were unlikely to get any lower, and, in fact, the general tone was somewhat firmer, but there was little indication of a reinvigorated market. More contracts for hematites have been given out, but they have been obtained by price-cutting. The lowest official quotation for East Coast mixed numbers is 68s., but the figure is not tempting buyers. West Coast are varying between 76s. and 78s. Makers of Derbyshire common irons are taking a firmer stand in regard to prices, and the Lincolnshire quotations have not been altered. Finished iron is in fair demand. Scrap iron and steel are depressed, and some merchants are clearing stocks at a loss. The position of the steel trades is little changed. Manufacturers still find many factors retarding full expansion and limiting profits. Foreign competition does not relax, the price of raw materials is a serious consideration, and for the most part they are paying high wages. The scarcity of new business is, of course, a good deal due to the season, but it has its effect nevertheless. The rolling-mills are again fully occupied, and there is a substantial amount of work at the forges. The armament and the other principal heavy branches of trade pursue an even course of activity. Messrs. Vickers and Messrs. Brown are busily engaged on armour for two English battleships as well as work on Spanish and Russian orders respectively. In the general steel trades the growth of activity is widespread and continuous. The American demand has improved a little and other over-sea orders are increasing in volume. As an evidence of expansion, particularly in the employment of newer methods, it is stated that another electric melting furnace has been put down in the city. An important home engineering contract has been booked by a Sheffield firm, and the engineering prospects generally are good. Home inquiries for tool steel are a little quieter, but there is a big foreign demand. The lighter trades are mostly working well.

THE INCORPORATED INSTITUTION OF AUTOMOBILE ENGINEERS.—A committee of this institution has been at work for some months collecting information from many large motor-car manufacturers and others as to the practice in vogue in their works with regard to the admission and instruction of pupils and apprentices. This information has now been tabulated, and will be placed at the disposal of parents seeking advice on the subject, for which purpose application should be made to the secretary, 13, Queen Anne's Gate, Westminster, S.W., by letter in the first instance. It is hoped that by this means parents will be saved a great deal of trouble and anxiety and possible expense by being placed in a position to have access to information extending over a very much wider area than they could obtain by their own unaided efforts, and it is also hoped that, through the institution, the various works will be brought into contact with those youths who are likely to show themselves specially apt in the branch of the industry in which they are to be placed. In this connection it should be noted that advice to parents and others will be given absolutely free of cost, and the circumstances of each individual case will be taken into consideration in giving an opinion on the subject.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Though what is usually the quietest period of the year is not yet past, buyers are now coming forward in a most satisfactory manner. They seem to have come to the conclusion that they are not likely to gain anything by waiting, as values promise to advance in the near future. There is reason to believe that requirements for the back end of the year will be heavy, and consequently a brisk autumn business is anticipated. Already some contracts have been made, but buying for the fall of the year does not usually occur to any great extent until about the middle of August. It is very gratifying to see the output of pig so well taken up at this season of the year. Values of Cleveland pig iron are as high as any that have ruled since the early part of April. The present situation is such as to inspire confidence in the future, and when the autumn demand is in full swing the statistical situation should improve considerably, providing the output is not materially increased. No. 3 g.m.b. Cleveland pig is steady and firm at 47s. 3d. f.o.b.; whilst No. 1 is 50s. 9d.; No. 4 foundry and No. 4 forge, each 46s. 9d.; and mottled and white iron, each 46s. 6d.—all for early delivery. There is rather more doing in East Coast hematite pig iron, and as several consumers are believed to be getting short of supplies, there are prospects of further substantial transactions. Unsuccessful efforts have been made by would-be buyers to force prices down. Second hands and several makers quote 61s. 6d. for early delivery of mixed numbers, but some of the latter are inclined to hold out for 62s. Business in foreign ore is still very dull. Best Rubio is in the neighbourhood of 19s. 6d. ex-ship Tees. Average furnace coke is firmer at 14s. 6d. to 14s. 9d. delivered here.

Production of Pig Iron.—Messrs. James Watson and Co., iron merchants, of Glasgow, Middlesbrough, Liverpool, and Swansea, have just issued their valuable and interesting statistics of the production of pig iron. The returns show that during the year 1910 the world's production of pig iron amounted to 65,607,788 tons—an increase of 5,242,008 tons as compared with the output of the previous year, and 17,433,000 tons more than the make of 1908. Last year the United States again produced far more pig iron than any other country, the output amounting to 27,295,545 tons. Germany was second with a make of 14,793,325 tons, and Great Britain third with an output of 10,216,745 tons. France produced 4,032,459 tons; Russia, 2,956,000 tons; Austria and Hungary, 1,990,684 tons; and Belgium, 1,803,500 tons. Cleveland, with a make of 2,647,201 tons, was the district that produced the largest quantity in Great Britain, Scotland being second with an output of 1,404,816 tons, and Durham third with a make of 1,215,524 tons.

Manufactured Iron and Steel.—Good accounts are now given of nearly all branches of the manufactured iron and steel industries. Production is heavy, and there are good inquiries in the market. The placing of further shipbuilding orders should have a beneficial influence on important departments. Under the present favourable conditions values show a marked upward tendency, but as yet prices have not been actually advanced. The following are the principal market quotations:—Common iron bars 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 15s.; iron ship-plates, 6*l.* 12s. 6d.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 7s. 6d. to 6*l.* 10s.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; and galvanised corrugated sheets, 10*l.* 15s.—sheets less 4 per cent. f.o.b., railway material net, and all other descriptions less 2½ per cent.

MR. T. N. ELY AND THE PENNSYLVANIA RAILROAD.—The American journals to hand announce that Mr. Theodore N. Ely, chief of motive power on the Pennsylvania Railroad, retired on June 30 last, under the pension rules of the company. Mr. Ely had been with the Pennsylvania Road since 1868. From 1869 to 1870 he was superintendent of the middle division of the Philadelphia and Erie division. In 1870 he was made assistant general superintendent of the Philadelphia and Erie, and in 1873 superintendent of motive power of the same division. He was made superintendent of motive power of the Pennsylvania Railroad division in 1874, and in 1882 general superintendent of motive power of the lines east of Pittsburg and Erie. In March, 1893, he was appointed chief of motive power of the lines east and west of Pittsburg. Mr. Ely is a member of the Institution of Civil Engineers, of the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the Franklin Institute, American Philosophical Society, American Association for the Advancement of Science, and other technical and scientific institutions, and an honorary member of the American Institute of Architects. He is president of the Eastern Railroad Association and a member of the permanent commission of the International Railway Congress. He is also a director of the Pennsylvania Steel Company and the Cambria Steel Company, and a trustee of the Drexel Institute of Art, Science, and Industry, and the Philadelphia Commercial Museum. The honorary degree of Master of Arts was conferred upon him by Yale University in 1897, and that of Doctor of Science by Hamilton College in 1904. With the retirement of Mr. Ely the position of chief of motive power of the Pennsylvania system will be abolished; the office of chief mechanical engineer will take its place.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has been comparatively quiet, both buyers and sellers awaiting developments in connection with the labour question. Admiralty coal has shown continued firmness, colliery owners having good orders on their books. The best large steam coal has made 18s. 6d. to 19s. per ton; while secondary qualities have ranged from 16s. to 17s. 9d. per ton; best bunker smalls have made 9s. 9d. to 10s., and cargo smalls 7s. 9d. to 8s. 3d. per ton. The best ordinary household coal has brought 14s. 6d. to 16s. 6d.; No. 3 Rhondda large 17s. to 17s. 6d., and smalls 7s. 6d. to 10s. 9d. per ton. No. 2 Rhondda large has been quoted at 11s. 9d. to 12s. 3d., and smalls 8s. to 8s. 6d. per ton. Foundry coke has realised 18s. to 20s. 6d. per ton, and furnace ditto 16s. to 17s. per ton. As regards iron ore, Rubio has made 18s. 6d. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Llanelly.—Tin-plates have been in good demand, and there have been large clearances from stocks, while prices have ruled firm. New mills are making good progress at Old Castle and Burry, and rolling will be shortly commenced. Steel bars have shown steadiness, the demand having been well maintained.

A Welsh Light Railway.—The annual report of the directors of the Welshpool and Llanfair Light Railway states that the gross receipts from traffic during the year ending December 31 last were 297*l.*, as compared with 299*l.* in the previous year. The net receipts of the company, after deducting the charges of the Cambrian Company for working and general expenses, amounted to 116*2l.*, and out of this all interest and charges against revenue for the year had been provided for. There is now standing to the credit of revenue 76*2l.*, which it is proposed should be carried forward.

Dowlais.—The blast-furnaces have been fully employed. The Goat Mill has been producing heavy sections of steel rails and a moderate quantity of tin-bar. There has been a good production at the collieries.

MARINE TURBINES AND SPEED-REDUCING GEAR.—The Westinghouse Machine Company, Pittsburg, have recently completed the steam-turbines with speed-reducing gear for the 19,000-ton collier Neptune for the United States Navy. It is stated that the speed-reducing gear is mounted on a floating frame with a view to the maintenance of uniform tooth-pressure, the pinion-frame being also supported on plungers in a way which, besides reducing vibration, provides a kind of hydraulic dynamometer, enabling the reading of the shaft horse-power transmitted.

THE COPPER MARKET.—In their report dated the 17th inst., Messrs. James Lewis and Son state that standard copper advanced from 56*l.* 12s. 6d. for cash on the 3rd inst. to 57*l.* 5s. on the 11th, three months prompt realising 57s. 17s. 6d., when large purchases were made by one firm which were thought to be against sales of sulphate of copper for delivery next year. Values subsequently fell away to 56*l.* 13s. 9d. cash, and 57*l.* 5s. three months. European consumption continued large, but that of the United States was disappointing. The future course of prices mainly depended upon whether this latter recovered more nearly to the level of last year, and absorbed any further increase of home production. Shipments from the United States to Europe for the past fortnight were large, amounting to 16,518 tons.

ALEXANDER PRIZE COMPETITION FOR AERIAL LIGHT MOTORS.—We are informed that the entries in connection with the motor competition for a prize of 1000*l.* offered by Mr. Patrick Y. Alexander, under the auspices of the Aeronautical Society, the Royal Aero Club, and the Aerial League, are now closed, and that the following entries for the competition have been received:—1. W. L. Adams, Bournemouth. 2. The Aero-Flight Engine Company. 3. The E.N.V. Motor Syndicate, Limited, London. 4. The Green Engine Company, London. 5. The Isaacson Radial Engine Company, Limited, Leeds. 6. The New Engine Motor Company, Limited, London. 7. The Requa Motor Company, of New York, U.S.A. The engines are required to be delivered for test at the National Physical Laboratory, Bushy House, Teddington, Middlesex, on or before September 30, next.

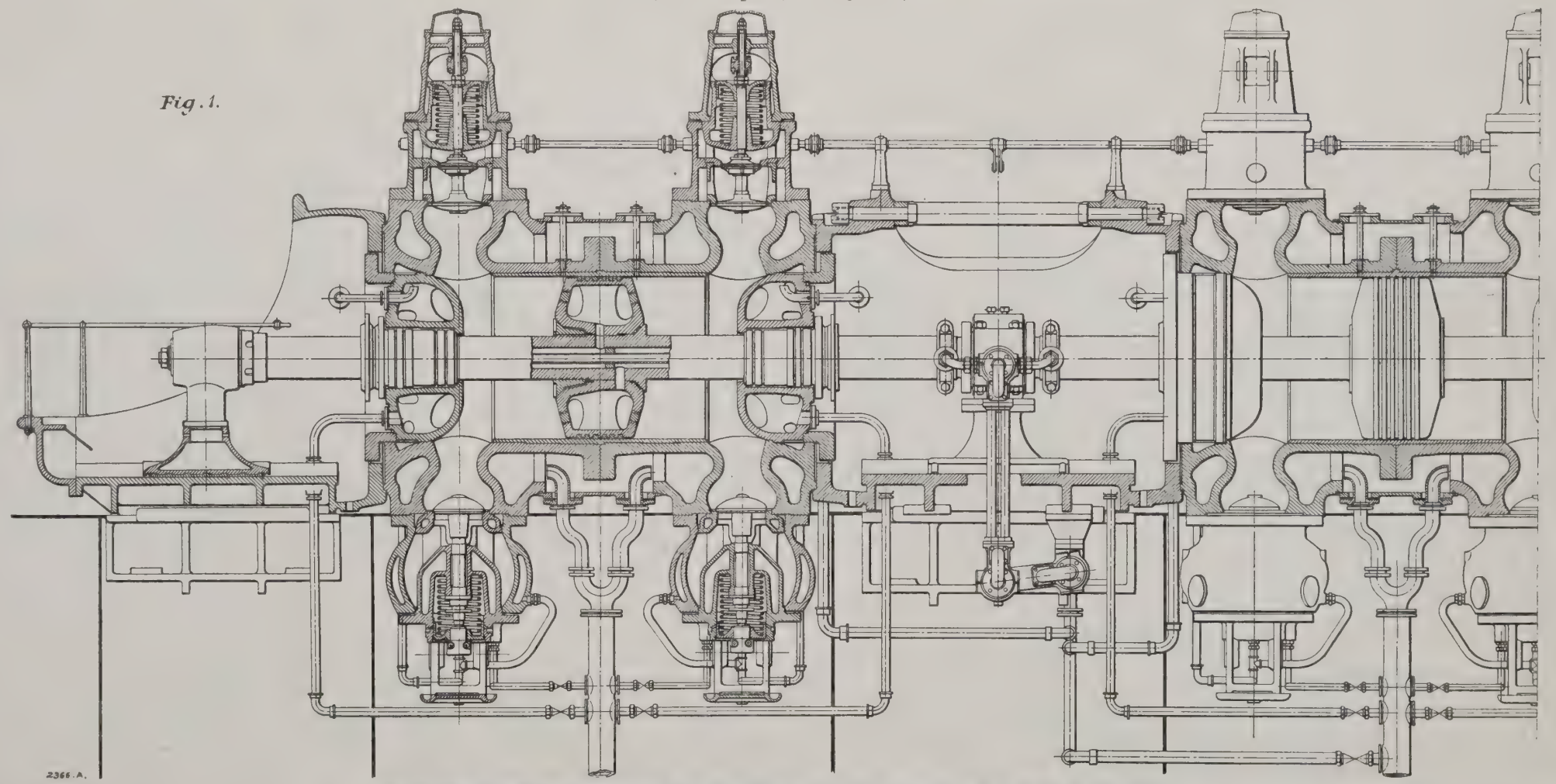
NAVAL ARCHITECTURE SCHOLARSHIPS.—The University of Liverpool announces that an examination will be held on September 12 next for the award of the first scholarship given by Lloyd's Register of Shipping. This scholarship is of the annual value of 50*l.*, tenable for three years, and, in special cases, a free studentship may be attached thereto by the University, bringing the total value up to 80*l.* a year. The scholarship is confined to British subjects whose age on October 1 does not exceed 23 years, and who have already served three years' apprenticeship in a mercantile shipyard. The subjects of examination are English, French or German, mathematics, and mechanics, the papers being the same as those set for the matriculation examination at the northern universities. In addition, a special paper is set in practical shipbuilding. Other things being the same, preference will be given to the candidates who show a good knowledge of English and French or German. The holder of the scholarship must specialise in naval architecture, reading either for the degree or certificate of engineering.

1350-BRAKE-HORSE-POWER DOUBLE-ACTING FOUR-CYCLE HORIZONTAL TANDEM GAS-ENGINE.

CONSTRUCTED BY MESSRS. GALLOWAYS, LIMITED, ENGINEERS, MANCHESTER.

(*For Description, see Page* 104.)

Fig. 1.



CONTRACTS.—Messrs Strain and Robertson, civil engineers, 154, West George-street, Glasgow, have placed an order with Messrs. Kermode, Liverpool, for their liquid-fuel system for 43 boilers of various types, for Cheuto, in Chili.—The Great Western Railway Company have renewed their contract with the Pearlite Steel Company (1910), Limited, Sheffield, for another year for the supply of their "Hardening-Only" tool steel.

PERSONAL.—Messrs. John Davis and Son (Derby), Limited, All Saints Works, Derby, state that they have recently doubled the capacity of their foundry for casting brass, gun-metal, and aluminium, and that they are able to execute orders very promptly.—In consequence of the rebuilding of Gresham College, the head offices of the City and Guilds of London Institute have been removed temporarily to 3, St. Helen's-place, E.C.—Mr. Arthur W. Richards, for twenty-five years with Messrs. Bolckow, Vaughan, and Co., Limited, of Middlesbrough, and for the last six years as general works manager, will open offices at Army and Navy Mansions, 109, Victoria-street, Westminster, London, S.W., on Wednesday next, as a consulting engineer on iron and steel practice, and metallurgist.

FIG. 2.

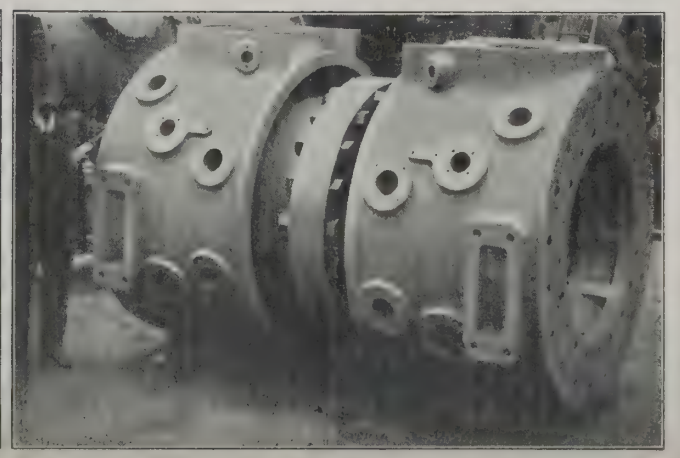


FIG. 3.

ILLUSTRATED RAILWAY-GUIDES.—The Great Eastern Railway Company have issued an illustrated pamphlet, entitled "On the East Coast," which gives interesting information on all the holiday resorts on that coast. The Great North of Scotland Railway, Aberdeen, also issue an illustrated pamphlet on "The Moray Firth Coast—the Scotch Riviera"—containing data upon the district which it serves.

THE GERMAN NAVY.—The *Moniteur de la Flotte* states in a paragraph which it takes from *Nauticus* that the battleships of the Heligoland class, the first of which—the Thüringen—has recently entered the service, have a speed of 20.5 knots, an armour protection 280 mm. (11 in.) thick at the water-line, and an armament consisting of twelve 310-mm. (12.2-in.), fourteen 150-mm. (5.9-in.) and fourteen 88-mm. (3.46-in.) guns; the 310-mm. projectile weighs 444 kg. (978 lb.). The armoured cruiser Moltke has a displacement of 23,000 tons, Parsons turbines of 50,000 horse-power, a 25.5-knots speed, and a 3100-ton coal-bunker capacity. It is armed with ten 280-mm. (11-in.) guns, in five turrets, with twelve 150-mm. (5.9-in.) and twelve 88-mm. (3.46-in.) guns. The Goeben is, it appears, similar to the Moltke in every detail.

ON THE DEVELOPMENT OF MERCHANT SHIPBUILDING IN JAPAN.*

By Dr. S. TERANO, Member, and M. YUKAWA, Director of the Mercantile Marine Bureau.

FROM the time of the prohibition of the building of vessels above 500 "koku" (or 50 tons net) during the reign of the third Tokugawa Shogun until the last days of the Tokugawa Shogunate, the Japanese shipbuilding industry was at a low ebb, and there seemed no way for its recovery. This covered a period of 218 years—from 1635 to 1853.

In 1853, when an American fleet, under the command of Commodore Perry, appeared off the Japanese coast, the Shogun's Government were suprised at the enormous size of their warships, and awakened from the indolent dreams of the past. They soon felt the necessity of developing the shipbuilding industry and of abolishing the law prohibiting the construction of large vessels A few ships of European type were built by some of the Daimyos, but, as the Japanese shipwrights were quite ignorant of the proper mode of shipbuilding, they were content to imitate the outside appearance only.

It happened, in 1854, that a Russian man-of-war arrived at Shimoda, in the province of Idzu, to promote intercourse with the Empire; she was washed ashore and sunk by tidal waves caused by a great earthquake. The Russians, with the sanction of the Shogun, soon started to build a wooden schooner, at the village of Heda, in Idzu, being assisted by the village shipwrights. Figs. 1, 2, and 3 are facsimiles of the plans made on that occasion. This gave the Japanese the first opportunity of observing the actual construction of European vessels, and, amongst other matters, they became acquainted with the method of building ships with frame timbers erected first; the essential difference in Japanese junks being that they are without frames, and rigidity of hull is obtained by thick outside planks nailed together and supported by beams (see Fig. 4). Soon afterwards six vessels of similar European type were built to the order of the Shogunate Government, one of which existed till the end of 1887. Their principal dimensions were as follow:—

	ft.
Length over all...	81.2
Extreme breadth	23.2
Length on keel...	62.5
Depth, moulded	9.9

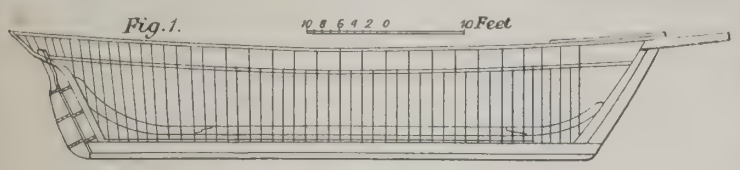
In 1855 a war vessel was presented to the Shogun by the Dutch Government, and in 1857 another war-vessel, fitted with a screw propeller, was purchased from the same country, thus forming the nucleus of the Japanese navy. The Government, being supplied with naval vessels, felt the necessity for the establishment of shipyards and iron-works for repairing and building war-vessels. The first shipyard was started in 1857, at Nagasaki; Dutch engineers and shipwrights were employed, and the necessary machinery was brought from Holland. This formed the origin of the present Mitsu-Bishi Works. In 1864 iron-works were established at Yokohama, and a shipyard at Yokosuka; the latter was planned out by a French naval constructor, and took four years to complete. The Prince of Mito had also started a shipyard at Ishikawajima, in Tokio, where, in 1861-3, the first wooden steamship, the Chiyodagata, was built entirely by Japanese.

Thus an enterprising naval policy was established, and, about the same time—in 1861—for the encouragement of the mercantile marine, permission to own large vessels was granted to the general public. It was also enacted that officers and crews for handling such vessels would be supplied by the Government, if desired.

In the next year the policy of closing ports to foreign trade, which had been practised for nearly 220 years, was abandoned, and the veto against leaving the country was removed. The shipbuilding industry then began to develop gradually; but in 1867, the time of the Restoration, civil struggles hindered the Shogunate from the policy of opening the country to foreign trade, and the extension of shipbuilding enterprise was interrupted owing to the ruin of maritime business.

Of the shipyards started by the Shogun and other authorities, those at Yokosuka, Yokohama, and Ishikawajima were transferred to the navy department of the Empire after the Restoration, while the yard at Nagasaki passed to the Department of Public Works, under whose superintendence merchant shipbuilding was commenced. The last-named department also formed a shipbuilding and engine-works at Kobe. Again, in 1876, the site of the Ishikawajima engine-works, in an outlying district of Tokio, was leased to a private concern, which was afterwards named "The Ishikawajima Shipbuilding and Engineering Company." This was really the first private yard of modern type founded in Japan. Provided with these facilities ships of Western type continued to be constructed.

In January, 1870, a mercantile marine regulation was issued, advising the building of European-style vessels



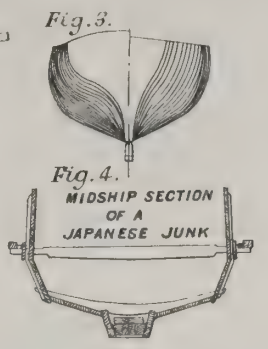


TABLE I.—SHOWING NUMBER AND TONNAGE OF HOME AND FOREIGN-BUILT STEAMERS ABOVE 700 GROSS TONS REGISTERED DURING YEARS 1879 TO 1910.

YEAR.	WHERE BUILT.	700 TO 1000 TONS.		1000 TO 2000 TONS.		2000 TO 3000 TONS.		3000 TO 4000 TONS.		4000 TO 5000 TONS.		5000 TO 6000 TONS.		6000 TO 7000 TONS.		7000 TO 8000 TONS.		8000 TO 10,000 TONS.		ABOVE 10,000 TONS.		TOTAL.	
		No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.
1879	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1879	Abroad	..	..	4	7,112	3	6,270	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	13,382
1880	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1880	Abroad	4	3,577	2	3,104	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	6,681
1881	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1881	Abroad	6	5,123	6	8,603	3	6,421	..	..	..	..	..	..	..	..	..	..	..	..	..	..	15	20,147
1882	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1882	Abroad	..	..	1	1,010	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1,010
1883	Home	..	..	1	1,416	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1,416
1883	Abroad	1	877	3	4,040	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	4,917
1884	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1884	Abroad	1	721	1	1,124	1	2,305	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	4,150
1885	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1885	Abroad	3	2,528	2	3 751	2	5,000	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	11,279
1886	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1886	Abroad	1	721	2	3,027	1	2,193	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	5,941
1887	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1887	Abroad	..	..	7	10,245	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	10,245
1888	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1888	Abroad	..	..	1	1,786	2	5,813	1	3,307	..	..	..	..	..	..	..	..	..	..	..	..	4	10,906
1889	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1889	Abroad	..	..	4	5,729	1	2,452	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	8,181
1890	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1890	Abroad	3	2,401	4	5,440	2	5,050	..	..	..	..	..	..	..	..	..	..	..	..	..	..	9	1?,891
1891	Home	1	707	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	707
1891	Abroad	1	949	2	2,430	..	..	1	3,275	..	..	..	..	..	..	..	..	..	..	..	..	4	6,654
1892	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1892	Abroad	1	829	4	6,093	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	6,922
1893	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1893	Abroad	..	..	4	6,598	2	5,007	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	11,605
1894	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1894	Abroad	..	..	6	9,384	19	48,041	7	22,338	2	8,810	1	5789	..	..	..	..	..	..	..	..	35	94,362
1895	Home	..	..	1	1,502	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1,502
1895	Abroad	4	3,507	13	20,109	12	29,694	4	12,959	..	..	..	..	..	..	..	..	..	..	..	..	33	66,269
1896	Home	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1896	Abroad	3	2,895	9	11,693	6	14,311	1	3,770	..	..	..	..	..	..	..	..	..	..	..	..	19	32.669
1897	Home	..	..	1	1,610	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1,610
1897	Abroad	1	731	6	10,288	4	8,730	1	3,620	..	..	..	..	7	43,099	..	..	..	..	..	..	19	66,468
1898	Home	1	727	..	..	..	..	..	..	..	..	..	..	1	6,172	..	..	..	..	..	..	2	6,899
1898	Abroad	..	..	..	..	1	2,523	3	10,605	..	..	..	..	5	30,821	..	..	..	..	..	..	9	43 949
1899	Home	..	..	1	1,694	1	2,691	..	..	..	..	..	..	1	6,309	..	..	..	..	..	..	3	10,694
1899	Abroad	..	..	1	1,378	2	5,255	2	7,659	1	4,128	..	..	1	6,063	..	..	..	..	..	..	7	24,483
1900	Home	1	867	3	4,432	2	4,490	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	9.789
1900	Abroad	1	777	2	2,834	4	9,638	2	7,740	..	..	..	..	1	6,387	..	..	..	..	..	..	10	27,376
1901	Home	1	735	4	4,992	2	4,787	..	..	..	..	..	..	2	12,620	..	..	..	..	..	..	9	23,134
1901	Abroad	1	885	1	1,536	4	9,875	1	3,329	..	..	1	5076	..	..	..	..	..	..	..	..	8	20,701
1902	Home	2	1,415	3	4,334	2	5,569	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	11,318
1902	Abroad	..	..	7	10,421	2	5,636	..	..	1	4,624	..	..	..	..	..	..	..	..	..	..	10	20,681
1903	Home	4	3,401	4	6,177	1	2,183	..	..	..	..	1	5538	1	6,443	..	..	..	..	..	..	11	23,742
1903	Abroad	..	..	3	3,961	6	14,664	3	10,001	1	4,513	..	..	..	..	..	..	..	..	..	..	13	33,139
1904	Home	7	5,415	2	2,834	1	2,029	..	..	..	..	1	5068	..	..	..	..	..	..	..	..	11	15,346
1904	Abroad	1	980	20	29,540	22	54,852	18	60,403	6	26,144	1	5248	..	..	..	..	..	..	..	..	68	177,167
1905	Home	3	2,302	6	9,579	..	..	..	..	..	..	..	..	..	..	1	7463	..	..	..	..	10	19,344
1905	Abroad	16	14,473	27	41,209	25	57,642	7	23,498	..	..	..	..	..	..	..	..	..	..	..	..	75	136,822
1906	Home	5	4,095	7	9,385	2	4,227	..	..	..	..	..	..	1	6,715	..	..	..	..	..	..	15	24,422
1906	Abroad	7	6,020	12	18,818	9	23,327	3	10,508	2	8,810	1	5217	1	6,167	..	..	..	..	..	..	35	78,867
1907	Home	6	4,739	..	..	2	5,017	3	10,764	..	..	..	..	..	..	..	..	..	..	..	..	11	20,520
1907	Abroad	3	2,664	5	7,244	11	27,466	7	24,387	4	17,831	..	..	..	..	..	..	..	..	..	..	30	79,592
1908	Home	3	2,450	2	3,620	..	..	1	3,204	..	..	..	..	..	..	..	..	3	25,544	2	26,880	11	61,698
1908	Abroad	1	998	2	3,037	..	..	1	3,418	1	4,713	1	5151	..	..	..	..	..	..	..	..	6	17,317
1909	Home	4	3,356	..	..	..	..	1	3,272	..	..	..	..	2	12,360	..	..	3	25,535	..	..	10	44,523
1909	Abroad	..	..	1	1,661	1	2,112	1	3,432	..	..	..	..	1	6,617	..	..	..	..	..	..	4	13,372
1910	Home	1	757	..	..	..	..	..	..	..	..	..	..	3	18,300	..	..	1	9,287	..	..	5	28,344
1910	Abroad	3	2,716	1	1,842	3	8,046	3	10,816	4	17,267	..	..	..	..	..	..	..	..	..	..	14	40,687

* Paper read at the Jubilee Meeting of the Institution of Naval Architects, July 6, 1911.

and indicating the defects of vessels of Japanese type. Suitable timbers for the construction of small wooden vessels were abundant, and after the commencement of the Meiji Era, several ships up to about 300 tons gross were built every year. The first ship worthy of special mention in this connection was the Kosuge Maru, of 1496 tons and 240 ft. long, built at the Mitsu-Bishi Works, Nagasaki, in 1883; she was the only home-built ship of more than 1000 tons existing before the Japan-China War of 1894.

As the superiority of the Western style of vessel had become thoroughly recognised, the Government took the step in 1885 of prohibiting entirely the construction of Japanese junks above 500 koku (50 tons net), and at the same time, regulations for ship-survey were promulgated in order to guide builders and owners with respect to the proper design and construction. This proved very troublesome, and a process was therefore introduced to convert old junks to what is known as "Ainoko-sen" (or half-caste boat), with some approach to Western type in the matter of framing, planking, and rigging, making them stronger and more seaworthy; the principle of Western construction was thus adopted without the enforcement of a periodical survey. With a view to giving a check to the production of this kind of craft, the Government extended the inspection regulations to junks of built prior to the promulgation of the Shipbuilding Encouragement Act, and was the first ship fitted with a complete cellular double bottom.

Although the ships built in the Empire were very few in number and also very small in size, the Japanese mercantile marine had received great stimulus from foreign nations, and since the Restoration had made slow but steady progress. Large vessels were bought from abroad: for instance, in 1879 seven vessels, aggregating about 13,382 tons, were so acquired, and in 1881 fifteen steamers above 700 tons each were imported. In 1888 the Miike Maru, of 3364 tons, a record breaker in size, was purchased and entered on the register; she continued to be the largest vessel in the country until the outbreak of the Japan-China War.

At this time the state of affairs in the country was such that, although there were a score of large vessels, proper appliances for their repair were scarce; the ships had to be sent to Nagasaki, or, perhaps, receive assistance from the Imperial dockyard at different naval stations. It was recognised both by the Government and the public that subsidies should be granted for shipyard expansion, but the difficulty was still unsettled when, in 1894, the Japan-China War broke out.

When this occurred the number of merchant ships available for war purposes was very considerable, and

Fig. 5.

TOTAL NUMBER AND TONNAGE OF REGISTERED STEAMERS (ABOVE 20 TONS GROSS) AT THE END OF EACH YEAR

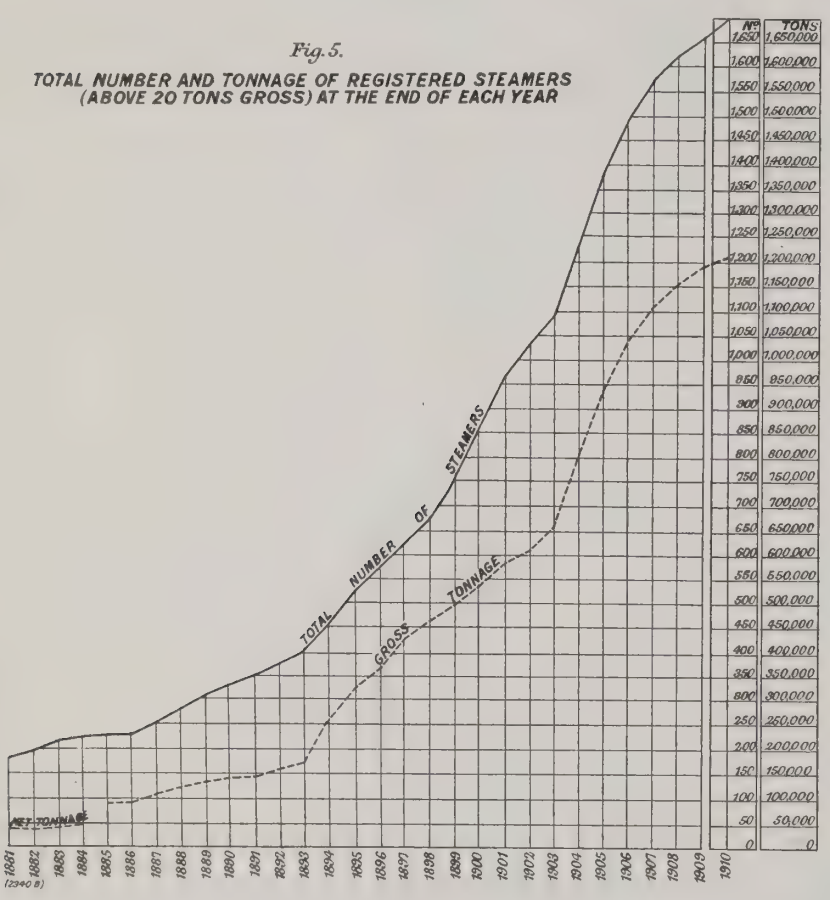
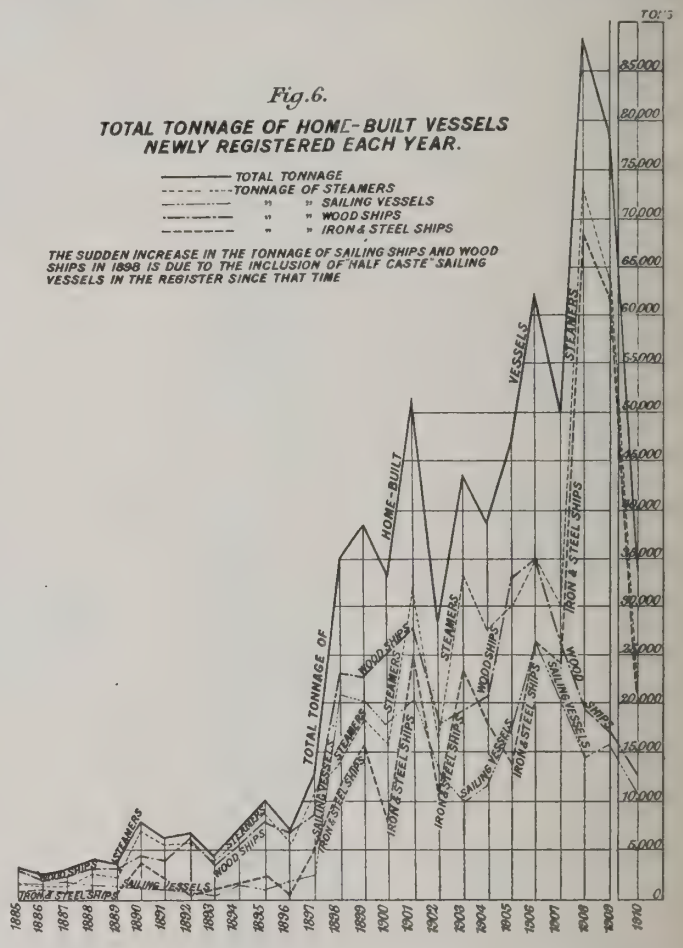


Fig. 6.

TOTAL TONNAGE OF HOME-BUILT VESSELS NEWLY REGISTERED EACH YEAR.

TOTAL TONNAGE
TONNAGE OF STEAMERS
" " SAILING VESSELS
" " WOOD SHIPS
" " IRON & STEEL SHIPS

THE SUDDEN INCREASE IN THE TONNAGE OF SAILING SHIPS AND WOOD SHIPS IN 1898 IS DUE TO THE INCLUSION OF HALF CASTE SAILING VESSELS IN THE REGISTER SINCE THAT TIME



above 20 tons gross in 1898, after which this special class gradually decreased in number.

The days of wooden vessels were already long past in Europe; Japan having no iron or steel material produced in the country, it was found more convenient to build small coasting vessels of wood, while vessels of larger size were all imported from abroad. Thus out of about 800 ships, both steamers and sailers, built from 1870 to 1884, all were of wood, the maximum size being 500 tons. Even after the development of steel shipbuilding, wooden ships continued to be built; in 1902 these included two steamers of 1208 and 1526 tons respectively (see diagram, Fig. 6, above). As cheapness of prime cost was the main object in view, there was a natural tendency to attend insufficiently to strength and seaworthiness. In order to guard against this, the Government in 1900 issued a code of regulations for the construction of wooden ships, with the intention of bringing unworthy shipowners and builders to a minimum standard in the matter of construction. This proved very successful, and had a remarkable effect in improving the wooden shipbuilding of Japan.

Early in the seventies a few iron steamers were built, partly for experimental purposes; but it was not until 1884 that Japan really began to build ships of iron. In that year the Osaka Shosen Kaisha (Osaka Steamship Company) placed an order for an iron screw steamer, the Asahi Maru, of 496 tons gross, which was soon followed by three others of similar size. This formed an epoch in iron shipbuilding, but Japan has been spared the "iron age," only about twenty steamers, ranging in size from 50 to 500 tons, having been so built, the last recorded being in 1893. The first steel vessel, the Chikugogawa Maru, of 664 tons, was laid down in 1890, at the Mitsu-Bishi Works in Nagasaki, to the order of the Osaka Shosen Kaisha, and two sister ships in the following year. In 1895 the Suma Maru, of 1592 tons, was launched from the same yard; she was the largest steel merchant ship during the war the Government was able to obtain the use of no less than 240,000 tons. The withdrawal of so large an amount of tonnage from the trade of the country threatened to bring about very serious difficulties and complications; to avoid these the Government and private owners bought largely from abroad. The number of steamers registered at the end of 1893 was about 400, with an aggregate tonnage of 167,490, whereas by the end of 1895 they were increased to 528, totalling 331,374 tons; so that in two years the merchant fleet was doubled. (See Fig. 5.) Since the victorious ending of that war, the commerce and industry of the country have expanded enormously; the sphere of navigation has greatly enlarged, partly owing to the annexation of Formosa; and the building of large merchant ships has thus been fostered, especially those with high speed and sufficient power to be used for war purposes when needed.

The shipbuilding industry in Japan, was, as has been shown, quite insignificant at the time of the Japan-China War, consisting for the most part of small wooden vessels, which in other countries were already out of date. As to the building of large iron or steel vessels, shipyards were still incomplete in their equipments; the materials had to be imported from abroad; shipbuilders and engineers were of limited experience; and high cost of production was the natural consequence. The protection and encouragement of shipbuilding was thus deemed necessary, and during the ninth session of the Imperial Diet, bills for the encouragement of navigation and shipbuilding were presented and passed with overwhelming majorities in both Houses. These Acts were promulgated in March, 1896, to be in force for fifteen years from October 1 of the same year.

A committee for the drawing up of rules for ship construction to accompany the "Encouragement Act" was appointed. Rules in use in various countries were carefully studied, the Empire's interests were also considered, and the Regulations for Shipbuilding (based mostly on Lloyd's Rules) were thus constituted. These regulations came into force in September, 1896; they were the first Japanese rules for shipbuilding, and have been revised from time to time to keep pace with the general advancement of the industry. To bring them up to date, the new Lloyd's Rules (1910) have been taken into consideration, and revised regulations were issued in June last year.

The law for the encouragement of navigation showed a remarkable result; new routes for Europe, America, and Australia were soon started, trades along the coasts of Eastern countries were rapidly extended, and there was great expansion of shipping. The numbers of steamers at the end of 1899 had increased to 753, with an aggregate tonnage of 498,376 tons; compared with similar figures at the end of 1893, just before the Japan-China war, the number was doubled and the tonnage trebled.

Under the Shipbuilding Encouragement Act of 1896, the subsidy of 20 yen (1 yen = 24.582 pence) per ton was given for iron or steel vessels of more than 1000 tons, and 12 yen per ton for ships between 700 and 1000 tons, with an additional bounty for machinery at the rate of 5 yen per indicated horse-power actually developed on the official trial. The aim of this Act was to bring down the cost of imported materials to the level of prices paid by British shipbuilders, so that, assisted also by their cheaper labour, home builders could compete with the latter. But owing to the lack of experience on one side, and to the greater expenses incurred in equipment of shipyards and in keeping a larger stock of materials on the other, the cost of home-built ships was still very far from being so low as that of other maritime nations. The first ship built under the law was the Iyo Maru, of 727 tons gross, launched in 1897, and the most noteworthy ship at that period was the Hitachi Maru (torpedoed and sunk by a Russian warship in June, 1904), of 6172 tons gross; she was built at the Mitsu-Bishi Works in Nagasaki, in 1898, to the order of the Nippon Yusen Kaisha, which at the same time built, mostly in Great Britain, twelve steamers of similar size for their European service. The undertaking of so large a ship as the Hitachi Maru seemed rather a bold one, as the builders' experience of large shipbuilding was very limited at that time; but the ship proved in every way very successful, and orders for large ships began to be placed with the home shipyards. Since then ships built under the Encouragement Act have gradually increased in number (as shown in Table I. and also in Fig. 6). Earlier, the Mitsu-Bishi Works at Nagasaki, and the Kawasaki Dockyard Company at Kobe, were the only firms receiving shipbuilding bounties; but later the Osaka Iron Works, the Ishikawajima Shipbuilding and Engineering Company (Tokio Bay), and the Ono Shipyard (Osaka), were added to the list. Although ships under 1000 tons gross could receive no grant in the shape of navigation bounty, the extension of steamship routes around the coasts, together with the advancement in the art of shipbuilding, gave an inducement for the building of such small vessels, there being about thirty steamers of between 700 and 1000 tons built after the enactment of the law.

While the industry was making steady progress the war broke out with Russia in 1904, and a large number of

merchant steamers were again taken up by the army and navy for transport service.

In consequence, the shipping trade was in danger of being actually stopped, and to meet the urgent necessity a large number of steamers were purchased during the war. Thus at the end of 1905 the number of registered steamers had increased to 1390 vessels, of 932,740 tons, as against 1088 vessels, aggregating 657,269 tons, at the end of 1903 (see Fig. 5). During the war all shipyards, both Government and private, were busy with repairs, and not much work was done in point of new construction; the Tango Maru, of 7400 tons gross, launched at Nagasaki in 1904, was the only important vessel constructed at this period.

knots (loaded) on trial; in finish and fittings they are quite equal to the highest class Atlantic liners now afloat.

The Nippon Yusen Kaisha also improved their European service by the addition of six steamers of 8600 tons and 16 knots; the success attained in recent years by this company has been very marked. Of the new steamers four were built at the Mitsu-Bishi Works at Nagasaki and two by the Kawasaki Dockyard Company, Kobe. The Osaka Shosen Kaisha, which were formerly engaged chiefly in the coasting trade, opened a new line to the United States, and ordered six 6000-ton ships of 14 knots speed at the Mitsu-Bishi and the Kawasaki Works for the purpose. As a consequence of the general

TABLE II.—SHOWING THE TYPE OF VESSELS BUILT UNDER THE SHIPBUILDING ENCOURAGEMENT LAW, YEARS 1897-1910.

TYPE.	HEAVY-DECKED VESSEL.			SPAR-DECKED VESSEL.			AWNING-DECKED VESSEL.			SHELTER-DECKED VESSEL.			SHALLOW-DRAUGHT STEAMER.			TOTAL.		
Year.	No.	Gross Tonnage.	Indicated Horse-Power.	No.	Gross Tonnage.	Indicated Horse-Power.	No.	Gross Tonnage.	Indicated Horse-Power.	No.	Gross Tonnage.	Indicated Horse-Power.	No.	Gross Tonnage.	Indicated Horse-Power.	No.	Gross Tonnage.	Indicated Horse-Power.
1897	..	..	..	..	..	..	1	727	877	..	..	..	..	..	..	1	727	877
1898	2	7,691	4,193	..	..	..	..	..	..	..	..	..	..	..	..	2	7,691	4,193
1899	2	8,026	5,452	..	..	..	..	..	..	..	..	..	1	1,694	1,042	3	9,720	6,494
1900	..	..	..	2	3,144	3,798	..	..	..	..	..	..	2	4,489	4,452	4	7,633	8,250
1901	3	13,332	11,207	1	1,600	1,368	3	2,950	3,105	..	..	..	2	4,787	3,982	9	22,669	19,662
1902	5	13,943	12,724	1	1,933	1,565	1	1,075	1,335	..	..	..	..	..	..	7	16,951	15,624
1903	4	15,076	13,122	3	3,912	3,674	..	..	..	..	..	..	2	1,870	1,599	9	20,858	18,395
1904	3	10,548	10,835	6	5,120	5,272	..	..	..	..	..	..	..	..	..	9	15,668	16,107
1905	..	..	..	5	7,053	7,499	3	4,617	6,067	..	..	..	1	1,759	1,428	9	13,429	14,994
1906	1	6,715	5,519	7	7,052	6,904	3	3,981	2,372	..	..	..	2	5,046	4,413	13	22,794	19,208
1907	1	8,523	7,582	8	10,789	9,745	..	..	..	2	26,880	..	2	7,176	6,391	13	53,368	23,718
1908	4	34,043	34,917	4	6,675	11,404	..	..	..	..	..	..	..	..	..	8	40,718	46,321
1909	5	36,341	31,095	2	1,785	1,047	..	..	..	1	3,272	9414	..	..	..	8	41,398	41,556
1910	2	12,120	10,522	1	757	586	..	..	..	..	..	..	..	..	..	3	12,877	11,108
Total	32	166,358	147,168	40	49,820	52,862	11	13,350	13,756	3	30,152	9414	12	26,821	23,307	98	286,501	246,507

TABLE III.—SHOWING THE GROSS TONNAGE OF VESSELS BUILT UNDER THE SHIPBUILDING ENCOURAGEMENT LAW, YEARS 1897-1910.

GROSS TONNAGE.	UNDER 1000.		1000 TO 2000.		2000 TO 3000.		3000 TO 4000.		5000 TO 6000.		6000 TO 7000.		7000 TO 8000.		8000 TO 9000.		9000 TO 10,000.		ABOVE 10,000.		TOTAL.	
Year.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.
1897	1	727	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	727
1898	..	..	1	1,519	..	..	..	..	..	..	1	6,172	..	..	..	..	..	..	..	..	2	7,691
1899	..	..	2	3,411	..	..	..	..	..	..	1	6,309	..	..	..	..	..	..	..	..	3	9,720
1900	..	..	2	3,144	2	4 489	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	7,633
1901	2	1,447	3	3,815	2	4,787	..	..	..	..	2	12,620	..	..	..	..	..	..	..	..	9	22,669
1902	1	724	3	4,215	2	5,569	..	..	..	..	1	6,443	..	..	..	..	..	..	..	..	7	16,951
1903	3	2,615	2	3,167	2	4,470	..	..	2	10,606	..	..	..	..	..	..	..	..	..	..	9	20,858
1904	5	3,921	2	2,255	1	2,029	..	..	..	..	..	..	1	7,463	..	..	..	..	..	..	9	15,668
1905	2	1,523	5	7.680	2	4,226	..	..	..	..	..	..	..	..	..	..	..	..	..	..	9	13,429
1906	4	3,109	7	9,382	..	..	1	3,588	..	..	1	6,715	..	..	..	..	..	..	..	..	13	22,794
1907	5	3,964	1	1,808	2	5,017	2	7,176	..	..	..	..	..	..	1	8,523	..	..	2	26,880	13	53,368
1908	2	1,660	1	1,811	..	..	1	3,204	..	..	..	..	..	..	4	34,043	..	..	..	..	8	40,718
1909	2	1,785	..	..	..	..	1	3,272	..	..	3	18,542	..	..	1	8,512	1	9,287	..	..	8	41,398
1910	1	757	..	..	..	..	..	..	..	..	2	12,120	..	..	..	..	..	..	..	..	3	12,877
Total	28	22,232	29	42,207	13	30,587	5	17,240	2	10,606	11	68,921	1	7,463	6	51,078	1	9,287	2	26,880	98	286,501

TABLE IV.—SHOWING THE INDICATED HORSE-POWER OF VESSELS BUILT UNDER THE SHIPBUILDING ENCOURAGEMENT LAW, YEARS 1897-1910.

INDICATED HORSE-POWER.	UNDER 1000.		1000 TO 2000.		2000 TO 3000.		3000 TO 4000.		4000 TO 5000.		5000 TO 6000.		6000 TO 7000.		7000 TO 8000.		8000 TO 9000.		9000 TO 10,000.		TOTAL.	
Year.	No.	Indicated Horse Power	No.	Indicated Horse Power	No.	Indicated Horse Power	No.	Indicated Horse Power	No.	Indicated Horse Power	No.	Indicated Horse Power	No.	Indicated Horse Power	No.	Indicated Horse Power	No.	Indicated Horse Power	No.	Indicated Horse Power	No.	Indicated Horse Power.
1897	1	877	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	877
1898	1	305	..	..	..	..	1	3,888	..	..	..	..	..	..	..	..	..	..	..	..	2	4,193
1899	..	..	2	2,382	..	..	..	..	1	4,112	..	..	..	..	..	..	..	..	..	..	3	6,494
1900	..	..	2	3,798	2	4,452	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	8,250
1901	2	1,380	4	5,270	1	2 495	..	..	..	..	2	10,517	..	..	..	..	..	..	..	..	9	19,662
1902	..	..	4	5,531	2	4,645	..	..	..	..	1	5,448	..	..	..	..	..	..	..	..	7	15,624
1903	4	3,057	3	4,726	..	..	1	3,832	..	..	..	..	1	6,780	..	..	..	..	..	..	9	18,395
1904	5	3 894	2	3,272	1	2,438	..	..	..	..	..	..	1	6,503	..	..	..	..	..	..	9	16,107
1905	2	1,105	3	4,093	4	9,796	..	..	..	..	..	..	..	..	..	..	..	..	..	..	9	14,994
1906	4	2,891	6	7,722	..	..	1	3,076	..	..	1	5,519	..	..	..	..	..	..	..	..	12*	19,208
1907	5	2,959	1	1,347	2	5,439	2	6,391	..	..	..	..	..	..	1	7,582	..	..	..	..	11*	23,718
1908	2	1,049	1	1,207	..	..	..	..	..	..	..	..	..	..	..	..	3	25,905	2	18,160	8	46,321
1909	2	1,047	..	..	..	..	..	..	1	4,975	3	17,069	..	..	..	..	..	..	2	18,465	8	41,556
1910	1	586	..	..	..	..	..	..	..	..	2	10,522	..	..	..	..	..	..	..	..	3	11,108
Total	29	19,150	28	39,348	12	29,265	5	17,187	2	9,087	9	49,075	2	13,283	1	7,582	3	25,905	4	36,625	95	246,507

* Old engines were fitted in the Ishikari Maru, built in 1906, and turbine-engines for the Tenyo Maru and Chiyo Maru, built in 1907, were imported from England. These are not included in the numbers above.

Directly peace was established, and as a result of the fever for public enterprises, important shipping companies laid out extensive schemes for the expansion of their fleets, and this formed another epoch in the history of Japanese merchant shipbuilding. The Toyo Kisen Kaisha, which from 1898 had been running three steamers, each of 6000 tons gross and 17 knots speed, on the Pacific, for the passenger service between San Francisco, Japan, and China, decided to build the fastest and best equipped ships on the Pacific, and placed an order for three 20-knot passenger steamers of 13,500 tons gross each with the Mitsu-Bishi Works at Nagasaki; the first two, Tenyo Maru and Chiyo Maru, were finished in 1908. They are turbine driven, and attained an average speed of 20.6 expansion of trade, orders for smaller ships were also placed with different builders throughout the Empire. In addition to the above, the Imperial Navy had developed a big extension scheme in the very midst of the war, and invited some private firms to assist in the new construction. Thus all the important firms were crowded with orders, and they made enormous extensions in their premises, erecting new building berths and machine shops, and adding a large number of modern machine tools. The Mitsu-Bishi Works and Kawasaki Dockyard Company especially were developed to such an extent as to be comparable with first-class yards in Europe and America in all their equipments.

The rapid growth promoted by the Shipbuilding Encouragement Act can be clearly seen from Table I. and Fig. 6, page 108. The ships built under this Act are 98 in number, with an aggregate tonnage of 286,501 and total indicated horse-power of 246,507; in Tables II., III., and IV., annexed, they are classified according to type, gross tonnage, and indicated horse-power, and arranged in the order of launching. As will be seen, they comprise five passenger steamers, four of which are turbine-driven, two channel steamers, 64 cargo and passenger steamers, ranging in size from 727 tons to 8523 tons, eight cargo steamers, one oil-tanker, two training sailing ships with auxiliary machinery, one cable steamer, one salvage steamer, two lighthouse tenders, and 12 river steamers (all 12 used on the Chinese rivers, between Shanghai, Hankow, Ichang, and between Hankow, Shangtan, and Changteh, &c.) of from 935 to 3588 tons gross.

The total amount of subsidy paid has increased year by year in proportion to the advance of shipbuilding, and the progress of the industry has thus been largely due to assistance from national funds. For ships under 700 tons gross no assistance was given by the Government, but owing to the development of the coasting trade, a good many were built every year; and as timber has lately been getting scarce, owing to over-felling in old days, there is a natural tendency to construct even smaller vessels of steel.

Besides the ships for purely mercantile purposes, a few of the private shipyards have, in recent years, built for the Imperial and other navies. A number of torpedo-boat destroyers for the Japanese navy have been built by the Mitsu-Bishi, Kawasaki, and Uraga Dockyards and Osaka Iron Works. The despatch vessels Mogami and Yodo, of 1350 tons displacement each, were constructed at the Mitsu-Bishi and Kawasaki Works, respectively, the Mogami, as will appear later, fitted with Parsons turbines, the Yodo fitted with reciprocating engines. Light-draught gunboats for the Chinese Government, torpedo-boats and torpedo-boat destroyers, for the same country, and also for Siam, have been produced in the Kawasaki Dockyard. To another type belong the Sakura Maru and the Umegaka Maru, turbine steamers of 3200 tons gross, built by the Mitsu-Bishi firm for the Japanese Volunteer Fleet.

Semi-modern sailing ships are unknown in Japan, the only two large steel sailing-ships mentioned above having been built specially as training-ships for the Nautical College.

The building of minor craft, like dredgers and shallow-draught river boats, became specialised at the Osaka Iron Works, where, on account of the restricted depth of water, at the establishment, attention was more particularly directed to the building of vessels of somewhat small type, and the firm have turned out about 30 dredgers of all descriptions, ranging in dredging capacity from 100 to 800 tons per hour, the first dredger, No. 2 Taishun Maru, being completed in 1894. Dredgers, however, can now be constructed by all important builders.

The development of internal communications have necessitated the construction of shallow-draught river boats. Paddle-steamers of recent type, have, however, never come into general use, while the few stern-wheelers built have not proved very successful; the present tendency is more towards the adoption of the screw-steamers of light draught. The Osaka Iron Works patented a special type of this craft, and have from time to time built about 10 steamers, ranging in draught from 9 in. to 20 in.; the first boat, No. 1 Yuragawa Maru (43 ft. by 8 ft. by 2 ft. by 15 in. in draught), was launched in 1902.

Fishing boats in Japan were originally of junk build, small and unseaworthy; the Government passed an Encouragement Act in 1898, which was amended in 1905, with the object of improving them and enabling fishermen to go out into the open sea. Sealing schooners and whalers (some sailing barques after the American style, others, steamers after the Norwegian style) were built; and recently steam-trawlers and carriers with refrigerated holds have also been added. But the most noteworthy event in the improvement of Japanese fishing boats is the adoption of oil-motor craft; these vary in size from 20 to 30 tons gross, are somewhat similar in form to those of the English ketch, and are fitted with oil-motors of 15 to 40 brake horse-power. The first boat of this type, the Fuji Maru, 25 tons, was built in 1906, and proving successful was soon followed by many others; there are now about 400 vessels scattered all over the country.

Turning now to marine engineering, very little is known of its early days. The first marine steam-engine built in the Empire seems to have been that for the Chiyodagata, built in 1861, a geared engine, horizontal and non-condensing, with two cylinders 16 in. in diameter and 15⅝ in. stroke; her boilers were of a land type, 3 ft. 10 in. in diameter and 13 ft. 11 in. long, three in number, the working pressure being 38 lb. per square inch. For earlier steam vessels engines were mostly imported from abroad. The first compound engine built was in 1873, for the Kiyokawa Maru, by a firm in Nagasaki (not the Mitsu-Bishi), cylinders 12 in. and 21 in. in diameter respectively with a stroke of 18 in. Most marine engines made before the 'eighties were of single-expansion type, not exceeding 300 horse-power, and the engine for the Kosuge Maru, built in 1883, (mentioned in page 108), was the largest compound engine ever made in Japan (diameter of cylinders 36 in. and 63 in.; stroke, 36 in.; steam pressure, 60 lb. per square inch; indicated horse-power, 642).

Triple-expansion engines were introduced, in 1888, by purchase from England, and fitted in the Osaka Shosen Kaisha's steamers Ujikawa Maru of 270 tons, and some others; at about the same time the Miike Maru (referred to on page 108) and two other steamers fitted with triple-expansion engines were imported. Soon afterwards this type of engine began to be popular, the first being built

in 1890 at the Mitsu-Bishi Works, Nagasaki, for the Chikugogawa Maru (referred to on page 108), the size of cylinders 15 in., 23 in., 39 in.; stroke, 30 in.; steam pressure, 155 lb.; indicated horse-power, 472. After the enactment of the Shipbuilding Encouragement Act engines of larger size were built, the largest being that of the Nikko Maru, built in 1903 at Nagasaki, developing 6780 horse-power with a single set.

Very few quadruple-expansion engines have been made; the earliest and largest were those for the Wakamatsu Maru and her sister ore carriers, of 2400 indicated horse-power, built in 1902 at Nagasaki.

When steam turbines were generally accepted for marine purposes, the Mitsu-Bishi Works secured the licence for the construction of Parsons turbines, and have built two sets for the Japanese Volunteer Fleet steamers, the Sakura Maru and Umegaka Maru, of floating-docks of 7000 and 12,000 tons lifting capacity, and are doing mostly repair work.

The Kawasaki Dockyard Company, Limited, consisting of shipyards and engine works at Kobe, and steel foundry at Hiogo, are only next to the Mitsu-Bishi Works in their capacity. The works at Kobe were originally founded by the present Government, and were sold to Mr. Kawasaki in 1886, being again transferred in 1896 to the present company. They have been extended to nearly four times their original size, and now cover about 70 acres of ground, with a water frontage of 1 mile. There are five building-berths of 400 ft. to 650 ft. in length, a graving-dock 377 ft. long, and two hauling-up slips.

The Osaka Iron Works were commenced in 1880, and have engine works at Ajikawa-Guchi, shipyard at Sakurajima, and repair works at Temposan. They have four building-berths and three dry-docks; a fourth dry dock

gross, according to the respective class. For machinery construction the amount of 5 yen per indicated horse-power is given in all classes.

The necessity of promoting the iron and steel industry was recognised some time ago, and Government steel works were established in 1898 at Wakamatsu. After successive extensions the works now comprise three blast furnaces, eight Siemens-Martin's basic furnaces and two converters, and can produce nearly 100,000 tons of steel of different descriptions in a year. The quality of steel is quite up to the British standard, and plates and bars of any size and section can be supplied, but not yet in sufficient quantities to meet the demand of all home builders, both naval and private. The cost of production and selling price also leave a good deal to be desired. Builders have still to continue to import foreign material.

It will thus take some time before Japan can become

TABLE V.—GENERAL PARTICULARS OF PRINCIPAL TYPES OF SHIPS BUILT IN JAPAN.

Name of Steamer.	Service and Type.	Builder	Gross Tonnage.	Length.	Breadth.	Depth.	Draught.	Displacement.	Trial Results.		Engines.				Boilers.				Year of Completion.
									Speed	I.H.P.	No.	Type.	Cylinder. Diameter.	Cylinder. Stroke.	No.	Type.	Size. Diam.	Size. Length.	
				ft. in.	ft. in.	ft. in.	ft. in.	tons	knots				in.	in.			ft. in.	ft. in.	
Asahi Maru	Home trade cargo and passenger steamer	Kirby, Kobe	504	155 0	23 3	19 6	13 7	860	10.5	241	1	Compound	20¼ by 36	22	1	S.E.	11 6	10 0	1884
Chikugogawa Maru	Ditto	Mitsu-Bishi Works	710	170 0	28 0	18 0	13 0	1,060	11.14	437	1	Triple-expansion	15½, 23, 39⅛	30	1	S.E.	13 0	10 3	1891
Suma Maru	Ditto	Ditto	1,561	246 9	34 0	22 9	18 1¾	3,070	10.5	818	1	Ditto	18⅛, 30, 49½	36	2	S.E.	12 8	10 6	1895
Hitachi Maru	Ocean-going cargo and passenger steamer	Ditto	6,172	443 0	49 0	33 6	25 0	..	14.28	3,890	2	Ditto	20, 33½, 56	48	2	D.E.	13 3	17 0	1898
															2	S.E.	13 3	10 0	
Oura Maru	Salvage steamer	Ditto	716	186 0	29 0	16 2	11 6	1,005	12.3	690	1	Ditto	13, 22, 36	27	1	S.E.	13 3	10 1	1901
Daiya Maru	Ore-carrier	Ditto	2,798	320 0	42 0	25 0	18 0	5,432	13.25	2,365	1	Quadruple-expansion	20½, 29, 42, 60	45	1	D.E.	15 6	17 5½	1902
Niigata Maru	Cargo ship	Ditto	2,183	279 0	39 6	23 3	19 9	4,735	12.3	1,577	1	Triple-expansion	21, 35, 58	36	2	S.E.	12 0	10 9	1903
Shangkiang Maru	Shallow-draught river steamer	Osaka Iron Works	935	195 0	38 0	7 0	4 0	685	10.66	834	2	Ditto	10, 16, 28	15	1	S.E.	13 10¼	10 1½	1903
Nikko Maru	Ocean-going passenger steamer	Mitsu-Bishi Works	5,539	420 0	50 0	30 6	25 0	9,600	17.8	6,780	1	Ditto	31, 51, 85	54	2	D.E.	15 6	17 5	1903
															2	S.E.	15 7½	9 10½	
Taisei Maru	Auxiliary training ship	Kawasaki Dockyard	2,287	270 0	44 0	26 9	20 0	4,370	9.98	932	2	Ditto	13, 21, 33	27	2	S.E.	12 0	10 3	1904
Chohakusan Maru	Steam collier	Mitsu-Bishi Works	2,030	280 0	37 11	21 6	17 6	4,183	12.0	1,880	1	Ditto	21, 35, 58	36	2	S.E.	14 6	10 6	1904
Iki Maru	Channel steamer	Ditto	1,680	260 0	36 0	22 0	12 6	2,110	15.0	1,640	2	Ditto	16, 26, 43	30	2	S.E.	14 0	10 11	1905
Ogasawara Maru	Cable steamer	Ditto	1,455	243 3	34 0	22 3	15 3	2,526	13.0	1,790	2	Ditto	14½, 24, 40	30	2	S.E.	14 0	9 11	1906
Shiga Maru	Home trade cargo and passenger steamer	Osaka Iron Works	783	180 0	28 0	18 8	13 3	1,237	12.3	770	1	Ditto	14½, 24½, 39	30	1	S.E.	13 9	10 6	1906
Yohyang Maru	Shallow-draught river steamer	Kawasaki Dockyard	3,588	310 0	44 0	14 6	9 0	2,460	15.35	3,076	2	Ditto	17, 28, 46	33	2	S.E.	15 6	10 11	1906
Kagi Maru	Home trade cargo and passenger steamer	Ditto	2,509	300 0	41 0	24 0	18 0	4,268	15.0	2,811	1	Ditto	23, 38, 63	39	2	S.E.	15 0	11 6	1907
Tenyo Maru	Trans-Pacific liner	Mitsu-Bishi Works	13,454	550 0	63 0	38 6	31 8	21,660	20.6	20,000*	3	Parsons turbines	..	..	13	S.E.	15 9	10 10½	1908
Kamo Maru	Ocean-going cargo and passenger steamer	Ditto	8,523	465 0	56 0	34 6	27 0	15,970	16.4	7,520	2	Triple-expansion	25, 41½, 69	48	6	S.E.	14 3	10 11	1908
Sakura Maru	Volunteer Fleet steamer	Ditto	3,204	335 0	43 0	23 9	17 0	3,881	21.4	9,500*	3	Parsons turbines	..	..	6	Miyabara water-tube	13 4 / 8	18 11 / 4½	1908
Tacoma Maru	Ocean-going cargo ship	Kawasaki Dockyard	6,178	410 0	51 3	32 6	26 0½	11,825	14.15	5,000	2	Triple-expansion	19, 32¾, 55	46	3	S.E.	15 6	11 6	1909
Kiyo Maru	Oil-tank steamer	Mitsu-Bishi Works	9,287	470 0	56 6	33 0	27 11½	17,180	14.2	5,856	1	Ditto	29, 48, 78	54	4	S.E.	14 3	11 6	1909
Shimonoseki Maru	Railway ferry	Ditto	188	99 2	27 0	9 0	..	..	8.0	194	2	Ditto	6¾, 11, 18	12	1	S.E.	8 6	8 1½	1901
Robert K.	Ocean tug	Osaka Iron Works	321	125 0	24 0	14 0	12 0	..	12.25	557	1	Ditto	13, 21½, 36	27	1	S.E.	12 6	10 6	1904
Tamsui Go	Self-propelling bucket and pump dredger	Ditto	196	105 0	26 9	9 0	5 10½	299	6.5	100	1	Compound	12, 24	16	2	S.E.	8 6	9 0	1908
Dai-ichi Maru	Trawler	Ditto	199	103 0	21 6	11 10	10 0	300	10.25	406	1	Triple-expansion	11, 18, 30	22	1	S.E.	10 6	9 6	1908

* Approximate value.

9500 indicated horse-power, in 1908. Those for the Pacific liners Tenyo Maru and Chiyo Maru, and for H.I.M.S. Mogami, built in the Mitsu-Bishi Works in 1908, were imported from the Parsons Marine Steam-Turbine Company at Wallsend. The Mitsu-Bishi Works are now constructing a set of 20,000-horse-power turbines for the third ship of the Tenyo Maru class, and two others to the order of the Japanese Navy Department.

The Kawasaki Dockyard Company at Kobe hold the licence for building in Japan the Curtis marine turbine, and are now constructing some for the Imperial Navy.

Marine boilers built in the country were of iron till 1887, when the Mitsu-Bishi Works at Nagasaki made the first steel boiler for the steam-tug Yugawo Maru, of 206 tons, the steam pressure being 80 lb. per square inch. Steam pressure increased to 100 lb. about five years later, and with the introduction of triple-expansion engines, boilers for 150 lb. pressure began to be built. Water-tube boilers have not yet been used in the Japanese mercantile marine, except for the Volunteer Fleet steamers Sakura Maru and Umegaka Maru.

The number of private shipyards has greatly increased of late years, there being 230 in 1910, as against 66 in 1896. Of these the majority are of very small size, and only capable of building wooden sailing ships and junks. Only a few of them are provided with modern appliances. Among these the Mitsu-Bishi Dockyard and Engine Works, the Kawasaki Dockyard Company, and the Osaka Iron Works are the most important.

The Mitsu-Bishi Works at Nagasaki, the largest and oldest shipbuilding establishment in Japan, consist of the engine works at Akunoura, the shipyard and dry docks at Tategami, and the hauling-up slip at Kosuge. The whole works passed in 1884 by purchase from the Government to the present proprietors. Of late the works have been very much improved by enormous extensions, and now cover nearly 85 acres of land, with a water frontage of a mile and a-half; there are three dry-docks, the largest being 730 ft. long, and seven building-berths ranging from 185 ft. to 700 ft. in length. The firm has an experimental tank for experiments with models, and also a well-established technical school for the education of foremen and draughtsmen. The same company has a branch works at Kobe, where they possess two (over 400 ft. in length) is now in course of construction. In the matter of equipment, the principal shipyards are quite equal to first-class firms in Europe and America, but being later in the field than other nations, Japan has many advantages in avoiding experimental stages, and adopting the latest inventions and improvements much more freely and quickly. Most of the machine tools in the principal yards are electrically driven; hydraulic and pneumatic tools are now very extensively employed. The methods of handling heavy materials have undergone great changes; a 150-ton electric hammer-crane is installed at the Mitsu-Bishi Works, Nagasaki, and a floating crane of 165 tons lifting capacity is now owned by the Kawasaki Dockyard Company at Kobe; but none of the recent material-conveyors over building-berths have yet been adopted in private yards.

The Japanese shipbuilding industry has thus greatly advanced of late years, and its capabilities in the way of actual production have been proved in a good many instances. The effect of the application of the Subsidy Act already outlined has been very remarkable, but more remained to be done. The period of the enforcement of the Shipbuilding Encouragement Act of 1896 was to expire in 1911, but the shipbuilding industry is not yet independent of Government aid, neither can Japanese shipbuilders yet compete on equal terms with those of other maritime nations.

This problem has been taken up by the Government, and in 1908 a committee was appointed for the further investigation of protective regulations for ocean traffic; the revised laws for the encouragement of both navigation and shipbuilding were drafted out and passed by the Diet of 1909, to be in force from 1910 for a period of ten years.

A brief outline of the essential points of the revised law, as regards shipbuilding, is as follows:—The subsidy for ships of less than 1000 tons gross was withdrawn, for the reason that more assistance is needed for larger vessels, which enter into competition with foreign-built ships. Ships over 1000 tons gross are divided into two types, viz., passenger ships and non-passenger ships, which are again subdivided into four classes:—ocean service, home trade, coasting trade, and smooth-water service. The subsidy granted varies from 11 yen to 22 yen per ton perfectly self-supporting in the shipbuilding industry. On the day that the various deficiencies at present existing are made good, the subsidies may be withdrawn without injury.

In concluding this paper, it is the writers' earnest desire to acknowledge the very large debt that Japan owes to the assistance of Great Britain, without which the development of its shipbuilding industry could not possibly have advanced so speedily and with such satisfactory results.

TANK SHIP "VULCANUS" FITTED WITH DIESEL OIL-ENGINE.—As considerable interest now attaches to vessels fitted with Diesel oil-engines, the following particulars relating to the above vessel, which was recently constructed by Messrs. Perman and Co., Limited, 43-45, Great Tower-street, London, E.C., require no apology for their publication, particularly as the working of the boat has so far been very satisfactory. The leading dimensions of the vessel are:—Length, 196 ft.; beam, 37 ft. 9 in.; depth, 13 ft. 2½ in.; displacement, 1900 tons on load draught; and dead-weight capacity, 1000 tons of oil in bulk. The engine has six cylinders, and is of the four-cycle reversible Werkspoor-Diesel marine oil-engine type, made by the Nederlandsche Fabriek van Werktuigen en Spoorwegmateeriel, of Amsterdam. In a recent voyage from Rotterdam to Stockholm and back, a distance of 735 knots each way, the time occupied was 100 hours on the outward journey and 98 on the return. The vessel was loaded with 1000 tons of benzine in bulk on the outward voyage, and the maximum speed for 24 hours was 8.5 knots, the total consumption of oil being 16,281 lb. On the return journey, with 475 tons of water ballast on board, the maximum speed was 8.9 knots, and the consumption of oil 16,060 lb. This corresponds to about one ton of fuel for every 100 knots covered both out and home. As the price of suitable liquid fuel is about 42s. per ton, owners of steamships which carry about 1000 tons dead-weight will readily see, from the cost of 42s. per 100 knots, that the actual saving in the cost of fuel is 50 per cent. when compared with that of their steamships. To this must be added a further saving of wages on board, owing to fewer men being required.

ARMOUR FOR SHIPS (1860 TO 1910).*

By CHARLES E. ELLIS, Honorary Treasurer of the Institution.

THE period under review practically coincides with the history of the use of armour, and its manufacture for ships of war, from its inception to the present time. As will be seen, there has been an unbroken struggle for ascendency between the weapon of attack and the material produced to resist it, the advantage now lying with one side and now with the other, the most gratifying features being that it is a story of continuous development on both sides, modifications and improvements in ordnance necessitating and suggesting modifications and improvements in armour, and *vice versâ*. My object is merely to set out, historically, the principal features of the various types of armour, during the period in question, from which the modern plate has been evolved.

In the year 1860 there were under construction in France and England the first two armoured sea-going battleships, the Gloire, building at Toulon, and the Warrior, at Blackwall, the former having broadside protection of 5 in., the latter similar protection of 4½-in. iron plates. Of the two vessels, the Gloire was commenced in March, 1858, the Blackwall ship being ordered in June, 1859. The use of armour in the two navies, for all important vessels, was subsequently uninterrupted, and in this country armour was gradually increased in thickness until it culminated in the maximum of 24 in. of armour fitted on the sides of the Inflexible (1881).

Prior to 1860, a large number of experiments connected with the manufacture of iron armour plates had been made, the thickness varying from ½ in. to 4 in., and plates of this material, of varying dimensions, had been fitted to floating batteries in many countries of the world. It is somewhat difficult to state positively the names of the firms who were most successful at this period of the history of armour. I am inclined, from the materials at my disposal, to give the honour in France to the St. Chamond Company, and in England to the firm of Beale and Co., of the Parkgate Iron Works, near Rotherham. The former company held practically the monopoly of iron armour manufacture in France for a considerable period—1855 to 1870—and I am informed that their success was mainly attributable to the pure quality of their iron, and to the fact that, contrary to the general opinion, their plates were much improved by water treatment. In England the competition was much more severe, various makers competed against one another, both with rolled and hammered plates, with varying success, and in a paper written by Captain Inglis in 1862, giving a full account of various trials, the following are some of the practical conclusions which he laid down as the result of his investigations :

1. Good, tough wrought iron of high elasticity, but not necessarily of the highest ultimate tensile strength, is the best material for use in iron defences.
2. Rolled iron, though not perhaps equal in resistance to the best hammered iron, has such great advantage as to cost, if used in simple forms, as to justify its use when lightness is not of extreme importance.
3. In plates of ordinary dimensions, the resistance to cannon shot varies in proportion (approximately) to the square of the thickness of the plate.
4. Rigid backing is immensely superior to elastic backing, so far as the endurance of the front face is concerned.
5. The larger the masses,† and the fewer the joints, the stronger the structure, so long as the limits of uniform and perfect manufacture are obtained.

It is curious to note, in passing, how many of the conclusions of this eminent officer have been found to be applicable to nearly all the subsequent kinds of armour fitted for the protection of war vessels. I should like to quote here the opinion of another distinguished authority, Captain Dyer, on the results of the same experiments about the same period.

1. Plates of hard crystalline structure are inferior to those of a soft fibrous nature.
2. The great weakness in forged plates is unsoundness in welding.
3. The quality necessary for an armour-plate is ductility. The purer and better the iron is, the more this quality is perceptible : any impurity or alloy hardens the metal and produces brittleness.

Rolled armour, was in the end, adopted for use in all the ironclad vessels for the British Navy, including the Warrior. The following description of the method of manufacture, given at this period, is of interest: —"Several bars of iron were rolled 12 in. broad by 1 in. thick, and were cut 30 in. long. Five of these bars were piled and rolled down to another slab, and these two slabs were welded and rolled down to a plate 1 in. thick, which was sheared to 4 ft. square. Four of such plates were then piled and rolled down to one plate, measuring 8 ft. by 4 ft. and 2 in. thick. Lastly, four of these were piled and rolled to form the final and entire plate. There were thus welded together sixteen thicknesses of plate, each of which was originally 1½ in. thick, to form one plate 4½ in. thick. In this operation from 3500 to 4000 square feet of surface had to be perfectly welded by the process of rolling."

The increase in the calibre of guns, and to some extent the use of steel shot, soon brought about an increase in the thickness of wrought-iron armour. Thus we find experiments against 5½ in., 6½ in. and 7½ in. iron plates in March, 1863, with guns of varying diameter of bore up to 10 in., while the side armour of the Bellerophon (1866) was increased to 5½ in. in thickness. Another important factor in this connection was the introduction of Palliser's ogive hardened chilled iron shot, which was first tried at Shoeburyness in November, 1863, and afterwards, with slight modification in form, generally adopted for use in armour trials. Against these improvements in attack, the iron manufacturer could, at the time, only reply by increasing the thickness of his armour. This is exemplified by the following table, showing the maximum thickness of armour in later ships down to the period of the construction of the Inflexible :—

		Thickness of Side Armour. In.
1868 ...	Agincourt ...	5½
1870 ...	Repulse ...	6
1872 ...	Swiftsure ...	8
1874 ...	Rupert ...	11
1877 ...	Thunderer ...	12
1878 ...	Belleisle ...	12
1881 ...	Inflexible ...	24 (in two thicknesses of 12 in.)

In each case I have given the date of the completion of the vessel. In the meantime, however, important experiments were being carried on in connection with the use of steel for armour-plates. The Spezzia trials of 1876 proved that the resisting power of steel was far greater than that of iron, although the plate itself was broken up in the act of repelling the attack, which was, in this trial unduly severe. The manufacture of steel in large masses was, however, in its infancy ; the metal was wanting in toughness, and could not stand up to the racking effect of heavy projectiles.

Other interesting proposals were made and adopted at this period in connection with the use of steel. A notable case is that of the Polyphemus, in which compound steel plates, in two layers, were fitted by Sir Joseph Whitworth and Co., in the years 1879 to 1881, the inner layer being composed of steel plates of considerable area, with a tensile strength of 45 tons per square inch, the outer layer being formed of small steel plates about 10 in. square, having a tensile strength of 60 tons per square inch, all the plates being oil-hardened.

The introduction of compound armour about the same period, however, effected a revolution in ship protection. In the Inflexible the highest point, so far as iron protection was concerned, had been reached, and to meet the increasing power of the attack it had been found expedient to increase the thickness of side protection as above stated to 24 in., with the result that only the vital parts of the vessel were protected at all. The design was much discussed at the time in papers read before the Institution, and, curiously enough, it was during its construction that the new type of armour came to the front, and its quality was sufficiently proved to justify its adoption in the turrets of the same ship. The two Sheffield firms, Brown and Cammell, working on independent lines, conceived the idea of a steel face, welded to an iron back, the object being to break up the point of the shell by means of a hard steel face, and to hold the plate together by the tough iron back. The modes of manufacture were different in detail, the Wilson plate being made by casting a steel face on to the top of a rolled iron back ; while Mr. J. D. Ellis made a comparatively thin rolled-steel plate for the front of the target, and cast steel between it and the iron back. In each case the plate was subjected to heavy rolling after the casting was completed. Various proportions of steel and iron were tried, and in the result a proportion of about one to two was found to give the best results. The increase in resistance afforded by this type of armour was soon recognised in Great Britain, and its partial adoption for the turret protection of the Inflexible effected a saving of 600 tons in weight.

Speaking generally, the superiority of compound armour over iron was computed to be in the proportion of three to two, and it was generally adopted in the British Navy for a long period. Orders were given for all the armour for the celebrated Admiral class to be of the compound quality, together with a number of armoured cruisers, which were completed about the same time—1882 to 1889. On the Continent, the superiority of the compound plate was not so universally acknowledged, and in France the battleships building during this period were protected by steel and combined armour in about equal proportions.

Considerable improvements had been made by M. Schneider in the manufacture of solid-steel plates, and for a long period of years this eminent firm competed, with varying success, with the compound armour makers. Numerous International trials were held, of which the following were the most important :—(*a*) Spezzia, 1882 ; (*b*) Ochta, 1882 ; (*c*) Copenhagen, 1884 ; (*d*) Spezzia, 1884 ; (*e*) Pola, 1885 ; (*f*) Annapolis, 1890 ; (*g*) Ochta, 1890. It is not within the scope of this paper to give the result of these trials, but from an examination of the various reports it would appear that in *b*, *c*, *e* the superiority lay with the compound armour, and in *a*, *d*, *f*, *g* with the all-steel plate. In the case of the Annapolis trial, the superiority lay with a plate containing a considerable portion of nickel. The Ochta trial of 1890 introduced another firm as manufacturers of steel plates. Messrs. Vickers had produced an excellent solid-steel armour-plate in the year 1888, which was tested on the Nettle, and this class of armour was adopted for use, to some extent, at a later date by the British Admiralty.

M. Barba, the chief engineer of the Creusot Works, in a paper read before this Institution in March, 1891, strenuously argued in favour of the all-steel plate, but in the discussion that followed the preference generally appeared to be given to the compound plate. In the First Lord's Memorandum of the same year, explanatory of the Navy Estimates, it was expressly stated that for the main defence of first-class battleships compound armour was to be preferred, but that steel armour had been adopted for the secondary defence of battleships, for the protection of auxiliary armaments, and for the protection of machinery in vessels of the cruiser classes. In accordance with this decision, the main defence of the Royal Sovereign class and other vessels built at this period, consisted of compound armour, whilst the secondary armament of these ships was protected by 4 in. of steel. The greatest thickness of compound armour fitted to British ships was 20 in. tapering to 16 in. I refer to the Nile and Trafalgar, two powerful vessels carrying four 67-ton breech-loading guns.

Numerous experiments were, however, being made by all armour manufacturers, both with compound, steel, and nickel-steel plates, in order to improve their quality. Various processes of hardening were tried—air, steam, water, lead, and oil, all with more or less encouraging results. The earliest case I can find of water-hardening on one side only of the plate appears in the records of the eminent firm of Fried. Krupp, in 1885, in connection with a compound experimental plate (one-third crucible steel and two-thirds mild Siemens-Martin steel). This was followed by other plates, treated in the same way, the water impinging on the face by the force of gravity only ; but, as the firm were not makers of armour for ship protection at the time, the idea was not carried out beyond the experimental stage.

In England, the attention of Captain Tressider was drawn to the importance of making the face of the plate so hard as to break up the point of the projectile before it had time to effect any serious penetration. The particular process he adopted was the application of a cold douche of water, under sufficient pressure, and of sufficient volume, to prevent any envelope of steam forming on the face of the plate, and thus ensuring a rapid face chilling of consequent hardness. Various compound plates were tested, treated in this manner, and the object was attained. The best forged-steel armour-piercing projectiles were broken up by the hardened face, and a considerable increase of resisting power was obtained.

In October, 1891, however, a plate was being tested in America which was the precursor of a complete change in armour manufacture. Mr. Harvey had obtained considerable success in applying water-hardening to cemented steel, in the construction of small articles, and conceived the idea of the manufacture of armour-plates in the same conditions. The process was, shortly, as follows :—A solid-steel armour-plate was pressed and rolled, and highly cemented on the face ; it was then subjected to a severe water-hardening process, somewhat similar, in the later plates, to that above referred to. The resultant was a glass-hard face, with a mild-steel back, and subsequent trials in various parts of the world secured its nearly universal adoption. The resisting power of armour was raised by 50 per cent. Sir William White, in a speech made at the meeting of this Institution in 1894, put the superiority even higher, referring to experiments which showed that, so far as resistance was concerned, 6 in. of Harveyed steel was equal to 10 in. of compound armour. This being so, naturally we find in the battleships of this period a corresponding diminution in thickness of the plates utilised for ship protection ; thus in the well-known Majestic class (1895-1897) the thickness of side armour was reduced to 9 in., advantage being taken of the saving in weight effected by the new armour for a given resistance by fitting two tiers of the thickness above mentioned on the belt of the vessel, and greatly increasing the length so protected.

The best American results had been obtained with Harveyed nickel steel, but the value of the nickel alloy was not sufficiently proved by later experiments as to make its adoption universal. The Harvey plate, however, with all its merits, had one defect ; the back was not sufficiently tough to withstand the racking effect of steel projectiles. It is due to the genius of the experts of the firm of Fried. Krupp that a most valuable improvement was effected in this connection. After various experiments with different alloys of mild steel, chrome steel, and nickel-chrome steel, the first properly so-called Krupp plate was made in the year 1894, and on trial gave excellent results. In this plate, which was in nickel-chrome alloy, for the first time the principle of differential treatment in the final processes of hardening was adopted. A special heating-furnace was built, and the temperature of the face of the plate was raised to a certain depth, sufficiently to allow of the highest degree of hardness being obtained. The remainder of the plate was only heated sufficiently to ensure toughness and a fibrous structure when hardened by water. The hardening was then effected by spraying under pressure the front and back of the plate simultaneously until completely cooled.

In the following year the results obtained by this mode of treatment were repeatedly confirmed, and the invention became a practical success. The crystalline structure of the back of the Harvey plate was replaced by a tough fibrous quality, which prevented cracking, and, by spreading the resistance to the impact of the projectile over a wider area, assisted materially in reduction of penetration. Trials of similar plates made by British makers followed, with similar results, and this class of armour was soon afterwards universally adopted in the Service.

In the year 1894 it was my privilege to be allowed to give to the Institution the results of trials of Harveyed armour, and it will be of interest to give a few instances of trials of the more modern type, without going into detail, but giving particulars sufficient to show the advance that had been obtained in ship protection. In 1899 a trial of a Krupp plate 5.9 in. in thickness took place. Six shots (Wheeler-Stirling armour-piercing projectiles) were fired at striking velocities ranging from 1928 to 2211 foot-seconds. In each case the projectile was completely broken up, the greatest penetration did not

* Paper read at the Jubilee Meeting of the Institution of Naval Architects, July 7, 1911.

† It was subsequently proved at Shoeburyness, conclusively, in 1877, that a solid plate of 17 in. to 17.5 in. was the equivalent, so far as resistance was concerned, to three plates of 6.5 in. each.

exceed 5 in., and the plate was practically free from cracks, a slight opening only being observable in the bulge at the back in the case of one of the shots. The behaviour of a plate 8 ft. square by 8.8 in. in thickness was practically similar when attacked by an 8-in. armour-piercing projectile with velocities of 1854, 1964, and 2039 foot-seconds respectively. I give a further instance of a plate 12 in. thick tested in 1897. The plate, which measured 10 ft. by 7 ft., was attacked by three armour-piercing projectiles of high quality, weighing 720 lb. each, at velocities of 1860, 1861, and 1868 foot-seconds. In each case the projectile was completely broken up, no cracks appeared in the plate, and the greatest penetration was computed to be 2.75 in.

The instances above given are put forward as being fairly representative, and not selected as showing the highest point of efficiency this type of armour has reached. They are, however, sufficient to show the great characteristics of the Krupp plate; resistance to perforation, and practical freedom from cracking. In each case the plate could have stood considerably more punishment. Summing up the results, it would appear that the relative thickness of wrought iron to give equal resistance to the attack would be, according to the recognised formula, from 230 to 280 per cent. of the thickness of the plate tried, and it must be remembered that in no case was the plate tested to the point of complete perforation.

The superiority of the Krupp type of armour has been long acknowledged. It must not, however, be assumed that finality has been reached. It may well be that, particularly in connection with capped projectiles of large diameters, as compared with the thickness of armour attacked, improvements will be made, and this Institution may rest assured that armour-plate manufacturers are very desirous of taking advantage of any invention of practical utility which may be brought to their notice, or which may be discovered in their own research laboratories. Consideration of these matters may, however, be left to the future.

I feel, in conclusion, that I have only touched on the fringe of this great question. Had it been possible, I should have liked to refer in detail to the excellent work which has been done by the various firms individually in connection with the manufacture of armour, and to have noted the great success which the newest of the armour-making countries, Japan, has achieved in supplies to war vessels, both battleships and cruisers. I should have liked, also to have referred to the important question of power of production in the various armour-making countries of the world. These are facts, however, well known to many of the foreign guests of the Institution. It is sufficient to say that the world supply appears more than equal to the world demand, and, speaking in the name of armour makers generally, I am confident that any increased requirements will be readily met, whether in quantity or quality. At any rate, no effort has been, or will be, spared to give to the navies of the world the best protection that can be devised. Many papers have been read at this meeting illustrating the great advance which has been made during the past fifty years in various branches of naval architecture and marine engineering. I trust that the remarks I have had the honour to make may be sufficient to show that, in the manufacture of armour for ships during the same period, satisfactory progress has been achieved, commensurate with the great importance of the subject.

THE LATE MR. GUSTAVE CARELS.—We regret to record the recent death of Mr. Gustave Carels, head of the well-known engineering company, the Société Anonyme des Ateliers Carels Frères, Ghent, Belgium. The deceased, together with his brother, Mr. Alphonse Carels, succeeded, in 1873, to their father, the late Mr. Charles Louis Carels, the founder of the firm. Mr. Carels, senior, commenced the construction of steam-engines and hydraulic machinery in 1838, the latter machinery being specially built for draining the marshy lands in the Low Countries. He undertook, in 1851, the construction of railway rolling-stock, and, in 1865, that of locomotive engines. Mr. Carels, senior, died in 1873, and his two sons, on taking over the business, as aforesaid, made it a special point of developing their export trade, a matter in which they have been most successful, their firm being now universally known. They exhibited, in 1880, at Brussels the first compound steam-engine built in Belgium, one novel feature of which was the rope-drive. In 1898 they introduced steam-engines working with superheat. They started building the Diesel internal-combustion engine in 1900, and, since, they have so greatly improved it that licences for their type, the Diesel-Carels engine, have been purchased from them by engineering works in this country, France, and Germany. Mr. Gustave Carels had long held the opinion that the organisation of professional education was a social duty, and he was convinced that when the Belgian working classes had the advantage of a suitable and rational technical and trade education, this, added to their natural skilfulness and industry, would enable the country to maintain and to improve the very favourable place she had succeeded in gaining for herself in foreign markets. He joined example to precept, and, in conjunction with his brother, he founded an arts and crafts school in Ghent, on whose work and progress he always kept himself carefully informed. He was the moving spirit of the proposed Ghent Exhibition of 1913. Mr. Gustave Carels was Commander of the Order of Leopold, Belgium, Officer of the Legion of Honour, France, and had a large number of other foreign distinctions. In him Belgium loses one of her most patriotic sons and most enterprising engineers.

FOREIGN AND COLONIAL ENGINEERING PROJECTS.

WE give below a number of engineering projects, concerning which further information can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C.

Egypt: The following information is from the report by H.M. Vice-Consul at Alexandria on the trade of that district in 1910, which will shortly be issued:—There was last year an increase in the imports of chemical manures, due to the increasing demand for intensive cultivation, chiefly of agricultural crops, and to some extent (in Alexandria only) of vegetables and fruit. Of a total of 35,559 tons imported into Egypt in 1910, of which 50 per cent. came from Belgium, 33 per cent. from Chili, and 14 per cent. from the United Kingdom, there were 30,505 tons of nitrate of soda, 3318 tons of superphosphates, 1660 tons of sulphate of ammonia, and 76 tons of miscellaneous manures. There is also an increasing demand for potassic manures for use on poor lands. The British share of the chemical manures imported in 1910 is four times as much as in 1909, and constitutes one-seventh of a total that has increased by 66 per cent. Tenders for the Kait Bey, or western branch of the East Port breakwater, are to be asked for during 1911; six months are to be allowed for the consideration of the project by contractors. The main drainage scheme of Alexandria has not yet been started, as the formalities for the loan have not yet been completed.

Southern Nigeria.—The Commercial Intelligence Branch of the Board of Trade is in receipt of a copy of an Ordinance (No. 12, of 1911) of Southern Nigeria providing for the raising of a loan of 3,500,000*l.* for public works, as follow:—Lagos harbour works, 739,215*l.*; Lagos wharfage scheme, 500,000*l.*; Apapa extension and wharf, 42,825*l.*; railway extension and construction, 1,101,028*l.*; rolling-stock, 200,000*l.*; loan to Northern Nigeria to complete Baro-Kino line, 200,000*l.*; Niger bridge, north and south (with line across Jebba Island), 130,925*l.*; Lagos water supply, 340,000*l.*, &c.

French West Africa.—The *Journal Officiel du Sénégal* publishes a decree granting an extraordinary credit of 5,130,000 francs (205,200*l.*) to be expended as follows:—Extension of Guinea Railway from Kurussa to Kankan (Niger-Niandam section), 2,170,000 francs (86,800*l.*); extension of Porto-Novo to Sakete tramway, 1,000,000 francs (40,000*l.*); construction of branch of Theis Kayes Railway from Guinguineo to Kaolack, 1,800,000 francs (72,000*l.*); construction of five sheds at port of Dakar, 160,000 francs (6400*l.*).

Netherlands: H.M. Minister at the Hague reports that a contract has been entered into between the Netherlands Government and M. Jacob de Bourgraaf, of Flushing, for the execution of embankment works at Axelsche Gat, near Hoek, in Southern Zeeland.

Italy: The *Gazzetta* contains a copy of a decree granting to Giosuè Tortora e Cia., Pagani, a concession for the construction of a railway from the station of Pagani, on the Naples-Battipaglia State Railway.

Spain: The *Gaceta de Madrid* contains a decree authorising the Spanish Ministry of Marine to invite tenders for the following works:—(1) Construction and installation of a bridge between the Carraca Arsenal and Avanzadilla; (2) repair, &c., of the channels communicating with Dam No. 4 of the arsenal, and, if necessary, extension of the work now in prospect, for the immediate use of the dam; (3) construction in the arsenal of a tug-boat, tank-boats for water transport, and lighters. The *Gaceta* also announces that tenders will be received up to September 9 next at the Dirección General de Obras Públicas, Madrid, for the construction of a horse tramway from Villarreal to Grao de Burraiana, in the province of Castellon. The estimated cost of construction is 81,171 pesetas (about 3000*l.*). Although the foregoing contracts will in all probability be awarded to Spanish firms, nevertheless the carrying out of the works may involve the purchase of some materials out of Spain.

Portugal: The *Diario do Governo* contains a notice, issued by the General Directorate of Public Works and Mines, inviting tenders for the construction of a bridge across the River Sorraia Velho, situated between Coruche and Monte da Barca. The upset price is put at 8000 milreis (about 1600*l.*), and a deposit of 200 milreis (about 40*l.*) will be required to qualify any tender. Tenders will be received up to September 17 at the offices of the Direcção Geral das Obras Publicas e Minas, Lisbon.

Russia: H.M. Commercial Attaché for Russia reports that Imperial authorisation has been given to the town of Ekaterinoslav to conclude a bond loan of 2,600,000 roubles (about 274,000*l.*) for tramway and water-works extensions, building operations, &c., and to the town of Reval to conclude a loan of 1,500,000 roubles (about 158,000*l.*) for town needs. The *Deutscher Reichsanzeiger* (Berlin) states that tenders are invited by the municipal authorities of Ssysran for the construction of an electric tramway and an electric lighting system. Tenders, for both undertakings or for the lighting system only, will be received at Gorodskaya Uprava, Ssysran, up to October 14. According to the *Moniteur des Intérêts Matériels* (Brussels) tenders are invited by the Ministry of Commerce, St. Petersburg, for the construction and improvement of dry docks and of chain-testing stations, at a cost of 1,982,000 roubles (about 209,000*l.*).

Mexico: H.M. Consul-General at Mexico City reports that, according to the *Mexican Herald*, the concession granted in January last for a railway from Port Lobos, Sonora, to Sasabe, on the frontier, has been purchased by the Arizona and Gulf Railroad Company. The first 50 kilometres must be completed within two years from April 26, 1911.

Uruguay: The *Diario Oficial* contains a decree, issued by the Ministry of Public Works, approving in general the plans submitted by the Pan-American Trans-Continental Railway Company for the construction of a railway from Colonia to San Luis, in accordance with the modifications introduced by the National Department of Engineers.

Brazil: H.M. Consul at Porto Alegre reports that a company is being formed in that town under the name of the "Alliança do Sul, Sociedade Anonyma," with a nominal capital of 2,000,000 milreis (about 133,000*l.*), to import machinery, building requisites, iron, &c. The *Diario Official* publishes Decree No. 8627 authorising the Compagnie Française du Port de Rio Grande do Sul to construct a branch line of railway from the Capão do Leão stone quarry to the station at Pelotas. It also contains Decree No. 8775, opening, in favour of the Ministry of Communications and Public Works, a credit of 250,000 milreis (about 17,000*l.*) for the purpose of extending the Central Railway of Brazil from Lafayette, by way of Bello Horizonte, in the direction of Paraopeba.

THE WESTINGHOUSE COMPANY.—The gross earnings of the Westinghouse Electric and Manufacturing Company in 1910-11 were 38,119,312 dols., showing an increase of 8,870,630 dols. as compared with 1909-10. The net income for 1910-11 was 4,881,105 dols., a gain of 1,820,441 dols. The profit for the year was altogether 5,964,224 dols. The value of the property and plant owned by the company is set down at 17,692,146 dols.; the investments held amounted to 24,034,636 dols., and the working and trading assets were 14,321,474 dols. The company has a funded debt of 22,607,000 dols.; the capital represented by its stocks at the close of 1910-11 was 40,693,288 dols. The revenue of the British subsidiary company has not been sufficient to clear working expenses and the up-keep of patents during the last two years. The book value of this property has been written down by 1,273,000 dols. The operations of the French subsidiary company have also been unprofitable, although it earns sufficient to clear its interest charges. Debentures of this company are carried on the books of the Westinghouse undertaking at 1,430,731 dols. The operations of the Italian subsidiary company have not produced results equal to expectations, in consequence of delay on the part of the Italian Government in improving its railways. The Russian subsidiary company has also been a losing proposition, the aggregate loss to date having been 1,800,000 dols. The Austrian subsidiary company has been fairly prosperous. The Canadian Westinghouse Company has also been successful, and has paid dividends regularly since 1903 at the rate of 6 per cent. per annum.

THE ROYAL SANITARY INSTITUTE.—This institute has now issued its final programme for the Congress, to be held in Belfast from Monday the 24th to Saturday the 29th inst. A large number of visits of inspection and excursions have been arranged for. The following subjects have been arranged for discussion in the various sections: Section I.—Sanitary Science and Preventive Medicine: "The Prevention of Typhoid Fever," to be opened by Alderman J. King Kerr, M.D., M.Ch., J.P. "Sewage Purification," to be opened by Samuel Rideal, D.Sc., F.I.C. Section II.—Engineering and Architecture: "The Planning of a Modern City, from an Engineer's Point of View," to be opened by Chas. Brownridge, M. Inst. C.E., Borough Engineer and Surveyor, Birkenhead. "Model Bye-Laws in relation to Architectural Practice," to be opened by H. D. Searles-Wood, F.R.I.B.A. Conference of Municipal Representatives: "Municipal Lodging Houses." "Municipal Hospitals," to be opened by Philip Boobbyer, M.D., M.S., M.R.C.S., M.O.H., Nottingham. Conference of Port Sanitary Authorities: "Plague Precautions in reference to the destruction of Rats," to be opened by Herbert Williams, M.D., D.P.H., M.O.H., Port of London. "The Importation of Unsound Food," to be opened by William Hanna, M.B., D.P.H., Assist. M.O.H., Port of Liverpool. Conference of Medical Officers of Health: "The Possibilities of Extension of the System of Compulsory Notification of Disease," to be opened by Meredith Young, M.D., D.P.H., County M.O.H., Cheshire. "The Medical Officer of Health in Ireland," to be opened by Samuel Agnew, M.A., M.D., M.O.H., Lurgan. Conference of Engineers and Surveyors: "The Discharge of Sewage into Tidal Waters," to be opened by W. Harpur, M. Inst. C.E., City engineer and surveyor, Cardiff, from the engineer's point of view. "The Discharge of Sewage into Tidal Waters," to be opened by Professor E. A. Letts, D.Sc., Ph.D., F.R.S.E., F.C.S., from the scientific standpoint. "The Dust Nuisance, its Evils and Abatement," to be opened by John S. Brodie, M. Inst. C.E., Borough engineer and surveyor, Blackpool. Conference of Veterinary Inspectors: "The Hygiene and General Arrangements of a Modern Slaughter-House." "Meat Branding and the Uniformity of Meat Inspection," to be opened by W. G. Barnes, M.R.C.V.S., Chief Veterinary Inspector and Superintendent of Abattoirs, Metropolitan Cattle Market, Islington. Conference of Sanitary Inspectors: "The Smoke Nuisance and its Abatement," to be opened by John Macaulay, Chief Smoke Inspector, City of Liverpool. "Dairies and Milk Supply, from a Sanitary Inspector's Point of View," to be opened by John T. Cowderoy, Chief Sanitary Inspector, Kidderminster. Conference of Women on Hygiene: "The State Endowment of Mothers," to be opened by G. Eric Prichard, M.A., M.D., M.R.C.P. "The Reduction of Infant and Child Mortality from Measles," to be opened by John McCaw, M.D., L.R.C.P. Conference on the Hygiene of Childhood: "The Hygiene of School Life," to be opened by Professor J. A. Lindsay, M.A., M.D., F.R.C.P. "Infantile Mortality in Towns," to be opened by Alfred Greenwood, M.D., D.P.H., M.O.H., Blackburn.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

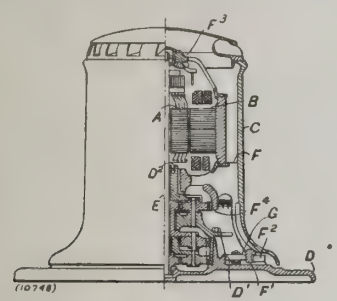
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

LIFTING AND HAULING APPLIANCES.

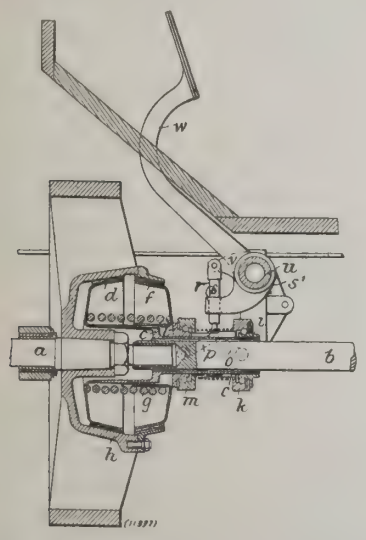
10,748/10. J. A. Liddle, Edinburgh. Capstans. [8 *Figs.*] May 2, 1910.—According to this invention, an electrically-driven capstan comprises in construction an electric motor, the component parts of which are arranged concentrically to the barrel of the capstan, and in one form comprises the adoption of an electric motor in which the armature and field-magnets are arranged in driving connection with one another and adapted to rotate in opposite directions, and, further, constructs a capstan having an electric motor, and associated gearing, mounted above the base on which the capstan is arranged and housed within, or mainly within, the barrel of the capstan. The electrically-driven capstan shown embodies an electric motor having an armature A and a field element B mounted to rotate in opposite directions, the field element B being associated in construction with a capstan barrel C, a driving connection being established between the armature and field element, which, in the operation of the motor, imparts the required drive to the capstan barrel. The component parts of the electric motor and associated gearing are disposed upon a base-plate D, on which the capstan is mounted, and housed entirely within the barrel C. The base-plate D is circular, and



is provided at its centre with a step-bearing, to receive the foot of the armature-shaft. For the support of the frame F, carrying the field element B, bearings are provided associated with an inner complementary bearing-race D^1, formed as a flange projecting from the base-plate D. Between these races a circular series of rollers G are disposed, and provision made, if required, for keeping them distanced apart. The periphery of the annular rim F^1 may be formed with teeth, into which a pawl F^2, or series of such pawls, pivoted on the base-plate D, are adapted to engage in order to restrict the rotation of the frame to one direction only. For the further support of the frame F and armature shaft other bearings may be provided; for example, the frame may comprise a crown F^3, formed with a bearing at the centre of its head to receive the top of the shaft E, and, if required, a bearing D^2 may be formed to support the shaft. For establishing a working connection between the armature shaft and the frame F, gearing may be interposed between, say, the foot of the shaft and an annular toothed wheel F^4 formed on the frame F. (*Accepted May* 10, 1911.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

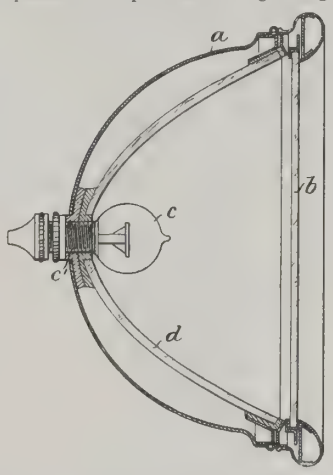
11,337/10. Daimler Motoren Gesellschaft, Untertürkheim, Germany. Friction-Clutches. [2 *Figs.*] November 26, 1909.—In a double-friction cone-coupling with reversed friction cones in which an axial tubular extension of one of the movable friction cones passes through the other or outer friction cone and is axially movable on the shaft to be coupled,



lever mechanism is arranged between the outer cone and a collar on the tubular extension of the second cone, the lever mechanism being adapted, when operated, to move the two cones towards one another and away from their co-operative surfaces. The driving shaft *a* is aligned with the driven shaft *b*, and a sleeve *c* is axially movable on the shaft *b*. A friction cone *d* is fixed to the sleeve *c*, which also supports a second friction cone *f*, the latter being axially movable, but prevented from rotating on the sleeve. The two friction cones are pressed asunder by a spring *g*, so that they bear against the corresponding friction surfaces of the enlarged hub *h* of the fly-wheel. A ring *i* is securely seated on the end of the sleeve *c*. This ring *i* is formed as a ball-race, and a ring *k* constitutes the counter ball-race and serves to displace the clutch part *d*. Outside of the friction-cone *f* is seated loosely on the sleeve *c* a ring *l*, formed as a ball-race, with the corresponding ring *m* serving for displacement of the clutch part *f*. The two rings *m* and *k* are pressed apart by a spring, so that they bear against the balls situated between them and the rings *l* and *i*; the ring *l* resting against the friction cone *f*. The two arms *o* and *p* of the toggle, the knee joints of which are connected with push-bolts *r*, are pivotally connected with the rings *k* and *m*. The push-bolts *r* are movable in vertical guiding sockets *s* carried by a sleeve or ring s^1 fixed to the shaft *u*. The upper ends of the push-bolts *r* are jointedly connected with arms *v*, fixed on a sleeve on which the pedal lever is also fixed, the sleeve being revolubly mounted on the supporting shaft *u*. If it is desired to disengage the coupling, the push-bolts *r* are pressed down by pressing down the foot-lever *w*. By this means the two arms *o*, *p* are spread, and the rings *k* and *m* are pressed apart and act on the rings *i* and *l*, so that the ring *i* is moved to the right and the ring *l* to the left. The ring *i* is securely connected with the sleeve *c*, and moves the latter, and therefore the friction cone *d*, to the right; whilst the ring *l*, which bears direct against the friction cone *f*, moves the latter to the left. By this means the two friction cones are simultaneously moved to the same extent from their respective friction surfaces on the enlarged fly-wheel hub *h*, and the coupling is thus disengaged. (*Accepted May* 10, 1911.)

MOTOR ROAD VEHICLES.

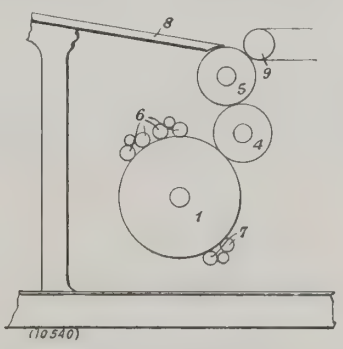
14,159/10. S. O. Cowper-Coles, London. Motor-Car Lamps. [1 *Fig.*] June 11, 1910.—According to this invention, the lamp consists of an outer casing in which is fixed a deep glass reflector of parabolic form provided with a gold or golden-coloured



reflecting surface. *a* is the lamp casing, *b* is the front protective glass, *c* the source of light, and *d* the deep glass reflector of parabolic form. Apertures are provided in the lamp casing and the glass reflector to admit the electric lamp-holder c^1. The reflector *d* is held in position by mounting rings. (*Accepted May* 10, 1911.)

PRINTING AND ALLIED MACHINERY.

10,540/10. A. H. Walker, London, and H. Pearce and T. R. G. Parker, Broadheath. Offset Printing-Presses. [1 *Fig.*] April 29, 1910.—The improvements refer to the relative diameters and positions of the forme-cylinder and offset and impression cylinders. 1 is the forme-cylinder, 4 is the offset cylinder which receives the impression from the cylinder 1 and transfers it to the paper carried around by the impression-cylinder 5, which latter is provided with the usual grippers. 6 are the inking-rollers, 7 the damping-rollers, 8 the feed-board, and 9 a part of the delivery mechanism. Concerning especially the cylinders



1, 4, and 5, the two last-mentioned cylinders are both of the same diameter and each is of half the diameter of the cylinder 1, and further the axes of the three cylinders are situated in three different vertical planes, the vertical plane containing the axis of the impression cylinder 5 being between those containing the axes of the cylinders 1 and 4. The cylinder 1 has attached to it the usual lithographic plate, which extends around practically one-half of its circumference, and for each sheet printed, it makes one complete revolution, while the cylinders 4 and 5 make two complete revolutions each. (*Accepted May* 3, 1911.)

PUMPS.

17,875/10. J. S. Raworth and T. Browett, London. Rotary Pumps. [5 *Figs.*] July 27, 1910.—In rotary pumps of the kind in which radially-arranged blades are distributed around a rotor, and are movable parallel to the axis of the same, the longitudinal or reciprocatory movements of the blades during the rotation of the rotor are effected by a cam that is disposed and arranged to act upon a part of each blade that does not abut against, or make contact with, the end wall of the cylindrical casing containing the rotor. 1 is the cylindrical casing which contains the rotor. The parts 3, 4 form the end closures of the casing 1. The inner face of each end closure is not made as of one plane, but is in two planes, which are in parallelism, and each end closure, as seen in elevation, comprises two sector-like parts, the one sector being smaller, or extending through a smaller angle than the other sector. The inner face of each sector is in one plane only, and the plane of the inner face of the smaller sector (11 or 13) is nearer the centre of the length of the casing than is the plane in which the inner face of the larger sector (12 or 14) lies. The disposition of the sectors on the end closures is such that when the end closures are placed in position, the sector 11 is opposite the sector 14, and the sector 12 opposite the sector 13. 16 is the cam for operating and reciprocating the blades within the grooves of the rotor. The cam is formed or

Fig.1.

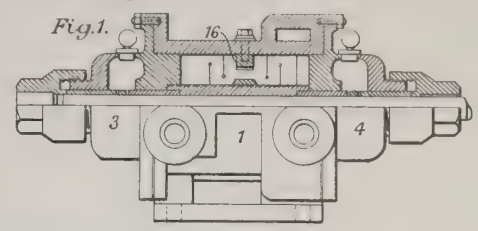


Fig.2.

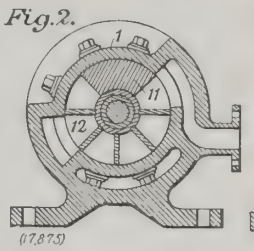
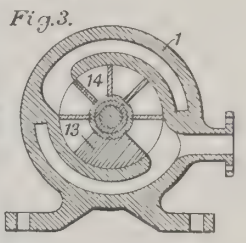


Fig.3.



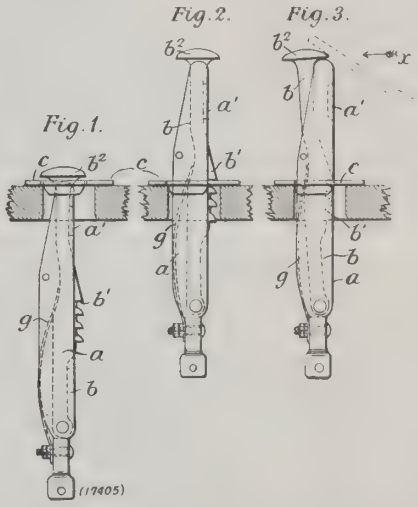
(17,875)

mounted on, and extends around the full length of, the inner periphery of the casing, and is disposed at or about the centre of the length thereof. The blades are cut away or recessed on their outer edges, and in these recesses the cam 16 enters and engages. The rotor is also cut away or recessed around its periphery in a similar manner to the blades, but the width of the recess in the rotor is greater than the width of the recesses in the blades, and is equal to the travel or movement of the blades plus the width of the cam. The cam may be made in one piece, or may be of segmental construction, and is secured in position by set screws or bolts, which pass through the wall of the casing, and enter holes in the outer face of the cam. (*Sealed July* 13, 1911).

RAILWAYS AND TRAMWAYS

17,405/10. J. Whiteley and J. M. Moss, Manchester. Tramcar Lifeguards. [7 *Figs.*] July 22, 1910.—A re-setting-rod for the lifeguards of tramcars is characterised, according to this invention, by being made in two parts, whereof one is shorter than the other, and is pivoted at a point above the lower end of such other part. Either part at its upper end is formed with the usual foot-plate, and both parts are designed to pass through a slot in a plate fixed to the floor of the vehicle. In one edge of the shorter part are formed notches or teeth, and fixed at one extremity to the longer part, and at the other and free extremity pressing against the shorter part is a spring. Under the action of this spring the two parts are caused to bear respectively against the opposite ends of the slot in the plate. The two parts are indicated by the letters *a* and *b*, the part *a* being the longer and comprising a bifurcated member designed to receive the part *b*.

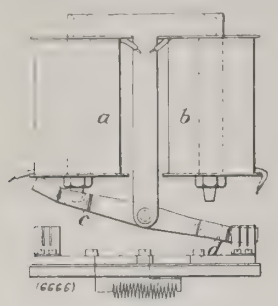
Fig.1.



c is the plate fitted to the floor of the car, and through a slot therein and in the floor passes the rod. The slot in the plate *c* is of such dimensions as to insure the rod engaging with one or other edge when raised. The part *b* about midway of its length is provided with teeth b^1. Secured at one end to the part *a* is a spring *g*, which, at its free extremity, bears against the part *b*, and holds this part in contact with the part a^1 of the part *a*. The part *b* also carries the foot-plate b^2, which, with the rod in its normal position, rests clear of the plate *c*. When, therefore, the rod is raised by the action of the lifeguard until one of the teeth b^1 lies above the plate *c*, the spring *g* holds the parts in such positions and the tray is lowered. In this position, however, the teeth can be readily freed from the plate *c* by the driver of the car pressing the foot-plate b^2 in the direction of the arrow *x*, the spring only resisting the unlatching of the resetting-rod by the lifeguard. (*Accepted May* 3, 1911.)

6666/10. J. Stone and Co., Limited, Deptford, and A. H. Darker, Blackheath. Lighting, Heating, and Ventilating Railway Trains. [8 *Figs.*] March 16, 1910.—In electrical systems intended more especially for the lighting, heating, and ventilating of trains, automatic apparatus is arranged and operates always to connect the terminal of the fan or like motor circuits directly and without interposition of resistance with the brush of the dynamo, which, for the time being, is positive According to this invention, a switch operated by two electro-magnets *a*, *b*, which may be placed either side by side as shown, or tandemwise, and which operate upon a rocking-switch lever *c*, *d*, or upon a sliding rod carrying a contact or

contacts, is employed for automatically changing over the connections of the motor circuits of the ventilating fans, or other current-consuming devices to which variation of voltage is not of much consequence, in such a manner that the fan circuit always takes its current from the particular battery lead which happens to be connected directly to the positive terminal of the



dynamo, and not connected thereto through a resistance. The arrangement of switch is such that when the circuit of either electro-magnet is closed by any suitable means, either the circuit of the other electro-magnet is broken or the other electro-magnet is short-circuited so that the lever or rod is moved in one direction. (*Sealed July* 6, 1911.)

11,157/10. E. M. Munro and the Railless Electric Traction Company, Limited, London. Trolley-Poles. [6 *Figs.*] May 5, 1910.—The invention relates to trolley-poles for electric traction systems, in which two or more overhead conductors supply power to a vehicle travelling without rails, and, according thereto, a trolley-base comprises a plate or carrier pivoted upon a central support and carrying two pole-sockets, each capable of rotation relatively to the carrier and geared or connected together, so that they each rotate in the same direction and through similar angles. A is the central pivot provided with a foot intended to be bolted on the vehicle. Mounted upon the pivot is a carrier B provided with hollow extensions B^2 forming a support for an outer sleeve C, which can rotate relatively to the hollow member B^2. Each of the sleeves C is provided with a spur-wheel D, and the two spur-wheels engage with a pinion D^1 mounted upon the top of the central support A. The upper portion of each of the sleeves C carries, or is formed as, a hood C^3 serving to protect the mechanism of the trolley-base from the

Fig. 1

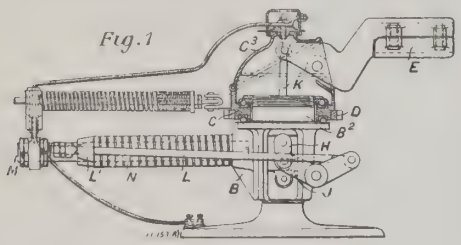
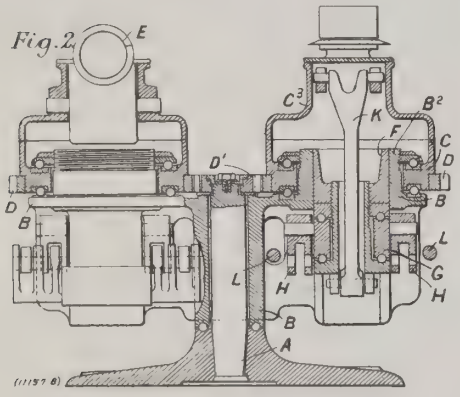
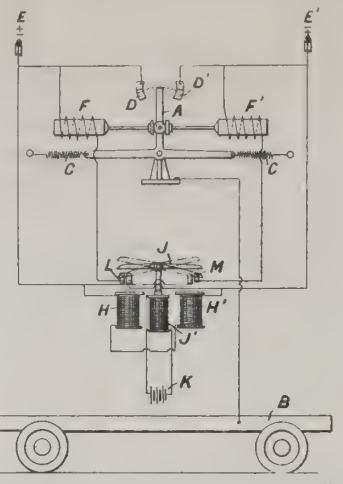


Fig. 2



weather, and also to support the pivots of the trolley-socket E. Each hollow member B^2 receives an inner sleeve F capable of rotating and of sliding longitudinally therein. The sleeve F holds a ring G provided with gudgeon-pins connected by links H to bell-crank levers J pivoted to the carrier B. The lower end of the inner sleeve F is provided with lugs, to which is attached the lower extremity of a link K, the upper end of which engages a fork formed on the end of the pole-socket E. Each pair of bell-crank levers J is connected by adjustable rods L to a yoke or cross-bar L^1 capable of sliding on tubes M, which extend from the carrier B. Encircling each tube M is a spring N. Each pair of springs acts through the cross-bar L^1, the rods L, and the bell-crank levers J, to pull down the ring G and the inner sleeve F. A downward pull is thus transmitted through the link K to the inner end of the pole socket E, and the upper extremity of the pole bearing the shoe or collector tends to be raised into contact with the conductor. (*Accepted May* 10, 1911.)

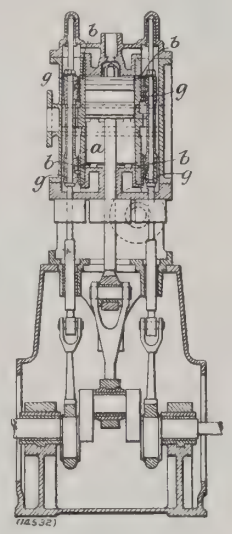
17,874/10. E. M. Munro and the Railless Electric Traction Company, Limited, London. Railless Traction Systems. [2 *Figs.*] July 27, 1910.—In electric-traction systems, in which railless vehicles are supplied with power from two or more overhead conductors, one of which is at or about earth potential, the frame of the vehicle is normally kept in connection with the earthed conductor, and this is effected, according to this invention, through a change-over switch which automatically opens whenever there is a break in the overhead line circuit, leaving the frame disconnected if the break is a simple one, connecting the frame to the other conductor if there is a change in the polarity of the conductors, or connecting the frame once more to the original conductor if the overhead line circuit is again completed without a change of polarity. The change-over switch has a contact arm A electrically connected to the vehicle frame B. The "off" position of the arm A is vertical, and is made definite by springs C. The arm A co-operates with contacts D and D^1 joined respectively to the overhead conductors E and E^1 through the trolley collectors. On each side of the arm A is an electromagnet F or F^1. When either electromagnet is energised, the arm A is moved over into connection with the contact D or D^1 against the action of the springs C. The electro-magnets F, F^1 are energised from the conductors E, E^1, their circuits being controlled by a switch comprising two electro-magnets H, H^1 and an armature J polarised by a coil J^1 energised by a battery K. This armature J also acts as a switch-arm and co-operates with contacts L and M. The armature J has three positions—one a neutral position and two operative positions—in which it makes connection either between the contacts L or M. It occupies the neutral position through the action of a spring



when the coils H, H^1 are not energised. The coils H, H^1 are connected in series and across the conductors E, E^1. The armature J, being polarised, will be tipped into one or other of its operative positions, according to the polarity of the conductors E, E^1; but when these conductors are dead, the armature will assume its neutral position. (*Accepted May* 10, 1911.)

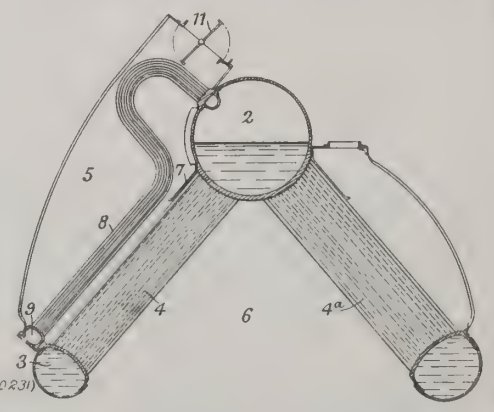
STEAM ENGINES, BOILERS, EVAPORATORS, &c

14,532/10. J. Davidson, Pendleton. Steam-Engines. [4 *Figs.*] June 16, 1910.—The invention relates to that type of high-speed steam-engine in which steam is admitted by valves at each end and exhausted at the middle of the cylinder by the piston uncovering ports at or near the end of its stroke, and consists in forming in each cylinder end a number of steam-admission



ports, and fitting around the ports a sleeve-like valve adapted to cover and uncover the same as required. *a* is the cylinder, *b* are the steam-admission ports formed in each end of the cylinder *a*. Around the admission ports *b* is fitted a sleeve-like valve *g* actuated independently or by means of rods and eccentrics from the crank-shaft. (*Accepted May* 10, 1911.)

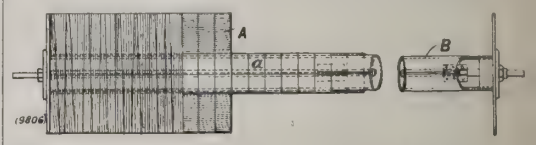
10,231/10. A. F. Yarrow, Blanefield. Superheaters. [14 *Figs.*] April 26, 1910.—According to the present invention, a superheater is provided on one side only of boilers of the type in which a steam and water-drum is connected by two sets of downwardly extending tubes with two water-drums, one on each side of the combustion space of the boiler furnace, the superheater-tubes being arranged in one or more nests or banks in the path of the furnace gases which pass between generator-tubes on the



same side of the boiler, and being either interspersed amongst these generator-tubes, or disposed on the further side of the bank of generator-tubes in the direction of flow of the furnace gases, or interposed between two banks of generator-tubes on the same side, or between the generator-tubes and the feed-water heater, if such be used. The drawing shows in transverse section a water-tube boiler of the Yarrow type fitted with a superheater embodying in one form the improvements constituting the present invention. The superheater tubes 8 are placed substantially parallel with and at a small distance from the outer row of one of the banks of generator-tubes 4, and may extend longitudinally so as to be co-terminous with the generator-tubes, or they may extend only over a fraction of the total length of the bank of generator-tubes. It will be observed that this bank of generator-tubes is of less depth than the bank 4*a*, and that the water-drum 3 is correspondingly reduced in dimensions. The superheater tubes, which at their upper ends are curved to U-shape, so as to cause them to be traversed three times by the hot gases, as well as to allow for yielding or expansion, have their upper ends expanded into the upper part of the steam-drum 2 and open into a space within the drum, which is partitioned off from the remainder of the steam collector. The lower ends of the tubes 8 are similarly expanded into a lower steam-chamber 9 which may be divided into compartments so as to cause the steam to traverse the bank of superheater-tubes two or more times, as may be desired. The furnace gases from the combustion space 6 divide between the two sides of the boiler, part passing through the bank of tubes 4*a* and thence to the main uptake, part through the bank 4 and the lower parts of superheater-tubes 8 to space 5 and thence through the upper curved part of the tubes 8 to the main uptake which is controlled by damper 11. Along the upper part of the generator-tubes 4 is a baffle 7 adapted to prevent the furnace gases passing directly to the upper part of the superheater-tubes. Instead of expanding the upper ends of the superheater-tubes into the wall of the steam-drum 2, they may be arranged to communicate with the steam-drum, should the boiler be furnished with one. By closing the damper 11 more or less, the flow of the furnace gases through the left-hand side of the boiler may be checked to a greater or less extent, or may be stopped entirely by completely closing the damper, in which case the whole of the furnace gases pass through the bank of tubes 4*a*. (*Accepted May* 3, 1911.)

TEXTILE MACHINERY.

9806/10. W. T. Smith, Bolton. Spinning Slivers. [14 *Figs.*] April 22, 1910.—This invention relates to the method of spinning direct from the condenser card, and consists essentially in building up a number of condenser slivers, each taken from a different carding-engine or different condenser bobbin, upon a creel bobbin, and, in the course of spinning, drawing a number of condenser slivers, each taken from a different carding-engine or condenser bobbin, and spinning same into a thread or yarn. The fleece from the doffer cylinder of a condenser carding-engine is wound up into a number of slivers A upon short bobbins *a* on a bobbin B. One sliver A on its bobbin *a* from each of the condenser bobbins B is then placed upon a creel bobbin until any



desired number—say, 6 to 10 or more—are placed thereon. There are thus 6 to 10 or more condenser slivers each taken from a different condenser bobbin on each creel bobbin, and there are thus 6 to 10 or more ends or slivers to be placed in the creel and drawn out or spun into one thread. If more than this number of slivers are to be doubled and drawn a second creel bobbin so built up may be employed to produce the one thread. Thus any number—preferably 6 to 10 cards or condenser bobbins—contribute each its sliver to one thread or end of yarn, and any irregularity or inequality of carding on one carding-engine is neutralised by the others, and the yarn spun will be of much more uniform quality. (*Accepted May* 3, 1911.)

10,130/10. B. Crossley, Blackpool, S. Lawson and the Palatine Automatic Loom Company, Limited, Burnley. Weft-Replenishing Looms. [11 *Figs.*] April 26, 1910.—In automatic weft-replenishing looms, mechanism is arranged to be put into action by the weft fork or cop-feeder motion on the failure of the weft, the said mechanism causing the tension of a spring or of springs to be increased during the forward beat of the slay effecting the change of weft, thereby retarding the speed of the slay and loom, the spring or springs accelerating the speed of the slay and loom during the following backward beat of the slay. Between two brackets 8 and 9 a long helical spring 10 is stretched. The rod 12 has a nut, and on the slay sword 2 a swivel catch 14 (Fig. 3) is mounted, the one end of which is so arranged that it can seize over the rod 12 when pressed down, but is held clear of it by the spring 16 attached to it at one end, and at the other end to the slay bottom 3. On the shaft 7 a lever

Fig. 1.

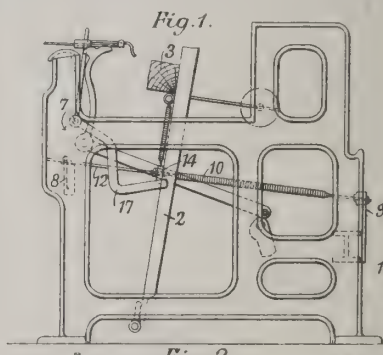


Fig. 3.

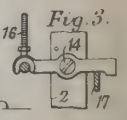
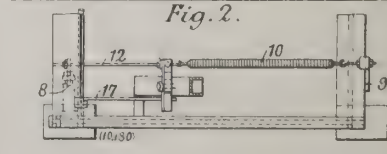


Fig. 2.



17 is mounted, the end of which passes under the other end of the catch 14. When on the failure of the weft, the shaft 7 is turned forward, the end of the lever 17 is raised and lifts up the catch 14 into the position shown in Fig. 3, just as the slay reaches the end of its backward movement. The catch then seizes over the rod 12 behind the nut thereon, and in its forward movement carries the nut and rod 12, which slides in the bracket 8, forward with it and thereby stretches the spring 10, whereby the forward movement of the slay is retarded, while the next following backward beat of the slay is accelerated by the pull of the spring upon it. The pull of the spring holds the catch 14 and rod 12 engaged till the slay has nearly returned to its backward position when the rod 12 is held back by engagement with the bracket 8 so that the catch 14 becomes disengaged, and the spring 16 pulls it up into its normal position, the lever 17 having dropped meanwhile. (*Accepted April* 26, 1911.)

THE STRENGTH OF STEELS IN COMPOUND STRESS, AND ENDURANCE UNDER REPETITION OF STRESS.

By L. B. TURNER, B.A.

IN a former article* the writer described some experiments carried out with the purpose of ascertaining how closely the elastic breakdown of a material is dependent only on the maximum shear to which it is subjected. The nature of, and necessity for, the inquiry were set forth, and a brief summary of the earlier experimental work was added. The new experiments of that article constituted the first instalment of results under the scheme of work there outlined. The present article is the sequel of the former. It embodies (1) some further tests with static pull and torque; (2) experiments in three-dimensional stress; and (3) an investigation of the endurance of various steels under alternations of tension and shear.†

I. *The Elastic Limit in Two-Dimensional Stress.*—The chief results in the former article were from tests on annealed, thin-walled, mild-steel tubes, subjected to stress-distributions of simple tension and simple shear, the stress being continuously increased until the specimen ceased to remain elastic. In the one case (pull tests) the elastic limit occurred at a stress with principal tensions

$$p,\quad 0,\quad 0,$$

and in the other (torque tests) with principal tensions

$$p',\quad 0,\quad -p'.$$

The limiting elastic shears in the two cases were therefore

$$\frac{p-0}{2} = p/2, \quad \text{and} \quad \frac{p'-(-p')}{2} = p'$$

respectively. The experiments showed that these shears, produced by the two different stress-distributions, were equal to within some 4 per cent. For the particular material tested, therefore, the shear theory was remarkably confirmed, and the tension and stress formulæ of Rankine and Saint Venant were demonstrated to be inapplicable.

As formerly explained, this series of tests was undertaken to supply an accurate idea of the truth of the shear theory for some one material. That chosen was a mild steel, such as is commonly used for structural purposes, and was similar to material for which other experiments had already shown roughly the constancy of shear at breakdown.

TABLE I.—*Stress at Elastic Limit under Simple Pull and Simple Torque. Units: Inch, Pound.*

Material.*	Simple Tension (Pull).	Simple Shear (Torque).	Maximum Tension.	Maximum Shear.
Mild-steel tubes, containing 0.15 to 0.30 per cent. carbon. [ENGINEERING, 1909, page 204.]	31,600	..	31,600	15,800
	..	16,400	16,400	16,400
Mild-steel, containing 0.32 per cent. carbon	42,100 42,300 42,400 Mean = 42,300	..	42,300	21,200
		25,200 23,600 24,400		
		Mean = 24,400	24,400	24,400
Tool-steel, containing 1.25 per cent. carbon	67,200 69,300 66,600 Mean = 67,700	..	67,700	33,900
		39,400 37,500		
		Mean = 38,400	38,400	38,400
Nickel steel, containing 3.01 per cent. nickel	81,000 81,300 Mean = 81,200	..	81,200	40,600
		44,500 39,700 38,100		
		Mean = 40,800	40,800	40,800

* Complete analyses will be given in Appendix II.

* "The Elastic Breakdown of Materials submitted to Compound Stress," ENGINEERING, February 5 and 12, 1909.

† The research was carried out in the Engineering Laboratory of Cambridge University. My thanks are due to Professor B. Hopkinson, F.R.S., for his kindness in permitting and encouraging the work.

In the later experiments with alternating stress, described hereafter, various steels have since been used, and a few static tests with pull and with torque have been made on them. The results are tabulated in the preceding column, and for comparison with the former tests the mean figures for them also are included in the table. The specimens were all annealed at 760 deg. Cent., except the nickel steel, where the temperature was 800 deg. Cent. They were used in the testing-machine in the form of $\frac{3}{8}$-in. rods as rolled, but for the torsion tests they were turned down, for a length of about $3\frac{1}{2}$ in., to about 0.33 in. in diameter. In all the materials the elastic limit and the yield-point in the testing-machine coincided. A fresh specimen was used for every test. It is clear from this table that the shear theory is no general law which covers all elastic materials. The mild steel, although stronger than the steel of the tube tests, is a fairly similar material; but for it the discrepancy of the shears is considerably greater. The tool-steel shows the greatest inequality of shear in the two distributions of stress; yet even for it the theory that failure occurs through shear is obviously very much closer than the tension hypothesis. In the nickel-steel the shears in the two sets of experiments are nearly equal. The experiments show, therefore, that the shear theory is in some materials very nearly accurate; in other materials, quite appreciably inaccurate; but in all the very diverse materials tested it is greatly superior to the more generally accepted tension hypothesis.

II. *Experiments in Three Dimensional Stress.*—The stress set up in a rod or tube by any combination of torque and pull is everywhere two dimensional; one of the three principal tensions at each point is zero. In experiments where an internal hydrostatic pressure is applied to a thin tube—as in some of Mr. J. J. Guest's work*—the third principal tension, although not everywhere zero, is very small. All experiments hitherto made had, therefore, only employed stress distributions which were practically two dimensional; and it was desired to extend the investigation to cover cases of stress in which all three principal tensions were large.

The three-dimensional stress was produced in thick-walled steel tubes, by loading them with a large internal fluid-pressure,† accompanied by more or less longitudinal pull. The same tubes were subjected to longitudinal pull alone, and to torque alone.

The stresses due to an internal fluid pressure P in a tube whose internal and external radii are a and b respectively are

Radial tension

$$R_1 = P \cdot \frac{a^2}{b^2 - a^2}\left(1 - \frac{b^2}{r^2}\right);$$

hoop tension

$$R_2 = P \cdot \frac{a^2}{b^2 - a^2}\left(1 + \frac{b^2}{r^2}\right);$$

longitudinal tension

$$R_3 = P \cdot \frac{a^2}{b^2 - a^2};$$

where r is the distance of the point from the axis of the tube. At the inside layer, where the radial and hoop tensions are arithmetically greatest,

$$R_2 = P\,\frac{b^2 + a^2}{b^2 - a^2};$$

$$R_1 = -P.$$

If there is additional longitudinal tension R^1 from the testing-machine, the greatest shear in the material is

$$\tfrac{1}{2}(R^1 + R_3 - R_1), \text{ or } \tfrac{1}{2}(R_2 - R_1),$$

according as the longitudinal or the hoop tension is the greater.

According to the shear theory, if the material ceases to be elastic in the testing-machine at a tension p, or in the torsion-machine at a shear q, the internal pressure P necessary to overstrain the inside layer of the specimen is given by

$$\frac{p}{2} = q = \frac{R_2 - R_1}{2} = P\,\frac{b^2}{b^2 - a^2}.$$

Hence with a thick tube an internal pressure nearly equal to half the elastic-limit tension P is required, so that all three principal stresses may be made large.

* "The Strength of Ductile Materials under Combined Stress," *Philosophical Magazine*, 1900, vol. ii. Results of similar tests by the present writer are given in the former article (*loc. cit.*).

† This method of obtaining the three-dimensional distribution was adopted at the suggestion of Mr. C. E. Inglis, M.A.

Longitudinal Pull.—The longitudinal pull was applied in these tests through the special knife-edge shackles described before, ensuring centrality of pull. Fig. 1, page 116, shows a specimen fitted up for a test. The beam of the testing-machine supports the casting A A, which carries the saddle B on knife-edges lying parallel to the direction A A; B supports the collar C on knife-edges perpendicular to the direction A A, and this collar C encloses a gun-metal block, into which an end of the specimen D is screwed. At the other end of the specimen the arrangement is similar. A flexible coil of copper pipe G ($\frac{3}{8}$ in. diameter, $\frac{1}{8}$ in. bore) conveys high-pressure oil to the inside of the specimen. Longitudinal and diametral strains are measured by an ordinary 8-in. Ewing extensometer E and the latometer F, described below.

Production and Application of the Fluid Pressure.—The internal fluid pressure for the thick tubes was obtained by means of a hand-pump delivering oil at a pressure up to 3 tons per square inch, used in conjunction with an intensifier designed for the purpose of these experiments.

Referring to the sketch, Fig. 2, A is a very thick mild-steel cylinder fitted into a heavy casting B. C is a tool-steel ram, which can be forced by the screw D into the cylinder, through a leather gland E. F is a gun-metal block, in which are fitted the pipe-unions, and the needle-valve G. Union H leads to a pressure-gauge, and the corresponding union opposite this, on the other side of the block, leads to the specimen in the testing-machine. When G is screwed up, the pump is cut off from the rest of the system, as is indicated by the dotted-line oil passages in the diagram.

The intensifier was designed for pressures up to 8 tons per square inch. It proved very convenient in use for both high and low pressures. By turning the hand-wheel on the screw the ram is very gradually forced in, and the pressure is adjustable with great nicety. The pump was used to produce pressures up to 3 tons per square inch, which were accurately adjusted by the intensifier; above 3 tons per square inch, the pump was cut off by screwing in the needle-valve. All unions were packed with leather washers sunk in recesses, so as to be completely surrounded by metal. This is illustrated in Fig. 3. Before this arrangement was adopted, trouble was experienced owing to flowing of the leather under the great pressures. Pressure was measured on a gauge specially calibrated (up to 10 tons per square inch) by the makers.* It could be read to within 0.1 ton per square inch.

The "Latometer."—For these tests it was obviously desirable to read diametral strains; it was rendered imperative by the quite inadequate sensitiveness of the extensometer to indicate yield-point due to internal pressure in thick tubes. An instrument was designed, to which the name "Latometer" has been given. Owing to the minuteness of the lengths to be measured by the instrument, and to the fact that it is suitable for obtaining Poisson's ratio from a test in simple tension†, the instrument is here described at some length. Its sensitiveness is such that it will measure the Poisson contraction of a 1-in. solid steel bar under longitudinal pull, with about the same accuracy as the Ewing extensometer measures the longitudinal stretch. This implies measurement of change of diameter to within $\frac{1}{1,000,000}$ in. (10^{-6} in.).

The principle of the instrument is seen from the diagrammatic plan in Fig. 4. Two aluminium levers A and B are pressed together, gripping the specimen between them, by a pair of springs C. The levers A and B hinge on a knife-edge at D. The specimen is gripped between blunt steel points E. As the specimen contracts, say, the ends F of the levers approach each other, and, by a simple mechanism seen in Figs. 5 and 6, cause a small mirror to rotate.

It is believed that the unsatisfactory behaviour of other instruments designed to measure lateral strain is due chiefly to the mistake of making the measuring points carry the weight of the instrument. In the present design, the latometer is free to swing about the diameter of the specimen, but is maintained in an approximately horizontal posi-

* Messrs. Schäffer and Budenberg.

† The equation $\sigma = \frac{E - 2C}{2C}$ is ill-adapted to give accurate values of σ in steel and iron, since E and 2 C are so nearly equal for these materials. Accurate determination of Poisson's ratio may be important for calculations of stress arising from thermal gradients.

tion by a link vertically over its centre of gravity. This is sufficiently clearly shown in the photograph (Fig. 6). The centre of gravity of the instrument varies when adjusted for different sizes of specimen ; so the small plate G (Fig. 4), to which the link is attached, is adjustable. By this device, the only reaction between the points and the specimen is that due to the springs.

The knife-edge seating shown in Fig. 4 is not a plain groove cut in a block. Such a simple form of seating cannot be at once sufficiently frictionless and definite. The actual fulcrum consists of a hardened steel knife-edge resting on a composite seating of four separate flat steel faces, as indicated in Fig. 7, which is a plan of the seating.*

Calibration of the instrument showed that the deflection as observed on a scale distant 100 cm. from the mirrors was 1 cm. for a change of diameter on the specimen of 1.025×10^{-4} in. Despite the many experiments to abolish friction in the instrument, leading to the final design described, there is still a very small remnant, resident probably at the contacts between the points and the specimen, in tiny pits made by a finger-drill. A slight tap on the testing-machine (or the thumping of a gas-engine in the vicinity) is sufficient to remove all effect of the friction. The instrument, while naturally requiring delicate manipulation, has proved itself quite satisfactory in use.

The Thick-Tube Specimens.—For the experiments in three-dimensional stress, weldless drawn tubes of mild steel* were used, manufactured by the same firm as was the thin tube, and asserted to have the same composition. Two sizes of tube (as supplied) were used ; specimen 6 was of $1\frac{1}{8}$ in. diameter, with $\frac{7}{16}$ in. bore ; the rest were of $\frac{7}{8}$ in. diameter, with $\frac{3}{8}$ in. bore. Each specimen was about 18 in. long ; a screw-thread and two flats for a spanner were cut on each end ; the middle 14 in. or so was turned down to 0.920 in. for specimen 6, and 0.625 in. for the others. Care was taken that no torque was applied to the specimen when screwing it into the gun-metal blocks through which the pull and fluid pressure were applied.

The annealing was performed in a gas muffle-furnace, the specimen lying in an iron gas-pipe on which the flames played. The furnace was heated up, then the specimen was put in, and was left—a matter of 9 minutes or so—until its temperature rose to the desired value, as indicated by a thermo-electric junction placed within the bore. It was then removed, and allowed to cool in a vertical position in the air. Specimens 4 and 5 were annealed at 800 deg. Cent., and specimen 6 at 860 deg. Cent.

The mean bore of the fresh specimen was measured by filling it with mercury. After the tests had all been made, the specimens were cut across near the middle section, where the latometer had been attached, and the dimensions were again taken with a sliding gauge ; the mean thickness was sometimes found to be slightly different. The mean of the values found in the two ways has been used in the calculations. This examination of the old specimens by sawing them across brought to light an unexpected fact—viz., that in some the bore was by no means nearly concentric with the surface. Care had been used in selecting specimens which appeared to have a straight bore ; so that the eccentricity in the machined specimen was probably due, in part at least, to springing during the turning, owing to the presence of initial stress in the material. This view is supported by the fact that specimens 2 and 3, which were turned before being annealed, exhibited the eccentricity much more pronouncedly than did specimens 4, 5, and 6, which had been annealed before turning. The variations in thickness above and below the

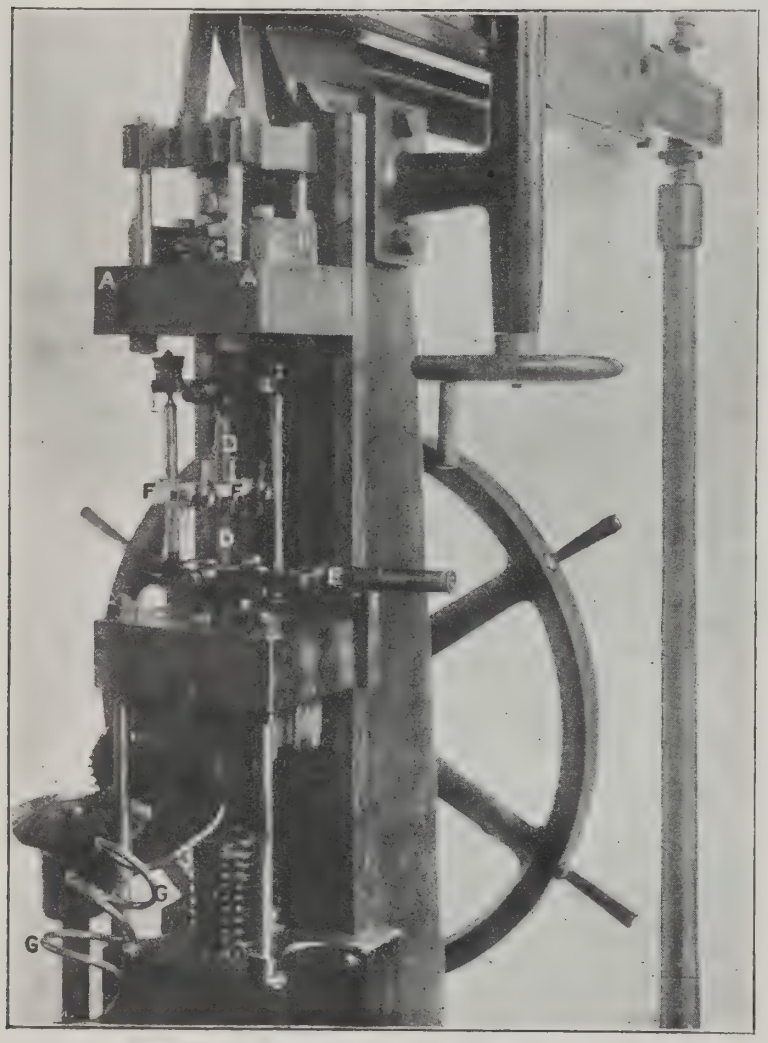


FIG. 1.

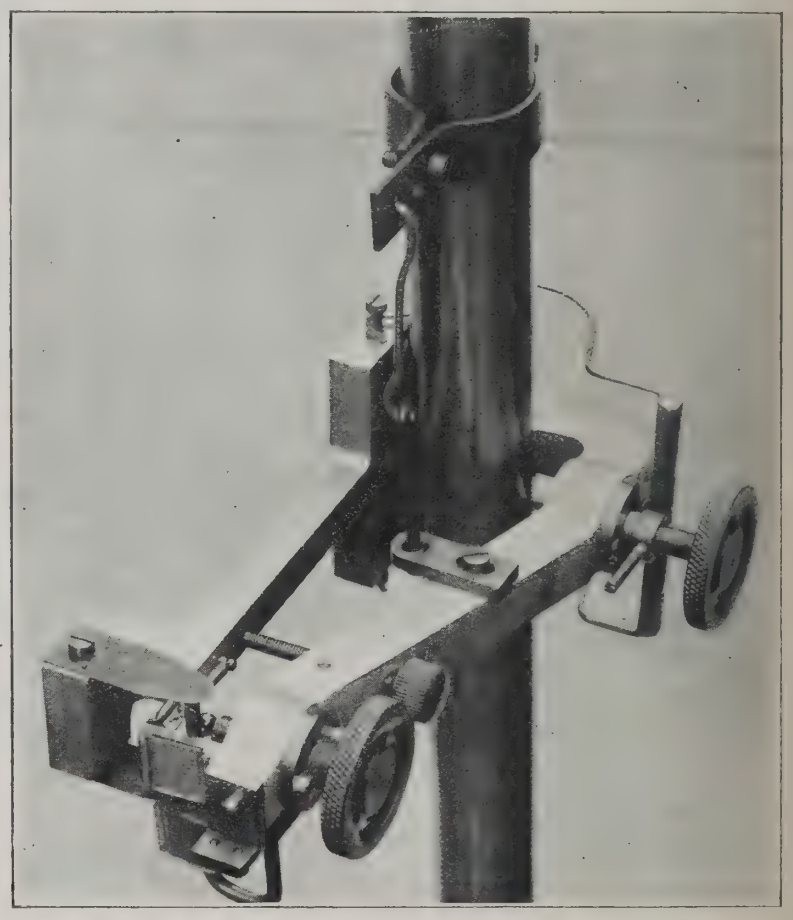
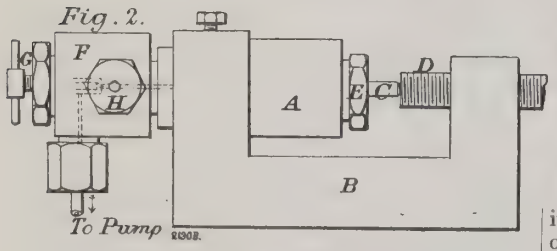
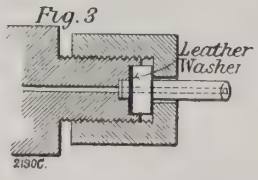
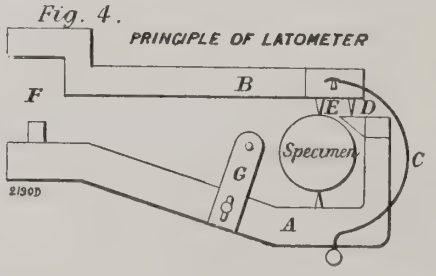
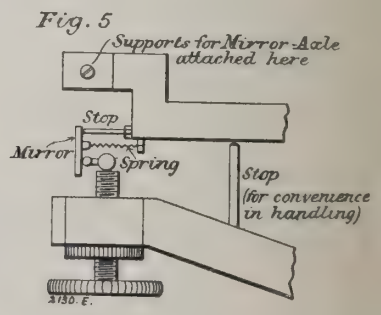


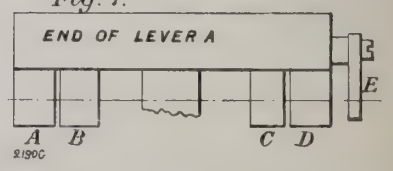
FIG. 6.











A, B, C, D are the faces ; A and D slope at about 45 deg. to the paper in one direction, B and C at 45 deg. in the other. The knife-edge rests along the dotted line. To prevent the knife-edge slipping along its seating, a small hardened steel plate E is fixed to the lever A, and on this the bottom end of the knife-edge rests.

To avoid errors due to bodily rotation of the specimen and instrument, an adjustable fixed mirror is attached to the lever A in proximity to the moving mirror. It is seen in Fig. 6. The mirrors are observed by a telescope and scale. A vertical scratch on the scale, as seen by one mirror, is read against the scale, as seen by the other mirror. Thus the difference of the deflections is given by a single reading.

* This was suggested by a description of a similar device in a microtome made by the Cambridge Scientific Instrument Company.

* For analysis, &c., see Appendix II.

mean value, as measured at the sawn section, are given for the several specimens in Table II.

TABLE II.—*Variation of Thickness of Walls of Specimen.*

Specimen.	Variation from Mean. Per Cent.
2	13
3	17
4	1.7
5	2.6
6	4

Results with Three-Dimensional Stresses.—In the experiments included in Table III., below, the manner of loading was :—

1. Torque, applied in the torsion-machine by a weight at the end of a long lever fitted to the spanner-flats at one end of the specimen, twist being measured over an 8-in. length ; or,

2. Pull from the testing-machine, stretch being measured by a Ewing extensometer ; or,

3. Constant pull from the testing-machine, with an increasing internal pressure, strains being measured by extensometer and latometer.

With load (1) the stress is greatest at the outside surface ; with (2) it is uniform throughout ; and with (3) it is greatest at the inside surface. Thus, as long as overstrain is kept small, any of these three tests may be made in succession, without intermediate annealing. It will be seen from the table that such successions of tests were sometimes made. The figures in the table refer to the elastic limit (*i.e.*, departure of the graph from rectilinearity), and this was determined by plotting the load against the twist, extensometer, and latometer readings.

TABLE III.—*Tests with Three-Dimensional Stress.*

(Units :—in., lb.)

Test.	Pull from T.M.	Principal Tensions. Internal Pressure.	Longitudinal Tension	Hoop Tension	Produced by Torque.	Maximum Stretch × E.†	Maximum. Shear.
Specimen 4.—External Diameter = 0.629 in.; Internal Diameter = 0.400 in.; Annealing Temperature = 800 deg. Cent.							
1*	0	0	..	..	± 20,900	27,200	20,900
2	6100	0	33,100	0	..	33,100	16,600
3*	500	10,950	10,200	25,800	.	26,000	18,400
4	6600	0	35,900	0	..	35,900	17,900
5*	3500	11,600	26,900	27,400	..	22,800	19,500
6	6400	0	34,800	0	..	34,800	17,400
7*	2000	12,100	19,200	28,600	..	26,500	20 300
8	6800	0	37,000	0	..	37,000	18,500
9*	3640	11,200	27,500	26,500	..	22,900	19,300
10	6200	0	33,700	0	..	33,700	16,900
Specimen 5.—External Diameter = 0.627 in.; Internal Diameter = 0.395 in.; Annealing Temperature = 800 deg. Cent.							
1*	0	0	..	..	± 18,500	24,100	18,500
2	500	11,200	10,100	25,900	..	26,200	18.500
3	6500	0	34,900	0	..	34,900	17,400
4*	5900	4,480	34,700	10,400	..	32,700	19,600
5*	4000	7,160	26,200	16,600	..	23,400	16,700
6	5700	0	30,660	0	..	30,660	15,300
Specimen 6.—External Diameter = 0.930 in.; Internal Diameter = 0.445 in.; Annealing Temperature = 860 deg. Cent.							
1*	0	0	..	..	± 19,700	25,600	19,700
2	200	17,200	5,500	27,500	..	31,000	22,300

* Denotes that the specimen was freshly annealed for this test.
† Reckoned from $\sigma = 0.3$.

It has already been stated that the figures in the table refer to the elastic limit as indicated by departure of the graph from rectilinearity. The writer was astonished to find that in every one of these tests with internal pressure the departure occurred in the direction of *decreased* rate of change of diametral strain with change of load—*i.e.*, in the manner of Fig. 8, instead of Fig. 9, as would generally be expected.

If the shear theory of breakdown holds good, we should look for this kind of yield in those cases where the longitudinal tension exceeds the hoop tension ; for then the plastic slide has component plastic stretches in the radial and longitudinal directions, and the latter might well be accompanied by lateral contraction, after the manner of the Poisson effect during elastic strain. But in these experiments it occurred also when the hoop tension exceeded the longitudinal tension. In some cases it was as though the specimen were undecided whether to decrease or increase in diameter ; it would first do one, and then, with further increase of internal pressure, or merely with the same pressure maintained, it would do the other. This is exemplified by the graph for specimen 4, test 5, shown in Fig. 10. The same figure includes the graph for specimen 5, test 2.

When the phenomenon was first observed, misbehaviour of the latometer was naturally suspected. But it was soon proved that the suspicion was certainly unfounded. There was no slipping of the points on the specimen, for example. One could stand at the telescope of the latometer and watch the decrease of diameter slowly and steadily taking place.

In most of the tests, extensometer readings were taken ; but changing so slightly with increasing internal pressure, they gave a very uncertain indication of the elastic limit, and so were not used for the purpose. The yield indicated by the extensometer was generally in the ordinary forward direction ; but in one case (specimen 4, test 5) it was slightly backwards, and in another (specimen 5, test 2) quite definitely so. The latter is shown in Fig. 10. The tests on specimens 2 and 3 (not tabulated) showed only the smallest indication of this queer backward-yield phenomenon ; but nothing is to be deduced from this, seeing that the bores were found to be so eccentric.

Fig. 8.

Fig. 9.

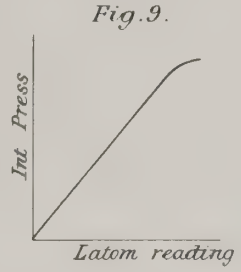
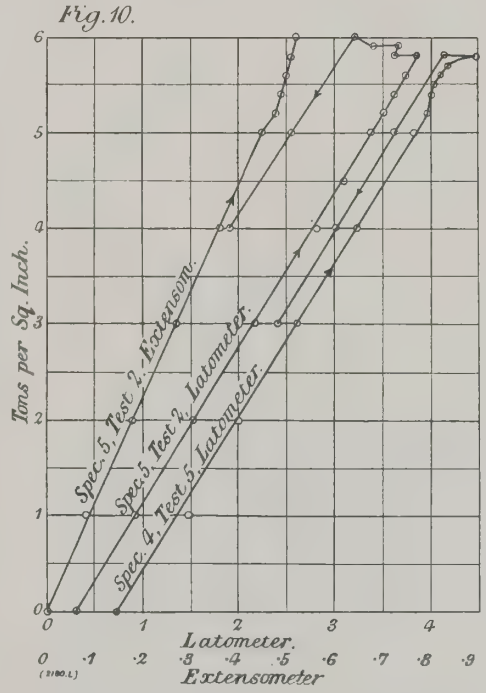


Fig. 10.



The whole problem of the manner of yield under a three-dimensional stress distribution, such as we have been considering, is extremely complicated, and seems to have been as little explored on the theoretical as on the experimental side. The writer has sought elsewhere* to investigate it from the standpoint of the shear theory on the theoretical side, but he is unable to account for the effect above described. Further experiments are urgently wanted. They should be made with specimens accurately machined both inside and outside. Such would be more costly to prepare, but the present experience with unbored drawn tube renders them advisable. With the latometer to measure the strain, quite short specimens can be tested.

Putting aside consideration of the form of the graph after the elastic limit is passed, the cessation of rectilinearity does give us the elastic limit, and we may consider that the stresses in Table III indicate :—

(1) That the shear theory is not very far from true.

(2) That it is sensibly untrue.

The shears in the last column are not very discrepant, yet they clearly tend to be smaller for the cases of simple tension than for those of two and three-dimensional stress. Until further more embracing and more accurate results are obtained, these, the only experiments in three-dimensional stress, justify the displacement of the tension by the shear criterion for purposes of design.

(*To be continued.*)

* "The Stresses in a Thick Hollow Cylinder Subjected to Internal Pressure" (Transactions of the Cambridge Philosophical Society, vol. xxi., No. XIV., 1910). Practical results are here arrived at regarding the strength and construction of guns and other thick cylinders with initial stress distribution, subject to intense internal fluid pressure.

THE CATSKILL WATER SYSTEM OF THE CITY OF NEW YORK.

By H. PRIME KIEFFER, C.E.

THERE are three very costly constructions now in hand in America : the Panama Canal, the Ashokan Reservoir and Aqueduct of the Catskill water system, and the New York Barge Canal. The work of building the aqueduct of the Catskill Mountain system and the impounding dam is now being actively prosecuted ; they form together one of the largest and most interesting works now under construction in any country. It is thought that the additional water supply from this source will provide for New York's ever-increasing population for at least thirty years to come.

The City of New York is made up of five boroughs, with a population of 4,766,883, according to the 1910 census, divided as follows :—

Borough of Manhattan	2,331,542
Borough of The Bronx	430,980
Borough of Brooklyn...	1,634,351
Borough of Queens	284,041
Borough of Richmond	85,969

The population of the city is increasing at the rate of about 3 per cent. per year, which, under existing conditions, means an annual increase in the consumption of water of about 15,000,000 gallons per day.

The boroughs of Manhattan and The Bronx are supplied from the watersheds of the Croton, Bronx, and Byram rivers, having a total area of 382 square miles, of which the Croton shed represents 360 square miles. The average draught from the Croton watershed in dry periods, when fully developed, is estimated at 320,000,000 gallons per day.

Two aqueducts are available for conveying Croton water to the city : the old Croton aqueduct, with a carrying capacity of about 40,000,000 gallons per day, and the new Croton aqueduct, which conveys 300,000,000 gallons per day. The source of water supply in the scheme under completion is the Catskill Mountain watershed, which is divided into four parts : (1) the available watershed of the Esopus Creek and its tributaries, containing 255 square miles ; (2) the available watershed of the Rondout Creek, which includes the head waters of the Rondout Creek and its tributaries, consisting of 131 square miles, and also three small watersheds tributary to the Rondout, having an area of 45 square miles ; (3) the available watershed of the Catskill, which includes the head-waters of the Catskill Creek and its tributaries, and contains 163 square miles, and also six small watersheds tributary to the aqueduct between Catskill Creek and the Ashokan Reservoir, having a combined area of about 82 square miles ; and (4) the available watershed of the Schoharie, which includes the head-waters of the Schoharie Creek and its tributaries, and contains 228 square miles. The present scheme includes reservoirs in each of these watersheds, the largest being that at Ashokan, with a surface about 590 ft. above sea-level, and capable of holding 130,000,000,000 gallons of water. The reservoir is to be connected with New York City by an aqueduct having a carrying capacity of not less than 500,000,000 gallons every twenty-four hours. It is estimated that the sources will afford a daily yield of at least 500,000,000 gallons of soft and wholesome water.

The estimated cost of constructing the Ashokan Reservoir and an aqueduct of 500,000,000 gallons daily capacity from this point to Hill View equalising reservoir, including the Kensico storage reservoir, together with the construction, within the city limits, of an 18-mile tunnel, a terminal reservoir, and 16.3 miles of steel and cast-iron pipe mains, so

as to furnish water to all the five boroughs, is as follows :—

	Dols.
Ashokan Reservoir	29,177,000
Aqueduct to Hill View Reservoir...	52,772,000
Kensico Reservoir	12,719,000
Hill View Reservoir	7,200,000
City Tunnel, mains and terminal reservoir	25.000,000
Total	126,868,000

This estimate includes 20 per cent. allowed for engineering contingencies.

To furnish the additional 250,000,000 gallons per day necessary to develop the full capacity of the main aqueduct, the Rondout and Schoharie watersheds will later be drawn upon, and the additional expenditure, including filtration of the entire supply of 500,000,000 gallons per day, will be :—

	Dols.
Rondout Development	12,099,000
Schoharie Development	11,847,000
Filtration plant at Eastview ...	17,525,000
Total	41,471,000
Plus 20 per cent. for engineering contingencies	8,294,000
	49,765,000

Total Cost of Completed Works of 500,000,000 Gallons Daily Capacity.

	Dols.
Cost of development and delivery of first 250,000,000 gallons	126,868,000
Cost of development and delivery of second 250,000,000 gallons ...	49,765,000
Total	176,633,000

Cost of the Aqueduct —The aqueduct which will carry the water from the Ashokan Reservoir to the Hill View Reservoir will be the largest, longest, and most wonderfully built structure of its character in the world. The total length will be 110 miles. The aqueduct will consist of four distinct types of constructions—namely, tunnel on hydraulic gradient, tunnel below hydraulic gradient (pressure tunnel), cut-and-cover construction, and steel pipe-line. This 110 miles of confined aqueduct is divided as follows :—

	Miles.
Tunnel on hydraulic gradient	14
Tunnel below hydraulic gradient (pressure)	35
Cut-and-cover work	55
Steel pipe-line	6

Fig. 1, above, shows the route of the aqueduct from the watersheds to greater New York, and Fig. 2 the location of the several dams in the Ashokan Reservoir, which is here shown to a larger scale. Concrete is being employed on all of this aqueduct, even upon the steel pipe sections. The tunnel on an hydraulic gradient will be as shown in Fig. 3. It will be lined with concrete of a thickness of from 1 ft. to 3 ft. Those portions of the aqueduct which are below hydraulic gradient, such as siphons, will be of circular sections, as shown in Fig. 4, and lined with concrete of varying thickness. Where topography permits, the cheapest type is used. These portions will be of concrete with earth sides and top, as shown in Fig. 5, opposite, while Fig. 6 is a perspective view of the cut-and-cover work near Peekskill.

The Siphons.—By far the most interesting work in connection with this aqueduct is the giant tunnels or siphons, entirely in rock, under the various streams, including one under the Hudson River. Work is in progress on the driving of these siphons, that of the Rondout being nearly completed. This siphon is a portion of the Catskill aqueduct and is situated near High Falls, Ulster County, N.Y. It will carry the water under Rondout Creek. The work is being carried out by the T. A. Gillespie Company, of New York City, under a contract price of 6,290,803.50 dols. The section embraced in this contract is a little over five miles long, about 4.5 miles being a pressure-tunnel siphon, about 3000 ft. being grade tunnel, and only a few hundred feet being cut-and-cover work.

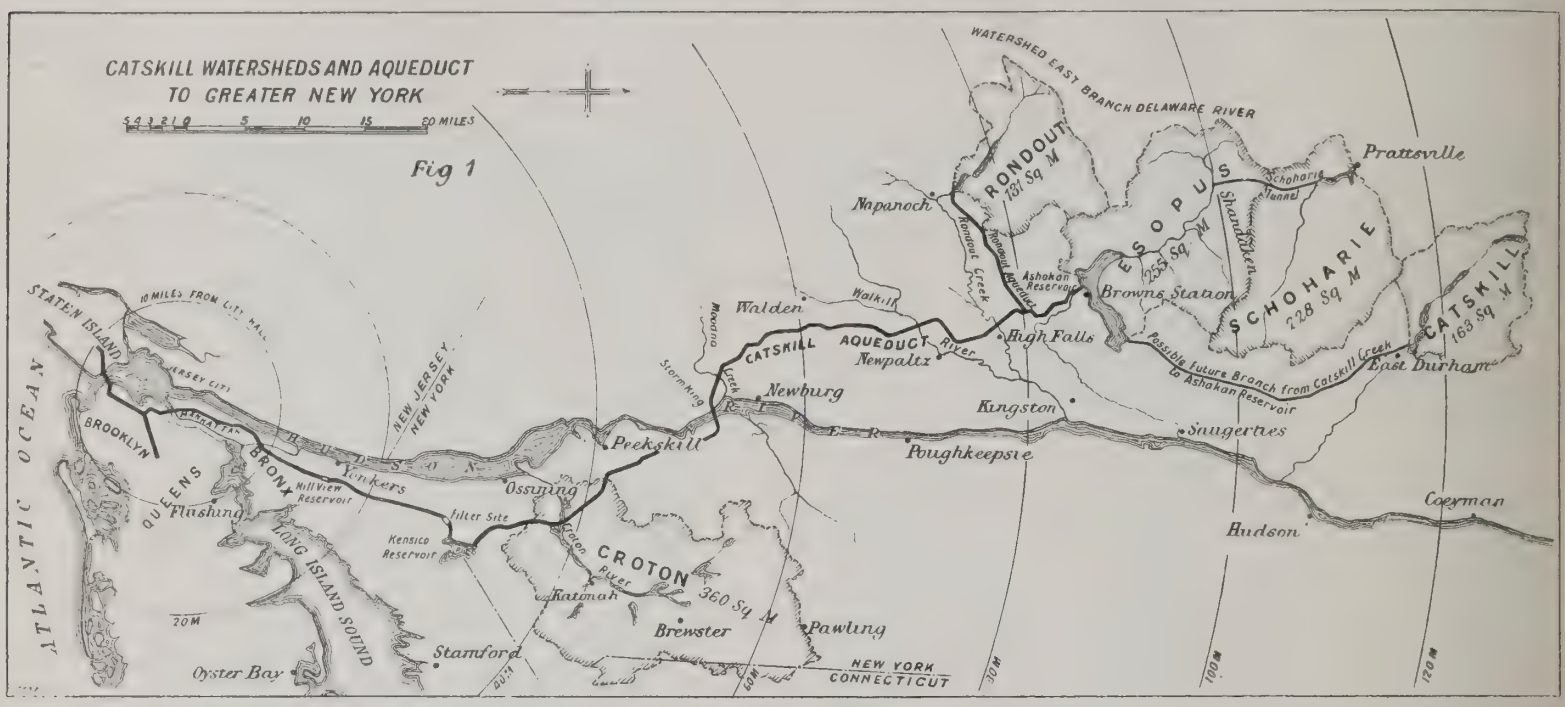
The tunnel siphon is being driven from shafts which range in depth from 375 ft. to 710 ft. Water will enter the pressure tunnel through a downtake shaft about 600 ft. deep at the north end of the siphon, flow under Rondout Creek through about 24,000 ft. of tunnel, and emerge at the hydraulic gradient through an uptake shaft about 700 ft. deep at the southerly end. The uptake and downtake shafts, besides a drainage shaft about 460 ft. deep located near Rondout Creek, to be used for unwatering the siphon, are circular in section, with finished diameters inside of 14 ft. 6 in. for the waterway shafts and 14 ft. for the drainage shaft. The two waterway shafts will have a concrete lining about 2 ft. thick, and the drainage shaft a lining about 3 ft. thick, separated into an outer and an inner shell by an interlining of porous tile. The other five shafts are for construction purposes only, and will be partially refilled and sealed at the top when work is completed. They are rectangular in section, and measure about 10 ft. by 22 ft.

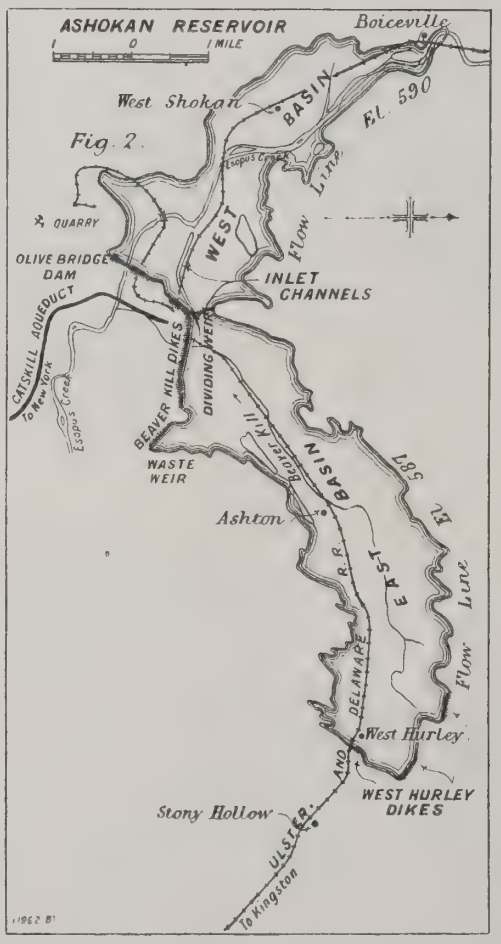
The northerly half of Bouticon Tunnel on the hydraulic gradient, whose total length is 6823 ft., is being constructed under this contract ; it is 17 ft. high and 13 ft. 4 in. wide, inside dimensions. The southerly half, as well as the portion included in this contract, were driven from their respective portals without the use of shafts.

The cut-and-cover aqueduct, amounting, on this contract, to only a few hundred feet, is 17 ft. high and 17½ ft. wide, inside dimensions, and has a section of the horseshoe type, as shown in Fig. 5. The time allowed for the completion of the contract is 4½ years, and the contract was let in June, 1908. Among the more important quantities estimated are 4130 ft. of shaft, 27,000 ft. of tunnel, and 143,000 cubic yards of concrete. On June 10, 1911, 83 per cent. of this contract had been completed.

The machinery used, including drills, hoists, pumps, grouting apparatus, pneumatic tools, and other small machines, is operated by compressed air, so that the methods of obtaining and of delivering this power were of first importance. A plant at each shaft was undesirable, because, many of the shaft locations being in exceedingly inaccessible places, the expense of handling coal and other supplies would have been considerable. A location was finally secured at High Falls on the Kingston division of the New York, Ontario, and Western Railway. The plant is equipped with two batteries of Heine boilers, each with a capacity of 375 horse-power, and four 250 horse-power Stirling boilers. Forced draught is furnished by two blowers, under the "Acme" control system, the engines being built by the American Blower Company. The air is compressed by ten "Imperial" type Ingersoll-Rand high-pressure high-speed cross-compound compressors. Their combined capacity is about 25,000 cub. ft. of free air per minute. Mr. Robert A. Shailer is the resident engineer in charge of the work for the Gillespie Company.

At the location of the Hudson River siphon the Board of Water Supply began the work of sinking two test-shafts with its own forces. Chambers





were excavated one in each shaft, so that drill borings could be made from them for the purpose of determining the elevation of continuous rock beneath the river-bed. The putting down of vertical holes has proved to be a very difficult undertaking on account of the great depth of cover over the rock and the interference due to vessels and tug-boats in the river. Even had a number of vertical holes been put down to the rock, it would still have been necessary to depend upon horizontal borings for a final determination of the character of the rock.

The Olive Bridge Dam.—The Ashokan Reservoir, 86 miles in a straight line from the New York City Hall, will be formed by the Olive Bridge Dam and the Beaver Kill dykes, as shown on the plan, Fig. 2, on page 118. At its easterly end the basin will be closed by the West Hurley dykes, which will aggregate 1.5 miles in length, and will have a maximum height of about 60 ft. The reservoir will be divided into two basins by a dividing dyke and weir. The elevation of the flow-line in the two basins will be 590 ft. and 587 ft. above mean tide for the westerly and easterly basins respectively. The total available capacity of this one reservoir will be about 127,000,000,000 gallons; the maximum depth of water will be about 190 ft., while the average will be about 50 ft. The volume of the water impounded would be sufficient to cover Manhattan Island to a depth of about 28 ft. The area of the water surface of the west basin will be about 7½ square miles. The total area of the water surface in these two basins is, therefore, equivalent to the area of Manhattan Island below 106th-street. The reservoir will have a length of about 12 miles and an average width of about 1 mile. Its shore-line will be about 40 miles in length. In connection with its construction, about 40 miles of new highway will be constructed, as will also about 13 miles of new location for the Ulster and Delaware Railroad which at present traverses practically the entire length of the reservoir basin. Seven small villages now exist in the territory to be submerged, and in order properly to control the shores of the reservoir a total area of about 23 square miles of land will be acquired. The total length of all the dams and dykes necessary for forming this reservoir will be about 5½ miles.

The most impressive single structure is the Olive Bridge Dam, which will consist of a central masonry portion 1000 ft. long, and rising to a height of 210 ft. above the bed of Esopus Creek. A section of this dam is shown in Fig. 7, page 120. Each end of the masonry will be flanked by an earthen wing. These wings will aggregate about 3600 ft. in length. The top of the dam will be at an elevation of 610 ft. above mean sea-level, its maximum thickness at its base will be about 200 ft., while at its top, which will be traversed by a roadway, the width will be 26 ft. The total volume of masonry in this portion of the structure will be about 550,000 cubic yards, of which about 65,000 cubic yards will be in the form of concrete blocks. The dam has a cross-section of the same general type as the new Croton Dam, the Wachusett Dam and the Cross River Dam. Its construction corresponds substantially to that of the Cross River Dam, with the exception of some features, including the inspection gallery and the provision for the collection of drainage and any seepage water that may be found in the completed structure. The maximum width of the eastern wings (Fig. 8) at their base will be about 800 ft.; their top width will be about 34 ft., and the total quantity of embankment materials will be about 2,000,000 cubic yards. Core walls of concrete, founded on ledge or impervious bottom, will be built into the earthen wings. The top of the dam will be at an elevation 20 ft. higher than the flow-line in the west basin, which will be at an elevation of 590 ft. During the construction of this dam, the stream-flow is being taken care of through a large opening left in the masonry of the dam; the dimensions of this opening are about 35 ft. in width and 45 ft. in height.

The Beaver Kill dykes will have a total length of about 2.3 miles. Their maximum height above the original surface will be about 110 ft., and their maximum width on the bottom will be about 650 ft. The total quantity of embankment material in these dykes, including also dividing dyke, will be about 5,000,000 cubic yards. These dykes, like the wings of the Olive Bridge Dam, are being built with concrete-core walls, and the total quantity of masonry in them will be about 180,000 cubic yards. The dividing dyke will have a length of about 1100 ft., and, together with the dividing weir, also of a length of about 1100 ft., will serve the purpose of dividing the reservoir into two basins. The intake gate-house will be located within the dividing dyke, and the water will come to it through inlet channels excavated for this purpose. The east inlet channel will have a length of about 3000 ft., while the west channel will have a length of about 5500 ft. The maximum depth of excavation for both will be about 75 ft., with an average depth of about 40 ft. From the intake gate-house, two pressure aqueducts, constructed of concrete in a trench in the rock and beneath the core-wall of the dividing dyke, will lead to the lower gate chambers, where the controlling apparatus will be located. The aeration devices will be situated close to these gate chambers, and will be controlled therefrom. The dividing dyke and weir accomplish the object of separating the reservoir into two parts, and, together with the arrangement of the gate-house and inlet-channels, make it possible to draw from either one or both of the basins, as, during the operation of the works, may be found desirable, or as the quantity of the water in the two basins may demand.

The spillway located near the easterly end of the Beaver Kill dykes will have a length of about 1000 ft., and its crest will be at an elevation of 587 ft. From the spillway the distance to Esopus Creek is about 1½ miles, and this point is at a distance of about 3 miles below the Olive Bridge Dam, measured along the centre of the creek.

The construction of the main dams for the Ashokan Reservoir was let to MacArthur Brothers Company and Winston and Co., at about 12,670,000 dols. The date set for completion is February 19, 1915. It is required, however, that by August, 1912, the work shall have so far advanced as to permit of the storing of water in the west basin, and of its delivery into the aqueduct. The following are the approximate quantities as given in the engineer's rough estimate:—

Earth excavation	2,055,000 cub. yds.
Rock excavation	425,000 ,,
Embankment and refilling	7,200,000 ,,
Portland cement	1,100,000 barrels
Masonry, all classes	874,000 cub. yds.
Rubble paving and riprap	105,000 ,,

Work on this contract was begun in the fall of 1907, and on May 20, 1911, about 52 per cent. of the work had been completed.

Construction of Dam and Dykes.—The foundations for the masonry part of the structure were first thoroughly explored by 15 diamond-point-drill borings to a minimum depth elevation of 300 ft., or 100 ft. below the bed of Esopus Creek. A careful study of the cores was made, and each hole was thoroughly tested by a special apparatus to determine positively the permeability of all portions of its length, as to underlying rock, location of seams, and the probability of seepage or flow through them. It was decided from a study of the data that the general foundations need not go more than about 10 ft. below the surface, except in the case of the cut-off wall. Heavy blasting is not permitted, and the sides of the cut-off channel have been cut smooth by Sullivan channellers. The earth is very compact, and before removal was shattered slightly with dynamite, and excavated with pick and shovel. This material will form the fill for the embankment portion of the dam.

For protection and drainage, a heavy layer of riprap is built on the outer faces of the sides, and carefully-selected earth is deposited in layers of not more than 6 in. on the down-stream side, and 4 in. on the up-stream side. This is moistened, levelled, and thoroughly compacted with steam-rollers made by the Monarch Road-Roller Company, of Groton, Tompkins Co., N.Y. It is specified that the weight and proportions of the rollers shall be such that, with a penetration of 1 in., the rear wheel shall have a pressure of 30 lb. per square inch on an area of the cylindrical surface, having a middle ordinate of one. It is stated by the contractors that this rolled earth has a weight of 135 lb. per cub. ft. All of the embankments have core-walls, and require the construction of extensive drainage ditches in addition to the stripping, clearing, and some excavation of the entire area. The photographs reproduced on page 132 illustrate the actual construction work on the main portions of the dam. Fig. 11 gives a general view of the works looking north across the gorge of Esopus Creek, which is being closed by the masonry portion of the dam. Excavation is in progress. The cement-mixing building is to be seen, while in the distance are four towers in connection with the Lidgerwood cableways for the conveyance of material. These towers are a prominent feature in Fig. 12, which also shows the power-plant, stables, and the derricks serving the block-yard. Fig. 13 is a view of the bed of the Esopus Creek at the site of the dam. The temporary cofferdams are seen completed, and the 8-ft. diameter steel pipe is for the passing of the dry-weather flow. Fig. 14 illustrates the work further advanced, the building of the masonry being in progress. The concrete blocks forming

Fig. 3.

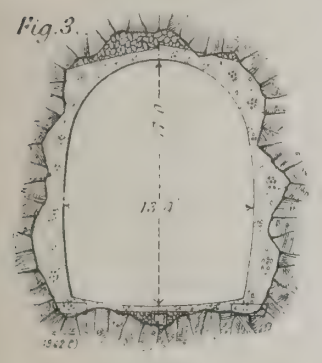


Fig. 4.

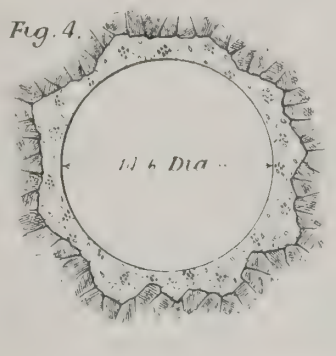


Fig. 5.

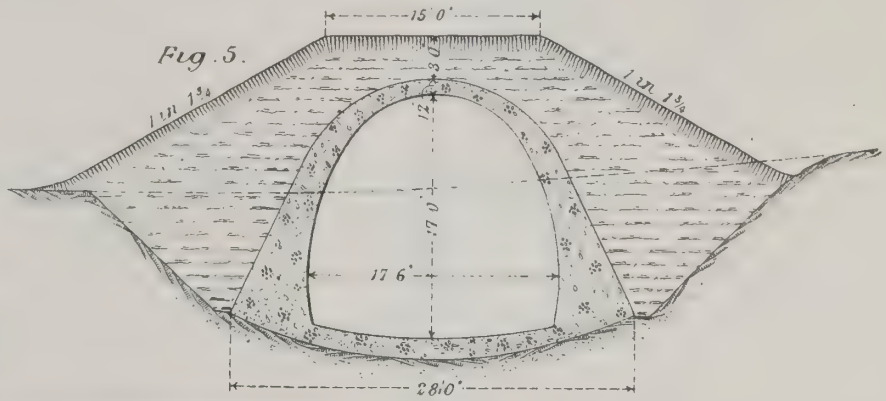


FIG. 6. CUT-AND-COVER AQUEDUCT UNDER CONSTRUCTION NEAR PEEKSKILL.

the up-steam face of the wall, and the cyclopean blocks forming "plums" in the concrete hearting will be seen, while the channelling out for the core wall of the wings is discernible beyond. The concreting of the main dam is now 75 per cent. complete. The concrete mixture is 1 : 3 : 5, used with large pudding-stones. The concrete-mixing plant will be described later.

Plant Employed on Olive Bridge Dam and Dykes.—MacArthur Brothers and Winston and Co. brought a large amount of equipment and experience on to this work, which had been employed and gained in similar constructions. Nearly all of the plant and temporary constructions are, therefore, installed on a scale much larger than would ordinarily be considered requisite for work of this magnitude, in order to provide not only for the severe progress requirements of the official schedule, but to secure the highest quality and greatest rapidity in the work that it is possible, irrespective of the contract specifications. Hundreds of thousands of dollars' worth of plant has been installed, a large quantity being of special design or construction intended for this particular work, and in many cases chargeable exclusively to this contract. The estimated value of the total plant is about 1,500,000 dols.

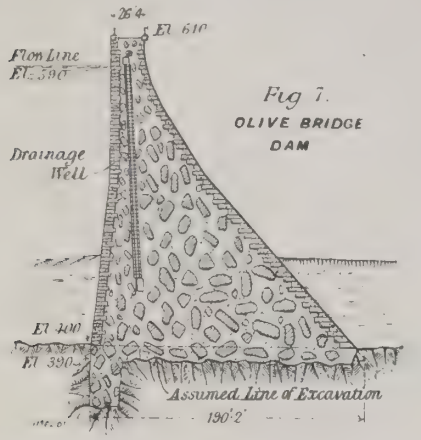


Fig. 7. OLIVE BRIDGE DAM

For the execution of the work, the principal equipment includes four great cableways and a derrick system for the Olive Bridge Dam, a stone quarry and several sand-pits, excavating and transporting plant for the construction of cuts and fills, rollers for compacting the embankments of the dykes and dam, derricks, steam-shovels, pumps, and other standard machinery, a large power plant and distribution service, two systems of water supply and distributions, a sewage-disposal system, an extensive railroad service, dump-wagons, a large stone-crushing plant, a concrete-mixing plant, concrete cars and handling apparatus, and a complete yard with moulds and facilities for casting and handling 200 cubic yards of concrete-block work per day. It was, of course, necessary to provide a camp organisation, with provisions and other improvements, on a large and extensive scale, calculated for the safety, comfort, and welfare for a great body of men for several years, and equal or superior in many respects to excellent municipal systems.

The cableways (Figs. 11 and 12, page 132) were built by the Lidgerwood Manufacturing Company, and, together with a row of powerful stiff-leg derricks, were installed parallel with the axis of the dam; they handle all materials of excavation and construction, including, of course, the concrete, and can be shifted up and down stream. The cableways have a span of 1530 ft., with a 15-ton capacity. The towers for these cableways are about 95 ft. high, and are constructed of first-quality pine timber from 12 in. by 12 in. down. About 60,000 ft. were employed on them. The cableways and all other hoisting-engines and apparatus, pumps, and other standard machinery, except the steam-shovels, locomotives, and remotely attached plant, are being operated by compressed air. The air is furnished by two Ingersoll-Sargent compressors, delivering 500 cubic feet of free air per minute. A complete machine-shop has been erected, as well as a smith's shop, equipped with steam-hammers, bending-machines, and four blasts. Power is furnished by a 65-horse-power General Electric engine, also operating an electric dynamo, furnishing current for 600 lamps. A carpenter's shop, tool-house, and supply store-house, 32 ft. by 125 ft., were built. The quarry is located about 1 mile west of the Olive Bridge Dam. The standard-gauge track leads from the crusher-house to it, and crosses the Esopus on a steel girder viaduct, 1200 ft. long. The rock found here is an outcropping of bluish-grey sandstone, and is stratified in approximately horizontal layers about 3 ft. or 4 ft. thick. A Marion shovel was used in stripping the quarry face.

The Concrete Plant.—The Olive Bridge Dam will contain about 550,000 cubic yards of concrete and a facing of moulded concrete blocks. It is desired to put the dam in service at the earliest possible date, and the construction and mixing plants have, therefore, been in excess in size of those installed on similar public works.

In a single-frame building, 80 ft. by 100 ft. by 65 ft. high (seen in Fig. 11, on page 132), are carried on the operations of crushing the stone, handling and storing the materials, and mixing the concrete and putting it on the work. Sectional drawings are reproduced in Figs. 9 and 10. The working platforms are at different elevations, and the sand, cement, and broken stones are stored at the top of the building, and are sent by gravity through the measuring devices to the mixers, which receive the charges from above and dump them below. The conveying machinery is all belted from two main shafts driven by a 250-horse-power Chandler and Taylor engine. The steam comes from the boilers located in the main power-house, about 150 ft. away.

There are installed on the ground floor of this building two No 6 Austin and one No. 9 McCully rock-crushers with a total capacity of about 200 cubic yards of stone per hour. The stone comes to the crushers direct from the quarry and is delivered to them from the surface track by stiff-leg derricks. The stone is placed in 4-yard steel skips in sets of four, on flat cars at the quarry. The crushers discharge into 48-in. screens, 16 ft. long, which separate the screenings less than $\frac{1}{4}$ in. and more than 2 in. The concrete stone is raised to the top of the building by a link-belt conveyor, about 90 ft. long. It has 24-in. by 30-in. open-top steel buckets, and runs at a speed of 85 ft. per minute. The stone from this conveyor discharges into a shoot which delivers it to two 30-in.-link-belt horizontal conveyors, which run the full length of the building, and which, in turn, deliver the stone to the storage bins. The screenings are sent through a shoot to a conveyor belt below the crusher floor, which discharges them on the sand belt. The stone larger than 2 in. is sent on a conveyor to the No. 6 crushers.

Sand is brought from the pit in 7-yard Western side-dump cars and dumped in a storage bin of about 500 yards capacity, made by an excavation

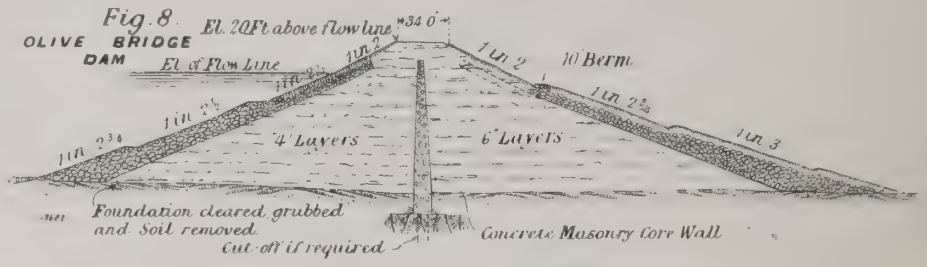


Fig. 8. TRANSVERSE SECTION THROUGH CRUSHER PLANT

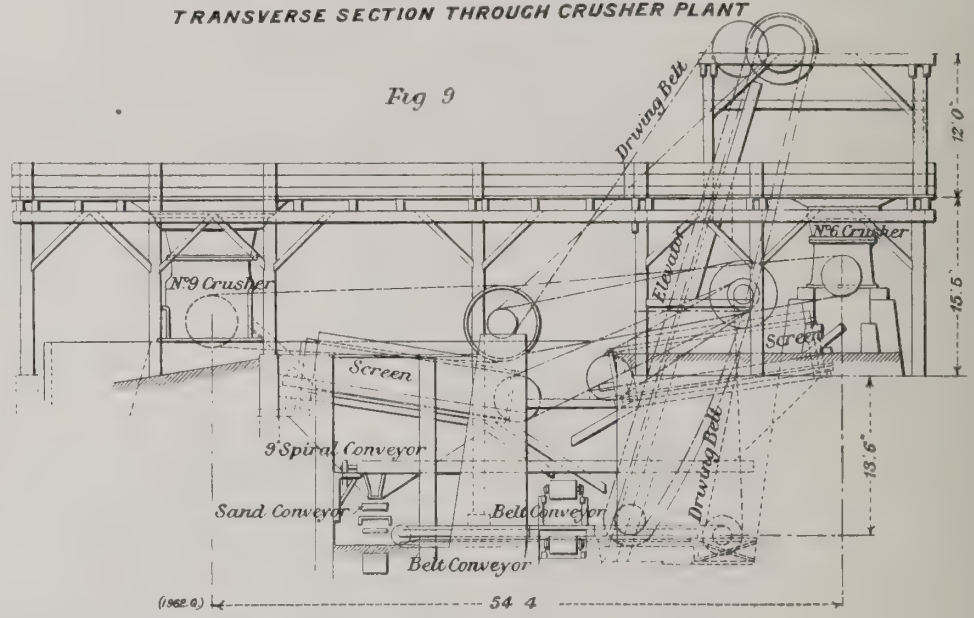


Fig. 9

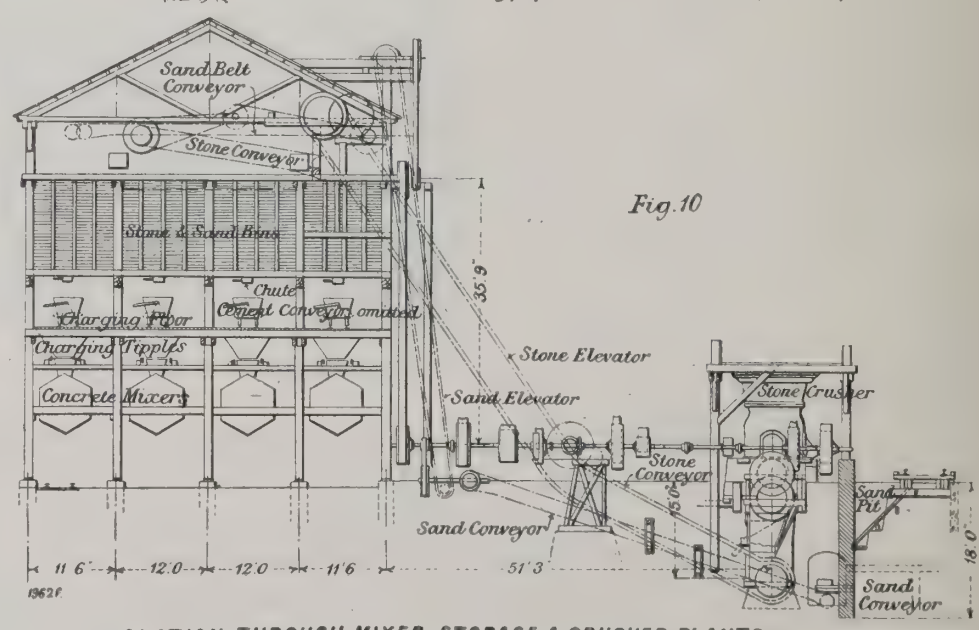


Fig. 10. SECTION THROUGH MIXER, STORAGE & CRUSHER PLANTS

just outside of the crusher and mixing plant. The sand is delivered by gravity to a belt conveyor which carries it to a bucket elevator, discharging at the top of the building to the distributing conveyor of the storage bins. The stone and sand bins are about 15 ft. deep and 100 ft. long, separated by a timber wall. They have a capacity of 1000 yards of stone and 500 yards of sand, and they are 24 ft. above the ground at their lowest point.

The Alsen and Giant Portland cement used is delivered in bags to the storage house, from whence it is sent as desired to the mixer hoppers by a 24-in. conveyor. The stone and sand are taken from the bins through steel gates on to conveyors which deliver to the inverted pyramidical steel charging-hoppers in any quantity desired.

The concrete used runs from 1:2.7:5 to 1:3:5, and requires 14 bags of cement for each 2½-yard batch. The water is taken through a valved pipe from a cylindrical steel tank near by, and the amount is determined by the concrete inspector. The water is added only while the machine is in operation, and it is sent through perforations in the hollow axis. The four mixers used are of the 2½-yard Keltenbach and Creis cubical type, and each can deliver thirty 2½-yard batches an hour. They discharge into Cyclopean bottom-dump buckets made by the G. L. Stuebner Iron Works. These buckets are placed in pairs on flat cars and are drawn by mules directly beneath the mixers. Four lines of track lead to the concrete-block-making yard and four lead to the four main Lidgerwood cableways. Up to the present, the plant has worked well when called upon for its full capacity, about 1200 yards being used on the dam and about 200 yards in the block-yard per day.

The concrete blocks are placed on both the up-stream and down-stream faces of the dam, and between 45,000 and 50,000 blocks will be used in this work alone. The blocks contain about 1⅓ cubic yards of concrete, and their height depends upon their position in the dam, those at the bottom being 2 ft. 9 in. high, while those in the middle and top have a height of 2 ft. 6 in. and 2 ft. 5 in. respectively (Fig. 14). Generally the blocks are rectangular, excepting those in the down-stream face of the dam, and they have one bevelled surface. These bevelled surfaces, as well as all surfaces exposed in the faces of the dam, are made against steel-lined sides of the moulds. The concrete-block-casting yard adjoins the mixing plant. The concrete is taken from the mixers to a movable platform in the yard, and it is then shovelled by hand into the forms, the platform being drawn to the location of the moulds. A force of fourteen men has made as many as seventy-five blocks in one eight-hour day. The moulds are sometimes removed from the blocks in 36 hours' time. The sides and ends (if they may be so called) of the moulds are simply dropped flat, and the blocks are hoisted by derricks and stacked to await their disposition in the dam.

Labour, Quarters, and Sanitation.—About 3000 workmen, mostly unskilled labourers, including negroes, Poles, Italians, and Slavs, are at work in the vicinity of Brown's Station. At the Ashokan Dam camp there is a daily house-to-house sanitary inspection, with removal and incineration of refuse. The sanitary regulations are posted on the trees along the streets in all languages spoken in the camp. There is a hospital with two doctors, who also have free dispensary hours, and there are three trained nurses. There is an adequate water supply, with a filtration plant. There are also a commissariat department, a bakery, a cold-storage plant, eating-houses, clean workmen's cottages, a pool-room, and an engineers' club. A school-house has a day-school in three grades, a kindergarten for the camp children, and a night school in which English is taught to the workmen. A school, garden, and a band are other features of camp life.

There have been very few cases of contagious diseases, and this is, of course, due to the excellent quarters and sanitation provided by the contractors.

Personnel.—The Ashokan Dam and Reservoir, the aqueduct and accompanying works, were designed, and are being constructed, under the supervision of the Board of Water Supply of the City of New York; Messrs. Charles Strauss, Charles N. Chadwick, and John F. Galvin, commissioners; Mr. J. P. Morrissey, secretary of the administration bureau; and Mr. R. H. Burk, inspector, Board of Water Supply Police. The engineering bureau consists of Mr. J. Waldo Smith, chief engineer; Mr. Merritt H. Smith, deputy chief engineer; Messrs. John R. Freeman, William H. Burr, Alfred Noble, and Frederic P. Stearns, consulting engineers; Messrs. Alfred D. Flinn, Robert Ridgway, Carleton E. Davis, Frank E. Winsor, Walter E. Spear, and Thaddeus Merriman, department engineers.

Summary of Board of Water Supply Forces.

Commissioners			3
Administration bureau :—			
Secretary and clerical	55		
Patrol-men on aqueduct	335		
		—	390
Engineering bureau :—			
Chief engineer and staff	15		
Headquarters department ...	225		
Reservoir department	225		
Northern aqueduct department ...	583		
Southern aqueduct department ...	270		
		—	1318
Totals...			1711

The general contract for the dam and dykes was awarded to MacArthur Brothers and Co. and Winston and Co. Mr. M. J. Look is the general superintendent for the contractors. Mr. F. H. Trow and Mr. Harry A. Briggs are the engineers, and Mr. C. H. Peters, the master mechanic, for the contractors. The T. A. Gillespie Company have the contract for constructing the Rondout siphon, and other contracts are still to be let.

ELECTRIC TRACTION IN SWITZERLAND.*

By E. HUBER-STOCKAR, of Zürich.

ELECTRIC traction on railways has occupied the minds of scientists and inventors as far back as the times of Faraday's memorable and fundamental discovery of the electro-magnetic mechanical production of electric current. In those times Davidson experimented with an electric locomotive on the railway between Glasgow and Edinburgh. His locomotive weighed about 5 tons; it had two axles, each driven by an electro-magnetic machine, and current was supplied from two Sturgeon's primary batteries carried on the locomotive. It was one of those unsuccessful but historically necessary attempts of science applied to practice prematurely.

It took about fifty years to make the electrical machine a thing really worthy of this designation, the signification of which was always determined by the high state of the art of mechanical engineering in general at the particular time. The decided and increasingly rapid development of electric locomotion began not much later than that of electric lighting, but earlier than that of electric power transmission proper. The key to electric traction was the self-adjusting trolley running underneath a contact-wire suspended overhead. The necessary requisites in the form of electrical machinery of sufficient voltage and power, of the so-called working in parallel or constant voltage distribution, and of a certain practical experience in electrotechnics, were in existence some time previously. After the start was made with the practical application of electricity to locomotion on rails shortly after 1880, electric traction developed along the lines of technical possibilities and actual demands, a good deal of which were modified or created by the very possibilities inherent to electricity as applied to traction.

There were the street railways, first the new ones, then those previously worked by horse-power, where the electric motor became absolutely triumphant before the end of the last century. Street railways extended beyond the boundaries of the cities, extension lines of neighbouring cities met, and the inter-urban electric railways became facts. New possibilities of traffic intercommunication were demonstrated, and severe competition with existing steam railways began. Electric traction developed into a mode of railway operation which made railways possible that were or had become impossible or impracticable with steam, for one reason or another.

In the large cities, elevated, underground and tube railways were equipped electrically. In Switzerland mountainous districts, inaccessible to steam traction, became possessed of efficient railways, invaluable for their commercial and touring development.

Electric railways proved to be an economic possibility where steam railways could no longer be financed. Especially in Switzerland, where living and manufacturing had become very expensive in the large towns, electric railways opened up agricultural and out-of-the way districts for commercial enterprise, and furnished a system of communication by rail, thus completing and feeding the system of main-line railways in a most beneficial manner.

Since 1890 electric traction has been adopted on one or another section of railway where steam traction appeared suitable. Subsequently, however, and more particularly since the beginning of this century, the question arose whether electric traction would not be the proper method of operating railways altogether, and it was, for a certain time, a matter for discussion whether the steam locomotive was to disappear and to be superseded by the electric locomotive and motor-car.

To-day the question is put in a restricted and more definite manner, and is treated with more recognition and knowledge from the part both of the electrical engineer and the railway manager. The one is realising more fully the enormous responsibility of the service of the railways he wished to electrify; the other is recognising more appropriately the reliability and efficiency of electric traction.

At the present time a number of remarkable electrifications have been carried out or are in course of completion, so that it is not necessary to waste words in justifying railway electrification as the subject of a paper to be read before a technical society, even not directly interested in electricity. At any rate, railway electrification will furnish work to a number of branches of mechanical engineering. More particularly the locomotive builder need not fear being deprived of work. His co-operation with the electrical engineer has been most significant and useful until now, and will be so in future. The era of motors geared to driving axles, as in street-cars, has probably passed, as far as the more powerful vehicles are concerned, and the electric locomotive of to-day is, with regard to its mechanical part, to a large extent the work of the steam-locomotive builder.

The reason for dealing more particularly on railway electrification in Switzerland is not because greater progress has been made in this direction, but because of the more general interest it presents in comparison with many other countries.

First of all, it may be found astonishing that progress has not been greater in this country than it actually has been, when one considers that Switzerland has to buy all its coal from foreign countries, and has a large amount of water-power still waiting for utilisation.

Secondly, Switzerland has had certain railways electrified at a comparatively early date, and might be expected to have gone onward on this basis, especially as applied electricity is highly developed in the country generally.

Thirdly, the very reason of the progress being less than might be expected adds greatly to the interest of the problem as presented in Switzerland. There are no such sections of railways as the terminal section of the New York Central and Hudson River and the New York, New Haven, and Hartford Railways, where steam has played out its *rôle* on account of the frequency of the trains or the smoke nuisance, and no such sections as the London Bridge and Victoria of the London, Brighton, and South Coast Railway, where over a million passengers were to be recovered that had been better served by competing tube and street railways. Though railway electrification in Switzerland is inseparable from the use of water-power, and though this use is evidently beneficial to the financial situation of the country in the long run, still it must, for various reasons, be effected in a way so as not to disturb the balance of traffic receipts on the one hand and the operating expenses and interests on loans on the other. The time is still far distant where even State railways will be built, as the principal street roads have been built all through the country and over the mountain passes, simply because they are necessary, no matter whether they are remunerative or not. Railways are still built and operated for the greater part, and most fortunately so, even by the State, on the basis of a commercial enterprise conducting a household of its own. Therefore, more particularly in Switzerland, where railways are, on the whole, not making profits because of cost of construction, heavy grades, rather irregular traffic, short average distance of travel, high wages, low fares, and so on, the problem of railway electrification is in every case a problem mainly of general economics of railway operation, since the technical problem has admittedly been satisfactorily solved so far.

The electrifications of importance that have hitherto been, or are being, carried out are almost all either of an experimental or preparatory character, or were brought about by considerations not directly or purely economical. In Switzerland the economy of operation is having a decisive weight, and makes the problem, as it is presented, difficult.

In Switzerland, as in other countries, the railways already electrified, or about to be electrified in the near future, are such that the smoke nuisance would be an almost prohibitive feature of steam, as in the case of the Simplon Tunnel, or where the capabilities of steam are near exhaustion, as in the case of the St. Gothard Railway.

To prevent misunderstanding it is expressly stated that in this paper by railway electrification is meant the introduction of electric traction either on existing steam railways or on such new railways that would or could, on account of their general character of road and traffic, and by analogy with similar existing steam railways, be operated by steam. By railway is meant simply a line or system of lines of railway comparable with a steam railway line or system of lines of medium or great importance. This involves a somewhat high standard of construction, of passenger and freight trains of a certain weight and frequency, a traffic of a certain volume, and of a service of high responsibility. It excludes railway lines of a purely local character and smaller importance as links of the whole system of railways of the country; it excludes street railways of the character of tramways, whether urban or interurban; it also excludes railways of a special character, such as rack and rope railways or railways operated during a part of the year only, even if their kilometric traffic or their local or tourist interest be great.

The gauge of the track, however, is not a feature which decides whether a railway does or not belong to those which are comprised in the railway electrification problem. There are, in Switzerland, only two gauges, 1.435 m. "normal" (English standard), and 1 m. "narrow," to be considered, There are normal-gauge, interurban, and

* Paper read before the Institution of Mechanical Engineers, at the Zurich Meeting, July 25.

NOTE.—For English equivalents of metric measures, see page 122

branch lines similar to tramways, playing no *rôle* in the electrification problem, except as experiments, and there are narrow-gauge railways that are important in their district and in general, and run trains of a weight exceeding that of many normal-gauge steam railways. These narrow-gauge railways must be included in the problem.

As regards the railways, electrical from the beginning, already electrified or now being so, it must be kept in mind that their importance lies either in their being sections of railways within the scope of this paper, or in their electrical equipment being representative of such systems of traction that were, or are now, considered suitable for the electrification of railways.

Space does not allow one to deal with all those narrow-gauge railways, with one exception, that had or have a significance in the evolution of electric traction on railways. All these railways appear on the tables giving the principal technical data; the description of them in detail must be left to the discussion, if it should be desired. Among these railways are notably the Montreux-Oberland Bernois and the Bernina Railways, both of considerable length, which demonstrate possibilities of railway construction and operation far beyond what can be done on the basis of steam traction.

There are among those also the Locarno-Bignasco and the Bellinzona-Mesocco Railways, which are representative of types of railways and electric equipments capable of extension on to lines and systems of lines of great importance.

Another general observation must be made as regards mentioning the names of the makers or designers. On account of the restriction in number of the railways to be described more in detail, the Electricitäts Aktiengesellschaft Alioth, of Mönchenstein, near Basel, hereinafter called Alioth, is not mentioned except in one case, their important work having been, as far as Switzerland is concerned, confined to narrow-gauge railways, which do not come under the head of railways within the scope of this paper. For this very reason the Compagnie de l'Industrie Electrique et Mécanique, of Geneva, hereinafter called Geneva, is not mentioned at all. To simplify the references, the following short names of firms will be used:—

A.E.G. = Allgemeine Electricitätsgesellschaft, Berlin.
B.B.C. = Brown, Boveri, and Co., Baden.
Neuhausen = Schweizerische Industriegesellschaft, Neuhausen.
M.F.O. = Maschinenfabrik Oerlikon.
Schlieren = Schweizerische Wagonfabrik Schlieren.
S.S.W. = Siemens-Schuckertwerke, Berlin.
Winterthur = Schweizerische Locomotiv- und Maschinenfabrik Winterthur.

Reference must also here be made to the fact that the metric system will be used for all indications in figures. Appended is a list of the English equivalents:—

English Equivalents of Metric Measures.

Linear	1 metre (m.) = 3.2809 feet. 1 millimetre (mm.) = 0.001 m. = 0.03937 inch. 1 kilometre (km.) = 1000 m. = 0.6214 statute mile. 1 foot = 0.3047945 m. 1 inch = 25.39954 mm. 1 statute mile = 1.609315 km.
Surface	1 square metre (m^2.) = 10.764 square feet. 1 square kilometre (km^2.) = 247.11 acres. 1 square foot = 0.0929 m^2.
Volume	1 cubic metre (m^3.) = 35.317 cubic feet. 1 cubic foot = 0.0283 cubic metre.
Weight	1 kilogram (kgm.) = 2.20462 lb. 1 ton = 1000 kgm. = 0.9842 (long) tons. 1 lb. = 0.45359 kgm. 1 (long) ton = 2240 lb. = 1.01605 tons (metric). 1 short ton = 0.9072 ton (metric).
Weight Moved	1 ton-kilometre = 0.61157 ton-mile.
Power Effect	1 PS. (Pferdestärke) = 75 kilogrammetre per second = 0.9863 h.-p (horse-power). 1 h.-p. = 1.0139 PS.
Money (Swiss) (approximate)	1 franc (fr.) = 9.6 pence. 1 centime = 0.01 fr. = 0.096 penny. 1 shilling = fr. 1.25. 1 pound sterling = fr. 25.

1 % = one in hundred.
1 ‰ = one in thousand.
1 m/s/s = 1 metre per second per second (acceleration).
= 3.2809 feet per second per second.

Certain references in the illustrations and diagrams are given in the German language. The author is highly indebted to the A.E.G., B.B.C., M.F.O., S.S.W., the Schweizerische Bauzeitung, and Messrs. M. Weissenbruch, of Brussels, for having allowed certain illustrations to be reproduced. He is also indebted to the Département fédéral des Postes et des Chemins de fer for having given permission to attach to the paper the general map of the railways of Switzerland, forming part of its statistical annual report (hereinafter called official statistics) on which the lines operated electrically, or about to be so, are marked with blue dotted lines parallel to the distinctive coloured lines.* The author is also indebted to the Schweizerische Landestopographie for their kind permission to make use of several maps.

Fig 1 B.T.B. 300 H.P. THREE-PHASE ELECTRIC LOCOMOTIVE, TYPE 1899. (BROWN, BOVERI.)

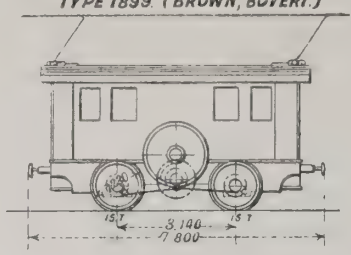
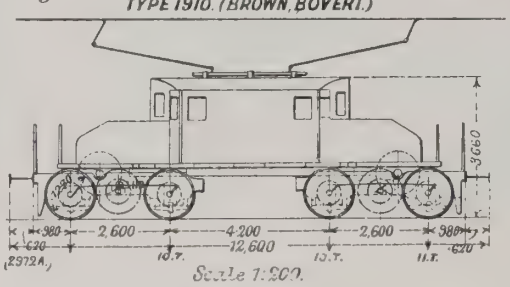
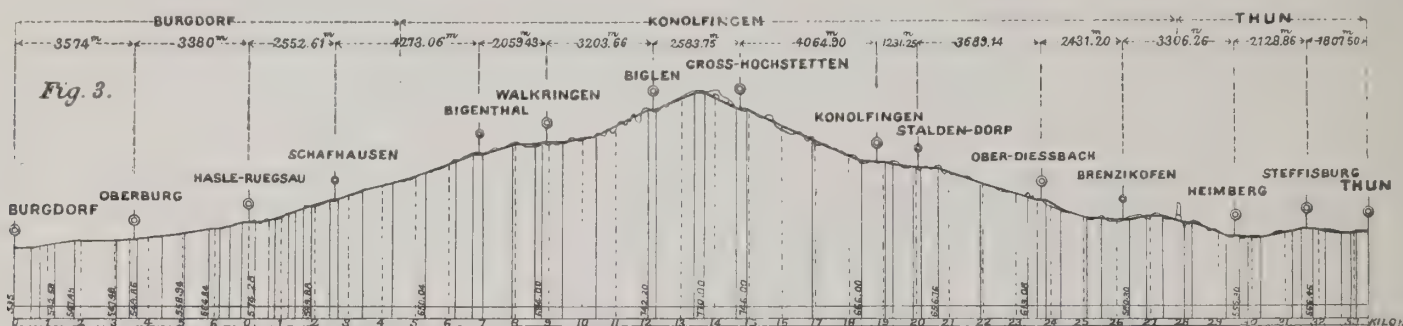


Fig. 2 B.T.B 800 H.P. THREE-PHASE ELECTRIC LOCOMOTIVE. TYPE 1910. (BROWN, BOVERI.)



Scale 1:200.



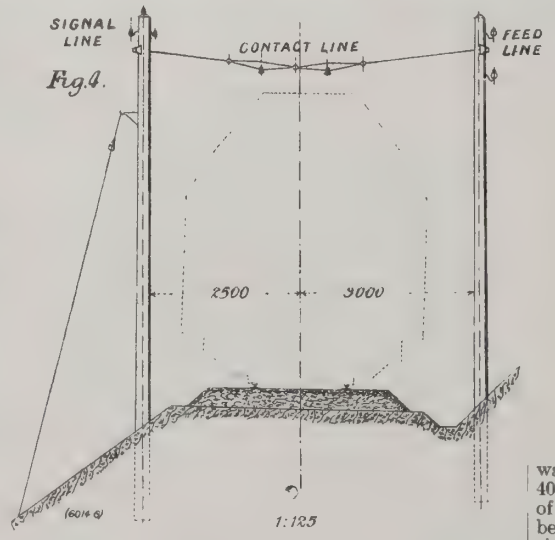
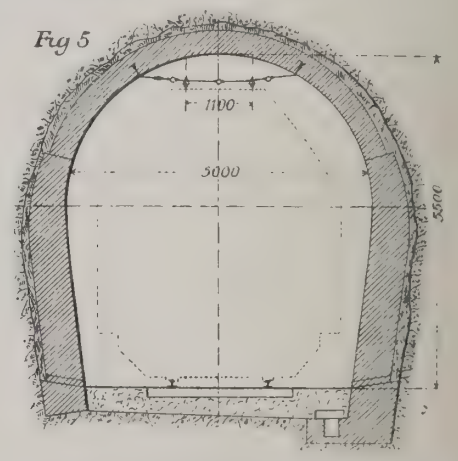


Fig 5



He is also much obliged to the above-mentioned firms, to the companies of the railways mentioned in the paper, and to the Bernische Kraftwerke A.-G. for the information they have given or offered to him.

The description of electric railways will be preceded by some general information on the railways of Switzerland, compiled from the official statistics. Rack and rope-railways, being a special feature of Switzerland, and tramways, will be included for comparison.

Attention is called in Table I. (page 123) to the slow progress of normal-gauge railways since about 1883, and the rapid progress of narrow-gauge railways since about 1887.

Some information on the aggregate length and the character and cost of construction of the railways, compiled from the official statistics for 1909, the latest published, will be found in Table II. (page 123).

The extent of electric traction on rails in Switzerland, and particularly that of electric-locomotive traction, is seen from Table III. (page 123), compiled from the official statistics for 1909. Special attention is drawn to the improvement in the percentage of normal-gauge electric railways up to the present time — 5.4 per cent. instead of 2.9 per cent. in 1909.

On Table IV.* (page 127) are found, more or less in the chronological succession of their electric operation, particulars of railways coming under the head of electrification within the scope of this paper, and of those other electric railways that have an historical or technical interest as important steps in the progress of electrification of railroads in Switzerland and in general. On this table the names of the original contractors are indicated, but it must be borne in mind, in several cases, that other firms have supplied plant for extensions or additional traction motor equipments. This is the case, especially as regards the power stations, not particularly referred to in this table, which are almost invariably operated by independent enterprises of general power distribution, though, as a rule, the current for electric railways is generated by separate machinery specially installed for the purpose. A comprehensive statement on the character of all these railways is offered in Table V.* (page 127).

Some of these railways will be described in detail, while the more interesting of the data of the remaining railways in Table IV., are given in Table VI. (to be printed in a later issue). Other details of these railways which are almost all of considerable interest in the problem of electrification, if it is framed a little wider than admissible in this paper, must be left to the discussion.

Burgdorf-Thun, B.T.B., Figs. 1 to 12.—(No. 3 on Tables IV. and V.).† It is noteworthy that the first electric traction on a railway of the general character of normal-gauge railways of medium importance was on the alternate-current principle, and more particularly on that of three-phase current. At the time of construction of the B.T.B., three-phase current was almost universally used for all power transmission and distribution dealing with distances of some importance.

The supply of electric power to the trains of the B.T.B., the terminal of which is Burgdorf, is over 50 km. distant from the source, where hydraulic power then was ready for use. Owing to the length of railway of 40 km., and the means then available, sectionising of the line was obviously necessary, 500 to 750 volts being then still the limit of electric-traction voltage considered necessary, and sub-stations were also required. According to the then practice, at least two such sub-stations with converting machinery under constant attention would have been necessary. The trains likely to be hauled were of a weight, and the grades of a length, not yet customary in electric-traction practice in general; those sub-stations would have become of a size and cost, both of plant and operation, not compatible with the small average useful load of the few trains on them. Briefly, the problem of electrification, with its awkward features under average Swiss conditions, was set forth in the case of the B.T.B. The solution in an economical way, as regards cost of plant and specially of operation, was obviously the elimination of costly sub-stations and the adoption of the three-phase current transmitted from the power-house to the contact-line and traction-motor equipments, instead of first to converter stations.

* This map is not reproduced here.

* Parts only of Tables IV. and V. are reproduced in this issue; the other parts will be given in a later issue, when the lines enumerated in the tables are described.

† See also Thomann, Schweiz. Bauzeitung, vol. xxxv., Nos. 1, 2, 3, 4, 5, 6, 11, 17; I. Mech. E., 1900, page 435 (Carus Wilson); TRACTION AND TRANSMISSION, vol. ii., page 32; ENGINEERING, vol. lxx., pages 99 and 133.

The essential feature of all alternate-current methods is the possibility of transforming current of high or low voltage into current of low or high voltage with relatively little loss of power in apparatus relatively cheap, having no moving parts and requiring only occasional attention.

The credit of having introduced three-phase current into electric locomotion on railways is largely due to the B.B.C. The scheme was not entirely novel, as the same firm had already equipped a few kilometres and cars of the tramway in Lugano, the Gornergrat rack railway and the Stansstad Engelberg railway (No. 2, on Tables IV. and V., on page 127). The adoption of three-phase current involved a compromise of advantages and disadvantages which are more or less evident. The advantages were:—The elimination of costly sub-station plant and operation, and the reduction in investment or loss of power, or both, in the contact line, by making more sections of smaller length, supplied each with a simple transformer sub-station, the aggregate cost of which was far below that of even a much smaller number of converting sub-stations.

The disadvantages, on the other hand, were:—A more complicated contact line, composed of two contact-wires that were to be interinsulated; certain difficulties in the construction and operation of the contact line above points and crossings of track; the impossibility of increasing, by whatever means of controlling apparatus, the speed above a certain almost constant speed, which had to be accepted as the normal speed on load; also working at lower speeds being connected with considerable loss of power in the form of heat. That speed depends on the fixed and constant number of periodic cycles of any kind of alternating current and the then unalterable number of poles of the motors. The motor runs almost as if it was positively geared to the machines in the power-station, and those features of three-phase motors of these times can properly be called the one-speed feature and the gear-wheel feature. Consequently the speed of a train remains practically constant on all up-grades as long as the electric current is on, and the required torque of the traction motors, corresponding to the resistance of the whole train, keeps within certain limits, beyond which the motors get "out of step," and stop. This feature has, however, not been felt as a source of trouble, and will not be so felt if motor equipments and train-loads are properly proportioned, as they must no less be in steam practice.

TABLE I.—*Historical Development of the Railways in Switzerland.*

Year.	Normal Gauge.	Narrow Gauge.	Rack.	Tramways.	Rope.	Total.
	km.	km.	km.	km.	km.	km.
1844-46	1.0	..	..	..	..	1.0
1855	210	..	..	..	..	210
1860	1052	..	..	..	..	1052
1865	1321	..	5.7	..	..	1227
1870	1420	..	5.7	..	..	1426
1875	1926	36	24.0	6	..	1991
1880	2448	48	24.0	12	2.8	2535
1885	2727	57	24.0	22	3.7	2835
1890	2784	262	57.0	84	10.0	3198
1895	2962	354	102.0	141	17.0	3576
1900	3101	441	126.0	287	24.0	3980
1905	3290	795	131.0	350	26.0	4594
1909	3372	1011	141.0	373	32.0	4931

TABLE II.—LENGTH AND COST OF CONSTRUCTION OF THE RAILWAYS IN SWITZERLAND.

Railways.	Number of Companies.	Length of Lines Constructed.	Length of Lines on Public Roadways.	Number of Tunnels.	Length of Tunnels.	Number of Bridges 2 to 10 M. Wide.	Number of Bridges 10 to 30 M. Wide.	Number of Bridges 30 and More Metres Wide.	Aggregate Length of Bridges in Kilometres.	Per Cent. Level Tracks.	Per Cent. Straight Track.	Aggregate Difference of Altitudes in Metres.	Total Cost of Construction and Equipment in Thousands of France.	Kilometric Cost of Construction, including Land, excluding Rolling-Stock, in Thousands of Francs.	Kilometric Cost of Railway Complete in Thousands of Francs.
		km.	km.		km.										
Federal Railways, including St. Gothard, excluding Brünig	1	2626	..	201	113	1857	313	219	33.5	27.0	64.0	16,565	..	..	..
Federal Railways, excluding St. Gothard and Brünig	1	2353	..	121	67	1534	234	171	27.1	27.7	64.0	14,002	1,035,262	316	426
St. Gothard Railway	..	273	..	80	46	322	79	48	6.4	20.4	57.0	2,563	296,823	810	1083
Other normal-gauge railways	35	6 9	41	50	17	340	67	45	6.4	..	..			72 to 508	89 to 654
Narrow-gauge adhesion railways	48	1070	263	138	33	498	174	82	12.3	..	..	49,424	342,427	28 ,, 292	46 ,, 418
Rack railways	14	94	0.4	49	8	74	31	7	1.4	..	..			171 ,, 626 Jungfr. 1376 to 1693	214 ,, 749
All railways	96	4491	294	438	171	2769	585	353	53.6	22.4	62.4	67,155	1,674,512	281	378
All railways, excluding Federal Railways and St. Gothard	95	1865	294	237	58	942	272	134	20.1	15.8	63.4	49,424	342,427	161	203

TABLE III.—DISTRIBUTION OF ELECTRIC MILEAGE AND ELECTRIC VEHICLES OVER THE RAILWAYS OF SWITZERLAND.

DECEMBER 31, 1909.

Types and Name of Railways.	Kilometres of Railway Operated by Steam.	Kilometres of Railway Operated by Electricity.	Electric Railways in per Cent. of all Railways.	Number of Electric Locomotives.	Number of Passenger Electric Motor-Cars.	Number of Freight Electric Motor-Cars.	Number of Steam Locomotives.	Number of Passenger Cars without Electric Motors.	Number of Freight Cars without Electric Motors.	Observations.
Normal Gauge.										
Federal Railways, including St. Gothard, excluding Brünig	2713	21.7	0.8	4	..	..	1183	3060*	14,777	*One petrol or steam motor-car
Arth-Goldau	..	2.6	..	..	2	..	..	1	..	Electrified.
Burgdorf-Thun	..	40.2	..	2	6	..	..	10	71	*Electric from beginning. 1911, 3
Fribourg-Murten-Ins	..	32.3	..	..	4	..	..	6	49	Electrified.
Orbe-Chavornay	..	3.9	..	..	2	2	..	3	1	Electric from beginning.
Normal-gauge railways, excluding Federal Railway	597*	79.0*	11.7	2	14	2	127	385†	1,193	*In 1911 | 604 | 166 | 21.6
All normal-gauge railways	3310.0*	100.7*	2.9*	6	14	2	1310	3445	15,970	†In 1911 | 3317 | 188 | 5.4
Narrow-Gauge Railways.										
Aigle-Leysin	..	6.8	..	1	4*	..	1†	4	13	*Adhesion and rack mixed. †Stand-by.
Bex-Villars-Chésière	..	13.8	..	4	11*	..	..	1	11	*Adhesion and rack mixed. †Stand-by.
Grütschalp-Mürren	..	4.3	..	3	.	..	..	2	2	
Martigny-Châtelard	..	20.5	..	2	12*	..	1†	8	21	*Adhesion and rack mixed. †Stand-by.
Sissach-Gelterkinden	..	3.1	..	1	.	..	2†	4	2	†Want of water-power.
Stansstad-Engelberg	..	22 5	..	4	10	..	2†	5	21	*Rack rail sections. †Stand-by.
Other electric narrow-gauge railways	..	464.1	..	..	159	17	3	121	420	
All narrow-gauge railways (steam and electric)	537.8	585.1	49 8	18	196	17	152	593	1,294	
All normal and narrow gauge railways	3847.8	635.8	14.2	24	210	19	1462	4038	17,264	
Rack Railways.										
Brunnen-Morschach	..	2.0		3	..	..	..	4	2	
Gornergrat-Bahn	..	9 3	..	4	..	.	.	9	2	
Jungfrau-Bahn	..	5.6	..	7	..	.	..	12	4	
Montreux-Glion	..	2.7	..	3	.	..	..	5	10	
Wengernalp-Bahn	.	(18.0)†	..	4†		..	10	22	11	†Electrification commenced; since completed, with ultimately 18 locomotives.
Other electric rack-railways	..	9.1	..	.	4	..	..	11	6	
All rack-railways (steam and electric)	67.7 (49.7)†	28.7 (46.7 †)	30.0 (48.6)	21	4	..	56	139*	39	†See observation under Wengernalp-Bahn. *Eleven steam motor-cars.
All tramways	..	1.7	388 7	99 5	..	742	3	6*	222	105	*And two horses.
All rope-railways	8.2	..	..	..	..	..	..	24	..	Water ballast.
	1.8	..	..	..	..	..	..	8	23	Steam and hydraulic motor.
	..	22.3	69	..	..	..	..	52	1	Electric motor haulage.

The B.T.B. was electrically equipped from the beginning; it is operated by the Emmentalbahn Company, which works a steam line of their own of 43 km. between Solothurn and Langnau. About 7 km. of track east of Burgdorf are common to both railways, and are therefore operated by steam and electricity at the same time.

As much information is given on the profile of the railway (Fig. 3) and illustrations (Figs. 1 to 12), and Tables IV. and V., on page 127, further observations will be confined to descriptions of the motor-cars and locomotives.

Passenger trains of 90 tons weight are operated with motor-cars of the following type and equipment (Figs. 6 to 8):—

Number of axles, all driving	Two four-wheel bogies
Total weight equipped, empty	32 tons
Number of seats	66
Weight of electric equipment	10 tons
Length between buffers	16.300 m
Distance between centres of bogies	9.500 ,,
,, ,, bogie axles	2.200 ,,
Diameter of wheels	1.020 m.
Motors, three-phase induction, rheostatic control for reduction of normal speed.	
Voltage of motors	750
Periodicity of alternating current	40
Power per motor, one hour rating	60 h.-p.
Total motor power on car	240 h.-p.
Gear ratio: single reduction	1:3
Normal pull on tread	1800 kg.
Normal and maximum speed	36 km. per hour.
Contact: two-part bow.	
Brakes: air pressure.	

From the commencement there were two locomotives (Figs. 9 to 12) for dealing with freight trains of 100 to 150 tons weight. As may be seen from the illustrations, they could work with two different ratios of gearing, the one or the other gearing being clutched in. The one-speed feature is thus overcome to a certain extent. The locomotive can run economically at two speeds, 36 km. and 18 km. per hour, while the one-speed feature is reserved for each of these two particular speeds.

In 1910 another locomotive, of a type first introduced in the Simplon Tunnel (No. 8, Tables IV. and V.), was added which allows much heavier trains to be hauled. Instead of purely mechanical means of overcoming the one-speed inconvenience, not desirable in heavier traction, purely electrical means were adopted. The multi-speed feature, adopted and developed for other purposes than traction proper many years before, was resorted to and adapted in a way so as specially to suit the case. By means of a controller switch, sectionising the windings of the motors, these are made, in the case of these locomotives, of one out of four different numbers of poles. Consequently the motors run, according to the number of their poles, by virtue of the position of the switching controller, at one of those particular speeds. It is seen that there are, so to speak, four different motors incorporated in one motor, properly called a multi-speed motor. With reference to each of these four speeds the one speed and the gear-wheel features obtain, but there is, as experience seems to prove, yet a sufficient freedom of adjustment of the economical speeds to the varying requirements of practical locomotive driving on the railways having such locomotives (B.T.B. and Simplon).

The two types of locomotives of the B.T.B. are of the following description:—

	Type 1899.	Type 1910.
Number of axles, all driving	2	two 4-wheel bogies
Total weight equipped	30 tons	42 tons
Weight of electrical equipment	10 ,,	18 ,,
Weight on single wheels	7.5 ,,	5.0–5.5 tons
Length between buffers	7.800 m.	12.600 m.
Distance between front and rear axle	3.140 m.	9.400 m.
Diameter of driving wheels	1.230 m.	1.230 m.
System of motors	Three-phase 1-speed, rheostatic control, slip-rings and brushes.	Induction multi-speed, intermediate voltage control, no slip-rings nor brushes.
Voltage of motor	750	750
Periodicity of alternate current	40	40
Power of each motor, one hour rating	150 h.-p.	400 h.-p.
Number of motors	2	2
Mechanical arrangement	Gears, (changeable) countershaft connecting-rods	Gears, countershafts, connecting-rods
Gear ratio	1 : 1, 88 and 1 : 3, 72	1 : 4
Contact	Two-part bow	Two-part bow, articulated
Brakes	Pressure air	Pressure air
Normal (economical, constant) speeds in km. per hour	18 36	15.75 21.0 31.5 42.0
Total power of locomotive in horse-power	300 300	500 600 700 800
Total pull on head, kg.	4400 2200	8570 7720 6000 5140

The mechanical part of the locomotives is by Winterthur, the electrical by B.B.C.

The electric traction on the B.T.B has been satisfactory. Disturbances interfering with traffic have practically disappeared, and at no time has any dissatisfaction been noticed. It is of the greatest benefit to the electrical operation, especially since a powerful locomotive had been added, that power is supplied from a large power-station near Spiez on the Lake of Thun, capable of dealing with the heavy variations in load. The power-

station belongs to a large power transmission and distribution supply enterprise, the Bernische Kraftwerke A.G., who operate about 60,000 horse-power and are controlling very large additional power in course of development. All power is hydraulic.

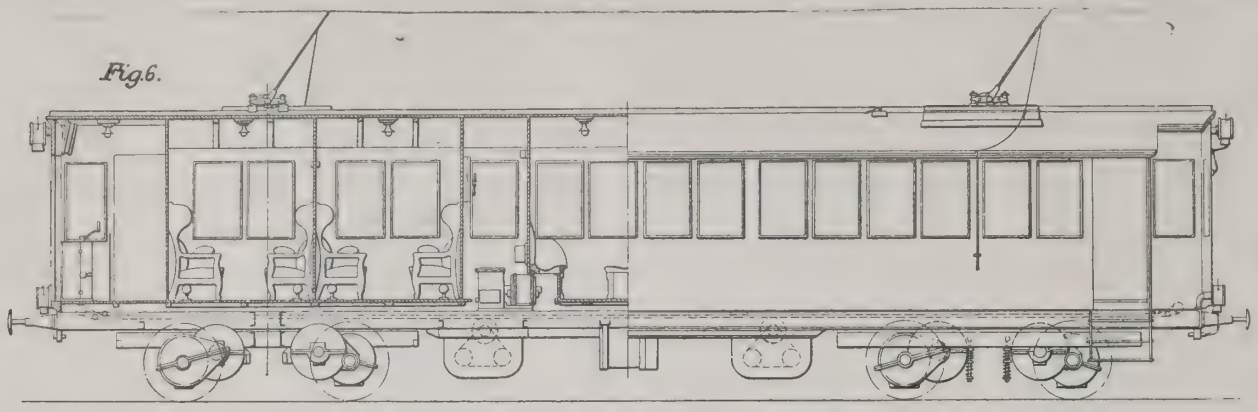
supply enterprise adjacent. The electrification was completed in 1902 as far as Murten, and in 1903 on the extension to Ins only then constructed. The whole electric equipment of the railway was supplied by M.F.O. There are only four motor-cars. Locomotives will come if freight traffic becomes sufficiently developed. This electrification was the first, and is the only normal-gauge one in Switzerland carried out on the continuous-current system with a third rail. The pressure of 800 volts was a novelty in third-rail practice at that time, and has proved safe and satisfactory.

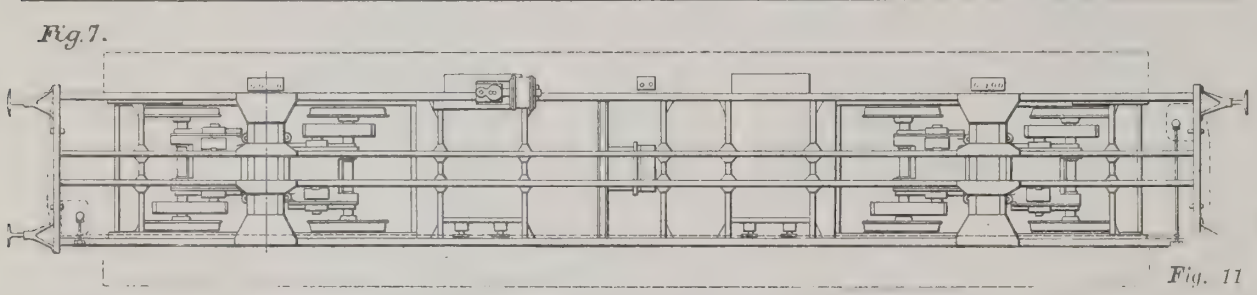
Three-phase current of 8600-volt tension and 50 cycles is supplied from Hautersive, about 3 km. south of Fribourg, a power-station of 6000 to 10,000 horse-power, all hydraulic, distributed for all kinds of purposes in the district. The third rail is fed from two converter stations, each equipped with converting machinery of relatively moderate size, and accumulator batteries to provide for peak loads.

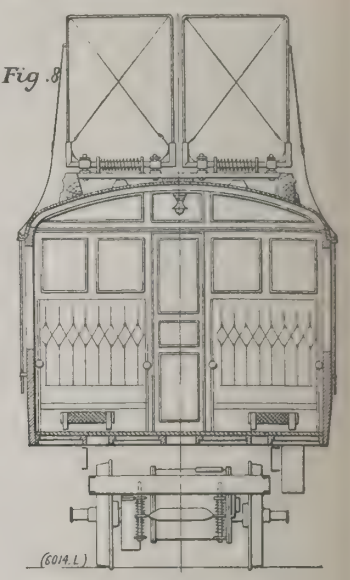
The consumption of power is about 34 watt-hours per ton-kilometre, exclusive of losses in converting machinery and batteries. Inclusive of these losses, the consumption is to be estimated at 60 to 80 watt-hours according to circumstances.

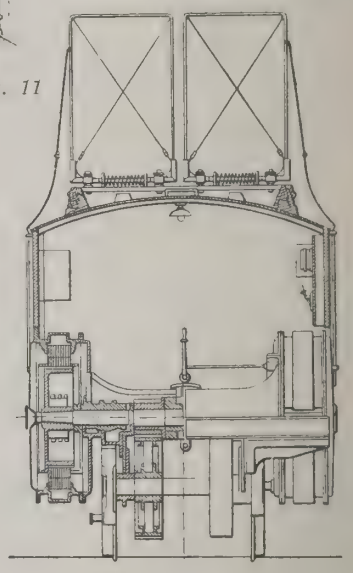
The F.M.A. is the only railway of which a comparison of steam and electric operation is available. The result of electrification has been satisfactory, as far as could be expected with the hitherto small traffic.

The following figures cover the years from immediately before until immediately after the electrification. The increase in capital is caused both by the construction of the extension Murten-Ins (about 10 km.) and the electrification of the whole line of over 32 km.

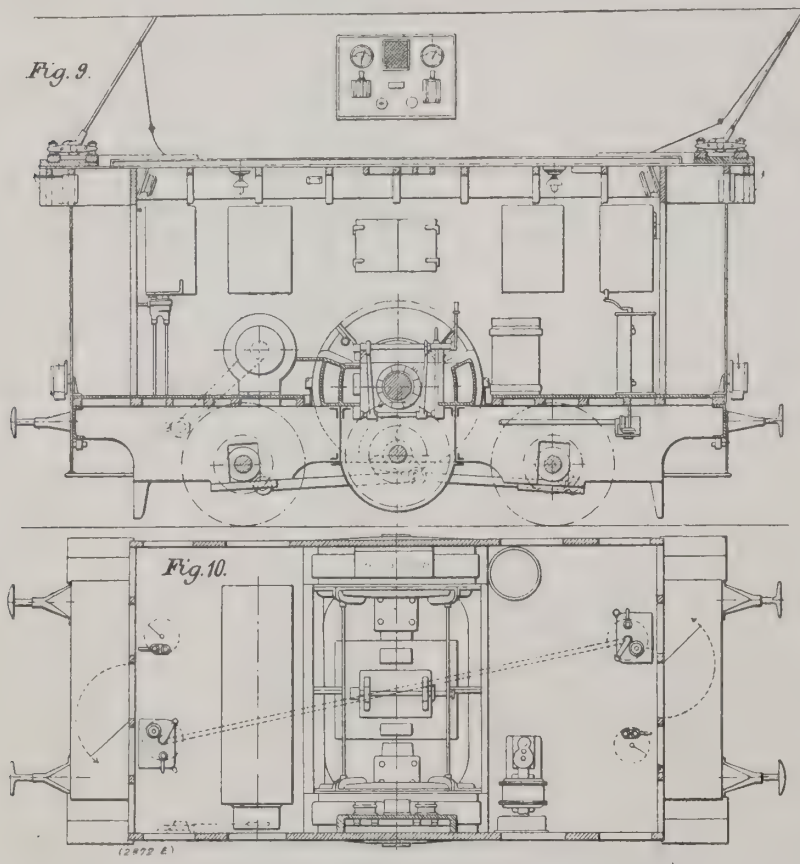


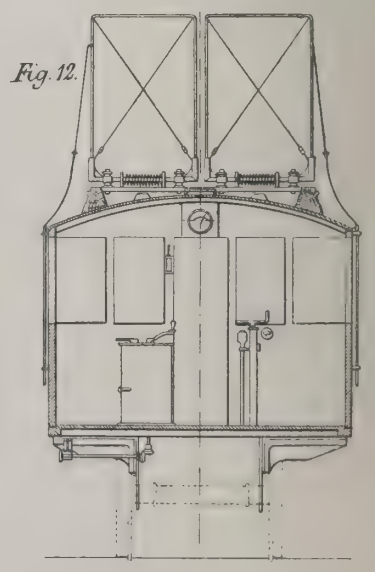






FIGS. 6 TO 8. THREE-PHASE ELECTRIC MOTOR-CAR OF B.T.B. (BROWN, BOVERI).





FIGS. 9 TO 12. 300-H.-P. ELECTRIC LOCOMOTIVE, TYPE 1899, OF THE B.T.B. (BROWN, BOVERI).

The transmission voltage between Spiez and the fourteen transformer sub-stations along the B.T.B railway is 16,000. The consumption of electrical energy is 68 watt-hours* per ton-kilometre. The expense for current at 4 centimes per kilowatt-hour in 1904 was 0.284 centime per ton-kilometre and 18.35 centimes per train-kilometre. In the same year 290,807 train-kilometres were run. Lubrication cost 0.94 centime per train-kilometre.

Fribourg-Murten-Ins, F.M.A.—(No. 4 on Tables IV. and V.)—The F.M.A. is interesting as the first normal-gauge railway which has undergone actual electrification. This railway is of invaluable service to the district traversed, but the financial results are unsatisfactory. The electrification was made possible by the controlling influence and financial interest of the State of Fribourg both in the F.M.A. (Fribourg-Morat-Anet) and in the electric-power

* This result and the majority of the corresponding results referring to the railways (Nos. 2 to 8 on Tables IV. and V.) are taken from the compilation by Professor Dr. W. Wyssling 621, 33, Bericht No. 3 über Frage VIII., Electrische Zugförderung (International Railway Congress, Berne, 1910).

Results of Operating the F.M.A. Before and After Electrification.

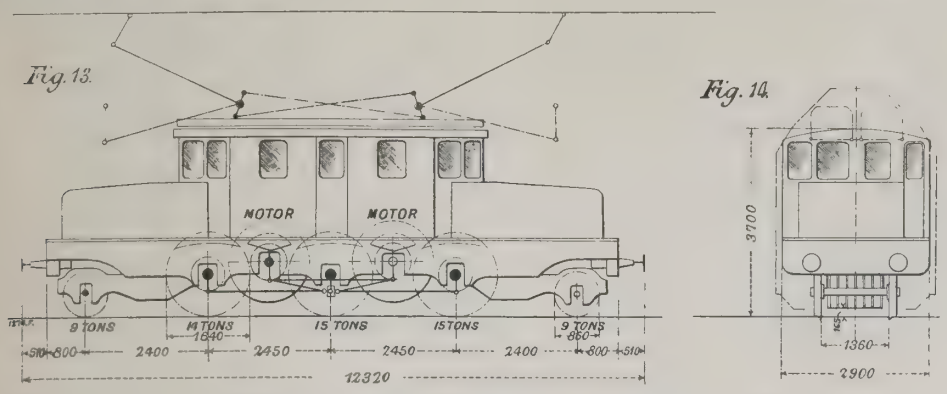
—	1901.	1902.	1903.	1904.
	francs	francs	francs	francs
Capital investment ..	1,715,658	2,292,174	2,692,952	2,895,676
Excess of operating expenses	34,254	29,904	—	—
Excess of receipts from traffic	..	..	18,025	35,548
Interest on capital investment .. p.c.	..	..	0.485	1.23

The electric system requires no detailed description; it

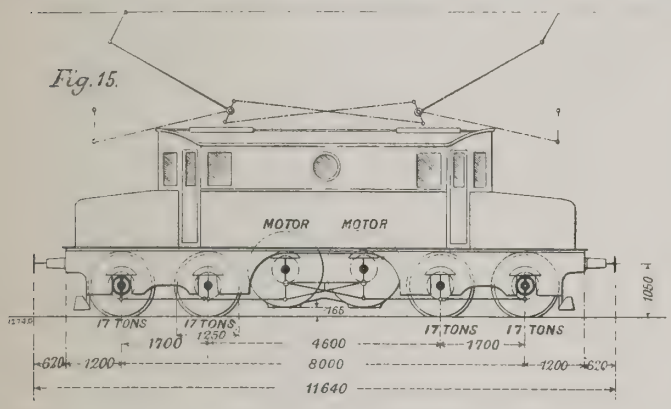
is sufficiently known from the large number of third-rail elevated, underground, tube, and other railways in other countries.

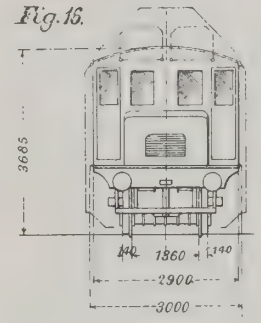
The particulars of the motor-cars (cars by Neuhausen and Rastatt, electric equipments by M.F.O.) are given in the following tabular description :—

Distance between bogie-axles	2.000 m.
Diameter of wheels	1.010 ,,
Number of motors in car ...	4
System of motors	Continuous current. Series-parallel and rheostatic control
Maximum speed	54 km. per hour
Contact	Third rail top contact-shoe
Weight of trains (with one motor-car)	80 tons
Maximum acceleration	0.15 m. to 0.20 m. per second per second



FIGS. 13 AND 14. THREE-PHASE TWO-SPEED ELECTRIC LOCOMOTIVE, 800 TO 1100 H.-P., 1906 PATTERN, FOR SIMPLON RAILWAY; BROWN, BOVERI.





FIGS. 15 AND 16. THREE-PHASE MULTI-SPEED ELECTRIC LOCOMOTIVE, 1100 TO 1700 H.-P., 1907 PATTERN, FOR SIMPLON RAILWAY; BROWN, BOVERI.

Simplon Tunnel, Figs. 13 to 21 (No. 8, Tables IV. and V.).—The electric traction in the Simplon Tunnel is mainly justified by a desire to complete one of the most significant feats of railway construction with a mode of traction appropriately modern, and to prevent the nuisance of smoke in the longest tunnel in the world (19.803 km. = 12.306 miles).*

On the completion of the Simplon Tunnel, railway engineering had progressed so far that engineers were prepared to electrify a straight tube with no grades of any importance. The Baltimore and St. Claire Tunnels were sufficient precedents. On the other hand, the operation of the tunnel by steam was, from the traction point of view, easy, as there was steam traction at both ends (the Federal Railways performing the traction as far as Iselle on the Italian side). In fact, the Federal Railways neither expected nor were prepared for electric traction in the Simplon Tunnel. Only quite shortly before the opening of the tunnel in 1906 were proposals made, both on behalf of the Italian Government and of B.B.C., with a view to electrify the tunnel. The Valtellina Railway offered to lend five of its three-phase current locomotives, built by Messrs. Ganz and Co., of Buda-Pesth, a few years earlier. Two three-phase-current locomotives in course of construction at that time with B.B.C. were also available. The Federal Railways were thus persuaded to adopt, on trial for one year, electric traction on this particular section. The B.B.C. succeeded, through an extraordinary effort in carrying out the work, in commencing a regular service of electric trains on June 1, 1906.

Since the opening of the B.T.B. Railway on the three-phase-current system, the Valtellina Railway—a section of the Rete Adriatica of the Italian railways—had been electrified by Messrs. Ganz and Co. on a large scale. Three-phase traction was an established possibility on normal-gauge ordinary railways, and the Valtellina locomotives appeared, at least for the beginning, perfectly capable of dealing with the trains through the Simplon Tunnel.

On the other hand, this tunnel section presented no particular difficulty, beyond the shortness of the time allowed for its being equipped. The power-stations existed, as far as the hydraulic part was concerned, and had been operated for the purposes of the construction of the tunnel. Still, the successful electrification of the Simplon Tunnel appears to be one of the finest examples of quick and good work of construction and erection of electrical plant known.

FIG. 17. STEAM AND THREE-PHASE ELECTRIC LOCOMOTIVES OF APPROXIMATELY EQUAL POWER FOR SIMPLON TUNNEL.

Number of seats	48 to 56 (baggage compartment)
Number of axles, all driving ...	4 (two bogies)
Total weight, equipped ...	33 to 42 tons
Weight of electric equipment	12 tons
Length between buffers ...	17.300 m. to 19.800 m.
Distance between centres of bogies	11.500 m.
Voltage of motors	400
Power of one motor, one hour rating	110 horse-power
Mechanical arrangement ...	Single reduction, usual spring suspension.
Ratio of gearing	1 to 4
Total normal pull on tread ...	5000 kg.
Normal speed	21 km. per hour

The Italian locomotives have since returned to Italy, and have been superseded by two locomotives of the type F. 3/5, and two of the type F. 4/4, all built by B.B.C. (the mechanical part being by Winterthur).

* See TRACTION AND TRANSMISSION, vol. ix., pages 39, 154, 231; ENGINEERING, vol. lxxix., page 254; vol. lxxxiv., pages 99 and 705.

THREE-PHASE MULTI-SPEED ELECTRIC LOCOMOTIVE FOR THE SIMPLON TUNNEL.

CONSTRUCTED BY MESSRS. BROWN, BOVERI, AND CO., ENGINEERS, BADEN.

(*For Description, see Page* 121.)

Fig. 18.

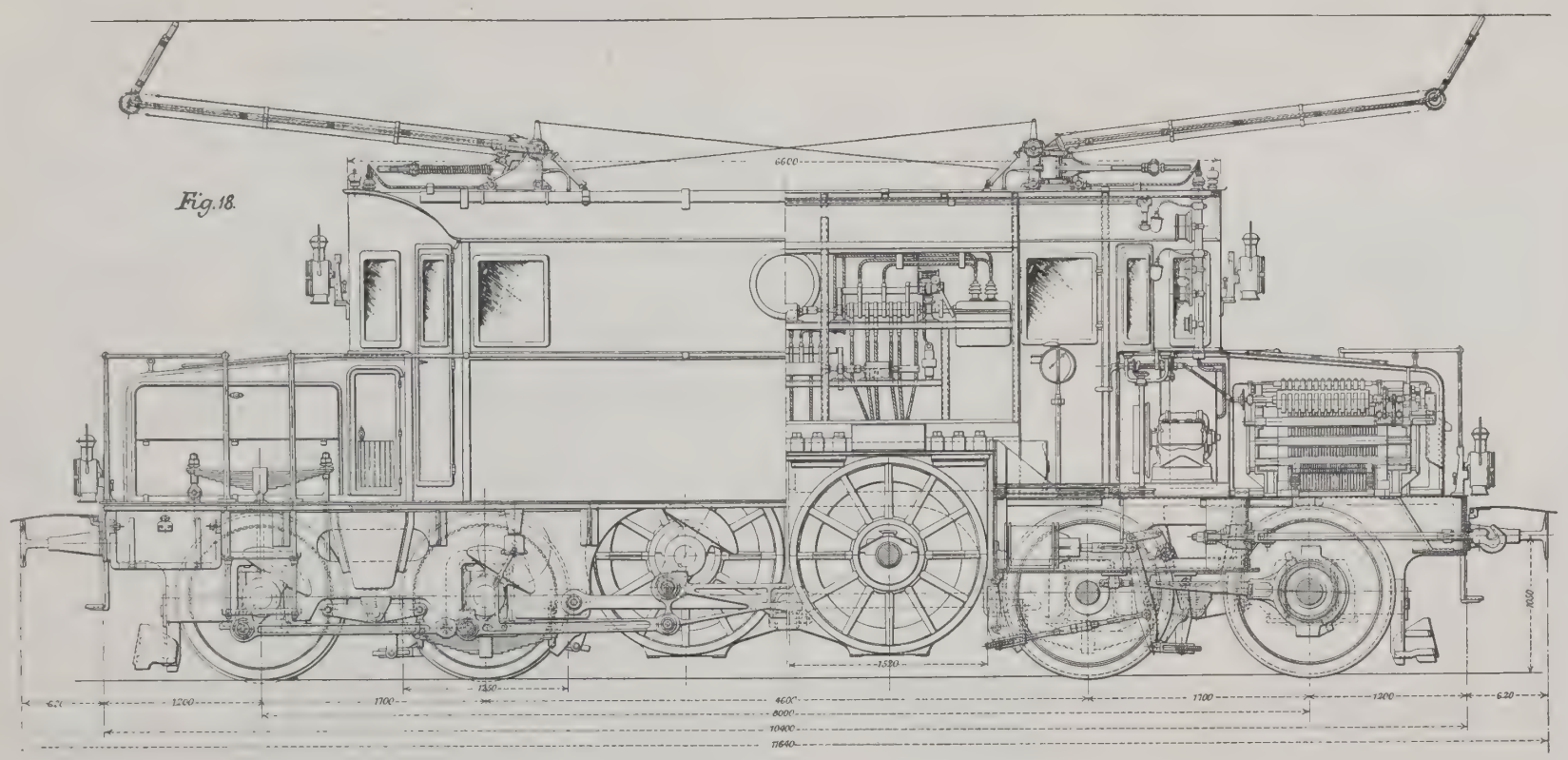


Fig. 20

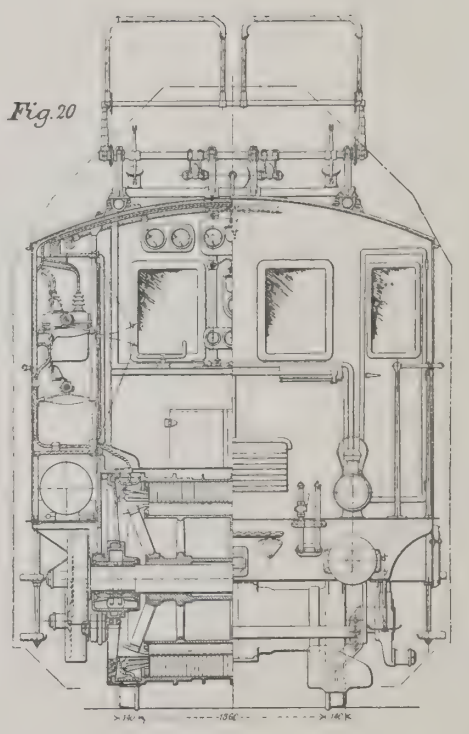


Fig. 19.

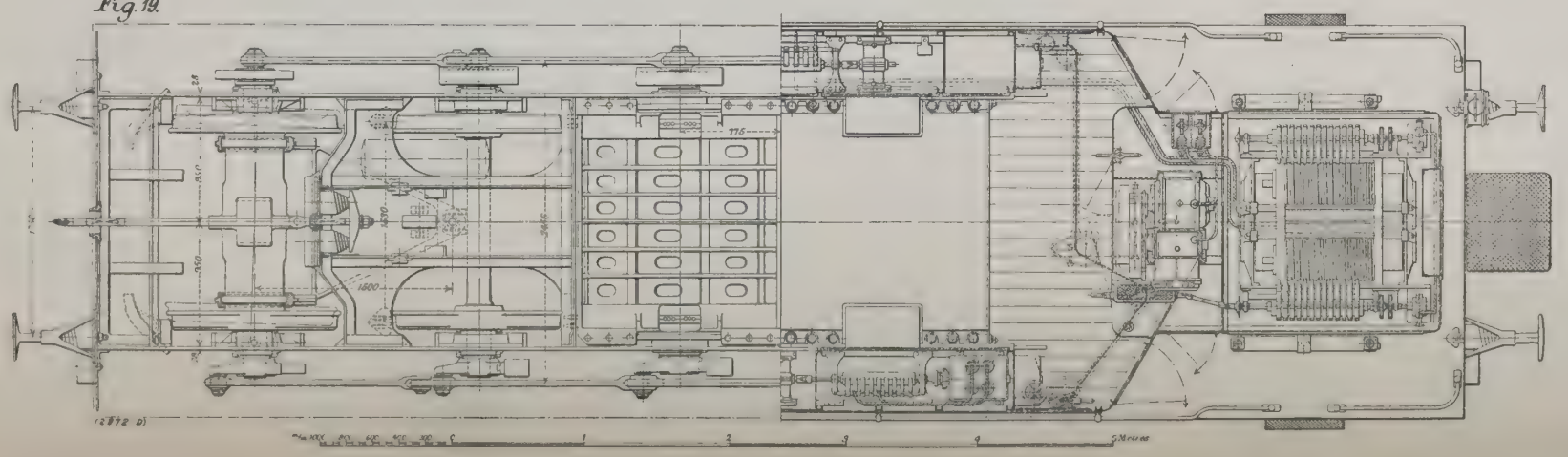


Fig 21

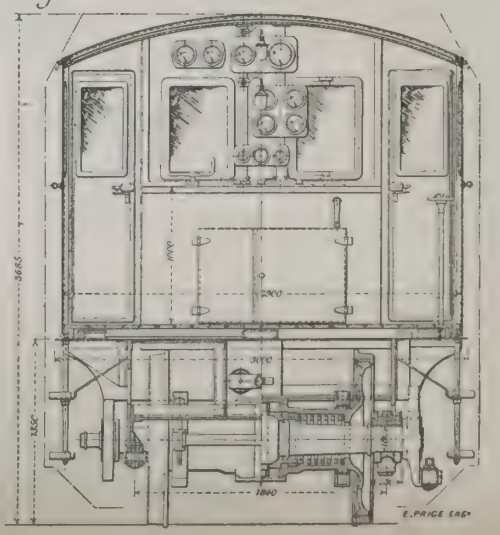


TABLE IV.—PRINCIPAL ELECTRICALLY-OPERATED RAILWAYS IN SWITZERLAND.—(*To be continued.*)

No. of Order	Railway, Name and Short Name (if any).	Year of Opening Railway.	Electric Operation since	Gauge of Track in Metres.	Length in Kilometres of Railway Operated Electrically.	Electric Current, Periodicity, Contact Voltage.	Type of Contact Line.	Motor Vehicles.	Observations.	Names of Original Contractors.
1	Orbe-Chavornay	1894	1894	1.435	3.9	Continuous 500	Overhead trolley	Motor-cars (trailing)	Historically interesting, as first normal-gauge electric traction in Switzerland in direct connection with main railway	Geneva
2	Stanestad-Engelberg	1898	1898	1.000	22.5 1.5 rack	Three-phase 33 cycles 750 to 800	Overhead bow	Motor-cars (trailing) Locomotives on rack section	First three-phase railway of considerable length	Brown, Boveri, and Co.
3	Burgdorf-Thun B.T.B. (Figs. 1 to 12)	1899	1899	1.435	40.2	Three-phase 40 cycles 750 to 800	Ditto	Motor-cars (trailing) and locomotives	First normal-gauge three-phase railway	Ditto
4	Fribourg-Murten-Ins. F.M.A.	1898	1902	1.435	32.3	Continuous 750 to 800	Third rail	Motor-cars (trailing)	First electrification of normal-gauge railway in Switzerland	Maschinenfabrik Oerlikon
5	Gruyère, Chemins de fer Electriques	1901-04	1901-04	1.000	43.5 2.3 on public roads	Continuous 750	Overhead bow	Motor-cars (trailing)	Prominent representative of mountain district railway	Alioth. Elect. A.-G.
6	Montreux-Berner-Oberland M.O.B.	1901-05	1901-05	1.000	62.4	Continuous 750 to 1000	Ditto	Motor-cars (trailing)	Prominent representative of a narrow-gauge through line across the high mountains	Alioth.
7	Martigny-Châtelard	1906-08	1906-08	1.000	20.5 2.5 rack 5.0 on public roads	Continuous 750	Third rail (overhead bow, on public road)	Motor-cars (adhesion and rack mixed)	Idem, adhesion and rack mixed, through line to Chamonix.	Geneva M.F.O.
8	Simplon Tunnel (Figs. 13 to 21)	1906	1906	1.435	21.7	Three-phase 16 cycles 3000	Overhead bow	Locomotives	First normal-gauge main-line electric traction on the Federal Railways	B.B.C.

TABLE V.—CHARACTER AND COST OF CONSTRUCTION OF RAILWAY, ROLLING-STOCK, TRAFFIC, OPERATION. (*To be continued.*)

YEAR, 1909.	1. Orbe-Chavornay.	2. Stanestad-Engelberg.	3. Burgdorf-Thun.	4. Fribourg Murten-Ins.	5. Gruyère, Chemins de fer Electriques.	6. Montreux-Oberland Bernois.	7. Martigny-Châtelard.	8. Simplon Tunnel.
Gauge, in metres	1.435	1.000	1.435	1.435	1.000	1.000	1.000	1.435
Length, in kilometres	4.0	22.5 (rack 1.5)	33.2 constructed 40.2 operated electric	25.1 constructed 32.3 operated electric	44.3	62.1	20.6 (rack 2.48)	21.7 (tunnel 19 803)
Length on public roads	..	..	..	..	2.3	..	5.0	—
Minimum radius of curves, metres	200	50	250	200	100	40	80 (rack 70)	300 at entrance
Level sections, per cent. of total	7.4	8.85	24.33	26.5	19.2	9.93	34.99	4.30
Grade maximum, ‰	25	25 (rack 250)	25	30	30	67	70 (rack 200)	10
Grade, average of sections not level, ‰	10.9	..	15.86	12.9	15.8	34.45	..	4.87
Lowest point, metres a.s.l.	450	438	535	435	672	398	470	630
Highest point, metres a.s.l.	473	1002	770	632	861	1272	1227	705
Aggregate up and down in metres of height	39	564	483	307	556	1935	885	98
Kilometres above 10 ‰	1.4	11.5	21.0	10.9	21.9	48.6	10.8	—
Kilometres above 30 ‰	..	—(exc. rack)	..	..	..	29.9	8.9	..
Weight of rail in kilogrammes per metre	20.6	20.0	36.1	36.0	24.5	24.3	25.2—30.5	49.0
Number of electric locomotives	..	4 (rack)	2 (1911 : 3)	..	..	..	..	4
Number of motor-cars	4	10	6	4	13	24	12	—
Number of ordinary cars	4	26	17	55	104	145	29	—
Average number of trains over whole line	29.15	22.16	20.79	15.65	19.40	16.44	10.11	Passenger 11 freight 5
Average number of axles per train	4.16	5.32	9.67	8.71	8.91	10.55	4.78	
Trains, kilometres run, 1 = 1000	43	186	311	189	312	378	78	146†
Passengers carried, 1 = 1000	105	290	656	277	365	443	231	
Tons of all kinds of freight, 1 = 1000	46	13	103	77	51	41	3	
Thousand Francs per Kilometre:								
Cost of purchase of land	11	18	24	12	20	28	27	
Cost of electric line equipment	9	12	21	14	13	16	23	
Cost of buildings and station machinery	5	26	15	18	36	43	29	
Cost of construction complete	96	106	133	99	136	221	292	
Cost of rolling-stock, locomotive and other	24	23	20	15	130	34	65	
Cost of railway complete	125	133	162	122	179	272	418	
Total amount	505	3007	5554	3291	7903	16,894	8664	
Total operating expenses	48	223	420	243	333	519	207	
Total receipts from traffic	71	401	564	298	406	1236	542	

Section of the Federal Railways. No individual figures on hand.

* Maximum weight of passenger-trains, 300 tons; of freight-trains, 400 to 600 tons, without locomotive.
† From June 1, 1908, until May 31, 1909; 22,933,000 ton-kilometres without, and 32,458,000 with, locomotive weight.

Technically, the Simplon Tunnel electrification brought, besides important improvements in locomotive construction,* nothing very novel, being more or less an exact copy of means and methods that had been practically used on the Valtellina Railway for several years. It was not complicated by electric-power transmissions, as current could be generated at each end of the tunnel with a voltage directly to suit the locomotives—3000 volts, 16 cycles. The contact line in the tunnel consists of two pairs of copper wires, each of 8 mm. in diameter, one pair for each phase of the three, the third being placed in the metal of the rails as in previous cases. The suspension is overhead from cross-wires hinged on to hooks in the masonry of the tunnel, and in the stations on the top of iron poles. Contact is made by means of articulated bows.

An important departure in three-phase electric locomotive design, realised in connection with the electric traction in the Simplon Tunnel, was the operation with multi-speed induction motors as already described with reference to the B.T.B. The multi-speed locomotives for the Simplon Tunnel preceded that of the B.T.B., and are, at the same time, of considerably greater capacity. Their design and appearance is seen from the illustrations on pages 125 and 126.

The particulars of the locomotives and of their electric equipments are given in the tabular statement on the third column of this page.

The piston-like action of the train in the long single-track tunnel absorbs, at a speed of 70 km. per hour, no less than 700 horse-power,* according to observation, at 35 km. per hour presumably about 100 horse-power. The requisite total pull on the tread is, therefore, for the fast trains about 5700 kgm., for the slow trains about 5500 kgm., while on open track of light grade these pulls are about 2700 and 700 kgm. less respectively. From the foregoing table it is seen that the F. 4/4 type is of a characteristic which is meeting traction requirements very well at certain intervals. Driving between the distinct normal speeds, often called the (not quite) synchronous speeds, is practicable and, in the case of the F. 4/4 type, at not too great a loss in efficiency and tractive qualities within certain limits below. Whether this is a feature that could decide the question in the absence of other arguments, "three-phase or single-phase?" practical experience alone, under conditions much less special than those prevailing in the Simplon Tunnel, could settle. In the special case the working of three-phase current seems to be entirely satisfactory, and will, in analogy with other Italian lines electrified (Valtellina, Giovi Tunnel) be adopted on the Italian side of the Simplon. The consumption of power has been 37 watt-hours per ton-kilometre.

(*To be continued.*)

* See Thomann, *Zeitschrift des Vereines deutscher Ingenieure*, 1909, page 612.

Particulars of Three-Phase Locomotives, Simplon Tunnel.

—	F. 3/5 (1906).	F. 4/4 (1907).
Number of axles, driving	3	4
,, ,, other	2	0
Arrangement of axles	Driving axles parallel, two pony trucks	Two axles parallel front and rear axle radially adjustable (Klein-Lindner system)
Total weight .. tons	62	68
,, on drivers .. ,,	44	68
Weight of electric equipment ,,	18	29
,, on single wheels .. ,,	4.5-7.5	8.5
Length between buffers .. m.	12.300	11.640
Distance between front and rear axles .. .. .. m.	9.700	8.000
Diameter of drivers .. ,,	1.640	1.250
,, other wheels .. ,,	0.850	—

	Type F. 3/5.	Type F. 4/4
System of motors	Three-phase multi-speed induction	
	With intermediate rheostatic speed control	With intermediate voltage speed control
Voltage of motor	550	850
Transformers on locomotive between contact and motors.		
Periodicity of current	15-16	
Number of motors per locomotive	2	2
Mechanical arrangement	Motors low, rigidly mounted in main frame, no gearing, no countershaft, all connecting-rod motion parallel	
	Central driving-axle between motors	Both motors between inner driving-axles

Number of normal speeds	2		4			
Speeds .. km. per hour	35	70	26	35	53	70
Revolutions of motors per minute	113	230	110	150	225	300
Number of poles in motor	13	6	16	12	8	6
Total pull on tread kg.	5800	4000	11,500	10,000	7700	6400
Total power, one hour rating in horse-power	800	1100	1100	1300	1500	1700

Performance according to Specification.

Weight of train in tons without locomotive.	Speed in km. per hour	On Grade in per 1000.
300	70	2
400	35	

ROME AS A SEAPORT.—The Provincial Council in Rome is negotiating with a strong French syndicate about the construction of a seaport for Rome. The place likely to be chosen for the new port is Palidoro, situated some 12 miles to the north-west of the city, the banks of the rivers being there more steep, which makes it easier to obtain the desired depth of 30 ft. than if the harbour were located at Ostia. A short railway will connect Palidoro with the Rome-Civita Vecchia Railway. Civita Vecchia strongly opposes the new scheme, however, the realisation of which would oust it from its present position as Rome's most important seaport; but this opposition will hardly be able to interfere with the consummation of the plan.

THE TURBINE WORKS OF MESSRS. BRIEGLEB, HANSEN, AND CO.—The foundry and engine works of Messrs. Briegleb, Hansen, and Co., of Gotha, distinguished in the field of water-turbine construction, celebrated their jubilee on July 1. The firm was established in 1861 by Wilhelm Hansen, in conjunction with L. Bonsack and A. Henneberg. A. Briegleb, who retired some years ago, joined in 1871. Wilhelm Hansen died in 1906, after having been succeeded in the firm by his son, Friedrich Hansen. The construction of turbines and Pelton wheels was introduced by Gustav Knop in 1874, and after his death, in 1894, Professor Rudolf Camerer took up the construction of Francis turbines as a speciality. The works employ 570 men, and turn out about 300 turbines a year. The turbine-testing plant of the firm has been thoroughly rebuilt and perfected within the last years. We may also mention that Messrs. Oscar Schimmel and Co., A.-G., of Chemnitz, manufacturers of spinning machinery, who started work in 1861 with 16 hands, and now employ 900, have likewise been celebrating the fiftieth anniversary of their establishment; Mr. Gustav Rohn has been the technical manager for 30 years.

* See Thomann, *Zeitschrift des Vereines deutscher Ingenieure*, 1909, page 614.

SOME NEW TYPES OF DYNAMOMETERS.*

By Dr. ALFRED AMSLER, of Schaffhausen.

[*Translated from the German.*]

IT is not the author's intention to deal with all devices recently introduced for measuring power, but he will confine himself to describing two types of transmission dynamometers, constructed by his own firm, the one type—the torsion dynamometer—being designed for measuring the power transmitted to or from high-speed machines, such as centrifugal pumps, fans, turbo-compressors, steam-turbines, dynamos, &c., where the torque is fairly constant and therefore need not be recorded in a diagram; the other type—the hydraulic dynamometer—being intended to be used for measuring and recording the energy absorbed by slow-running machines of variable resistance, such as machine-tools, plunger-pumps, and the like.

Torsion Dynamometer.—Figs. 1, 2, and 3, annexed, illustrate the different types used. It should be remembered, however, that many other types could be designed, and the apparatus can without any difficulty be modified to suit the most varying conditions.

Figs. 1 and 2 illustrate a dynamometer which couples the shaft of the driving engine direct to the driven machine. Fig. 3 shows a dynamometer which can either be used as a coupling or the power may be transmitted to one end by means of a belt, and taken off at the other end also by means of a belt. Either end of this machine is capable of being direct-coupled to a machine-shaft. The two shaft ends are securely coupled together by means of the shaft G; this shaft has therefore to transmit the entire power from the one machine to the other. Consequently the shaft G is subjected to torsion and will be twisted; the shaft should, of course, be so designed that the yield-point is not exceeded. It therefore works as a torsion spring. Provided the shaft is perfectly elastic, the angle through which the opposite ends are turned will be proportional to the twisting moment—that is, proportional to the power transmitted. If the shaft is made of a special spring steel of very high yield-point—that is, above 6000 kg. per sq. cm. (90,000 lb. per sq. in.)—it can be twisted to a considerable degree without breakage or permanent distortion. For example, in the diagram shown in Fig. 2 the twist of the rod 40 cm. (15¾ in.) long is for a twisting moment of 20 m.-kg. (1736 in.-lb.), about 20 deg. The shaft has a cross-section of 12 mm. by 12 mm. (0.4725 in. by 0.4725 in.), and is therefore subjected to a stress of 5200 kg. per sq. cm. (78,000 lb. per sq. in.), which is well below the yield-point. The various parts attached to the shaft G serve partly for indicating its angle of twist, and partly to prevent it from being twisted excessively, and overloaded.

For reading the angle of twist, three discs, M, N, and O, are used. M is fixed firmly to the end H of the shaft, N and O are fixed firmly to the end F of the shaft. The disc O is provided with a radial slit P. To the disc M a transparent rim U, made of celluloid, is fixed, on which the divisions are cut. Opposite to the slit P a small window has been cut out in the disc N, and is provided with a fine slit T.

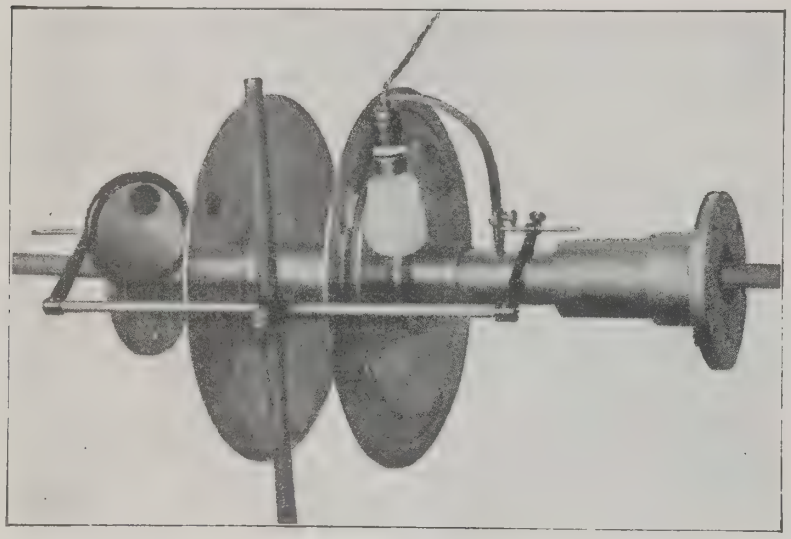
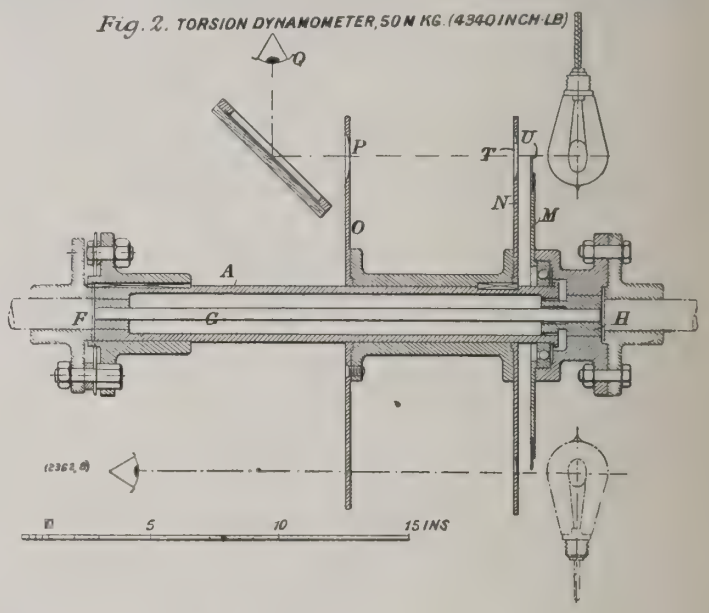
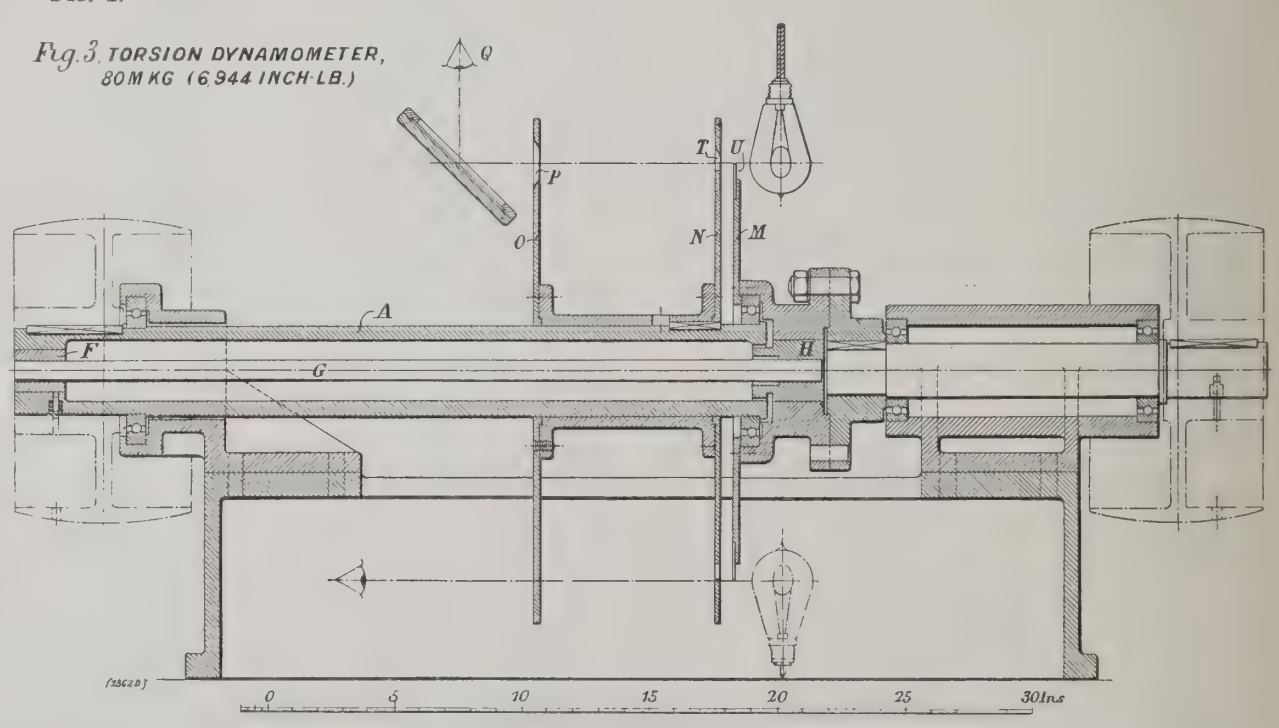


FIG. 1.





When the eye Q looks through the slit P, the slit T will be seen as a streak of light, and the divisions will show black on the scale U. The slit T serves as a pointer for indicating the relative motion of the two discs N and O as compared to the disc M. The line of vision is perfectly defined by the two slits P and T; parallax is therefore impossible when reading the scale, and the observation is therefore independent of the distance between the scale U and the slit T.

When the apparatus is stationary it will be clear that, if the shaft is twisted, the angle of twist will be shown by the movement of the pointer T over the division U. But this pointer and division will also be visible when the instrument is running; in fact, it will be clearer and more defined than when the instrument is at rest, for whilst it is necessary to place the eye close to the slit P when the instrument is at rest in order to be able to see the pointer and the scale, it is possible, when the instrument is in motion, to read the scale at some distance from the slit P. The greater this distance is, the more the scale will appear to be enlarged; this enlargement, it should be stated, is independent of the speed. The reason why the scale is still seen when the machine is running is due to the following:—The eye looking at the scale through the slit P sees the pointer and scale once for every revolution, and this only during the very short time when the small slit P is passing before the eye; the light impression is therefore instantaneous. One of these impressions would be too small to leave a permanent image in the eye, but since a number of impressions is given to the eye in rapid succession—namely, once at each revolution of the disc, the eye appears to receive a continuous stationary image of the pointer. Should the machine work at a speed below 250 revolutions per minute these images are not continuous, and the reading of the divisions becomes cumbersome but still possible.

In order to obtain a permanent impression on the eye, the scale must be subjected to a strong light. The short period of observation must be strengthened by the intensity of the light, since a fixed minimum amount of light energy—that is, intensity multiplied by duration, is required to affect the optic nerve. A 50-candle-power lamp provided with a ground glazed globe suffices for illuminating the scale, and should be placed as close as possible behind the disc M. Instead of looking at the slit P direct, it will be found better to insert a mirror so that the scale can be observed from the side, as shown in Figs. 1, 2, and 3. In order that the eye be not dazzled by other light, the daylight should be screened off.

The observations can be best carried out in a dark room with only one eye used, since each eye would tend to form a separate image, which would blur the actual reading. If the head be held in such a manner that the line connecting the two eyes is parallel to the slit P, the two separate images will coincide. The angle of torque thus observed shows the twist-strain in the shaft, since the slit P passes the eye at regular intervals. Should the power transmitted, and consequently the twist of the shaft, vary rapidly, the eye will see different parts of the scale in rapid succession, and the image will become blurred, so that it is impossible to read the scale accurately. When high-speed machines are used, this disturbance need not be feared, whilst the inertia of the machine itself and that of the discs M, N, and O of the dynamometer will restrain any oscillations thus formed. If the twist varies periodically in synchronism with the rotation of the shaft, the wave of twist variation being repeated, every revolution can be followed by the eye by looking at the scale through the slit at different points around the dynamometer shaft.

Since the shaft and the other parts which are connected to its extremities have no tendency to move due to the centrifugal force, the readings of the dynamometer are independent of the speed. The instrument can therefore be run at any speed desired, provided, of course, no forces are set up greater than can be resisted by the material of which the discs M, N, and O are made. The instrument is made generally for high speeds of about 4500 revolutions per minute, but some instruments have already been made for speeds of 7000, and even 8500, revolutions per minute. The coefficient of elasticity of the shaft can be determined when at rest by fixing a lever of known length at one end and loading this with weights.

The largest instrument at present made can measure torques up to 1500 m.-kg. (130,200 in.-lb.), and the smallest

* Paper read before the Institution of Mechanical Engineers, at the Zurich Meeting, July 25.

up to 8 m.-kg. (694 in.-lb.). The instrument suffers from but one defect—namely, the air resistance of the rotating parts. For the time being, it need merely be stated that the influence of the air is very small, especially when the dynamometer is so inserted that the disc M is placed nearest to the machine the power of which is to be measured. It is possible, although somewhat laborious, to make accurate determinations of the influence of the air-resistance on these readings. The dynamometers are so constructed that they can without any difficulty be placed or taken out from between the driving and driven machines, and another shaft can readily replace the former without having to move either of the machines. The instrument can be run in either direction without any alteration having to be made. It is fairly obvious that, working on this principle, dynamometers can be constructed which possess every desired degree of accuracy; all degrees of power can, therefore, be measured, the shaft is simply made thicker in proportion as the torque is increased. Its length will consequently have to be increased, so that an observable twist can be obtained.

Hydraulic Dynamometers.—This type of dynamometer, which is used for measuring and recording the power absorbed by machines subjected to a variable load, is illustrated in Figs. 4 to 11 below. The dynamometer is driven from the engine by means of a belt, and transmits the power by means of a second belt to the driven machine. The driving and driven pulleys D and B are placed close together on the common shaft. The pulley B is fixed to the shaft C, whilst the pulley D runs loose on the shaft without any appreciable friction. To the pulley B the two cylinders F are fixed, which are connected by means of the two tubes G to the centre of the hollow shaft C. The pulley D is provided with two projections J which press against the piston L. The piston works without any friction in the cylinder F owing to the omission of any packing, and the entire system is filled with oil. When the pulley rotates in the proper direction, the projection J will have a tendency to press back the piston in the cylinder F, thus exerting a pressure on the oil. This oil-pressure is transmitted through the hollow shaft C, and to a fixed tube, the end of which fits axially into the shaft C, and is properly packed by means of a stuffing-box. The pressure is further transmitted to the casing N, to which on one side a pressure-gauge O is fixed, and to another side the recording apparatus. The pressure-gauge indicates the torque with which the pulley B drives the pulley D, since the latter is proportional to the oil-pressure. The transmission of the oil-pressure to the recording apparatus is quite similar to that of an ordinary steam indicator. P (Fig. 8) is the indicator mechanism, the paper strip is rolled up in the hollow drum Q, and passes under the pencil of the recorder, and is then rolled up on the drum R. The paper strip passes under the pencil at a velocity proportional to the speed of the shaft C. In order that the number of revolutions of the shaft C may be checked readily, a small hammer is attached which gives an audible tap at every tenth revolution of the shaft C. These taps can readily be timed by means of a watch. The area of any portion of the diagram represents the energy absorbed by the machine, and the mean height, that is the area divided by the length of the diagram, the average power transmitted.

If the resistance of the machine, the power absorption of which is to be measured, is very irregular, the pointer of the pressure-gauge will oscillate violently, and the recorder will draw a zigzag line. These oscillations can be readily reduced by closing the valve U to a greater or lesser degree; by so doing the opening through which the oil enters through the shaft C into the casing N can be increased or decreased as desired. This dynamometer is not nearly as simple, and does not indicate the power as directly as the torsion dynamometer; it is consequently less accurate, and needs watching. On the other hand, measurements can be made which are impossible to obtain with the torsion dynamometer—namely, the power is continuously recorded on a strip of paper, and can be accurately determined however much it may vary.

The readings given with the hydraulic dynamometer are not entirely independent of the speed; the centrifugal force tends to drive the oil in the tubes outwards and has a tendency to move the piston L axially, according to the position in which the pistons are relative to their respective cylinders. By means of a suitable arrangement of the pistons and cylinders with regard to the pulley B it is possible to compensate these two forces; this is only possible, however, for one position of the pistons—namely, the middle position. If the dynamometer is allowed to run at a low speed, the disturbing action of the centrifugal force in the pistons when no complete compensation is obtained becomes negligibly small. Another reason for keeping the speed of the instrument low is on account of the centrifugal force causing the pistons to rub against the sides of the cylinder. The dynamometers illustrated are used for maximum torques of 50 m.-kg. and 150 m.-kg. (4340 in.-lb. and 13,020 in.-lb.) respectively.

The same principle of construction can be applied for measuring higher powers; the instrument is then simply placed in series with the transmission-shaft, and instead of the pulleys B and D, couplings are used. It is, however, necessary in this case that one shaft should be hollow for its entire length, so that the hydraulic pressure can be measured at the end.

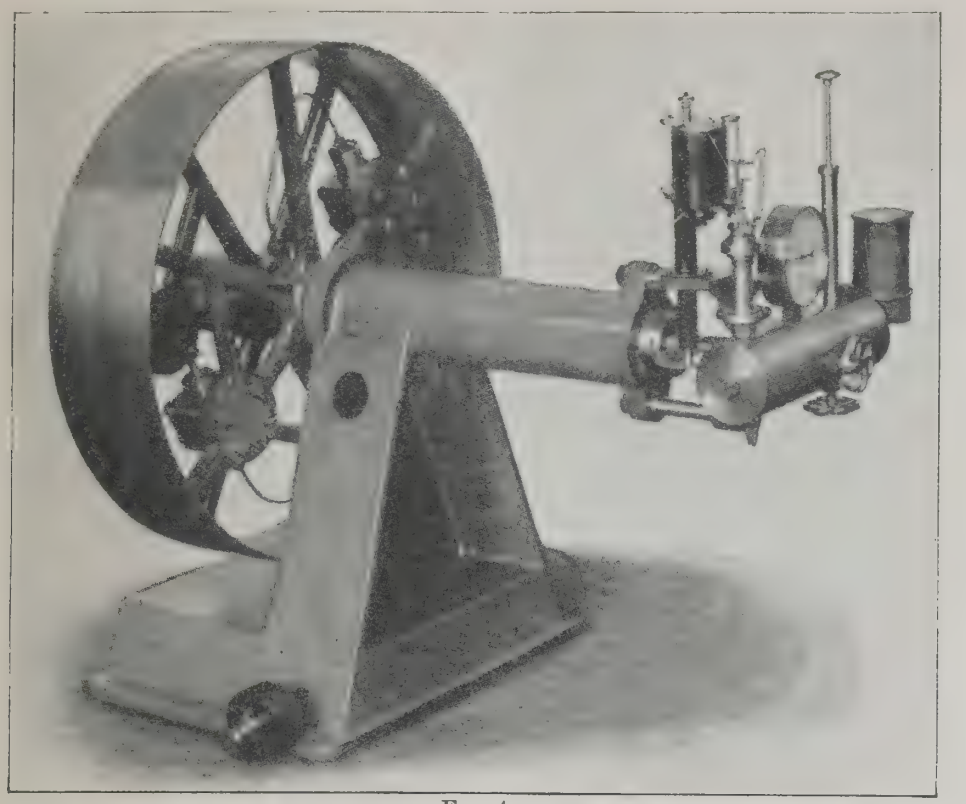
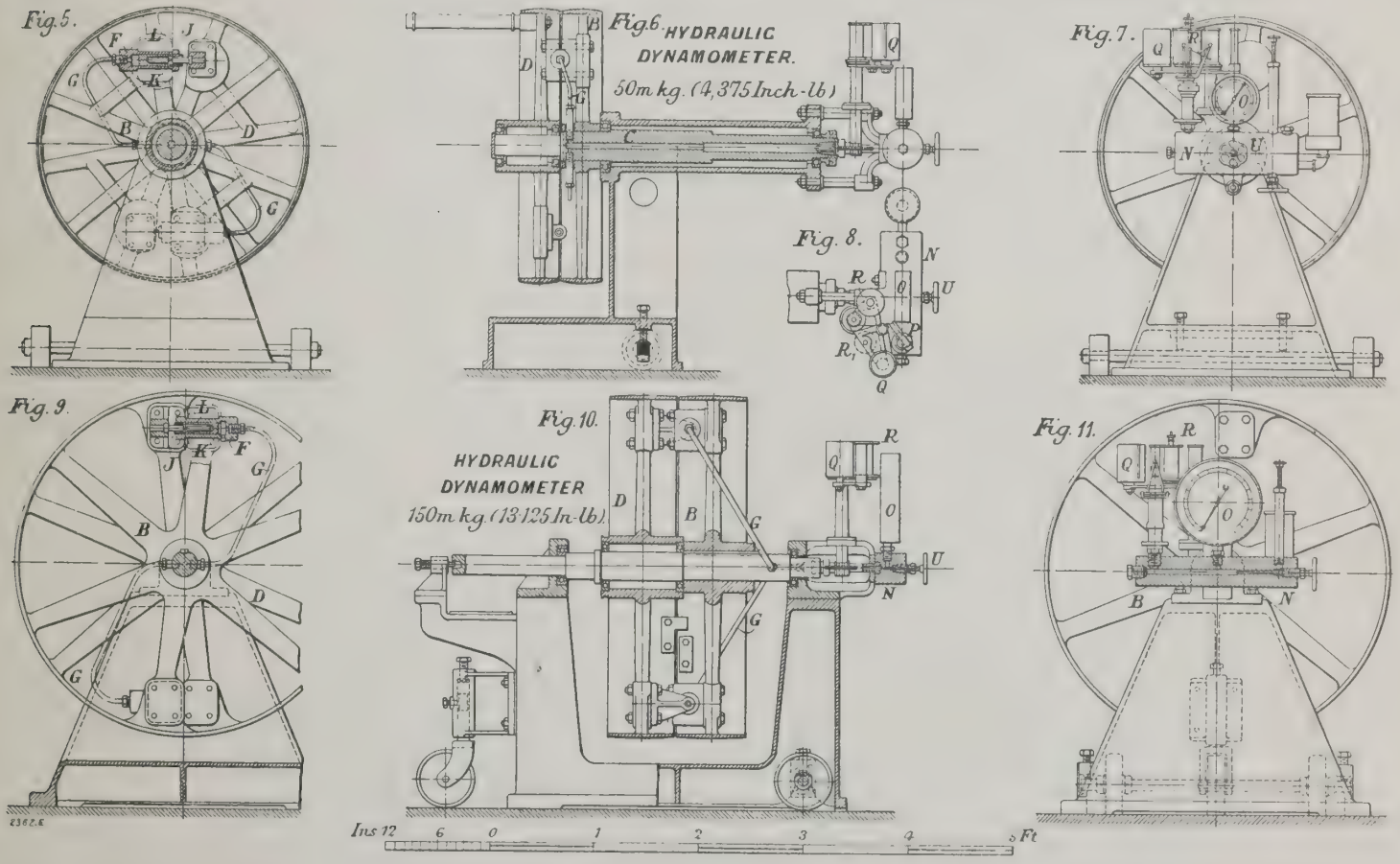


FIG. 4.



FOUR-CYCLE GAS-ENGINES DRIVING GENERATORS.

On our two-page plate we illustrate two large gas-engines recently constructed by Messrs. Thyssen and Co., of Mulheim-Ruhr, for driving electric generators. The engine shown in Fig. 1 is a twin-engine, but in details of construction this engine is identical with that illustrated in Figs. 2, 3, and 4, which is a single-crank engine erected at the Pluto Mine of the Gelsenkirchen Company at Wanne, and runs on coke-oven gas. It has, it will be seen, two double-acting cylinders, arranged tandem-fashion, the diameter being 1150 mm. (45.3 in.) and the stroke 1300 mm. (51.2 in.). The jacket, it will be seen, is cast in one with the cylinder, but it is fitted with a renewable liner of hard cast iron, which takes all the wear. Both cylinder heads and pistons are water-cooled, as is best shown in Fig. 2; the water-cooling of the exhaust-valves and their casings has been most amply provided for.

The gas supply to each end of each cylinder can be independently adjusted by means of the hand-wheels shown on the side of the right-hand cylinder in Fig 2, which actuate link-work by which may be opened or closed the valves shown at *a*, Figs. 2 and 3. This gas supply reaches the engine through the pipe shown at *b*, Fig. 3, and, as indicated at *c*, a hand-hole is provided in the port leading to the gas-valves through which deposit can be removed if required. The air-supply pipe is represented at *d*, Fig. 3, and, as will be seen, a throttle-valve is provided at *e*, by means of which the proportion of air drawn in can be adjusted by hand. Having these two adjustments, the engine can be run on all qualities of gas, since, by varying the relative opening and closing of these valves on the air and gas supplies, the proportion of air to gas can be varied through a practically infinite range. The ports which lead from these adjustable gas valves to the cylinder are, as will be seen on reference to Fig. 2, provided with additional throttle-valves at *f* and *g*. These are under the control of the governor by means of the link-work, best seen on the right-hand of the cylinder in Fig. 3.

The inlet valve, it will be seen, is double, there being a gas-valve on the same spindle as the main inlet-valve; and there is also, it will be observed, a sleeve on the same spindle, which, when the valve is seated, covers the air-port. Thus the opening to air is always proportional to the opening for gas. These inlet-valves are operated by an eccentric on the side shaft, and have, it will be seen, a constant opening, the governing being effected, not by varying the lift or the duration of opening of this valve, but by opening or closing the throttle-valves at *f* and *g*. The exhaust-valves, it will be seen, are located below the cylinder, and are wholly contained in independent castings, which can readily be removed should the valves require examination or repair. As will be seen from Fig. 2, a crosshead is fitted between the two pistons, and the left-hand cylinder has a tail-rod, also supported by a guide. Hence the weight of the pistons and rods is entirely taken off the glands, which have thus no tendency to wear oval. The gland packings are of the metallic type.

As is best seen in Fig. 1, the two cylinders in tandem are connected at the top by steel stays supplementing the "tween" casting below. Similar stays lead from the first cylinder to the top of the main bearings, and the engine-framing is thus relieved from the bending strains which in the past have frequently proved disastrous. These stays, being of steel, occupy little room, and scarcely affect the accessibility of the glands and crosshead. Forced lubrication is fitted to the cylinders, oil being pumped in through a pipe passing through the water-jacket, as indicated at *h*, Fig. 3. The engine operating on the 4-cycle principle, the side-shaft has, of course, to be geared down. This is effected by spiral gearing, located between the fly-wheel and one of the main bearings, as shown in Fig. 4. This gearing is completely enclosed, and runs in an oil-bath.

As will be seen, the crank-shaft has three bearings, that on the right hand having a spherical seat. The brasses are lined with white metal, and the lubrication is forced, so that long, continuous runs present no difficulty.

Messrs. Thyssen, we may add, have supplied the equipment for the largest gas-power station on the continent of Europe—viz., that of the "Gewerkschaft Deutscher Kaiser, in Bruckhausen." Here there are in all eight large blowing-engines and four large gas-engine generator sets, having an aggregate rated capacity of 60,000 brake horse-power. The engines run on blast-furnace gas. The equipment for cleaning this gas is very complete, and as it enters the engines the gas does not contain more than 0.003 gramme of dust per cubic metre. As a consequence, it has been found possible to run the engines without cleaning them for from 1½ to 2 years. The station load, as a whole, is very steady, and the power factor is consequently high, reaching the very satisfactory total of 70 per cent. in 1910.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, July 19.

THE continued curtailment of pig-iron production has no observable influence on prices or demand. Basic and Bessemer are generally neglected. Large consumers feel they are not running any risk in waiting. A few mills have already resumed after the midsummer repairing season. A large shipment of steel for gates for the Panama Canal was made this week from near Pittsburg. Special trucks were built for their transportation. Additional canal requirements will soon be let. The railroads are at last buying more liberally in structural material, their orders for the past two weeks being for 40,000 tons of material out of a total of 70,000 tons ordered. Another batch of orders for steel cars will soon be in, specifications being now in preparation. The car plants are now running to fuller capacity than since May 1. It is widely circulated that the railroad companies contemplate a general buying of equipment and supplies. Their purchases for the past twelve months have been considerably below the average, a fact which manufacturers of railroad equipment have not failed to observe. The improvements along the Ohio river, aimed at improving the navigability of that stream, have given the Pittsburg Mills a good deal of work during the past four dull months. All the tin-plate mills are busy, and preparations are being made for a heavy autumn run. The railroads are demanding heavier steel freight-cars, of considerably larger capacity, and this new type of car will soon be in use. It is said the enlarged capacity will be from 80 to 100 tons. The General Electric Company will create a large central plant at Erie, Pennsylvania, on Lake Erie, which will call for 10,000 tons of steel. Three additional steel bridges have been projected at Pittsburg, which will call for 12,000 tons of steel. The outlook is favourable for large structural steel orders.

THE FASTEST TRAIN IN GERMANY.—The fastest train in Germany, since June 1, is the express train between Munich and Nüremberg. The distance is 198.8 kilometres, and this is covered in 2 hours 15 minutes, an average of 88 kilometres, or 55 miles an hour. Over certain sections this train, however, travels at a speed of 105 kilometres, or 65 miles an hour.

MARINE-MOTOR EXHIBITION, COPENHAGEN.—It is announced that the International Marine-Motor Exhibition, in connection with the Scandinavian Fisheries Exhibition and Fourth Scandinavian Fisheries Congress, will be held at Copenhagen from the beginning of July till the end of August, 1912, and the Board of Direction now invite participation in it. The exhibition will be held at the Brygge islands, immediately adjoining Langebro. The fisheries exhibition will comprise everything connected with salt-water and fresh-water fisheries, and the marine-motor exhibition anything concerning marine motors. Diplomas, with gold, silver, and bronze medals, will be awarded to the prize winners. Further particulars may be obtained from Captain A. Sölling, R.D., 61, Heathland-road, Stoke Newington, London, N., Commissioner for Great Britain and Ireland.

THE LATE MR. W. C. STEADMAN.—In the death of Mr. W. C. Steadman, which occurred on Friday last, at the age of sixty, the Trade Union Congress has lost its secretary. Mr. Steadman's health had been giving way for some time, and he had, consequently, placed his resignation in the hands of the Parliamentary Committee of the Congress. His views were advanced, and as a Labour leader his methods were aggressive, but he never attained to any very high position in the Labour movement, although he held the position of President of the Trade Union Congress. He had an intimate knowledge of the conditions of life on the Thames, owing to his position as secretary of the Barge-Builders' Union. At the time of his birth at Poplar, shipbuilding on the Thames flourished, and he was himself apprenticed to a local barge-builder, and worked at his trade up to 1892. His first appearance in public life was as a member of the London County Council for Stepney, being in the course of his life returned five times at the head of the poll for this constituency. Mr. Steadman was a Radical in politics, and his political career was somewhat varied.

CONTRACTS.—We are informed by Messrs. Ed. Bennis and Co., Limited, Little Hulton, Bolton, and 28, Victoria-street, that they have recently received seventy-three orders for their stokers and compressed-air furnaces.—The Paignton Urban District Council has decided to pass the whole of the water from the Holne Reservoir, Dartmoor, through Candy filters, and they have therefore ordered a fourth filter of this type from Mr. Frank Candy, 5, Westminster Palace-gardens, Artillery-row, Victoria-street, Westminster, S.W.—Messrs. Wm Geipel and Co., Vulcan Works, St. Thomas's-street, London, S.E., have secured a contract for the annual supply of Henrion Arc-Lamp Carbons, open, enclosed, and flame type, amounting to nearly 1,150,000 carbons, to the London and North-Western Railway Company. This is, we understand, the third year that they have secured this contract. We understand that, notwithstanding keen competition on the part of local firms, Messrs. Wm. Geipel and Co. have also secured a contract for sixty-eight Geipel steam-traps for the New Copenhagen Hospital.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was fairly active, and business amounting to 5000 tons of Cleveland warrants was put through at from 46s. 11½d. to 46s. 11d. and 46s. 11½d. cash, and at 47s. four days, and 47s. 2½d. one month. Closing sellers quoted 47s. cash, 47s. 3d. one month, and 47s. 8½d. three months. Hematite was quoted at 61s. 4½d. cash buyers. In the afternoon the market was just the turn easier, and the dealings were limited to 1000 tons of Cleveland warrants at 47s. 2d. one month, and at the close the quotations were 46s. 11½d. cash, 47s. 2½d. one month, and 47s. 8d. three months sellers. On Friday morning there was little change in the market, and Cleveland warrants were done at 46s. 10½d. cash, with buyers over, and at 47s. fourteen days. The turnover was 2000 tons, and sellers' closing prices were 46s. 11d. cash, 47s. 2d. one month, and 47s. 8d. three months. The afternoon session was quiet, and only two lots of Cleveland warrants were dealt in at 46s. 11d. cash and 47s. 7d. three months. Closing sellers quoted 46s. 11d. cash, 47s. 2d. one month, and 47s. 8d. three months. On Monday morning the market was firm in tone, but no dealings were recorded. At the close there were sellers of Cleveland warrants at 47s. cash, 47s. 3d. one month, and 47s. 9d. three months. In the afternoon there was little doing, and only one Cleveland warrant was done at 46s. 11d. cash, with sellers over at that figure and at 47s. 2d. one month, and 47s. 8d. three months. On Tuesday morning the market was again idle, but Cleveland warrants were nominally firmer, with closing sellers quoting 46s. 11½d. cash, 47s. 2½d. one month, and 47s. 8½d. three months. Weakness prevailed in the afternoon, when one lot of Cleveland warrants changed hands at 47s. 0½d. one month. Closing prices were 46s. 10d. cash, 47s. 1d. one month, and 47s. 7d. three months sellers. When the market opened to-day (Wednesday) the tone was inclined to be easier, and Cleveland warrants to the extent of 4000 tons were dealt in at 46s. 9d. cash, 47s. one month, and 47s. 6d. three months. At the close sellers quoted 46s. 10d. cash, 47s. 1d. one month, and 47s. 6½d. three months. In the afternoon the market was dead idle, and no dealings were recorded. Closing sellers of Cleveland warrants quoted 46s. 10d. cash, 47s. 1d. one month, and 47s. 7d. three months. Cash buyers of hematite offered 61s. 3d., but sellers wanted 3d. more. The following are the market quotations for makers' (No. 1) iron:—Clyde, 60s. 6d.; Calder and Gartsherrie, 61s.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 64s.; Shotts (at Leith), 62s.; and Carron (at Grangemouth), 63s.

Sulphate of Ammonia.—A strong demand for sulphate of ammonia has been experienced during the past few days, and the price has again begun to rise. For prompt lots the quotation to-day is given as 14*l.* per ton, Glasgow or Leith, and that figure is only 10s. per ton under the highest point touched during the spring season. Inquiries from the United States point to a fair amount of business coming from that quarter in the near future.

Scotch Steel Trade.—The Scotch steel trade has once again got under weigh, and plate-rolling mills are running full time. The specifications for ship-plates have been fairly numerous, but the same cannot be said about the demand for angles, which is still rather poor. In light steel connections a healthy tone exists, and inquiries are satisfactory; indeed, it is stated to-day that some respectable quantities are wanted shortly for shipment to Australia and India and other destinations. Structural sections are only in moderate request at present. Prices all round are quoted firm.

Malleable-Iron Trade.—Although the holidays are over and work has been resumed in the malleable-iron trade of the West of Scotland, the state of the industry has not improved. Some of the producers have a fair amount of work on hand, but that is not general, as some of them can only see a few days ahead.

Scotch Tube Trade Amalgamation.—Particulars are now to hand of an important amalgamation in the Scotch tube trade, which will eliminate the ruinous competition of recent times, and will be the means of effecting some much-needed economies. The preliminary agreement has now been signed, and with the exception of Messrs. Stewarts and Lloyds, Limited, practically all the producers of wrought-iron and steel tubes in this country have agreed to amalgamate. The combine, which will be known as the Scottish Tube Company, Limited, will have a fixed capital of 600,000*l.*, and will be composed of the following two public companies:—The Wilsons and Union Tube Company, Limited, and Messrs. David Richmond and Co., Limited, and the private firms of Messrs. David Marshall and Sons, Messrs. James Eadie and Sons, Messrs. Hendry Brothers, Limited, the Caledonian Company, the Coats Tube Company, and the Tradeston Tube Company. The prospectus of the new concern will probably be issued in October, and it may be mentioned that although Messrs. Stewarts and Lloyds' name is not included in the above list, they, as a firm, will be much interested in the new company, as they will hold a large number of shares, and will nominate a director to the board. Some time after the break-up of the International Tube Trade Association, when the cutting of prices became so keen, we mentioned that proposals were on foot to form some combine which would be of mutual benefit to the trade. Various schemes were talked of, and the new company, which is the result of much consideration, has now almost sprung into life. It is hoped that this concern, when finally completed, will be of considerable benefit to the tube trade in Scotland.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Visit of Admiral Togo.—The visit of Admiral Count Togo to the East End of Sheffield last week-end recalls other occasions when men famous in the world's history have been shown the huge workshops where the materials for Britain's naval supremacy are fashioned. At Hadfield's Works, Sir Robert Hadfield, who received the distinguished visitor from Japan, recalled that it was there that in September, 1905, Viscount Hayashi made the first public announcement of the treaty between England and Japan. Admiral Togo was very much interested in all he saw, both at these works and at those of Messrs. Vickers Limited, particularly in the manufacture of projectiles and the rolling of armour-plate for a Japanese battleship. As a result of improved armour, all the armament firms in Sheffield have found themselves obliged to make great advances in the manufacture of projectiles, and the most skilled metallurgists have been employed on this work, with the result that Messrs. Hadfields have produced armour-piercing shot which has perforated Krupp cemented plates of the latest type. Sir Robert stated that in a recent test the shell, after piercing hard-faced armour-plate, had travelled two miles beyond. Admiral Togo was also shown the big foundry at Hadfields, which is the largest in the world, covering, as it does, six acres of ground. Another department visited was that for the manufacture of track-work for tramways and light railways, where, in addition to points and crossings for various municipalities, a considerable amount of work for the conduit system of the London County Council was in course of construction, most of this work being made in Hadfield "Era" manganese steel, which combines remarkable properties of hardness and great toughness. Other departments were also visited. The distinguished visitor was entertained to luncheon at Vickers Works, and expressed himself highly pleased with what he had seen.

South Yorkshire Coal Trade.—One of the chief reasons for the present somewhat unsatisfactory state of the hard coal market, and the fact that the tonnages going for shipment are below the usual figure for this period of the year, is that the stocks which accumulated at the ports and on colliery sidings during the recent strike have not yet been cleared, and the shipping world has not yet recovered from the disturbances consequent upon the action of the seamen. There has been some improvement during the past week, and collieries are expecting it to be maintained. Prices are fairly firm, but at some pits where considerable stocks are held second-grade qualities can be obtained at reductions. Most of the gas-coal contracts have been arranged, and good tonnages are going away on shipment. Slacks are very well placed, particularly best qualities, and collieries are experiencing difficulty in executing orders. Top prices rule. House coal is extremely depressed, for which the excessive heat is, to some extent, responsible. But for a little buying by farmers who are stocking before harvest commences, there is practically no business passing. Orders are just filtering into the pits, many of which are only working two days a week, and merchants are keeping their stocks at the lowest possible level. Prices are fairly steady, although there is a little underselling. Coal-owners are now waiting for the London demand to revive in order to give an impetus to trade. Latest 'Change quotations are:—Best branch hand-picked, 13s. to 14s.; Barnsley best Silkstone, 11s. to 12s.; Silkstone, 9s. to 10s.; Derbyshire house, 9s.; large nuts, 7s. 3d. to 9s.; small nuts, 5s. 6d. to 6s. 6d.; Derbyshire brights, 9s. 6d. to 11s.; washed nuts, 7s. 6d. to 8s. 6d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. to 5s.; smalls, 1s. 6d. to 2s.

Iron and Steel.—More activity is noticeable on the part of iron buyers, and attempts have been made to purchase material at easier prices. Makers, however, have held to their quotations, with the result that consumers have postponed any considerable buying until a little later. A few transactions have been effected in hematites at the lowest figure. Derbyshire makers are offering slightly better terms than Lincolnshire producers. A fair trade is being done in billets, but it is mostly for immediate requirements. Few forward orders have been booked. The bar-mills are mostly working well. The extreme heat of the past few weeks has not been without its effect upon the steel trade, making speedy production a matter of considerable difficulty. The armament branches are well occupied and have plenty of work for some months, and the casting and forging departments have recently received good orders. The rolling-mills also are busy. The foundries, for the most part, have as much work as they can turn out; and at one of the largest firms very considerable extensions have been made to cope with growing trade. Railway steel manufacturers continue to feel the benefit of recent activity in the railway world and their order books are well filled. The competition in steel prices is as keen as ever, and is likely to be even more severe from the fact that increased prices are being asked for Swedish bars. Makers of these state that the cost of production has gone up so seriously within recent years that their profits have been materially reduced. The miscellaneous steel trades of the city are all actively engaged. Manufacturers of engineers' and edge tools are making a heavy demand for steel, and the expansion of their trades is further indicated by the growing inquiry for emery grinding-wheels which do the greater proportion of the work once done by means of hand filing. General exports are good, and there are signs that the American trade will be much improved in the autumn. The most reassuring indications are the reports of a good harvest in the States. At home, too, the outlook for the winter is considered to be very good. The only fear is of possible labour troubles.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is little business doing in pig iron just now. Buyers are once more backward, and sellers are not keen to operate, as they anticipate higher prices in the near future. Deliveries to the Continent are on a very limited scale, but such is usually the case at this season when the inland waterways abroad are dried up; in addition this year a number of steamers are laid up. There is, however, a lot of iron to deliver to Continental customers, and shipments next month promise to be rather heavy. A number of inquiries for both Cleveland and hematite pig delivered over the first half of next year are reported, but they have not resulted in business, buyers and sellers failing to agree to terms on forward account. At the same time confidence in the future is emphasised by the fact that purchasers are prepared to pay more for forward than for early delivery. Sales of No. 3 g.m.b. Cleveland pig have been made at 47s. for prompt f.o.b. delivery, and that is the general market quotation; whilst No. 1 is 50s. 6d.; No. 4 foundry and No. 4 forge each 46s. 6d.; mottled and white iron each 46s.; and mixed numbers of East Coast hematite pig 61s. 3d. to 61s. 6d. Efforts to buy the last-named at 61s. appear to have been unsuccessful, makers preferring to wait, as they believe many consumers will be compelled to enter the market shortly, and the general opinion is that the price will advance. There is little or nothing doing in foreign ore. Rubio of 50 per cent. quality is 19s. to 19s. 6d. ex-ship Tees, and freights, Bilbao-Middlesbrough, have been fixed at 4s. 6d. Coke is stronger. Average blast-furnace qualities are 14s. 6d. to 14s. 9d. delivered here.

Manufactured Iron and Steel.—There is not much new of moment to report concerning the various branches of the manufactured iron and steel industries, but it is gratifying to know that what slight changes are noticeable are for the better. Works generally are well employed, and the output is on a heavy scale. What is still more satisfactory is the fact that inquiries are numerous. Under these favourable conditions values show a marked upward tendency, but up to the present no quotable changes have been made. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 15s.; iron ship-plates, 6*l.* 12s. 6d.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron girder-plates, 6*l.* 17s. 6d.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 7s. 6d. to 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 10*l.* 15s.—sheets less the usual 4 per cent. f.o.b., railway material net at works, and all other descriptions less the customary 2½ per cent.

DURHAM COAL-FIELDS DEVELOPMENT.—A pit sunk at Etherley Dene, near Bishop Auckland, for Sir S. A. Sadler, Limited, has been recently opened. The borings, which were undertaken in September, 1909, disclosed a thin seam of coal at a depth of 90 ft., and the Hutton seam was met with at a depth of 204 ft. This latter seam averages 3 ft. in thickness. Lower still the main seam was found, but this was comparatively unsatisfactory; and, for the present, the owners propose to concentrate their efforts upon the 3-ft. Hutton seam. A shaft has been sunk and working operations are to be commenced now.

"THE HOLIDAYS: WHERE TO STAY AND WHAT TO SEE."—The issue of this volume for 1911 has just appeared. It forms a complete guide to places of interest and holiday resorts in England and Wales, and contains the official guides of the principal English railway companies. It is profusely illustrated, and its value is enhanced by lists containing the names of farmhouses and other places where visitors can be accommodated. There is also a part devoted to Brittany which is well worth studying by anyone contemplating a visit to that part of France. The book is published by Mr. Walter Hill, 67, 69, and 71, Southampton Row, London, W.C., the price being 1s., or 1s. 6d. post free.

THE GERMAN IRON SYNDICATES.—The negotiations concerning the renewal of the pig-iron syndicate have apparently reached a dead-lock. This is more especially due, as it would appear, to difficulties on the part of the Hüstener concern, but other works are also placing obstacles in the way of an agreement being arrived at, and the Geisweider iron works and Luxemburg Lorraine works seem to hold aloof. The opinion is expressed that the negotiations will probably prove futile in the end, although almost all the Siegerland works have agreed. As far as the defunct Bar-Iron Convention is concerned, its members keep in touch with each other, and at a recent meeting several questions of mutual interest were discussed. A possible reunion was also referred to, but seemed to meet with no response. A fresh meeting will be held shortly. Contrary to what was expected, the Union of Rivet-Makers has been renewed for a year—to September 30, 1912. The large Mannesmann concern was not represented at the meeting, and is understood to be retiring from the Union, so as to stand free with the output from the Reishalzer works. The attempts to form an All-German Hoop-Iron Union, it will be remembered, led to no result, and unsatisfactory conditions still prevail within this branch; the old works extend their plant and increase their output, and prices give way all round.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Labour difficulties have become—at any rate, for the present—more serious than ever, and it is feared that, even after work has been recommenced, some time will elapse before matters return to a normal condition. The best large steam coal has made 18s. 6d. to 19s. per ton; secondary qualities have ranged from 16s. 6d. to 17s. 9d.; bunker smalls from 9s. 9d. to 10s.; and cargo smalls from 7s. 9d. to 8s. 3d. per ton. The best ordinary house coal has been quoted at 14s. 6d. to 16s. 6d.; No. 3 Rhondda large at 17s. to 17s. 6d.; and smalls at 10s. 6d. to 10s. 9d. per ton. No. 2 Rhondda large has brought 11s. 9d. to 12s. 3d., and smalls 7s. 6d. to 8s. per ton. Foundry coke has realised 18s. to 20s. 6d., and furnace ditto 16s. to 17s. per ton. As regards iron ore, Rubio has brought 18s. 6d. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Welsh Railway Difficulties.—The effect of current labour troubles upon Welsh railways is disastrous. Already hundreds of railway employees have either been put on half-time, or their services have been temporarily dispensed with. In the case of the Taff Vale Railway many men have been affected in this way. A number of porters have been discharged, and their work has been taken on by employees drafted from the various traffic departments.

Rhymney Railway.—The ordinary stock dividend of the Rhymney Railway Company for the first half of this year is officially recommended at the rate of 9 per cent. per annum. The dividends for the first halves of the ten years ending with June, 1911, inclusive, have been as follows:—1902, 5½ per cent. per annum; 1903, 1906, 1907, and 1908, 7 per cent. per annum; 1905, 7½ per cent. per annum; 1904, 8½ per cent. per annum; 1909 and 1911, 9 per cent. per annum; and 1910, 9½ per cent. per annum.

Aberpergwm Collieries.—Mr. Godfrey Williams, owner of the Aberpergwm Collieries, which have been idle in consequence of industrial troubles since January, states that operations will not be resumed until the beginning of next year. In the meantime, however, the most up-to date electric plant is being installed, and sufficient power will be developed to supply the collieries in the Neath Valley and the Swansea Valley with lighting and motive power.

Dowlais.—The Dowlais Works have been going full time, and the out-turn has been large. The Goat Mill has been occupied with light-section steel rails, bridge-work, and steel sleepers. The Big Mill has been engaged upon light colliery material, angle-iron, fish-plates, &c.

Bristol Docks.—The finance committee of the Bristol City Council proposes a further expenditure of 103,358*l.* upon the Avonmouth Dock, the Royal Edward Dock, and the general purposes of the Bristol Dock undertaking. With regard to the Royal Edward Dock, it is proposed to devote 30,000*l.* to the development on the west wall of sheds, sidings, cranes, and capstans, which are required to provide for the expansion of Australian trade. The docks committee has experienced difficulty in meeting the demand for cold storage, frozen meat which had been stored at Avonmouth having had to be forwarded to London and other towns by railway. Additional storage capacity of 154,000 cubic feet is proposed to be provided by insulating the upper floor of transit-shed No. 2, at a cost of 20,000*l.*

AGRICULTURAL MACHINERY.—The value of the agricultural machinery exported from the United Kingdom in June was 177,675*l.*, as compared with 181,837*l.* in June, 1910, and 142,215*l.* in June, 1909. European countries figured in these totals for 145,927*l.*, 150,167*l.*, and 125,076*l.* respectively. The aggregate value of the exports to June 30, this year, was 845,761*l.*, as compared with 753,218*l.* and 608,388*l.* Of these totals European countries took 639,105*l.*, 557,817*l.*, and 453,129*l.* respectively. It should be noted, however, that we shipped agricultural machinery to South America in the first half of this year to the value of 47,242*l.*, as compared with 79,814*l.* and 56,978*l.*

BARNSLEY.—At a meeting of the Barnsley and district Chamber of Commerce Mr. Middleton, secretary of the Old Silkstone and Dodworth Colliery Company, said the establishment of a by-product plant of 80 ovens at Barugh would lead to the development of the Stanhope Silkstone Colliery, the estimated product of coke being 2300 tons per week. They were going to put down an electricity generating station of about 2000 kilowatt capacity, which would be run by the surplus gases from the ovens. The Yorkshire Electric Power Company had agreed to take the electricity, and with cheap power available, he thought the district would develop. They hoped to have the works completed by March, 1912.

AUXILIARY OIL-ENGINE IN SAILING-SHIP.—The sailing-ship Quevilly, belonging to Messrs. Prenteout-Leblond and Leroux, of Rouen, has just completed the voyage from Havre to New York, and interest attaches to the voyage, in view of the fact that the vessel is fitted with two Diesel engines of 350 horse-power for driving her during calms or against adverse winds. The voyage occupied thirty-eight days, due to adverse winds. The motors gave excellent results during the 650 hours in which they were in operation, this period extending over twenty-six days of the voyage. Another feature was that the vessel was able to enter New York Harbour without requiring a tug. The motors were fitted by M. Augustin Normand, of Le Havre, and they are of the two-cycle Nurnberg type.

THE CATSKILL WATER SYSTEM OF THE CITY OF NEW YORK; ASHOKAN RESERVOIR, OLIVE BRIDGE DAM.

(*For Description, see Page* 117.)

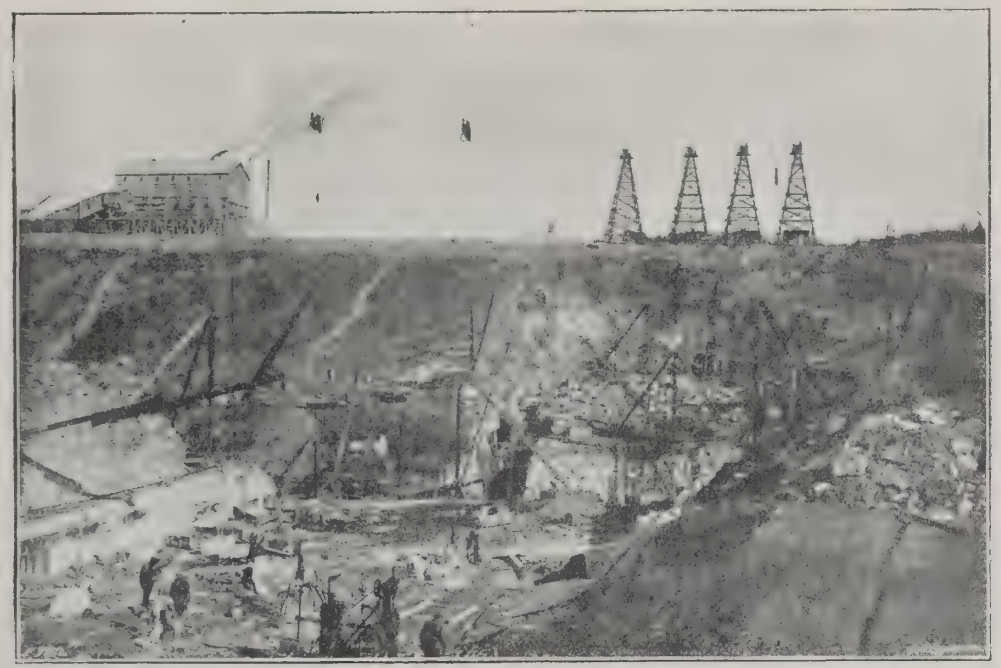


Fig. 11. View Looking North Across Gorge of Esopus Creek at Site of Masonry Portion; Excavation in Progress.

Fig. 13. Bed of Creek at Dam Site Between Two Temporary Cofferdams.

Fig. 12. Head Towers of the Lidgerwood Cableways for Conveying-Material.

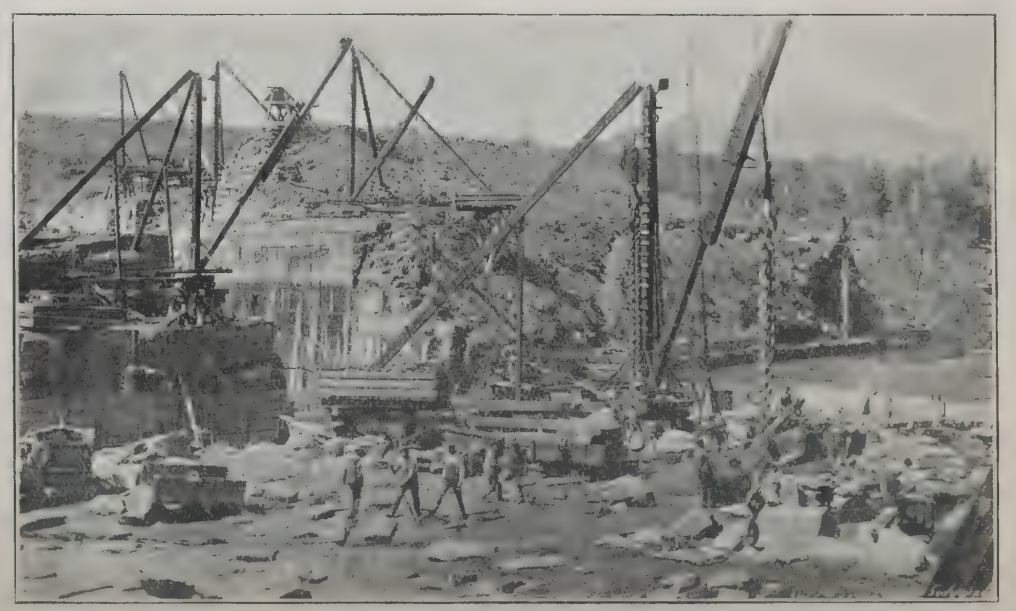


Fig. 14. Building of Masonry in Progress.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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NOTICE.

Immediately following the Index to our last volume, which is published with the current issue, will be found a Classified Directory of Current Advertisements in ENGINEERING, together with a List of the Telegraphic Addresses of the Advertisers and Key. This Directory and List with Telephone Numbers and Telegraph Codes in use, together with Glossaries for the use of Foreign Buyers, is also published in compact book form for handy reference, and may be had gratuitously on application to the Publisher. This Directory is sent at regular intervals to the principal purchasers of machinery throughout the world.

ENGINEERING.

FRIDAY, JULY 28, 1911.

INDUSTRIAL PROFITS AND MANUFACTURING EXPERIMENTS.

WE are told on the authority of the Chancellor of the Exchequer that we have enjoyed "a wonderful year of prosperity." The statement is worthy of consideration, and first it is pertinent to inquire as to the extent of the prosperity. This at once forces to the forefront the fact that activity and prosperity are not synonymous terms. As this is not always realised, the measure of prosperity is liable to be over-estimated. It is true that at the present time the volume of production in this country is most satisfactory; there is less unemployment than has been the case for a long time, and the collated statistics of the trade unions show only 3 per cent. of members unemployed, while the aggregate imports and exports are greater than ever before. But against all these gratifying results is the eloquent fact that manufacturing companies which have never been more actively engaged than during the past year are unable to pay a dividend on their ordinary capital, and that in several cases even the debenture and loan interest is not being earned. This is a consequence, of course, of excessive competition and of the difficulties that manufacturers have in meeting foreign competitors not only on common ground, but even in our home market. That our working men should have full employment at satisfactory rates of wage is cause for congratulation; this, indeed, should be the aim not only of the leaders of industry, but of those responsible for government. Consequently, activity is in itself satisfactory, and has a direct bearing on the social life of the people. We are hopeful, for instance, that the increase in the money to the credit of the working classes in the Post Office and other trustee banks is an indication that full employment is being utilised to ensure for the worker and his family a more independent and comfortable social position. But it cannot be said that the tendency of legislation encourages the people to this end. There is still, unfortunately, too great a desire to enjoy the fruits of the present and to leave future contingencies to take care of themselves. At no time in the social life of the nation have there been so many opportunities for expenditure which neither physically restore nor mentally invigorate the participants. Men and women, and, above all, children, will have their excitements; and they only enjoy them in many cases in proportion to their deficiency in those qualities which are essential to bodily and mental culture. On the other hand, for instance, an increase in the passenger receipts of our railways running to health resorts shows that healthy pleasures, which are attended with an improvement in physique, are sought by a section of the working classes.

Our main object, however, is to consider rather the more direct effect of activity on the foundations of future industrial prosperity. A firm which cannot meet the just expectation of even the ordinary shareholder for a dividend cannot have much money to spend on industrial experiment or scientific research, so that our progress in improvements in processes of manufacture and in the design and efficiency of the product, which is essential to continuous industrial prosperity, may be unsatisfactory. Are our manufacturing and commercial conditions conducive to the prosecution of this experimental work? Are our competitors in foreign countries assisted to a greater extent by the prevailing economic conditions in developing this important department of industry? The vital importance of these questions need not be enforced. Neither is it necessary to enter into a discussion as to whether any political party in the State is alive to their importance. Certain it is that the present state of unrest is due to a most pernicious view that the main function of a political party is to secure power by pleasing those having the greatest number of votes. There is too little broad thinking as to the general trend of government and its ultimate influence on the national prosperity. The resort to force in industrial affairs, with the disgraceful displays of rioters, is a consequence of that laxity of discipline which no one cares to combat. Moreover, the uncertainty as to the course of legislation, and the lack of fairness in dealing with economical questions, is tending to divert the flow of capital essential for British enterprise into foreign channels, where more stable conditions seem, at all events, to prevail.

While labour is thus demanding first consideration, the purchaser in most cases is encouraging ruinous competition. We say "ruinous" advisedly, because the ultimate economic effect of employment which yields only remuneration to labour, and does not leave a sufficient margin for capital, far less for scientific development, cannot be other than disastrous. One cannot blame the purchaser for buying in the cheapest market, although there is no disputing the fact that he comes pretty near to the committing of a moral offence when he purchases an article with the full consciousness that the price paid is less than the real cost of production. The responsibility is the greater in the case of a municipality or Government department, as they are not actuated by personal gain; and, moreover, ought to be examplars. The Government or municipal purchasers shield themselves behind their consultant, and place upon him increased responsibility in ensuring that the article shall be efficient according to the standard set, apart altogether from the loss in producing it. The consultant may do his duty, but on him rests the moral offence of demanding more than is being paid for. There is no doubt that the price paid has been less than the cost of production in many recent cases, for instance, in connection with electrical machinery, and also with warships. The practice of accepting the lowest tender is defended because of economical conditions and of the guarantee it affords against favouritism. But there should, at the same time, be some recognition of the fact that just as low wages may not conduce to high efficiency, because tending to delay improved mechanical means of production, so a loss in the selling price is not conducive to permanent efficiency in manufacture, as it prevents expenditure on research. Mr. Yarrow put this admirably in his short address at the opening of the experimental tank at the National Physical Laboratory, when he pointed out that "striving after cheapness will lead to the inevitable result of securing present gain at the sacrifice of future progress, for it must be borne in mind that if contractors are deprived of the margin of profit which enables them to make investigations, it will put a stop to their enthusiasm in scientific work."

Obviously it should be the aim, if not the duty, of manufacturers to secure a certain margin for research work. This, indeed, is as important as the percentage for establishment charges and for profit, if the work of invention and improvement is to continue. In all works there should be a department for special originative work. Many of our establishments have succeeded in maintaining their experimental work, and, by reason of their success in meeting guaranteed conditions, have found in some respects a readier market for their productions. But with every desire to be patriotic, we must incline to the view that more of this originative work is being done on the Continent and in America than in this country. It is too large a question to discuss what are the many and various conditions in those countries which assist manufacturers in securing a higher margin of profit in their home markets. We only accept the fact that higher prices are realised, that profits are surer, and that a greater amount is therefore available for experimental research. It is known, for instance, that Messrs. Krupp have a great building fitted with the most modern apparatus for physical tests and chemical analyses of steel and other products, a department presided over by two professors with ten university-trained experts and 150 men. When short-sighted critics contend against our warship-building firms having a moderate margin of profit, they fail to recognise the importance of some concession in favour of corresponding experimental work in this country. Those of our readers who read our recent articles on the Swiss works must also have

been impressed with the extent of originative work in progress there, and the members of the Institution of Mechanical Engineers when they visited those works this week probably found convincing reasons for adopting a still more liberal attitude towards experimental research of a practical nature. The present position of the oil-engine industry affords another illustration. We have lagged behind in respect of mechanical application, and it seems amazing, in view of our undoubted supremacy in mechanical engineering, that we should have needed to pay large sums in order to gain some experience from Continental sources. We do not in any way decry the value of the experience gained by these Continental firms, but we are persuaded that, as in all the affairs of life, experience which is bought can never have the same influence, or be so certain in ensuring the avoidance of mistakes, as the lessons learnt from trial and error. For this reason it must be regretted that we have not maintained our position in connection with the development of the internal-combustion engine. However, we are satisfied that if our manufacturers will take the matter up with characteristic British determination, lost ground will soon be recovered in this as in other branches of applied mechanics.

We may seem to have ignored the great amount of research in progress in physical laboratories—public and private; but this is only because such work is not germane to the main point at issue. Such experimental research work has its influence on industry, but more direct is the experimental work on practical details, which is best carried out in manufacturing works. Now that trade is active, and that work can be more easily got, it should be the aim of manufacturers to resist the temptation to cut prices. They should recognise that, as we have already said, competition which does not yield a margin for improvements that will add to our manufacturing prestige must be ruinous. The advantage of filling an establishment with cheap work is, as we have said, transitory; it helps the workman for the time, but will not add to the nation's ultimate and permanent success.

THE EFFECT OF SALTS IN POTABLE WATER

SINCE 1894 the city of Magdeburg, on the Elbe, the capital of the Prussian province of Saxony and an important industrial centre with about 300,000 inhabitants, has been engaged in a gigantic lawsuit against the Mansfeld Copper-Mines, situated about 50 miles to the south of the town, and against the salt-mines and some of the numerous salt-works dotted all over the central part of the province and the Duchy of Anhalt. The Duchy is enclosed by Prussian territory, and lies some 20 miles from Magdeburg, also in a southerly direction. The city of Magdeburg charged those mines and works with polluting the River Elbe, upon which the city depends for its water supply, with their refuse waters, which were so strongly salt, it was alleged, that the Elbe water was rendered very hard, bitter, offensive, and injurious to health. After fifteen years of litigation the lower court decided, in April, 1909, in favour of the salt-works, and thus in a measure against the city and against the copper-mines. Both these participants have since lodged appeals, and unless the parties come to an understanding, another lawsuit will be fought out in the higher court. We are, of course, not concerned with the rights and wrongs of the litigants, and it would be improper to comment upon a case which remains *sub judice*. But certain instructive general features can be discussed without reference to the legal aspect of the matter. We have the more reason to dwell upon the difficulty of this water supply, because we dealt with the cause and history of the salinity of the Elbe water in our issue of February 19, 1909,* and with the Puech-Chabal system of water filtration, which was adopted at Magdeburg in 1909, in our issue of February 4, 1910.† The city of Bremen might, moreover, become involved in similar difficulties, and salt contamination affects certain British sources of water supply as well.

Not to repeat previously-made explanations, we will merely say that the famous potash and rock-salt treasures of the district lying between the Elbe in the east and the Weser in the west, and situated in what was, in the early mediæval days, the Duchy of Saxony, are regarded as the salt deposits of an ancient, dried-up sea, which may have been as large as the Adriatic Sea. Thus it is possible that all the water from the district may permanently or periodically become salt. When the suit was commenced in 1894, the Mansfeld mines (in which copper is smelted from schists) were credited with supplying 91.3 per cent. of the salt found in the Elbe water. The potash works and soda works were supposed to contribute 6.4 and 2.3 per cent. The Mansfeld works sent their refuse, through a tunnel about 20 miles in length, to the little River Schlenze, which joins the Saale, the chief tributary of the Elbe in this portion of its course. The potash-works discharged their refuse more or less directly into various rivers, with the consent of the authorities.

By the end of 1910 the contributions of the various works to the salinity of the Elbe water were estimated as follow:—Mansfeld, 78 per cent.; old potash-works, 7 per cent.; new potash-works, 11 per cent.; soda works, 4 per cent. By old potash-works we mean the ten firms against which the suit was brought in 1894; the Prussian Treasury, as owner of five works, was one of these ten. During the course of the litigation, several of the original defendants practically ceased to produce salts, whilst other firms, not made defendants, have become more and more important. In fact, the whole centre of responsibility has shifted, and that is almost inevitable in a prolonged lawsuit of this kind, which necessarily can only be decided on the strength of statistics, which it takes years to collect and to digest.

The number of potash-mines had, by the end of 1910, increased to sixty-eight. Of these, thirty-one lie in the basin of the Elbe, and thirty-seven in that of the Weser; of the former, three, being situated below Magdeburg, may be disregarded. But there have been changes in other respects as well. When writing early in 1909, we mentioned that part of the magnesium chloride which is discharged by the chemical works, because it is, broadly speaking, the most soluble and the least valuable of the many salts occurring in these mines, was supposed to be re-precipitated in the river and thus to be removed by the self-purification of the flowing water. This assertion met with little credence, but it has since found support. Some of the magnesium salt is now believed to be converted into insoluble carbonate and silicate, and thus to settle with the mud. Professors Kraut and Erdmann favour this view. Professor Kraut, of Hanover, was one of the first of the many distinguished experts consulted, and the analytical data collected by him and also by the German department for hygiene had formed the basis of several expert memoranda of imposing length submitted to the Court. In 1902 the Court charged Professor Vogel, of Berlin, with a new investigation into the salinity of the water of the Elbe and its tributaries; this inquiry lasted two years, and further experimental data were submitted by Government departments and chemists. No wonder that the decision of the Court was delayed, and that the type-written judgment finally covered 158 folio pages.

As regards the evil influences of the magnesia, opinions were, and are still, divided, but the opinion is gaining ground that magnesia has been maligned. The engineer will be interested in the statement made by the director of the Magdeburg Association of Boiler-Users, that the supply water of Magdeburg had never corroded the steam boilers in any unusual way, in spite of its 60 or 100 milligrammes of magnesia per litre. What is equally striking is, that the injurious influence which the continued drinking of such water was assumed to have on the health of the inhabitants must apparently be questioned. First, the Elbe water was occasionally alleged to be nauseous; that feature, Professor Volhard, of Halle, declared from the first, had nothing to do with magnesia, but was probably due to organic impurities. Further, the waters of Göttingen and of Würzburg contain many times more magnesia than the Magdeburg water, and have not been regarded as detrimental to health. According to the valuable work on the municipal water supplies of Germany by E. Grahn, the people of fifteen German towns, comprising Bamberg, Erfurt, and Munich, drink water which is at least as salt as the Magdeburg water. Hall, a small town in Württemberg, has an exceedingly hard water, containing 122 milligrammes of magnesia and seven times as much lime, and the water is yet a popular beverage. Leopoldshall, in Anhalt, the seat of some of the best-known mines of the district in question, has always had a very salty water, and matters have become worse in that respect than at Magdeburg, as careful analyses taken during the last six years prove. Yet the leading physicians of the town have not assailed the water. The mortality of Magdeburg itself has decreased very considerably, while the number of salt-works in the neighbourhood has increased fourfold; in fact, the mortality of Magdeburg is below the average of the kingdom of Prussia. That may, of course, be attributable to many other causes. But the conviction is spreading that the magnesia scare has been exaggerated. That is also the conclusion at which Professor Ost, of Hanover, arrives, who has studied the problem, with special regard to the water supply of Bremen.

At Magdeburg matters have improved of late, since the intake, about 20 miles above the city, was shifted in 1909 from the left bank of the river—*i.e.*, the side on which the salt-mines are situated—over to the right bank.

If we can draw a lesson from this consideration, it is that a water source need not necessarily be condemned right out on account of a relatively high percentage of salts. That is important, for water engineers are becoming more inclined to rely on well-filtered and sterilised river water rather than upon supplies from distant lakes in mountain regions, through huge conduits which may fail, and which, after all, may bring water whose pollution would be discovered too late. Our views on hygiene are undergoing modification, and will continue to do so. Many an assumed fact finally appears to be no more than a deeply-rooted prejudice, based on insufficient evidence. Litigation in the law courts may clear up obscure problems of the kind with which we have been dealing. But the case of Magdeburg emphasises that such litigation must, of necessity, be very protracted and expensive.

IMPROVEMENTS IN PYROMETERS.

THE handling of thermo-couples demands some special skill, and their indications often require various corrections. These difficulties detract from their usefulness, and raise a prejudice against them. It was with the object of showing how the difficulties could be overcome by the aid of simple devices, that Mr. R. S. Whipple, of Cambridge, delivered a discourse on "Some Recent Improvements in Pyrometers" before the Birmingham Metallurgical Society, the occasion being a joint meeting of the Staffordshire Iron and Steel Institute and other bodies. Taking the several features affecting the industrial use of pyrometers and thermo-couples, Mr. Whipple first referred to compensating leads for thermo-couples. The inner end of the couple is the "hot junction," the outer end the "cold junction;" the latter is also called the "head of the couple." That head should be at a uniform, known temperature, to ensure which the wires should be taken to a considerable distance away from the furnace. That can easily be done with inexpensive couples made of copper and constantan, but not with the expensive couples made of platinum and its alloys. For this reason the head is sometimes jacketed with steam or with cold water; compensating leads are more convenient, however. These leads were introduced by Professor W. H. Bristol in 1904, who used wires of a high resistance, such that the couple itself practically formed the platinum tips of the wires. Mr. W. S. Peake, independently of Professor Bristol, succeeded in preparing wires of copper-nickel alloys (containing very little nickel, less than constantan), which, while of low resistance, would give the same electromotive force against nickel as platinum against its alloy with iridium or with rhodium. The composition of the particular alloy depends upon the couple to be used; but a very good compensation can be obtained for the range 0 to 300 deg. Cent. The compensating leads are joined to the head, and are taken either directly to the galvanometer or to a junction-box, which is buried in the ground or otherwise maintained at a constant temperature, copper wires then connecting the junction-box with the galvanometer.

The heating of the galvanometer itself introduces two sources of error, because the temperature of the cold junction may not be the assumed temperature, and because the resistance of the millivoltmeter varies with the temperature. These errors

* See ENGINEERING, vol. lxxxvii., page 256.
† See ENGINEERING, vol. lxxxix., page 133.

are corrected with the aid of bi-metallic arrangements, which move the zero scale backward and forward (C. R. Darling), or adjust the width of the polar air-gap in the galvanometer (Thwing). The Cambridge Scientific Instrument Company recommends a bi-metallic spring attached to the millivoltmeter control-spring, and also the cold-junction thermostat of Mr. Horace Darwin, which we mentioned among the exhibits shown in the Physical Society last December. Another apparatus for this purpose, which Mr. Whipple described, is Peake's scale control-box. It is designed to set up electrically the zero of the recording instrument, so that the scale covers only the actual working temperature—say 600 to 900 deg. Cent.—while the instrument may be used for the range 0 to 1000 deg. Cent.; combined with Peake's compensating leads, the control-box eliminates (practically) the influence of atmospheric temperature changes. In this scale-box two circuits are joined in opposition; the "potentiometer" circuit comprises three accumulator cells and resistances; the pyrometer circuit comprises the thermocouple and the recorder. At some temperatures—say 750 deg. Cent.—the two currents would just be balanced, and no current flow through the pyrometer; when the temperature of the couple falls or rises, a current will flow. As the accuracy of the device depends largely upon the constancy of the accumulator current, a Clark standard cell has been connected across the resistances; as long as the accumulator current is normal, this cell will practically be cut-out; but when the accumulator potential decreases, the standard cell helps to keep constant the voltage across the resistances. A Clark cell is chosen by preference to a Weston cell because it has a low temperature coefficient. The accumulator need only be charged once a month, and the standard cell will last many months. The device, Mr. Whipple said, promised an accuracy of 3 or 4 deg. Cent. at 900 deg. Cent. without application of any corrections.

Mr. Whipple also showed an automatic triple-commutator switch for tracing several curves on the same sheet. While deprecating on the whole the practice of recording several temperature records on one card, he recommended this switch for special cases; there would be no objection, for instance, to recording the temperatures of an annealing furnace and of the flue on the same sheet. Other instruments which he described—the Brearley recalescence curve-tracer, the Joly meldometer, and the Féry spiral pyrometer—have already been noticed in our columns. The Whipple-Féry pyrometer for determining the temperatures of molten iron and steel and other metals is new. Such determinations are difficult. There are differences between the true and the apparent "black-body" temperatures, and they vary with the experimental conditions, the depth to which the crucible is filled, and, further, with the oxidation of the metallic surface, the formation of slag, &c. In the modification of the Féry pyrometer which Mr. Whipple has designed, aided by suggestions from Mr. Saniter, the whole pyrometer forms a straight tube, about 4 ft. long, which is joined by a flexible cable to the galvanometer; a reading can be taken in one minute. The main portion of the tube is steel; the inner end of it, the "salamander end," is made of fireclay. This clay tube is spherical at its closed extremity. When the tube has been immersed in the metal the heat rays from the closed end pass along the steel tube to the concave mirror of the pyrometer at the outer end of the tube, which they reach directly or after having passed through a stop; the instrument part of the tube may also be fixed to the main steel tube at an angle. A shield pushed over the tube protects the hand which dips the pyrometer into the molten metal. The readings are said to be independent of the depth to which the tube is inserted, provided that the depth be at least equal to three times the diameter of the tube.

THE INTERNATIONAL SEISMOLOGICAL ASSOCIATION.

A MEETING of the permanent committee of the International Association of Seismology was held at Manchester on July 18 and following days, under the presidency of Professor Schuster. Of the various countries which are represented on the Association, delegates attended from seventeen. Among the more distinguished foreign seismologists present may be mentioned Professors Wiechert, Hecker, and Schutt from Germany, Professor Lagrange from Belgium, Professor Reid from the United States, MM. Angot and Lebeuf from France, Professor R. de Kovesligethy from Hungary, who acted as secretary, Professor Omori from Japan, Professors Palazzo, Oddone, and Rizzo from Italy, Prince Galitzin, Professor Lewitzky, and M. Orloff from Russia, and Professor Forel from Switzerland.

The proceedings were opened by a speech from the Vice-Chancellor of the University (Sir Alfred Hopkinson), who welcomed the Association to Manchester. Professor Schuster, who represents the British Government, then delivered a presidential address, emphasising the purpose of the Association and the functions it fulfilled in the scientific world and in public estimation. He said that the interest and sympathy of the public were aroused mainly by the human suffering which followed in the trail of these seismic catastrophes. At present they felt helpless, though perhaps not altogether hopeless, in the face of the destructive convulsions of the earth. The problem of construction—of erecting buildings which could withstand earthquake shocks—did not enter into their programme, but the public wanted to know, and their interest in that meeting would be increased if it could be definitely asserted, whether there were any preliminary indications which would allow science to predict the occurrence of a dislocation of the soil, and enable precautions to be taken to mitigate, to some extent, its destructive power. Meteorologists had been successful in predicting the course of cyclones in the Indian Ocean and the Gulf of Mexico, and it did not seem impossible that similar warnings might be successfully employed in fighting the dangers of earthquakes. Unfortunately, the cases were not analogous, and if their knowledge of earthquake phenomena did not exceed that of the air, the dangers attending such predictions might overbalance the benefits. The precautions which could be taken in a harbour against an approaching storm were of a comparatively simple character, and the meteorologist was therefore justified in warning us against a storm which did not appear. But would the seismologist be justified in creating a panic and dislocating trade by predicting an earthquake which failed to take place? A seismic forecast which represented a town as "unstable and collapsing" was a more serious matter than a weather forecast which described the weather as "fine to doubtful and stormy." The fear of creating panics by premature forecasts was one which had already cast its shadows in advance, and insurance companies in this country had shown some irritation at the early publication of the indications of a destructive earthquake which had taken place in a distant part of the world.

To the "man in the street" the question whether a thing was large or small was all-important; to the scientific man it mattered not at all. As a matter of fact, a great part of their deliberations would deal, not with catastrophes, but with microscopic movements of the soil—movements so small that the vibrations due to the traffic in a city compared with them as the waves of an ocean did to the ripples on a pool. There were two types of short waves which were frequently observed. One of them had been traced, independently in different countries, to the intensity of local winds. These oscillations had a period of about half a minute, and appeared to originate on land in a similar manner to that in which waves were produced on the ocean. The second type of vibration, which exhibited periods of from 5 to 10 seconds, was more difficult to trace. Professor Wiechert had suggested that this wave motion was caused by the impact of ocean waves on coast-lines.

Whilst they rightly attached much value to the systematic investigation of minute disturbances, they must not forget to keep in mind the source and origin of all dislocations of the soil. The recent advances in physical science rendered it imperative to review their position with regard to this fundamental question. We were once taught that the earth originally was a molten globe, which had gradually cooled down, leaving the inside still hot, but gradually cooling and contracting. This contraction of the nucleus was looked upon as the primary cause of geological dislocations. But how did the question stand now? In the breaking up of radioactive products we found a source of heat which, if the amount of radium and thorium in the interior of the earth were not decidedly less than that found near the surface, would not only balance the earth's loss of heat by radiation, but actually increase its average temperature. Though reasons might easily be found why the surface layer of the earth might be richer in radioactive products than the internal core, we were nevertheless driven to the conclusion that the earth was now, and had been for a long time, in thermal equilibrium, and that shrinkage by cooling did not account for any of the more recent displacements. Why, then, should not the earth long ago have settled for itself all seismic questions, and have come to rest in a comfortable state of equilibrium? After the four or five million years which it had had to calm down we might have expected that everything would be quietly arranged in uniform layers round the centre of the earth. Instead of this regular distribution of matter we had not only mountain chains, but also the depressions and elevations which caused the distribution of land and water over the globe.

After referring to the work of Professor Hecker at Potsdam, and of Professor Love at Oxford, the president concluded by remarking that investigations of the tidal deformation of the earth overlapped the work of the International Geodetic Association, and that a communication from that body would have to be considered. The extreme specialisation which found expression in the formation of so many different societies and associations was an evil which might be a temporary necessity, but which should be mitigated as far as possible. He suggested that there should be a central body that would draw them away from the minute elaboration of detail towards the great problem that ought never to leave the mind of a man of science. As to where this central body was to be found, and what were the bonds which were to unite it to associations of varied interests and constitution, he had formed his own opinion, but he was afraid on such an occasion to enter on ground which might prove controversial.

Dr. Oskar Hecker, the Director of the Imperial Institute for Earthquake Investigation at Strassburg, and President of the Central Bureau of the International Seismological Association, described the observations he had made in a deep well at the Geodetic Institute at Potsdam, employing horizontal pendulums to detect the amount of the deflection of the vertical. For $6\frac{1}{2}$ years these observations had been continued, and had definitely established the fact that at Potsdam the deformation of the body of the earth was greater in the north-south direction than in the east-west direction. It had been suggested that the greater stiffness in one direction might be explained by the earth's rotation, but Professor Love had proved that this cause was inadequate. As an alternative, Professor Love had suggested that the asymmetry might be due to the geographical situation of Potsdam. For such delicate inquiries, Potsdam was too near the western margin of the great Eurasian Continent. Professor Love explained the causes as due to the tides in the North Atlantic, and the pressure they exercised on the bottom of the sea. It was believed that stations had been equipped with suitable apparatus at the bottom of mines at Fribourg and at Pribram, at a depth of 189 m. and 1160 m. respectively. But in order to gain a better insight into the phenomena of the deformation, and to be able to decide whether the influence suggested by Professor Love really explained the difference, he proposed that the Association should establish two new international stations. He suggested Paris and Johannesburg, but would be glad if one could be established in the centre of Russia, and another in the centre of the North American continent.

Professor Love cordially supported the proposal to establish new stations, and the question was referred to the Finance Committee.

Professor Orloff, of Dorpat, who had a paper on "The Deformation of the Globe under the Influence of the Attraction of the Moon," stated that he had found a difference of rigidity in the two directions similar to that mentioned by Dr. Hecker, but smaller in amount.

Dr. Klotz, who was responsible for a paper on "Auxiliary Instruments for the Interpretation of Seismograms," suggested that it was desirable to secure greater uniformity in nomenclature and form in bulletins recording seismic disturbances. He said, with the general approval of the meeting, that there was no science in which there was such divergence of method and nomenclature in recording events as there was in seismology. At his suggestion a committee was appointed to draw up a form

of bulletin which the Association could recommend to the various recording stations for adoption.

Among other papers read were two by Dr. Wiechert, on "What can be Deduced from Earthquake Diagrams," and on "The Constitution of the Earth's Crust," in which he repeated his views concerning the plasticity of the earth and the complex geologic processes which determine its formation.

Professor Reid, of Baltimore, U.S.A., in the light of recent research, opposed the theory that mountains had been caused by volcanic action. Neither did he favour the theory that attributed mountains to the result of tangential pressure of the surface. Mountain ranges, he insisted, must have been the result of the expansion of the material. It was impossible to increase or decrease the equilibrium quantity of any segment of the earth, and ranges must be due to the material beneath them becoming less dense, and causing faults. The upward force caused strain in the crust, and when these strains became sufficiently great, they developed into a break and a fault, and at that particular moment the starting of an earthquake. As the result of his observations he found that earthquakes did not occur at the same fault line, except after long intervals; if a number of severe earthquakes occurred quickly, the movements took place at different faults.

Dr. Oldham could not accept the hypothesis that earthquakes were caused by a long, slowly-accumulating strain which was suddenly released. There was an alternative hypothesis that earthquakes might result from some unknown cause which produced a great strain rapidly. When measurements had been made of the ground after an earthquake, they found indications of expansion, not merely of contraction or distortion. There was no doubt that, as a result of the San Francisco earthquake, the Coast of California, from north to south, was now about 30 ft. longer than it was fifty years ago, and other earthquakes had shown similar characteristics.

Mr. F. Napier Denison, of Vancouver, whose work on seiches and the variation in barometric load on the earth's surface is well known, is endeavouring to trace this effect in the escape of gas in coal-mines. He has examined, throughout a long period, the behaviour of two Milne horizontal pendulums installed at Victoria, British Columbia. He found that both pendulums had a tendency to move in the direction in which the air-pressure was greatest. He explained that he had detected the presence of certain pronounced long-period undulations, possessing marked rhythmic characteristics, and too great to be caused by local meteorological conditions. In order to ascertain whether any correspondence existed between colliery explosions and seismic frequency, the dates of explosions had been carefully compared with the charts, and it was noted that explosions occurred more frequently during the month of extreme pendulum movements, and especially when the pendulum was near the limit of its westerly swing. This suggested connection between pendulum oscillations and colliery explosions was not confined to the winter months, when such coincidences might be expected, but continued throughout the summer months. His curves supported the theory that the earth was undergoing a great strain, and it was possible that the rocks in collieries and the coal-seams were affected to such an extent that the coal-gas might be able to come up and flood the workings. He added that the Canadian Government would be disposed to find money and instruments for the prosecution of this inquiry, if the Association approved of the work. The meeting passed a resolution recognising the importance of Mr. Denison's work, and urging its further continuance.

Prince Galitzin read papers on the method of observing the vertical component of the earth's motion, and on the determination of the position of the epicentre of an earthquake on the data to be derived from a single seismological station.

Professor Schuster exhibited and described an instrument for observing the impact of waves on the sea-coast against which the waves struck, the object being to throw light upon the origin of the small waves with a period of from five to ten seconds, which had been registered. This instrument had been set up on the sea-shore of the east coast of England, and the oscillations transmitted were recorded, so that the number of waves striking the shore in a given time could be automatically counted. The instrument had proved itself only too delicate in construction, but there was no doubt it would fulfil its purpose, though the observations at present were too few to allow any conclusion to be drawn.

On the conclusion of the meeting, the delegates, on the invitation of Dr. Shaw and Mr. Walker, visited the observatory at Eskdalemuir.

NOTES.

Utilising Waste Wood by Distillation.

A discussion on "Utilising Waste Wood by Destructive Distillation," which took place last April at New York at a meeting of the Society of Chemical Industry, in connection with a paper with the above-mentioned title, by Messrs. J. Lawrence and J. C. Lawrence, shows that the wastage of wood, which is still formidable in countries like the United States, could be prevented by various means. The United States Forest Service estimates that 150,000,000 tons of wood were wasted in 1907; the statistics are based on Frankforter's estimate that 65.16 per cent. of wood were wasted in that year. It is difficult to conceive how such estimates are arrived at. Possibly the figures are grossly incorrect; but a deplorable waste of wood in the lumber and saw-mills is undisputed. In their experiments Messrs. Lawrence used a wrought-iron retort and hard-wood waste, oak lumber offal from slabs 1 in. or 2 in. in thickness, 2 in. to 4 in wide, cut in lengths of 2 ft.; the retort charges were of about 200 lb. of wood, dry or green. It had generally been thought, the authors stated, that the wood should not be less than 4 in. or 5 in. in diameter for destructive distillation, as otherwise spontaneous heating and burning would set in when the temperature reached 270 deg. Cent. Their results had been satisfactory, and they mentioned the case of some small lumber-mills which had profitably been utilising their waste in a similar manner for several months. The experimenters had obtained about 40 per cent. of acid liquor (yielding tar, crude alcohol, and acetate of lime) in addition to wood gas (containing heavy hydrocarbons, marsh gas, hydrogen, and carbon monoxide and dioxide) of a calorific value of 11,493 British thermal units per lb. During the discussion, Dr. J. E. Teeple stated that the destructive distillation of irregularly-shaped waste required reduction of the wood to fine chips. If the retorts were stationary, the wood acted as an insulator; if the retorts were rotated or screw conveyors were used, the high temperature produced soon spoiled the machinery, and the resulting charcoal was of little good for blast-furnaces. But saw-mill waste could be utilised, and was utilised in other ways as fuel, or by making producer-gas, or by extracting turpentine and a residue useful for paper pulp; one plant made glucose, and fermented it into ethyl alcohol. All these plants dealt with soft wood, however, which did not yield sufficient quantities of methyl alcohol and acetate, and the hard-wood distillation was a different problem. Mr. George Walker said that he had distilled waste wood in a cast-iron cylinder, 12 in. diameter, 12 ft. in length, in which an Archimedean screw was rotated; the carbonised sawdust was discharged into air-tight vessels, and a large quantity of tar was gained annually. Mr. J. W. Hornsey remarked that he had carried out hard-wood distillation in Northern Michigan, and the plant of Max Klar at the Cleveland Cliffs Iron Works, at Marquette, had proved that the ordinary apparatus could be made much more economical. There are, no doubt, great difficulties in the treatment of sawdust which are more easily overcome in experiments than in continued practice. But the chemist and engineer should together succeed in devising apparatus for a really profitable utilisation of waste wood.

The Labour Conflicts in Scandinavia.

The Scandinavian labour conflicts have developed in opposite directions in Norway and Sweden. In the former country matters have assumed a more serious aspect, and the efforts made to terminate the great lock-out have proved altogether futile. At the conciliation meetings both the masters and the men put forward proposals, on the basis of which, however, no agreement could be arrived at; and it was evident that the men could hardly intend their offer to be taken *bona fide*, inasmuch as it was almost offensive in its exorbitant demands, since, amongst other things, they utterly ignored market fluctuations. Their leaders have also continued to use highly inciting language, and there are increasing signs of "sympathy strikes," the seamen, for instance, having offered to strike with a view of utterly disorganising Norway's coasting traffic. The men also seem to expect municipal support in the towns where the Socialists control the majority in the councils. The conciliators however, put forward a compromise proposal, which both parties promised to consider; but this proposal, which was based upon arbitration, was rejected both by the masters and the men. The Central Board of the employers did not consider the dispute to be suitable for arbitration, but the Board was willing to lay the matter before an adjourned meeting in case the men accepted arbitration, which, however, they did not. In spite of the inciting language of the leaders, no disturbances have so far taken place; in many places the sale of spirits has been stopped by the local authorities at the instance of the Government. The lock-out, which may be said to be entirely due to the men, is likely to prove a most serious matter for Norway's mining industry, which, although affording work for a large number of men, has been anything but remunerative for the owners during recent years. The strikes and subsequent lock-outs may prove fatal to some mining concerns. Thus it is stated that the ancient Röros copper works, founded in the year 1644, are stopping altogether, all its employees having been given three months' notice. The works have, during the last three years, shown an increasing loss, and the greater demands of the men brought matters to a climax. Should a reconstruction prove impossible, which is not at all unlikely, the whole of Röros' community will have to leave the place; many of the men own their own houses, which will practically be worthless when the works are closed. About 100,000,000 kr. (5,555,500*l.*) have been invested in the Norwegian mining industry, which annually pays some 20,000,000 kr. (1,111,100*l.*) in productive costs, and this sum remains in the country. In Sweden the position is less clear. The conflict has entered upon a new phase, inasmuch as the masters' union has decided to resume work within the building branch (the locked-out branch) with unorganised men. This decision has been arrived at principally to assist the masters who have their buildings nearly ready, so that they may be completed before the autumn, but the decision is not expected materially to affect the course of the conflict. In Denmark the most important trouble is the strike announced to commence on August 1 at two of the tramway companies. The Copenhagen Corporation from that day will take over the most important system of tramways, and material concessions have been made to the men in question; the other companies' employees now hold out for similar or even more extravagant concessions, which would virtually absorb the profits of the companies. Negotiations are proceeding.

The Cunard Liner "Laconia."

The new Cunard liner Laconia, which was launched on Thursday from the yard of Messrs. Swan, Hunter, and Wigham Richardson at Wallsend-on-Tyne, belongs to a type which has been found to be a most important unit in our mail steamship fleets, as at moderate speed they combine extensive accommodation of exceptional comfort for passengers, as well as large cargo-carrying capacity. Thus, on a total displacement of about 25,000 tons, the Laconia will accommodate about 300 first-class, 400 second-class, and 2000 third-class passengers, while, at the same time, taking over 7000 tons of cargo, in addition to bunker-coal and stores. The Laconia is of further interest as she is the first of the British liners to embody in her construction Frahm's system of water-tanks for counteracting the rolling motion otherwise inevitable in the case of a ship steaming with a beam sea running. The remarkable results got with this system on one or two German ships, and already very completely reviewed in Engineering (vol. xci., pages 480 and 533), give promise that this, the last remaining source of discomfort to Atlantic-liner passengers, will be overcome, so that the Laconia is sure to be a popular ship in the service. Her length over all is 625 ft., her beam 72 ft., and her registered tonnage 18,150 tons. The passenger accommodation is arranged on six decks, and in every way is equal to the best provided even in larger vessels. As the Laconia is a sister ship to the Franconia, completed a few months ago by the same builders, and as the plans were at that time published in Engineering (vol. xci., page 246),

it is not necessary here to enter into details regarding the arrangement of the passenger accommodation, nor to describe the extensive equipment of auxiliary machinery. The propelling machinery has been built at the works of the Wallsend Slipway and Engineering Company, Limited. The main engines are of the quadruple-expansion type, balanced on the Yarrow-Schlick-Tweedy system, in order to minimise the vibration. The cylinders are respectively 33 in., 47 in., 67 in., and 95 in. in diameter, with a stroke of 60 in. Steam at 210 lb. pressure is supplied by six double-ended boilers, 17 ft. 6 in. mean diameter, and 21 ft. 6 in. long. The design follows in its main features that applied to so many merchant-ships under the direction of Mr. Andrew Laing, the managing-director of the works, and perhaps the most interesting feature of the machinery is that its completion makes up over a quarter of a million horse-power built under his direction for the Cunard Line. This is a notable achievement for any one engineer, and is the more remarkable as the fourteen vessels, whose engines make up the 255,000 horse-power, have been built on three rivers and by six different firms. Many of the ships, too, were record-breakers, and the influence of the progressive policy of the Cunard Company is reflected by the fact that these ships have reduced the ocean-crossing from seven and a-half days to under five days, the sea speed having increased from 15¼ to 26 knots, while the power of the propelling machinery in one ship has advanced from about 6300 horse-power to about 80,000 horse-power. The earlier ships, of course, were built on the Clyde, when Mr. Laing was responsible for the machinery production at Fairfield, and the later ships on the Tyne and Wear. A further point is that since Mr. Laing went to the Wallsend Works, fifteen years ago, the total production has averaged 60,000 horse-power per annum, or 830,000 horse-power in all, including machinery of all types for vessels of every class in the Royal and merchant services.

ROLLED-METAL TRADES.—We understand that several conferences of rolled-metal manufacturers have recently been held in Birmingham for the purpose of considering the question of prices, and that, as a result of a friendly interchange of opinion, it has been agreed to fix the present basis price of rolled metal at 6½d. per pound. A list of extras to the basis price has also been agreed upon.

THE "ROYAL NAVY LIST AND NAVAL RECORDER."—We have received a copy of the July issue of the "Royal Navy List and Naval Recorder" from Messrs. Witherby and Co., 326, High Holborn, and 4, Newmans-court, Cornhill, E.C., which they issue at the price of 10s. The additions in this case are of special interest, owing to the large number of promotions and decorations consequent on the Coronation. The book has been somewhat rearranged. The list of officers according to seniority, formerly given, has been omitted, except in the case of flag officers, and the alphabetical list of officers has been brought forward from the end to the earlier part of the book. This list gives the rank and a reference to the ship directory which includes the list of officers, but it is not possible from such record to indicate the date of advancement from one grade to another. The omission, however, is partly met by a very complete record of war, meritorious, and special services and honours and rewards of officers on the active and retired list, to which there has been a very considerable addition. As in former volumes, there is a record of the current history of the Navy, which deals not only with the Coronation review and the naval proceedings attendant upon it, but also of the progress of shipbuilding and of aviation in the Navy.

CARGO-WEIGHING DEVICE.—Porhydrometer, Limited, inform us that a porhydrometer has recently been fitted on board the new Norwegian steamer Rolf Jarl; the device has given great satisfaction to the captain and the owners. The company have also received orders to fit their instrument on the s.s. Mont Agel, a vessel of 6500 tons, now building at Dunkirk, to the order of the Société Générale de Transports Maritimes á Vapeur, and on a new oil-tank steamer, now building by Messrs. Sir W. G. Armstrong, Whitworth, and Co., Limited, for the Indo-Burma Petroleum Company, Limited. The s.s. Koursk, a new steamer just built at Wallsend, by Messrs. Swan, Hunter, and Wigham Richardson, Limited, has also been fitted with a porhydrometer. She loaded her first cargo on the Tyne for Port Said, and the results given by the device at that loading were very satisfactory. The vessel, according to the railway weights and water-meter, took on board 7685 tons of cargo, 839 tons of bunker coal, 75 tons of stores, and 180 tons of fresh water, making a total of 8779 tons. The porhydrometer gave the weight on board as 8771 tons, or 8 tons less. This difference—about 1 per cent.—is doubtless accounted for by the loss of weight on the cargo during transit and loading. The schooner Baleares, which was built at Dundee for the Argentine Navigation Company, Limited, also has a porhydrometer on board, and the readings in this case have given every satisfaction.

THE ZURICH MEETING OF THE INSTITUTION OF MECHANICAL ENGINEERS.

THE summer meeting of the Institution of Mechanical Engineers, which it had been decided to hold this year in Switzerland, commenced at the beginning of this week, the official programme terminating to-morrow (Saturday). Members assembled in good numbers at Basle during the week-end, and by Monday there was quite a large body to take part in the several excursions arranged for that day, all of which terminated with arrival by train at Zurich.

A large party left Basle at 9.50 A.M. by train for Rheinfelden, and on arrival at that station were driven through the old town in brakes out to the Rheinfelden water-power station. The central station of the Rheinfelden Power-Transmission Works is situated on the right bank of the river, the dam and sluices being about 1000 yards above the power-house. The fall varies with the state of the river—between 13 ft. and 18 ft. The dam across the river has eight sluices and three fish-ladders. The canal is provided with a screen at the dam end, and the water passes through a finer screen at the power-house before reaching the turbines. The power-house is a building 574 ft. long, containing 20 wheel-pits, in each of which are two Francis turbines on one vertical shaft. A total of 16,800 horse-power is developed by the 20 units. Governing is effected by closing the gates. The vertical turbine-shafts carry electric generators, of which six are 6000-ampere machines developing continuous current at 90 volts, working at 55 revolutions per minute. Two are 4000-ampere generators of continuous current at 155 volts, running at 68 revolutions per minute. There are four continuous 130-140-volt 4500-ampere generators running at 68 revolutions per minute, and eight three-phase generators, three of which are 59 ampere machines at 6800 volts, running at 55 revolutions, and five machines of the same voltage and capacity, but working at 65 revolutions per minute. Of the last eight machines, the first three have stationary fields, the last eight having rotating fields. The station also contains, for exciting the alternating generators, two rotary converters, either of which can supply the current needed.

A stand-by, or supplementary plant, is situated in a separate building, and consists of two Brown-Boveri-Parsons steam-turbine sets, one of 1400 kw. and the other of 2400 kw. capacity, generating current at 6800 volts, and running at 1500 revolutions per minute. The steam is generated by Guilleaume and Babcock and Wilcox boilers, and is superheated to 518 deg. Fahr. at 183.75 lb. pressure.

After a thorough inspection of these works, under the guidance of the vice-director, Mr. Otto Albrecht, and of Mr. S. Streiff and Mr. R. May, the party returned by brake to Rheinfelden Station, whence the train was taken to Baden. On arrival at Baden the members were conducted to the Casino connected with the works of Messrs. Brown, Boveri, and Co., and were there entertained to luncheon by that firm. A few words of welcome were expressed for the company by Mr. Sydney W. Brown, who said that it gave them much pleasure to be able to receive the Institution at their works. Mr. E. B. Ellington (President) made suitable acknowledgment of the kindly expressions to which Mr. Brown had given utterance, and at the close of the lunch the toast of the company and directors was drunk by the members with considerable enthusiasm. On proceeding to the works, members were given an idea, by means of a lantern lecture by Mr. Eric Brown, of the various classes of work dealt with at the Baden shops. Mr. Brown said that the chief features of recent developments in steam turbines consisted in the continual increase in the size of units, and the adoption of the combined impulse and reaction machine. The latter machine had the advantage over the simple reaction turbine, in that it allowed of the shortening of, so to speak, the front end of the generator, and enabled expansion to be continued lower. They managed to obtain an efficiency of 70 per cent. for such combinations. Several of the modern features were described in some detail, such as the governing-gear and the device used for the prevention of hunting, the automatic valves for the impulse-wheels, and the design of the impulse-nozzles, &c. A design was described in which the turbine was fitted with an automatic valve between the impulse and reaction parts, by means of which steam could be drawn off beyond the impulse portion for industrial purposes of one kind or another. Mixed-pressure turbines were also designed by Mr. Brown, as well as sets for ships, &c. Other plant constructed at Baden, and to which the lecturer gave some attention, included condensers arranged so that half of the condenser could be out of service for cleaning, &c., while the other half was at work, injector air-pumps for condensers, blowers, gas-exhausters, &c.

The works of Messrs. Brown, Boveri and Co., which were then visited, were described in a recent issue of ENGINEERING,* and we need not now repeat the information then given. Members were conducted round the various departments, including the turbine blading, testing, and other shops, and the winding, transformer, and other electrical departments. At the termination of their inspection they were again entertained in the Casino to refreshments, before leaving by train for Zurich.

RECEPTION AT ZURICH.

On Tuesday, July 25, the meeting at Zurich commenced at 10 A.M. in the Aula of the Swiss Polytechnikum, when Mr. Eduard Sulzer-Ziegler, Vice-President of the Schweizerische Maschinen-Industrieller, extended, on behalf of that body, a hearty welcome to Switzerland to the Institution of Mechanical Engineers. Mr. Sulzer-Ziegler said that they all considered it a great honour that their country had been selected as the scene of a visit. Speaking in excellent English, he said that he thought the reason for the selection was to be found not only in the well-known fact that their country was one of the finest playgrounds in the world, but also, he thought, because British mechanical engineers took a keen interest in the developments of industry and products of manufacture such as the Swiss could show. Sixty or seventy years ago the founders of Swiss mechanical industry went to England as students to learn from the English as masters, and on their return brought with them young Englishmen, such, for instance, as Jackson, Charles Brown, and others. Thus the country was indebted to England. The engineers introduced in this way had done good work, and it was with no little pleasure that they saw in England one of their best customers. Until lately Great Britain was the country's chief supplier of raw materials, tools, &c., and until the present day the English technical papers, *The Engineer* and ENGINEERING, remained their main sources of information. The relations between the two countries had thus been intimate, and he hoped they would continue so in the future. This intimacy extended to other fields. They were not a little proud of being held up as an example in politics in connection with such questions as the referendum and military service. He admired the arrangements that had been made for the meeting, and hoped the ensuing time would be both agreeable and useful to all the members of the visiting Institution.

The President of the Institution of Mechanical Engineers then thanked Mr. Sulzer-Ziegler for the kind and instructive words to which he had just given expression. He was sure all the members present would wish most heartily to reciprocate them. Though not exactly on the same lines, Britain claimed to be also the most democratic of countries, and the two peoples had much in common. He was convinced that at this meeting members would acquire much interesting and useful information and would carry back with them many pleasant recollections of the visit.

The President then asked leave for the minutes of the last meeting to be taken as read, in order to expedite matters, and the ballot-list was also accepted and treated, with the meeting's approval, in a similar manner. The formal business having been concluded, the first two papers were taken.

ELECTRIC TRACTION IN SWITZERLAND AND SWISS RACK-RAILWAY LOCOMOTIVES.

The first paper to be read was one by Mr. E. Huber-Stockar, of Zurich, and was entitled "Electric Traction in Switzerland." This was read in curtailed form by the author, and it was followed by the reading, by Mr. S. Abt, of a paper jointly written by Mr. T. Weber and himself, entitled "Rack-Railway Locomotives of the Swiss Mountain

* See page 45 *ante*.

Railways." The former paper is printed in part and the latter in full elsewhere in this issue. At the conclusion of the reading the President proposed a hearty vote of thanks to the authors, which was carried by acclamation. Both papers, the President said, were important. The first referred to the phase question, which was creating so wide an interest at the present time. The second dealt with a development in Switzerland which claimed the admiration of the world. It was interesting to note that the first locomotive was introduced into Switzerland in the year of the founding of their Institution.

The discussion on these papers was opened by Dr. E. Hopkinson, who said that the papers brought to his mind the need for engineers to study what had been previously done. Engineers should pay more attention to the history of their science. Such study, especially in regard to electrical matters, would pave the way to future work. He would like to go back historically even further than the papers just read had gone—to a time when, he believed, there were no electrical tramways in Switzerland. The date he had in mind was about 1882-3, when he had been responsible for the design of the little Bessbrook and Newry line in Ireland. In those days there were no transformers, the first of which only made its appearance two or three years later. The plant put down included a 60-horse-power turbine and two 25-horse-power dynamos. Each dynamo cost 250*l*., and if this cost had remained till the present day he thought there would not have been any electric traction at the present time. The reduction in cost had been largely responsible for the wonderful development witnessed. The gradient of their line was 1 in 50. The bogie carriage had been fitted with 15-horse-power motors and was used to draw wagons behind it. The first reduction had been by helical cast wheels—not cut wheels, of course, for the latter were then unknown. They were made by Messrs. P. R. Jackson, of Salford, with whom the late Mr. H. Sulzer had served his apprenticeship. The subsequent drive was by chain. This had been made by Mr. Hans Renold on the roller-chain principle, and it was the prototype of those chains used on bicycles to the present day. Electrical instruments as we knew them now did not then exist. He had to test the voltage against a stardard Clarke cell with a reflecting galvanometer. The current was taken to the conductors by a bow-collector, though part of the line had been on the third-rail principle. The Board of Trade regulations then set 250 volts as the limit, and distant transmission was, of course, impossible.

In considering the development of electric traction in Switzerland, he thought that although the advantages accruing from good supplies of water-power would be doubtless regarded as a contributory cause, one of the chief reasons lay in the successful development of the transformer. Without efficient distribution, water-power would be of little value ; and the industry was greatly indebted, therefore, to Messrs. Brown, Boveri, and Co., who had given special attention to this branch of the subject. To this was due, at least in part, the wonderful development now to be seen in Switzerland. In this connection, also, the name of Messrs. Ganz, of Budapesth, should also be mentioned.

Dr. W. Wyssling, who spoke in German, said that, considering the number of details given in the paper, it was difficult to add much in the way of remarks. He (the speaker) would, however, like to mention a few points of simple information. The question of electric traction was for Switzerland mainly an economical question. That the problems which had arisen at different times from the purely technical point of view had gradually been solved was a fact which the various installations made throughout the country, including those for heavy traction, could amply prove. Speaking generally, in all large towns and districts in which there were crowded populations, it was absolutely necessary to devise a system of traction which constituted an improvement on ordinary steam traction, and the necessity of rapid dealing with the passenger traffic had led many railways in England, the United States, and elsewhere to adopt electricity in place of steam. In Switzerland they had no heavy traffic to deal with rapidly, and the main point to be considered was that of cheapness ; in comparing steam with electric traction the companies had to strike a balance between the cost of the two. Further, they had to purchase coal from abroad, while they had water-power at home in very great abundance. The application of electricity to railway traction in Switzerland had therefore started from quite different motives from those which obtained elsewhere, and had reached a very high degree of development. It should be remembered, however, that it was the privately-owned lines which had been electrified to a large extent, the State-owned systems being still operated by steam. The third-rail system of traction had not been much resorted to in Switzerland; the companies had generally taken advantage of three-phase current generated at high pressures. The Swiss railways had also been in the van as regards single-phase traction, and in this connection the author of the paper had done much good work. The Schweizerische Studien Commission für Electrische Bahnbetrieb (Swiss Commission for Electric Railway Traction) had been of great assistance in the support which it afforded to private enterprise. In short, electric traction using water power, when rightly carried out, was, at the present time, to say the least, not more expensive than steam traction ; electric traction would tend to become cheaper still as years went by, and these conditions would continue to rule in Switzerland, unless the coal-producing countries sent in their coal at greatly reduced prices compared with the present ones. The newest example of single-phase traction was that to be found on the Lötschberg railway, now in course of completion. Particulars as to this were given in the paper. The speaker asked, in conclusion, to be excused for taking up so much time, but he wanted to lay stress upon the standpoint from which they worked in this matter in Switzerland.

Mr. Wm. Patchell was the next speaker. He said the papers formed an excellent supplement to those read in 1910 at the summer meeting. He thought the electrification of railways would appeal to all who had had to travel during the last few days, as it would partly solve the dust problem. It was interesting to note that the value of electrification was not confined to mountain tunnels, but had solved a great problem in underground traction generally. He wished to ask Mr. Huber-Stockar whether the figure of 32 watt-hours per ton-kilometre given in his paper for the Seebach-Wettingen line was for a non-stop run or not, as this had a great influence on consumption. At the recent Toronto Conference it had been stated that a consumption of 25.9 watt-hours per ton-mile on a non-stop run of 17 miles had increased to 58.8 when four stops were made. The author had pointed out that electrification became a question of power economics. A little more or less in the price paid for current scarcely affected the question. Capital cost swamped everything else. He would like more information as to what was included in the capital cost per kilometre given in the tables of the paper. In England there was a tendency to think that water-power was cheaper than anything else. In Italy, however, he believed it to be a fact that some steam stations had cost less than water-power stations. In the hydro-electric scheme, in addition to the turbines alone, there were the heavy expenses involved in pipe-lines, dams, &c.

Mr. T. Weber, who replied, said he had not much to add to the information given in the paper. He would, however, like to emphasise a few points. It was absolutely essential that every single detail of rack-railway locomotives be most carefully designed and manufactured, special attention being, moreover, given to the brakes; these latter should be of ample strength and absolutely reliable. They all knew that good rack-railway locomotives were built in England, and in this conection, it sufficed to mention the firm of Beyer, Peacock, amongst others. He was very glad, personally, to have good English colleagues. He wanted also to add that on rack railways in which the gradient was constant, such, for instance, as the Rigi and the Pilatus Railways, the work to be supplied by the locomotive was also constant. Experiments made with superheated steam had given very good results. The first superheated-steam locomotive was run on the Pilatus Railway five years ago, and this had shown a fuel economy of 43 per cent. Some older types of engines had been transformed for using superheated steam. One such, used on the Rigi Railway, had shown a saving in coal consumption of 40 per cent. In the new locomotives to be built for traffic on lines on which the stations were not too close together, superheated steam should always be resorted to.

Mr. E. Huber-Stockar, referring to the first paper, said that the figure of 32 watt-hours quoted by Mr. Patchell was the average for the whole year for a service including six intermediate and the two terminal stops. It was an average operating figure, including shunting, &c. He regretted that figures could not be given in greater detail for the cost of stations, &c. ; in many cases it was impossible to apportion the cost from the material available. The figures relating to line equipment were reliable.

The President, in closing the discussion, pointed out how important it was that it should be plainly understood what the figures quoted included. After a vote of thanks the next paper was considered.

Diesel Oil-Engines.

The paper next taken was one by Mr. F. Schubeler, and was entitled "Modern Diesel Oil-Engines." This paper is reprinted elsewhere in this issue of ENGINEERING. After a vote of thanks proposed by the President, and passed with acclamation, the discussion was opened by Mr. R. Warriner. He said he believed that he was the only shipbuilder present, and he spoke from that point of view. For four or five years the Diesel engine had claimed a great deal of attention in the engineering world, and now development appeared to be moving in the direction of its application to other purposes than the driving of dynamos. He believed that engines to develop 1000 horse-power in a single cylinder were now in hand. The problem was of interest equally to shipbuilders and owners. If it were possible to make a four-cylinder two-cycle Diesel engine for the same weight as an equally powerful triple-expansion steam-engine, the Diesel engine would be an advantage. Such an engine, with four cylinders developing 1000 horse-power, complete with propellers, could be made as light as the corresponding triple-expansion engine. The fuel needed on board was only one-third that needed for the steam-engine, while the oil-engine obviated the need of boilers, and their space and weight could be put to use for carrying cargo and earning dividends. The oil question was important. The tendency was, he thought, for oil to become cheaper, but he did not think that the cost of fuel for the two systems would come out very different. He understood that both on the Continent and in Great Britain trial was to be made of a combination installation embodying an internal-combustion engine. It was not proposed to adopt the internal-combustion system for the complete installation. At first it would be used in conjunction with steam plant.

Mr. Sulzer-Imhoof said that the development of the Diesel engine had occurred largely in Swiss electric stations. Since 1902-3 it had been in constant use, and in that time they had now got to 2000-horse-power units, as illustrated in the paper. In developing the four-stroke cycle system it was found impracticable to go to more than four cylinders, and therefore attention would have to be turned to the two-stroke system. With this type of engine, however, scavenging was a matter of difficulty. It was complicated, but it could be done, both from the bottom and the top of the cylinders, but only to an extent equal to an efficiency of 85 per cent. Such an efficiency, of course, reduced the power developed, and it was not possible to get double the power in the two-stroke cycle engine of that in the four. If, however, it could be improved, it might be possible to secure a power development of from 190 to 195 per cent. of the four-stroke engine in the two-stroke engine. A Diesel engine had been working in an electric station in Aarau during the last four or five years. When it had been put in, guarantees had been insisted on with regard to upkeep and repairs. As a result, it had been found that upkeep was very much less than had been expected, and worked out at a very low figure. The engine was on long runs, and from that experience he thought it would be found quite possible to build marine engines on the Diesel principle for long voyages. A start in this direction had been made on the Swiss lakes and in the Adriatic, and by carefully watching the behaviour of these boats it would ultimately be possible to build marine engines of the larger sizes of quite a high standard of reliability. Development had been so promising that he thought it would not be long before 1000 horse-power in one cylinder would not only not be thought anything extraordinary, but 2000 horse-power in one cylinder might before long be under consideration. Progress needed to be careful and slow ; it was only by experience and careful investigation and

study that it would be possible to find solutions to the difficulties of cooling, of obtaining satisfactory combustion, and the other troubles attendant upon the use of large cylinders. One of the chief advantages of Diesel engines, in some connections at least, was the ease with which they could be started up and put in parallel quickly with other generators. He knew of one case of a 1000-horse-power engine driving an alternator which only took 1½ to 1¾ minutes to get up to full load, which was a valuable feature in stand-by plant, not only in central stations, but also in connection with hydro-electric schemes.

Mr. C. Day wished to make a few remarks on the relative positions of the two and four-stroke systems, confining his remarks to 1000-horse-power engines and less, which was as far as his experience as yet extended. He thought that when driving machinery with which there was no speed limit the four-stroke cycle would be found the better of the two. When the speed was limited, as, for instance, when driving the propeller of a tramp steamer, the case was different. Many people wanted a speed under these conditions of only 80 revolutions per minute; others refused to go above 150; and then he thought the two-stroke cycle better than the four. With the two-stroke there would be, say, 150 combustions or explosions per minute, which was a reasonable number. If the speed were high, as, for instance, 300 revolutions per minute, the four-stroke cycle might be used, and would result in about the same number of heat fluctuations per minute, as the two-stroke cycle at 150.

The Delproposto oil-electric system had been mentioned, together with the fact that the efficiency on that system was low on account of the losses inseparable from it. Nevertheless, the system was a success. Messrs. Mavor and Coulson had recently developed a system of a somewhat similar nature, which also promised success. In his own system he used an engine directly coupled to the propeller up to half speed, and above that it drove electrically. He agreed that there was need of cautious rather than of impulsive and rash development.

Professor Constam, speaking as a fuel-testing chemist, said he must dispute the author's statement as to the impossibility of deciding whether a particular oil was suitable for Diesel-engine working or not. In the Federal Fuel-Testing Laboratory, Zurich, they had been able to decide in every case that where an oil gave 10,000 calories, and had 10 per cent. hydrogen, it was suitable. If it did not work satisfactorily, the fault lay with the engine. What Dr. Rieppel published on this subject years ago still held good. Now, however, motor manufacturers had begun to employ other oils, such as coal-tar and the tar oils. What the criteria were in connection with these oils was certainly not yet solved, but he had grounds for saying that the solution was not distant. The Federal laboratory, in conjunction with Messrs. Sulzer, had carried out investigations which had already reached a point which furnished them with information as to probable essentials, but they had not yet arrived at the stage where wide generalisation was possible.

In reply to the discussion, Mr. Schubeler said that one of the advantages of the two over the four-stroke cycle engine was, of course, that of lower first cost. With regard to Professor Constam's remarks he had in his paper referred to exact information, and he was glad to hear that such information would soon be forthcoming with regard to tar-oils.

NEW TYPES OF DYNAMOMETERS.

At the close of the discussion on Mr. Schubeler's paper, Dr. A. Amsler was invited to read his contribution entitled "Some New Types of Dynamometers." This Dr. Amsler condensed considerably, and adjournment was then made to another room in the building, in which the dynamometers described were fitted up. The paper we reprint elsewhere in this issue, so that readers may refer to it for a description of the two machines. For greater convenience Dr. H. S. Hele-Shaw explained the details of the two dynamometers which members thus had the opportunity of inspecting.

In the afternoon of Tuesday visits were paid to the works of Messrs. Escher Wyss and Co., and to the Oerlikon Engineering Company's works. The former of these works was described and illustrated in our issue of July 21. The afternoon in both cases was pleasantly spent, the visit in each case terminating with tea given by the directors. A third alternative excursion, patronised largely by the ladies of the party, consisted of an enjoyable afternoon on the Lake Zurich at the invitation of the Verein Schweizerische Maschinen-Industrieller, in a special steamer. The Institution dinner in the Tonhalle concluded a most successful day.

On Wednesday, the 26th, members assembled at the Polytechnikum at 9.30 A.M. for the reading and discussion of papers. After lunch visits were made to Winterthur and Schaffhausen and to Benzau. Yesterday (Thursday) was given up to whole-day visits. The proceedings of Wednesday and subsequent days we shall deal with in our next issue.

THE STEAM TRIALS OF H.M.S. "DARTMOUTH."

THE protected cruiser Dartmouth, built and engined by Messrs. Vickers Limited, at their Naval Construction Works, Barrow-in-Furness, has completed her official steam trials, with highly satisfactory results. This vessel is an improvement upon the original "Town" class, for although of the same length, 430 ft., the beam has been increased 18 in., to 48 ft. 6 in., and the draught by 3 in., to 15 ft. 6 in., in consequence of an addition to displacement of 450 tons, the displacement of the Dartmouth being 5250 tons. This increase was made largely to enable the armament to be augmented. Thus, instead of two 6-in. breech-loaders and ten 4-in. breech-loaders, the new vessel has eight 6-in. guns, which very materially add to its effectiveness as a scout cruiser.

The machinery is the same as in most of the ships—being of the Parsons turbine type, with four ahead and four astern turbines on four shafts, the turbines working in series on two shafts on each side of the centre line of the vessel. Cruising turbines have been dispensed with, the high-pressure ahead turbines being extended at the high-pressure end to increase the range of expansion when running at less than full power; with a by-pass to admit steam at an intermediate stage for the higher speeds. It was anticipated in the design that, in consequence of the increased displacement and the maintenance of the same weight and power of machinery, the speed would be 24¾ knots, as against 25 knots; but no difficulty was experienced in the Dartmouth on the full-power trials in maintaining 25.9 knots, although the power was only 1550 indicated horse-power in excess of that anticipated.

The trials, as with all the vessels of the class, included a 30 hours' run, during which the vessel for eight hours maintained a speed of practically 25 knots, which is in excess of the design, although the power was only 19,028 shaft horse-power. Thus, it will be noticed that the designed full speed was attained with 3000 less shaft horse-power than the designed full power. The second part of the 30 hours' trial, extending to 22 hours, was run at 23½ knots speed, the power being 14,235 shaft horse-power. Following this was the full-power trial of eight hours, when, as we have said, the rate attained was 25.9 knots on the measured mile on the Clyde. The principal results are tabulated :—

	30-Hours' Trial.		Eight-Hours Full Power.
	8 Hours.	22 Hours.	
Mean revolutions on trial ..	456	422	485
Mean power	18,839	14,287	23,467
Fuel consumption .. lb.	1.75	1.72	1.48
Revolutions on 6-mile runs ..	457	421	487
S.H.-P. on 6-mile runs	19,028	14,235	23,550
Speed on 6-mile runs	24.97	23.49	25.9

Throughout the whole trial the machinery worked most satisfactorily, a notable feature being the high vacuum, which exceeded 28¼ in. The trials were run on the estuary of the Clyde and the Irish Sea in fine weather, with the exception of the full-power run, which was carried out in squally weather. The gun and torpedo trials, circling and manœuvring tests, were also carried out before the ship returned to Barrow on the 22nd inst.

CONCRETE IN RUSSIA.—A Swedish company has just been formed for the purpose of carrying on in Russia and the countries belonging to Russia trade in cement blocks and kindred contracting work, either direct or through other companies formed for the purpose. The new company takes over a previous Swedish cement firm in St. Petersburg, which has already gained a good footing.

OCEAN-GOING TORPEDO-BOAT DESTROYER "SANDFLY."—On Wednesday, the 26th inst., Messrs. Swan, Hunter, and Wigham Richardson, Limited, launched, from their Wallsend shipyard, H.M.S. Sandfly, a 27-knot ocean-going torpedo-boat destroyer. The Wallsend Slipway and Engineering Company are constructing the propelling machinery, which consists of an arrangement of Parsons turbines driving three separate shafts. The boilers of the Sandfly—three in number—are of the Yarrow water-tube type, and furnaces are fitted with an oil-burning installation.

PROMOTION OF NAVAL ENGINEER OFFICERS.

THERE has just been announced the promotion from the rank of engineer-commander to engineer-captain of four naval officers, who, as the following records show, have done notably good service, and well merit their advancement.

Engineer-Captain William George Hogg served as engineer-student at Keyham, and entered the Service as acting assistant engineer on October 1, 1881. He next successively served as assistant engineer in the Raleigh (Cape Station) from February, 1885, to July, 1888; as instructor of engineer students, Devonport, from August, 1888, to January, 1891; in Hong Kong Yard from December, 1891, to May, 1894; as staff-engineer of Royal Arthur (flagship, Australian Station) from January, 1901, to June, 1904; as chief engineer of the Russell from December, 1906, to December, 1908; and on duty with the captain of the Devonport Dockyard from April, 1910, to the date of his promotion now. He was promoted engineer June 1, 1887; chief engineer, October 6, 1894; staff engineer, October 6, 1898; fleet engineer, October 6, 1902; became engineer-commander, with seniority, October 6, 1898 (change of titles); and his promotion to engineer-captain dates from April 27, 1911.

Engineer-Captain James Michael Thompson served as an engineer student at Portsmouth, and entered the Service as an acting assistant-engineer on October 1, 1881. He successively served as assistant-engineer in the Northampton from October, 1882, to April, 1886; as engineer in the Collingwood (Mediterranean, North American, and West Indian Stations) from November, 1889, to October, 1892; as chief engineer of the torpedo-store at Malta from September, 1897, to October, 1900; was appointed to the Essex (building) August, 1901, and, on commissioning, March, 1904, remaining until August, 1907; to the Leander for duty in connection with torpedo-boat destroyers and torpedo-boat tenders from November, 1908, to December, 1910, when he was appointed chief engineer of the Queen (Atlantic Fleet). He was promoted engineer on June 1, 1887; chief engineer, January 1, 1895; staff engineer, January 1, 1899; fleet engineer, January 1, 1903; became engineer-commander, January 1, 1899 (change of titles); and his promotion to engineer-captain dates from May 20, 1911.

Engineer-Captain Edouard Gaudin served as an engineer student at Portsmouth, and entered the Service as acting assistant engineer on July 1, 1886. He passed through the Royal Naval College, Greenwich, and successively served in the Raleigh (Cape) as assistant engineer from March, 1888, to July, 1890; as chief engineer of the Spartiate from April, 1899, to October, 1903; as chief engineer of the Good Hope from October, 1903, to January, 1905. He served in the Naval Intelligence Department at the Admiralty from January, 1905, to December, 1908, when he became chief engineer of the Dreadnought (flagship, Commander-in-Chief of the Home Fleet, Admiral Sir W. May), December, 1908, to March, 1911. He was appointed engineer-inspector in the Controller's Department at the Admiralty in March, 1911, and is still serving in this capacity. He was promoted assistant engineer on July 1, 1886; chief engineer (special promotion for services in connection with Belleville boilers), on May 18, 1897; became engineer-commander on May 18, 1901; and is now specially promoted to engineer-captain, to date May 31, 1911.

Engineer-Captain William Onyon served as an engineer student at Portsmouth, and entered the Service as acting-assistant engineer on July 1, 1884. He passed through the Royal Naval College, Greenwich, served as assistant engineer in the Monarch (Channel) from September, 1885, to April, 1886, and in the Agamemnon (Mediterranean), from July, 1887, to December, 1890. He was next chosen for duties in connection with torpedo-boats at Malta from August, 1891, to November, 1894; as chief engineer of Jamaica Dockyard from October, 1898, to January, 1902; as engineer-overseer at the Fairfield Shipbuilding Works and in the Clyde District from June, 1902, to July, 1905; and specially on the Dreadnought (when building) from July, 1905, to September, 1906. He was appointed to the Dreadnought in commission (flagship of Home Fleet) from September, 1906, to December, 1908, when he became engineer-inspector in the Controller's Department at the Admiralty, and still continues in that position. He was promoted assistant engineer, July 1, 1885; engineer, September 1, 1889; chief engineer, November 5, 1898; became engineer-commander, November 5, 1902; and is now specially promoted to engineer-captain, to date from June 29, 1911.

OUR RAILS ABROAD.—There was a considerable contraction in our rail exports in June, the total for the month falling to 15,785 tons, as compared with 37,029 tons in June, 1910, and 53,042 tons in June, 1909.

BRIDGE COMPETITION IN GERMANY.—The city of Cologne recently offered five prizes of 350*l.* each for designs for a new bridge to replace the existing pontoon bridge over the Rhine at that city. The designs placed first and second were offered by the Gutehoffnungshütte, of Oberhausen, which were submitted in conjunction with Messrs. Holzmann and Co., and Dr. Lauter, as engineer for the sub-structure, whilst Professor Schwechten was the architect. In the design placed second the architect was Mr. G. Eberlein. Both designs were for stiffened suspension bridges, with shore spans of 325 ft. each, and a main span of 650 ft. The cables are to be of wires laid parallel, and nickel steel is to be used for the stiffening girders. The bridge is to provide accommodation for two electric railway tracks, the roadway being 40 ft. wide between kerbs, and there are to be two footpaths, each 10 ft. wide.

INDUSTRIAL NOTES.

AT the end of last week the seamen and others were still in a state of unrest at Cardiff. On the Thursday a resolution was passed in favour of a general stoppage if the men's union were not recognised. No further disturbances took place, however. Two hundred and twenty Metropolitan Police were sent to the docks in the early morning of the Thursday, among them being twenty mounted men; they were received with jeers by the men. With other detachments, the Chief Constable of Cardiff had a force of about 600 men, and two companies of the 2nd Devonshire Regiment were at Newport Barracks in readiness. About 1500 dock labourers joined the seamen on strike, and tried to intimidate other sections of workers to leave their jobs. They did not succeed very well, however. The loading of a good many vessels in the dock was stopped. In addition to the men alluded to, there were over 1000 ship-repairers and dry-dock labourers on strike. Mr. Havelock Wilson stated that if the Conference were not fixed before the end of the week he would have 50,000 men out in the port of London on the following Monday.

The aspect of things is very serious, for business in the South Wales ports is paralysed; large detachments of extra police have been drafted into Cardiff, in addition to which about 600 men of the Lancashire Fusiliers arrived from Salisbury on Friday last. Among many changes, one thing, at any rate, that appears to be certain is the spread of the strike. It is stated that the importation of military has been resented; but, in view of the widespread disorder and the attacks that have been made on laundries owned by Chinamen, on Thursday in last week, their presence is a wise precaution. Mysterious fires have broken out at Cardiff, which are said to be the work of incendiaries, intimidation has been practised by the strikers on a large scale, and from what has taken place it appears as though even more force was necessary in order properly to protect men who are willing to continue at work. It is really disgraceful that brutal mobs of strikers should be permitted to intimidate men who have not joined them.

Efforts were made all through Monday last by the Lord Mayor of Cardiff to bring about a settlement of the dispute, but in the evening of that day a conference with a large number of the employers was adjourned till the following day without any definite conclusion being arrived at. The proposals of the strike committee, which were drawn up on Sunday last, were as follow:—(1) The official recognition of all unions involved. (2) That no legal proceedings shall be taken by any employer against any workman or union in respect of cessation of work without notice. (3) Satisfactory assurances that no men, or section of men, shall suffer from boycott or victimisation for participation in the present strike. (4) That the employers shall undertake to meet the men's representatives immediately to consider the various demands and grievances with a view to a speedy settlement. These proposals were considered by the employers for several hours, with the result that, with certain modifications, they were agreed to. The following was the altered form that the masters were willing to accept:—(1) The official recognition of all unions involved, with the exception of the railway companies, who are willing that the method of conciliation already in operation shall be continued. (2) That no legal proceedings shall be taken on this occasion by any employer against any workmen or union in respect of cessation of work without notice. (3) Satisfactory assurances that no men, or sections of men, shall suffer from boycott or victimisation for participation in the present strike. (4) That the employers shall undertake to meet the men's representatives immediately to consider the various demands and grievances with a view to a satisfactory settlement. After considering these proposals the strike committee requested that a joint conference of employers and members of the strike committee should be called.

Unfortunately, the negotiations on Tuesday were broken off on the question of the delivery of flour from the mills to the bakers, the strike committee declining to allow any such delivery to take place. This was really the important question of the discussion. The employers were firm that the embargo should be removed before they would consent to consider the claims of the various trade unions. With regard to certain firms the strike committee offered to remove the embargo, but the employers insisted that its partial removal was not sufficient, it must be complete and unconditional.

On the resumption of the conference on Wednesday the masters were still firm that they would not consider any matters until the embargo had been removed from flour, and the strike committee eventually gave way on this point, and flour, potatoes, and other food-stuffs were soon carted from the mills and warehouses to the tradesmen. It was then agreed to appoint a sub-committee, including six representatives from each side, to draw up terms of settlement, to be submitted afterwards to a conference representing the whole body. The strike has extended to the laundries in the city.

The coal-trimmers and dockers at Port Talbot struck work on Tuesday morning, and they were soon joined by the patent-fuel workers, the dry-dock workers, and the labourers at the Rio Tinto Copper Works. The Cardiff and Dowlais Iron Works are idle. The Great Western Railway Company's supernumeraries at Cardiff have not left work, having obtained an advance of 1s. per week. There was more rioting in the Rhondda Valley on Tuesday and Wednesday, and there were severe conflicts between the strikers and the police. The engine-house at the Ely Colliery was damaged, but the disorder was eventually quelled.

Rioting was renewed at the Tareni Colliery, Swansea, on Thursday last week, and the manager's house at the colliery was wrecked; colliery property was also very much damaged by stone-throwing. Some of the police and some of the strikers were seriously injured.

The men of the Boilermakers' and Gas-Workers' Societies, to the number of 800, went out on strike at Lincoln on Wednesday, and at Gainsborough 400 others were locked out.

Mr. John Wilson, M.P. for Mid-Durham, speaking at the fortieth annual gala on Saturday, at Durham, told a mass meeting of miners that missionaries from South Wales were going about Durham trying to persuade the miners to join in a national strike to aid the South Wales men. To strike would, he said, be madness in itself, and foolish in the circumstances. There was nothing equal to the agreement against which the South Wales men were striking. If the Durham miners struck work for the South Wales men, they would do what was wrong, and what would bring them no benefit.

There is now a strike of furnacemen at Corby, near Kettering, and the furnaces have been closed down. Last week, however, an attempt was made to restart the works with non-union labour. These efforts to commence work caused an attack to be made on the non-unionists by the strikers, who raided the works armed with sticks and stones. The bands of ruffians were, however, cleared out by the police, and every approach to the works was stopped.

No agreement having been come to by the Midland Railway Central Conciliation Board, the whole of the applications of the goods guards and yard and siding foremen for revised terms of employment, along with the company's proposals in regard to the goods guards, have been referred to arbitration. The arbitrator chosen is Lord Cromer.

The result of the ballot of the Northumberland miners as to the proposed strike was announced on Saturday last. It will be remembered that the resolution submitted to the vote was "That in order to secure the abolition of the three-shift system and the restitution of the short shifts to stonemen and shifters that existed previous to the operation of the Eight Hours Act in Northumberland, we tender fourteen days' notice to terminate our hiring agreements under the Eight-Hours Act agreement." The result of the voting was 19,516 for and 9259 against the resolution. As a result of this ballot a request will be made to the Miners' Federation of Great Britain that they will sanction a national stoppage in support of the Northumbrian demand.

A very interesting bulletin has recently been issued by the United States Bureau of Labour at Washington, in which there are some statistics relating to German experience between 1897 and 1907 of industrial accidents and loss of earning power. The Imperial Insurance Office of Germany makes the practice of publishing at ten-year intervals special studies of the industrial accidents involving compensation under the national accident insurance system; and these official detailed returns furnish some interesting information which relates, however, only to serious industrial accidents. By this is meant accidents which resulted either in disability lasting longer than thirteen weeks or in death, and for which compensation was paid in the year 1907. There was, of course, a much larger number of accidents causing disability of shorter duration, but these are not included. The number of persons included in the study was 8,600,000, and they were considered to be employed 300 days in the year. Taken in this way, it was found that out of every 100 persons about one received injuries causing serious disability or death.

During the years between 1897 and 1907 there had been a decrease in the percentage of accidents causing death, as well as in the ratio of accidents causing total permanent disablement, and also in the ratio of accidents causing partial permanent disablement. There was, however, a marked increase in the accidents causing temporary disability lasting longer than thirteen weeks. The highest accident rate was among workmen employed in teaming, hauling, flour-milling, mining, quarrying, wood-working, brewing, engineering construction, inland navigation, iron and steel, and express and storage; while the lowest was among workmen in the tobacco, clothing, textile, printing, pottery, paper, glass, and private railway industries, as well as in chimney-sweeping and marine navigation. The accident rate for males was found to be higher than for females.

The question as to whether injuries to workmen occurred more frequently at one part of the year than at another, and at what part of the day they were most frequent, was also studied, with very interesting results. It was found that the rate was slightly higher in October than during the other months of the year, during which it was fairly uniform. Coming to the days of the week it was found that injuries occurred more frequently on Monday afternoon and on Saturday afternoon than during the rest of the week, and that they were more frequent in the latter part both of the forenoon and afternoon than during the rest of the day. Of the 81,248 workmen injured, about 5 per cent. were hurt during the first hour that they were at work, 8.6 per cent. during the second hour, 9.2 per cent. during the third hour, 11.3 per cent. during the fourth hour, and 12.2 per cent. during the fifth hour, which was the highest for the day. During the remainder of the day the percentage was irregular. The most frequent form of injuries were fractures, contusions, &c., to the arms and legs, and it was found that workmen were most frequently injured when they had been employed in an establishment only for a short time. They were also more frequently injured when they had been employed in a particular occupation but for a short time. The five most frequent causes of injury were (1) machinery (presses, lathes, looms, &c.); (2) collapse, fall, &c., of materials; (3) loading and unloading; (4) falls, falling from ladders, stairs, &c; and (5) railway operation. Fatal injuries were found to be caused most frequently from collapse and fall of materials; next from railway operations, then falls from ladders, stairs, &c., after that from inflammable, hot, or corrosive substances, and lastly, from teaming, hauling, draying, &c. About 50 per cent. of the injured workmen were still disabled to a greater or lesser extent at the end of five years. Workmen injured by accidents due to the faults of fellow workmen formed 5.9 per cent. of the total, while 12.6 per cent. were injured by accidents due to the fault of the employer. What is called the general hazard of the industry caused 37.7 per cent., and accidents due to the fault of the workmen themselves 41.3 per cent. of all the injured persons studied.

According to *Co-Partnership*, the Stafford Municipal Gas Department has adopted the following method of profit-sharing:—(1) When the total cost of manufacture and distribution of gas is less than 10d. per 1000 cubic feet of gas sold, a bonus equal to one-fourth of the difference between that sum and the actual cost shall be divided among the workmen and clerks who have been employed in the Gas Department for not less than three months during the year in which the bonus has been earned. (2) In any year where special charges, such as main-laying operations, have been charged against revenue, the amount of such (correctly speaking) capital charges are to be deducted from the true manufacturing and distributing charges, in addition to the net cost of coal, rates and taxes, depreciation, and depreciation on cookers, &c., and that effect be also given to the profit and loss on gas-fittings.

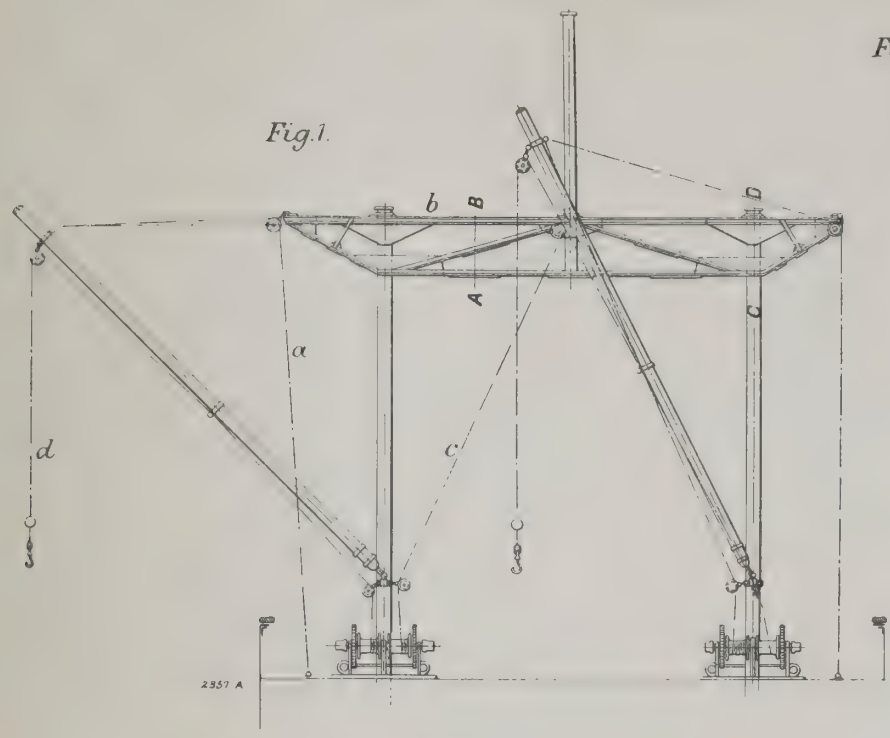
FIRST AUSTRIAN "DREADNOUGHT": ERRATUM.—We regret that, owing to an error in the paragraph which appeared on page 103 *ante*, in the seventh line, the cost of the vessel was given as 3,333,000*l.* This should have been 2,500,000*l.*

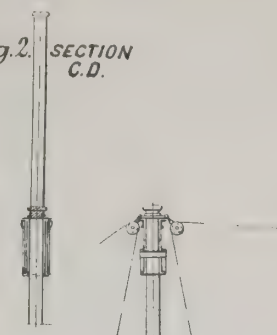
INTERNATIONAL AERONAUTICAL CONGRESS.—The fifth International Aeronautical Congress will be held in Turin from October 25 to October 31 this year. It has been organised by the permanent International Commission of Aeronautics, presided over by M. le Commandant Renard, with the assistance of the Aviation Society of Turin. The congress will be divided into four sections:—ballooning, aviation, legislation, and scientific and various applications.

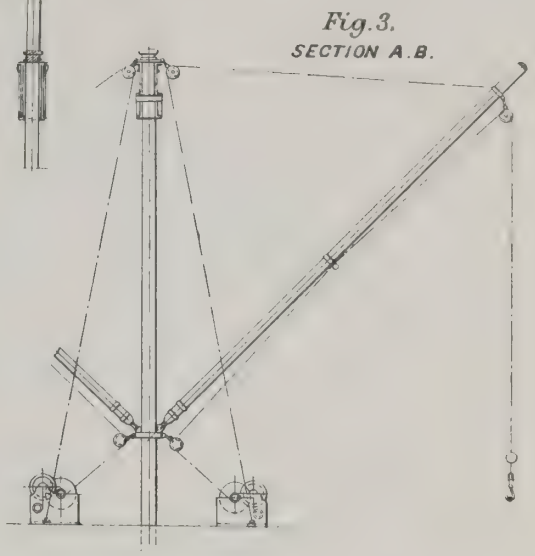
THE DANISH TORPEDO-BOAT "SÖRIDDEREN."—This boat, built by Messrs. Yarrow, Glasgow, has arrived at Copenhagen. During her voyage, in all kinds of weather, the vessel behaved admirably, and, in fact, surpassed expectations. The Söridderen is the first of six new Danish torpedo-boats to be finished; the Tumleren, which is being built at the Schichau yard, and the Söulven, the Vindhunden, the Späkhuggeren, and the Flyvefisken, which are being built at the Royal Dockyard, and by Burmeister and Wain, are also expected to be ready soon.

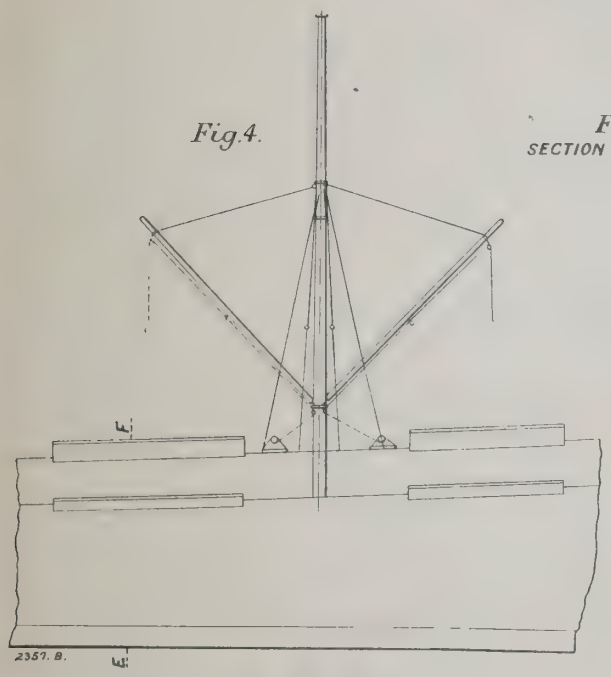
THE PUISSESSEAU CARGO DERRICK.

MESSRS. LANGSTAFF, EHRENBERG, AND POLLAK, LONDON.









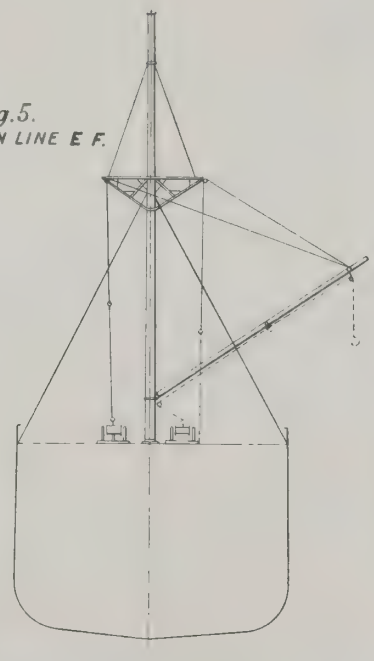
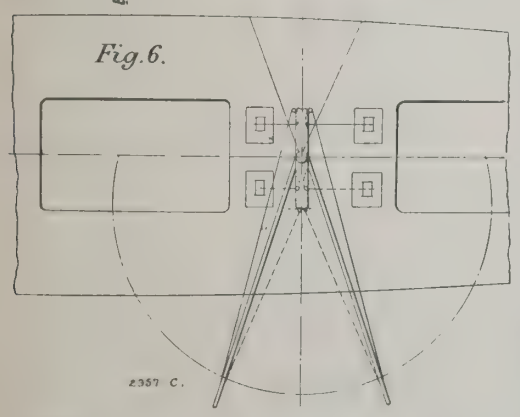


FIG. 7.



RECENT years have seen great improvements carried out at almost all the important ports of the world. A most notable development at many of them being the installation of quay-cranes and other cargo-handling appliances. These, by facilitating loading and discharging, tend to reduce the time which steamers have to spend in port. Appliances of this sort are, however, chiefly of value for special services—for liners sailing between regular ports. Ordinary tramp steamers, and, indeed, to a large extent, liners as well, particularly if they are engaged in the Eastern trade, have to depend on their own appliances for handling their cargo. In many important ports the transference of cargo is carried out while ships lie in open roadsteads, so that they have to put reliance upon their own cargo-handling gear, and if that gear is such that loading and discharging can take place during relatively bad weather, much valuable time will be saved. This latter point is of the first importance, and adds interest to the cargo derrick illustrated on this page.

The appliance, which is the invention of M. R. Puissesseau, superintendent-engineer of the Nouvelle Société Navale de l'Ouest, is of a simple nature. Various applications are illustrated in Figs. 1 to 7, herewith. It consists of a boom pivoted at the lower end to a point near the bottom of its supporting mast, and arranged to derrick on a hinge, and to slew in the usual way. Its upper end, however, instead of being supported by a single pendant attached to the mast and lying in the plane of the boom, as is usual, is held by two pendants which lie approximately in a horizontal plane. These are carried from the boom to blocks fixed at the outer ends of a crosstree (Fig. 5), which lies athwartships, and is secured to the upper part of the mast. One of the pendants is fixed to a cleat on deck, and remains of a fixed length while the derrick is working; the other is led round the drum of a winch, so that it can be either wound up or payed out. The operation of the winch controlling this second pendant also slews the derrick.

The arrangement will be easily followed from Fig. 1, but, to avoid confusion, it should be pointed out that the construction there shown consists of two derricks arranged side by side, and intended for a broad ship. Referring for the moment to that on the left-hand side only, it will be seen that *a* is the fixed pendant led round a block at the end of the girder *b*, and secured to a cleat on deck, while *c* is the moving pendant led to the winch-drum as shown. It will be clear that as *c* is increased or shortened in length by the operation of the winch, the derrick will be caused to slew, either outwards over the side of the ship, or inwards over the hold. Further, it will be seen that as the fixed pendant is of constant length, and its point of attachment to the mast is out of the vertical plane passing through the hinge of the derrick, the outer end of this latter will move slightly downwards as it slews outwards. The effect of this action is that gravity slewing is obtained in one direction, with a consequent cheapness of operation owing to a saving of steam. The lifting of the cargo is carried out quite independently of the gear, by means of the rope *d* as shown, which is led to a second winch-drum. Lifting can be carried out while slewing is in progress, exactly as with ordinary arrangements.

It will be seen from the above description that the system is remarkably simple, and that its essential feature is the double-pendant attachment of the derrick. Several important advantages are, however, claimed for the gear, of which the first is that the speed of working is about double that of an ordinary derrick gear, owing to the rapid and easy slewing that is possible. In the second place, it is stated that when a boat is lying in an open roadstead with quite a fair sea running it is still possible to work cargo. This point, which is, of course,

of very great importance, follows from the disposition of the pendants holding the derrick. Even with a considerable list on the boat, the pendant on the higher side will still exercise a controlling pull on the derrick and determine its position in a way that is impossible with a single pendant lying in the plane of the jib. This second feature of the appliance is not merely academic, and has been well brought out in practice on boats fitted with the gear. A third point which is claimed is that, as the whole of the controlling-gear is overhead, there is less likelihood of accidents to men owing to their tripping over ropes or stays, and falling down hatches or overboard.

As before mentioned, Figs. 1 to 3 illustrate the double-derrick arrangement which is adopted for ships of large beam. Stump masts are fitted carrying a common upper table, which supports the ship's mast in the centre, as shown in Figs. 1 and 2. These views also show the double-drum winch which is recommended for the gear. The two drums are operated by a single engine, but have separate gearing. One is used for cargo-hoisting, and the other for slewing. They are both controlled by a single winchman. Figs. 4 to 6 illustrate the single-derrick arrangement and show the lifting and slewing gears operated by different winches. This system is particularly suitable for ships fitted with the common arrangement of two winches to a hatch, which it is desired to convert to the new system. A number of conversions of this sort have already been carried out. Fig. 7 is a view taken from a photograph of one of these installations. In conclusion, we should say that the Puissesseau derrick is being introduced into this country by Messrs. Langstaff, Ehrenberg, and Pollak, of Leadenhall-buildings, London, E.C.

TEMPORARY REDUCTION OF THE DRAUGHT OF THE "THÜRINGEN."—In floating the German warship Thüringen—one of the heavy Dreadnought type, of 22,000 tons displacement and 27½ ft. draught, which was built on the wharf of the A. G. Weser at Bremen—down the shallow Weser river, a temporary reduction of the draught was required, and was obtained, in April last, by the aid of camels somewhat in the way which the Vulkan Company has successfully used on the Oder. We illustrated this method in our issue of June 10, 1910, on pages 746 and 748 of vol. lxxxix., when describing the German warship Rheinland. In the case of the Thüringen six camels were used, three on each side. The inner top board of each camel abutted against an angle-iron bracket secured to the side of the ship. In order to prevent upward tilting of the pontoon while exerting its lifting power, ropes were fastened round the pontoons, two ropes for each pontoon. These ropes extended from a special plate fixed to the keel of the ship, round the bottom of the pontoon, to the off side of the camel, where they were attached to its edge. In this respect the arrangement differs from that employed by the Vulkan Company, where raking timber struts have been resorted to. The Thüringen device has also given satisfaction. The camels were attached without interfering with the work on board, and the draught was reduced by 1 m. (40 in.) on the average, and by 1.25 m. (50 in.) aft. The width of the warship to be transported was, by these additions, increased to 42 m. (138 ft.).

CERTIFICATED MINE MANAGERS.—The Amalgamated Mine Managers' Association of Australia have made some remarkable allegations regarding certain reforms advocated by the leading members. The chief point of interest at present is an attempt to make it compulsory that all mine managers should be certificated. A ballot of the members of the association was taken at the beginning of the present year regarding it, the result being that, with two exceptions, the whole of the managers approved of the proposal. The Victorian branch of the association numbers as many as 72 members. The association has issued a circular in which it is contended that every mine manager should hold a certificate from the Government that he is fully qualified to take charge of a mine. It is thought that such a certificate would be a guarantee to the investing public that the possessor was a trustworthy man, and one with the necessary practical knowledge of mining work. The circular also points out that two rules of the Amalgamated Mine Managers' Association warn members to work their mines fairly, and in the interest of shareholders. The unfortunate part of the matter, according to the circular, is, however, that "many mine managers find they cannot do this without risking their positions, and it is beyond dispute that many of our mines are to-day being worked, not in the interests of the investing public or shareholders, but in many cases in the interests of one or two men who control the board. We do not claim that certificates would end this kind of work, but they would make mine managers more independent, and help to bring about better conditions." The Mine Managers' Association are very careful to safeguard the public interests as much as they can, and make strict inquiries as to the antecedents of candidates. The other applicants were also not considered satisfactory, and the whole lot were, it is stated, rejected. It was found subsequently, however, much to the surprise of the officer of the association, that two of the applicants, who had in fact served terms of imprisonment for dishonesty, had actually been appointed managers of mines in the State. The association promptly bought the matter before the mine-owners, and the two delinquents were dismissed and left the country.

RACK-RAILWAY LOCOMOTIVES OF THE SWISS MOUNTAIN RAILWAYS.*

By T. WEBER, Managing Director, and S. ABT, Works Engineer, of the Swiss Locomotive and Machine Works, Winterthur.

[*Translated from the German.*]

General.—The first rack-railway locomotive was tested by John Blenkinsop on August 12, 1811; that is to say, exactly 100 years ago, on the Middleton Mineral Line, near Leeds. On the outside of one rail corrugated teeth were cast, into which the driving-wheel geared, which was outside the carrying-wheel. Rimber, in 1831, in America, proposed placing a rack in the centre between the two rails, and this idea was carried out by Cathcart in 1847 on the Madison-Indianapolis Railway.

Blenkinsop did not know that the friction between the rail and the wheel was sufficient to provide for the progress of the locomotive and the traction of the train. It was not until 1813 that Blackett, owner of the pits at Wylam, showed that this was possible, and subsequently Stephenson built his locomotive as a purely adhesive engine.

Owing to the rapid and enormous development of the railways, many improvements were made in locomotive construction, and great progress was attained. The necessity of dealing with heavy trains and lines with very steep gradients naturally called for heavy locomotives, with an increased number of coupled wheels, which required special designs in the carrying parts of the locomotive, in order that they might be in a position safely to deal with curves, at the same time offering the lowest resistance. This led to the adoption of axles with lateral play, the double engines designed by Fairlie, Meyer, Mallet, &c.

The mountainous nature of the country in Switzerland gave particular opportunity for designing mountain locomotives. In normal adhesion railways a gradient was permissible up to 2½ per cent. (the Gothard Railway), and in secondary railways one had gone up to as much as 5 per cent. (South-Eastern Railway). The Uetli Mountain Railway formed an exception, as it had gradients of 6.7 per cent., and the purely adhesion locomotive which is used on this line can, when developing its utmost power, draw a train after it of a weight equal to itself.

Experience has shown that for mountain railways the limit for adhesion locomotives was a maximum of 4 per cent., but it was better not to go higher than 3½ per cent., and that if the railway had steeper gradients than this, rack-gear should be used.

For railways on the mixed system of driving by adhesion and by rack-gear, 12 per cent. gradient should not be exceeded in view of an economical working of the system.

On purely rack railways gearing vertically into the rack (Riggenbach, Abt, and Strub systems), it is to be recommended that the maximum gradient should not exceed 25 per cent. By careful and very heavy design of the road when the rack is maintained in very good condition, combined with suitable design of the locomotives, particularly their brakes, a safe working of the line can be ensured both when the trains are ascending or descending. For gradients up to 30 per cent. it is necessary to be most accurate in the control of the rack-teeth, as, when the train is braked going down banks, very small differences assist the rack-wheel to mount on the rack.

If the contour of the country necessitates a still steeper gradient, it is necessary to use a rack with lateral gearing (Locher's system).

Mr. N. Riggenbach, locomotive superintendent of the Central Swiss Railway in Olten, who brought the first ordinary locomotive into Switzerland in 1847, was the builder of the first rack-railway locomotive for the Vitznau-Rigi Railway. In 1862 Riggenbach brought out a special form of rack and rack-locomotive. In 1868 he took a long journey in North America, where he saw the Mount Washington line, which was the first rack railway built on proper principles with locomotives which worked well, and had been supplied by Messrs. Baldwin, of Philadelphia. In 1869 he returned from America, and he built a mixed system of railway, having taken the Mount Washington Railway as his pattern. This line was of the ordinary gauge, and ran to the quarries in Ostermundingen, near Berne. The same year he, in conjunction with Messrs. Naeff and Zschokke, obtained the concession for a railway to Vitznau, on the Rigi. This line was opened in 1871, and with this opening the rack-railways were introduced in Switzerland.

Construction of Rack.—The whole systems of racks which are used in Switzerland have been designed in the country itself.

Riggenbach's rack used on the Vitznau-Rigi Railway Fig. 1, page 143, was an improvement and a variation on Marsh's rack, as the cheeks formerly made by angle irons were replaced by ⊏ irons, and, instead of the cylindrical form of the tooth, the taper form was adopted. This form of evolute teeth was maintained by all the following rack systems, as it produces a simple form of tooth, and permits the gear locking at different depths. The form of Riggenbach rack is exceedingly efficient in resisting the mounting of the cog-wheels, and gives great security against the engine going off the road.

In order to produce safe interlocking of the cog-wheels, the position of which is dependent upon the play of the springs, large diameters of wheels are to be chosen with small pitch, 80 mm. to 100 mm. (3.15 in. to 3.94 in.).

The rack, formed also like a ladder, and designed by Mr. Klose (for the St. Gallen-Gais Railway), resembles the Riggenbach rack.

The ends of the teeth are lodged in round holes in the cheek, and their turning is prevented by a rib rolled on to the carrier. For the new line between Lauterbrunnen and Wengen, the L. v. Roll Berne works have made the same construction of rack.

Roman Abt published his arrangement of rack in 1884, in Switzerland (Fig. 2, page 143). It was first used on the Mount Generoso Railway in 1890. The rack consists of flat-toothed plates, of which two or three, according to the tractive power, are bolted together on chairs in such a way that the tooth of one plate in regard to the other is displaced of half or one-third of the pitch. This pitch amounts to 120 mm. (4.7 in.). The Abt system of rack ensures a quiet motion of gearing, and permits the trains to work at high speed. It is specially applicable to long railways on the mixed system. The Abt rack has been adopted the most, and now about 520 km. (323 miles) are fitted with it. It is constructed by the Union Dortmund and by Cammell Laird and Co., of Sheffield.

The rack, designed by Colonel Edward Lacher (Fig. 3, page 143), was used in the year 1888 on the Pilatus Railway, which has a maximum gradient of 48 per cent. The arrangement consists of a plate having gear-teeth on each side of it, into which two gear-wheels drive, placed opposite to each other; these rack-plates, being riveted to a Vautrin rail which is so rolled that guide-discs can be provided on the gear-wheel, ensure a correct guiding of the vehicle, and prevent riding of the wheels. The pitch is 85.7 mm. (3.37 in.). The heavy gradient necessitates a road very solidly built in masonry, the whole being properly anchored down.

Strub's rack, shown in Fig. 4, page 143, is a broad-footed toothed rail having a wedge-formed top, similar to the rail which is used on rope railways, provided with clamp brake-gear. This head of the rack furnishes a good guide for the safety-grips; the latter, however, have not proved to be satisfactory when worked as brakes.

Strub's rack-gear was first put into use in 1898 at the Jungfrau Railway. The pitch is generally 100 mm. (3.94 in.). The Berne foundry of L. v. Roll has taken over its construction.

I. STEAM LOCOMOTIVES.

The map, Fig. 5, page 143, shows the railways on which the following locomotives are at present working:—

(*a*) *Locomotives with Rack-Gear Only.*—As already stated, the now well-known Vitznau-Rigi Railway was opened in May, 1871, as the first European rack-railway for passenger traffic. The gauge is the ordinary English gauge. The line has a length of 7058 m. (4.38 miles), and gradients from 6 per cent. up to 25 per cent., the mean gradient being 20 per cent. The curves have 180 m. (591 ft.) radius. The original road was built with longitudinal and cross sleepers, but between 1885 and 1895 the road was rebuilt, the timber sleepers being replaced by iron ones, and the iron rails being replaced by steel rails.

The first locomotive for this line was built in the works of the Central Railway in Olten; the engine had a vertical boiler similar to the engines on Mount Washington in order to reduce as much as possible the variations in water-level arising from the different gradients over which the engines worked. The following locomotives were built at the Swiss Locomotive Works in Winterthur, and were the first work turned out by that firm. After eleven years' use the vertical boilers were replaced by horizontal ones.

Fig. 6, page 144, shows the vertical-boiler engine carried on two axles, on the lower of which is mounted, running loose, the driving cog-wheel, which is driven by gearing from the crankshaft. The cylinders lie on both sides outside the frames, and drive the intermediate shaft by means of connecting-rods and cranks. The upper axle carries a toothed brake-wheel with an arrangement to be used in case of an accident to the driving-wheel. The ordinary brake works on the discs of the crankshaft.

When going down hill, an air counter-pressure brake is made use of—that is, the valve-gear is reversed and the regulator is shut off. The pistons then draw air into the cylinder which is compressed up as far as the regulator. This braking is governed by throttling the exhaust of the compressed air by means of a valve worked by the driver.

In the latest locomotives of the Rigi Railway, Fig. 7, page 144, which were built at the Winterthur Works between 1899 and 1902, the cylinders are placed farther towards the leading end. The driving cog-wheel, which is driven by means of gearing from the intermediate axle, has a larger diameter, and is placed close behind the front carrying-axle; the trailing carrying-axle is provided with rack-brake. The brakes are arranged in the same manner as on the old engines, but, in addition, a centrifugal governor is made use of, which automatically controls the maximum speed, at which point a steam-brake is put into action. This automatic speed-regulator (a special construction of the Winterthur Works) has to be applied, by order of the Swiss Railway Department, on all rack-locomotives in service on Swiss lines. The speed of the Rigi locomotive is 2.1 m. (6.8 ft.) per second (4.7 miles per hour), and the total weight of the train is between 25 to 28 tons, about 200 horse-power being developed by the engine.

The Arth-Rigi Railway was opened in 1875, having a length of 9.8 km. (6.1 miles), with 20 per cent. gradients, and has engines similar to those used on the Vitznau-Rigi Railway, which, however, is at present partially served by electricity. The Rorschach-Heiden Railway, with a length of 6.08 km. (3.8 miles) and 9 per cent. maximum gradient with a total rise of 406 m. (444 yards), has engines of the same pattern.

In June, 1889, the Pilatus Railway, the steepest rack-railway in the world, was opened. It has a length of

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* Paper read before the Institution of Mechanical Engineers, at the Zürich Meeting, July 25.

NOTE.—For other particulars of these railways see paper on "Electric Traction in Switzerland," by Mr. E. Huber-Stockar.

4610 m. (2.86 miles), a total difference of level of 1630 m. (5346 ft.), gradients being 19.2 to 48 per cent., the mean gradient being 38.1 per cent. The road has 80 cm. (2 ft. 7½ in.) gauge. The rack-gear is on Locher's system.*

The locomotive carriage (Fig. 8, page 144) takes thirty-two passengers. The underframe of the coach forms at the same time a tender containing 800 litres (176 gallons) of water. The carriage is carried on two axles on three points. The boiler is of the ordinary locomotive form, but, on account of the varying gradients, it is placed transversely to the rails. The cylinders drive by a spur-wheel gearing on an intermediate axle, from which the power is transmitted by two pairs of conical wheels on the two vertical driving-axles. At the lower end of these driving-axles the driving-wheels are placed together with their guide-rollers in order to ensure that the wheels gear properly into the rack. The leading gear-wheel is only used for the purpose of a brake, and its rollers have to guide the carriage against the Dantrin rail. The leading toothed-wheels run freely when the coach is going up the inclines, and they are locked when running down hill by means of a coupling through which they transmit reverse motion to two symmetrical worm-wheels, their axle carrying the brake-disc. By reason of the high gear-ratio relatively small braking power is sufficient to bring the train to a standstill. The brake is automatically put on when the speed limit is exceeded. The following brakes are arranged:—An air-compression brake when running down the banks, a frictional brake on the crank-shaft, as well as friction and self-acting brakes on the leading pair of geared wheels, as already described. The normal speed of the train is 1.2 m. (47.24 ft.) per second (2.7 miles per hour), the weight of the combined engine and carriage is 12 tons, and the engine develops 100 horse-power. Very excellent results have been obtained by the use of superheated steam.

The locomotive, Fig. 9, page 145, has been designed by Mr. Roman Abt, and executed for Abt and Riggenbach rack-rail by the Winterthur Works. The engine is a special type for narrow gauge, steep gradients, and small curves. It is constructed with two driving and one Bissel axle. On the driving-axles are keyed the cog-wheels with brake-discs. The carrying wheels are running loose. The steam-power is transmitted from the cylinders by means of connecting-rods and rocking-levers on the crank-axles. The boiler, of ordinary locomotive type, is so mounted on the frame that its axis corresponds with the medium gradient. This type of locomotive works on a gauge of 800 mm. (2 ft. 7½ in.), minimum radius of curves of 60 m. (175 ft.), and gradients up to 25 per cent. It has been accepted on the following railways:—Generoso, Brienz-Rothorn and Glion-Rochers de Naye with Abt's rack-rail; for Schynige Platte and Wengernalp with Riggenbach rack-rail. These lines were built between 1890 and 1893.

As the traffic on the Wengernalp Railway (Lauterbrunnen-Grindelwald) increased from year to year, heavier construction was asked for. In the year 1904 the Winterthur Works erected a new type for this railway, with a tractive power of about 11,000 kg. (10.8 tons), against 6500 kg. (6.3 tons) of the old type. The engine is built with three carrying-axles; the trailing one is a Bissel axle (Fig. 10, page 145). The steam power is transmitted in the ordinary way by means of two intermediate crank-shafts on two rack driving-axles. A special construction regulates the equal division of the tooth-pressure on both cog-wheels. The brake arrangements of all these engines are the same as those on the Rigi locomotive.

(b) *Locomotives for Rack and Adhesion Driving.*—In the year 1888 the first line for adhesion and rack-gear service had been opened with the Brünig Railway, constructed by the Jura-Berne Lucerne Railway Company, now belonging to the Swiss State Railway.* It is divided into three parts, the lengths between Brienz-Meiringen and between Giswyl and Lucerne are worked by adhesion, but the length of 9013 m. (5.6 miles), having a maximum gradient of 12 per cent., is fitted with the Riggenbach rack. The total length of the line is 56.37 km. (35 miles), the normal radius of the curves is 150 m. (490 ft.) and the sharpest curve is 90 m. (295 ft.).

The original engines have two driving axles for adhesion, two cylinders and rigid coupling between the adhesion and the rack-gear mechanism. The cylinders are placed between the frames below the smoke-box and drive by means of the intermediate shaft and a spur-wheel gearing on the rack driving-wheel, which is coupled by a special design of coupling-rods to the adhesion axles.

A new locomotive for this line, the "Winterthur type," was designed in the year 1905, and is shown on Fig. 11, page 145. This locomotive is constructed as a four-cylinder compound engine, the cylinders being placed by couples outside the frame as well as their driving gears, so that the maintenance and repairing of all parts is rendered easy. The lower cylinders are the high-pressure cylinders and work as a twin engine on the adhesion mechanism, while the rack-gear mechanism, driven by the upper, viz., the low-pressure cylinders, is stopped, the steam exhaust going from the high-pressure cylinders directly to the exhaust-pipe. As soon as the locomotive enters the rack, the drivers change, by means of two steam-manipulated valves, the direction of the high-pressure exhaust; the low-pressure cylinders and the rack-gear mechanism begin also to work. Generally the four cylinders have the same dimensions, and the relation of their volume for good steam-compounding is obtained by the relative dimensions of the intermediate spur-wheel gear of the low-pressure mechanism, viz., by the relation of the number of revolutions of the two mechanisms. The following brakes are provided:—one hand-brake having four blocks on the trailing adhesion axle; a band-brake acting on discs on the intermediate crank-shaft; an emergency braked gear-wheel which is carried loosely on the leading adhesion axle, as well as an air repression brake for going down hill. The locomotive is also arranged with Westinghouse brakes for acting directly on the train.

The Bernese-Oberland Railway was opened in 1890, has a gauge of 1 m. (3.28 ft.), and the rack is of the ladder form. The length of the line is 23.446 km. (14.35 miles) out of which 4978 m. (3 miles) are fitted with the rack. The difference in levels are as follows:—Between Interlaken and Lauterbrunnen 229 m. (752 ft.), Interlaken and Grindelwald 467 m. (1532 ft.). The gradients for the first line are 9 per cent. and for the latter 12 per cent. The maximum gradients where adhesion is used are 2.5 per cent. The original locomotives, Fig. 12, page 145, are six-coupled, four cylinder twin tank-engines with separate driving gear for the adhesion and for the rack working. The inner pair of cylinders, drives on an intermediate shaft with pinion gearing directly in the toothed driving rack-wheel. A loose braking rack-wheel is placed on the first adhesion axle. Each pair of cylinders has a separate regulator, but both of them are manipulated by means

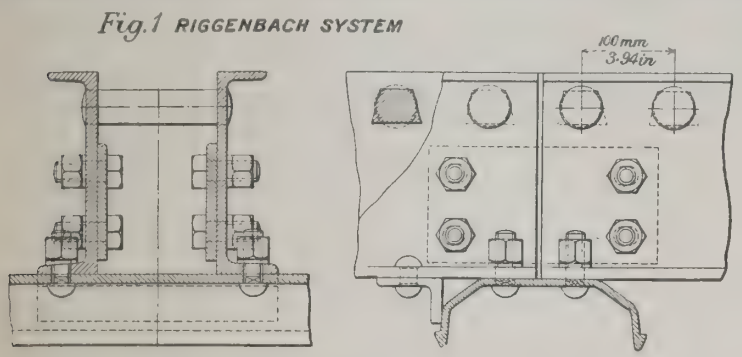


Fig. 1 RIGGENBACH SYSTEM

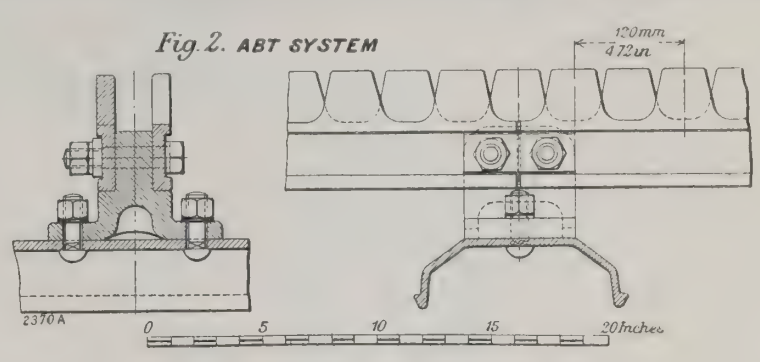


Fig. 2. ABT SYSTEM

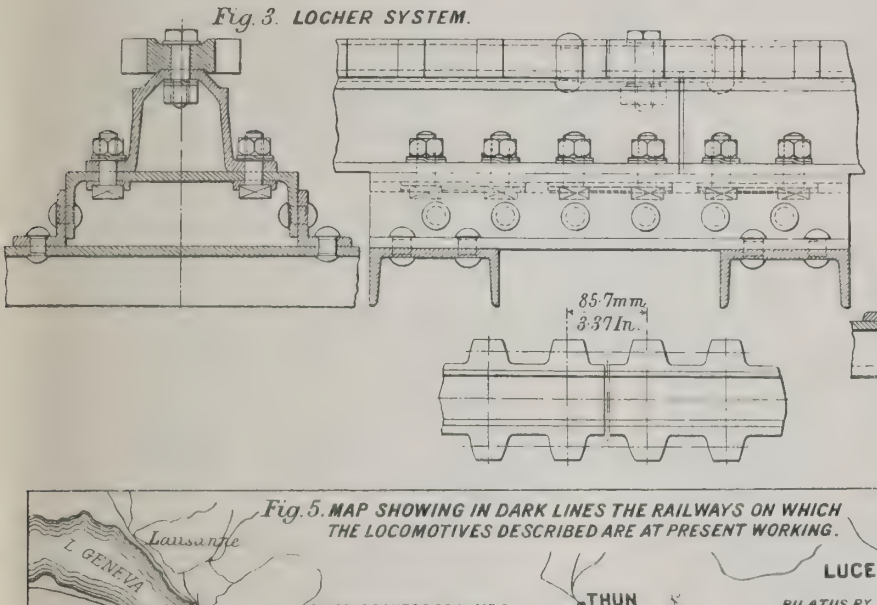


Fig. 3. LOCHER SYSTEM.

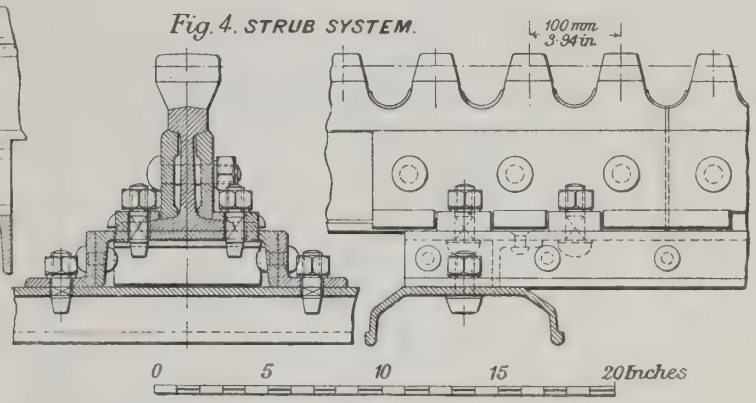
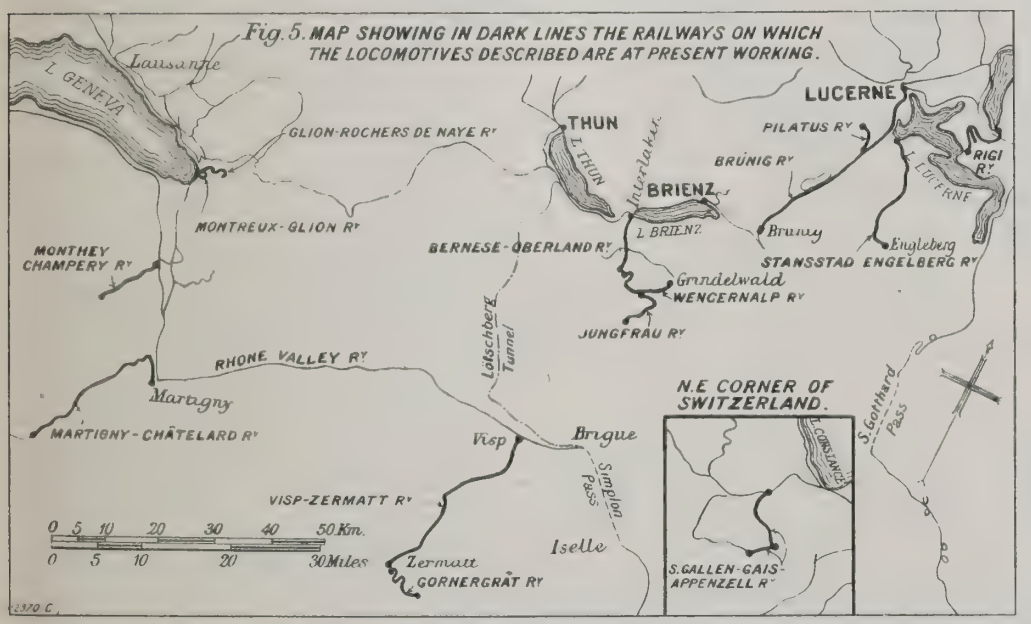


Fig. 4. STRUB SYSTEM.



* The Pilatus Railway and its rolling-stock was illustrated and described in ENGINEERING, vol. xliii., page 444.

* The Brünig Railway was illustrated and described in ENGINEERING, vol. lviii., page 627.

of one controlling screw. Both the rack and the adhesion mechanism are controlled by an air-repression brake, in addition to which both rack-wheels are also provided with separate hand-brakes. The third hand-brake, which acts on all adhesion driving-wheels, is chiefly used as a shunting brake. Further, the engine is provided with a Klose continuous steam-brake for braking the train itself.

In the year 1906 the Bernese-Oberland Railway ordered two new locomotives of the "Winterthur" type, equal to those of the Brünig, shown on Fig. 11. Now they are providing their boilers with Schmidt's superheater.

In 1890 the only mixed system of railway mounted on the public road was built between St. Gallen and Gais.* The gauge is 1 m. In a total distance of 19.52 km. (12.12 miles) 15.1 km. (9.4 miles) are built on the ordinary high road. Twenty-six per cent. of the line has gradients above 4 per cent. provided with Klose's system of rack. The steepest gradient is 9.2 per cent. and the smallest curve has 30 metres radius.

The first locomotives of this line were built between 1889 and 1891, according to the Klose system, shown on Fig. 13, page 145. The engine has four-coupled adhesion wheels, as well as a Bissel trailing bogie which carries the tank. The Bissel bogie axle is fitted with a brake rack-wheel. The four adhesion wheels are driven by two outside cylinders. They are constructed as Klose's radial axles—that is to say, axles which can accommodate themselves to the curves, so they are fitted with the whole complicated mechanism necessary to do this. The rack-wheel is driven by two inside cylinders by means of an intermediate shaft and pinion which gears directly in it. The adhesion engine works compound in connection with the engine driving the rack. This arrangement was designed by Klose.

The new engines of the St. Gallen-Gais line are of the "Winterthur" type, shown by Fig. 14, page 145. They have four-coupled adhesion wheels, the rack driving-wheel being placed between them. They have also leading and trailing two-wheel bogies. In other particulars these locomotives are similar to the new Brünig locomotives, Fig. 11.

The Visp-Zermatt Railway has also 1-metre gauge, is 35 km. (21¾ miles) long, rises 955 m. (3132 ft.), and has 100-m. (328 ft.) minimum curves, where the gear is in use. There are six sections having rack-rails on the Abt system, with a total length of 7.2 km. (4½ miles). The heaviest gradient on the rack is 12½ per cent. The remaining five heavy gradients are only 10 per cent. The adhesion sections have a maximum gradient of 2½ per cent., and are arranged with curves of a minimum radius of 80 m. (262 ft.). The locomotives draw the trains.

The engines shown on Fig. 15, page 146, are combined four-cylinder twin-engines on the Abt system. The cylinders driving the adhesion-wheels are placed outside, those driving the rack gear are placed inside. The two rack driving-wheels are mounted in a separate frame suspended on the two driving adhesion-axles, and so they are independent of the springs' play, according to the Abt system. There is a Bissel bogie underneath the driver's foot-plate which ensures the engine taking curves properly.

The small engine shown in Fig. 16, page 146, is used for easy traffic, and as contractors' locomotive for construction of rack railways. On the mean gradient the boiler is level. The frames are carried by two adhesion axles, which are connected by means of connecting-rods with the rack driving-wheel placed between them. One of the adhesion axles carries a loose rack brake-wheel. The cylinders placed between the frames drive by an intermediate crank-axle with pinion and spur-wheel on the rack-wheel axle, just as described for the first Brünig locomotive.

* This line and its rolling-stock was illustrated and described in ENGINEERING, vol. liv., pages 741 and 805.

Fig. 6.
RIGI RAILWAY

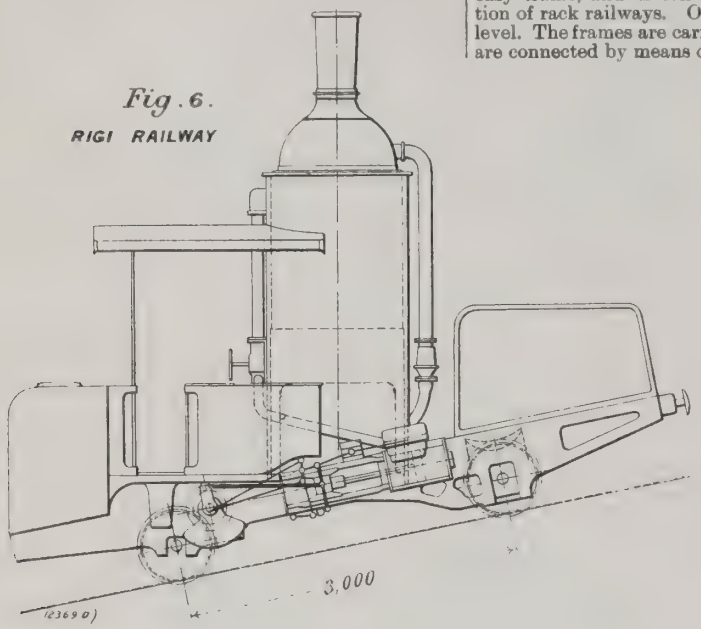


Fig. 7. RIGI RAILWAY

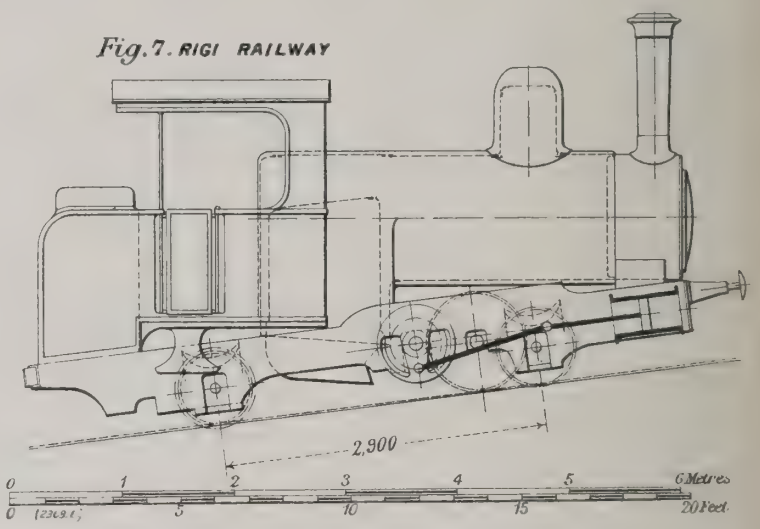


Fig. 8.
PILATUS RAILWAY

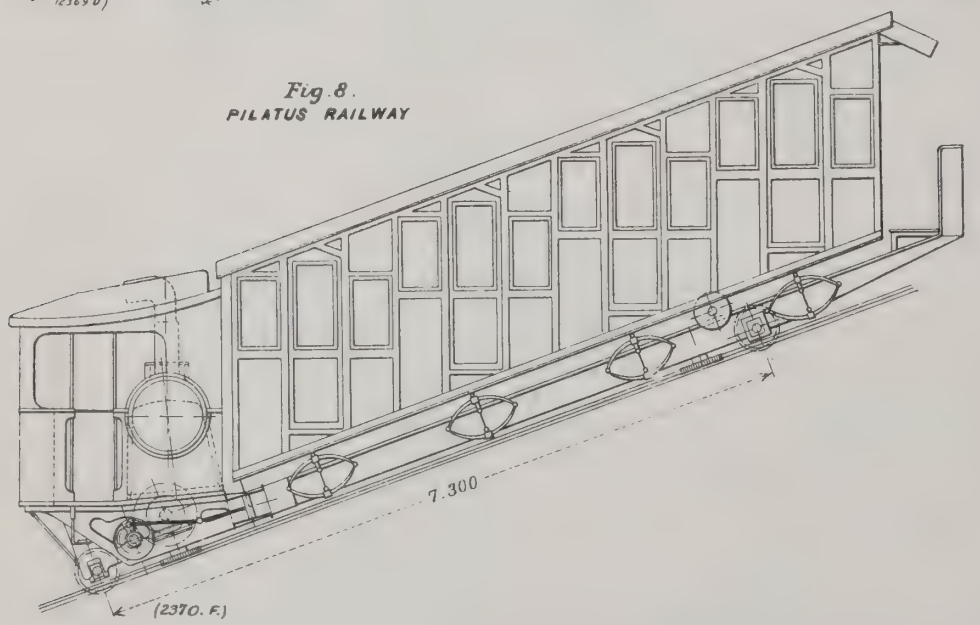


TABLE I.—*Particulars of Service of Locomotives Illustrated on this Page.*

——	Fig. 6.	Fig. 7.	Fig. 8.
Name of railway ..	Rigi	Rigi	Pilatus
Gauge	1435 mm. (4 ft. 8½ in.)	1435 mm. (4 ft. 8½ in.)	800 mm. (2 ft. 7½ in.)
Rack system ..	Riggenbach	Riggenbach	Locher
Maximum gradient	1 in 4	1 in 4	48 in 100
Minimum radii of curves	120 m. (394 ft.)	120 m. (394 ft.)	80 m. (262 ft.)
Speed per hour ..	7 to 7.5 km. (4.3 to 4.6 mls.)	7 to 7.5 km. (4.3 to 4.6 mls.)	4.5 km. (2.7 miles)
Tractive power (maximum)	8500 kg. (8.36 tons)	8500 kg. (8.36 tons)	6500 kg. (6.3 tons)

II.—ELECTRIC LOCOMOTIVES.

The very great improvements made in electrical traction were naturally utilised also to carry on the working of rack-railways. The Gornergrat line, which starts from the terminus of the Visp-Zermatt Railway, was the first rack-railway to use electricity, and afterwards a whole series of other railways followed this example.

(*a*) *Railways on Rack only.*—The Gornergrat line was opened in 1898; the gauge is 1 metre, the rack on the Abt system, it has a length of 9346 m. (5.8 miles), and ascended a height of 2359 m. (7740 ft.). The maximum gradient is 20 per cent., and the smallest curves are 80 m. (262½ ft.). The locomotive is shown in Fig. 17, page 146; it has two polyphase motors, each having a maximum output of 90 horse-power at 800 revolutions per minute with 500 volts pressure. The motion is conveyed to two independent rack driving-wheels by means of an intermediate shaft and double spur-wheel gearing. The locomotives rest on two carrying axles having springs with a definitely-controlled range. The passenger coach is suspended to the locomotive frame in accordance with Mr. Rowan's design. By this construction a part of the coach's load increases the weight of the locomotive and so prevents the rack-wheels from riding. The engine is fitted with two hand-brakes, each of which acts on both driving rack-wheels, and an automatic brake working on the rotor-axles. This brake can be manipulated also by hand, either by the engine-driver or by the conductor in charge of the train. When the train is going down hill, the motors act as generators; the current which is then developed goes up by means of the bows back into the cental station, where it tends to reduce the load.

One month after the Gornergrat Railway was opened, the first part of the Jungfrau Railway was also started. The part between Kleine Scheidegg and Eismeer has a difference in level of 1092 m. (3580 ft.), and it was opened in 1905. The length is 5.8 km. (3.6 miles) and the gradient is generally 25 per cent. The gauge of the line is 1 metre. Where the line is in the open cutting the curves have a radius of 100 m. (328 ft.), the curves in the tunnel having 200 m. (656 ft.), and the curves leading into the points 80 m. (262½ ft.). Strub's rack was first applied here and three-phase current used.

The locomotive shown in Fig. 18, page 146, is of the same construction as the Gornergrat locomotive, its performance being somewhat higher. The speed of the train is 7.5 km. (4.65 miles) an hour. When running down-hill the braking is controlled by means of an electric resistance, which is cooled by a fan. The motors then work as ordinary generators, owing to a special change in their connections, and the current thus generated is transformed into heat.

In the years 1900 and 1901 the Aigle-Leysin and Bex-Gryon-Villars Railway had been opened as the first rack-railways with continuous current. The gauge is 1 metre, gradients from 9 to 23 per cent.; minimum curves, 60 metres radius. The rack is on the Abt system. The locomotives are fitted with two driving and a brake rack-wheel. With these engines the Winterthur Locomotive Works pattern of friction-disc coupling was first applied. It serves to reduce shocks resulting from short-circuiting and those coming from irregularities of the rack-pitch.

The Brunnen-Morschach Railway, on the Vierwaldstätter See, was opened in the year 1905. The line is 2.05 km. (1¼ miles) long, the mean gradient being 12.6 per cent., the maximum gradient 17 per cent. The line rises 257 m. (842 ft.), and the curves are 80 m. (262 ft.) radius. Strub's rack-gear was used in this case. The locomotives are connected to the coaches on Rowan's system. These engines have only one single driving-wheel, driven by two polyphase motors, each of 80 horse-power, by means of double transmitting-gear. The trailing carrying-axle is provided with a brake rack-wheel, and it and the driving rack-wheel are both braked. On both the up and down journeys a safety-grip is used, in addition to which the brake-wheels are fitted with guide-flanges, in order to provide for greater security against the wheels mounting the rails.

The Wengernalp Railway commenced to use electric driving in June, 1909, and now has ten locomotives of 300 horse-power each. These engines, shown on Fig. 19, page 146, are generally of the same construction as those of Gornergrat and Jungfrau. It is a notable locomotive, as up to now they are the only ones built for 80-cm. (2 ft. 7½ in.) gauge, which presents great difficulties in arranging for the transmission of power and the arrangement of the brakes. They have an equalisation of pressure on the rack-wheels arranged by means of balancing levers. This arrangement has been adopted by the Swiss Locomotive Works, as well as a system of automatic interlocking which prevents the automatic brakes from being put in action when the train is going up-hill.

Each locomotive is provided with two-series continuous-current motors, each of 150 horse-power, this full power being capable of continuous use. The motors make 750 revolutions per minute, and they are worked in series by bow contacts at 1500 to 1800 volts. The braking when running down-hill is done by the ordinary method of short-circuiting.

(*b*) *Mixed Rack and Adhesion Lines.*—The Stansstad-Engelberg line was opened in the year 1898, and has a length of 22.5 km. (14 miles). It is driven by three-phase current of 750 volts. The gauge is 1 metre, and for a length of 1½ km. (4920 ft.) the ladder form of rack-rail is used. The total ascent is 564 m. (1850 ft.), and it is worked by adhesion up to 5 per cent. gradients, the steepest rack-line gradient is 25 per cent.

The two motors of the engine, shown on Fig. 20, page 146, develop 150 horse-power each, and work by means of "V" gearing and an intermediate shaft to the only rack driving-wheel. A special construction of a friction switch (made by the Winterthur Locomotive Works) permits the two carrying-axles to engage as driving-axles on the adhesion lines by means of coupling-rods.

The Martigny-Châtelard Railway was opened in the year 1904. It is 19.132 km. (11.9 miles) long, is provided with a Strub rack arrangement for a length of 2477 m. (1½ miles), of which 1914 m. (1.2 miles) have a gradient of 20 per cent. The adhesion part of the line has gradients up to 7 per cent., and the smallest curves have a radius of 25 m. (82 ft.). The locomotives of this line are worked by continuous current. Their general construction is the same as those of the Jungfrau Railway, but they are independent of the carriage. As those engines have to serve also on adhesion lines until 7 per cent. gradients, they are provided with a rigid coupling by means of connecting-rods between the rack driving-axles and the carrying-axles. The locomotive is equipped with the differential Westinghouse brake.

In addition to the locomotives there are, on the Martigny - Châtelard line, nine motor - carriages, each of which rests on two four-wheel bogies. Each bogie has two motors of 80 to 100 horse-power, which, by means of spur-wheel gearing an intermediate shaft, transmit the power on the rack as well as on the adhesion axles. This rigid connection between adhesion and rack-wheels is not to be recommended, but up to date the system has worked without any interruption.

The line between Monthey and Champery was opened in 1906, and has a length of 11.4 km. (7 miles), having three heavy banks of 13 per cent. up to 13 6 per cent. It rises a total height of 640 m. The gauge of the line is 1 m.; it is fitted with Strub rack-gear, having curves of 80 m. radius, and is worked by means of a mixed system of motor-coaches, shown on Fig. 21, page 146. The portions worked by adhesion have maximum gradients of 5 per cent., and curves of 60 m. The bogies, each of which has one adhesion and one rack-wheel driving-motor, each independent of the other, allow various gradients to be worked in the most efficient manner by the rolling-stock. The adhesion axles are driven by the adhesion motor, and are connected by coupling-rods. The rack-wheel motor works by means of double-spur gear on a rack driving-wheel mounted loose on one of the adhesion axles.

In order to make the direct communication of the steam rack-railway between Glion-Rochers de Naye, which starts from the upper end of the Territet-Glion rope railway above Montreux, the Montreux-Glion line was built in the year 1909; it has a gauge of 80 cm. (2 ft. 7½ in.), and the Abt double-flitch rack, which was used in order that it might form a direct communication between Montreux and Rochers de Naye. The line has a total length of 2.8 km. (1¾ mile), and rises 300 m. (984 ft.), the maximum gradient being 13 per cent. The radii of the curves are 80 m. (262 ft.) in the open part of the line, 60 m. (197 ft.) in the railway station, and 50 m. (164 ft.) at the points.

The locomotives shown on Fig. 22 (page 147) are arranged so that they can run either by adhesion only or by the rack gear only. The two rack driving-axles are each

Fig. 9. GLION–ROCHERS DE NAYE RAILWAY

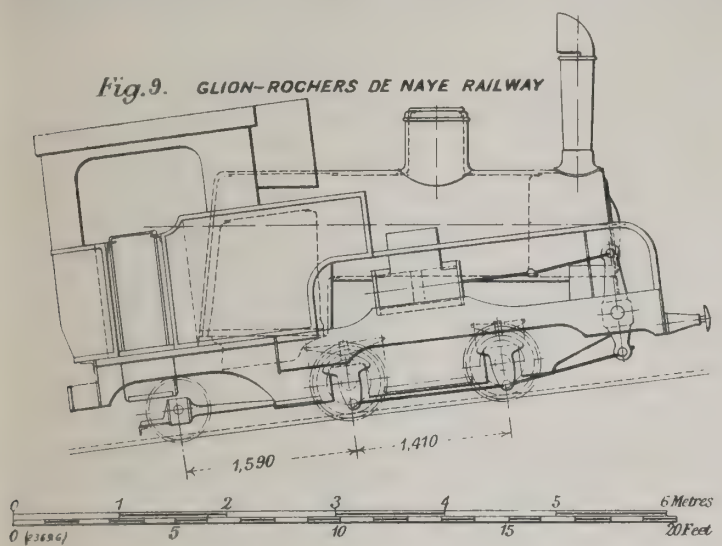


Fig. 10. WENGERNALP RAILWAY

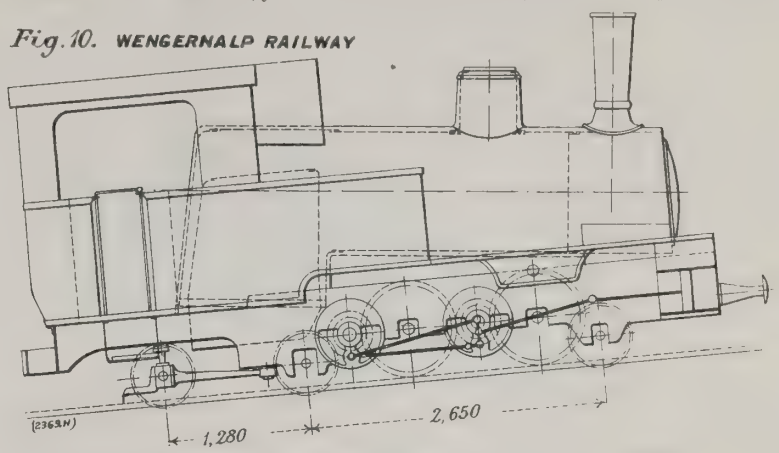


Fig. 11. BRUNIG RAILWAY.

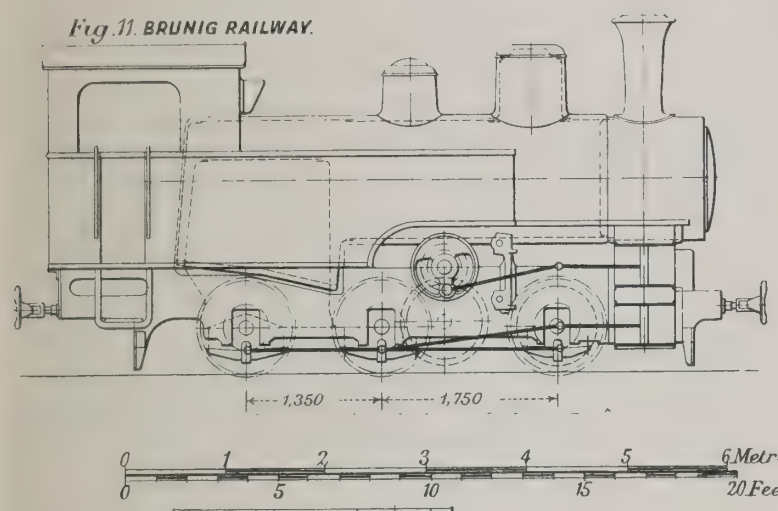


Fig. 12. BERNESE-OBERLAND RAILWAY

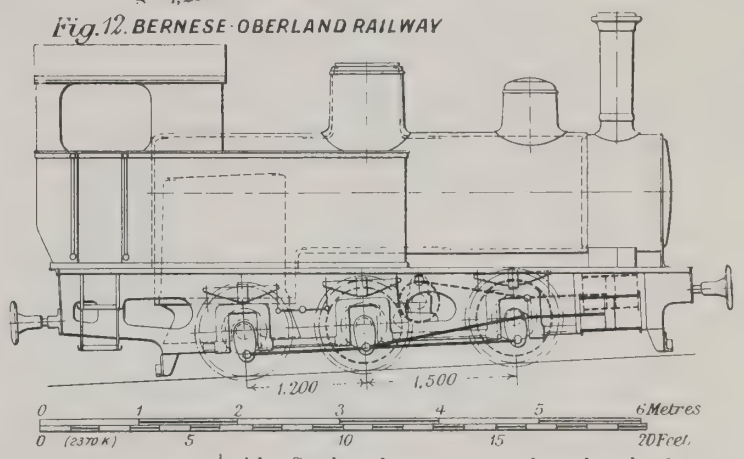


Fig. 13.
ST GALLEN-GAIS-APPENZELL RLY

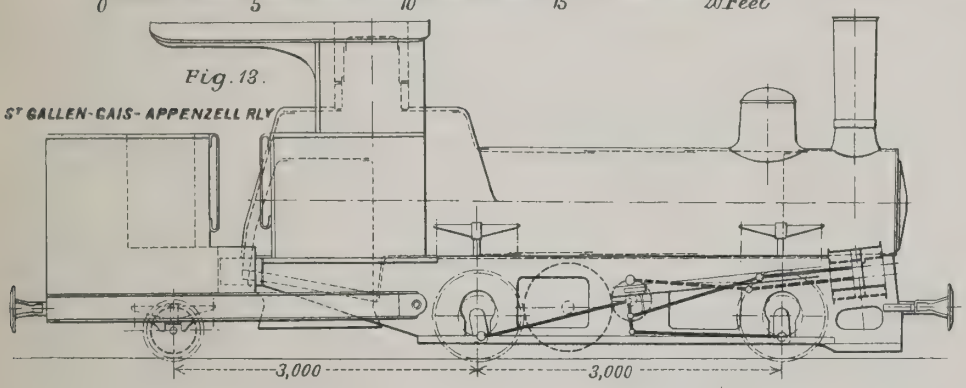


Fig. 14.
ST G.A.R.Y

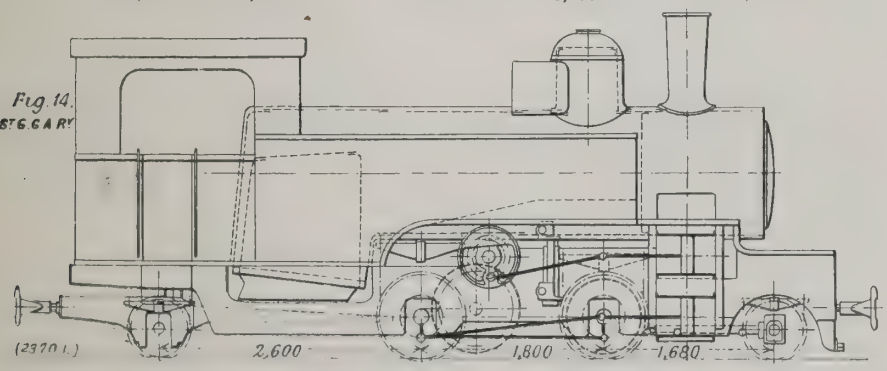


TABLE II.—PARTICULARS OF SERVICE OF LOCOMOTIVES ILLUSTRATED ON THIS PAGE.

	Fig. 9.	Fig. 10.	Fig. 11.	Fig. 12.	Figs. 13 and 14.
Name of railway	Glion-Rochers de Naye Railway	Wengernalp Railway	Swiss Confederation Railways (Brünig Railway)	Bernese-Oberland Railway	St. Gallen-Gais-Appenzell Railway
Gauge	800 mm. (2 ft. 7½ in.)	800 mm. (2 ft. 7½ in.)	1000 mm. (3 ft. 3⅜ in.)	1000 mm. (3 ft. 3⅜ in.)	1000 mm. (3 ft. 3⅜ in.)
Rack system	Abt	Riggenbach	Riggenbach	Riggenbach	Klose
Maximum gradient ..	22 in 100	25 in 100	12 in 100	12 in 100	23 in 250
Minimum radii of curves	80 m. (262 ft.)	60 m. (197 ft.)	90 m. (295 ft.)	80 m. (262½ ft.)	30 m. (98½ ft.)
Speeds	7.5 km. per hour (4.7 miles per hour)	7.5 to 12 km. per hour (4.7 to 7.4 miles per hour)	12 and 45 km. per hour (7.4 to 28 miles per hour)	12 and 35 km. per hour (7.4 to 21.7 miles per hour)	12 and 30 km. per hour (7.4 and 18.6 miles per hour)
Tractive power, max. ..	6500 kg. (6.3 tons)	11,000 kg. (10.8 tons)	11,000 kg. (10.8 tons)	10,000 kg. (9.8 tons)	10,000 kg. (9.8 tons)

connected to the neighbouring adhesion-axles and carry a loose rack brake-wheel. The rack-wheels are always in motion, as they are coupled up through double spur-wheel gearing to the motors. The arrangement for running on the adhesion part of the line is as follows:—A friction-clutch coupling is keyed on to the intermediate shaft and transmits the power from this by spur-wheel gearing and connecting-rods to the adhesion axles. In principle the general construction is that of the Engelberg locomotive, Fig. 20, above.

In conclusion, it may be mentioned that the Blonay-les-Pleiades and the Altstätten-Gais Railway lines are intended to be brought into service during the present summer. Both these lines have metre gauge and Strub's rack-gear. The first line works with mixed locomotives similar to those on the Montreux-Glion line, the second line has six-wheeled motor-carriages having bogies similar to the Monthey-Champery type.

The locomotives and motor-cars described have all been designed at the Winterthur Locomotive Works, which carried out the mechanical part; the electric equipment was constructed and furnished by the different Swiss electric firms: Brown, Boveri, and Co., Baden; Maschinenfabrik Oerlikon; Elektricitätsgesellschaft Alioth, Münchenstein, Cie. électrique et mécanique, Genf.

Switzerland has a total of 120 steam locomotives as well as 45 electric locomotives, and motor coaches arranged for working with rack-gear. The total length of the rack railways is 140 km. (87 miles).

The diversity of the construction of rack-gearing locomotives in Switzerland has given those connected with the Swiss locomotive industry an opportunity of exercising their experience in the construction of rack-railway locomotives owing to the continually increasing demands made by the problem.

Fig. 15. VISP-ZERMATT RY

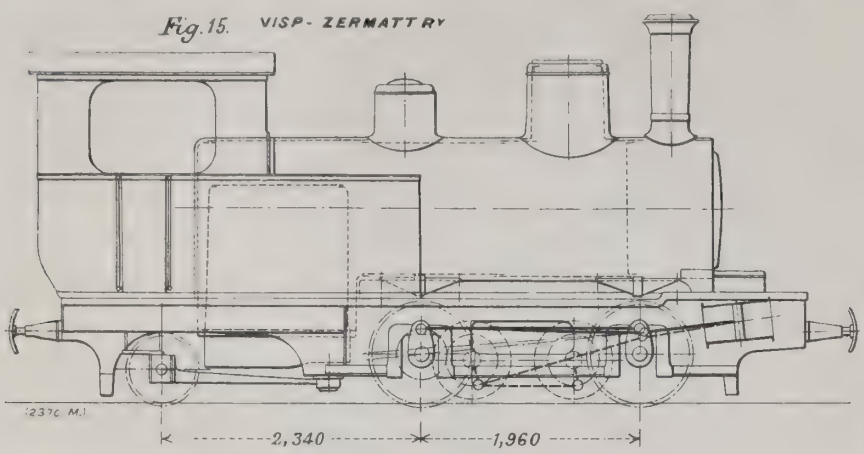


Fig. 16. MARTIGNY-CHÂTELARD RLY

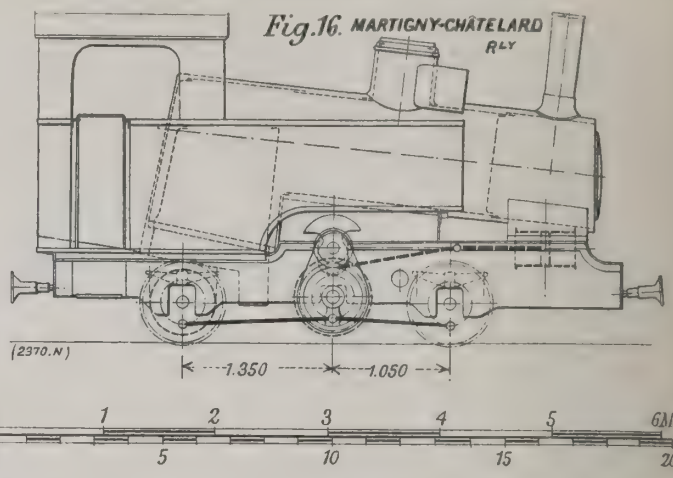


Fig. 17. GORNERGRAT RAILWAY.

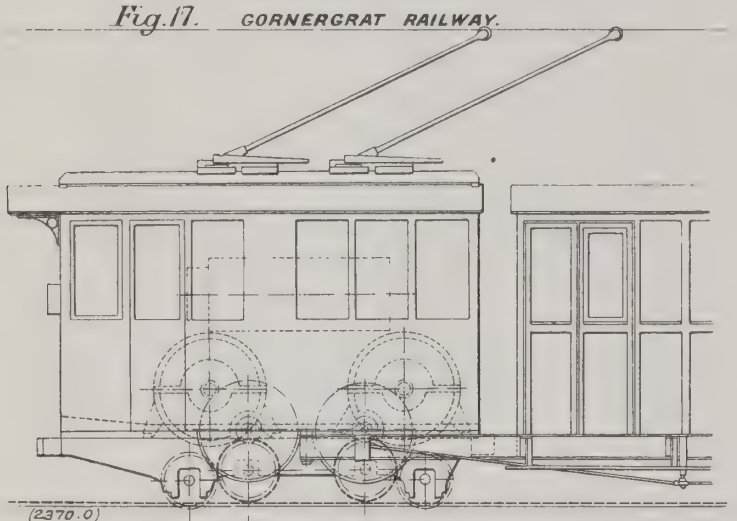


Fig. 18. JUNGFRAU RAILWAY

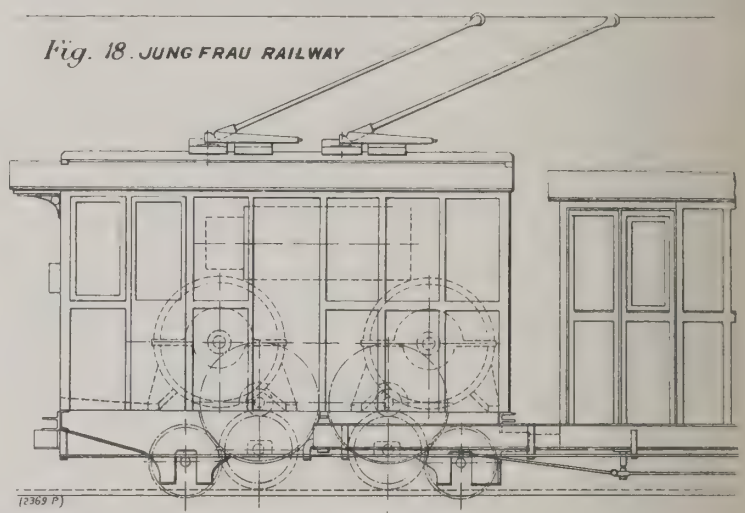


Fig. 19. WENGERNALP RLY

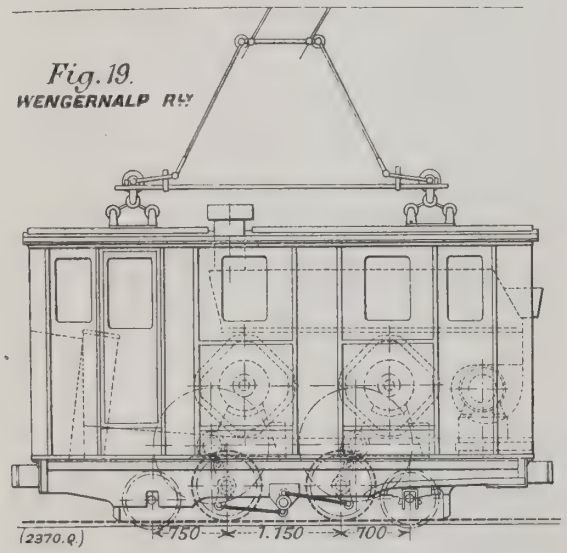


Fig. 20. STANSSTAD-ENGELBERG RLY

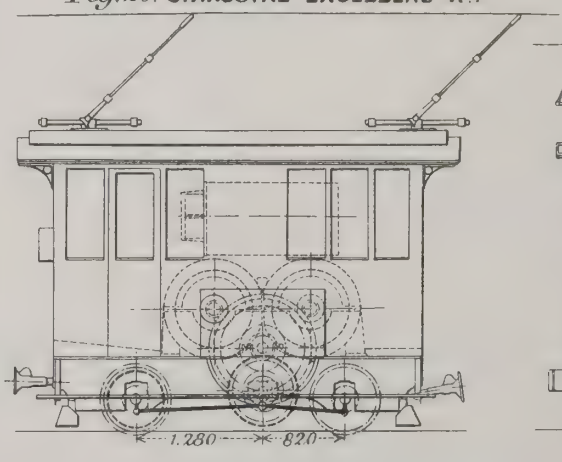


Fig. 21. MONTREUX-GLION RLY

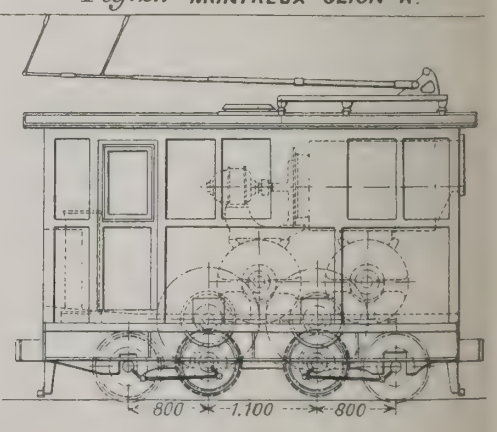


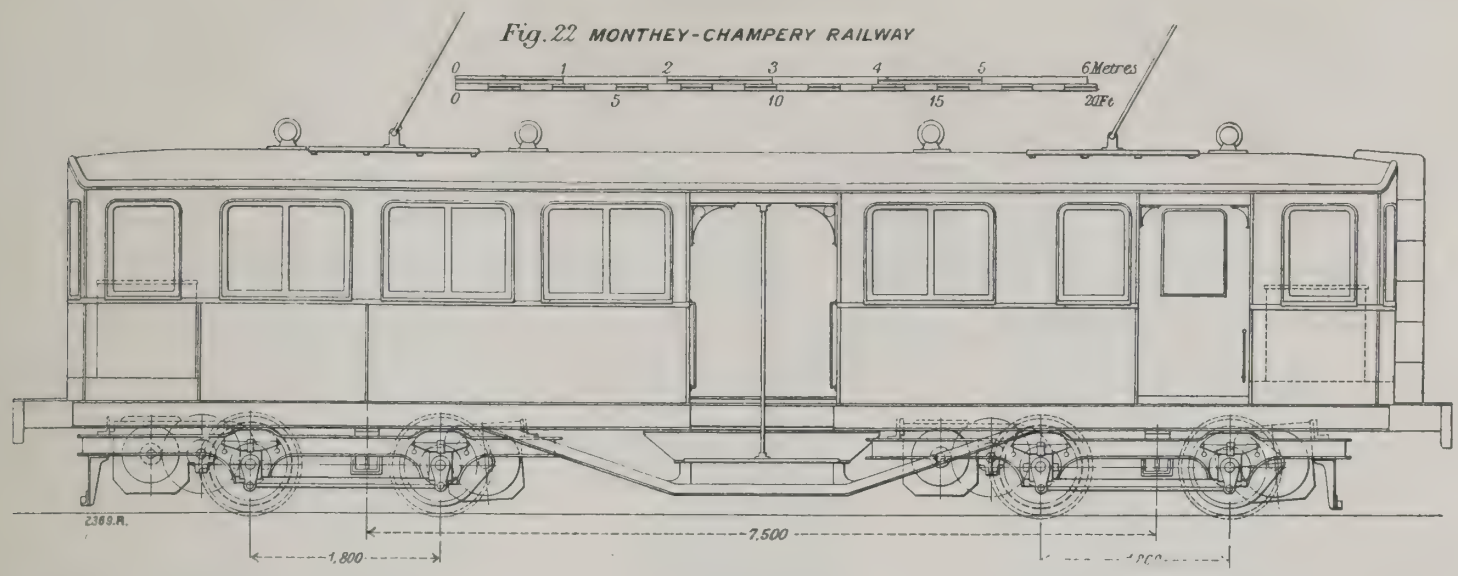
TABLE III.—PARTICULARS OF SERVICE OF LOCOMOTIVES ILLUSTRATED ON THIS PAGE.

	Fig. 15.	Fig. 16.	Fig. 17.	Fig. 18.	Fig. 19.	Fig. 20.	Fig. 21.
Name of railway	Visp-Zermatt Railway	Martigny-Châtelard Railway	Gornergrat Railway	Jungfrau Railway	Wengernalp Railway	Stansstad-Engelberg Railway	Montreux-Glion Railway
Gauge	1000 mm. (3 ft. 3⅜ in.)	1000 mm. (3 ft. 3⅜ in.)	1000 mm. (3 ft. 3⅜ in.)	1000 mm. (3 ft. 3⅜ in.)	800 mm. (2 ft. 7½ in.)	1000 mm. (3 ft. 3⅜ in.)	800 mm. (2 ft. 7½ in.)
Rack system	Abt	Strub	Abt	Strub	Riggenbach	Riggenbach	Abt
Maximum gradient	12 in 100	20 in 100	20 in 100	25 in 100	25 in 100	25 in 100	13 in 100
Minimum radii of curves	80 m. (262½ ft.)	60 m. and 80 m. (197 ft. and 262½ ft.)	80 m. (262½ ft.)	100 metres (328 ft.)	60 m. (197 ft.)	50 m. (164½ ft.)	60 m. (197 ft.)
Speeds	12 and 30 km. per hour (7.4 and 18.6 miles per hour)	7 and 25 km. per hour (4.3 and 15.5 miles per hour)	7 km. per hour (4.3 miles per hour)	9 km. per hour (5½ miles per hour)	8.5 to 12 km. per hour (5.2 to 7.4 miles per hour)	5.5 and 11.5 km. per hour (3.4 and 7.1 miles per hour)	10 and 15 km. per hour (6.2 and 9.3 miles per hour)
Tractive power, maximum	10,500 kg. (10.3 tons)	8500 kg. (8.36 tons)	6000 kg. (5.9 tons)	7000 kg. (6.8 tons)	9000 kg. (8.8 tons)	6500 kg. (6.3 tons)	6000 kg. (5.9 tons)

SWISS MOUNTAIN RAILWAY RACK-LOCOMOTIVE-CARRIAGE.

(*For Description, see Page* 142.)

Fig. 22 MONTHEY-CHAMPERY RAILWAY



WORKMEN'S COMPENSATION CASES.

COURT OF APPEAL.

Injury or Disease?—The Court of Appeal has recently given judgment in a number of appeals from the County Courts. Among the disputed points settled by the Lords Justices was that which arose out of the case of Cory Brothers, Limited, *v.* Hughes.

The workman was a collier, who met with an accident in 1906 which caused permanent injury to his hand. The employers paid him half wages till August, 1908, when he was given "light work" as a signalman underground at a wage which was rather more than he had had before the accident. He continued at this signal work till April, 1910, when he stopped work altogether. The medical evidence was that at this time he was suffering from heart disease. The walk to his work was uphill, and, therefore, impossible.

In December, 1910, the workman applied to have a memorandum of agreement registered. The agreement was implied from the payment of the half wages—12s. 1d. —from February, 1906, "and during incapacity." The employers then applied to terminate the agreement as from April, 1910. The matter came before the County Court Judge, who declined to terminate the compensation, but reduced it to 10s. a week. The Judge found that the heart disease had no connection with the accident. The employers carried the case to the Court of Appeal, by which it was dismissed. The Master of the Rolls, in giving judgment, said it had not been suggested that 10s. a week was too much. The amount was, of course, for the County Court, and not for the Court of Appeal. It had been argued that it was the duty of the County Court Judge to say that the man was no longer incapacitated as a result of the accident. The man was shown to have given up work in April, 1910. The disease was not caused by the accident; therefore it was contended that since April, 1910, the man had not suffered loss on account of the accident. But this was not the point in this case. The point was not that there was disease and not accident, but that there was admitted to have been an injury demanding compensation, and that there had been an agreement between the employers and their workman as to the amount of compensation. An agreement was as binding as the award of the Court. In the case of an award, as of an agreement, there was power given to either party to review or to terminate the agreement or the award, and the applicant for review or ending was always the person on whom rested the onus of proof. If the employers in this case, when they asked for a review, had shown good cause for claiming to diminish the compensation, on payment of which they had agreed, they ought to have given proof that the injury to the man's hand was not permanent. This they did not attempt to do, but contented themselves with the statement that the new job as signalman was retained by the man for two years after the accident, at increased wages. They ought to have remembered that they had agreed to compensate him for a permanent injury to the hand, and that to the payment of half pay, as agreed, the man had a legal right in respect of that permanent disability suffered in the course of his employment. To the plain, honest man it may seem unjust that generous employers, as in this case, should have to continue compensation, for which they might never have been asked by the workman but for the development of heart disease, which had no connection with the accident. The suitable job as signalman would have been a satisfactory settlement of the injured workman's claim if his heart had continued sound; but when his heart became affected, the unfortunate man could no longer afford to forego his legal claim to half pay in respect of compensation for his maimed hand. The employers were not asked to compensate him for his heart disease. The disability from two separate causes had no connection. The County Court Judge held that 10s. a week would be sufficient rather than 12s. 1d, already agreed upon, and it had never been argued for the employers that it was too much. That the signalman's work was not suitable "light work" was proved by the man's physical inability to continue it. Therefore the "light work" which the workman had accepted as the consideration for settling his claim for compensation for the injury to his hand had disappeared. The employers may think it hard upon them, but the 10s. compensation which the Judge ordered on review was less than the 12s. 1d. half pay which they themselves had agreed upon, and which the workman acted legally in regarding as an available asset coming to him when both injury and disease had totally incapacitated him for earning wages.

The employers' appeal was dismissed, because the Judge evidently thought that when the employers elected to give proof merely that the man was in his new job getting his old wages, the "light job" was apparently not such as a man with the applicant's physical disability could do. This case brings home the fact that the workman's accident justified the man asking for a memorandum of agreement to pay half-wages during incapacity. This decision shows the danger of offering light work. The payment of a lump sum in final satisfaction would be a safer mode of settlement than continuing the workman's services unless there were reasons to believe it was such light work as would be equal to his physical capacity.

Review of Sailor's Injury Case.—The appeal of Moss and Co. was that of the employers in the case of an award to a workman named Akers, made by the Swindon County Court Judge, who, having heard all the facts of the case, recorded the award, and dismissed the employers' appeal to terminate or diminish compensation payments. It appeared that in October, 1909, the workman—a fireman on board the employers' ship—contracted blood-poisoning in his hand, and was taken to hospital. On June 10 a memorandum of agreement was filed, and in December an application was made for review. In February it was sent to the medical referee, before whom it was contended on behalf of the employers that the blood-poisoning was better, but that the muscles of the hand were stiff for want of exercise. It was argued that a new chain of causation had been set up—that is, that the accident for which compensation was awarded was no longer the cause of the man's present incapacity, but unreasonable refusal to use the hand. The Court of Appeal agreed with the County Court Judge, who determined on the medical facts, and dismissed the appeal.

HOUSE OF LORDS.

Arising out of Employment.—The question whether an accident for which compensation is claimed arose out of and in the course of the workman's employment is the crux of most cases. As a rule, the facts are made clear in the County Court, but when some obscure legal point is in dispute the appeal may be carried to the House of Lords, as in the case of Kitchenham (pauper) *v.* Owners of the s.s. Johannesburg. In this case the appeal from the Court of Appeal was taken to the highest Court, free of costs to the applicant, by the widow of George Kitchenham, a deceased workman, who, on December 28, 1909, was in the employment of respondents when the fatal accident happened for which compensation was claimed.

The question was whether drowning happened in the course of the man's employment or arose out of it. The deceased was a steward on the respondents' s.s. Johannesburg, which was anchored in South Shields harbour on December 28, 1909. The man had liberty to go on shore, without applying for leave, when he had finished his day's duties. On the day of his death he had gone ashore to post money to his wife, and at 10.25 at night he returned on board ship, there to sleep. His next day's duties would have begun in the morning at 7.30. He was seen at night going aboard by the watchman, at the dock gates, and soon after the alarm "man overboard" was raised by the watchman on board ship, a splash being heard in the water near the ship's side. The only access to the ship was by the gangway, resting on the quay.

The County Court Judge made an award for 250*l*. The shipowner's appeal from the County Court was allowed by the Court of Appeal, and the widow's appeal dismissed by the Lords. For the employers it was argued that the deceased had not been on any duty arising out of his employment, and that his errand ashore never brought him in the way of the fatal fall into the dock in the course of his employment.

The law in such circumstances is regulated by the Appeal and House of Lords cases, and determines the question "whether the accident arose out of, and in the course of, the workman's employment." The cases are of infinite variety, but the Lord Chancellor said, "I am only going to say that in my view I agree with the doctrine of Moore *v.* Manchester Liners, 26 T.L.R. 618, 1910. In the present case, we are to say, first, whether the accident was in the course of the employment. I think it was. The return of this man to his ship was in the course of his employment. We are next to say, Did the accident arise out of the employment? I think not." The other noble lords agreed, without comment, and dismissed the appeal on a point of law, for, of course, they left the facts of the case to the County Court Judge, who alone decides questions of fact. The difference between an accident, demanding compensation when it arises out of the employment, and one occurring in the course of the employment, is made clear by these seamen's cases, such as the above, and the leading case of Moore *v.* Manchester Liners.

Seamen frequently meet with an accident when in the course of their employment in a strange port. It often happens when they are not at work on board ship, but on going or coming to their ship, and, of course, their leisure, as well as their working hours, is occupied away from home as sailors, and in the usual course of their employment. What they may be doing when the accident arises does not always arise out of the employment.

The Lord Chancellor remarked, "the facts of each case were infinitely different, and if they were to differentiate them in courts of law, judgments would lead to confusion rather than enlightenment. The appeal judgment in Moore *v.* Manchester Liners, reversed by the House of Lords, is an instance of the subtle differences of opinion between the Court of Appeal and the House of Lords."

TABLE IV.—*Particulars of Service of Locomotive Illustrated on this Page.*

FIG. 22.

Railway	Monthey-Champéry
Gauge	1000 mm. (3 ft. 3⅜ in.)
Rack system	Strub
Maximum gradient	34 in 250
Minimum radii of curves ..	60 m. (197 ft.)
Speeds	10 and 25 km. per hour (6.2 and 15.5 miles per hour)
Tractive power, maximum ..	8000 kg. (7.8 tons)

THE BAGDAD RAILWAY.—The different works in connection with the Bagdad Railway progress satisfactorily according to the plan. The laying of rails has already been carried beyond the highest point of the Taurus section, the first section to be opened for traffic being the 25 miles from Bulguren to Ulukischla; a further section, from Dorak to Deirmen-Odjak, across the Adana Plain will be opened before the end of the year. An alteration in the direction of the line, whereby the main line, Constantinople-Bagdad-Persian Gulf will go direct *via* Aleppo, has somewhat retarded their work on this portion of the line. Apart from the concession, about the continuation of the main line, the company has concluded a convention with the Government about the construction and working of a branch line, some 45 miles long, from Osmanié or Mustapha Bay to the projected port of Alexandrette.

MODERN DIESEL OIL-ENGINES.*

By F. SCHUBELER, of London.

IN undertaking to read a paper on Diesel engines before this Institution the author is somewhat afraid that it will hardly be possible to bring forward entirely new information. This subject has been dealt with so thoroughly in many recent publications that very probably many members have learnt more about it than can be discussed in the short time at the author's disposal. Furthermore, the author regrets it has not been possible to show lantern-slides, which would have greatly assisted his explanations; but he is glad that there will be an opportunity for those who are specially interested to study this question when visiting the works of Sulzer Brothers. The paper will therefore only give a short survey of the very practical development of the Diesel engine up to the present day. This may be taken as having started shortly after Mr. H. Ade Clark read his paper† on "Diesel Engines" before this Institution in 1903.

As is already known, it was the intention of the inventor to burn coal direct in the working cylinder, which, however, proved to be impossible, as the unburned residues could not be removed from the cylinder. This condition of things will remain unchanged, and only oils will be used as fuel; these. however, are of the most composite properties, as will be described later.

For dealing with liquid fuel the propositions made by different designers varied principally only in the arrangement of the air-pump and the construction of the fuel-valve. For instance, Haselwander and Trinkler used the working cylinder, so to speak, as the first stage of the air-pump by extracting air during the compression stroke from the former as soon as a certain pressure (about 100 lb.) was reached, and only producing the differential pressure for the injection air (700 lb. to 900 lb.) in the actual air-pump. Haselwander had his air-pump combined direct with the working piston by a differential arrangement, whereas Trinkler provided a special air-pump in the cylinder-cover. Other designers proposed an intermediate process between those of the ordinary gas-engine and the Diesel engine. Thus Sabathé advocated compression up to 300 lb. and artificial ignition of part of the fuel. The Brons motor, as still carried out by the Gasmotoren-Fabrik Deutz for smaller units, has also similar features. Generally, however, it can be stated that most of the above-mentioned propositions have disappeared, and some have not even been carried out, all of them giving place to the well-known Diesel principle, with its characteristics: compression in the working cylinder up to the ignition temperature of the fuel (about 500 lb., or about 1000 deg. Fahr.), and creation of the pressure of the injection air (600 lb. to 850 lb. per sq. in.), by means of which the fuel is introduced atomised into the cylinder, in an independent multiple-stage air-pump. It is only natural that the development of this principle has caused some difficulties in the beginning. In the hitherto-known steam-engine the working process takes place partly in the boiler, and only partially in the working cylinder. The boiler, which has no moving parts, deals with the heaviest part of the process, and furnishes the working fluid in a refined state to the working cylinder, whereas with the Diesel engine the whole process has to be dealt with in the working cylinder. That it has been possible within a respectively short period to develop the Diesel engine to such a degree as to enable it to compete successfully with the steam-engine also for large units, certainly proves the present-day skill and thoroughness of engineering. It may be stated that, as regards reliability, the Diesel oil-engine can now be considered as fully equal to the steam-engine, it being only a question of economy in each individual case which of the two prime movers takes the preference. There was one principal difficulty which had to be overcome. The extreme high pressures and temperatures of the Diesel process put a limit to the dimensions of the cylinders, which will hardly exceed a diameter of 39 in. This corresponds to an approximate cylinder output of 300 to 400 horse-power, assuming 150 revolutions per minute of the shaft and ordinary Otto cycle. Theoretically there would be nothing in the way to obtain any desired output by arranging any number of cylinders side by side. Practically, however, it is not advisable to provide for more than six cranks, as a larger number would produce an inadmissible twisting of the shaft. Furthermore, such units require a great amount of space, and would become extremely costly. These reasons called forth the necessity of seeking other means by which to increase the specific cylinder output of the ordinary single-acting Otto-cycle engine.

For this there are the following possibilities:—

(1) By carrying out the single-acting Otto-cycle machine as a double-acting one.

(2) By adopting the single-acting two-stroke cycle working process.

(3) By adopting the double-acting two-stroke cycle working process.

The double-acting Otto-cycle cylinder under (1) corresponds approximately to a doubling of the cylinder output.

Almost the same result can be obtained by the procedure under (2), which, however, necessitates, as will be explained later on, the provision of special scavenging pumps.

The solution under (3) would, theoretically, even quadruplicate (in fact, by increasing about 3.4 times) the output of the ordinary Diesel-engine cylinder, and mean the adoption of the usual working process of steam-engines also for the oil-engine.

The author will try in the following to throw a little more light on these various solutions in order that their respective advantages and disadvantages may be seen. As is known, this subject is, for the time being, a very disputed one, and has not developed so far yet as to permit any definite statement with regard to which of the solutions will be ultimately adopted for the large Diesel units. It has, however, been ascertained that for smaller and medium size units the single-acting Otto cycle takes the preference, the same involving the smallest working strain on the cylinder. Although this type of engine necessitates a more or less frequent cleaning of the internal parts, especially of the exhaust-valves, the author is informed that such machines have worked for periods of six to eight weeks without interruption, even in cement factories and mills.

The normal type of the single-acting four-stroke cycle engine is a vertical one with trunk piston and without special crosshead. This has not only the advantage that

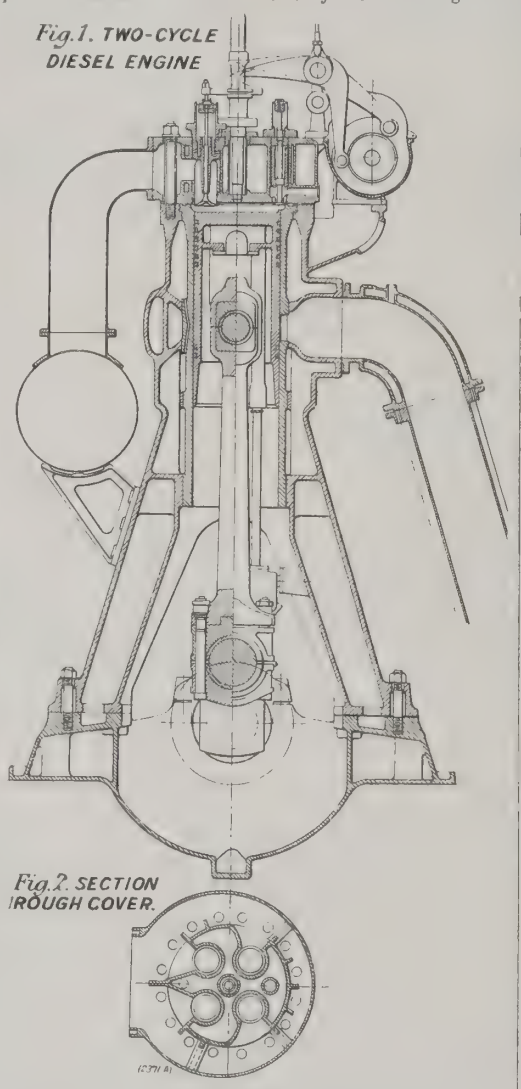


Fig. 1. TWO-CYCLE DIESEL ENGINE

Fig. 2. SECTION THROUGH COVER.

the wear and tear of the piston is very slight, but also others with regard to the construction of the fuel-valve and the symmetric shape of the combustion-chamber. The space required is comparatively small, which is frequently to-day an important advantage, and permits a good utilisation of the foundations upon which the enormous free forces of the cylinders are transmitted vertically.

The horizontal type, which is carried out by various firms, is specially suitable where small heights are essential, and resembles in its construction that of the normal gas-engine. The free forces are more awkward to deal with, and some difficulty also arises with regard to the formation of the combustion-chamber and the introduction of the fuel into the cylinder.

The author will proceed first with the single-acting two-stroke cycle-engine shown in Figs. 1 and 2, and will deal with the double-acting engines later on. The first trials with a Diesel engine of this type were made some 10 years ago. Owing, perhaps, to the choice of too small an output, and also some other inadequacies, this first attempt was not repeated for some time. It may be useful to recall some of its principal features. An exhaust-valve is dispensed with, the piston uncovering, at the end of its outward or downward stroke, slots arranged in the cylinder wall, through which the burnt gases escape from the cylinder. By means of a special scavenging pump an air-pressure of about 4 lb. is produced. This lightly compressed air enters the cylinder through a valve arranged in the cylinder-cover, drives the burnt gas out of the cylinder and fills the latter again with a new charge of air as soon as the piston in its upward motion covers the slots. The air-valve being closed, the air is compressed as in the ordinary Otto-cycle engine, and the fuel is introduced in the same way at the end of the upward stroke. The whole process of driving out the gases and the refilling of the cylinder takes place within a very short time at the end of the outward or downward stroke. The length of the slots is about one-fifth of the stroke. With the ordinary Otto-cycle machine two entire strokes are available for this process, giving, however, thus only half the number of impulses which can be obtained with the two-stroke cycle type.

As to the two-stroke cycle process, this is the same as the well-known one employed with the highly-developed gas-engines (Körting, Oechelhäuser). It will be seen from the following that it is even more suitable for the Diesel engine. The two-stroke cycle gas-engine scavenges also at the stroke end with fresh air, the difference, however, being that already at this stage of the process the combustible mixture is introduced into the cylinder by a special gas-pump, and this even before the exhaust slots are entirely closed. It therefore cannot be avoided that part of the combustible gases escape unused in the exhaust, creating thereby a possible danger for the engine. With the Diesel engine the fuel is only introduced at the end of the compression stroke, thus preventing any losses of fuel and danger of pre-ignition. The Diesel engine has furthermore the advantage that the rather bulky and power-absorbing gas-pump can be dispensed with. It has also been ascertained that two-cycle gas-engines show an increased fuel consumption at partial loads, whereas the consumption of the two-stroke cycle Diesel engine, with smaller load, only differs slightly from that obtained at normal load. With regard to the fuel consumption in general, it must, of course, be expected that the consumption of the two-cycle engine will be somewhat larger with respect to the effective output than in the case of the single-acting Otto-cycle engine. This must amount at least to the percentage of the energy absorbed by the air-pumps. There must also be another increase due to the short cleaning and filling process of the cylinders, which does not allow as perfect a scavenging as with the four-cycle engine. With the latter under its worst conditions, about 7 to 10 per cent. of the cylinder volume (representing the compression space) is liable not to be fully replaced by fresh air. Fig. 3, on the opposite page, is a diagram from a two-cycle Diesel engine.

As a main advantage it may be mentioned that the turning moment is much more favourable, and consequently the revolving masses for obtaining a certain degree of cyclic variation are much lighter. The two-cycle engine furthermore guarantees better starting and better conditions for regulation, which is specially important for direct coupling with alternators. The space required is considerably smaller, and the engine is also lighter, and therefore cheaper. To give a figure, the difference in price between an ordinary single-acting four-cycle and a single-acting two-cycle engine for a capacity of 1000 horse-power already amounts to about 25 to 30 per cent., which figure would have to be considerably increased if larger units were compared. Furthermore, the lubricating-oil consumption is somewhat smaller per horse-power, as the same cylinder and bearing dimensions are sufficient for producing about double the output.

It still remains for reference to be made to the chief advantage of the two-stroke engine—that is, the elimination of the exhaust-valve (or two in larger units). Some difficulties cannot be avoided with the latter, as soon as the same attains larger dimensions. Generally speaking, the fewer working parts coming into contact with the hot gas the better. The scavenging-valve (or valves) in the cylinder-cover may be dispensed with. Only a part of the cylinder slots are then used as exhaust-slots, the remainder on the opposite side being used for the introduction of the scavenging air. A special shape is given to the top of the piston to guide the current of the scavenging air and to guarantee a thorough removal of the burnt gases. The scavenging-valve is thus removed from the high temperatures, and only the fuel-valves and starting-valves exposed to the same.

It is self-evident that for the continually advancing engineer the problem of the double-acting Diesel engine was attractive, especially as he already had excellent models in the gas-engine, for which the stuffing-box problem may be regarded as solved. On the other hand, it must be admitted at once that with the Diesel engine the conditions to be dealt with are much more unfavourable, only to mention the higher pressure. It will, therefore, be preferable to avoid the difficulties with the stuffing-box in the first instance, and to develop the new type on the lines of the single-acting four-stroke cycle engine, especially as the gain in output is practically the same. To go at once to the double-acting two-cycle engine without first gaining experience with the single-acting engine seems to the author not to lie in the course of a natural development, and to be somewhat risky. As to the design of an engine of the latter type—namely, the double-acting two-stroke engine—this favours the provision of a special crosshead, and also the horizontal arrangement. This being so, it may be derived from gas-engine and steam-engine practice that for the support of the pistons a rear stuffing-box, with bearing support for carrying the weight of the pistons, has to be provided, which is certainly far from being desirable. In addition, great inconvenience is caused by the piston-rod having to pass through the combustion-chamber, and necessitating an eccentric introduction of the fuel. The combustion process must therefore be far more unfavourable, and the construction of the valve-gear more complicated. The proper setting of the two compression clearances on both sides of the piston is not as simple as with the single-acting engine, where by a shortening or lengthening of the connecting-rod the compression can be proportioned to any amount desired. With the double-acting machine a compromise has always to be made, and the length of the piston-rod has to be provided for an average compression on both sides.

When used for special purposes—the author has in mind its application for ship propulsion—the engine must be

* Paper read before the Institution of Mechanical Engineers, Zurich Meeting, July 25.

† Proceedings of the Institution of Mechanical Engineers, 1903, Part III., page 395.

built as a vertical one, and it seems to him that the valves arranged in the lower cover of the cylinder are not easily accessible. Moreover, the difficulties with regard to the gear should not be overlooked. He would also mention the excessive height of this kind of machine, which is a great disadvantage when used for men-of-war, as there would be considerable difficulty in arranging such engines within the armoured height.

The constructive details of the various types of Diesel engines may be described together, as a large number of the component parts remain the same whether used for this type of Diesel engine or the other. This especially applies to the fuel-pump, fuel-valve, air-pump, piston, &c. The author will not, however, spend much time on this subject, as it is already sufficiently known, and as a visit to Winterthur is arranged. The air-pumps are to-day generally carried out as two or three-stage piston-pumps, with inter-coolers. Whereas smaller units have, as a rule, an air-pump attached to each cylinder, driven by a lever from the connecting-rod, it is a general practice to provide for larger units one large common air-pump producing the injection air for three or more cylinders. The pump may be arranged either horizontally or vertically at one end of the bed-plate. This arrangement reduces the number of engine parts to be controlled, and also the first cost. The valves are generally metallic ones, which alone are able to stand the high temperatures.

The design of the scavenging pump used with two-stroke cycle engines does not call for any special remarks. The air-supply may be controlled and regulated by poppet or slide-valves. A very neat combination of this scavenging-pump with the air-pump is carried out by Messrs. Sulzer Brothers, who use the crosshead of the scavenging-pump as low-pressure stage for the injection-pump, which they hope to be able to show in the works.

For lubricating the cylinders, special small oil-pumps—that is, one for each cylinder—are provided. For bearings, connecting-rods, &c., forced lubrication is generally advocated. The pump for the forced lubrication is driven direct from the shaft, and may be a piston or cog-wheel pump. The motors fitted with forced lubrication are totally enclosed, the dripping oil being gathered in the bed-plate and sucked up again by the pump after having passed through filters and coolers. Oil-holes are bored in the shaft and connecting-rods, which take the oil from the bearings up to the respective crosshead pins and other places where lubrication is required. The cylinders are always cooled, the pistons only from a certain size upwards. The water is generally led to the engine by gravity, and only under a small head.

For piston-cooling several solutions are possible. In most cases a telescopic arrangement is provided. The disadvantage of this solution is the necessity of providing a stuffing-box to prevent leaking water getting into the plate and mixing with the lubricating oil. With the stuffing-box arranged in the piston it is impossible to tighten it when the engine is running. If the same is arranged unmovable on the frame, heavy arms have to be attached to the piston, which involve a considerable eccentric strain on the latter, and cannot therefore be recommended. In other devices joints are made use of, which, however, are subject to similar disadvantages. A very simple arrangement for the piston cooling, which does not require any stuffing-box, and the working of which is absolutely reliable, deserves mention. With this arrangement the water does not entirely fill the cooling space of the piston; the water is only squirted against the highly-heated surfaces and drains off through a pipe which surrounds the spray-pipe. By this arrangement all additional pressures and strains are eliminated. Some firms use oil for piston-cooling, which may have some advantages, but which, on the other hand, has the disadvantage of a smaller cooling effect owing to the smaller specific heat and the smaller coefficient of transmission of this liquid. If the oil is taken from the general oil system of the engine, the cooling device for the oil has to be increased accordingly. The exhaust-valves for smaller motors are not cooled. Some firms use no cooling device even for larger motors, which is an important constructive simplification; whereas other firms have the larger exhaust-valves water-cooled.

The author will now make a few remarks about the regulating process of the Diesel engine. In practically all types the fuel-valve is operated through levers and rollers by cams fixed on a side shaft, which open the valve during 10 to 15 per cent. of the stroke, irrespective of load. The amount of fuel allowed by the regulator for any specified load accumulates around the fuel-valve spindle in a space filled with the highly-compressed air, which, at the opening of the spindle, forces the oil through an atomiser into the cylinder. At smaller loads the regulator acts upon the fuel-valve in such a way as to reduce the quantity. The fuel-pump has a constant stroke, and the regulating of the fuel quantity takes place by the governor acting upon the suction-valve, through which part of the fuel thus flows back into the suction-chamber. If a greatly-reduced oil quantity is delivered to the fuel-valve, or, in other words, at small loads, it may happen that no ignition is effected, probably on account of the great air surplus extinguishing the forming flame. To avoid this the air-pressure has to be reduced at smaller loads, which is done by hand in the case of smaller engines. Should this regulation be forgotten, no danger arises from the engine, the result being only a decrease in the number of revolutions until the regulator again delivers a somewhat increased fuel quantity. For larger engines, and especially where the conditions for synchronising are more stringent, the regulation of the injection air is done automatically by the regulator.

A question which is of the greatest interest both to the manufacturer and to the client is the choice of fuel. It is certainly very surprising that the results of chemical analyses of different fuels do not furnish exact information with regard to the suitability of the fuel for Diesel engines, so that this can only be decided by the actual tests. It happens that oil of a certain composition is quite satisfactory, whereas another of an absolutely similar consistency is unsuitable. It may be stated here that there is a large selection of cheap liquids available, the most important being: crude mineral oils, mineral oil residues (crude naphtha, mazout), gas-oils—that is, intermediate products of oil-refineries from which the lightest constituents, such as benzine and petroleum, have been distilled, and the gas oil-tars of water-gas works. More recently it has been found possible to utilise the by-products of the distillation of coal and paraffin, tar-oil, solar-oil, and paraffin-oil. Explosions or danger of fire on account of the high flash-point are eliminated, and any quantities of such fuel may be stored without danger, and without being subject to the restrictions made by law.

Different working conditions naturally require different types of the Diesel oil-engines. The piston speed is generally between 600 ft. and 1000 ft. per minute, which cannot be reduced below a certain limit, as otherwise the slightest leakage could prevent the compression attaining the required amount. This is especially important for marine Diesel engines when they are to run dead slow. The piston speed can, however, be as low as 180 ft. to 200 ft. per minute for continual service.

For standard slow-speed single-acting four-cycle engines the number of revolutions lies between 150 and 300 at respective capacities of 1000 to 15 horse-power. These engines have the best fuel consumption, but have also the

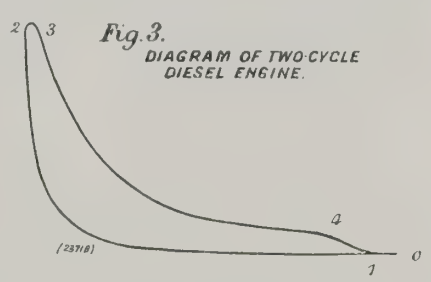


Fig. 3. DIAGRAM OF TWO-CYCLE DIESEL ENGINE.

disadvantage that they are heavy and expensive. For this reason a single-acting multiple-cylinder high-speed four-stroke cycle engine was created, which is especially suitable for direct coupling to dynamos. The speed varies between 220 and 350 revolutions per minute at units varying between 1000 and 100 horse-power. These high-speed types, if suitably designed and carried out by first-class manufacturers, are just as reliable in service as the slow-speed types. They have, however, a slightly higher fuel consumption. On account of their smaller first cost they are especially suitable where the Diesel engine is intended as a stand-by. For very small auxiliary engines, up to about 100 horse-power, on board ship, the speeds are still higher and range from 400 to 600 revolutions per minute and even higher.

Single-acting two-stroke engines with outputs ranging between 700 and 3000 horse-power are carried out with speeds of 160 to 140 revolutions per minute.

For ship propulsion there is a tendency to use lower speeds in order also to obtain a good propeller efficiency. To give some figures, 100 to 350 revolutions per minute may be taken as limits for sets of several 1000 horse-power down to 100 horse-power.

This approximately defines the application of the Diesel oil-engine for various purposes, amongst which the last-mentioned for ship propulsion is at present of universal interest. Hardly ever before has so much been written and discussed about an engine type as at present of the marine Diesel engine. It may well be stated that this is frequently done by firms who have not recognised and thoroughly studied the difficulties of the problem. Such a treatment of this question, though somewhat characteristic of modern times, is certainly an unsound one, and failures are sure to follow. This will no doubt affect the reputation of the Diesel engine for marine purposes, and retard its general application, which will especially be regretted by those firms who are really able to build reliable engines for this purpose. The author takes this opportunity of requesting the members to initiate a development, which is somewhat slower, and thereby more natural, as this alone will guarantee a lasting success.

Following this course, the normal four-cycle Diesel engine was first adapted for marine purposes, and there are several boats running with such engines. This type, however, having, as already mentioned, a limited output, and being, moreover, heavy, has the further disadvantage that the most essential feature of the marine engine—namely, the problem of direct reversibility—cannot easily be solved. For smaller crafts the propeller can be made reversible, or a special reversing gear can be fitted upon the shaft, similar to those used in motor-cars. Another possibility is to produce with a normal non-reversible Diesel engine electricity in a generator, and have the propeller coupled to an electric motor, which can easily be made reversible. This system, the so-called Delproposto system, which otherwise gives good results, is not very economical on account of the numerous transformations of energy. It is also rather complicated, expensive, and heavy. The first boat of this type is the steamer Vandal, on the Wolga, carried out by Messrs. Nobel. A similar Diesel boat, the Venoge, was built by Messrs. Sulzer Brothers in 1904 for the Lake of Geneva. The engine has an output of 100 horse-pewer. Another inconvenience of the four-stroke cycle type is the presence of exhaust-valves, which necessitate a more or less frequent cleaning.

These difficulties, including also the last-mentioned one with the exhaust-valves, could be overcome by adopting the two-cycle engine. A number of boats fitted with such engines, with outputs up to about 1000 horse power, are in satisfactory service. The reversibility can easily be attained. It may be mentioned that Messrs Sulzer Brothers have done the pioneer work here in exhibiting the first engine of this type at the Exhibition of Milan in 1906. For outputs below 1000 horse-power these engines may be of the ordinary trunk-piston type, whereas for larger units crossheads should be provided. The appearance of such an engine does not differ considerably from that of the well-known steam marine engine. Some firms have already gone further, claiming to be able to carry out a double-acting two-stroke machine. Unfortunately, the results obtained with such engines are unknown to the author, and a definite decision—whether single-acting or double-acting engines are most suitable for marine purposes—cannot be given for the time being. The author for his part feels somewhat doubtful whether success has already attended such efforts. Preferably a two-propeller arrangement is adopted, and with larger units the scavenging-pumps will be separated from the propulsion engines and driven by independent non-reversible Diesel units.

The space required for marine Diesel engines is smaller than for steam plants, the difference amounting to about 30 to 50 per cent., and the saving in weight is also considerable, reaching as much as 50 per cent. With marine Diesel engines it is possible to attain a larger radius of action for ships, which can be five to six times as large as that for ordinary steamboats. The taking on board of the fuel is also simpler, cleaner and quicker, than the coaling of steam vessels. An advantage, which must not be overlooked, is the saving in fuel consumption through the absence of preliminary heating and stand-by losses.

Reference may here be made to the paper read by Mr. Shackleton at the Institute of Marine Engineers, which gives an interesting comparison between "steam" and "oil," and contains in addition noteworthy information about the marine Diesel engine. Another important point is that the Diesel engine can be started at any time and within the shortest period, no extensive preparations being required. The largest output per cylinder may be taken at present at about 500 horse-power, but, considering the great efforts being put forward, 1000 horse-power cylinders will soon be no rarity. As soon as this is the case the marine Diesel engine will be in a position to compete successfully with the steam-engine, and will certainly hold the field.

Regarding other applications of the Diesel engine, attempts have been made to build also Diesel locomotives, but the author regrets not being in a position to furnish any information. The adoption of the Diesel engine for motor-cars and aeroplanes does not seem to be very promising, on account of the high pressures and consequent heavy and expensive constructions, not only for the engine, but also for the accessories.

One word is required as to the thermal conditions of the engine. The calorific efficiency, respective mechanical output, may attain 30 to 40 per cent.; 25 to 30 per cent. are lost in the cooling water, and the rest is contained in the exhaust-gases. Of the latter heat, about 20 per cent. can eventually be utilised for heating purposes, and in adding also the heated cooling water, the total efficiency of a Diesel unit may go up to 80 per cent., which is certainly remarkable. Messrs. Sulzer Brothers have brought out a special waste-gas utiliser, which it is hoped may be shown in the works.

With regard to the actual costs per brake horse-power hour, in assuming a fuel price of 50s. per ton (which is certainly an outside figure), this will amount to about 0.11d. to 0.13d., or about 0.16d. to 0.2d. per kilowatt-hour. These figures are the actual figures maintained during actual service, assuming, of course, that the engines are kept in good condition. The author hopes that the discussion will raise other points of general interest, which are omitted in this paper, or throw further light on others mentioned therein.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Through the courtesy of Mr. Maurice Fitzmaurice, C.M.G., M. Inst. C.E., Chief Engineer of the London County Council, and Vice-President of the Association, arrangements have been made that will enable the members, on Saturday, July 29, at 3 p.m., to visit the sewage pumping works at Crossness, Kent.

THE HEALTH RESORTS ASSOCIATION.—This association, whose offices are at 29, John-street, Bedford-row, W.C., have issued illustrated pamphlets dealing with Swanage, Cardiff, Penarth and Barry, Southwold, Deal, and Llandrindod Wells. These give useful information on the various places, and they can be obtained free by applying to the town clerk in each township.

THE INTERNATIONAL ELECTRO-TECHNICAL COMMISSION.—An interim report just issued by the International Electro-Technical Commission states that the British, French, and German delegates met at Cologne in the middle of May. Professor Eric Gerard (Belgium), who had presided at the Brussels Conference last year, was especially invited to attend. The other delegates present were Messrs. E. Brunswick (France), E. Budde (Germany), S. P. Thompson (Great Britain), and C. E. Le Maistre (secretary-general, 28, Victoria-street, Westminster, S.W.). Dr. Budde having stated that the Germans would be ready to abandon the symbol W for resistance (R), provided that I (not J, used in other respects) were adopted for current (instead of C), the meeting agreed to recommend this proposal to the Conference to be held a Turin. Thus the I, E, R would become international symbols. Fifty "industrial terms" and definitions, as distinct from scientific definitions, of the German list were then agreed to in English and French.

FOREIGN ENGINEERING PROJECTS.

WE give below a number of foreign engineering projects; further data concerning the same can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C. :—

Spain: The *Gaceta de Madrid* states that the Dirección General de Obras Públicas, Ministerio de Fomento, Madrid, announces a competition of plans for the construction of a strategic railway from Alcántára to San Vicente de Alcántara. The line must be single track, of 1-metre gauge, and the rails must weigh not less than 30 kilog., and for steep gradients not less than 35 kilog., per lineal metre. Means must be provided for the transport of artillery. Plans and specifications (legalised in Spain) should be sent in by February 10, 1912. The *Gaceta* also notifies that the Dirección General de Obras Publicas has awarded to the Compañia de los Ferrocarriles Estratégicos y Secondarios de Alicante a concession for the construction of a secondary railway from Alicante to Villajoyosa. It further contains notices, issued by the Dirección General de Obras Publicas, authorising Don Cipriano Tejero Sánchez to prepare plans for the construction of two steam tramways (1) from Almagro to Valdepeñas (Madrid), passing by way of Moral de Calatrava, and (2) from Quintanar de la Orden to San Clemente (Provinces of Toledo and Cuenca), passing by way of Toboso, Venta del Cuervo, Santa María de los Llanos, El Pedernoso, Las Pedroñeras, and El Provencio. It publishes a Royal Decree, under the Law of 1880, issued by the Ministry of Fomento, assigning a credit of 7,750,000 pesetas (about 287,000*l.*) to be distributed as subventions to various Harbour Boards as follows: — Alicante, 400,000 pesetas; Almeria, 400,000 pesetas; Algeciras, 100,000 pesetas; Barcelona, 150,000 pesetas; Bilbao, 350,000 pesetas; Cádiz, 800,000 pesetas; Cartagena, 220,000 pesetas; Castellón, 300,000 pesetas; Coruña, 590,000 pesetas; Huelva, 350,000 pesetas; Gijón-Musel, 300,000 pesetas; Málaga, 290,000 pesetas; Mundaca, 50,000 pesetas; Palma, 150,000 pesetas; Pontevedra, 150,000 pesetas; Ribadesella, 100,000 pesetas; Santander, 400,000 pesetas; Santa Cruz de Teneriffe, 100,000 pesetas; Seville, 420,000 pesetas; Tarragona, 300,000 pesetas; Valencia, 250,000 pesetas; Vigo, 300,000 pesetas; Las Palmas, 200,000 pesetas; Denia, 50,000 pesetas; Ferrol, 30,000 pesetas; Ceuta, 500,000 pesetas; and Melilla and Chafarinas, 500,000 pesetas. (27 pesetas = 1*l.* about), at present.

Cuba: The *Gaceta Oficial* publishes Decree No. 467, granting to the "Société Immobilière de Cuba" a subsidy of 11,000 pesos per kilometre in respect of the construction of a railway from Guantánamo to Baracoa. (Peso = 4s. 2d.).

Brazil: The *Diario Official* publishes Decree No. 8784 approving the plans submitted by the General Directorate of Communications and Public Works, for the carrying out of harbour improvements and extensions in the port of Paranagua, State of Paraná. The cost is estimated at 8,000,915 milreis currency (about 533,000*l.*) and 450,000 milreis gold (about 50,000*l.*). The *Diario* contains also Decree No. 8785, approving the plans, submitted by the General Directorate of Communications and Public Works, for the carrying out of harbour improvements at Jaraguá, State of Alagoas. The cost of the work is estimated at 11,700,000 milreis currency (about 780,000*l.*).

Argentina: With reference to the proposed expenditure in Argentina on public works, H.M. Legation at Buenos Aires has reported that on May 13 the Minister of Finance introduced a Bill to authorise the floating of an external loan of 12,000,000*l.* for the completion of certain public works in course of construction. The loan was to be external owing to the difficulty of floating bonds internally. The amount was raised to 14,000,000*l.* during the passage of the Bill, which finally became law early in June. The law provides for the carrying out of the following works:—

	£
Building of new warehouses at port of Buenos Aires, extension of breakwaters in North Basin, installation of machinery for loading and discharging merchandise (Law No. 5126)	1,790,000
Construction of railways and other public works for development of the National Territories (Law No. 5559)	3,348,794
Construction of railways (1) from the port of Diamante to join the line from Monte Caseros to Posadas, continuing by Cuchilla Grande and through Curuzu-Cuatia, and (2) from the Port of Paraná to join up with (1) and finally to make a junction with existing lines in the provinces of Entre Rios and Corrientes (Law No. 6341)	2,120,000
Construction and equipment of national railways (Laws Nos. 6011 and 8117)	4,000,000
Erection of the new Law Courts (Law No. 8115)...	792,000
Construction of various works to be provided for by a later law	2,000,000

The works to be paid for out of the external loan now being floated are different from those for which the internal loan was intended, except in two cases, viz.:—

1. Construction and equipment of national railways, under Law 8117:—The amount was fixed by the Budget Law at about 4,000,000*l.*, reduced by the decree of March 11 to about 2,600,000*l.*, and is now fixed for the external loan at 4,000,000*l.*, as above.

2. Building and furnishing of Law Courts:—The amount was fixed by the Budget Law at about 525,000*l.*, which provision was cancelled by the later decree, and the amount is now fixed at 792,000*l.*, as above.

Morocco: With reference to a call by the Special Committee of Public Works for the construction of the first section of the beach road at Casablanca, His Majesty's Consul-General at Tangier (Mr. H. E. White, C.M.G.) now reports that he is informed by the President of the Committee that the final date for the receipt of tenders is August 24, and not August 29, as previously stated. Tenders should be addressed to "M. le Président du Comité Spécial des Travaux Publics, Dar En-Niaba, Tangier."

MINING MACHINERY. — The value of the mining machinery exported from the United Kingdom in June was 81,055*l.*, as compared with 101,365*l.* in June, 1910, and 80,039 in June, 1909. In these totals shipments to British South Africa figured for values of 40,019*l.*, 43,611*l.*, and 34,920*l.* respectively. The aggregate value of the mining machinery exported to June 30, this year, was 502,075*l.*, as compared with 648,802*l.* in the first half of 1910, and 412,148*l.*, in the first half of 1909.

CORROSION OF STEAM-PIPES BY SODA.—A case of corrosion of wrought-iron steam-pipes and cast-iron valves of a boiler plant by the soda in the feed-water is reported by Dr. E. Westhoff, of Düsseldorf, in *Stahl und Eisen* of June 29. The boilers had been used, at about 180 lb. pressure, for four years; an examination revealed strong corrosion of the dry steam-pipes, while the wet steam-pipes had remained in good condition. The boilers were supposed to be blown off every Wednesday and Saturday. Sunday was a day of rest, and the discovery was made on a Tuesday, when 21 gramme of soda were found per litre of feed-water. This high percentage of soda was evidently the result of accumulation, and the steam had carried soda particles with it, which had dried on the dry pipes and formed a white incrustation, while the wet steam had prevented the formation of a solid deposit. At high pressure and temperature soda dissociates into caustic soda and carbonic acid. That the latter attacks iron in the presence of water and oxygen has never been disputed; that diluted caustic soda likewise corrodes iron has been questioned, but the fact was established by Stahlschmidt in 1886, and has been confirmed by the recent researches of Heyn and Bauer, of Kröhnke and others, in connection with the re-opened discussion concerning the problem of the rusting of iron.

SULPHALIUM.—A new alloy of aluminium, to which the name "Sulphalium" has been given, has recently been placed upon the market by Messrs. Edward Le Bas and Co., Dock House, Billiter-street, London, E.C. For this several valuable qualities are claimed. Through the courtesy of this firm we recently had the opportunity of seeing the alloy cast and worked, when we were particularly struck by the facility with which it could be machined and cut, there being no dragging of the material, nor clogging of files, troubles so much associated with pure aluminium. The melting point of the alloy is slightly higher than that of aluminium, being, we are informed, about 1200 deg. Fahr., and the material weighs about 3 per cent. more than that metal when pure, though slightly lighter than the general run of aluminium coatings. Recent tests carried out by Messrs. David Kirkaldy and Sons, London, showed that castings direct from the mould had a tensile strength of from 7.8 to 9.7 tons per square inch, and an elongation before fracture of from 1.2 to 0.4 per cent. in a length of 4 in. Under compression the elastic limit in specimens 2 in. long and 1 in. in diameter is about 5.7 tons per square inch. The fracture was in all cases granular and sound. We understand that sulphalium is not affected by sea-water, and that it is being supplied in large quantities for Admiralty work. It appears also to be well suited for many parts of mathematical instruments, where stiffness and lightness are required. Experiments are, we believe, now being carried out with a view of rolling and drawing the material into sheets and wire.

CAB-TYRE-SHEATHED CABLE. — An interesting and novel form of sheathing for trailing cables is being employed by the St. Helens Cable and Rubber Company, Limited, of Warrington. The company, in addition to being large manufacturers of electric cables, have been makers of cab-tyres for the last ten years, and decided, in view of the hard service which their special rubber compound for cab-tyres proved itself capable of meeting, to experiment with it as a covering for trailing cables. When employed for tyres the compound proved itself to have great resistance to abrasion, high resilience, tensile strength, flexibility, and non-corrodibility, in addition to being waterproof, and as all these qualities are desirable in trailing cables, it appeared probable that the compound would be a suitable one with which to cover them. This anticipation has been well borne out in practice, and cables covered with the compound have proved very suitable for coal cutters or other similar work in collieries, for portable tools in shipyards, &c., for quay-side cranes, for tram wiring, or, indeed, for any exposed and hard service. The cable is made up of two, three, or four conductors, insulated with rubber and covered with the compound, and no external armouring or braiding is used. The interstices between the cases are rubbed with the compound so that there are no internal air spaces. This resists moisture creeping in. The covering resists abrasion well, so that even if the cable is used in a position in which it is continually trodden on or kicked about, it is well able to meet the conditions. If the covering is cut it does not fray or tear away as a braiding would, and is easily repaired. This special cable has now been in use for 18 months, and has been supplied to some 50 firms, and the makers inform us that in no instance has a complaint in reference to it been received.

CATALOGUES.

Small Tools.—From Messrs. Wallach Brothers, Limited, Royal LondonHouse, Finsbury-square, E.C., a copy of their catalogue of tools has been received. This catalogue illustrates and states prices of a great variety of spanners, pipe-wrenches, stocks and dies, screw-plates and taps, pliers, braces and bits, drilling-machines, hack-saws, files, vices, hammers, measuring appliances, and other hand-tools for engineers, wood and metal workers, painters, glaziers, &c.

Milling-Machines.—A copy of their catalogue of milling-machines has been received from Messrs. Schuchardt and Schutte, 34, Victoria-street, Westminster, S.W. The catalogue illustrates and gives full particulars, including principal dimensions and prices, of plain, universal, and profile milling-machines, with all accessories. Worm-milling-machines, rack-cutting machines, and machines for rounding the teeth of motor-car gear-wheels are also fully dealt with.

Armouring-Machine for Rubber Hose, &c.—Mr. W. Fürstenberg, of Brussels-Anderlecht, Belgium, has sent us a circular printed in five different languages, relating to an automatic machine for winding armouring-wire or tarred cord on rubber hose-pipes, electric cables, &c. The machine, which will deal with wire up to ⅛ in. in diameter, can also be used for serving cables with insulating tape and for any other work of a similar nature. Prices are stated for the machine and for various accessories.

Suction-Gas Plants. — A circular giving a general description of Ruston gas-engines and suction-gas producers has been issued by Messrs. Ruston, Proctor, and Co., Limited, of Lincoln. The circular gives a brief general description, with illustrations, of both producers and engines, which are made in seventeen sizes from 8 to 260 brake horse-power. Tables giving the weights, principal dimensions, and other particulars of these plants are also given.

Circuit-Breakers and Motor-Starters. — From Mr. George Ellison, Victoria Works, Warstone-lane, Birmingham, we have received price lists of circuit-breakers and motor-starters. The former are totally-enclosed triple-pole switches, fitted with overload and no-voltage releases, and are suitable for alternating-current circuits up to 650 volts. Two sizes are listed for maximum currents of 50 and 100 amperes respectively. The starters are of the star-delta type for three-phase squirrel-cage motors. They are totally enclosed and oil immersed, and are supplied with or without no-voltage and overload releases for pressures up to 600 volts. Prices are stated for two sizes, with contacts suitable for maximum currents of 50 and 100 amperes.

Centrifugal Pumps.—We have received from Messrs. Ruston, Proctor, and Co., Limited, of Lincoln, a catalogue section devoted to centrifugal pumps. Full particulars are given in tabular form, of helical-type pumps in twelve sizes, in which the delivery pipes range from 3 in. to 20 in. in diameter. These pumps are suitable for contractors, irrigation work, drainage, and all industrial purposes, and are designed for total lifts up to 80 feet. For lifts up to 165 feet, the delivery of one pump is connected to the suction of a second driven by the same shaft, and particulars are given of six of the smaller sizes so arranged. The catalogue also deals with a 2 in. pump with side-suction pipe for lifts up to 50 feet, and with ordinary centrifugal pumps for lifts up to 30 ft.; the latter are listed in eight sizes up to 12 in. delivery. Illustrations of retaining valves, exhausters, and other accessories are included.

First-Aid Outfits.—Messrs. Burroughs, Wellcome, and Co., Limited, of Snow Hill-buildings, E.C., have issued a small booklet giving particulars of first-aid outfits. In spite of the most elaborate precautions, accidents sometimes occur in all establishments where machinery is employed, and as the consequences of such accidents may often be rendered less serious by immediate attention, economic, as well as humanitarian, considerations should urge those responsible to provide the necessary materials and appliances for first-aid treatment. The outfits dealt with in the booklet range in size from a very complete equipment, in a wood or japanned metal case, suitable for use in factories, mines, large engineering works, &c., to a small and light pocket outfit specially intended for the use of aviators. The former contains a large number of surgical instruments, and a full supply of dressings, ointments, liquid medicaments, and drugs in "Tabloid" form —in fact, everything necessary for first-aid treatment, together with all the appliances and materials a qualified medical man would be likely to require on his arrival; such a set would form a useful adjunct to the medical equipment of a yacht or merchant steamer. The other outfits naturally vary in completeness according to the price.

CANADIAN SHIPBUILDING.—The British Canadian Shipbuilding and Dock Company has been organised by Mr. Grant Hugh Brown, of Broadway, New York, with a capital of 2,000,000*l.*, all of which has been subscribed. Sir Henry Pellat, of Toronto, is the chairman of the new company, and the directors include Lieut.-Governor Gibson, of Ontario, and Sir C. Ellis, of Messrs. John Brown and Co., Limited, Clydebank. The company will establish shipbuilding yards, docks, and shops at Sydney, Nova Scotia, where some 300 acres have been acquired. It is proposed to tender for the construction of four cruisers and six torpedo-boat destroyers for the Canadian navy. The company contemplates a line of fast steamers between Sydney, Nova Scotia, and Fishguard. The idea is to construct three 26-knot steamers of an improved Mauretania type.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

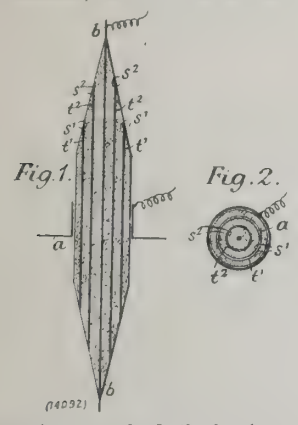
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

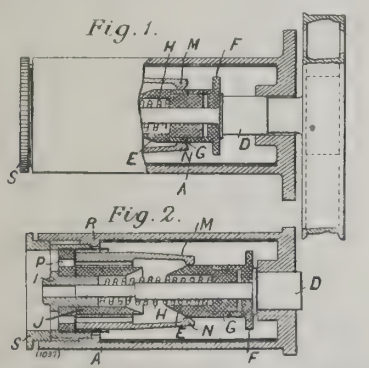
ELECTRICAL APPARATUS.

14092/10. Siemens Brothers' Dynamo Works, Limited, London. (*Siemens-Schuckertwerke, G.m.b.H., Berlin, Germany.*) **Electric Condensers.** [2 *Figs.*] June 10, 1910.—According to this invention, electric condensers in which intermediate conducting layers are inserted in the dielectric, either the intermediate conducting layers or the dielectric layers are formed of rigid bodies with hollow spaces into which, in the first case the dielectrics, and in the second case the conducting



material, is pressed or poured. In the drawings, s^1, s^2 represent metallic deposits on insulating surfaces t^1, t^2; the conducting powder between these surfaces and the glass or porcelain tubes are shown dotted; b is the leading in connection, and a is the outer sheath. It is only necessary, whatever may be the shape of the apparatus, that the insulating layers are separated one from another by layers which have relatively to the former, though not necessarily specifically, a high electrical conductivity. (*Accepted May* 17, 1911.)

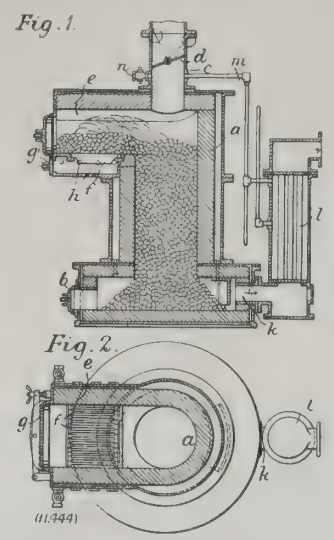
1037/11. A. W. Penrose, London. Electrical Switches. [6 *Figs.*] January 14, 1911.—This invention relates to switches for electrical lift systems for safeguarding gates, and is of the type in which a central guide-rod carries a contact-piece into or out of contact with spring terminals disposed in its path in certain positions. A is a casing, one end of which is closed and forms a bearing for the central spindle D, which has a collar to prevent its withdrawal through the bearing. The spindle D carries the insulating sleeves E and F engaging the metal contact-ring G between them, and it is also provided with a compression coil-spring H for actuating the switch when pressure on the spindle D is removed. The second bearing for the spindle D is formed by the terminal fixing I, which also takes the end



thrust of the spring H. The fixing I carries the insulating sleeve J and wedge-ended segments K, and the whole is fixed together, including the terminals M and N, by countersunk screws, so that the terminals will maintain a flexible contact with the ring G when opposite same. It will be seen that holes P are provided in the bases of the terminals M, N for the insertion of the wires, the bare wire being fixed and contact made by screws. The shoulder R stops the ingress of the fixing I, and, in conjunction with the finger-nut S, having a milled edge, firmly secures it in its place, while allowing of the whole of the fixing along with the terminal wires being slid off the spindle D at any time, and detached from the casing A by simply removing the nut S. (*Accepted May* 17, 1911.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

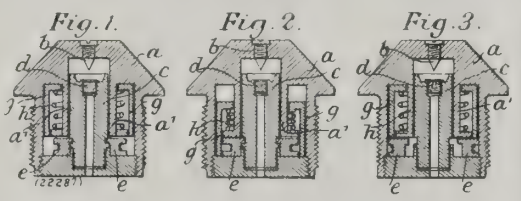
11,444/10. D. Clerk, H. N. Bickerton, and W. Bradley, Ashton-under-Lyne. Gas-Producers. [3 *Figs.*] May 9, 1910.—This invention consists in a gas-producer having a hearth, to which a limited quantity of air alone is supplied, situated at the side near the top of the producer, the fuel being charged on to this hearth and allowed to remain subject to coking action and then broken up and forced into the main vertical part of the producer, in which gas is formed by the action of steam and further air admitted at the top of the producer, the gas being let off at the bottom of the producer. The producer has the main part of the combustion-chamber a vertical, charging-doors b being provided at the bottom, a chimney c being provided at the top, in which chimney there is placed a damper d adapted to completely close the chimney when required. At the top of the producer and projecting on one side there is provided a continuation e of the combustion-chamber having a hearth f and doors g for charging, with apertures h for the admission of air below the hearth. At the bottom of the producer there is provided a pipe k leading from the combustion-chamber, to the cooling-chamber l and thence to the usual cleaning devices. Steam-pipes m and air-inlet n are provided to admit steam and air at the top of the producer, the steam being raised by regeneration from the cooling-chamber l. The operation is as follows:—The vertical part of the producer is first filled up with coke and is



fired from the bottom in the usual manner, the damper in the chimney being open. When the mass has become incandescent a charge of bituminous fuel is filled in on to the hearth at the top of the producer and is also fired. The damper in the chimney is then closed, and the steam and additional air turned on, and the gases are drawn off from the bottom of the producer and pass through the scrubber in the usual way. When a fresh charge is required, it is inserted on to the hearth at the top of the producer, after the previous charge which has been coked on the hearth has been broken up by poking and forced into the vertical part of the producer. (*Accepted May* 17, 1911.)

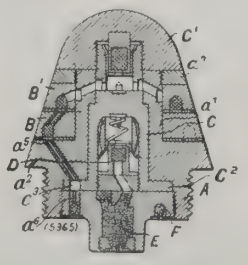
GUNS AND EXPLOSIVES.

22,287/10. E. Schneider, Le Creusot, France. Percussion Fuses. [10 *Figs.*] September 26, 1910.—In percussion fuses for explosive projectiles of the kind in which the striker is under the control of a centrifugal device, which, in turn, is controlled by an inertia device comprising a sliding ring under the control of a spring in such a manner that the centrifugal device is prevented from moving into the releasing position during the period of acceleration of the projectile, a movable safety ring is combined with centrifugal segments so as to come between the body of the fuse and the segments until the acceleration of the projectile ceases. The fuse comprises a fuse body a, in which there are arranged the fixed striker b and the movable plunger c carrying the priming d. This plunger, the front part of which is guided in a tubular extension a^1 of the fuse body, is normally retained in the position shown in Fig. 1 by means of segments e. By means of an inner flange, these segments engage in a groove in the plunger, where they are held engaged by a spring, common to them all, coiled in an external groove in the segments. The



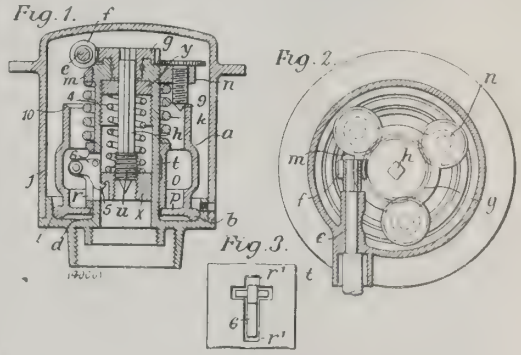
segments e tend to separate as soon as the projectile begins its movement, and this separation, during the period of acceleration, might result in premature ignition and bursting. In accordance with this invention, the segments are combined with a movable ring g which, by its inertia, prevents movement of the segments as soon as the projectile has been fired, this action continuing throughout the entire period of acceleration. The ring g is balanced by a spring h which normally tends to retain it in the position represented in Fig. 1; it therefore leaves the segments e perfectly free, these segments being engaged with the plunger only by their spring, which is sufficiently powerful to prevent the separation of the segments during transportation. When the gun is fired, the ring g by its inertia compresses the spring h and occupies the position indicated in Fig. 2. It retains this position so long as acceleration lasts. Immediately afterwards it is returned by the spring h to the position shown in Fig. 1. Centrifugal force can then act freely on the segments e, which separate in extending their locking spring and occupy the position in which the fuse is cocked as indicated in Fig. 3. (*Accepted May* 17, 1911.)

5365/11. Fried. Krupp Aktiengesellschaft, Essen, Germany. Fuses. [4 *Figs.*] April 16, 1910.—This invention relates to that class of combined time and percussion fuses



for composite projectiles which are provided with a retarding device that can be thrown into and out of operation and have a setting device which enables the time fuse to be put into communication either with the shrapnel charge or with the bursting charge of the projectile. The body A of the fuse has a hollow, upwardly extending pin a^1, which is surrounded by a revolving composition ring B which lies upon the base a^2 of the fuse and a composition ring B^1 which belongs to the time fuse of the well-known type of construction, and is arranged over the composition ring B. The composition ring B^1 is covered by a ring a^3, which is screwed to the pin a^1 and prevents the composition rings B, B^1 from moving in the direction of the axis of the pin a^1. In the body A of the fuse is mounted a revolving sleeve C, which passes through the hollow pin a^1 and the axis of rotation of which coincides with the axis of the pin a^1. At its front end the sleeve C is screwed into a head-piece C^1 which bears against the front end of the pin a^1 and of the ring a^3 and forms the foremost part of the point of the projectile. At its rear end the sleeve C is provided with a flange c^2, in which is formed a hole c^3. The hollow space within the sleeve C receives the firing-pin of the percussion fuse and a striker bolt D which contains the corresponding primer. When the fuse is in the transport condition the striker bolt D bears against a screw plug which closes the rear end of the space within the sleeve C and the bolt D is firmly held in this position by a safety device of any well-known kind. The screw plug is provided with an igniting passage which running obliquely to the axis of rotation of the sleeve C, and also the flange c^2, bears against the upper face of a bottom screw which closes in the body A of the fuse at the rear and contains a priming charge E communicating with the bursting charge of the projectile and a priming charge F arranged in an annular chamber and communicating with the shrapnel charge. Into the annular chamber which contains the priming charge F, opens an igniting passage which starts from the front end of the base of the fuse, and consists of two parts a^5 and a^6 in the base. A second ignition passage leads to the priming charge E. Either the ignition passage leading to the priming charge F, or the one leading to the priming charge E, can be connected to each other, by means of the hole c^3 in the flange c^2, according to the way in which the flange is set. (*Accepted May* 17, 1911.)

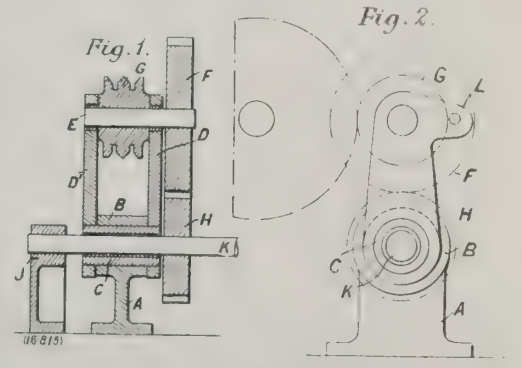
4060/11. A. E. Jones, Fiume, Hungary. Automobile Torpedoes. [8 *Figs.*] March 29, 1910.—This invention relates to percussion mechanism for automobile torpedoes in which the striker is held in its cocked position by a lever connected with a releasing member acting by inertia, and according thereto this inertia-releasing member is constituted by a cup surrounding the striker and resting upon the bottom of the mechanism casing, and held against this bottom by a moderator spring, mainly with the object of reducing sensitiveness to shocks and increasing the safety of the apparatus. The member, which, owing to its inertia, produces the release of the striker, is formed by a cup a surrounding the striker, and which rests by its base b (which presents a beaded form) upon the bottom d of the box j of the mechanism. The bottom d is, preferably, cup-shaped, and presents at its periphery a circular rounded portion i, the curvature of which is substantially the same as that of the beading b on the cup a. This latter is held against the bottom d by a spring k, which may be termed the moderator spring, which bears on the one hand on



a plate m with lugs n fixed to the upper part of the cylinder t, and, on the other hand, upon a movable sleeve o surrounding the cylinder t, and resting upon the bottom p of the cup a. The sleeve o is formed with an aperture r, and the cylinder t also comprises a cross-shaped aperture r^1; through these a lever 6 passes which is provided with two trunnions fitted into the small arms of the aperture r^1; this lever 6 is also pivoted by means of a pin to lugs projecting from the exterior of the sleeve o on both sides of the aperture r. The nose 5 of the lever 6 supports the piston x, into which the screw-threaded head u of the striker h is screwed; this striker carries the nut y which is adapted to compress the spring 4 for cocking the striker which passes through the gear-wheel g controlled by the endless screw f on the shaft e. The gear g also meshes with the toothed discs 7 carried by screws 8 passing through the lugs n of the plate m, their points 9 resting upon the upper chamfered flange 10 of the cup a. The box j of the apparatus is connected with its bottom d by a certain number of bayonet joints. (*Accepted May* 17, 1911.)

LIFTING AND HAULING APPLIANCES.

16,815/10. G. C. C. Henderson. Bristol. Hoists. [6 *Figs.*] July 14, 1910.—The invention relates to transmission mechanism for winches, hoists, and other lifting appliances. A is a bracket fixed to the bedplate of the hoist and having a boss B to receive the hollow pin C. To the pin C are fixed two links

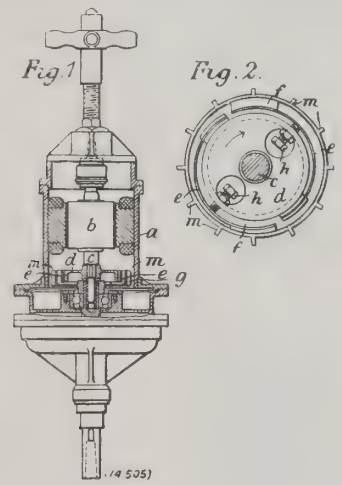


D and D^1, one on each side of the boss B. The links D, D^1, and the pin C are free to rotate in the boss B. The other ends of the links D, D^1 receive the pin E, which carries the gear-wheel F. Fixed to the pin E and between the links D, D^1 is the friction-wheel G. The pin E and wheels F, G revolve together.

The driving-shaft K of the motor projects through the hollow pin C and terminates in a bearing J upon the bed-plate. To the shaft K is fixed a gear-wheel H engaging with the wheel F. The operation is as follows:—The rotation of the wheel H rotates the wheel F and causes the friction-wheel G to revolve. A control rod is connected to the links D, D^1 at L for instance, and the links may thereby be rocked so as to bring the friction-wheel G into contact with the friction-wheel of the winch to be driven. In fitting the above mechanism to a winch, the controlling-lever is so arranged and connected to the links D, D^1 that a movement in one direction throws the friction-wheel G into gear with the friction-wheel of the winch and simultaneously releases the brake, a movement in the reverse direction disengaging the wheel G and putting on the brake. (*Accepted May* 17, 1911.)

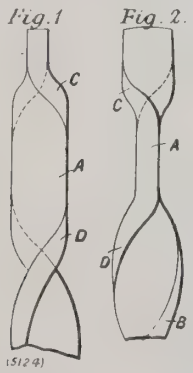
MACHINE AND OTHER TOOLS, SHAFTING, &c.

14,505/10. A. Stewart and the Westminster Tool and Electric Company, Limited, London. Electric Drills. [2 *Figs.*] June 15, 1910.—This invention relates to electric drills of the kind provided with an adjustable friction-clutch for transmitting the motion of the armature of the electro-motor to the drill gearing, and consists in the combination with the armature spindle of the electric-motor, of a collar or the like forming the driving part of a friction-clutch, and the motion of which is transmitted to the driven part of the clutch through the medium of a number of springs, each having shoes frictionally bearing upon the inner surface of the said driven part, which is arranged concentrically with the driving part. *a* is the casing of the drill, and *b* is the electric-motor for actuating the drill, *c* being the spindle of the armature of the motor. *d* is the collar, which is mounted upon the armature spindle, and *e*, *e* are the springs which project from the periphery of the collar *d*. *f*, *f* are the shoes, which are fitted upon the outer ends of the springs *e*, and which are held by the tension of the springs in contact with the inner face of the driven clutch part *g*. This clutch part *g* actuates the drill gearing through the medium of a pinion upon its boss. Means are provided for regulating the pressure with which the



shoes *f* are applied against the surface of the clutch part *g*. In the construction illustrated this regulation is obtained by means of a set-screw *h*, provided in conjunction with each spring *e*, the set-screw being mounted radially on the collar *d* in such a manner that its outer end bears against the inner face of the spring. It will be obvious that by adjusting the position of the screw it can alter the limit of the movement of the spring inwardly. The driven clutch part *g* may be formed with radial projections or vanes *m* upon its outer periphery. The object of these vanes is to generate a current of air when the drill is in operation, which air flows through the armature, and maintains the same cool. With the described construction it will be understood that as the armature shaft *c* rotates it revolves the collar, which carries with it the shoes *f*, *f*. These shoes bear against the face of the driven clutch part *g*, and so drive the same, and thereby the drill, the power being transmitted until the torque exceeds a predetermined amount, which can be adjusted by controlling the tension of the springs, so that when the predetermined degree of torque is exceeded the shoes will slip, thereby obviating the liability of injury accruing to the armature. In practice the friction surfaces of the clutch are lubricated. (*Accepted May* 17, 1911.)

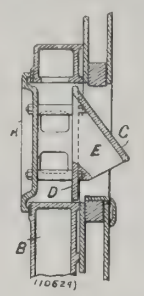
5124/11. B. O'Reilly, Sheffield. Twist-Drills. [2 *Figs.*] March 1, 1911.—This invention relates to twist-drills having two quarter-twists of the flat shank at any suitable distance apart, both twists being in the same direction, and consists in twisting the said two quarter coils upon the shank in opposite directions. The body of the drill is twisted from a flat, or approximately flat, bar of steel to the required helical configuration, the grooves, surfaces, and cutting edges being finished by the usual processes.



A represents the shank portion, B part of the twisted body. C is the upper twist, and D is the lower twist. The applicant has found as the result of actual experiments that by forming the upper twist C in the opposite direction to the lower twist, as shown in the drawings, a very considerable advantage in durability and in the life of the drill is obtained, the lower and stronger part of the shank taking the greater amount of the torsional strain, and thereby reducing the liability to fracture which so often occurs in the shank part of twist-drills. As there are both right and left-hand drills, the lower twist D is made in the same direction as the helical twist of the drill body—that is, either to the right or left-hand, as the case may be, and the upper twist C is made in the opposite direction. (*Accepted May* 17, 1911.)

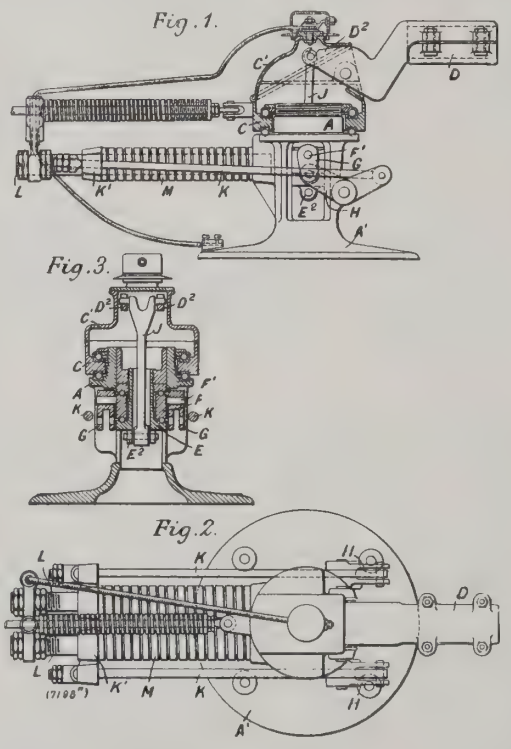
RAILWAYS AND TRAMWAYS.

10,624/10. James Howden and Co., Limited, and J. Howden, Glasgow. Locomotives. [3 *Figs.*] April 20, 1910.—This invention relates to locomotive furnaces in which a forced-draught air supply is provided partially through the furnace-door by devices connected therewith, which devices include an inwardly and downwardly inclined outlet portion adapted to direct the air current on to the fuel in the fire-box, and prevent its flow directly towards the fire-tubes. The invention consists in the particular construction and arrangement of parts. The framing of the door A includes a hollow structure which is dis-



posed externally of the furnace, and affords an air-jacket B; to permit the passage of air into the furnace, a director, composed of a casting C attached to the door, is provided, the said casting comprising a flat part D fitting the fire-door opening, so as to constitute the inner door-plate, but having a central open box-like part E inclined inwards and downwards, so as to form a downwardly-inclined directing passage for the forced-draught air entering through the hollow door. The air-director so formed is attached to the door front by means of bolts or the like, and projects from a point outside the furnace into the interior of the furnace, as shown. (*Accepted May* 10, 1911.)

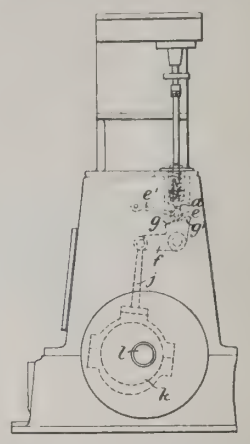
7198/11. E. M. Munro and the Railless Electric Traction Company, Limited, London. Trolley Bases. [3 *Figs.*] May 5, 1910.—In a trolley base having one or more tail springs extending more or less horizontally from the base or carrier, and acting upon the socket carrying the trolley-pole so as to raise the upper end of the pole into connection with the overhead conductor, the socket is rotatable, and the tail-spring is mounted on a relatively stationary carrier, which does not rotate with the socket. The pole-socket can be thus swung round relatively to the base without any rotary movement of the part upon which the spring is mounted. A central support is provided, having an upper portion A and a foot or base A^1, intended to be bolted in some convenient position on the vehicle. The upper part A is provided with ball bearings, between which is held a casing C having a hood C^1, serving to protect the mechanism of the trolley base from the weather, and also to support the pivots of the trolley socket D. The inside of the upper hollow portion A receives a sleeve E, capable of rotating and of sliding longitudinally within the member A. The sleeve E



is made in two parts, and contains between them a ring F, which is provided with gudgeon-pins F^1, connected by links G to bell-crank levers H to a part of the base A^1. The lower end of the inner sleeve E is provided with lugs E^2, to which is attached the lower extremity of a tie-rod J. The upper end of this tie-rod J is furnished with pins, which engage with a fork D^2 formed on the end of the pole-socket D. Each pair of bell-crank levers H is connected by adjustable rods K to a cross-bar K^1, capable of sliding on tubes L which extend from and are mounted on lugs forming part of the base A^1. Encircling each tube L is a spiral spring M which is in compression between the cross-bar K^1 and the stationary base A^1, and hence each pair of springs acting through the cross-bar K^1, the rods K and the bell-crank levers H, tends to pull down the ring F and the inner sleeve E. A downward pull is thus transmitted through the link J to the inner end of the pole-socket D, and the upper extremity of the pole bearing the shoe or collector tends to be raised into contact with the conductor. It will be obvious that in this construction, the pole-socket D and the sleeve C to which it is pivoted can rotate about a vertical axis passing through the centre of the support A, A^1 without causing any rotary movement of the rods K, tubes L, or springs M. (*Accepted May* 17, 1911.)

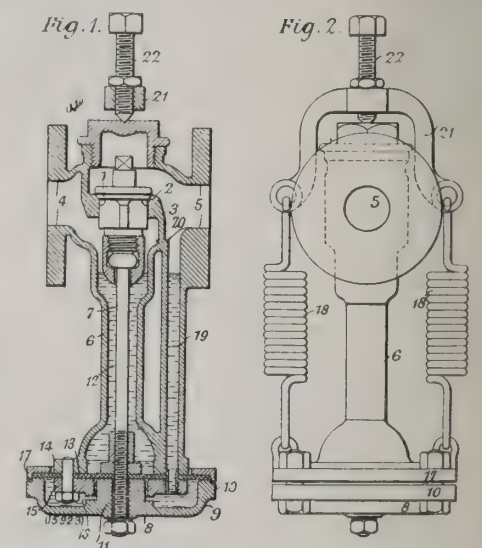
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

13,853/10. J. Davidson, Pendleton. Valve-Gear. [4 *Figs.*] June 8 1910.—The invention relates to the valve-gear of high-speed vertical engines of the type in which drop-valves, combined drop and piston-valves, or single piston-valves are employed. The invention is to enable the valves to be actuated direct from the crank-shaft. The valve is operated from a spring plunger as *a*, which is free to slide in a guide-box, but is not



connected to the valve. A roller *e* on the end of a link e^1 is interposed between the end of the plunger *a*, and a cam is formed on one end of a pivoted lever *f*, whose opposite end is connected to the rod *j* of an eccentric *k* on the crank-shaft *l*; the plunger *a* is lifted and the valve opened by a projection g^1 on the cam *g* when the said cam is oscillated by the action of the eccentric *k*. (*Accepted May* 10, 1911.)

15,923/10. J. Graham, A. Graham, Jun., and D. A. Graham, Glasgow. Reducing Valves. [3 *Figs.*] July 4, 1910.—The invention relates to a reducing valve fitted with a single diaphragm and a chamber underneath same open to the reduced pressure fluid, and consists in the combination of an elongated casing, a valve, a spindle connected to the valve, a balancing piston on the spindle, formed in one with a disc on the lower end of the spindle, a chamber above the disc, a diaphragm separating the chamber from the casing, and inner and outer ring-plates bolted to the casing and disc respectively, and a duct between the delivery side of the valve and the lower chamber. The valve 1 rests on a seat 2 formed in a partition 3 between the inlet and outlet chambers 4 and 5 respectively of the valve casing 6, and has a pendant spindle 7 secured at its lower end to a disc 8. This disc 8 has an annular circumferential wall 9, which is formed with a radial flange 10. Secured on the lower part of the spindle 7, and forming a central boss to the disc 8, is a piston 11, of a diameter to effect the balancing of the valve 1 when both are subjected to the same pressure. The valve casing 6 is continued down and forms a chamber 12 around the valve spindle 7, and this chamber 12 is expanded at its lower end. A flexible diaphragm 13 is inserted between the lower end of the casing 6, formed with a flange 14, and a ring-plate 15, these being bolted together. The central opening of the ring-plate forms a cylinder for the balancing piston 11. The diaphragm 13 is extended to cover



the chamber 16 formed by the lower disc, and is secured between its flanges 10 and a ring or rectangular plate 17 bolted to them. Constructed in this manner, the valve 1, spindle 7, and lower disc 8, with its ring 17, form a part which is capable of movement relatively to the other part, which consists of the valve-casing 6 and its ring 15. Direct-acting spring or springs 18, or weights acting through lever mechanism, may be employed to regulate the reduced pressure of the steam required. These springs 18, as shown, are attached to the ring-plate 17 and to the bridge-piece 21, bearing on the cover of casing 6 by the regulating screw 22. A duct 19 is formed between the outlet lower-pressure chamber 20 and the chamber 16 below the diaphragm 13, to permit the low-pressure steam to act on the lower part of the chamber to close the valve 1 when the desired pressure is attained or exceeded. The action is as follows:—Initial pressure enters by the inlet 4 and chamber 12 between the underside of valve 1 and upper side of balancing piston 11, which are thus in equilibrium. On the valve being opened by the action of the springs 18 the steam flows through the valve 1 to the lower-pressure outlet chamber 20, and continues to flow as long as the reduced-pressure steam is maintained at the pressure desired. Any tendency of the reduced pressure to rise or be increased reacts down the port 19 to the chamber 16 below the diaphragm 13, and closes the valve 1 by drawing down its spindle 7, and by acting on the top side of the valve 1. (*Accepted May* 17, 1911.)

THE OERLIKON ENGINEERING WORKS.

The Oerlikon Engineering Works at Oerlikon, a short distance from Zurich, which the Mechanical Engineers visited on Tuesday, July 25, were established in the early 'seventies of last century, by Daverio, Sieverdt, and Giesker, under the name of Daverio, Sieverdt, and Giesker, Werkzeugfabrik Oerlikon, mainly for the manufacture of wood-working machine-tools. The firm met with great success in this special branch, and decided, in 1876, to take up the construction of iron and steel-working machine-tools, a branch which they pushed with equally good results. To this they added, in 1877-78, the manufacture of Porzellan-Walzenstühlen. In the year 1874 the concern was formed into a share company, consisting of a limited number of shareholders, under the title of "Werkzeug- und Maschinenfabrik Oerlikon," the directors being Messrs. P. E. Huber-Werdmuller and Friedrich Wegmann. The works were enlarged, and an iron foundry was added to them; then a brass foundry followed, the directors deciding to take up also the manufacture of electrical machinery, a branch in which the Oerlikon Works were early pioneers.

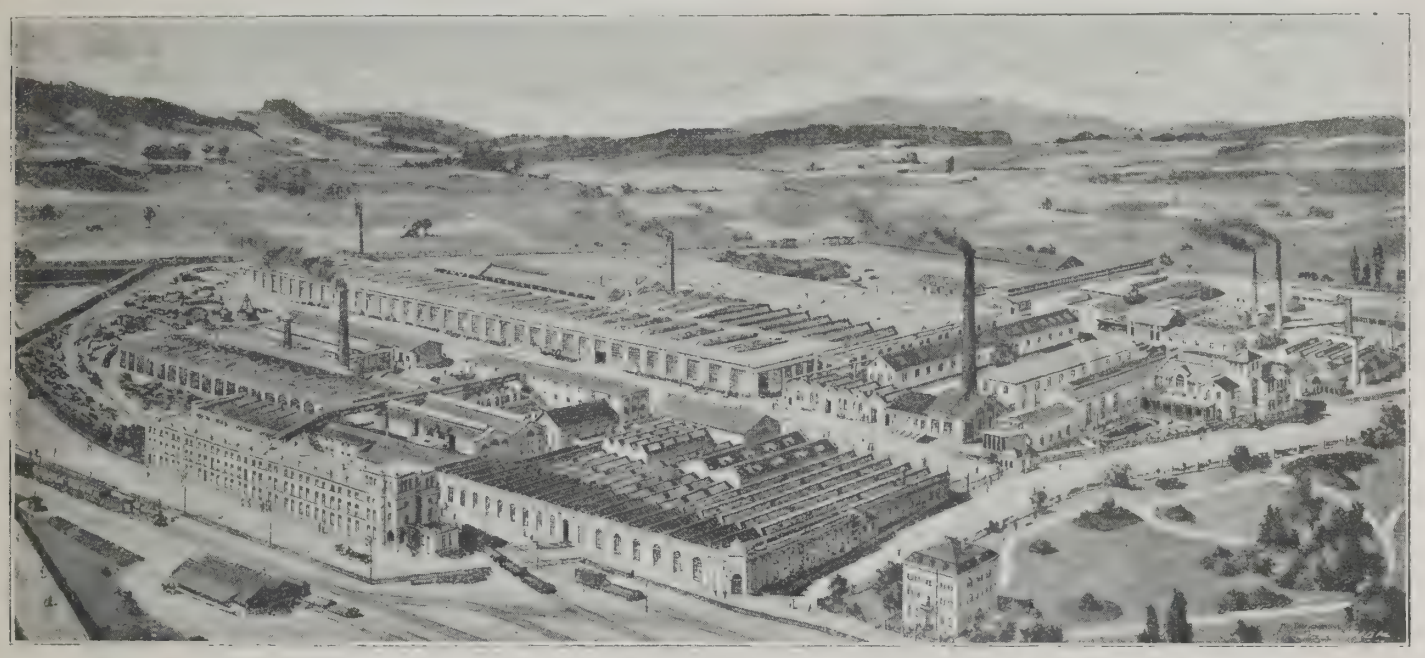


Fig. 1. Bird's-Eye View of the Oerlikon Works.

The honour of having constructed the first power-transmission line on an industrial basis belongs to this company. This installation had for its purpose the transmission of 50 horse-power over a distance of 8 kilometres, between Kriegstetten and Soleure. This installation, compared with modern ones, appears, of course, very small, but nevertheless it caused a great sensation at the time, being the first installation giving an over-all efficiency of 70 per cent. Shortly afterwards the Oerlikon Works, together with a German firm, installed the famous power-transmission plant of Lauffen-Frankfort, which demonstrated the possibility of transmitting 300 horse-power over a distance of 175 kilometres, at a pressure of 30,000 volts. The dynamo and the transformers used in this installation were built at the Oerlikon Works.

Since that time the Oerlikon Works have gradually abandoned their early specialities, and now manufacture exclusively steam-turbines of their own type, electric generators and motors for all purposes, and electrical plants complete, branches in which they have acquired a world-wide renown.

The name of the company was changed in the year 1887 into that of Maschinenfabrik Oerlikon, the name it bears at the present day. The works as they now stand are shown in the bird's-eye view above and in the plan, Fig. 2, on the next page. The site has an area of 103,000 sq. m., of which 50,000 sq. m. (12 acres) are covered by buildings, in which there are employed about 2300 men and staff. The specialities of the company now consist exclusively, as above stated, of steam-turbines and electrical machinery. Their steam-turbines are of the Oerlikon impulse type, and they build them of powers up to 20,000 brake horse-power and more. It is of particular interest to note that they build also small turbines of from 5 to 500 brake horse-power, which are eminently suitable for the driving of pumps, fans, blowers, &c. They have also specialised in the building of so-called mixed-pressure or series-parallel turbines and low-pressure turbines.

The company also build direct-current and alternating-current generators and motors up to 10,000 brake horse-power and more; also complete installations. As proof of their activity in regard to the supply of electrical machinery, we may state that they have recently equipped the following important extra high-pressure power transmission schemes:—

Obermatt (Lucerne-Engelberg), 8000 brake horse-power, 37,000 volts; Guadino (Spain), 4800 brake horse-power, 52,000 volts; Caffaro-Brescia, 8400 brake horse-power, 46,000 volts; Port de Lignon (Cie el. de la Loire), 4800 brake horse-power, 30,000 volts; Hemsjo, 4000 brake horse-power, 40,000 volts; Cervara, 10,000 brake horse-power, 27,000 volts; Albulawerke of city of Zurich in Sils, 24,000 brake horse-power, 46,000 volts (see Fig. 4, Plate XXXI.).

As a typical illustration of other installations, we may refer to the vertical-type generators in Schaffhausen (Fig. 5). We may also mention the five vertical 500 k.v.a. three-phase generators for the city of Bremen, which, due to the extremely low speed (40 revolutions per minute), are of particular interest. Fig. 19, page 155, shows the pole-wheel fitted with 150 poles. As a typical direct-current-generating station, we would refer to Chippis, the works of the Aluminium Industrie Gesellschaft Neuhausen (Fig. 6). The generators of this station are each capable of producing 1720 kw., the current being 8000 amperes. We would here mention that the Oerlikon Works have supplied a large number of generators, motor-generators, turbos, and other plant for British electricity works. Fig. 12, Plate XXXIII., illustrates a motor generator of 400 kw. for the Kensington and Knightsbridge Electric Lighting Company in the erecting-shop. Fig. 13 illustrates one of the 2 × 250 kw. in the test-room at the Oerlikon Works, for the Westminster Electric Supply Co.

Commencing with the foundries, these are three in number—viz., one for heavy cast-iron work (Fig. 7, Plate XXXII); one for brass and metal castings; and a foundry for light cast-iron work (Fig. 8) for small machines, turned out in series of about 50 to 100 or more at a time. The foundry for heavy castings measures 393 ft. in length and 65 ft. in width; it is served by seven 5-ton to 25-ton electric travelling cranes, and is set apart for the casting of large pieces, such as electric armatures, and so forth. The largest piece cast weighs 25 tons. There are two cupolas of quite modern construction, with a reservoir, each of 7 tons capacity. All the work is cast in sand. The side bays are set apart for manufacturing medium-size pieces.

The foundry for heavy work is well lighted and free from smoke and dust, and is illustrated in Fig. 7, Plate XXXII. In the forefront is shown the stator of a 12,000-brake-horse-power generator supplied to the Chippis Works of the Aluminium Industrie Gesellschaft Neuhausen. The weight of the casting is approximately 9900 kg. The brass and metal foundry adjoins this. It contains three crucibles. A feature of this is the new installation which the company are now testing, and which consists of two electrical smelting furnaces, built by the Oerlikon Works under the Heilberger patents: one of 200 kg. and one of 100 kg. capacity. Each furnace is fitted with two single-phase transformers of 100 and 40 k.v.a. respectively. Both transformers are at the moment connected up, according to Scott's system, to the three-phase supply circuit of the works. By regulating the primary pressure by means of a cellular regulating switch, fixed to the transformer, the temperature of the latter can be regulated at will.

The foundry for small castings (Fig. 8) has an area of 85 ft. by 105 ft., and is arranged in three bays, each served with a hand-crane. For the castings of standard small machines which are built in series the works use three hydraulic moulding-machines—two for pressures up to 4 atmospheres, and one for pressures up to 25 atmospheres.

Bordering on the foundry are the fettling-shops for the castings (Fig. 9). The very small parts are cleaned on the drum fitted with sand-blast, shown on the right-hand side of the illustration. Somewhat larger pieces are cleaned on the main sand-blast with a rotary table. Larger pieces up to about 1 metre in diameter, which, due to their shape, cannot be handled in the above-mentioned machines, are hand-cleaned. It was particularly noticeable that though the fettling-sheds were in full operation, there was no appreciable dust in the atmosphere. In the cleaning-tables, as also on the flooring of the cleaning-sheds, underground channels, covered in with perforated plating, serve for the drawing away all dust by means of a powerful fan equipment. The erection-shop for heavy turbine and electrical machinery, shown by the letter E in the plan, Fig. 2, page 154, is 690 ft. in length and 98 ft. in width, in two long bays, each served by eight overhead travelling-cranes of 15 and 20 tons capacity.

The end of what we may style the second bay is occupied by the steam-turbine testing department. At the time of our visit there were two Oerlikon turbines in process of testing—one of 10,000 brake horse-power for Marseilles, and one of 825 brake horse-power for Algiers.

In the steam-turbine test-room three Babcock and Wilcox boilers, each of 13,200 lb. hourly steaming capacity, supply the steam at varying temperatures according to requirements. The condensing plant at present installed is suitable for 16,000 lb. of steam per hour. Long-hour trials can be carried out in the laboratories. The various elements of turbines

and electrical machinery, stators, rotors, and so forth, are first machined and then assembled. The machining is carried out on a number of powerful machine-tools, among which we may mention a large radial drilling-machine, also close by, a very big horizontal lathe. The two arms of the drilling-machine cover an area of 26 ft. diameter, and the work-table is represented by accurately machined, specially constructed cast-iron plating recessed and grouted into the flooring. The face-plate of the above-mentioned lathe measures 20 ft. in diameter.

Another tool of some importance is a planing-machine with a table 18 ft. in length and 8 ft. in width. All the heavier machines throughout the works are driven by separate electric motors. For the smaller tools group drive (three to four tools per counter-shaft) is adopted. Some general views are given in Figs. 10 and 11, the first illustrating the turbine department, the latter the erecting-shop for large electrical machinery.

In the centre of the second bay is mounted a large boiler, in which the transformer coils are impregnated with oil under vacuum. On the occasion of our visit a 250-k.v.a. transformer of 200,000 volts secondary pressure was being impregnated therein. At the end of the second bay, opposite the steam-turbine test-room, is the main laboratory and testing department for electrical machinery and transformers. A section of the test-room is shown in Fig. 13. At the time of the visit a 2650-kw. direct-current generator, 300 revolutions per minute, 340 volts, 7800 amperes, attracted particular interest, as also a 300-volt direct-current submarine-boat motor.

The winding-shop occupies a parallel position with the erecting-shop above briefly described. This is set apart for the winding of magnets and armature coils. Of special interest is the manufacture of seamless mica tubes for the insulation of the stator-coils in connection with which the Oerlikon Works published their exhaustive periodical communication No. 36. There is an extremely simple and effective machine for winding exciter and pole-coils for three-phase generators, these coils being made of copper strip on edge.

Then follows the transformer department and the turnery which gives into it. The machines for corrugating the transformer-cases, as also the welding department for these latter, are found here; also the factory for mantles for transformer coils.

The Oerlikon Works receive in this shop generally the locomotive frames which they fit with requisite motors and other electrical gears. A large number of traction-motors shows that this department is kept very busy. In these works, for instance, the 2000-brake-horse-power locomotive of the Berner-Alperbahn Gesellschaft was constructed, the excellent results of which during the trial and thereafter are still in the memory of most readers. (Fig. 20, page 156.) This locomotive is the biggest of its class ever built. It was constructed for up to a speed of 70 km. per hour and has to pull behind it a train of 310 tons on an incline of 1 in 37 at a speed of 42 km. per hour, figures which have actually been improved upon at the trials. Close to the last-named department is the stamping department and sheet-paper insulating machine, which call for no special comments. In close proximity, also, is the infirmary for first aid to be given to the men in case of accident. This is in the constant charge of an experienced medical attendant and is equipped with all the necessary appliances and medicaments. A so-called eye-magnet serves the purpose of extracting small iron particles from the eyes of the workers.

From this place one arrives at the stock-rooms of the small motor department, which latter is referred to later on. The stock contains at the moment of writing approximately 1000 motors, and also all sorts of electro-mechanical appliances, fans, drills, &c., varying in size from $\frac{1}{16}$ to 80 brake horse-power, ready for immediate delivery.

Fig. 2

A. Head offices and sales department.
B. Foundry.
B 1. Brass foundry.
B 2. Foundry, with moulding-machines for repetition manufacture.
C. Department for cleaning castings, sand-blasts, &c.
D. Drawing-office.
E. Steam-turbine erection-shops.
F. Steam-turbine erection test-room.
G. Boiler-house, &c., for turbine test-room.
H. Erecting-shop for large machines.
I. Winding-shop.
J. Test-room for the electrical works section.
K. Railway department.
L. Stamping-shop (laminations, &c.).
M. Switchboard erecting-shop.
N. Carpenters' shops.
O. Smithy.
P. Motor and apparatus stock-rooms.
Q. Boiler-house for steam stand-by, central station.
R. Shipping and dispatching-rooms.
S. Crane and small motor section of works.
T. Steam central station and 30,000-volt transformers.
U. Workmen's club, restaurant, recreation-rooms, and baths.
V. 40,000-volt transformer station.
W. Pattern-shops.

Close by are also manufactured the well-known Oerlikon electrolysers for the production of hydrogen and oxygen. These apparatus are used in all kinds of industrial undertakings, metal-filament lamp factories, accumulator factories, metal, iron and sheet-steel welding processes, and they are also widely employed for the making of hydrogen for the inflating of balloons. A large installation has only quite recently been supplied by the Oerlikon Company to the British Government for the latter purpose. The very economical conditions under which these electrolysers work, and the very pure gases produced thereby, not to mention the safe running qualities and low up-keep costs of the same, secure the Oerlikon Works a rapidly increasing number of orders for this speciality.

The Oerlikon smithy measures 164 ft. in length and 56 ft. in width. It contains five steam-hammers of varying sizes, and whilst all smaller pieces are forged in this smithy, the largest are purchased

THE OERLIKON ENGINEERING WORKS, OERLIKON, SWITZERLAND.

(*For Description, see Page* 153.)

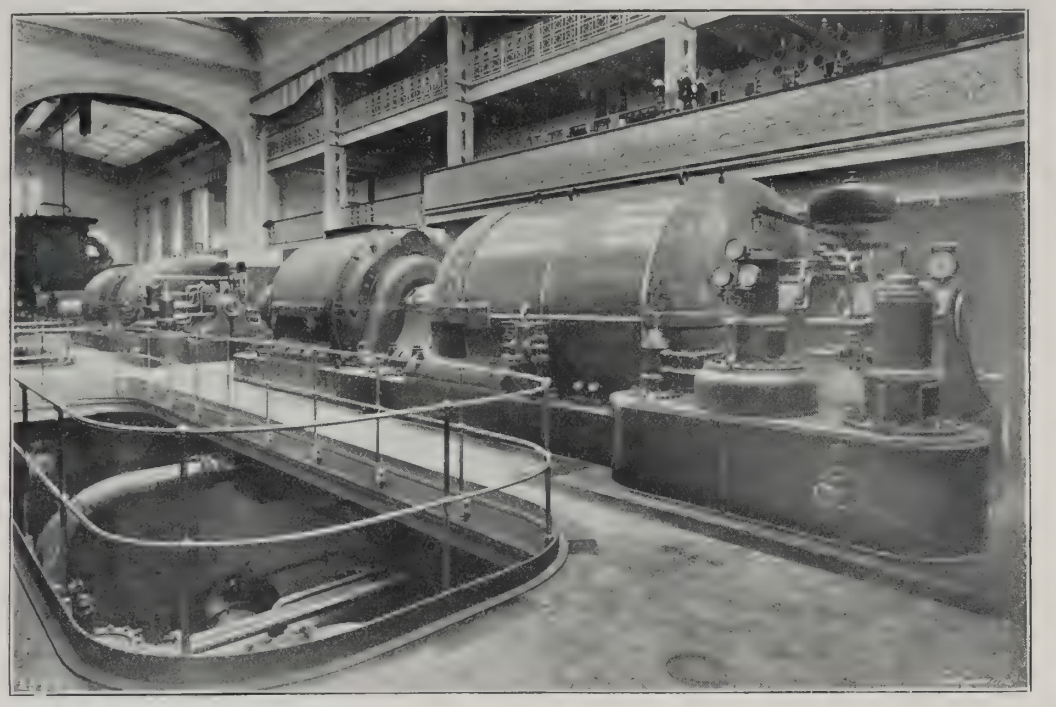


Fig. 3. 10,000-Brake-Horse-Power Three-Phase Turbo-Generators for the Gas and Electricity Works, Stockholm.

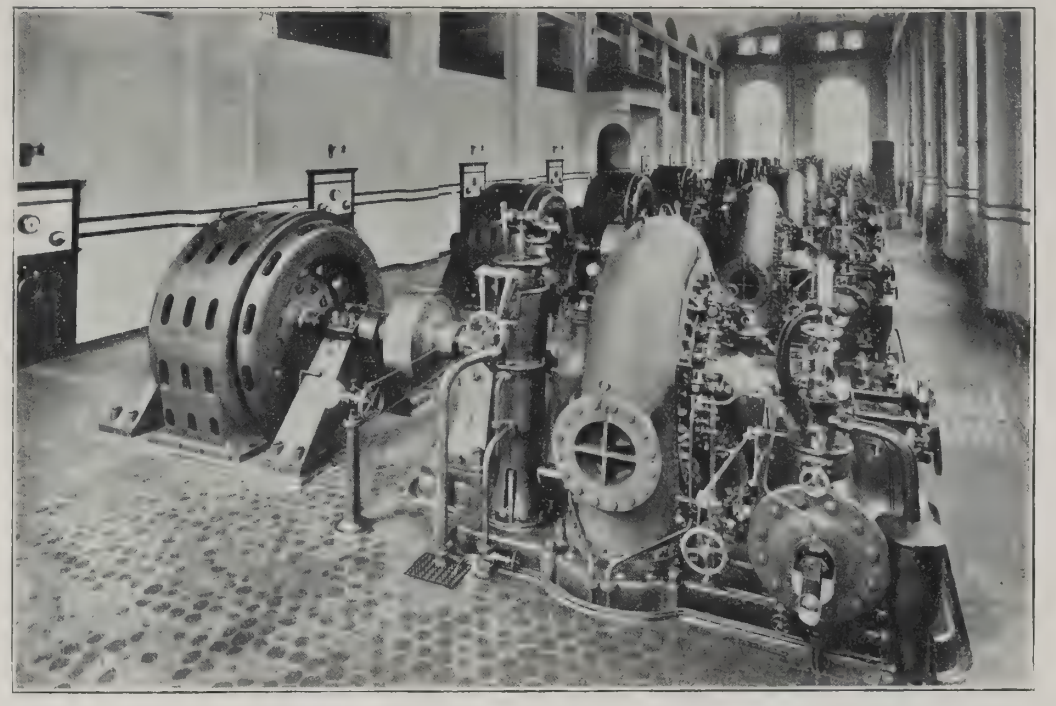


Fig. 4. High-Pressure Hydraulic Turbines and Electric Generators for the Albula Works, Zurich.

Fig. 5. Vertical-Type Electric Generators at Schaffhausen.

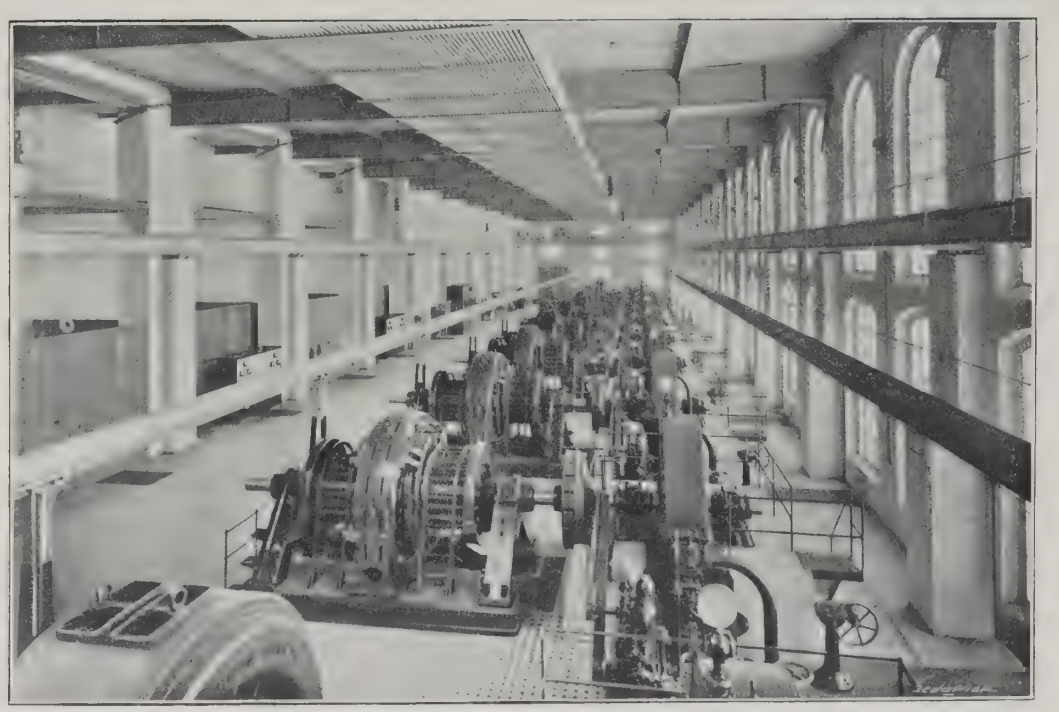


Fig. 6. Direct-Current Generating-Station of the Aluminium Industrie Gesellschaft, Neuhausen.

(*To face Page* 154.)

THE WORKS OF THE OERLIKON COMPANY.

Fig. 20. Electric Locomotive for the Bern-Lötschberg-Simplon Railway.

Company has its suite of offices at Oswaldestre House, 34-35, Norfolk-street, Strand, W.C., under the management of Mr. G. Wüthrich.

ENCASTRE BEAMS.

By Arthur Morley.

The following method of dealing with beams which are firmly clamped at their ends appears in its applications to be simpler than any other. It consists of treating the "encastré" beam as a particular case of the cantilever, of which the otherwise "free" end is subjected to (1) a supporting force, and (2) a couple, such as will together make the beam comply with the required end conditions.

Let A B $= l$ be the span of a horizontal beam, R be the reaction at B, and M be the fixing couple at B. If the beam were simply clamped at A, and otherwise entirely free, let i be the slope and δ be the deflection which the loads would produce at the free end B. Let E be Young's modulus, and I be the moment of inertia of cross-section for the beam. Then, if A and B are to be at the same level, and the beam is to have zero slope at these two points, considering the joint effects of R, M, and the loads in producing first slope, and second deflection at B,

$$\frac{R\,l^2}{2\,E\,I} - \frac{M\,l}{E\,I} - i = 0 \quad . \quad . \quad (1)$$

$$\frac{R\,l^3}{3\,E\,I} - \frac{M\,l^2}{2\,E\,I} - \delta = 0 \quad . \quad . \quad (2)$$

and from these two simple equations

$$R = \frac{6\,E\,I}{l^3}(2\,\delta - l\,i) \quad . \quad . \quad (3)$$

$$M = \frac{2\,E\,I}{l^2}(3\,\delta - 2\,l\,i) \quad . \quad . \quad (4)$$

The shearing force, bending moment, slope, and deflection anywhere may now be found, as for a cantilever, by superposing the effects of R, M and the loads, or the supporting force and fixing couple at A may be found by the ordinary rules of statics, and any method used to complete the problem.

If the ends are fixed at any slopes other than zero, it is only necessary to add to the left-hand side of equation (1) the increase of slope from A to B. And if the two ends are not at the same level, it is only necessary to add the increase of deflection from A to B to the left side of equation (2).

The results (3) and (4) may also be stated for a general form of loading thus :—

$$R = \frac{6\,A\,(2\,\bar{x} - l)}{l} \quad . \quad . \quad . \quad (5)$$

$$M = \frac{2\,A\,(3\,\bar{x} - 2\,l)}{l} \quad . \quad . \quad . \quad (6)$$

where A is the area of the bending-moment diagram for the loads with the end B quite free, and $\bar{x}$ is the distance of the centroid of this area from A (horizontally).

Similar methods are applicable to other kinds of beams ; for example, the beam freely supported at its ends may be regarded as a cantilever fixed horizontally at one end A, propped at the other end B with such a supporting force as will reduce the bending moment at A to zero, and then rotated about A through such an angle as will bring down to the level of A—viz., the angle

$$\frac{R\,l^3}{3\,E\,I} - \delta \div l.$$

This angle added to the slope of the propped

Fig. 21. The Wohlfahrtshaus.

THE ZOELLY STEAM-TURBINE; BLADING.

(*For Description, see Page* 160.)

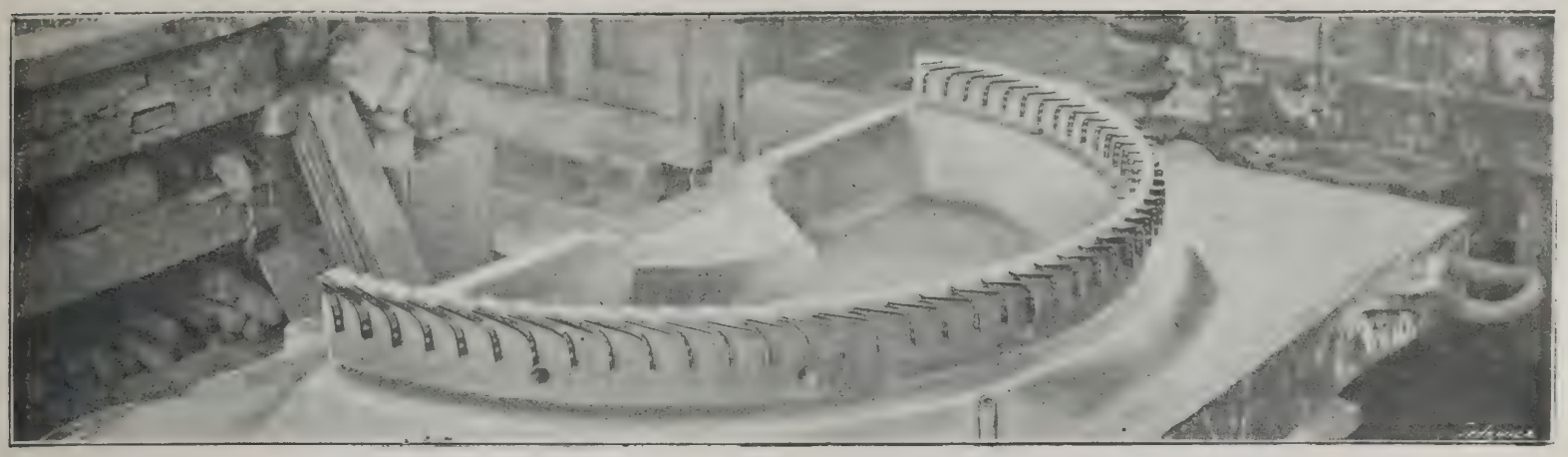


Fig. 1.

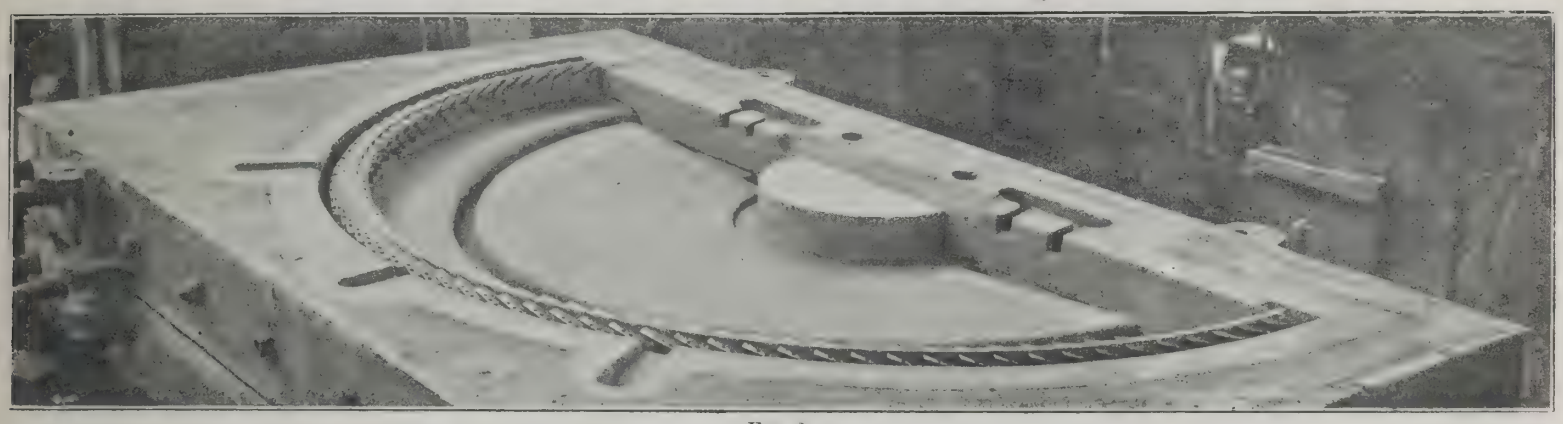


Fig. 2.

Figs. 1 and 2. Core and Mould for Guide-Channels, showing Nickel-Steel Blades in Position.

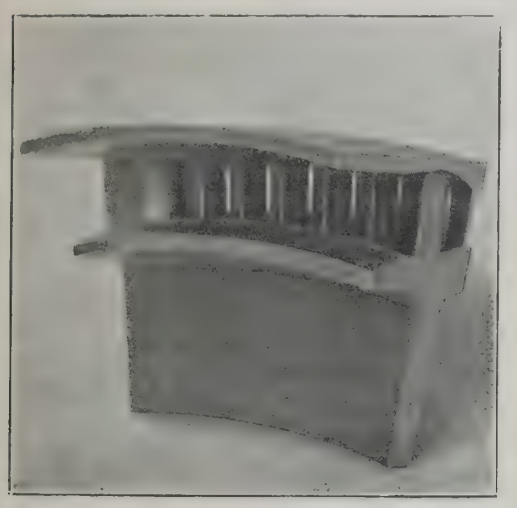


Fig. 3. Guide-Channels in Diaphragm-Plate.

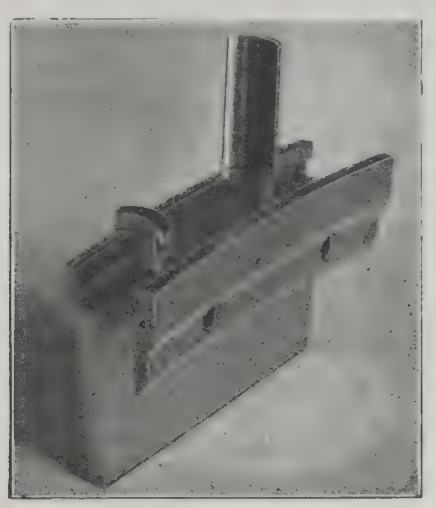


Fig. 4. Old Method of Retaining Blading.

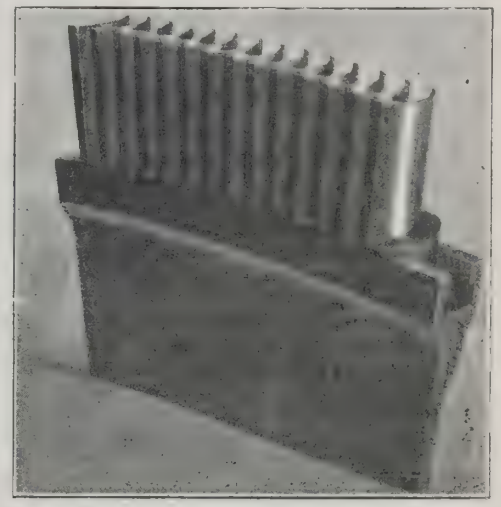


Fig. 5. Section of Runner Wheel.

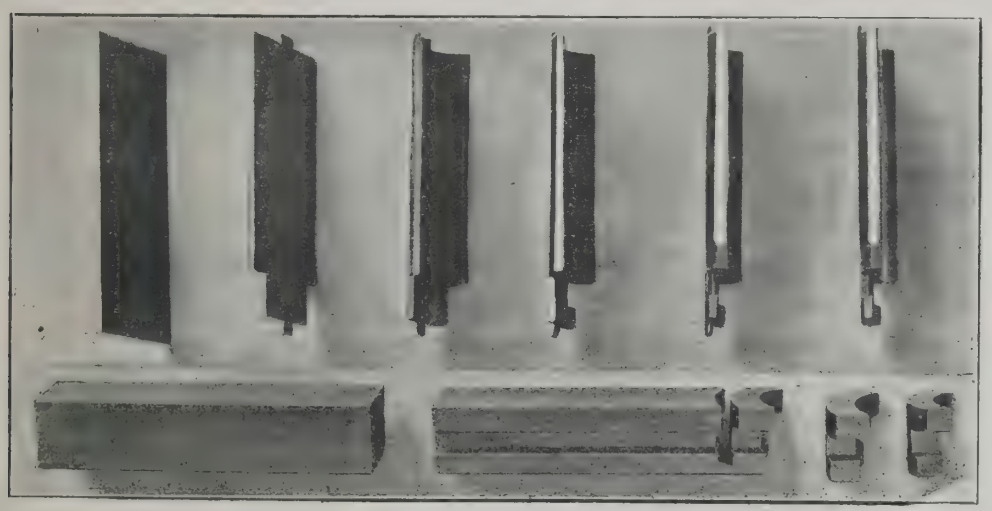


Fig. 6. Nickel-Steel Blades for Rotor in Successive Stages in Manufacture.

cantilever gives that of the freely supported beam; the deflection at a distance x from A is found by adding x times this angle to the deflection of the propped cantilever.

Example.—A beam of clear span l built in at both ends and carrying a load W at a distance $n\,l$ from one end (A).

For the cantilever,

$$i = \frac{W\,(n\,l)^2}{2\,E\,I} \qquad \delta = \frac{W\,l^3\,n^2\,(3-n)}{6\,E\,I},$$

and, substituting these in (3) and (4),

$$R = W\,n^2\,(3 - 2\,n), \qquad M = W\,l\,n^2\,(1 - n).$$

A Deep Bore-hole.—At Cynehow, in Upper Silesia, a bore-hole has been sunk to a depth of 2240 m. (7347 ft.) in order to ascertain the condition of the coal deposits. The work has extended over 982 days, of which 694 were proper working days. The cost of the boring operations has been about 15,000*l*. The temperatures at the various depths were as follow:—At a depth of 500 m. (1640 ft.), 26 deg. Celsius; at a depth of 1000 m. (3280 ft.), 40 deg.; at a depth of 1500 m. (4920 ft.), 69 deg.; and at a depth of 2221 m. (7285 ft.), 83.4 deg. Celsius.

THE ZURICH MEETING OF THE INSTITUTION OF MECHANICAL ENGINEERS.

(*Concluded from page* 139.)

In our last issue we gave a report of the commencement of the summer meeting of the Institution of Mechanical Engineers, held this year in Zurich. The meeting was continued on Wednesday, July 26th, members assembling at the Polytechnikum at 9 30 A M , when Mr. L. Zodel's paper was the first to be taken.

High-Pressure Water-Power Works.

Mr. Zodel's paper was entitled "High-Pressure Water-Power Works," and it was given in summarised form, illustrated by numerous lantern-slides, by Mr. Cory Wright. At the commencement Mr. Zodel said that he thought that a description of water-power development would be of great interest to English engineers, as it had not been possible to develop this form of power production in Great Britain to the same extent as other branches of engineering. England had little to learn from Switzerland, and the members of the Institution came from the mother-country of engineering. She had produced craftsmen of a reputation for all time. The country had the advantage of black coal, with which she had conquered the world. Switzerland, on the other hand, had no black coal and had to buy all she needed, but was provided in the form of rivers, &c., with power to which they frequently gave the name of "white coal." To convert this form of power and to utilise it by means of electricity was one of the chief problems of their engineers. The topic was wide and embraced a variety of subjects, including questions dealing with high heads, pipe-lines, speeds, &c , of turbines, and other matters. Unlike steam engineering, each individual case had to be considered independently. As several high-pressure water-power schemes would be inspected during the visit, he hoped his paper would lend something to the interest on those occasions. He regretted being unable to give, himself, the explanation of the slides owing to his restricted knowledge of English.

Mr. Cory Wright then described the slides and gave particulars of the plants dealt with in the paper, which we shall reprint in an early issue of Engineering.

Experiments with Francis Turbines and Tangential Turbines.

Mr. Zodel's paper was given in a room specially prepared for the use of the lantern, and on its termination the members adjourned to the Aula, where the meeting was continued with Dr. Franz Prásil's paper, entitled "Results of Experiments with Francis Turbines and Tangential (Pelton) Turbines." This paper we reproduce *in extenso* in this issue of Engineering. It was not read, but was summarised by Dr. Prásil in German. The discussion of the two papers was taken together.

The first speaker was Professor R. H. Smith, who said the details of the high-pressure water-power works in Mexico, given in Mr. Zodel's paper, were most interesting. They had there gone well beyond European practice, and far beyond what, as far as could be seen, was likely to be attempted here. Englishmen would naturally feel sorry that all this work was in the hands of even their good Swiss friends, as it was work of a nature which they could very well manage. The reason for it being lost to them was that at home, with the exception of work on a small scale, water-turbines were not suited to the country, and there had therefore been little encouragement for engineers to take up their manufacture. He thought, however, that the small turbines made in England equalled, if they did not excel, in efficiency those of the United States of America, but this only concerned small plants. It was almost overpoweringly surprising to see the size of modern water-power plants, and the success with which they were now carried out.

In regard to Dr. Prásil's paper, it appeared that the author had come to two important conclusions. The first of these was that large water-turbines could hardly be improved in efficiency, which now attained to about 85 per cent. He thought that the future would probably prove the author to be correct in this prophecy. A point to be observed, however, in connection with the working of water-turbines, was that this high efficiency was maintained over a long range. From three-eighths load to 25 per cent. overload the efficiency was in the neighbourhood of, or above, 80 per cent. The author's second conclusion was that though the efficiency might not be susceptible of much improvement, the regulation under sudden changes of load could still be improved. A diagram drawn on the blackboard enabled Professor Smith to point out what was involved in this matter. When the load changed, the speed rose, and the object of governing was to reduce the fluctuation and damp it out. The ideal sought was to reduce the momentary and instantaneous change of speed as much as possible, and to bring the final speed as near to the normal speed as possible. The fluctuation was, of course, dependent on other matters than mere change of load—such, for instance, as the inertia of the wheel, and the speed at which the servo-motor could be brought into action to cut off the water. Cutting off quickly meant resurgence in the pipes, for which provision had to be made ; and to deal with this, in addition to other accommodation, a by-pass had to be provided, to be instantaneously opened and to be closed again either by a cataract or some other arrangement.

Dr. H. S. Hele-Shaw followed, saying that Professor Smith had referred to the matter of regulation. This was one of the directions in which it was admitted that improvement was still possible. The design of the wheel itself had been brought to a state of great perfection, and now what were formerly the minor points were becoming important. He wished to draw attention to a system of regulation which might most fitly be applied in this connection, but which, on a large scale, had only as yet been used on ships. Dr. Hele Shaw then proceeded to describe, by means of a rough sketch on the blackboard, the pump used in the steering gear, of which he gave a description in a paper read and discussed before the Institution of Naval Architects in April last, and which we reproduced at the time *in extenso*.* The pump embodies a series of radial rotating cylinders, the plungers of which are attached to a large ring, which can be set concentrically with, or eccentrically to, the centre of the radial pump cylinders. If set concentrically, there is no pumping action ; but if thrown out eccentrically, pumping takes place in proportion to the eccentricity. Such an arrangement could be connected with the needle of the wheel. The pressure could be varied almost instantaneously, and with large pressures very little power was used. In the case of the steering gear already tried, a 4-horse-power motor replaced a previous one of 25 horse-power. The arrangement was at work in large steering gears, and gave satisfaction. The whole point was that the inertia of the revolving parts was ready to come into play instantaneously, this being, of course, the object desired in all governing gears.

Mr. William Patchell was the next speaker. He referred to the measurement of water, saying that in England it was often necessary to measure quantities of water, and the usual method there adopted made use of either the square or the V notch. In the work dealt with in Dr. Prásil's paper rotating meters were employed, and were quoted to 0.5 per cent. accuracy. He thought that if these figures could be accepted, it would add very considerably to the value of the paper if there could be added to it descriptions both of these meters and of the method of checking their accuracy.

The President said that he felt sure all were very interested in the development of water-power, in which the Swiss people had taken so large a share. Electrical distribution had, without doubt, greatly enhanced the value of water-power. In regard to the papers under discussion, he would like to hear more about the cost of hydro-electric works. At Rheinfelden he thought that probably all had been struck by the fact that so much steam-power reserve was needed in order that the obligations accepted in connection with the supply of current might be discharged. During part of the year, at least, this had to be relied upon. The influences at operation were complex. What, for instance, was the influence, in connection with the Mexican plants, of continuity of flow ? When the power was applied to some industrial processes it was not necessary for the works to run continuously; but this was not so in all cases. If continuous supply were necessary, both steam and water plant would often be required ; but they were not always possible. In any case, the interest on the additional capital expended must not exceed the value of the coal saved, and the value of water-power was thus very dependent upon its situation. For these reasons it often happened that the work was brought to the water, though electrical distribution had had an important and beneficial influence in this direction. Of course, artificial reservoirs were now sometimes used for storage for making up seasonal deficiency of supply, and this improved the situation. He wished to say a few words with regard to the size of turbines. He agreed with Dr. Prásil that the maximum efficiency of turbines had been about reached, and that it was in the direction of governing that improvement was now to be sought. In fact, the efficiency of control was still susceptible of improvement. High efficiency was, however, sometimes of comparatively small importance. It was of most importance where continuity of output was of vital necessity and the supply relatively small ; but often it did not greatly matter.

Mr. Zoelly, who spoke in German, said he wanted to deal in a few words with a point raised by the chairman. There existed in Switzerland several waterfalls which could not be turned to account ; in this connection it was often considered that a water-power station should not cost more than 1000 francs (40*l.*) per horse-power. As a rule the Swiss power stations cost for pipe-lines, buildings, turbines, and electrical generators 300 to 500 francs (12*l.* to 14*l.*) per horse-power. The equalisation of the water flow was a very important point, and this arose from the circumstance, among others, that there occurred great variations in the demand for power. A steam-turbine, or a Diesel engine installation, was only used at those power stations at which equalisation in the water flow could not be effected by natural means. When equalising reservoirs were resorted to, these were filled at night time, the water thus stored being utilised for power generation during the day. In such instances, the problem was to arrive at a right combination of water storage with heat-engines as a stand-by. In some plants, such as those for the manufacture of chemicals, for example, the working of the plant could be regulated on the basis of the power available. In the case, however, of power supply to townships it was absolutely necessary to provide means for meeting an irregular demand at any time.

Professor R. H. Smith then asked leave to make a few remarks on water-meters, three propeller meters being exhibited at the meeting. Two of these meters had, as Professor Smith pointed out, screws of fairly large blades. The third was a small meter with which several readings at selected points in the current were taken, in order to obtain a proper mean. With the larger propellers figures were obtained which were not true means. One of the larger meters counted the revolutions of the screw at the instrument itself below the water surface. In the other large meter the record of the speed was transmitted electrically from the propeller below to above the water surface. This constituted one of the most valuable changes recently made in such meters. At home a great deal of attention was now being given to the Venturi water-meter. A Breslau firm was, however, now manufacturing and introducing into England a form of flow-meter of the arrow type, which he considered even superior to the Venturi meter. He wished to impress upon the meeting the importance of obtaining a fair mean figure by measuring the flow at a large number of points. In an open channel it was difficult to obtain accurate measurements close to the walls, since, with even the smallest meters, the flow of the water was then impeded by the instrument. Bazin, in endeavouring to find a law connecting the distribution of flow over the whole area, failed to arrive at a general law because of this disturbing influence on the meter.

At the close of the discussion on the two papers, the President asked the authors to send in their replies in writing, instead of delivering them there, in order that as much time as was possible might be given to the paper on "Steam-Turbines."

Steam-Turbines.

Mr. H. Zoelly's paper, entitled "Steam-Turbines," was next taken. This paper is reprinted elsewhere in this issue (page 160). It was read for the author by Mr. E. R. Peal, who had translated it from the German.

After the passing of a vote of thanks to the author, Dr. E. Hopkinson was called upon by the President to open the discussion. After drawing attention to one or two slight corrections in the

* See Engineering, vol. xci., pages 513 and 516.

paper which Mr. Zoelly had asked him to bring to the notice of the meeting, and given effect to in our reproduction of the paper, he said that he thought that one of the principal attractions to many of the members in coming to the Zurich meeting had been the prospect of visiting the works of Messrs. Escher Wyss and Co., and of meeting Mr. Zoelly. He considered they had been amply rewarded in the visit to the works of that firm on the previous day. He had been much impressed then by the perfection of the foundry work, and especially in connection with the casting of the guide-blades into the wheel, as illustrated in the paper (page 157). The author had been commendably brief in his paper. He had scarcely done justice, however, to the remarkably rapid evolution of the turbine. Six years ago, at the time of Mr. Zoelly's first steam-turbine, the status of the art was very different to what it was now. Then the reaction turbine of the Parsons type held the whole field, and the impulse turbine had not passed out of the laboratory stage. The pure-action or impulse type had been selected by Mr. Zoelly as most promising, as a result of his previous experience with water-turbines. Having decided upon the type, the best steam velocity had to be discovered, and, this having been fixed, the pressure stages were determined. The steam velocity should be such that the necessary pressure stages might be obtained with parallel instead of expanding nozzles.

From the first Mr. Zoelly had always acknowledged the benefit he had reaped from the work of others. One name in particular was always coupled with this work, and that was the name of Professor Stodola, who had rendered the greatest assistance in the development. The evolution was remarkable in that Mr. Zoelly, having once fixed upon general principles, had not departed from them since. The Zoelly turbines now made in Switzerland and all over Germany were substantially the same as the original one made. That constituted a remarkable record. Within five years the total horse-power built, or building, in various countries had reached extraordinary figures, and yet the original principles had been in all cases retained, in spite, of course, of the numerous opportunities to depart from them which must arise under such conditions. In one case a compromise had been necessary—namely, in the case of marine turbines. In this case Mr. Zoelly had introduced a compound velocity wheel of one, two, or three stages, but the loss of efficiency thus introduced was all recovered in the later stages. For the compound velocity portion the wheel was used, and for the later stages a drum.

Dr. Stodola wished, in opening his remarks, to pay a tribute to the name of the Hon. Sir C. A. Parsons, as the originator of the turbine; to him Switzerland was greatly indebted. Their endeavour had been to improve the turbine in a scientific direction. The experimental stage had ended, and the practical stage had been reached. Guarantees were now given with confidence, and the obligations undertaken fulfilled. As regards reliability, a satisfactory state had been attained. To reach this condition great sacrifices had been necessary. Troubles had been encountered from the trial of unsuitable blade material, and from the use of too high superheat Rubbing had been caused, and troubles had also arisen from unequal expansion. These had been practically eliminated, but there were other troubles not yet quite solved. At present we had knowledge of what the action of the steam was in the nozzles, but nothing was known as to its action at the blades. At the blade it seemed that there was compression both on the concave and the convex sides, but little was yet understood of these phenomena. Then there was also the question of critical speed, on which Dunkerley had done so much work. It appeared that, with careful design, the critical speed might be passed in turbines without vibration being set up. It had also been shown that when shafts ran in water the amplitude of the vibration at the critical speed was very much reduced. Critical-speed phenomena sometimes appeared at limits not predicted by theory. Calculations, if made with extreme exactitude, might reveal facts which were not recognised when ordinary methods of calculation were pursued, and perhaps greater exactitude was really necessary.

A matter of some interest as regards turbines concerned the rapidity at which they might be run from cold up to full load. Disastrous effects had occurred from injudicious expedition in this operation, because of the unequal expansion of the casing. In cases in which the boast was made that a turbine had been run up in five minutes, or even three or two, the engineer was to be congratulated if the casing had remained intact. He would recommend greater caution in this connection. As regards regulation, he would draw attention to the fact that in the latest Sulzer turbines the governor was replaced by a little wheel with blades—virtually a small centrifugal pump. There were many new problems still to be faced, and the struggle due to competition would probably result in the improvement of all types. Perhaps in the end developments of a fundamental character would appear. A gas-turbine might even be evolved. This prospect had aroused much interest already. The reciprocating motion of the Diesel and other engines would then be superseded, though it was unwise at the present stage to exaggerate expectations. If the steelmaker could provide a steel capable of withstanding temperatures of 800 deg. Cent., the gas-turbine problem was practically solved. Although he had done much in connection with the development of the steam-turbine, he would heartily welcome the advent of the gas-turbine, and he hoped the practical engineer and the theorist would work together side by side for this end.

The next speaker was Mr. H. C. Sparks. He thought that the case against governing by controlling the number of nozzles had been considerably overstated in the paper. It was quite possible with this system of control to secure continuous safe running, and also satisfactory running in parallel with other machines. With regard to the question of critical speed, he would ask the author whether there was a margin allowed, or whether he relied wholly on the balance secured. He (the speaker) had had under observation and test a 2000-kw. turbine running on loads varying from three-quarter full load to one-quarter overload. It had run for about 85 per cent. of the total hours, and when tested a second time at the end of a twelvemonth, the builders (Messrs. Escher Wyss and Co.) had not any difficulty in reaching the guaranteed figures. When subsequently the turbine had been opened out for inspection, there was no sign of touching between the rotating and fixed parts, neither was there either erosion or corrosion. So satisfactory a result could only be due to the great excellence of design and to the great care in the selection of material.

Mr. F. Berry stated that in the Falcon Spinning Company's mill there were 100,000 spindles run by two Musgrave-Zoelly turbines, each driving three-phase generators. Each turbine worked at 160 lb. pressure with 150 deg. Fahr. superheat. There were ten expansions or stages. The steam consumption at full load was 12 lb. per brake horse-power, or 18 lb. per kilowatt-hour, the vacuum being 28 in. with a barometric condenser. The speed of running was 3000 revolutions. Each generator had a capacity of 460 k.v.a. With a power-factor of 0.87, working at 500 volts, the power developed corresponded with 600 horse-power. The turbines and generators had each been designed for 100 per cent. overload. The work performed by the turbine plant appeared to give satisfaction; but whereas with a piston-engine plant one engine sufficed, with the other system two turbines were put in. This seemed to him an important commercial factor. Why should it be necessary to duplicate turbines for mill-driving purposes? Such duplication was never dreamt of with Corliss engines. He would further be glad if the author would give some information as to the best percentage of nickel to use in the nickel-steel blading in order to obtain a steel that would not be too soft or too hard, or brittle when used with superheated steam.

Mr. J. C. Peache, in his opening remarks, testified to the excellence of the work seen the previous day at the works of Messrs. Escher Wyss and Co. He understood that the turbines running at 3000 revolutions per minute showed perfect balance. It seemed to him that there must be rather heavy losses from the revolving of big discs in the dense atmosphere at the high-pressure end of the turbine. In connection with the Parsons turbine, the reaction blading had lately been abandoned at the high-pressure end in favour of the compound velocity wheel. This seemed satisfactory, for, even if the efficiency of the latter were below 75 per cent., compensating savings resulted in other directions. He gathered from the paper that the Zoelly turbines running at 3000 revolutions per minute were built with flexible shafts, and those running at 1500 with rigid shafts. He wished to know if this were actually so. This system appeared to leave a narrow margin between the critical speed and the speed of running. If a turbine were started slowly, and allowed to heat up while running, there was not much to be feared. They should not be heated up while standing, as bad distortion was liable to occur there.

Dr. H. S. Hele-Shaw then made the suggestion, *a propos* of the mention of the name of Dunkerley, and the previous work of Osborne Reynolds on the whirling of shafts, that Professor Stodola should be invited to contribute something to the Proceedings on the subject of critical speeds, &c., as he was, he thought, the best able of any man to continue the work of Reynolds and Dunkerley on this subject.

The last speaker in the discussion was Mr. E. A. L. Chorlton, who touched on the subject of efficiency. In the paper it was stated that the efficiency of the simple-velocity impulse turbine was about 73 per cent. and more. Mr. Eric Brown two days previously had stated at Baden that they obtained an efficiency of 70 per cent. for the combined impulse-reaction set, and it appeared from this that somehow the pure impulse-turbine was more efficient than either the pure reaction or the combination type of turbine that Messrs. Brown, Boveri were building. Machines of one type might be expensive; a combination type, though less efficient, might be better, as the economic result might prove to be superior if the first cost were less. There was no point made in the paper with regard to one important advantage of the impulse-wheel. It had reference to blade-stripping. The clearances with the impulse-wheel were considerable, and greater safety was assured. He noticed that no blade-tip thinning was done at Baden to ensure greater safety. This was always done at home. The practice in the foundry of casting guides in was very interesting. He would like, if possible, for the author to furnish further particulars as to the patterns used. He had tried a wheel-moulding machine, and had cast blades in successfully, using only the small pattern on the revolving arm.

Mr. Zoelly, on being invited to reply to the discussion, made a few remarks in English. He said that without Sir C. A. Parsons the turbine would never have been brought to its present state as regards practice, neither would it have reached its present condition as regards theory had it not been for Professor Stodola. The maximum efficiency of steam-turbines would probably soon be reached, largely as the result of the work of these two men, and he asked the meeting to pass a hearty vote of thanks to both of them, a suggestion which met with very general approval, the expression taking the form of prolonged acclamation.

Votes of Thanks, &c.

The Wednesday morning meeting concluded with the passing of votes of thanks to the many authorities, gentlemen, and others who had assisted in the arrangements for the visit. The list was a very lengthy one, and it is not possible to reproduce it here in full. It will suffice to mention that it included, for instance, the authorities of the Swiss Polytechnikum, the Verein Schweizerischer Maschinen-Industrieller, the Swiss Federal Railways, &c., the names of Mr. E. Sulzer-Ziegler, Colonel P. E. Huber, Professor Stodola, Mr. G. L. Naville, Mr. Jacob Sulzer-Imhoof, Dr. W. Wyssling, and the firms of Messrs. Brown, Boveri, and Co., Escher Wyss and Co., the Oerlikon Engineering Company, Sulzer Brothers, the Swiss Locomotive Works, as well as other works visited, &c. The meeting then adjourned.

Visits on Wednesday, &c.

For the afternoon of Wednesday, the 26th ult., three alternative visits had been arranged. The most popular proved to be the excursion to Winterthur, where the works of Messrs. Sulzer Brothers and the Swiss Locomotive and Engineering Works were visited. The members were received by Mr. R. Sulzer, and were then divided into two parties, proceeding through different works. Each party was entertained to tea at the works first visited, and then transferred to the other works, where they were shown round, as the previous party had been. Members found a great deal to interest them in both works, but more especially, perhaps, in the works of Messrs. Sulzer Brothers, where the foundry work and the Diesel engines under test and erection, &c., attracted a great deal of notice. Both works were de-

THE ZOELLY STEAM-TURBINE.

Fig. 7. CURVE SHOWING NUMBER OF STAGES REQUIRED FOR EXPANDING FROM 10 ATM TO 0·1 ATM. FOR VARIOUS PRESSURE FALLS PER STAGE.

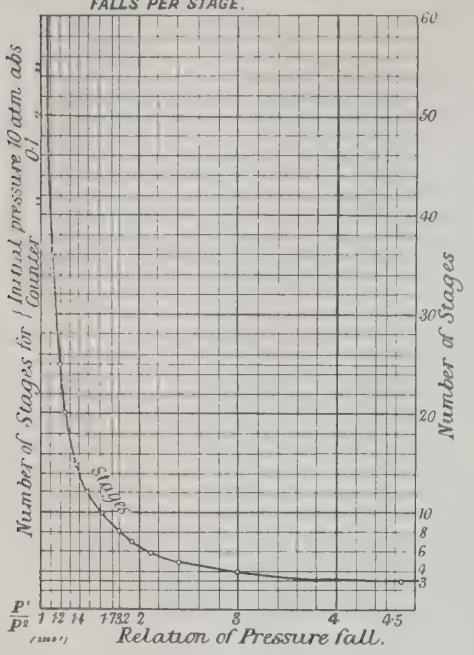


Fig. 8 CURVES SHOWING STEAM VELOCITIES FOR VARYING INITIAL PRESSURES

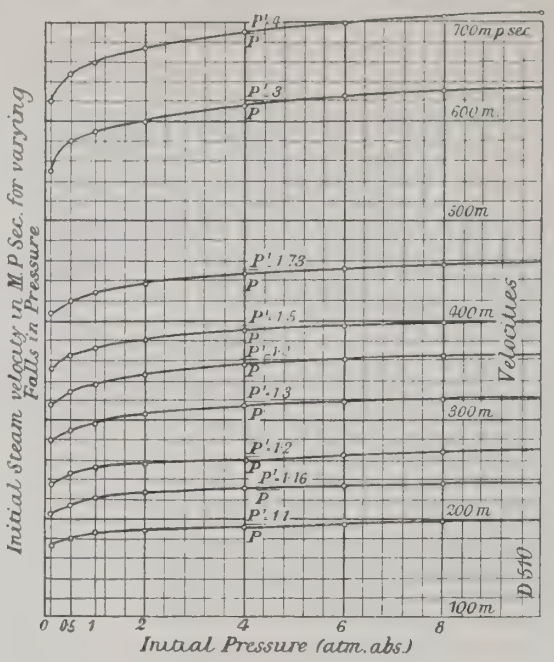
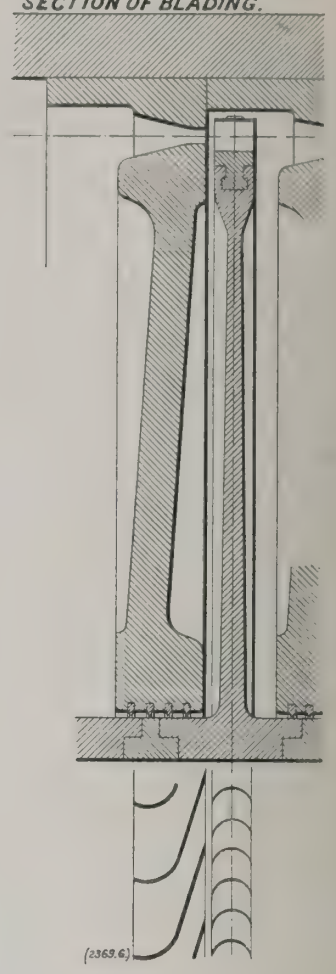


Fig. 9. SINGLE STAGE OF IMPULSE TURBINE AND SECTION OF BLADING.



scribed and illustrated in ENGINEERING on July 21. The Sulzer Works contain some exceptionally fine machine-tools, and the shops are very light and airy. Two large vertical Diesel engines were on the testing-bed in the large erecting-shop at the time of the visit, one a two-cycle 750-horse-power engine, and the other a 350-horse-power four-cycle engine. Both engines were started up, and got up to full speed in what appeared to be exceptionally short time. The dynamometers used were by Messrs. Heenan and Froude. In the shops of the Swiss Locomotive and Engineering Works a large number of gas-engines and Diesel engines, &c., were also seen in course of erection and under test.

On Wednesday afternoon the ladies of the party and some of the gentlemen went by train to Schaffhausen, where the falls were visited and the river crossed by boat below the falls. Neuhausen was also visited, and the hydro-electric station of the Schaffhausen Town Electricity Works was open to inspection. The party reached Zurich at 9.10 P.M. after a very pleasant afternoon.

On Thursday, July 27, two parties, numbering together about 190, left Zurich by special train for Netstal, where one party alighted and proceeded to the Beznau-Löntsch Power Company's water-power works, afterwards going up to the Klöntaler See. Thence members drove or walked to Glarus in the afternoon. The other party continued in the train as far as Linthal, where they took the rope railway up to Braunwald, from whence a magnificent panorama was enjoyed. After lunch the party descended again to Linthal, and proceeded to Glarus, where both parties met for dinner, returning subsequently to Zurich in the special train.

On Friday there were no special arrangements, though a number of excursions were made by parties of members in various directions, one of the trips being to the top of the Uetliberg, over Zurich, whence a view of the town and valley and the lake, &c., was obtained. In the evening members and ladies were invited by the President and Mrs. Ellington to a dance at the Baur au Lac Hotel. Saturday witnessed the departure of the majority of the party. Many proceeded, in accordance with the official programme, to Lucerne by way of Arth-Goldau, the Rigi-Kulm, and Vitznau, travelling thence to their destination by boat. There were several excursions to works, &c., arranged for Monday and subsequent days, one of the principal visits on Monday, the 31st ult., being that to Engelberg and Obermatt. At the former members were entertained to luncheon by Colonel P. E. Huber. Colonel Huber addressed a few pleasant words of welcome to the party, regretting that he had been unavoidably prevented from taking part in the reception of the members at Zurich during the preceding week. At the luncheon the health of their host was drunk by the members thus hospitably entertained by the President of the Verein Schweizerischer Maschinen-Industrieller, to whose kindly advice and assistance in the drawing up of the whole programme the Institution is greatly indebted. In the afternoon Colonel Huber accompanied the party down to Obermatt, and went round the power-station there with the members. The power-station visited at Obermatt derives its supply from the River Erlenbach, the available head at Obermatt being 1017 ft. gross, the flow varying from 220 to 550 gallons per second. The turbines are Pelton wheels, and consist of four units of 2000 horse-power each, two of 150 horse-power, and one of 600 horse-power. The four first are direct coupled to the generators, the two 150-horse-power units to the exciters, and the last to the generator supplying the Stansstad-Engelberg Railway. The first and last part of this excursion were made by boat on the Lake of Lucerne. Other visits arranged for this week were made to numerous other power-stations and hydro-electric undertakings, but these were by members either individually or in smaller parties. The programme carried out in Switzerland well maintained the high reputation of the Institution's summer meeting. Every day was enjoyed by the members, the only drawback experienced by some being the hot weather. Rain did not interfere with the programmes, and, for the most part, brilliant sunshine was enjoyed, so that everything possible contributed to the success of the visit. The Institution's secretary, Mr. E. Worthington, and his staff, are certainly to be congratulated on the efficiency of the arrangements, no hitch occurring throughout the week.

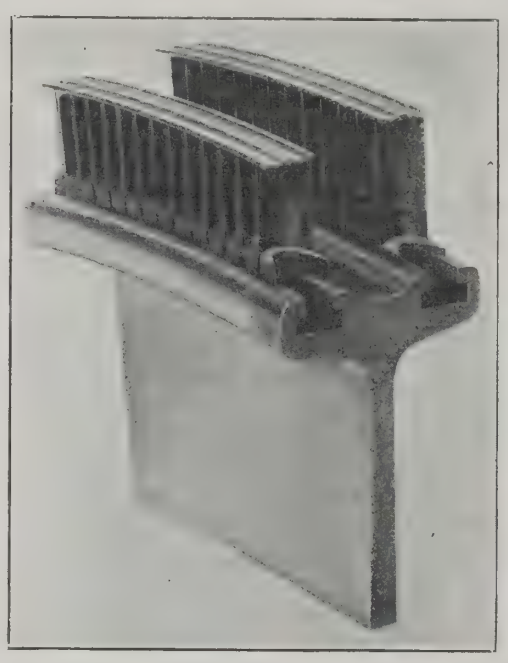


FIG. 10. SECTION OF DOUBLE-VELOCITY WHEEL OF IMPULSE TURBINE, SHOWING NEW METHOD OF RETAINING BLADING AND SECTION OF BLADING.

STEAM-TURBINES.*

By H. ZOELLY, of Zurich.

[*Translated from the German, by Mr. E. R. Peal.*]

Development of the Zoelly Turbine.—The author of this paper has for the last twenty-five years specialised in the design of water-turbines; during this period his firm, Messrs. Escher Wyss and Co., have unceasingly carried out very careful and systematic tests, obtaining very valuable experience in the governing and efficiency of these machines under a very wide range of working conditions.

At the beginning of this year the total number of high-pressure water-turbines of the radial-jet type supplied by his firm was 2580; the number of low-pressure water-turbines of the Francis type was 2240; in all a total of 4820, representing 1,981,600 horse-power. The dividing point between what is called the high fall (impulse type) and the low fall (reaction type) is at about 300 ft. In the first case only impulse turbines (of the Girard or jet type) can be used, and in the second only reaction turbines (of the Jonval or Francis type).

Based chiefly upon his experience gained with water-turbines, the author commenced about fifteen years ago to experiment with steam-turbines, considering that the

* Paper read before the Institution of Mechanical Engineers, at the Zurich Meeting, July 26.

THE ZOELLY STEAM-TURBINE.

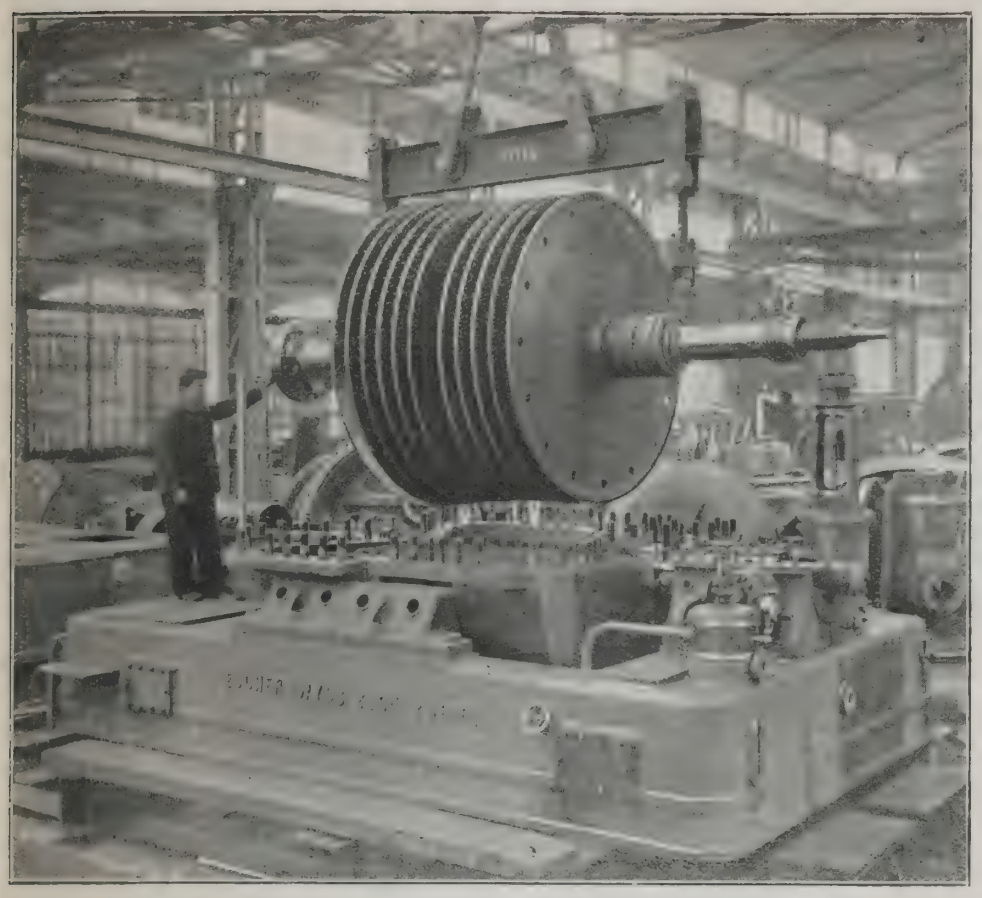


Fig. 11. Rotor of Turbine Raised for Inspection Purposes.

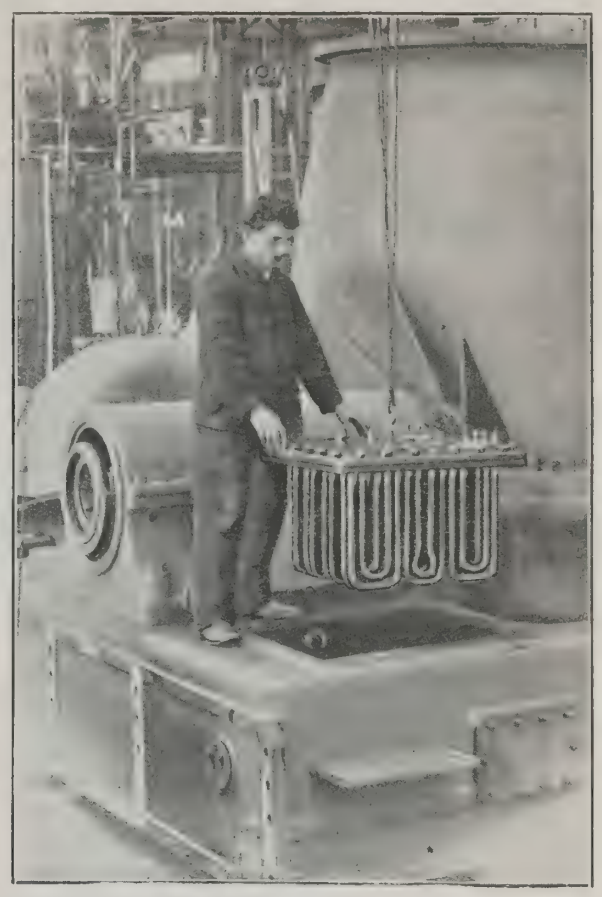
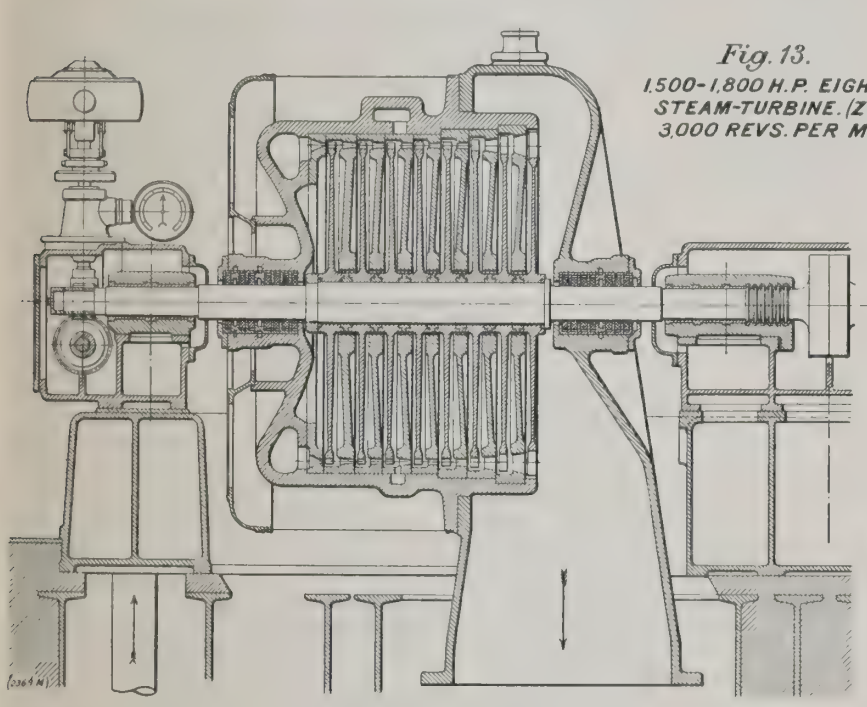
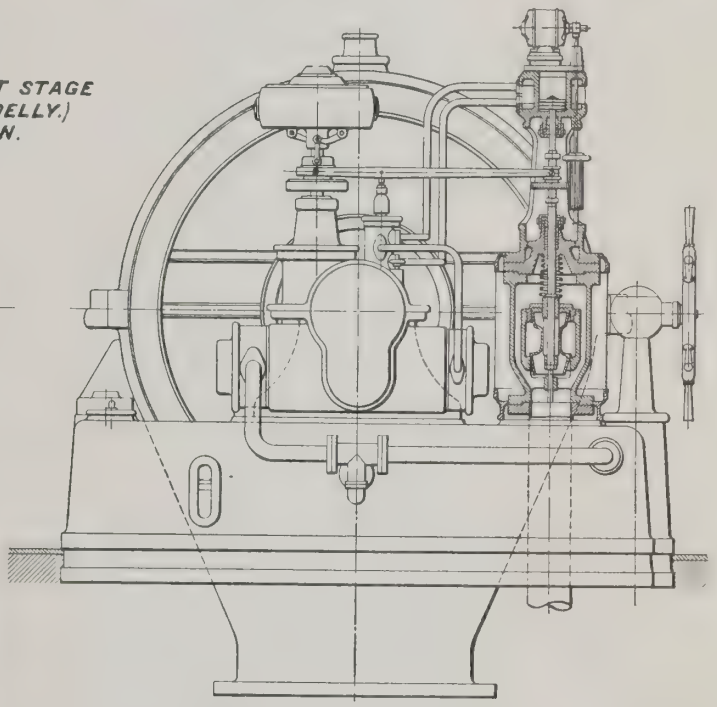


Fig. 12. Oil-Cooling Apparatus.





steam-turbine would resemble, in most respects, the water-turbine, only using a much higher working pressure. For this reason he was guided in adopting the pure action or impulse type of steam-turbine. The unusual experience that this firm had obtained in respect not only of water-turbines, but also of ordinary reciprocating steam-engines, during a period of over seventy years proved to be of very great assistance in carrying out these experiments.

As is almost invariably the case when experimenting with any new kind of machinery, it is very difficult to combine satisfactorily the ideas of the theoretical mind with those of the practical. In order to attain the most favourable efficiency, a very high circumferential speed of the rotor is necessary; but to obtain this result within economical limits is the chief difficulty of the constructor, whose contention was that a heavy and solid design was absolutely necessary for safe working, and was, further, a cheaper form to construct.

The first machine was designed on the radial-flow principle. In its design too much regard was paid to practical construction considerations, and too little to theory.

The second machine was constructed on the same principle; the blades, however, were curved in preference to being flat, as previously, the steam in this case impinging against the rotor blades in a radial direction. This form of construction constituted quite a considerable improvement upon the earlier design. Already at this period it was found advisable to divide the drops in pressure into at least six and sometimes ten to twelve separate pressure-stages. The diameters of the rotor-wheels were also increased in dimension towards the exhaust end in order to cope better with the increased volume of the steam.

As already observed, the principle of the action (impulse) type has been recognised and adopted from the commencement as being the best; the only alterations that took place for some time were in the manner of guiding the steam on to the wheels. The first wheels were constructed after the manner of the Pelton wheel, against which the steam impinged tangentially, after being directed through separate guide-channels. It soon became apparent, however, that after impact the steam became too dispersed. It was then decided to expand the steam axially instead of radially, at first only in the low-pressure stages, but subsequently throughout the whole turbine. This method had formerly been adopted by English constructors as being the most practical.

What has always been, and is still, the most characteristic feature of the Zoelly turbine is the designing of the runner-wheels and guide-channels in the diaphragms (Figs. 1 to 6, page 157). The former, in spite of the high factor of safety that is necessary, can thus be given a relatively high circumferential velocity. Consequently greater latitude is permissible in regard to the number of pressure stages, and the speed of the steam in each.

From the early start two very characteristic diagrams have been prepared (Figs. 7 and 8, on the opposite page). These diagrams were obtained from theoretical calculations, which have since been proved by actual results. Fig. 7 contains as abscissæ the pressure relation per stage $\frac{p\,1}{p\,2}$ (where $p\,1$ = the initial steam pressure in atmospheres absolute, and $p\,2$ = the final steam pressure in atmospheres absolute in the same stage), and as ordinates the requisite number of stages for

steam expanding from 10 atmospheres to 0.1 atmosphere (that is, 142 lb. per sq. in. to 1.42 lb. per sq. in.), assuming that the pressure ratio $\frac{p\,1}{p\,2}$ of the steam, both before and after passing through the guide-channels, is constant. Fig. 8 shows the steam velocity resulting from pressure ratios given for various initial pressures. For a ratio pressure fall of $\frac{p\,1}{p\,2} = 1.732$, it follows from Fig. 7 that about nine stages are required. For relative pressure-falls where $\frac{p\,1}{p\,2} = 1.1$; 1.2; 1.3; 2.1; 3; 4.6, the requisite and corresponding number of stages for a total expansion of from 10 to 0.1 atmospheres absolute would be 42, 25, 18, 6, 4, and 3 respectively. Should we assume a greater ratio of pressure-fall than 1.732 for the purpose of saving stages, then, in order to have only four stages, it is necessary to have a ratio pressure-fall of $\frac{p\,1}{p\,2} = 3$.

From Fig. 8 for a mean initial pressure of $p\,1 = 4$ atmospheres absolute, the steam velocity would be equal to 615 m. (2018 ft.) per second. This steam velocity, on the other hand, would require a circumferential speed of about 250 m. (820 ft.) per second—that is (for a simple velocity wheel) in order to obtain a reasonable efficiency, Again, if we take a smaller ratio of pressure-fall than $\frac{1.732}{1}$, for instance $\frac{1.30}{1}$, the necessary number of stages would be increased from 9 to 18—that is, exactly double. Such a turbine would be far too complicated and expensive; besides, it would not then work with perfect economy owing to the greater friction of the runner-wheels and the greater length of steam passage.

After carefully weighing up all these considerations, the ratio pressure-fall of $\frac{p\,1}{p\,2} = 1.73$ was chosen as representing the best combination of efficiency and practical constructional economy. This pressure-fall is called the "critical fall," and when this is exceeded then the resulting steam velocity approaches the velocity of sound. Directly one wishes to utilise a substantially higher pressure-fall per stage, it becomes necessary to depart from the simple construction of parallel guide-nozzles, which is peculiar to the Zoelly turbine, so that, instead of the simple parallel nozzle, one must adopt the expanding, or Laval, type of nozzle. The reason why Parsons employs such a small pressure-fall per stage is entirely to keep down as low as possible the losses through leakage, which are unavoidable in reaction turbines.

The author does not intend to deal more fully with the various stages of improvement, which from that period have been solely of a constructional character, but will describe the Zoelly turbine as manufactured at the present time by Messrs. Escher Wyss and Co. For turbines of 3000 revolutions per minute eight stages are usually employed; for 1500 revolutions per minute, twelve stages; and for 1000 revolutions per minute, sixteen stages. The first diaphragm plate (guide-wheel) of the high-speed turbines has nozzles which extend for a portion of the circumference only—in the bottom half of the diaphragms, whilst in the other diaphragms the nozzles usually extend completely round the circumference. In the case of large units, however, steam is admitted through channels extending completely round the circumference for all stages.

The governing is effected simply by throttling the live steam, and not by varying the number of channels through which the steam is admitted. The throttle-valve is actuated by oil under pressure in a small cylinder (servomotor) by hydraulic action, the oil being supplied by a small pump directly driven from the shaft.

This is the same form of governing as that which has been found to work so successfully for water-turbines, and is now being universally adopted by nearly all the different makers of steam-turbines on the Continent. Its inherent advantages are, that it is extremely simple and reliable, and, contrary to fears expressed by some engineers, this method of governing works particularly economically at partial loads, as is seen from the results shown later. This, however, is only possible when simple velocity wheels are used in connection with parallel guide-nozzles throughout the whole turbine, and provided that the most favourable choice is made in regard to the sub-division of stages. Fig. 9 (page 160) illustrates a simple velocity stage in a Zoelly turbine, showing a section of blading. The conclusion arrived at is that the compound velocity wheel design is only advisable in special cases, as, for instance, for propelling ships, where a low propeller speed is absolutely necessary. Fig. 10 (page 160) illustrates a portion of compound velocity wheel and section of blading, and shows the latest method of retaining the blading.

The chief reasons against the adoption of the compound-wheel design in the case of stationary turbines are the lower steam efficiency and the necessity of a complicated governing apparatus in order to obtain a favourable consumption at partial loads. In this type of turbine the governing has to be carried out by controlling the number of nozzles through which the steam enters. Experience has shown that this method does not satisfactorily answer practical requirements—*i.e.*, continuous safe running. Besides, the governing is not so accurate, and is less suitable for running in parallel with other machines.

The author would especially like to mention that for many years he has experimented with turbines designed with a high steam velocity and compound wheels. The many series of tests which he has carried out at different periods have all gone to show that under the most favourable conditions it is not possible to obtain a higher thermal efficiency with compound velocity wheels than 58 per cent., whereas with a turbine designed with entirely

THE ZOELLY STEAM-TURBINE.

Fig. 14. 3000-5000 H.P. TWELVE-STAGE STEAM-TURBINE. (ZOELLY.) 1500 REVS. PER MIN.

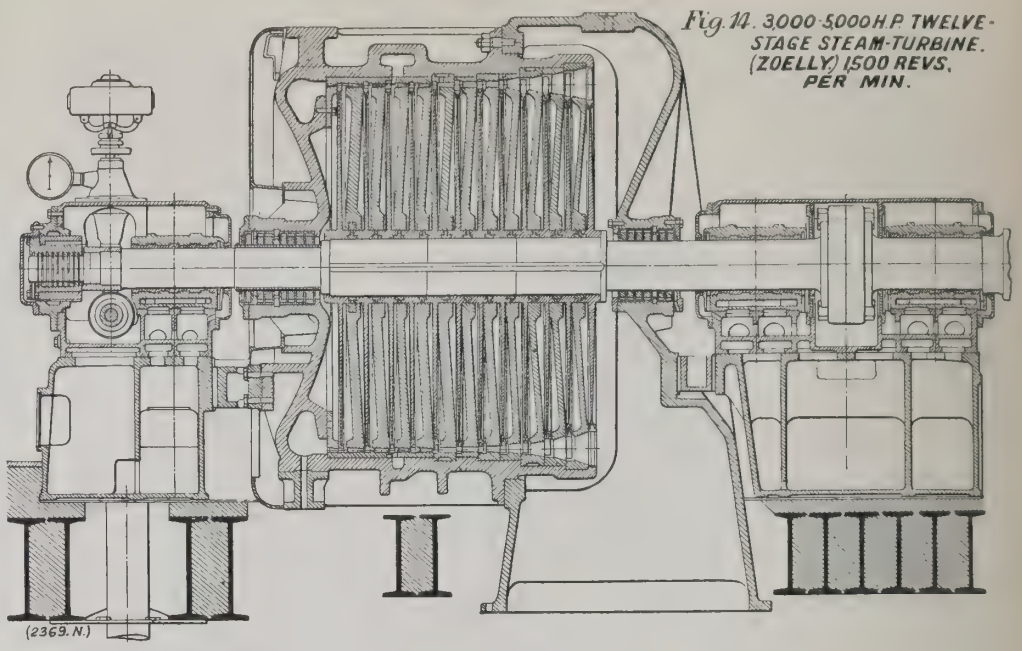
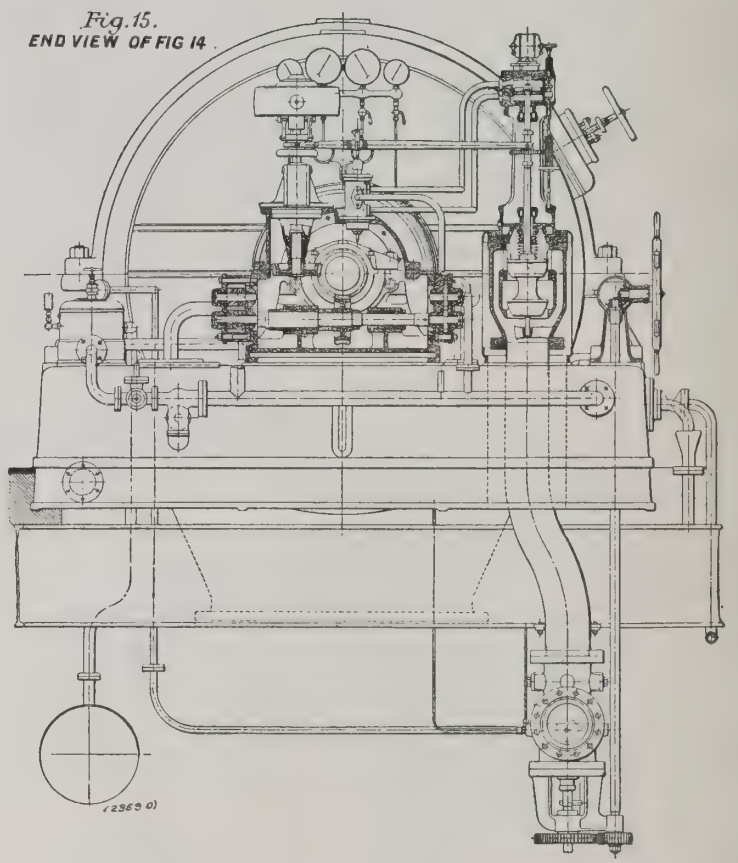


Fig. 15. END VIEW OF FIG 14.



Figs. 14 and 15. 3000—5000-Horse-Power Twelve-Stage Steam-Turbine (Zoelly); 1500 Revolutions per Minute.

TABLE I.—Some Test Results Obtained with Zoelly Steam-Turbines.

Installation.	Load in Kilowatts.	Steam Pressure at Stop-Valve. Pounds per Square Inch.	Steam Pressure at Stop-Valve. Temperature, Deg. Fahr.	Vacuum.	Steam Consumption. Per Kilowatt-Hour.	Steam Consumption. Per Horse-Power Hour.	Thermal Efficiency per Cent. Based on Condition of Steam In Front of Stop-Valve.	Thermal Efficiency per Cent. Based on Condition of Steam Behind Stop-Valve.
				per cent.	lb.	lb.	per cent.	per cent.
4000-kw. turbine	4189	164.7	556.7	95.8	13.25*	9.36	68.7	71.2
Charlottenburg	3092	168.3	558.3	96.2	13.77	9.58	66.2	70.8
1000 revolutions per minute	2199	161.9	518.5	97.4	14.40	9.84	63.2	70.75
Tested December, 1910 ..	1138	166.9	520.7	97.8	16.00	10.12	59 9	72.7
2000-kw. turbine	2052	179.0	584.6	94.9	13.04	9.18	70.5	73.0
Helsingfors	1514	181.7	563.3	95.5	13.67	9.52	67.2	72.8
3000 revolutions per minute	1026	177.5	565.5	95.8	14.53	9.76	65.2	73.8
Tested, November, 1910 ..	510	171.8	543.0	96.6	17.33	10.68	58.8	72.8
1700-kw. turbine	1691	206.0	670.2	93.3	13.04	8.91	69.7	69.8
Hagendingen	1366	202.3	673.5	94.2	13 77	9 18	66.5	69.2
3000 revolutions per minute	851	205 2	662.0	95.2	15.52	9.81	61.9	66.9
Tested, December, 1910 ..	457.5	208.0	642.9	94.9	18.91	10.68	57.1	67.9
1200-kw. turbine	—	—	—	—	—	—	—	—
Aurich	1235	162.3	451.0	94.0	15.34	10.77	67.9	68.3
3000 revolutions per minute	949	164.0	442.4	95.5	15.99	11.08	62.8	66.9
Tested, December, 1910 ..	606	166.7	427.4	96.5	17.1	11.48	59.0	66.6

* Not including steam required for condensing plant.

Fig. 16.

1,100 H.P. EIGHT-STAGE STEAM-TURBINE (ZOELLY), WITH DEVICE FOR DRAWING OFF STEAM FOR HEATING PURPOSES 3,000 REVS. PER MIN.

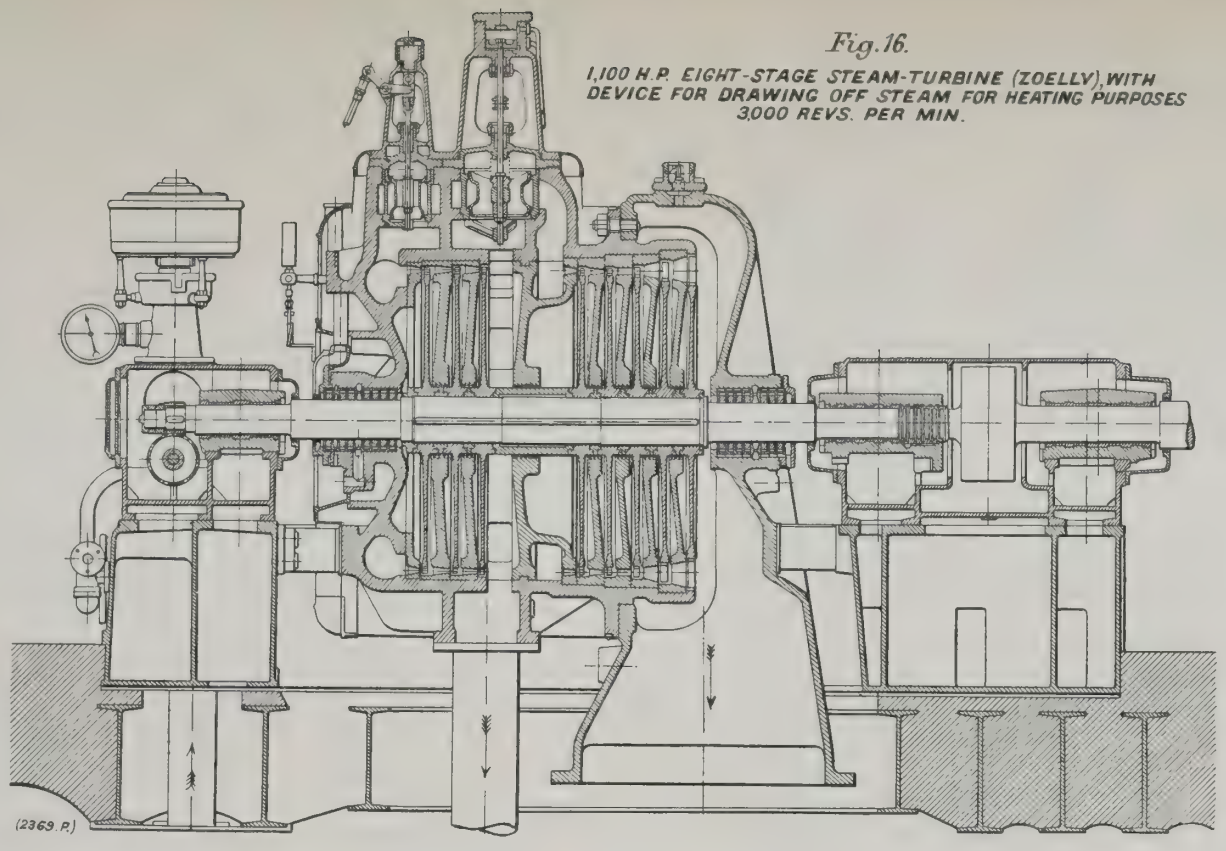
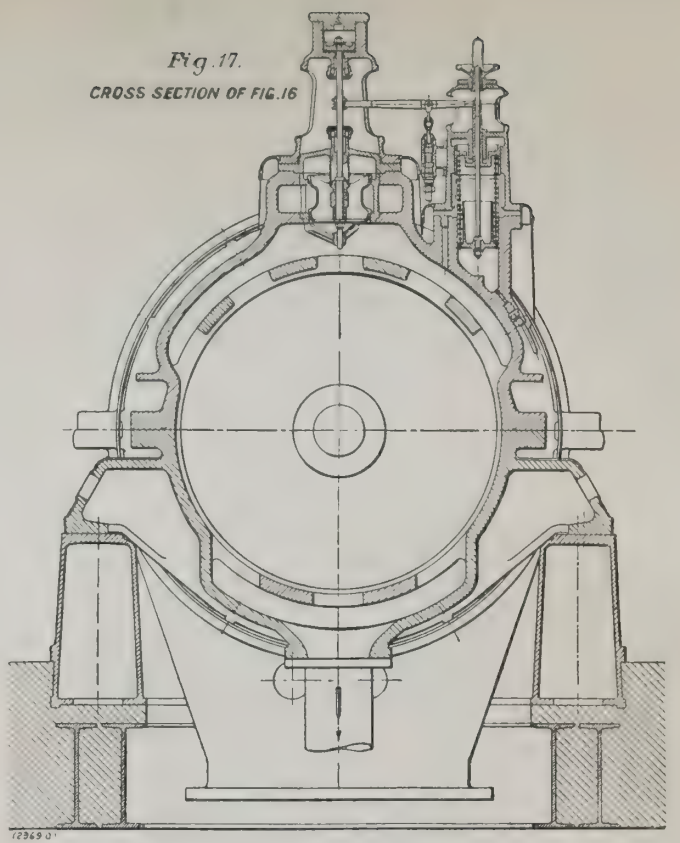


Fig. 17.

CROSS SECTION OF FIG. 16



simple velocity stages it is possible to obtain an efficiency of 73 per cent. and more. If, therefore, in an impulse turbine it is found necessary to employ a combination design of compound and single velocity stages for such special cases as exceptionally large units for land purposes, or where it is necessary to work at low revolutions, the comparatively poor efficiency of the high-pressure compound velocity stage or stages must be compensated for as well as is possible by obtaining a relatively higher efficiency in the subsequent low-pressure single velocity stages. For this purpose almost as many pressure stages must, on the whole, be provided for as in a design employing only single velocity stages.

It is often objected to in the Zoelly turbines that too high a pressure and temperature exists in the first pressure stage; against this it must be said that even with Zoelly turbines likewise large pressure-falls can be utilised for the first stage even within comparatively economical limits, provided that the lower pressure or subsequent stages have a correspondingly lower pressure-fall, and thus consequently work with a higher efficiency. In this way it happens that by the application of live steam at about 170 lb. per square inch and 570 deg. Fahr. (300 deg. Cent.) the pressure and temperature of steam after expansion in the first stage is 70 lb. per square inch and 465 deg. Fahr. (240 deg. Cent.). Such conditions as regards the solidity and durability of the casing and its stuffing-boxes are nowadays easily mastered by steam-turbine builders.

Following on the foregoing considerations, attention is now drawn to a few typical designs of turbines which have been constructed for various purposes. As the illustrations shown on pages 161 to 165 probably convey more to the mind of an engineer than a detailed explanation, only a short account of each design is given.

Construction of the Zoelly Steam-Turbine.—The Zoelly turbine has from the commencement always been constructed with a horizontal shaft: experience with water-turbines has shown that by this method the simplest form of bearing can be used, permitting an easy inspection at all times.

In the case of turbines running at 3000 revolutions per minute a flexible shaft is used, so that the critical speed is sufficiently below the working speed; but in the case of turbines running at 1500 revolutions per minute and under, the contrary is the case, the shaft is rigid, and the critical speed is above the working speed. The shaft is supported by two bearings, which are lubricated by oil under pressure, and is connected by means of a rigid or flexible coupling (usually rigid) to the generator or machine to be driven. The casing is built up in two halves, the joint being horizontal, so that the rotor can easily be inspected without dismantling the bearings. An idea of the accessibility of all the important parts can be gained from the illustrations shown. Fig. 11, page 161, shows the rotor of turbine raised for inspection. Fig. 12, on the same page, shows the oil-cooling apparatus.

Test Results.—In connection with the foregoing description and illustrations showing the characteristic features of the Zoelly turbine, it will now be interesting to consider some actual results obtained on trials (see table, page 162); these results are not what may be called "parade-results;" on the contrary, they have been reported by means of specially tested instruments and by impartial officials. These figures show the high economy that is obtained by this turbine, particularly at partial loads.

Fig. 13, page 161, shows to scale a section of a normal eight-stage Zoelly steam-turbine constructed to develop 1500 to 1800 horse-power at 3000 revolutions per minute with a steam pressure of 170 lb. per square inch at 570 deg. Fahr. (300 deg. Cent.), and with a vacuum of 95 per cent.

Figs. 14 and 15, on the opposite page, show to scale a section of a normal 12-stage Zoelly steam-turbine constructed to develop 3000 to 5000 horse-power at 1500 revolutions per minute with a steam pressure of 170 lb. per square inch at 570 deg. Fahr. and with a vacuum of 95 per cent.

Figs. 16 and 17 (above) show to scale a section of an eight-stage Zoelly steam-turbine, fitted with a connection for drawing off about 4500 lb. of steam per hour at a pressure of 3 lb. to 5 lb. per square inch, for heating and other purposes. This turbine was constructed for the Zürcher Papierfabrick, Sihl, to develop about 1100 horse-power at 3000 revolutions per minute, with an initial steam pressure of 115 lb. to 120 lb. per square inch at a temperature of 570 deg. Fahr., and with a vacuum of 95 per cent.

Figs. 18 and 19, page 164, show to scale a section of a mixed-pressure Zoelly steam-turbine, constructed for Zeche, Dannenbaum, and to develop 1800 horse-power at 3000 revolutions per minute, with a main steam pressure of 115 lb. to 120 lb. per square inch, using exhaust steam at a pressure varying from 5 lb. to 12 lb. per square inch and with a vacuum of 91 per cent.

Zoelly Marine Turbine.—During the same period that the previously-referred-to experiments were being carried out tests were in hand, particularly with a view to perfecting a design of slow-running turbine suitable for ship propulsion.

The high-pressure portion of these marine turbines is fitted with a series of compound velocity wheels. Fig. 10, page 160, illustrates a portion of one of these wheels and a section of the blading. Owing to the number of revolutions being too low, single velocity wheels cannot be utilised to their full advantage. In order to obtain a reasonable efficiency with the single velocity wheel only a very small drop of pressure in each stage could be allowed, and this would necessitate far too many stages.

Again, contrary to the theories put forward by Curtis, it was found advisable to adopt the ordinary parallel guide channels similar to those used in the Zoelly land turbine, in preference to expanding or Laval nozzles—a type of construction which has since proved its merits.

These turbines were contained in two entirely independent casings, together with the astern expansions. Owing to the low number of revolutions obtainable in marine turbines, it would only be possible to use single velocity wheels if there were a great number of pressure stages, which is not practicable owing to the length required, and still more to the very high cost of construction of such a design. The high-pressure portion of these turbines, therefore, consisted of a series of compound wheels; the low-pressure portion consisted of impulse-drum blading.

Messrs. Escher Wyss and Co. recently built in their workshops at Zurich a set of two marine turbines, each of 7500 horse-power, which are now in operation in the torpedo-boat destroyer "G 173" of the Imperial German navy. These turbines are illustrated on page 165; Fig. 20 shows the rotor complete, and Fig. 21 a model of the section of a turbine. In accordance with similar constructional designs and calculations made by Messrs. Escher Wyss and Co., a number of similar marine turbines are now being constructed for the German, French, American, Italian, and Argentine navies.

The author desires to acknowledge the assistance given to him in the preparation of the paper by Mr. E. R. Peal, the engineer of the British Zoelly Turbine Syndicate.

THE ZOELLY STEAM-TURBINE.

(*For Description, see Page* 160.)

Fig. 18.

1800 H.P. MIXED-PRESSURE TURBINE FOR "ZECHE DANNENBAUM" (ZOELLY) 3000 REVS. PER MIN.

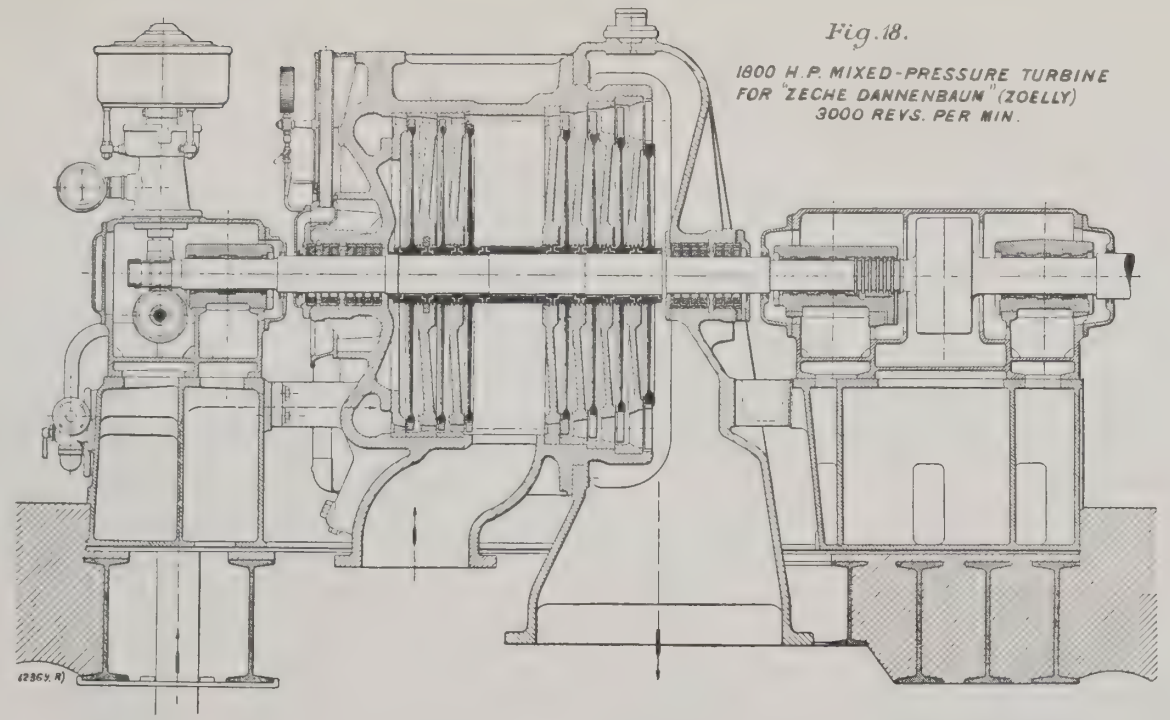
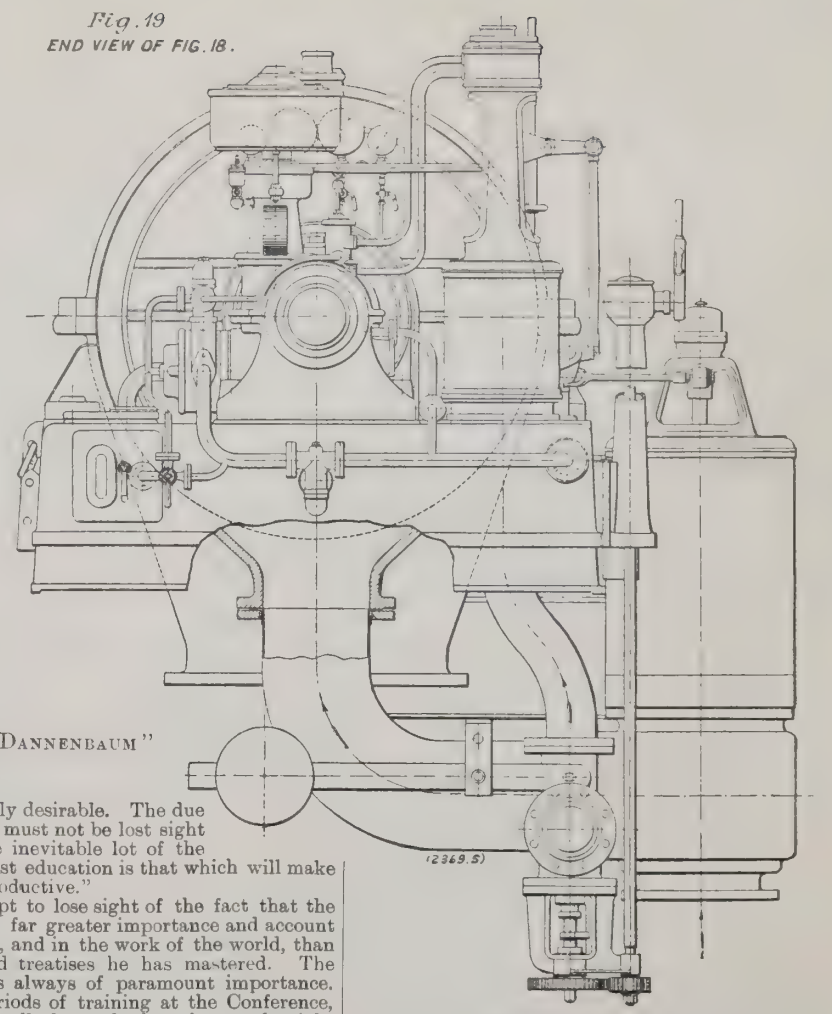


Fig. 19

END VIEW OF FIG. 18.



FIGS. 18 AND 19. 1800-HORSE-POWER MIXED-PRESSURE TURBINE FOR "ZECHE DANNENBAUM" (ZOELLY); 3000 REVOLUTIONS PER MINUTE.

THE EDUCATION AND TRAINING OF ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—Education is a perennial subject of thought and discussion. There are probably few subjects about which so much is said and written. On technical education or training in particular the number of persons who consider themselves qualified to express opinions is perhaps greater than on any other subject outside politics. Nevertheless on few subjects is so much said which is hardly worth saying. An attempt to give the profession of engineering a more recognised status, and to establish it as a closed profession, as other learned professions are closed, is known to find favour in some quarters. No practical scheme to attain this end has yet been formulated. We are not now concerned with arguments for or against such a proposition. The whole question is fraught with immense difficulties. The issues involved are wide and far-reaching, leaving room for grave injustices to all parties.

It is, however, generally acknowledged that much remains to be done, and indeed is urgently required, to improve the status and efficiency of engineers, thereby also promoting the wiser and more conservative expenditure of money. It is well known to all who take the trouble, and are competent, to look into the matter that engineers, or persons so designated, are responsible for the annual waste or misspending of considerable sums. Attention has of late been drawn to this on several occasions. Sir James Inglis referred to it in his presidential address to the Institution of Civil Engineers.

That unnecessary expenditure is, *à priori*, bad engineering needs to be more strongly impressed both upon practising engineers and on those on the threshold of the profession. We do not desire unduly to labour the point, but we do say that the expense incurred in attaining the object in view in many departments of engineering frequently amounts to inefficiency. The art of war has been defined to be the art of making the best use of the means available to attain the object in view. The art of engineering might with advantage be more often regarded as the art of incurring the least expenditure to attain the object in view, having due regard to all the circumstances of the case. As to the proper course to be pursued in the education and training of engineers, we seem to be in some confusion.

The recent Conference at the Institution of Civil Engineers, whilst eliciting a wide and comprehensive discussion, has done little to reduce the confusion. We desire to refer to a few aspects of the matter which were hardly, if at all, touched on by those who took an active part in the Conference. The physicians discussed and argued at the Institution about the disease and the remedies to be applied, but in all the talk it struck us there was a singular absence of any proper consideration of the victim. Any youth about to be entered to the engineering profession, without the knowledge and experience to put the right equation on all that was written and said at the Conference, might well be bewildered. According to some of the authorities, the young engineer's studies must be so wide that all except the stoughtest-hearted might well pause. Again, the length of time to be devoted to training requires, in the opinion of others, to be materially increased. Apparently the opinion is gaining ground that the college course ought to be of four years' duration, and that the customary three years is not enough. After, or at any rate as well as, the college course at least three years' training in shops, on works, and in offices is also held to be essential.

We should be the last to suggest that education is not of great value *per se*, and to be diligently sought after for itself. Education, however, is really a means to an end —at any rate, as far as engineers are concerned. It is a matter upon which, to quote a hackneyed phrase, clear thinking is eminently desirable. The due proportion of things must not be lost sight of. "Labour is the inevitable lot of the majority, and the best education is that which will make their labour most productive."

Enthusiasts are apt to lose sight of the fact that the man is, in reality, of far greater importance and account in everyday practice, and in the work of the world, than all the theories and treatises he has mastered. The personal equation is always of paramount importance. In discussing the periods of training at the Conference, it was not made at all clear whether the youth might expect to be paid anything during any part of the period of his so-called training. If the young engineer is to be subjected to a more lengthy and rigorous training and period of probation in the future, he is entitled to look for a better financial return than it is now usually in his power to obtain. We confess we see no sign of this. The tendency is more towards a reduction rather than an increase in the earnings of young engineers. Young men may not be worth much just at first in the serious affairs of life, but they have to live, and cases are not infrequent where they are paid according to their age, and not according to the work they do, or the responsibilities put upon them. The most obvious ways of raising the standard and status of a profession are restriction as to entry coupled with reasonable emoluments to attract a high class of recruit.

In matters appertaining to education we are too much in the hands of professors and others engaged in the profession of teaching. A large proportion of the speakers at the Conference were men engaged in teaching. No one is a good judge of his own case, and we submit, with great respect, that these gentlemen have too preponderating a voice. We recognise the change and improvement that has taken place in methods of teaching, and in the realisation of teachers that their *raison d'être* is to teach.

Many of us know people who tell us that at school or at college they were never taught anything! Those whose duty it was to teach were too often innocent of the first principles of their business, or perhaps lacked interest and enthusiasm to trouble to practise it in anything approaching an efficient manner. No doubt great changes have come about, and are taking place. At the same time there are still men engaged in teaching who have no gift for it. That a man has a great intellect, and has achieved distinction in some branch of learning, is in itself no reason for appointing him a teacher of youth. Many of the most distinguished holders of various chairs in the universities are not only wasting their own time, but that of the students also. A fine intellect is not necessarily required to teach undergraduates in any of the schools. Frequently a less brilliant scholar is a more competent and painstaking teacher. It is notorious that a great waste of time is liable to arise at colleges, principally from two causes: Firstly, where the lecturer has not the facility of making himself interesting and intelligible; and, secondly, where the lecturer, however brilliant, lacks the power or knack of "holding" his class. In the latter case the efforts of good lecturers are nullified because pandemonium reigns.

We think that some reform is desirable in the method and tenure of appointment of professors and lecturers whose duty is to be primarily to teach. These appoint

THE ZOELLY STEAM-TURBINE.

(*For Description, see Page* 160.)

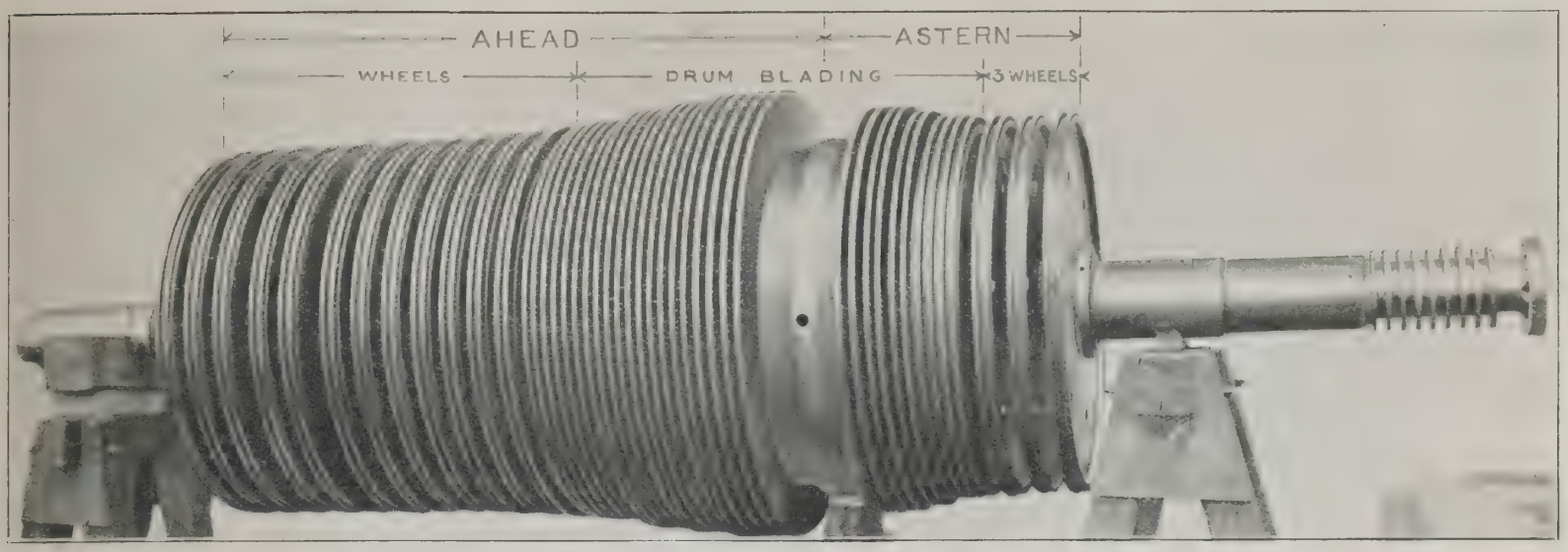


Fig. 20. Rotor of 7500-Horse-Power Marine Steam-Turbine (Zoelly).

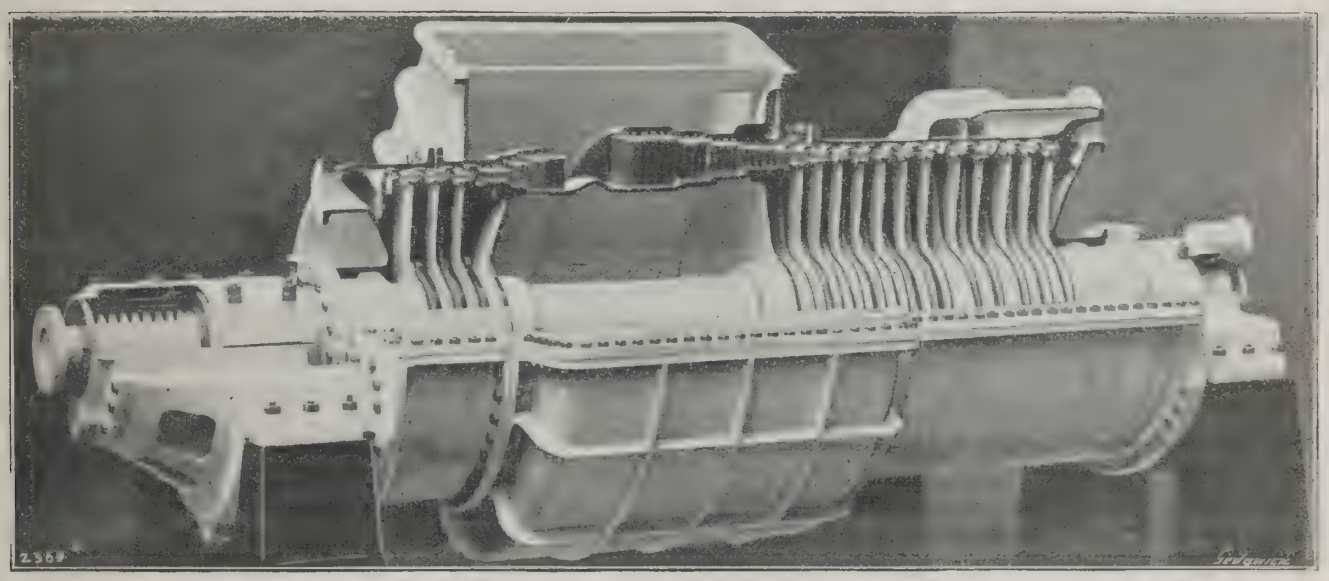


Fig. 21. Model of 7500-Horse-Power Marine Steam-Turbine (Zoelly).

ments ought, in our view, to be made for a term of years, and should be renewable at the expiration of the term under proper conditions. Probably, excluding schoolmasters, nobody ought to be a teacher only all his life. There are many difficulties, but some way surely might be found of meeting them. An interchange amongst various universities would, we believe, militate in favour of the students, for whom, after all, the universities mainly exist, by tending to keep men out of a groove, and up to date. Why should not a professor hold the chair of engineering for five years at one university, and for the next five years elsewhere? An age limit at which retirement would be compulsory should also be established.

We should like to have heard the views at the Conference of more of the younger men—men who have had a modern education and college course with ten or fifteen years of actual work and practical experience. The Conference was engaged too much setting and discussing the course the young beginner is to be put over, without giving any attention to the principal trainers of the aspiring candidate. If this latter side of the question had also come in for some attention, the value of the Conference would have been enhanced. It would be well if engineers in active practice more often found seats on the governing bodies of institutions where engineering courses are provided. More men of affairs are required; things at present are too much in the hands of mere educationalists.

As a part of all college courses in engineering a great advantage would accrue if short courses of lectures were delivered from time to time by engineers in actual practice. We believe this is done to some extent, but not nearly enough is done. The School of Military Engineering at the Royal Engineers' barracks, Chatham, has for years set an excellent example in this respect. From time to time engineers more or less eminent in some branch of the profession have been invited to lecture to the young officers, the lectures being afterwards printed. The lectures so delivered at Chatham are most valuable to engineering students.

Yours truly,

Experience.

Science Examinations.—The Board of Education have issued their Circular, No. 775, in which we find it stated that in 1912, candidates for the awards of Royal Scholarships and Studentships in Science, and of Whitworth Scholarships, will be examined in the subjects, and according to the standards prescribed respectively by paragraph 9 of Appendix I. to Part III. of the Regulations for Technical Schools, &c., 1909, and by Rule 3 of the Prospectus of Sir Joseph Whitworth's Scholarships, &c., 1908. So far as the reorganised examination system does not provide for examinations in these subjects or in the prescribed standards, special examinations will be held. In 1913, candidates for awards will be examined in the subjects prescribed by the Appendix or Prospectus above mentioned, but, according to the standards of the Board's General Examinations for this purpose, they will take the papers set in those examinations, and, in subjects not comprised in the reorganised scheme, special papers will be set of not more than two standards corresponding to those of the general examinations. Special examinations held in 1912 or 1913 will be open to candidates for these awards, but to no other persons.

University College, London.—The programme of next session's work in the Faculty of Engineering and the School of Architecture, at University College, London, has now been issued, and we note that an entrance scholarship of the value of 120 guineas will be awarded in September next. The dean of the faculty of engineering is Professor J. A. Fleming, F.R.S., and the vice-dean Professor J. D. Cormack, D.Sc., who is also chief of the department of mechanical engineering. The full engineering course extends over three years, and included in the faculty are departments of mechanical, heating and ventilating, electrical, civil, and municipal engineering. The mechanical engineering laboratory includes one 100,000-lb. testing machine and a 70-ton machine, in addition to small cement and wire-testing machines. The steam equipment includes one engine of 40 horse-power and another of 12 horse-power, in addition to a De Laval turbine, all of which are specially fitted up for test purposes. There is also a good equipment of machine-tools, which have been used in constructing a considerable proportion of the laboratory plant. Advanced students are encouraged to undertake research work.

The City Guilds Examinations in Technology.—The programme of the City and Guilds Institute for their examinations in technology next spring has now been issued. These examinations now cover seventy-nine different subjects, in many of which the student's knowledge is tested in practical work as well as by a written paper. In the subject of mechanical engineering, candidates are now allowed to take the papers in both Grade I. and Grade II. in the same year. The examination in Grade I., it may be noted, is intended to test the student's general knowledge, whilst in Grade II. he is asked questions relating to one particular branch only. In structural engineering the syllabus for the final examination includes the subject of ferro-concrete construction, in addition to structural steel-work. Unfortunately, the Institute does not now include in its syllabus copies of the papers set in preceding years, and this makes it impossible to get any idea of the standard of knowledge required from successful candidates, who must therefore be almost wholly dependent on the experience of their teacher. A first-class teacher, with no collection of past papers at his command, may thus be much less effective in passing his men than one with lesser powers, but possessed of copies of the papers set for several years past. The omission to publish the papers, in short, plays into the hands of the crammer.

AIR-COMPRESSORS FOR THE BOMBAY, BARODA, AND CENTRAL INDIA RAILWAY.

The illustrations, Figs. 1 and 2, on page 168, represent one of four large air-compressors recently supplied by Messrs. Murray Workman and Co., of Glasgow, to the Bombay, Baroda, and Central India Railway Company, and were built throughout at Messrs. Murray Workman's works, under Messrs. Rendel and Robertson's inspection. They are intended for supplying compressed air for caisson-sinking in connection with the building of several bridges for this company, and have therefore been designed with a view to lightness and portability. The specification called for an output of 1250 cub. ft. of free air per minute, compressed to a pressure of 30 lb. per square inch (gauge), when working non-condensing with saturated steam at a pressure of 150 lb. per square inch. The steam cylinders are 16-in. bore and 24-in. stroke, and are fitted with Meyer expansion-valves. The air-cylinders are 27-in. bore and 24-in. stroke, and are provided with mechanically-operated inlet-valves of the ordinary sliding D type.

The delivery-valves are of Messrs. Murray Workman's special type, and are mounted on the back of the inlet-valves. Fig. 2 shows the air valve-chest, with the cover removed; one of the delivery-valves has been taken out, and is seen in the right-hand bottom corner of the valve-chest. It consists of seven spring steel fingers, each of which covers a corresponding slot in the back of the slide-valve. These fingers are retained in position, and prevented from lifting more than a certain limited distance, and also from bending locally at the root, by means of the cast-steel keep-plates. These plates are cast in the form of grids to allow the air to pass freely through them. The effective area of both inlet and delivery-valves is 30 square inches, corresponding to an air velocity of just 100 ft. per second through them. Owing to the extremely light weight of the delivery-valves their action is rapid and perfectly noiseless; moreover, the spring tension required to give the necessary rapidity of action is so slight as to be practically negligible.

Each compressor was tested at Messrs. Murray Workman's works, and was required to run for six hours at its normal load and pressure, followed by two hours at 20 per cent. overload, the overload being obtained by raising the receiver pressure from 30 lb. to 45 lb. per square inch. The quantity of air delivered was measured by discharging it through an orifice in a thin plate. The diameter was calculated according to the accepted formula, but we are inclined to think that this formula over-states the quantity; for, according to this test, the actual quantity of air delivered was some 10 per cent. in excess of the volume swept by the air-piston. An examination of the indicator diagram (Fig. 4), however, shows that the actual quantity delivered was somewhere in the neighbourhood of 105 per cent. of the volume swept. At first sight this appears somewhat incredible, but it is to be accounted for by the fact that both the suction and delivery-pipes were fairly long and straight (the latter being 73 ft. from the air-cylinder to the receiver) with the result that the inertia of the air in the induction pipe produced an actual positive pressure in the air-cylinder at the end of the suction stroke, some 2 lb. in excess of the atmospheric pressure. In calculating the volume of air from the indicator diagrams, the formula $P V^{1.3} = C$ was used. The index 1.3 has been found to give the most accurate results for low-pressure slow-running compressors. This index is, of course, purely empirical, and was arrived at by taking the mean of a large number of laboratory tests on compressors in which the volume and temperature of the air could be accurately measured. On reference to the indicator diagram (Fig. 4), it will be observed that the point at which the delivery-valves open is very clearly defined, but that the pressure continues to rise until about seven-eighths of the stroke, when it falls below the receiver pressure. This is not due to any wire-drawing through, or faulty setting of the valves, as might at first be supposed, but to a resonance effect, due to the long, straight delivery-pipe in which a wave motion was set up having a definite periodicity of about one-fourth of a second, irrespective of the speed of the compressor. This curious effect is very clearly defined in the diagrams, Figs. 5 and 6, taken at 35 and 62 revolutions per minute respectively, in which it will be observed that the pressure in the delivery-pipe varies in some cases more than 10 lb. per square inch. Fig. 3 shows a pair of diagrams taken from the steam cylinder on one of these compressors. These diagrams call for very little comment. They are decidedly good ones, showing a clearly-defined cut-off, and very little wire-drawing. The consumption of steam was found to be 23.5 lb. per indicated-horse-power hour at normal load, and at 20 per cent. overload. The overall mechanical efficiency works out at 90.4 per cent. at normal, and 92 per cent. at 20 per cent. overload, both very creditable results.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, July 26.

Sales of pig iron during the past week in Western Pennsylvania and Eastern Ohio amounted to 130,000 tons, covering steel pig very largely. The entire market has gained in tone. The largest purchase was 60,000 tons of basic, made by the Republic Iron and Steel Company, to be delivered 6000 tons a month for ten months. The American Rolling-Mill Company at Middletown took 15,000 tons, to be delivered in four months. The average price was 13 dols. at the furnace.

A very interesting, but probably groundless, rumour has gained some acceptance; it is to the effect that the Steel Corporation has decided to make a general cut in prices to stimulate trade. Much is to be said for and against a general reduction. The market will wait until it happens before they will believe it. There is very little on the surface to warrant hope in this direction. The increased cost in rails forbids any reduction in that quarter. But there is a general improvement. Preparations are being made to put on more steel mills. If the old-time theory of demand and supply were operative, prices would long since have fallen. The long postponement of demands has reached a point where buyers must buy. This is especially true of railroads and steel cars. The trunk lines have ordered 20,000 steel cars within ten weeks, and 15,000 more will soon be ordered. This, of course, helps the plate-mills. Many of the cars are intended for coal-carrying. Railroads are getting rid of their old wooden cars as rapidly as possible. The rail-makers are satisfied with their export business and are running at 70 per cent. of their capacity. Japan has placed an order for 90-lb. to 110-lb. rails—the first for such heavy rails. From the same source an order has been received for 3100 tons of steel car-axles.

Considerable business will soon be received from Mexico in connection with railroad building and mine developments.

Personal.—We understand that Mr. Algernon Lewin Curtis, consulting engineer, late of Johannesburg, Philadelphia, and Chatteris, has recently associated himself with the Frodan Iron and Steel Company, Limited, London, and is representing them in Manchester and district.—We have been asked to state that Mr. W. W. Strafford, late works manager of the Crane Works, Parkhead, and previously of Easton and Andersons, has commenced business on his own account at 165, Liverpool Great Road, Crosby, Liverpool, and has been awarded by the Corrosion Committee of the Institute of Metals the contract for the design and supply of the experimental condensing plant to be used in connection with the researches into the causes of the corrosion of condenser tubes.

Contracts.—The following contracts have been secured by Messrs. Ham, Baker, and Co., Limited, Westminster:—Three patent automatic travelling distributors for the new sewage works now being carried out at Hornchurch; four automatic travelling distributors for the sewage works at Saffron Walden; eight of their Ham-Baker-Candy-Whittaker rotary distributors for the new sewage works now being carried out at Southall-Norwood, besides others at Bashford, for the Wolstanton United Urban District Council, and others at Kempston. The tender of Mr. William Jackson, of Langley Green, has been accepted for the extension to Messrs. Ham, Baker, and Co.'s works at Langley Green, near Birmingham, and that of Mr. C. A. Horton, Brierley Hill, for a pattern-shop and drawing-office for the same firm.

Hand-Book for Ironfounders.—The art of ironfounding, old though it be, is still full of deeply interesting problems, which provide engrossing studies for many able minds, and perhaps few greater mistakes have been made than to suppose that it requires little skill and can be readily mastered without much careful observation and long experience. All processes worth the name of art must be studied with devotion and sympathy, and ironfounding is one of them. To melt pig iron and scrap in a cupola and pour the molten metal into moulds is not necessarily an art, but it may become so, and sometimes does under the control of men who have devoted their best energies to it. Unfortunately, there are far too many instances where the results of the process of melting pig iron with or without scrap are such as to compel the conclusion that the operation has been far too carelessly carried out. It is therefore with pleasure that we have read a little pocket work, entitled "Hand-Book for Ironfounders," issued by the Frodair Iron and Steel Company, Limited. Fenchurch House, E.C., for it contains much in a condensed and handy form that should prove of value to all who aspire to follow iron-founding as an art, for its perusal cannot but help them on their way, and will, at any rate, act as a beacon to warn them off dangerous ground. It contains many useful hints as to the varying elements of pig iron, the interaction of different chemical elements, the selection of irons for special castings, sound cupola practice, blowing-machines, methods of judging temperatures by colour, regulation of blast, &c.; in addition to which there are some very useful tables and analyses of different irons. The book is beautifully got up, being well printed on thin paper, and bound in limp leather. The price is 3s.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a firm tone, but Cleveland warrants were dead idle. At the close of the session sellers quoted 47s. cash, 47s. 3d. one month, and 47s. 9d. three months. In the afternoon there was again nothing doing, but Cleveland warrants were nominally easier at 46s. 11½d. cash, 47s. 2½d. one month, and 47s. 8d. three months sellers. On Friday morning some weakness prevailed, and only 3500 tons of Cleveland warrants were put through at 46s. 9½d. cash and 47s. 0½d. one month, and closing sellers quoted 46s. 10d. cash, 47s. 1d. one month, and 47s. 7d. three months. The afternoon session was quiet, with Cleveland warrants the turn better. The business amounted to 2000 tons at 46s. 10½d. cash, and 47s. 2½d. September 20, and sellers' closing prices were 46s. 11d. cash, 47s. 1½d. one month, and 47s. 7½d. three months. Hematite was quoted at 61s. 6d. cash sellers. On Monday morning the market was again quiet, but the tone was steady, and Cleveland warrants were dealt in at 47s. 1½d. one month and 47s. 3½d. September 28 and 29. The turnover was only 2000 tons, and at the close there were sellers at 46s. 10½d. cash, 47s. 1½d. one month, and 47s. 7d. three months. In the afternoon Cleveland warrants were firmer, and a good business of 5000 tons changed hands at 46s. 11d. cash, 47s. 2d. one month, and 47s. 8½d. three months. The closing quotations were 46s. 11½d. cash, 47s. 2½d. one month, and 47s. 8½d. three months sellers. On Tuesday morning the market was idle and easier, with sellers of Cleveland warrants quoting 46s. 11d. cash, 47s. 2d. one month, and 47s. 8d. three months. The afternoon session was also easier in tone, and 3000 tons of Cleveland warrants were done at 46s. 9½d. cash, 47s. 1½d. and 47s. 1d. one month, and 47s. 7d. three months. At the close there were sellers at 46s. 9½d. cash, 47s. 1d. one month, and 47s. 7d. three months. When the market opened to-day (Wednesday) the tone was dull, and the only transaction was one lot of Cleveland warrants at 46s. 9½d. cash, with sellers over at that figure and at 47s. 0½d. one month, and 47s. 6½d. three months. In the afternoon the market was inclined to harden, and Cleveland warrants were dealt in at 46s. 9½d. cash, and 47s. 7d. three months, and closing sellers quoted 46s. 10d. cash, 47s. 1d. one month, and 47s. 7d. three months. The turnover only amounted to 1000 tons. The following are the market quotations for makers' (No. 1) iron:—Clyde, 60s. 6d.; Calder and Gartsherrie, 61s.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 64s.; Shotts (at Leith), 62s.; and Carron (at Grangemouth), 63s.

Sulphate of Ammonia.—The demand for sulphate of ammonia continues strong, and the price is on the rise. The quotation to-day for prompt lots is 14*l.* per ton, Glasgow or Leith. The amount shipped from Leith Harbour last week was 222 tons.

Scotch Steel Trade.—A fairly healthy feeling prevails in the Scotch steel trade this week, and with specifications for both ship and boiler-plates plentiful, mills are all running full. Indeed, a few producers are unable to guarantee delivery inside two or three weeks, and such a state of matters is looked upon as satisfactory. On the other hand, fresh orders are still very scarce, and angle-makers are complaining of a lack of demand. Black and galvanised sheets are very firm in price, and makers are being kept well employed. Inquiries are in the market for some respectable lots of material for abroad, ship-plates for New Zealand and Australia, boiler-plates for the Continent, and thin plates for India, and the prospects of securing a share of these orders are quite good.

Malleable-Iron Trade.—Malleable-iron makers in the West of Scotland report that business is a little better this week, and that specifications have increased in number. The booking of new orders is also reported as having improved, but prices are still on the level of 6*l.* per ton for crown bars.

Scotch Pig-Iron Trade.—The demand for Scotch pig iron has not been quite equal to the supply since the holidays terminated, and even at that the furnaces have not all been running to their full capacity. The conditions seem to improve daily, and local consumers are beginning to purchase more freely, while buyers in the south are also increasing their demands. An order for 500 tons of a special quality of Scotch iron for Russia has just been secured by a local firm. Hematite is being taken up very slowly, and stocks in makers' hands are getting fairly large. The price is nominally 64s. per ton.

Wages in the Iron Trade Reduced.—The following intimation has been made to Messrs. James C. Bishop and James Gavin, joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board, by Mr. John M. MacLeod, C.A., Glasgow:—"In terms of the remit, I have examined the employers' books for May and June, 1911, and I certify the average realised net selling price at works brought out is 6*l.* 1s. 4.47d. per ton." This means a reduction of 2½ per cent. in the wages of the workmen.

Reduction in Blastfurnacemen's Wages.—As a result of the report of Mr. John M. MacLeod, C.A., Glasgow, to Messrs. James C. Bishop and James Gavin, joint secretaries of the Board of Conciliation between the owners of blast-furnaces in Scotland and the blastfurnacemen, as to the price of Scotch pig-iron warrants in the Glasgow market for the months of May, June, and July, 1911, there is a fall of 2½ per cent. in the workmen's wages.

Shipbuilding: Government Orders for the Clyde.—The Admiralty, in placing orders for twelve new destroyers, have given six of them to Clyde firms. Messrs. John

Brown and Co., Clydebank, and the London and Glasgow Shipbuilding Company, Limited, Govan, have each received orders to build three. The vessels are to be of about the same displacement as the 33-knot ocean-going "Tribal" class, with, however, propelling machinery of much greater power. Their turbines are to be of 24,500 shaft horse-power.

Scotch Tube Trade: Prices Advanced.—Since particulars of the projected amalgamation in the Scotch tube trade became known a somewhat keener interest seems to have been taken in the industry by consumers. But producers are not now sellers at the old rates, and in some instances they have reduced their discount allowances by 5 per cent.—from 75 to 70 per cent. This is the first advance in prices which has taken place for a considerable time, but until the amalgamation is finally fixed up, it is not likely that there will be any general rise in values. New contracts cannot be entered into by individual firms in the meantime, as such matters are to be left for the new board of management to arrange when it comes into power.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Sheffield's Prosperity.—In view of the large volume of trade at present being dealt with in Sheffield, and the general impression therefrom of considerable prosperity, the remarks made by Mr. George Franklin, presiding at the recent annual meeting of the Sheffield and Hallamshire Bank, Limited, are interesting. Referring to the expansion of national trade he said that ought to bring to Sheffield a certain amount of reflected prosperity, but he did not know that anyone could show where that prosperity came in. The trade of Sheffield had improved, but he did not think they had had the benefit of the abnormal figures shown in the national returns. The Sheffield Banks Clearing House returns for 1910 were 21,328,000*l.*, as compared with 20,080,000*l.* in 1909, an increase of about 1¼ millions, which was not very much on those huge transactions. It may be pointed out in regard to Mr. Franklin's remarks that a very considerable volume of fresh trade came into the city during the first few months of this present year, and certainly if busy furnaces, foundries, mills, and workshops are to be taken as an indication, increased prosperity should be apparent when this year's trade comes to be reviewed. Activity is not always prosperity, however.

South Yorkshire Coal Trade.—There is not much change on the week in the local coal trade. About the same quantities of steams are being sent away for industrial purposes, and better orders for shipment are expected in the immediate future. Shippers at present, however, are taking much less than full deliveries, and several collieries are accumulating stocks. At these pits working hours have been reduced, and a certain amount of second-class material is to be obtained at lower prices. There are steady shipments of gas fuel, most of the contracts having been fixed up. Slacks still remain strongly quoted owing to the scarcity of supplies to meet a big demand. July has been a really bad month for the house-coal trade. The exceptional heat and the holidays have reduced business almost to a minimum. The dépôts are very quiet, and merchants are limiting stocks as far as possible. Pits are working about half-time, and have heavy accumulations. The revival of the London demand is now being awaited, and within the next week or so a general improvement is predicted. Prices are not much altered, latest 'Change quotations being:—Best branch hand-picked, 13s. to 14s.; Barnsley best Silkstone, 11s. to 12s.; Silkstone, 9s. to 10s.; Derbyshire house, 9s.; large nuts, 7s. 3d. to 9s.; small nuts, 5s. 6d. to 6s. 6d.; Derbyshire brights, 9s. 6d. to 11s.; washed nuts, 7s. 6d. to 8s. 6d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. to 5s.; smalls, 1s. 6d. to 2s.

Iron and Steel.—Although on the surface there is little change in the position of the iron market, things are actually somewhat more hopeful. No considerable buying has taken place, but prices have a firmer appearance. Recent weak prices of hematites led to some contracts being fixed up, but producers are now asking a trifle extra, and consumers are again inclined to hold aloof. The common irons have not found many customers, but there is a stronger tone about the Derbyshire sorts. The continuance of excessive heat has been a serious matter at the large works. It has been impossible to keep the rate of production up to normal figures. However, this and the fact that the quantity of work in hand is very large is giving an unwonted activity to what is usually a quiet period of the year. The foundries and the rolling-mills are, of course, the places where the heat has been most severely felt, but in many of the lighter trades much inconvenience has been caused. There is one very remarkable feature about the present condition of affairs, and that is the low price of raw materials compared with the volume of trade. Early in the year steel-makers stocked heavily, but at fairly high figures, in anticipation of a boom forcing up prices. Now, when quotations are particularly favourable, they have material in hand which renders further buying, for the present, superfluous. The rolling-mills have been very busy for a long time, so much so that extensions have been necessary. There is sufficient work to keep the armament departments fully employed for a considerable time, and the output of projectiles is especially heavy. A fair number of orders are being received by the railway steel manufacturers, and the makers of tramway material are well employed. Manufacturers of forgings for shipbuilding are facing competition from works nearer the shipyards. There is a big foreign demand for general steels. This is now one of the most prosperous branches of Sheffield trade.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The pig-iron trade is still characterised by extreme quietness, but what is usually a dull period is fast drawing to a close, and autumn requirements are believed to be such as will create a brisk trade over the fall of the year. Deliveries are fairly good for this season, and the home consumption of pig promises to grow, so that if the output is not materially increased in the near future, stocks should decrease. Values of pig move very little. No. 3 g.m.b. Cleveland is 47s. for early f.o.b. delivery, at which figure both makers and merchants have sold. No. 1 is 50s. 6d.; No. 4 foundry, 46s. 9d.; No. 4 forge, 46s. 6d.; and mottled and white each 46s.—all for early delivery, any inquiry on forward account eliciting rather higher quotations. East Coast hematite pig is very dull, but producers are not disposed to give way, and, as a rule, they do not name below 61s. 3d. for early delivery of mixed numbers, though some second-hands are prepared to accept 61s. A large local consumer has been endeavouring to make contracts at 57s. 6d. for mixed numbers delivered over six months, but all sellers have refused to entertain the offer. Foreign ore is still lifeless. Quotations are nominally based on 19s. ex-ship Tees for Rubio of 50 per cent. quality. Coke is in fairly good request for local consumption, and values tend upward. Average blast-furnace kinds can be bought at 14s. 6d. delivered here, but several sellers put the price at 14s. 9d. Middlesbrough warrants stand at 46s. 9d. cash buyers.

Manufactured Iron and Steel.—Rather better accounts are given of the various branches of the manufactured iron and steel industries. The output is heavy, and not only have producers good contracts made, but a fair number of inquiries are reported. Under these circumstances prices show a marked upward tendency, but as yet they are not quotably advanced. Bar-producers held a meeting this week to consider prices, but no change was made. Principal market quotations now stand: Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 15s.; iron ship-plates, 6*l.* 12s. 6d.; iron ship angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.*, 7s. 6d. to 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d. to 3*l.* 15s.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 10*l.* 15s.—sheets less 4 per cent. f.o.b., railway material net at works, and all other descriptions less the customary 2½ per cent.

Ironworkers' Wages.—The accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England have just certified the average net selling price of iron rails, plates, bars, and angles for the two months ending June 30 last at 6*l.* 5s. 6.18d., as compared with 6*l.* 6s. 7.04d. for the previous two months, and in accordance with sliding-scale arrangements wages for August and September will be the same as prevailed during the preceding two months.

Shipments of Iron and Steel.—Shipments for last month were only moderate, but they came up to expectations. Loadings of pig iron were returned at 88,055 tons, as compared with 109,219 tons for the previous month, and 84,541 tons for July last year. Of last month's despatches of pig, 74,235 tons went from Middlesbrough, and 13,820 tons from Skinningrove, 12,204 tons of the latter going to Scotland, and 1616 tons to Terneuzen. Of the pig iron sent from Middlesbrough, 47,280 tons went foreign, and 26,953 tons coastwise, Scotland once more being the best customer, receiving 10,825 tons; whilst France took 8928 tons; Japan, 8385 tons; Wales, 5590 tons; Sweden, 5203 tons; Belgium, 4436 tons; Germany, 4002 tons; Italy, 3999 tons; and Holland, 3945 tons. Only 10,805 tons of manufactured iron were cleared last month, 3929 tons going foreign, and 6876 tons coastwise, India being by far the largest buyer, with an import of 2443 tons. Steel shipped last month amounted to 44,378 tons, of which 36,274 tons went abroad, and 8104 tons went to coastwise customers. The best customer was the Argentine, with an import of 7610 tons; Egypt received 5558 tons of steel; Japan, 3723 tons; Northern Nigeria, 3703 tons; India, 3674 tons; and Canada, 3001 tons.

ZEITUNG DES VEREINES DEUTSCHER EISENBAHNVERWALTUNGEN.—The *Zeitung des Vereines Deutscher Eisenbahnverwaltungen* (Journal of the Association of German Railway Administrations) celebrated the fiftieth anniversary of its first appearance on July 1. From the start—*i.e.*, from July, 1861—the journal has been published twice a week as the organ of the association, the object being "to mediate between the apparently conflicting interests of the railway administrations and the public." German railways did not, of course, then constitute the Government monopoly they do now, and the venture might have been expected to secure more support from the public than it found in its early years. The immediate cause of starting the new journal was that the railway systems, including those of the Governments, desired some channel through which they could reply to attacks made in the Press upon railway policy and service in general and upon the new trade regulations of those days. The journal now contains original articles and brief notes on railway matters from all parts of the globe. Mr. D. von Mühlenfels is the editor, and Messrs. J. Springer, of Berlin, are the publishers of this contemporary of ours.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Labour difficulties having been at last adjusted, there has been a return of strength to the coal trade, but business has not yet fully regained its normal stability. Opinions as to the future course of the markets differ considerably. The best large steam coal has made 18s. 6d. to 19s.; secondary qualities have ranged between 16s. and 17s. 9d.; best bunker smalls between 9s. 9d. and 10s.; and cargo smalls between 7s. 9d. and 8s. 3d. per ton. The best ordinary household coal has been making 14s. 6d. to 16s. 6d.; No. 3 Rhondda large, 17s. to 17s. 6d.; and smalls, 10s. 6d. to 10s. 9d. per ton. No. 2 Rhondda large has brought 11s. 9d. to 12s. 3d., and smalls 7s. 6d. to 8s. per ton. Foundry coke has realised 18s. to 20s. 6d., and furnace ditto 16s. to 17s. per ton. As regards iron ore, Rubio has made 18s. 6d. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Welsh Labour Difficulties.—Recent Welsh labour difficulties, now happily at an end—at any rate, to a large extent—had a serious effect upon the earnings of the local railways. Upon the Taff Vale there was a falling off of 6054*l.*; upon the Barry, a decline of 6687*l.*; and upon the Brecon and Merthyr, a decline of 281*l.* Every department of South Welsh life was also prejudicially affected.

The Somerset Coalfield.—A new development has taken place in the Pensford portion of the Somerset coalfield. A shaft has been sunk about half a mile from the Pensford railway station, and the best appliances have been provided for working new pits which it is proposed to develop. The pits are to be linked up with the neighbouring Bromley colliery, which is about a mile distant. Workable seams of coal have been won, and the quality of the coal is expected to prove excellent, there being little ash in it.

Port Talbot Railway.—The directors of the Port Talbot Railway and Docks Company report that the accounts for the past year show a gross revenue from all sources of 73,312*l.*, and, after provision has been made for fixed charges, a balance of 32,381*l.* remains. Out of this balance the directors recommend a dividend upon the preference shares at the full rate of 4 per cent. per annum for the past half-year, and upon the ordinary shares at the rate of 6 per cent. per annum.

Alexandra (Newport) Docks.—The gross receipts for the past half-year show an increase of 20,210*l.* as compared with the first half of 1910. The working expenses amounted to 85,064*l.*, or 55.42 per cent. of the receipts, as compared with a corresponding ratio of 58.27 per cent. in the first half of 1910. The capital expenditure on works in progress, and at present unproductive, amounts to 580,125*l.* The expenditure on capital account in the past half-year was 57,084*l.* A Bill promoted in the present session to enable the company to construct certain railways in Monmouthshire has passed both Houses of Parliament.

GERMAN MANUFACTURERS AND INDIA.—Although Germany's export of machinery to India has hitherto been of but very small importance, the Allahabad Exhibition has resulted in heavy sales of German manufacture, most of the exhibits having been sold and a fair number of orders booked. The sale of German motor-cars was by no means unimportant, one firm especially having booked several orders. Orders have also been taken for two large portable engines, for two petrol-motors, for a rice mill, &c. This result is pretty sure to invite further German enterprise in India, and German makers are likely to become regular exhibitors at Indian shows.

NEW HARBOUR BRIDGE, COPENHAGEN.—A new bridge is to be built across one of the Copenhagen harbour inlets or branches, in lieu of the present bridge, which dates from 1874. The new bridge will be 40 feet broad facing Toldbodgade and somewhat broader at the other end against Holbergsgade. In addition to footways there will be a roadway broad enough for one line of carriages and two tramway lines. The bascule will be worked by electricity. At each corner a small building will be erected, which will answer several purposes. The building of the bridge is expected to occupy rather more than a year. A passage for vessels will be kept open during the construction of the new bridge. For foot passengers a pontoon bridge will be built, but all carriage traffic will in the meantime be stopped. The bridge has been designed by the well-known chief engineer of the Copenhagen harbour, Mr. Möller.

SEWAGE OF LEEDS.—The new Leeds Sewage Works will occupy eighteen months in construction; and when the formation of the first portion of the bacteria beds has been completed, the purified sewage which comes from these beds will be discharged into the main effluent channel and thence conveyed to the Aire. The channel is designed to meet the requirements of Leeds for the next sixty years, when the population, it is estimated, will have increased from 445,563 (the last census) to about 940,000. Allowance has also been made for the whole of the rainfall to pass into the channel from the stream which is known as Wyke Beck, and which proceeds from Shadwell through the districts of Roundhay and through the existing sewage works site. The total cost of the channel will amount to 16,000*l.*, and it forms the principal item in a contract of 43,542*l.* which has been let to Messrs. H. Arnold and Son, of Leeds and Doncaster. Mr. E. H. Howatson is the acting resident engineer in charge of the contract, under the direction of the sewerage engineer, Mr. G. A. Hart.

AIR-COMPRESSORS FOR THE BOMBAY, BARODA, AND CENTRAL INDIA RAILWAY.

CONSTRUCTED BY MESSRS. MURRAY, WORKMAN, AND CO., ENGINEERS, GLASGOW.

(*For Description, see Page* 166.)

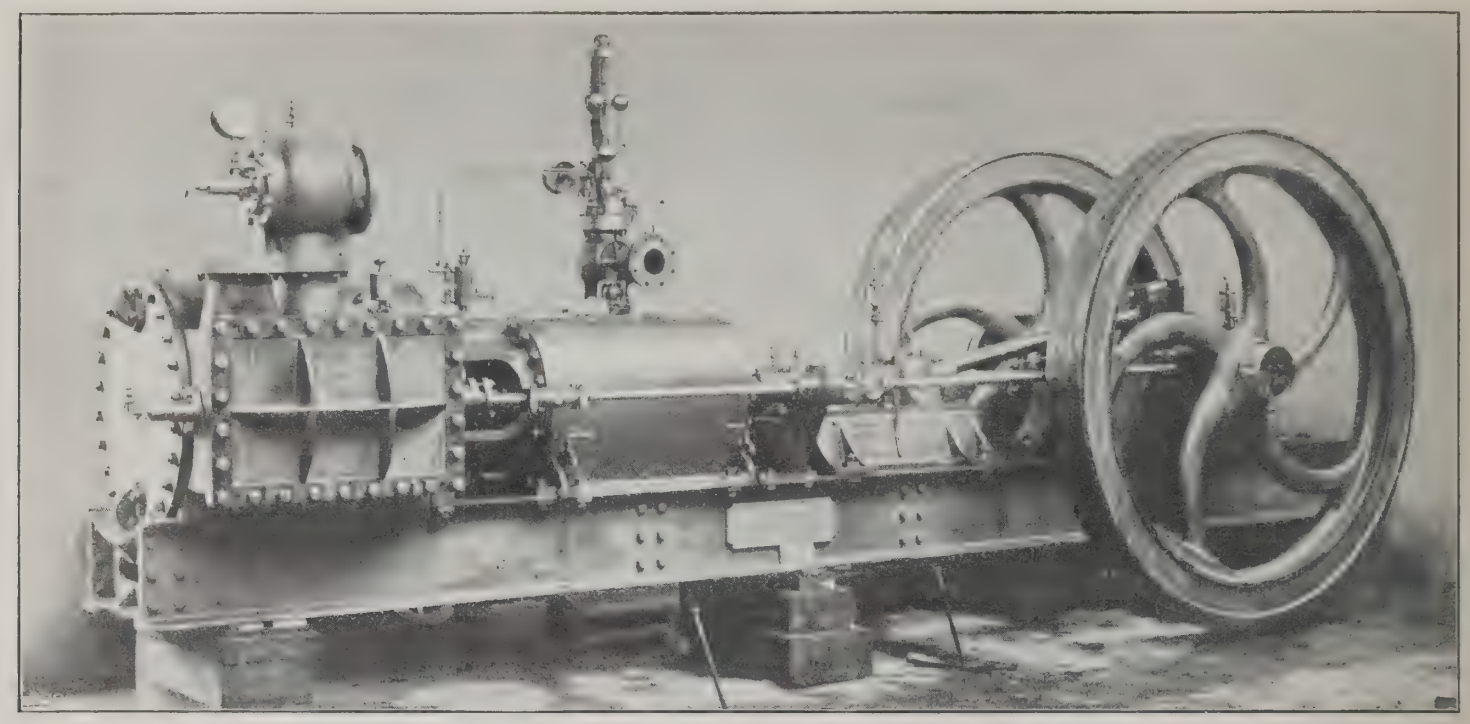


Fig. 1.

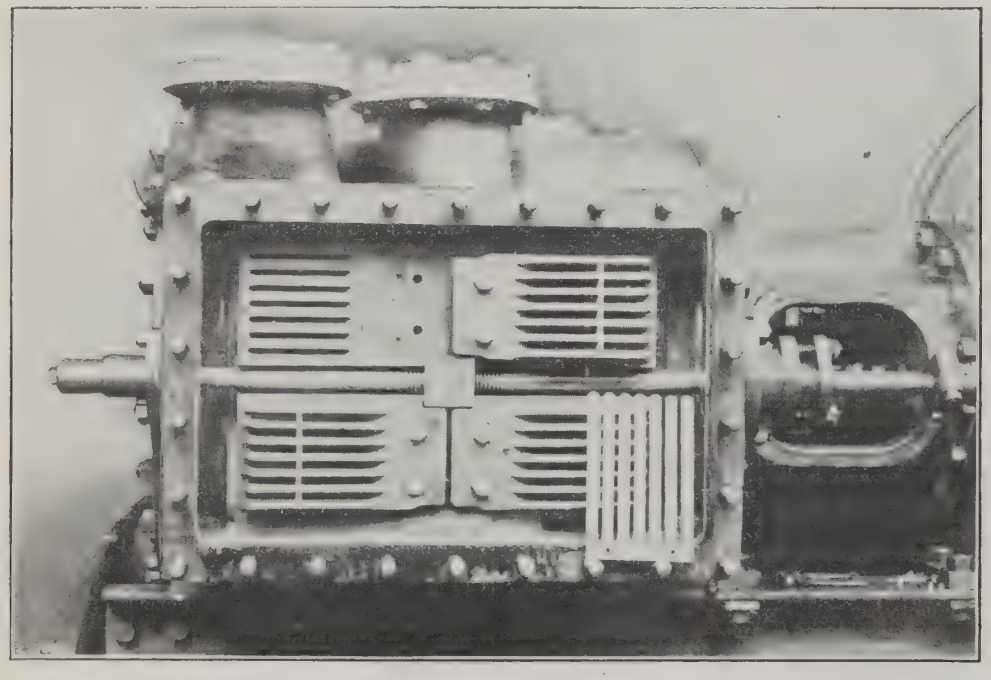
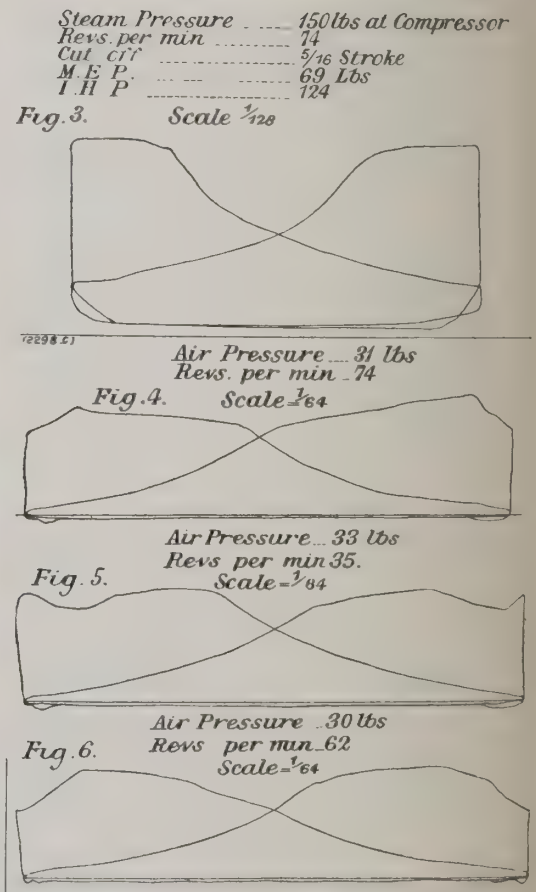


Fig. 2.


Steam Pressure ..... 150 lbs at Compressor
Revs. per min 74
Cut off ..... 5/16 Stroke
M.E.P. ..... 69 Lbs
I.H.P. 124
Fig. 3. Scale 1/128
(2298 E)
Air Pressure ... 31 lbs
Revs. per min ... 74
Fig. 4. Scale 1/64
Air Pressure ... 33 lbs
Revs per min 35.
Fig. 5. Scale = 1/64
Air Pressure ... 30 lbs
Revs per min 62
Fig. 6. Scale = 1/64

Proposed Electric Railways in Russia.—At the instance of the Finance Ministry and that of Communications, a project for the building of an electric railway from Moscow to Saergijew is being considered by the Government. It is proposed that the railway shall start from the Kretowski Gate in Moscow, and will have branch lines to the stations Lossinostrowskaja, Mitischtschi, and Puschkino, on the North Railway. The entire length of the railway will be 69.5 versts, and the cost is calculated at 8,674,900 roubles. It is proposed that a limited company shall construct the railway, the greater portion of the capital to consist of debentures, for which the State is not to give any guarantee. The Government is also considering a second electric railway project, purporting to construct a railway from Sebastopol, *via* Yalta, to Aluschta. The line will pass through some of the most picturesque parts of the Crimea, being planned to run along the slopes of the Yaila mountains. Including a side line to Balaclava, the aggregate length will be 126 versts, and the cost of construction is calculated at 28,500,000 roubles, to be raised, in addition to working capital, in the same way as the first-mentioned line, about one-sixth share capital and the rest in debentures, for which the State is not to offer any guarantee in this case either.

Proposed Norwegian Steamer Subsidy.—A special committee, appointed for the purpose, has reported in favour of a State subsidy to the new Norwegian-America Line, provided a share capital of 6,000,000 kr. (333,300*l.*) is subscribed. The subsidy is proposed to take the shape of an annual vote of 500,000 kr. (27,700*l.*) for the first three years. The company will start with two steamers of 10,000 to 11,000 tons, equipped as first-class boats. The route will be from Christiania, *viâ* Christiansand, Bergen, Stavanger, and, perhaps, Drontheim.

Sixth Annual Parade of Commercial Motor Vehicles.—The Commercial Motor-Users' Association has had under careful consideration the conditions to govern the sixth annual parade of commercial motor vehicles to be held in June, 1912. Entries will be invited, and the general conditions issued, approximately on September 15 next, and entries will close on January 1, 1912; late entries, however, may be received up to within a month of the parade, on payment of a fine. Further details of the parade may be obtained on application to Mr. Fred. G. Bristow, A.C.I.S., secretary, the Commercial Motor-Users' Association, 89, Pall Mall, London, S.W.

Almanack for 1911-12.—Messrs. W. T. Glover and Co., Limited, Trafford Park, Manchester, have sent us one of their almanacks which they are now issuing to the trade. This covers the period from July 1 last to June 30, 1912; it is of the now well-known Glover loose-leaf type, one leaf per day, each leaf giving interesting data upon electrical subjects in general and upon the firm's specialities in particular.

Netherlands East Indies.—The *Nieuwe Rotterdamsche Courant* says that the Hollandsche Aanneming-maatschappij, domiciled at The Hague, has been awarded the contract for the carrying out of the proposed extensive harbour works at Sourabaya. The cost of the undertaking is estimated at 12,808,000 gulden (1,067,000*l.*), but it is stated that the figure will reach 14,000,000 gulden (1,167,000*l.*) when the cost of various supplementary works is included.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

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We desire to call the attention of our readers to the fact that the above is our SOLE Address, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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Telephone Numbers—3663 and 8598 GERRARD.

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With Four One-Page Plates of the OERLIKON ENGINEERING WORKS, OERLIKON, SWITZERLAND.

NOTICE OF MEETING.

The North of England Institute of Mining and Mechanical Engineers.—Saturday, August 5, in the Wood Memorial Hall, Newcastle-upon-Tyne, at 2 o'clock. Annual general meeting. The following paper will be open for discussion:—"The Advantages of Freezing as a Method of Sinking through Heavily-Watered or Difficult Ground," by Mr. William Brumwell Wilson. The following paper will be read or taken as read:—"Experiments on Liquid Mixtures for Laying Coal-Dust," by Professor W. M. Thornton, D.Sc., D. Eng. (With experimental illustrations.)

DEATH.

Fielder.—On July 26, Herbert Fielder, M. Inst. C.E., at 55, Blenheim Park-road, Croydon South, Surrey.

ENGINEERING.

FRIDAY, AUGUST 4, 1911.

THE USE AND ABUSE OF INSPECTION.

It has been remarked that society in these days is rapidly becoming divided into two classes—the inspectors and the inspected. Engineers especially realise that there is a great amount of truth in this saying, as few orders are placed nowadays for engineering plant or materials which do not stipulate for inspection. This tends to become stricter every year, owing to various reasons, the chief being that manufacturers in selling their goods are now generally bound down both in price and time of delivery, the former being so low and the latter so short that mistakes are more liable to occur than was the case in the old days, when the manufacturer could ask and obtain his own price and could take his own time. In those days the buyer often had to take what the manufacturer gave him, and was glad to get it at almost any price. But now the buyer knows quite well in most cases what he wants, what price he ought to give, and exactly what he ought to get for that price, and his main object is to see that he gets it. It follows, therefore, that buyers have come to the conclusion that their interests will be best served by employing inspectors empowered to visit the works of the contractors at all reasonable times, without notice, and to follow the course of the order through the works, testing the materials and the finished work, and checking quantities, weights, &c.

The knowledge that the inspector may visit them at any time has a good effect upon contractors in keeping them up to the mark, both in quality and time. This effect is an all-round one and does not refer only to inspected work, as manufacturers know very well that when they are constantly having inspectors in the works it is not desirable to have too much second-rate work lying about. Inspectors do not judge a works entirely by the quality of the work they get themselves, and their opinion carries considerable weight. The very fact, therefore, that a number of buyers send inspectors to any one works makes that works a more reliable place for other buyers who do not employ inspectors, as the frequent presence of inspectors has a good effect on the general quality of the work turned out of any manufactory.

There is, of course, no attempt on the part of British firms of good standing deliberately to defraud their customers. But at the same time manufacturers cannot afford to do more than keep to the bare specification, and specifications are often interpreted differently by buyers and sellers. Then, again, the heads of a firm cannot always attend to every detail, and foremen and workmen will often scamp work, either because they are on piecework, or merely to save themselves trouble. In the matter of loose rivets in steelwork, blowholes in cast-iron pipes, and such-like small but important defects, the inspector cannot lay the blame on the manager or foreman unless the flaws are numerous. But it is his business to find these flaws out, and if he discovers a number and sees them put right in the early stages of an order, he will find that the workmen will take more care afterwards. Again, mistakes are frequently made in dimensions, and many firms have no system of checking their finished products, even when the matter is left in their hands.

A good inspector, dealing with large quantities of materials, will save his employers many times his salary in the course of a year. But, to gain the full benefits of inspection, a good man must be engaged. An inspector cannot be an expert in everything, but he must have a very clear idea of the difference between good and bad work, and must be able to read drawings easily. Then an inspector must be firm and able to hold his own, but at the same time tactful, and his honesty must be above suspicion.

An inspector with the above qualifications, and who is also the equal socially of the managers of the works he visits, can do a great deal for the firm which employs him. At the commencement of a contract he goes through the specification and drawings and clears up any doubtful points, both with his own firm and the contractors. He also informs the contractor what kind of work he expects to get and what processes are to be employed on the various details; for instance, it is often left to the inspector to say whether holes are to be drilled or punched; whether plates are to be sheared or planed, rods and bolts solid or welded, &c. When the work commences the inspector will test the materials and see that no unavoidable delay takes place at the rolling-mills, and will then follow the work through the contractor's shops and see that the various processes are carried out as specified, or as he wishes, and that the finished work comes together correctly, is of the proper dimensions, and, if necessary, is properly marked for re-erection. Besides these duties the inspector is often required to verify weights, and to attend to packing and shipping marks, and occasionally to see the goods actually put on board.

If he is a tactful man and knows his business, he can get the contractor's manager and foremen to agree to his suggestions and requirements with very little trouble, and to push his work on as quickly as possible, and in the case of any alteration he acts as a buffer between the buyers and the contractors. An inspector of this kind is worth a good salary, and if employers have not sufficient work to keep a highly-paid man of their own busy, it is better for them to employ an outside independent inspector than to keep a poorly-paid man, or to send out draughtsmen or others on inspection work, as it takes a regular inspector several years to find out the little tricks by which foremen and workmen sometimes try to deceive him.

There are, however, a number of independent inspecting engineers who will offer to take inspection work at extremely low and insufficient rates. They can only do this by employing very young and badly-paid men to do their work for them, or else by giving half the time to it that they should do. It may be taken as an axiom that in the majority of cases cheap inspection is worse than no inspection at all, as it relieves the contractor from liability without giving the buyer a sufficient guarantee that the work is properly carried out. There is, of course, certain work which can be attended to by an inexperienced inspector just as well as by an experienced one, but, as a general rule, when work which has been cheaply inspected turns out satisfactorily, it would have been just as satisfactory if it had not been inspected at all.

This brings us to the question of the abuse of inspection, about which manufacturers have a great deal to say, although it affects the buyers more than they are perhaps aware. An inspector may be very conscientious, but either through want of tact or experience, or both, he may be the cause of endless trouble between buyer and seller. Such a man walks into a works as though it belonged to him, calls the manager and foremen over the coals for the slightest cause, treats them openly as though he believes they are deliberately trying to cheat him, persists in sticking to the exact letter of the specification, and rejects quantities of material for little faults which do not matter in the least. The result of all this is that he is disliked wherever he goes, his work is delayed, and people who would not do it otherwise try to get the better of him in order to get him into trouble. Besides this, contractors who have had experience of an inspector of this kind make allowance for him in their next quotation and ask higher prices.

Unnecessarily strict and minute inspection is not, however, always due to the inspector, as his employers may tie him down to the specification, and practically refuse to allow him to use his judgment at all. Certain consulting engineers are very strict in this way, and are so well known that extra prices are always charged to cover their inspection.

Another abuse of the inspection system is to send an inspector to see very small quantities of material; we have known many cases in which inspectors have travelled long distances to inspect, perhaps, 1 cwt. of ordinary quality steel, the cost of the inspection coming to two, three, or four times the cost of the material. The Government

departments are probably the worst offenders in this way, the total cost of some of their small orders being out of all proportion to the value of the material or the use to which it is to be put. Considerable delay is often caused, also, by having these small orders inspected, as the inspector may have to wait days before he can visit the works, owing to pressure of more important work, and favourable opportunities of forwarding the material along with other goods are thus missed. Moreover, if the material has to be tested, the inspector may have to pay two visits to the mills, one to select and stamp the test-pieces and another to see them broken, as the mills cannot always prepare the test-bars the same day.

Then, again, inspectors are sent to examine such small items as wood screws, nails, door fittings, and other ironmongery. This is a waste of time, as the inspector cannot stamp such articles, and has no means of telling whether the goods he passed are the same as those received by his employers. The best way is to buy ordinary commercial goods of this kind on sample, and return them if not satisfactory; this gives the buyer a better hold upon the manufacturer than if he sent an inspector.

There are, of course, other and more serious abuses of inspection due to direct or indirect bribery of the inspector by the contractors. But this evil is not confined to inspection work, although a dishonest manufacturer has very much better opportunities for bribing an inspector than any other member of his customer's staff, having the inspector at his own works. Bribery, however, is not so common as it used to be, but, unless the inspector is of good class and reasonably well paid, the risk of collusion may always arise.

To sum up the whole question: inspection is useful and worth while under certain conditions, but not under all conditions. It pays well to inspect, provided the inspector is a firm and tactful man with a good general knowledge of engineering and inspection, and with an honest and honourable character, and provided also that he has plenty of work on big orders and is given a fairly free hand and allowed to use his judgment in the interpretation of a specification. In other words, the inspector must be a good one and must have plenty to do, and the more costly the work that he inspects the more worth while the inspection.

Inspection, as a general rule, does not pay when the reverse of these conditions is the case: when the inspector is tactless, of weak character, without workshop experience, or badly paid. It does not pay to be very strict on small variations from the drawing or specification which do not affect the quality of the work, nor to send an inspector to pass every small order, unless for special material. It is also a question whether it pays to inspect cheap materials, such as bricks, tiles, earthenware pipes, paving, &c. These things are bought in large quantities, and the inspector usually sees them stacked in the maker's yard. It is impossible for him to examine more than a small proportion unless he sees the whole order loaded up, which might oblige him to be at the works for several days, and would add considerably to the cost of the articles. He cannot very well mark each item unless he sees them loaded up, in which case there is no need to mark, and the result is he passes them in bulk, which leaves the manufacturer free to load up all the defective items not seen by the inspector.

In the case of materials of this nature it is certainly the best way to buy on sample, without inspection, and return defective goods. This course, however, would not be practicable when the material was required for abroad, in which case the inspector should see it loaded up.

Whether a firm should employ their own inspector or not depends on whether or not they can keep him busy all the time. If they only require to have goods inspected occasionally, it is better to employ a regular outside inspector than to send out one of their own staff, unless he is fully qualified for the particular work. A firm has a better hold in some ways on its own inspector, but as the outside inspector's living also depends on the satisfactory nature of his work, he is not likely to neglect it, and a well-established outside man has a wider experience of inspection than a man who only works for one firm, and experience counts for a great deal in inspection. The more works a man visits, and the greater variety of materials he inspects, the quicker he will be to detect bad work, to suggest improvements, and to get orders through satisfactorily.

THE NEW TURKISH BATTLESHIPS.

The Minister of Marine for the Ottoman Navy, Mahmoud Moukhtar Pasha, has been in this country for some days, and all the details have been settled in connection with the contract with a British group of naval constructors for the building of the first of the new battleships which Turkey is ordering in order that she may take the place to which she aspires among naval Powers. In view of the protraction of negotiations in Constantinople in connection with preceding schemes for the reconstruction of the Turkish navy, great credit is due to this young and enterprising Minister for the courage, pertinacity, and tact he has shown in overcoming the difficulties which beset all advocates of reform in connection with the Turkish navy. One important factor in gaining the support of his colleagues and Parliament was his determination to secure the services of the most experienced designers and constructors of warships. His contentions in this direction were strongly supported by the example set by Japan, when they recently placed an order with a British firm for the most powerful armoured cruiser which could be built, irrespective of financial and other considerations. The particulars we have been able to procure regarding the design of the Turkish battleships show that, as ships of the line, they will be as far in advance of other vessels of this class as is the Japanese cruiser in superiority to other armoured cruisers.

In the past foreign governments have sometimes experienced difficulty in giving effect to their belief in British superiority in production by placing orders in this country, because the financiers assisting the schemes desired to secure the work for their own country. In the case of Turkey, for instance, monetary support has hitherto been obtained through Paris financiers, or from those in other Continental countries. This has had effect in determining the selection of the successful tenderers for contracts. As a result, British manufacturers have not in the past profited to the same extent as the terms of their tenders merited. It is therefore gratifying to be able to record that, as a result of the founding of the National Bank of Turkey by Sir Ernest Cassel, British manufacturing efficiency is recognised more readily than formerly in Turkey; and now, largely through the ability of the chairman of the bank in Constantinople, Sir Henry Babington Smith, the necessary financial support has been secured through British agency. There is no need to enforce the importance of such aid to British production, because with such financial help there is a better chance of the satisfactory character of British work having its due reward.

As a matter of fact, the British group experienced very strong opposition from some Continental countries, solely from extraneous considerations, including political influence; but, so soon as the financial difficulty was overcome, there was no difference of opinion on the merits of the design. The first of the battleships, for which General Mahmoud Moukhtar Pasha has now had the credit of arranging, and a second, which will also shortly be laid down by the same group of naval constructors, will be vessels excelling anything yet built for the British or any foreign fleet. The displacement tonnage is to be about 23,000 tons, and the primary armament, which has been recommended by an Ordnance Commission under the presidency of Commander Hakki Bey, will include ten of the largest guns yet installed in any battleship, arranged in twin gun-turrets, so that all may fire on either broadside, while four can fire ahead and four astern. The guns, too, have an unusually wide arc of training before and abaft the beam. A feature of the design, however, is, we understand, the great power and admirable arrangement of the secondary armament, also decided upon by Commander Hakki Bey's Commission. These guns are separately of a muzzle energy equal to the best yet fitted in any super-Dreadnought, and there are sixteen of them. In addition, all the guns are in heavily armoured casemates, and are arranged well above the waterline, and so that half may fire on each broadside with a very considerable arc of training before and abaft the beam. Later we hope to give fuller details in regard to the novel disposition of these casemates, and need only now add that there are also a large number of machine-guns on the superstructure deck. All the ordnance and its machinery will be of British design and manufacture. As to the armour, here again the provision made is in accordance with latest practice and the great experience of the designers. The speed provided for is 21 knots—a result which is due in part to the design of the lines of the ship, and in part to the adoption of the latest type of Parsons combined impulse and reaction turbines working in series. These will give very high efficiency, in association with the coal and oil-fired water-tube boilers, not only at full power, but at cruising speeds.

It will thus be seen that the new ship will tend to place the Turkish navy in the front rank, especially if a realisation of the fighting qualities of the ship enables the Minister of Marine to induce Parliament to add other ships in order to make up a squadron of homogeneous vessels, as by this means only can the fullest success be achieved in maintaining Turkey's position in the Mediterranean. Advantage accrues in the interests of peace as British financial and manufacturing assistance helps towards a firmer bond of friendship between Great Britain and Turkey, old-time allies. Moreover, it is now accepted as the wisest policy to anticipate improvements in design, as is done in this ship, irrespective of the cost which these involve in the first instance, as cheaper ships of less efficiency are so soon rendered obsolescent.

THE LESSONS OF THE BRITISH CIRCUIT AIR RACE.

In many ways the aeroplane race round Great Britain, which occurred last week, is the most important event yet held in connection with aerial navigation. Up till the end of last summer competitions were mainly of the circus type on a prepared track for the sake of attracting gate-money. While these competitions no doubt served some useful purpose in the early stages of the movement, the tendency was to develop purely artificial conditions, with marked influence upon the design of machines and the promoters of the new manufacturing industry. This type of competition fortunately came practically to an end last year owing to the fact that it did not excite enough public interest to pay.

This year competitions have taken the form of cross-country races, and of these that compassing the greater part of Britain was in many ways the most interesting. Its technical interest was much greater than the circuit races on the Continent, from the fact that, in the latter, competitors were allowed to change or repair their machines to such an extent as to make the race no test of reliability, while the Gordon-Bennet race was too short to be of any value. In the British contest there were strict limitations as to renewals, some prominent units of the aeroplanes and motors had to be retained to the close, and for purposes of identification were specially marked at the outset.

In the British race the course was from Brooklands *via* Hendon, Harrogate, Newcastle, Edinburgh, Stirling, Glasgow, Carlisle, Manchester, Bristol, Exeter, Salisbury, and Brighton, finishing at Brooklands. A stop had to be made at each of the places named, and the taking of a certain amount of rest by the competitors during the circuit was compulsory. The winner was "Beaumont," who completed the distance of 1010 miles in 22 hours 29 minutes flying time, which gives a mean speed of about 45 miles an hour. Vedrines was second, taking 23 hours 38 minutes, and averaging, therefore, just under 43 miles an hour. The success of these two was so complete as to give a very striking demonstration of the progress which aviation has made during the last year.

The machines of both winners were monoplanes, "Beaumont's" being a Blériot and Vedrines' a Morane-Borel, which is generally of the Blériot type, differing in small details. Both had "Gnome" engines, "Beaumont's" being of 50 horse-power and Vedrines' of 70 horse-power. Both engines had seven cylinders, but the latter, of course, were of larger diameter. The extra horse-power, no doubt, was the reason for the greater speed shown by Vedrines' machine on several occasions, but there was the countervailing fact that "Beaumont," who is a captain in the French navy, had superior knowledge of air currents and compass direction.

Turning now from the successes to the failures, it is to be noted that there were thirty entries for the event, that twenty started from Brooklands, of whom three retired on the first day's run of 20 miles. The start for the really serious part of the journey

took place from Hendon on Monday, the day's run being to Edinburgh ; only two competitors got there in the day, while only five got so far as Harrogate, the first control position. Allowance must be made for the fact that the attempt to do 180 miles without a stop was a severe test. The human element has to be taken into consideration, as failures were often due to this more than to the machines.

The most fruitful source of failure seems simply to have been the difficulty in finding the way, and the unsuitability of the chassis for landing and starting in a country like Britain. In a few cases minor engine troubles also forced a descent. The difficulty of finding the way is a purely personal problem, and will be overcome by experience and a knowledge of the compass. The early morning, though the best time to fly for many reasons, is a time when many of the features of the country are liable to be obscured by mists, and then compass direction must be depended upon. Many of the competitors who had to land to ask the way, or for some other trivial cause, so damaged their running chassis that they could not re-start, or found re-starting impracticable without their own staff of mechanics. It seems necessary that the landing chassis should be made suitable for gliding on to much rougher ground than is at present the case, and that some means should be provided for starting the machine without external assistance. The first point is probably only a matter of providing larger wheels and skids, &c., but the re-starting seems a more difficult question. At present the practice is for a staff of mechanics to hold the machine stationary while the propeller is started and until the engine is going well, when they let go, and the machine rises. This is all right with competent mechanics, but not with casual assistants picked from a crowd or from a farmer's staff. What is wanted is some method of making the machine stand still until the engine has got up speed. Naturally the first means which suggests itself is a brake on the wheels, but this would probably not be sufficient. Some kind of anchorage which could be tripped might, however, be practicable. In many cases a tree, or something of the kind, could be found to fix a rope to, and where this could not be done possibly pegs could be carried to drive into the ground. The standing part and anchorage would, of course, have to be left behind, but it would be better to carry several spare ones and leave them than to have the machine wrecked by incompetent assistants.

Although the first and second machines were both monoplanes, it can hardly be said that the race has done much to settle the question of the monoplane *versus* the biplane, or, in fact, any of the vexed questions of aeroplane construction. In the first place, several of the best-known biplanes were not represented—*e.g.*, the Farman—and in the second place speed alone is by no means the only quality desirable in an aeroplane. The racing-type monoplane, with a powerful engine and wings of comparatively short span, and hardly any curvature, is no doubt the fastest machine there is at present ; but the most important point is not speed, but safety, while weight-carrying and many other factors must be considered.

It is interesting to note that the pilot of the winning machine is a naval officer, and that the personal factor had a great deal to do with his getting first place. We have always said that it seemed likely that a sailor would do best in an aeroplane, the handling being apparently more like that of a boat than anything else. It also seems likely that a sailor, who is accustomed to find his way with very slight indications, and to steer by compass, would have less difficulty in doing so in the air than most types of landsmen, and this seems to have been the case.

The greatest lesson of all is that the aeroplane has now got to a stage when it will have to be reckoned with as a serious fighting force, even if only for scouting duty, and that it is high time that some really serious effort was made to create an aerial fleet.

DETECTING MINERAL OILS IN OTHER OILS.

Since the introduction of oil-sand cores the question of the adulteration of vegetable oils with mineral oils has acquired considerable importance for the metallurgist. The oil is to bind the sand of the core. But vegetable oil alone has any value from this point of view ; mineral oils are non-drying and directly deleterious, therefore, because with them more fuel and more time is required for baking the cores than with other oils. The resin oils are less objectionable ; but owing to their relatively high price, their use is more restricted. The price difference between mineral oils and vegetable oils is very large. In the research which we are about to notice, Mr. Alexander E. Outerbridge, Jun., of Messrs. William Sellers and Co., Philadelphia, points out that linseed oil, the best binding agent for making sand cores, costs about a dollar per gallon, while the gallon of mineral oil can be obtained for 3 cents. Oil dealers are thus strongly tempted to dilute vegetable oil with mineral oil. The metallurgist can only regard this dilution as an adulteration ; but the compounding of core oils has become a large business, and nearly all the samples of core oils which have come under the notice of Mr. Outerbridge were mixed with mineral oils or resin oils.

The detection of the adulteration is very difficult except by the subsequent failure of the sand cores. Mr. Outerbridge found several samples which stood the skin test (evaporation of a few drops of the oil in a platinum capsule, when a good tough skin should result) very well ; but complaints came afterwards from the foundry that the cores broke in handling. Chemical analysis will decide the question ; elaborate analyses are necessary, however, which only the experienced chemist can perform, because the different oils resemble one another too much. The term "mineral" oil is a misnomer, justified only because the natural oil or petroleum is generally classed with the mineral resources of a country. The mineral oils are hydrocarbons, of course, which are known in great variety. Resin oils contain oxygen, and may be more closely related to the mineral oils than to the vegetable and animal oils or fats. The latter oils and fats are compounds of certain organic acids with glycerine and similar organic radicles. Treated with alkali these oils and fats are saponified—*i.e.*, turned into alkali salts of soapy consistency. Resin oils are slightly saponifiable, mineral oils not at all—at least, not so far. By these and other reactions the various classes of oils can be distinguished. But there has been no really reliable test known which would inform the metallurgist that his supposed linseed oil contained a small or large percentage of mineral or resin oil.

The test which Mr. A. E. Outerbridge has worked out and which he describes in the Proceedings of the American Society for Testing Materials,* is a fluorescence test, sufficiently simple for the man who has more experience in foundry practice than in chemical and physical experiments. That mineral oils—but not vegetable oils—display fluorescence under ultra-violet radiation, and even under ordinary illumination, has long been known. Mr. Outerbridge himself, in fact, points out that "de-bloomed" mineral oils are on the market, oils which have in some way been so treated that they have apparently lost their fluorescence "bloom." It is rather surprising, therefore, that this property has not been utilised for a practical test ; but this technical test seems to be new. Crude or partly refined mineral oils show a greenish fluorescence in reflected light, while their true colour—yellow, reddish brown, greenish—appears in transmitted light. Resin oils behave similarly, but their fluorescence is bluish. Vegetable oils do not show any fluorescence. Mr. Outerbridge observed that the fluorescence of bloom-oils could enormously be intensified, and that the percentage of mineral or resin oil in a pure vegetable oil could be estimated by a kind of calorimeter test—*i.e.*, by preparing comparison standards of vegetable oils containing definite proportions of the other oils. The intensification of the fluorescence is best obtained, not with a quartz-mercury arc, of which everybody would probably think in the first instance, but by the aid of an enclosed arc-lamp. Such an arc, Mr. Outerbridge states, burns in a partial vacuum, because more air is consumed than can gain entrance, and the lamp shows a faint rosy light in addition to the glowing arc. These rosy rays produce intense fluorescence of the oil even in daylight, and the presence of 1 per cent. of mineral oil in a linseed-oil can easily be detected in this way. Mr. Outerbridge, in fact, detected 1 per mille of mineral oil, and he emphasises that the comparison standard tubes or phials need not be of the same size and contents. In other words, the quantity of oil examined, and the dimensions of the bottles, do not, according to Mr. Outerbridge, affect the colour of the fluorescence, which can be observed, for instance, when a thin film of the oil is examined between glass plates, though the film itself may hardly be visible. Moreover, standards prepared with linseed-oil also serve for the testing of cotton seed oil, corn-oil, bean-oil, &c. China bean-oil and China wood-oil do not fluoresce at all, nor does pure lard-oil, while mineral lard-oil does fluoresce. The "de-bloomed" oils all turned fluorescent in the intensified arc-light.

The subject will require further investigation, and as Mr. Outerbridge does not claim any inventor's rights for his new test, there is no objection to such researches. His paper is interesting, but, we cannot refrain from adding, hardly of the standard of a publication in the proceedings of a society for testing materials. Mr. Outerbridge gravely quotes the New-Century Dictionary in order to answer the question "which will promptly be asked : 'What is fluorescence ?'" and he proceeds to liken the divergent beam of the spectrum to a closed fan. That would be acceptable for a daily newspaper. But if Mr. Outerbridge's colleagues should really have to consult a dictionary to find out what fluorescence signifies — which we do not believe, of course—the scanty details of his test will be of little use to them.

* See vol. xi. of the journal quoted, 1911.

INSURANCE AGAINST UNEMPLOYMENT IN FRANCE.

Unemployment insurance having attained to the importance of being incorporated in a Government measure in Great Britain, it may be interesting to give some account of the attempts which have been made abroad to insure against the risks of unemployment, and their attendant results. For the present it will suffice if we consider the system created for this purpose in France, which although named "insurance," does not properly correspond with what is usually conveyed by that term. Furthermore, insurance against unemployment in France is, in a sense, impracticable, for actuarial tables of unemployment, corresponding with the mortality or accident tables of ordinary insurance, do not exist there.

It is natural that there should be complaint about unemployment in a country so full of syndicates and trade unions as France. Figures, by no means authoritative, are advanced as to the proportion of "out-of-works" in this or that year, or as to the number of unemployed relative to the total population. Such unemployment statistics are, however, of doubtful value, more particularly as workmen who will not accept particular work, or who are on strike, &c., are grouped with those who cannot find work. As a French Socialist Deputy, M. Vaillant, recently stated, a considerable amount of unemployment always prevails, even in times of commercial and industrial prosperity, and the proportion of "out-of-works" often reaches 7, 8, 9, and 10 per cent. According to this authority, at every period of crisis quite a million persons in France may be estimated as unemployed, and the unemployed may always be counted by hundreds of thousands at least. It is true that the French Labour Bureau (Office du Travail) under the Labour Ministry, publish monthly and annual statistics relating to unemployment, but the figures given are, for the most part, furnished by the workmen's syndicates. There is a tendency on the part of the latter to exaggerate the proportion of unemployed ; and, in any case, supposing the estimates to be correct, the basis of the figures, relatively to the entire population, is very small, seeing that the majority of the workers in France are not members of the workmen's syndicates. In the statistics referred to, information emanating from the private or works societies is also utilised ; this information is, however, very confused and is of scarcely greater value. The census of population affords some indication of the people who have declared themselves out of work at the time of any particular census ; in this way, for example, the figure of 315,000 persons in 1901 was arrived at. In spite of these figures, much alarm was occasioned in France because, according to information supplied by the workers' syndicates, the average of the unemployed was estimated, in 1909, at rather over 8 per cent., while the corresponding mean for 1908

was estimated at 9.6 per cent. It should be mentioned that these latter averages were based upon an aggregate of less than 250,000 individuals, representing the syndicate which furnished particulars to the Labour Bureau. For the year 1910 the percentage of unemployed, taken in the same way, would amount to 6.5 per cent., which, again, concerns a working population very small indeed in comparison with the entire population of France.

Whatever the purely relative worth of these statistics, it is quite certain that unemployment occasionally makes itself painfully felt in some occupations, or at least in the case of certain workers. For this reason various means have been devised in this, as in some other countries, for aiding the unemployed, and at the same time for diminishing unemployment. We are now concerned more especially with that special form of aid which has been denominated "insurance against unemployment;" but, as explained already, in France, in the true sense of the term, this does not exist, although the phrase is used. What is done takes the form of assistance distributed by the workers' syndicates or unions and by special associations, in connection with which there is nothing corresponding to the premiums of an insurance or mutual assurance company, or to the indemnities paid to the victims of accident in the case of accident insurance. In these so-called "insurance" organisations in France, calls are certainly made upon the members, but these contributions are more frequently used for purposes quite other than that of assisting the unemployed. The special feature in connection with these associations and societies is that, on the one hand, the State, and, on the other hand, the towns, departments, and local authorities, aid them by granting subsidies which are considerable in amount when compared with the absolute value of the contributions of the workmen; the sums available for distribution among the unemployed are thus materially augmented.

What is the real value of these so-called insurances against unemployment? The designation has been preserved, notwithstanding that it relates to a system which has nothing in common with insurance properly so called, as it is the title usually given, even in official documents, to every organisation of funds for the benefit of the unemployed (*caisses de secours*) whatever may be their origin. In 1902, on the occasion of an inquiry into the subject by the Labour Minister of that period (M. Millerand), that gentleman dwelt with considerable satisfaction upon what he described as the admirable expansion of insurance against unemployment in France. He congratulated the country on the fact that it had more than 300 insurance funds (*caisses d'assurances*), comprising 30,000 members and receiving over 110,000 francs (4400*l.*) in contributions. It is easy to show, however, that the 30,000 members and the 110,000 francs are quite insignificant when regard is had to the working population of France. The greater part of the funds above enumerated belong to a single federation of workmen, composed of an aggregation of syndicates dependent upon what is called in France "le Livre," that is, the printing and allied trades. This Federation is the most important workers' federation in France. The greater number, indeed, of the funds for "insurance against unemployment" in France, have had no real importance. As far back as 1902 it was contended that the influence of previous legislation, dating from 1852, when it was expressly forbidden to any workers' organisation to distribute out-of-work aid, still made itself felt. Obviously, legislation of this sort was monstrous, opposed to common prudence, and, therefore, to ethics. It was feared then that insurance against unemployment would facilitate strikes. At the present time the working population of France takes the greatest liberties in regard to strikes, and there is no longer anything in the way of legislation to prevent it from practising unemployment insurance or seeking the security of an association, or, at the least, from paying contributions in order subsequently to receive assistance should unemployment occur. In considering the insufficient character of the funds assigned to meet critical periods of unemployment, many people have been led to demand, from the State and the municipalities or departments of France, the allotment of premiums of encouragement to the workers' organisations, so as to induce them to practise what is called "unemployment insurance." In 1902, for example, it is the fact that beyond the funds under the control of "le Livre," the lithographers, the hatters, and the moulders, the whole of France did not possess more than 110 funds for the various callings into which the working population was divided, and these 110 funds had distributed in one year less than 60,000 francs (2400*l.*) in aid of unemployment. Even the federation of "le Livre," notwithstanding its exceptional organisation, was, in 1900, only hoping to arrange for something definite with regard to the matter of unemployment. Indeed, the funds of this federation were, so to speak, continually in arrear, the resources being utilised to cover the sickness risk as well as the risk of unemployment proper. Again, in this federation, the number of out-of-work days increased from year to year in a manner wholly unforeseen. It is easy, therefore, to understand that in the case of funds less well organised, the likelihood of the regulations being sufficiently well devised to avoid the various inconveniences that might arise was remote. In the case of the plaster-moulders and moulders of Limoges, it is admitted that out-of-work benefit may be continued for an indefinite period. This is an arrangement which certainly does not operate as an inducement to the assured—the workman whose contributions have formed part of the fund—to seek work.

Since 1896 certain towns—Dijon and Limoges, for example, where socialism has considerable influence—have granted subsidies to the funds for the relief of unemployment, and to this we shall refer later. As regards State subventions, legislative provision has been demanded since 1895, and between 1895 and 1903 various legislative proposals were submitted by deputies with the object of instituting a general insurance against unemployment, embracing all French workers. These proposals were never debated. In the end the question was submitted to the Conseil superieur du Travail, specially composed of members elected either by the employers' or works' syndicates or by the workmen's associations, and of members nominated by the Government, and in this Council the tendencies of the Socialist and Interventionist have been manifest. Nevertheless, the Council has not pronounced in favour of compulsory insurance, but has merely requested that the State should step in for the purpose of distributing grants to the organisations intended to aid workmen out of employment. As a consequence of all this, by the Financial Law of April 22, 1905, Parliament decided that a preliminary sum of 110,000 francs should be appropriated by the Government to subventions to the funds in aid of involuntary idleness.

According to this law and certain subsequent modifications, all the funds which grant aids to members who are idle, by reason of failure to get work, have a right to State subsidies; only this form of unemployment is considered, to the exclusion of all others. Moreover, it does not matter whether the assistance to the unemployed workman takes the form of relief in a particular place or guarantees of travelling expenses, &c. In principle, it is essential that the funds applying for subsidies should be composed of members occupied in the same or a similar trade or calling. These funds should have at least 100 members, but 50 is sufficient if they already receive help from the local authorities. This course has been taken in order to obviate the differences in the risks of unemployment, and to facilitate the control of the workless men. Nevertheless, in towns of less than 50,000 inhabitants, local funds which group adherents of various trades may receive subventions, provided they have a minimum membership of fifty, and are subsidised by the commune or department. Also, grants may be allocated to funds distributing travelling expenses, and depending upon unions fed by the payments of affiliated associations, on condition that the resources of these associations have their origin in the contributions of the members. Subventions may also be accorded to syndicate funds and to certain philanthropic institutions and associations for mutual aid, or to others, but it is necessary that the fund soliciting such subventions should have been in existence six months, should guarantee a gratuitous service for finding work for men, and should submit its rules to the Minister, so that he may become acquainted with them. In addition, it is required that certain clauses should form part of the rules and regulations of the associations seeking and obtaining the subsidies. Thus the rules should indicate quite clearly instances of aid given to the unemployed, the duration of such aid, and the amount collected for assistance during enforced idleness. For the rest, the associations thus subsidised are free to fix the amount of their contributions and the rate and duration of benefits. It is nevertheless prescribed that the members of the associations subsidised should have no right to benefit until after an affiliation of six months, and that they should undertake to accept any employment in their particular line which the fund might indicate. They must, also, during the ordinary hours of work, sign a control register at least three times weekly. Each association must keep proper account of its expenses, and should be able to substantiate in some way its roll of membership, as upon this membership its receipts are calculated. Further, the subsidies of the State may be allocated for benefit not exceeding 2 francs per day or sixty days in the year. Any excess of this sum or period is disregarded in the calculations for allotment of subsidies. To show the large part which the subsidies play in the resources of the associations, it should be pointed out that it is only necessary for the contributions of the active members to represent at least one-third of the benefit paid to the "out-of-works;" that is to say, the participation demanded from the members concerned covers only a fraction of the outlay.

The legislation relative to State subventions in favour of the funds for unemployment specified, at first, that the maximum rate of these subventions should not exceed 16 per cent. of the amount of the benefits distributed by the funds to their members. It was admitted, however, that this proportion might rise to 24 per cent. for funds which embraced at least three departments and numbered more than 1000 members. That lack of enthusiasm for insurance against unemployment, or for any fixed provision, by the French workers' syndicates, even when they have the chance of receiving aid from the State, is shown by the circumstance that, after three years' experience, the credit of 110,000 francs available was never exceeded by the grants distributed. This being so, and as there was no wish to exercise economies in relation to the credits, it was decided that the rate of subvention should be increased.

This rate, it is said, can now be 20 per cent. or 30 per cent., dependent on the distinction above indicated. It should be noted that the 20 per cent. to 30 per cent. is only calculated after the subsidies given by the communes or departments have been deducted; these do not enter into the account in estimating the grants which should be given by the State. On the other hand, as it was a common experience to meet with funds that had no real importance, it was determined that the State subsidies should not be allocated to funds other than those which had distributed at least 30 francs in the way of benefits during the half-year. This, of course, is very little. It would appear, however, from certain figures that the organisations for insurance against unemployment have made very little progress in France in spite of the ample provision made in the Budget. It has hardly been possible for the State to distribute completely the credit of 110,000 francs which is placed at its disposal. It has been necessary therefore to fix upon a maximum rate of benefits which will fully employ the available funds.

It is true that, at the commencement of 1905, the number of funds for assurance against unemployment which desired to benefit by the half-yearly allotments of the State was only about 71. This number had risen gradually to 97 at the end of 1907, and to 112 at the end of 1908. Again, in the case of certain of the funds, the subsidies have not been fully paid, because the organisations did not conform to the conditions laid down and outlined above. In effect, during 1905, only 47 funds, with approximately a mean number of members of 33,700, received subsidies. In 1909 the number subsidised was 94, with a mean number of members approximately 40,000. In the first place, the number of "out-of-works" aided by the contributions of the funds themselves, and by the subsidies of the State, was 6650, while during the year 1909 the corresponding figure was 7350. These figures indicate a large proportion of "out-of-works" both for 1909 and 1905. But we must not be misled with regard to these numbers. They are composed, in the case of each fund, by the addition of the "out-of-works" for both half-years, and consequently in many instances the same person is counted twice over. The figures given really correspond to the total number of cases of unemployment—not to that of the actual persons unemployed. During the year 1905 the benefits

paid by the various societies in aid of unemployment amounted to 135,000 francs (5400*l.*). The State paid nearly 28,000 francs in subsidies, so that it may be said that the State grants play an enormous part in the provision of out-of-work benefit. In 1909 for 168,000 francs (6720*l.*) paid in indemnities by the same funds, the subsidies exceeded 42,000 francs (1680*l.*). The latter figure represents benefit for 95,000 days of idleness. It is clear, therefore, that only a small minority of the workmen have taken advantage of the financial sacrifices which the State has imposed upon itself. Notwithstanding this circumstance, it cannot be denied that these sacrifices are considerable in relation to the personal efforts of the members who contribute to the funds for unemployment, since the State grants represent more than one-fifth of the aid which the funds themselves are in a position to render to their members; in addition to which, the number of funds, as well as the insignificant number of workers taking part in the associations, show that the workmen care little about making any personal attempt to guarantee themselves against unemployment, even when they are certain of subsidies which the generosity of the contributors have made relatively so important. Again, we cannot be sure that the distribution of these subsidies does not leave room for fraud, for cases are heard of in which the associations have taken steps to secure the State grants and to distribute them among their members, without having paid to such members the aid which should come from their own resources; and sometimes, even, the beneficiaries, of this distribution of State aid, were not really the unemployed who had interests in the association. As a matter of fact, since 1905 certain frauds have only been checked as the result of accidental detection, and it is likely that many others have escaped discovery altogether.

It must not be forgotten that a large number of local funds in aid of unemployment are subsidised by the departments or communes. Of these we may give a few particulars. In 1910, 8 departments and 41 communes, situated among 25 departments, drew upon their budgets in order to grant subsidies and aids to the societies concerned, accordingly increasing the out-of-work benefit that the latter could distribute to their members. These subsidies amount to about 114,000 francs (4540*l.*). It may be said that this sum is insignificant, but the amount is based upon the general contributions, and consequently is demanded for all and each of the contributors, while there is no certainty that it is distributed to really deserving people. Moreover, this sum of 114,000 francs is increased by what may be termed charitable contributions in aid of unemployment, which the so-called "insurance against unemployment" associations distribute; this exaggerates still further, in the case of the associations concerned, the contrast between this form of benefit and ordinary insurance. The mode of division of the subsidies varies with the district or locality. Certain towns have adopted, at least in part, the method known as the "systeme gantois," practised in the town of Ghent. They restrict their aid to an increase of that paid by the funds. In other towns the amount of the subsidy is remitted to the fund itself, without any express stipulation, and the fund has the power to deal with it as it thinks proper. Certain towns again augment the contributions paid by the members of the fund; while others take as a basis for subsidy, the number of members, the contributions, and the financial position of the fund.

In short, if there is any conclusion to be drawn from the system instituted in France under this *régime* of subsidies granted either by the State or by the local authorities, it would be simply that the encouragement thus afforded appears to have had little effect on the development of out-of-work funds. Frequently in the case of municipal or departmental subsidies there are not enough funds which have either distributed sufficient aid, or, having done this, have a sufficient number of members to warrant the grant of the whole of the credits. The assumption is therefore that the people interested voluntarily forego these subsidies because the opposite course would involve some personal effort by compelling them to pay contributions to the fund, and to make some attempt at self-help.

CASCADE MOTORS.

Although the many excellent qualities of continuous-current motors render them, in some cases, superior to all other agents for transforming electrical into mechanical energy, the simplicity, strength, and other special properties of polyphase induction motors enable a strong case to be made out in favour of these machines, particularly when machinery is to be driven at a practically constant speed. The ordinary induction motor is essentially a constant-speed machine, as, although its speed may be varied by means of resistances connected through slip-rings to the rotor circuit, the power taken from the mains is unaltered for a given torque. This means that energy proportional to the reduction in speed must be absorbed by the resistance, so that this wasteful system of speed regulation is only available for short periods. There is, however, a method by which induction motors may be made to run efficiently at different speeds. It is carried out by coupling two of them "in cascade." If the rotor windings of one motor be connected to the stator of a second exactly similar machine, which is also coupled mechanically to the first, the two machines can be started up by means of a resistance in connection with the rotor of the second machine, and will then run at half the normal speed of either, or at the same synchronous speed as a motor having twice the number of poles of each separate machine. Similarly, if an eight-pole motor be connected in this way to a four-pole motor, the two machines will run "in cascade" at a speed equal to that of a single machine with twelve poles. Since either the rotor or the stator of an induction motor may produce the rotating magnetic field on which these machines depend for their action, it is easy to see that instead of connecting the stator of the second machine to the rotor of the first, the effect would be just the same if the two rotors were connected; the starting resistance would then be inserted in the stator circuit of the second machine, and thus the use of slip-rings could be avoided. The cascade arrangement can be carried a further step by combining double stator and rotor windings in a single machine, but, as usually carried out, this system tends to have a comparatively low efficiency, owing to large magnetic leakage and copper losses.

In the spring of 1907, in a paper read before the Manchester branch of the Institution of Electrical Engineers, Mr. L. J. Hunt described a special form of winding he had invented, which, while producing the double rotating field required by the cascade system, greatly reduced the losses obtained with two independent windings, and so made it possible to retain the advantages of the cascade system in a motor having practically the same efficiency as that of an ordinary slip-ring induction-motor. It will suffice for our purpose to say that the rotor windings were such that, when acted on by a rotating field having a certain number of poles, they produced a secondary field with a different number of poles. The windings were thus equivalent in effect to two independent windings, but they had the very important advantage that a number of bars could be omitted, since the currents in them, due to the two different fields, neutralised each other. The omission of these bars considerably increased the efficiency, diminished the cost of construction, and had other practical advantages. The stator windings consisted of two sections in parallel in each phase, wound for a different number of poles, the numbers being so chosen that the fields did not interlink, except through the rotor. The sections were directly connected at certain points, and at intermediate points connections were brought out to the starting resistances. Since no primary difference of potential existed between the ends of these connections, the currents circulating through them were entirely due to the secondary field produced by the rotor. The results obtained were thus similar in effect to those obtained by employing a starting resistance in the stator of the second of two cascade-connected machines, as suggested above. The fact that the starting resistances were connected to the stator windings rendered the use of slip-rings unnecessary for single-speed motors, and thus we had a machine which, while possessing all the characteristics of a slip-ring motor, avoided the difficulties which may arise from the slip-rings. The avoidance of these details is certainly a desideratum where motors have to work in dusty places, such as mines and quarries. Also the resistance of the brushes, leads, &c., in an ordinary machine may be of the same order of magnitude as that of the whole rotor windings, so that the elimination of this source of loss is worth considering.

Cascade motors are essentially slow-running machines, and this characteristic permits gearing to be entirely dispensed with in some cases, and in others considerably simplifies the problem of speed reduction. Very low speeds can be obtained with resistance in circuit, owing to the even turning moment produced by the two fields; for instance, a 50-horse-power motor whose normal speed is 490 revolutions per minute has been found to run steadily at two revolutions per minute while developing its maximum torque; but, of course, considerable energy is wasted in the resistances when running under these conditions.

If these machines are required to run at more than one efficient speed—that is, without waste of energy in resistances—a modified form of rotor winding, with slip-rings, is employed; for many purposes, however, a short-circuiting device will answer the purpose of the slip-rings. The two-speed rotor has all its slots filled with bars, and the added conductors are arranged with some of the others to form a symmetrical winding, the ends of which are brought out to slip-rings. When these slip-rings are open-circuited, the added bars have no effect, and the rotor runs at cascade speed; but when the slip-rings are short-circuited, no secondary field is produced by the rotor, and the machine runs as an ordinary motor at non-cascade speed. By varying the resistance in the rotor-circuit speeds between cascade speed and top speed can be obtained, while lower speeds can be got by means of the stator resistances. If the intermediate speeds are not required, the arrangements can be somewhat simplified, the stator resistances being replaced by a six-pole short-circuiting switch. The motor can then be started and run up to top speed by means of an ordinary three-phase starter connected to the slip-rings, the stator switches being open. If it be required to run at the lower speed, it must be started by means of the rotor resistance and the stator switch closed, the rotor switch being afterwards returned to the "off" position. The motor can be changed from cascade to top speed, or *vice versâ*, without opening the main switch.

Among the many uses to which a two-speed motor can be put may be mentioned the driving of mine-ventilating fans, which are often required to run at a lower speed during week-ends. For this duty, however, a special stator winding has been evolved, as, since the torque required to run the fan at a lower speed is much less than for normal speed, the power-factor of a machine with windings of the form usually employed would be poor. To overcome this objection, the stator winding is provided with three terminals, which, when short-circuited, change the effective number of conductors, so that the motor works with a high power-factor at much less than its normal torque. This type of winding is used in all cases where the torque is required to fall off with the speed. When a machine is required to run at three efficient speeds, one of the sections of the stator winding is rendered inoperative by means of a change-over switch, so that only one rotating field is produced, and the motor runs at a speed corresponding to the number of poles in this field. For example, a machine having eight-pole and four-pole stator windings would run as a twelve-pole machine with the rotor open-circuited, and as an eight-pole machine with the rotor short-circuited, while by means of the change-over switch a speed corresponding to four poles could be obtained. A large number of single-speed and multi-speed motors on this principle have been built by the Sandycroft Foundry Company, Limited, of Chester, for driving pumps, air-compressors, fans, coal-cutters, haulage gears, and other machinery.

The application of the cascade motor to mine haulage was due to Mr. Williams-Ellis, who described the system in a paper (to which we are indebted for some of the foregoing particulars) read before the Association of Mining Electrical Engineers. In this paper the author expressed the opinion that two-speed motors would be advantageous for mine winding and hauling work, since the losses in the resistances during the period of acceleration would be much less with two-speed machines than with ordinary induction motors. With machines of the latter type, if the pull on the rope, and therefore the torque, be constant during the acceleration of the load, the power input over the whole period will also be constant and equal to that required to produce the same torque when the motor is running at full speed. Since the output from the machine is proportional to the speed, the mean power production, neglecting internal losses,

&c., will be only one half of the power supplied, so that the remaining half of the energy is wasted in the resistances. With a two-speed cascade motor, under the same conditions, the power input from rest up to the intermediate speed is only that required to produce the given torque at cascade speed, and thus nearly half the energy wasted in a single-speed machine can be saved. It has also been suggested that this characteristic might be utilised to smooth out some of the peaks in the load curve of the power-station, an automatic device being employed to change to cascade connections, and allow the motor to slow down when the load was travelling up a steep gradient. When the pull on the rope had fallen to its normal value, the machine would automatically run up again to full speed. Cascade motors have certainly several interesting and useful properties which seem to render them superior to ordinary induction motors for many purposes, so that users of polyphase power, in mines and quarries especially, may find the special characteristics of these machines worthy of further investigation.

NOTES.

Lloyd's Wreck Statistics for 1910.

The annual statistics of vessels totally lost or condemned, which are published by Lloyd's Register, show that during 1910 there was a gross reduction of 863 vessels, of 947,690 tons, in the effective mercantile marine of the world. Of this total, 421 vessels, of 667,440 tons, were steamers, and 442, of 280,250 tons, were sailing vessels. These figures exclude all vessels of less than 100 tons. Of the gross total given above, 356,154 tons are accounted for by vessels broken up or dismantled from causes other than stress of weather; and this figure is the largest ever reported in the returns. Nearly 30½ per cent. of the steamers and over 39 per cent. of the sailing vessels removed during 1910 are accounted for in this way. Of the total tonnage reduction owing to this cause, 41½ per cent. represents vessels belonging to the United Kingdom. Of the figures relating to vessels classed as "wrecked," nearly 53 per cent. of the steamers and 49 per cent. of the sailing vessels are accounted for by stranding and kindred casualties. If losses of this class be taken together with cases of abandonment, foundering, and missing vessels, the total forms nearly 21 per cent. of the steamers and 29 per cent. of the sailing vessels actually removed during 1910. Of such losses, only twenty-two refer to vessels owned by the United Kingdom, which is the lowest figure recorded since the statistics have been compiled. On actual percentage losses of vessels and tonnage owned, the United Kingdom occupies a favourable position as compared with other principal maritime countries. Of vessels owned—that is, steam and sailing vessels together—the percentage lost was 1.37; and of tonnage owned, 1.27. Corresponding figures for Germany are 1.79 and 1.02; for the United States, 2.62 and 1.82, these figures excluding vessels trading on the Great Lakes; for Norway, 3.54 and 3.37; for the British Colonies, 2.12 and 1.86; for France, 2.12 and 1.10; for Italy, 1.57 and 1.40; and for Holland, 0.64 and 0.80.

Royal Sanitary Institute.

The Congress of the Royal Sanitary Institute met in Belfast on the 28th ult. under the presidency of Mr. P. C. Cowan, M. Inst. C.E., Chief Engineering Inspector of the Local Government Board for Ireland. In his inaugural address, Mr. Cowan drew special attention to the change which the Local Government Board of Ireland Act of 1898 made in the status of the county surveyors in that country. Up till that date the appointments were made on the result of examinations, and the salary (a moderate one) was fixed by Act of Parliament, and could neither be reduced nor increased. The incumbent's tenure of office was also secure, since he could be dismissed only with the sanction of the central authority. By the Act of 1898, though fixity of tenure is still secured, the schedule of salaries was abolished, and, as a consequence, many appointments as county surveyors and assistant county surveyors have been made at salaries markedly less than was considered reasonable and necessary in the past, when the duties were actually easier. Mr. Cowan also expressed the view that the absence of statutes to prevent incompetent persons acting as engineers and architects is much to be regretted; but on this head there is much room for difference of opinion. It is important to safeguard the interests of all by ensuring the absolute competency of the men appointed, but at the same time it is undesirable to enforce limiting conditions which would rule out men of great practical experience, fitting them for the post, because they might be unable to meet the letter of the statute. Quite a number of highly successful engineers did not pass through the usual course of training of engineers; they were engineers, one might almost say, by reason of innate ability or genius. Amongst them, for instance, is the late Lord Armstrong, while one of our most successful tool-designers and builders started life as an artist. In fact, engineering being common-sense applied to construction, competency is nearly as much a matter of hereditary endowment as of technical training.

Rapid Ordnance Work at Elswick.

The Elswick ordnance department of Sir W. G. Armstrong, Whitworth, and Co., Limited, have added one more record to the splendid work they have done, alike in respect of efficiency and rapidity, by putting on board the whole of the gun-mountings for the ten 13.5-in guns, as well as the ten guns, of His Majesty's battleship Monarch in three days. As is well known, the firm have a fitting-out naval yard down the River Tyne, and from this yard the Monarch was towed up to the 150-ton hydraulic crane at Elswick, on Sunday afternoon, the 23rd ult., in order that the machinery of the five barbettes should be put on board. The turrets for these barbettes had been completed in the ordnance shops at Elswick, and stored, when finished, until all five were ready for being put in place. On Sunday evening two turrets, with their side-armour, were placed in position on the turntable within their respective barbettes, while the twin guns in the turrets were placed in their slides. On the following day another turret, with its pair of guns, was similarly lifted on board, and on Tuesday morning the remaining two turrets, with their armour, were put into position, while on Wednesday the four guns for these turrets and the roof armour-plate of all the turrets were fitted in place. The loads lifted numbered 250, and the weights varied from 145 tons to 30 cwt.; all of the work was done by the one crane. The total weight of material lifted in the three days was 2800 tons. This performance by one crane establishes not only its rapidity of work, but range of action in respect of load. But credit must be given also to the staff, and particularly to Captain Edward Lloyd, C.B., the head of the ordnance department, for the remarkable organisation, of which the performance is proof. The ship had to be moved frequently to bring the respective barbettes within the radius of the crane, but, more important still, the material in the respective turrets had to be placed accurately in position, the armour keyed, the guns placed and keyed, and the machinery put in and secured in working place with that precision which is an essential condition in all gun-mounting mechanism.

Electrolytic Corrosion in Reinforced Concrete.

The account of experiments presented by C. E. Magnusson and G. H. Smith to the meeting of the American Institute of Electrical Engineers, which assembled at Chicago in the last days of June, does not advance the practical aspect of the problem much. The experimenters took cylindrical blocks of concrete, 9 in. high and 6 in. in diameter, embedded a ¾-in. steel bar, to one end of which a copper wire was soldered, along the axis of the block, and left 2½ in. of concrete between the lower end of the bar and the bottom of the block, which was kept in a moist condition for at least thirty days before the current of about 100 volts was applied. The blocks were placed in fresh water or salt water. All the blocks cracked sooner or later, and there was little doubt that the cracking was due to the increase in the volume of the iron, arising from its oxidation or its conversion into a salt. This electrolytic oxidation was the primary cause of the deterioration of the concrete; it was not that the water could gain access to iron through some fissures already existing or developing for some reason. The dry concrete was an insulator. It became a conductor when its pores were filled with water or some salt solution, and the conductivity was electrolytic. Magnusson and Smith placed cubical blocks of concrete (free of iron) between electrodes in water and salt solutions; the currents of 0.07 ampere and less did not deteriorate the mechanical properties of the concrete noticeably. Thus it must have been the iron in the ferro-concrete which caused the trouble. The oxidation of the iron might be prevented in the laboratory by making the iron the cathode; but that is practically out of the question. The electrolyte might be kept off by filling the pores of the concrete with some non-conducting material; the experimenters tried Sylvester's process (soap and alum) with little success; other cement-proofing materials might answer, but they would have to be applied with very great care. The authors also attempted to provide the iron, before embedding it in the concrete, with some protective coating. Zinc proved useless. Aluminium paint, prepared either with so-called banana oil (amyl acetate) or with some varnish, was tried for this purpose; the attempts were not more than temporarily successful, and it resulted that the value of the coating depended essentially upon the durability of the varnish. But it was also found that the application of insulating varnishes to the iron of ferro-concrete greatly reduced the maximum shearing strength of the concrete. Under these circumstances it is interesting to note that concrete containing an aluminium wire, instead of an iron bar, did not corrode when the blocks were immersed in water or salt solution. A current was observed to flow when the circuit was closed, but it dropped to 0.001 ampere in the course of ten minutes or less, and the concrete remained unchanged. This point might further be investigated. The experimenters suggest trying iron electrolytically coated with aluminium. What they say about alternating currents (the tests so far mentioned were made with direct currents) is in agreement with previous observations; alternating currents will not attack ferro-concrete, provided the positive and negative wave forms be equal and the heating not excessive.

Four-Cycle Gas-Engine Driving Generators: Erratum.—We regret that in our article on this subject, which appeared on page 130 *ante*, there are two errors, both of them in the last paragraph. In the first case, in the fifth and sixth lines from the top, there appear the words "four large gas-engine generator sets." This should have been "twelve large gas-engine generator sets." A few lines below appears "0.003 gramme of dust." This should have been "0.03 gramme of dust."

The Danish State Railways.—Whilst in several countries the State Railways have been doing exceedingly well of late, with increasing revenue and surpluses, the reverse is the case in Denmark, where the deficit is on the increase. A capital of some 14,200,000*l.* is sunk in the Danish State Railways, but not only do the railways yield no interest on this sum, but there has of late years been an actual deficit on the working, as to the exact amount of which opinions differ. Due to increased salaries and a reduction in the revenue, in spite of repeatedly increased rates, which increase on passengers' tickets amount to some 50 per cent. during the last ten years, the surplus of former years has become a thing of the past. Matters have now come to such a point, that it has been thought necessary to appoint a special committee to investigate the matter. Its aim will be apparently a double one, to find means of reducing expenditure and of simplifying the working arrangements, which are considered unnecessarily complicated and bureaucratic. The Danish State Railways have a staff of 14,000 employees, that is, rather more than an average of 10 employees, all told, per mile of line, which fact tends to illustrate its system of working.

"The Port of Grimsby and Immingham."—This is the title of a publication that has just appeared. It is issued annually, and this year contains an account of the two ports brought up to date. It has frequently been said by pessimists that Grimsby had seen its best days, but the prognostications of all these gloomy prophets have been upset by the course of events, the prosperity of the place having continued to grow steadily; and since the new dock at Immingham was completed the neighbourhood of the place has advanced more rapidly than ever. This prosperity is no doubt largely due to the faith and untiring labour of Sir George Doughty, J.P., M.P., who for many years has made the well-being of Grimsby one of the important considerations of his life. The publication gives an account of all the chief industries of the place, with statistics showing the growth of shipping that frequents the port; it is very fully illustrated by reproductions from photographs, and the accounts are given in English, French, and German. One special feature of the Immingham Dock which must be mentioned as being of particular importance is its accessibility from the sea at all states of the tide. The pamphlet is published by Messrs. W. H. Jackson and Co., 408, Victoria-street, Grimsby, the price being 6d.

INDUSTRIAL NOTES.

The monthly report of the Associated Iron-Moulders of Scotland for July has come to hand, and contains figures relating to the period of six weeks beginning May 20 and ending July 1 inclusive. It is satisfactory to note that the membership shows an increase of 36 when compared with the last report. When comparison is made with the same time twelve months ago, there is shown an increase of 77 in the total membership. The members at work numbered 5844 in July last, against 5690 at the same date a year ago, which result shows a distinct improvement in trade at the present time. During the six weeks alluded to the financial gain to the funds has been 376*l.* 6s. 5½d., the net income having been 3446*l.* 17s. 7½d., against 3070*l.* 11s. 2d. at the time of the previous report. The funds of the society now stand at 48,983*l.* 17s. 1½d. The outlay includes the working expenses. Idle benefit took 778*l.* 10s. 9d., superannuation benefits 1563*l.* 7s. 4d., and funerals 263*l.* 6s. 8½d.

During the whole of the half year idle benefit took 3232*l.* 8s. 0½d., or an average of 8s. 7d. per member. Superannuation benefit took 6471*l.* 19s. 10d., or a charge of 17s. 2d. on average members. Funeral benefit took 1537*l.* 16s. 2d., or a charge of 4s. 1d. on average members. Salaries accounted for 697*l.* 9s. 5½d., or a charge of 1s. 10½d. on average members; and miscellaneous absorbed 2*l.* 1s. 3d., or a charge of a fraction on average members. The total for the six months was 12,815*l.* 2s. 5½d.

Attention is called to the annual report of the Chief Inspector of Factories and Workshops regarding accidents, particularly with regard to the founding trade, in which the number of accidents appear to have increased to an alarming extent. In this trade the number rose from 7451 in 1909 to 8084 in 1910, and fatal accidents from 60 to 80, or 33 per cent. In ten years accidents in foundries caused by machinery rose from 2629 to 4088, and the ratio of accidents in foundries to the number of people employed is the second highest of any industry in the country. This matter requires very serious consideration, because it appears to be pretty certain that the majority of accidents are preventible.

According to the half-yearly financial statement and monthly report of the National Union of Boot and Shoe Operatives for July employment at the time the report was issued was fair, but it was not so good as a month ago. It was, however, better than a year ago. Returns from firms employing 63,503 workpeople in the week ending June 17 showed a decrease of 4 per cent. in the number employed, and of 10 per cent. in the amount of wages paid compared with a month ago. Compared with a year ago there was an increase of 0.5 per cent. in the number employed, and of 3.6 per cent. in the amount of wages paid. At Leicester employment was fair, but not so good as in the previous month, but it was better than a year ago. At Northampton and Kettering employment was fair and better than a year ago. It was slack, however, in the case of the army bootmakers. In Bristol the trade showed an improvement compared with a year ago, and at Leeds it was moderate, but better than a year ago. Trade was fair in Scotland and better than a month ago, and about the same as last year. The balance in hand of the trade department at the end of the half year ending December 31, 1910, was 74,930*l.* 9s. 1d., and the income in the same department, including interest for the past half-year, has been 11,663*l.*—a decrease on the corresponding half of 1910 of 135*l.* 16s. 10d. In the first six months of this year the total expenditure of the trade department amounted to 10,179*l.* 0s. 5d., against 8,737*l.* 15s. 7d. for the corresponding half of 1910—an increase of 1441*l.* 4s. 10d. The funds in hand of this department on June 30, 1911, amounted to 76,414*l.* 18s. 4d.—an increase of 1484*l.* 9s. 3d. during the half-year.

In the sick and funeral department the balance in hand at the end of the half-year ending December 31, 1910, was 15,767*l.* 16s. 11d. The income, including interest, during the past half-year amounted to 7618*l.* 10s. 5d., which, compared with the corresponding half of 1910, shows a decrease of 80*l.* 18s. 11d., and the expenditure amounted to 7865*l.* 12s. 8d.—an increase, as compared with the first half of 1910, of 171*l.* 11s. 7d. The funds in hand on June 30, 1911, were 15,520*l.* 14s. 8d.—a decrease during the half-year of 247*l.* 2s. 3d.

The saving on the half-year was considerably less than on either the previous half-year or the corresponding half-year of 1910, which was caused almost entirely by the very heavy expenditure in connection with unemployment, the payment for the out-of-work fund being 6457*l.* 17s. 1d., as against 4835*l.* 8s. 4d. in 1910.

The strike which for some time has paralysed the trade of South Wales and of the city of Cardiff came to an end at the close of last week, and work was resumed on Friday. The recognition of all the unions is included in the settlement, and the employers have agreed to meet the men's representatives at an early date. At Newcastle the provisional agreement between the North of England Steamship Owners' Association and the sailors was ratified and approved by the Hartlepool Shipowners' Society.

On Friday last the International Miners' Congress held its session at the Westminster Palace Hotel, and the following resolutions were set down on behalf of Belgium and France respectively: (1) This Congress is of opinion that the regulation of production is desirable, and that, in order to achieve it, it is expedient to employ every means at the command of the miners' union, and especially the international strike in case of necessity. (2) It is our opinion that when a general strike takes place in any country, the Miners' Federations of the neighbouring lands should limit their production by a fixed abstention from work. The Belgian representative pointed out that it was the seventeenth time that the question of limitation of output had been on the agenda at the International Congress, but there had never been proper discussion. The fact was that when a strike occurred in one country the owners in other countries increased their output in order to send coal to the strike-affected country. War also entered into the question, and it would be interesting to know how far it was possible to regulate the output of coal so as to make war impossible. In moving the second resolution, the French representative said that recently in the North of France, when the mine-owners were approached by the miners' representatives in order to renew existing contracts, the former brought forward the objection that the North of France was being flooded with German coal, and a German syndicate had arranged to put all their surplus stock on the French markets, and therefore no increase on the regular rate of wages could be promised. This, he thought, showed the necessity of the Congress being able to establish some sort of rule to regulate the output of coal in the different mines of Europe. The resolutions were supported by the English, German, and Austrian delegates, and it was decided to send the matter to the International Committee for consideration, with instructions that the subject should be placed at the head of the agenda at the next Congress. Holidays of a fortnight's duration for miners were advocated, and it was proposed that the Congress should be held every two years instead of annually, but this last was not adopted. The question of universal peace was discussed, but nothing of a really practical nature was decided.

On Tuesday last about 700 surfacemen and platelayers of the North British Railway Company, at Glasgow, handed in their notices to cease work in two weeks' time as a protest against the directors refusing 2s. weekly advances, and the establishment of an eight-hours' day instead of a ten-hours' day as at present.

As a result of a meeting of the Miners' Federation of Great Britain at the Westminster Palace Hotel on Saturday last, on the question of working in abnormal places, a resolution was adopted instructing the officials of the Federation to arrange with the coalowners of the United Kingdom for a joint meeting to consider the question of paying the district minimum rate of wages for working in abnormal places, and in case satisfaction on the question was not obtained to convene a conference to decide upon a ballot of all members of the Federation to ascertain if they are in favour of ceasing work until the district minimum wage is obtained. A deputation was appointed to meet the owners. The payment for work done in abnormal places has therefore now been made a question that carries with it the elements of trouble ahead in the coal trade, for it affects the coal industry of the whole kingdom. There is wide industrial unrest in the country. It has affected the shipping and carrying industries, and appears to be spreading to the miners and among a section of the Mining Federation, who would like to take extreme measures; but for the time being, at any rate, moderate counsels have prevailed. The English and Scottish mining districts have lately been visited by emissaries, who have advocated a national stoppage, and their words have, no doubt, in a great many cases, fallen on willing ears. The contention put forward by the employers has been that the conditions existing in England, Scotland, and Wales are in each case so different that no common basis of agreement can be arrived at.

After running its course for some months the strike at Tareni Colliery, Swansea Valley, was settled last Saturday in an amicable manner, and the men will begin work as soon as the workings have been cleared and made ready.

The strike of seamen on the North-East Coast is now, it is stated, definitely at an end, the Middlesbrough Shipowners' Association having decided to accept the same terms for the settlement as the other ports on the coast.

A strike of tramway men commenced at Cairo on Saturday last, the entire service being suspended. The strikers had twenty-four hours given them in which to return to work or be dismissed.

On Friday last the market place at Gainsborough was the scene of a mass meeting of workmen who wanted to place their case before the public—a rather curious proceeding by the way—and one of the local officials of the Boilermakers' Society said that the men had not been locked out, but had been discharged. When the men went to receive their wages on the previous Wednesday, expecting to be locked out, pending a settlement of the dispute, they received a paper on which were the words "paid off," and containing the men's check number. The speaker went on to use veiled threats of what would happen if any attempt were made to import labour. Picketing was organised near the works of Messrs. Marshall, Sons, and Co., Limited. The works of this firm were, however, closed at the end of last week for the annual week's holiday, so that just at present things will probably be quiet.

In the Openshaw district the labourers employed in the engineers' shops are giving trouble, and the strike which began last week promises to spread until it affects the whole of the engineering industry in Manchester and Salford. This will necessarily affect many more men, because idleness will be forced on the skilled workers owing to the behaviour of the labourers, so that it seems likely that some 30,000 men will be out of work. The demand the labourers make is that the employers shall give them 20s. per week as a minimum; some of them receive now only 17s. per week. There is a demand also for an increase of 2s. to the wages of men who are classed as "semi-skilled." The strike began without the official consent of the unions affected. The officials were quite aware, however, that the struggle must commence soon, because last winter it was decided by the workers' unions to insist on a minimum wage of 20s. if trade improved during the summer. They have therefore decided to support the men. The workers in the engineering shops of the Great Central Railway Company at Gorton and Dunkinfield obtained advances last week, and this appears to have precipitated matters. The advances resulted in a wage of 21s. a week for boilermakers, hand drillers, and foundry labourers, and 20s. a week for ordinary labourers. Similar increases are also demanded by men in other shops, and it is due to this, therefore, that the works of Messrs. Crossley Brothers, Messrs. Beyer, Peacock, and Co., and the Metropolitan Amalgamated Railway Carriage and Engineering Works have been thrown idle. About 2000 men are actually claiming the advance, but other workers are, of course, affected, and unrest seems to be on the increase in all the engineering shops of Manchester.

On Tuesday last many large ships lay idle on the Thames, and many perishable cargoes were left untouched owing to the strike of dockers, and it was announced in the evening of that day that the men working at the Tilbury Dock had decided to join the strike. At that time there were 7000 dockers and allied workers on strike. Large quantities of frozen meat and butter remained unloaded, and all the dock sides were well picketed. It is thought the boats of the Nelson Line will be particularly affected, because of the imports of frozen meat from Argentina which they carry. The White Star steamer Ionic, which arrived late on Monday evening, with 35,000 carcases of mutton from New Zealand and Australia, could not discharge on Tuesday, and the passengers were only able, with the help of the clerical staff, to land some of their luggage. The situation has been aggravated by the action of the clerks of the Nippon Yusen Kaisha Company, who have come out in sympathy with the dockers, in order that their own grievances may be redressed. The dockers state that the masters have not kept their word, having promised payment at the rate of 8d. per hour, with certain differences in the hours of "call" for work. When, however, the men received their wages on Tuesday, they were, they say, paid at the old rate. It is feared that the whole of the dock labourers may become involved. At the time of going to press about 12,000 men are out.

A strike occurred last Friday among the railway men at New Holland, on the Great Central Railway, which it is feared may develop into something serious if not quickly settled. The traffic between Lincolnshire and Hull has already been much dislocated. A curious feature of the dispute is that the girls and women employed at the Great Central Laundry at New Holland are included, and they all left work on Tuesday last. The Lancashire and Yorkshire Railway Company is also in trouble, for the goods porterage staff at the Liverpool North Docks goods station have handed in their notices to cease work in a week if their demands are not complied with.

According to the *Times*, nominations will soon be invited for candidates for the position of secretary of

the Labour Party. The present secretary, Mr. Ramsay Macdonald, M.P., who has held his position since the formation of the Party eleven years ago, will retire at the end of the year, and his successor will be elected at the annual conference of the Party, next January. There will probably be keen competition for the post, but it is thought that Mr. Arthur Henderson, M.P., will be nominated if he will allow it, in which case he will be almost certain to be elected.

A committee has been appointed by the Home Secretary to inquire into the conditions of employment in the making-up of articles of linen, cotton, and similar fabrics, as well as processes of weaving, &c., in Belfast and other places in the North of Ireland. The hygienic conditions of employment will receive attention, as well as the rates of wages, methods of payment, &c. Sir Ernest F. G. Hatch is chairman of the committee.

In the Scandinavian labour conflicts matters are assuming a serious aspect. The Union of Norwegian Employers held an extraordinary meeting on July 28. Of the 143 delegates summoned to the meeting 129 put in an appearance, and by 128 votes to 1 they passed the following resolution:—"This general meeting decides that the lock-out shall be eventually extended. The central board is authorised to bring about this extension in the manner and to the extent which may be found expedient." In the meantime representatives for the different political parties in the Storthing (the Norwegian Parliament) brought forward a proposal for the appointment of a committee of seven members, which committee is to try and bring about conciliation and arbitration in the matter of the great lock-out. This proposal was carried unanimously, but considerable doubt and uncertainty seems to prevail as to how the committee is to bring about the desired end.

The unconciliatory position taken up, more especially by the men, meets with much severe criticism, and the conflict is in reality a most serious matter for important branches of Norway's industry. The board of the Norwegian Iron and Metal Workmen's Union has placed a sum of 50,000 kr. (2777*l.*) at the disposal of men who are willing to emigrate—rather an undesirable move from the standpoint of national economy.

In Sweden a new proposal was brought forward to the effect that the conflict should terminate on a certain date—for instance, July 31—whilst all points in dispute should be made the object of negotiations, for each district and each branch, under the auspices of the local mediator. Questions not disposed of in this manner should be referred to negotiations between the respective chief organisations under the auspices of the Stockholm mediator. Should these negotiations not lead to any agreement, the points at issue were then to go to arbitration, the nature of which was to be agreed upon. Both sides rejected this proposal, but they stated their willingness to enter upon mutual negotiations, which were duly commenced, and are expected to lead to a compromise.

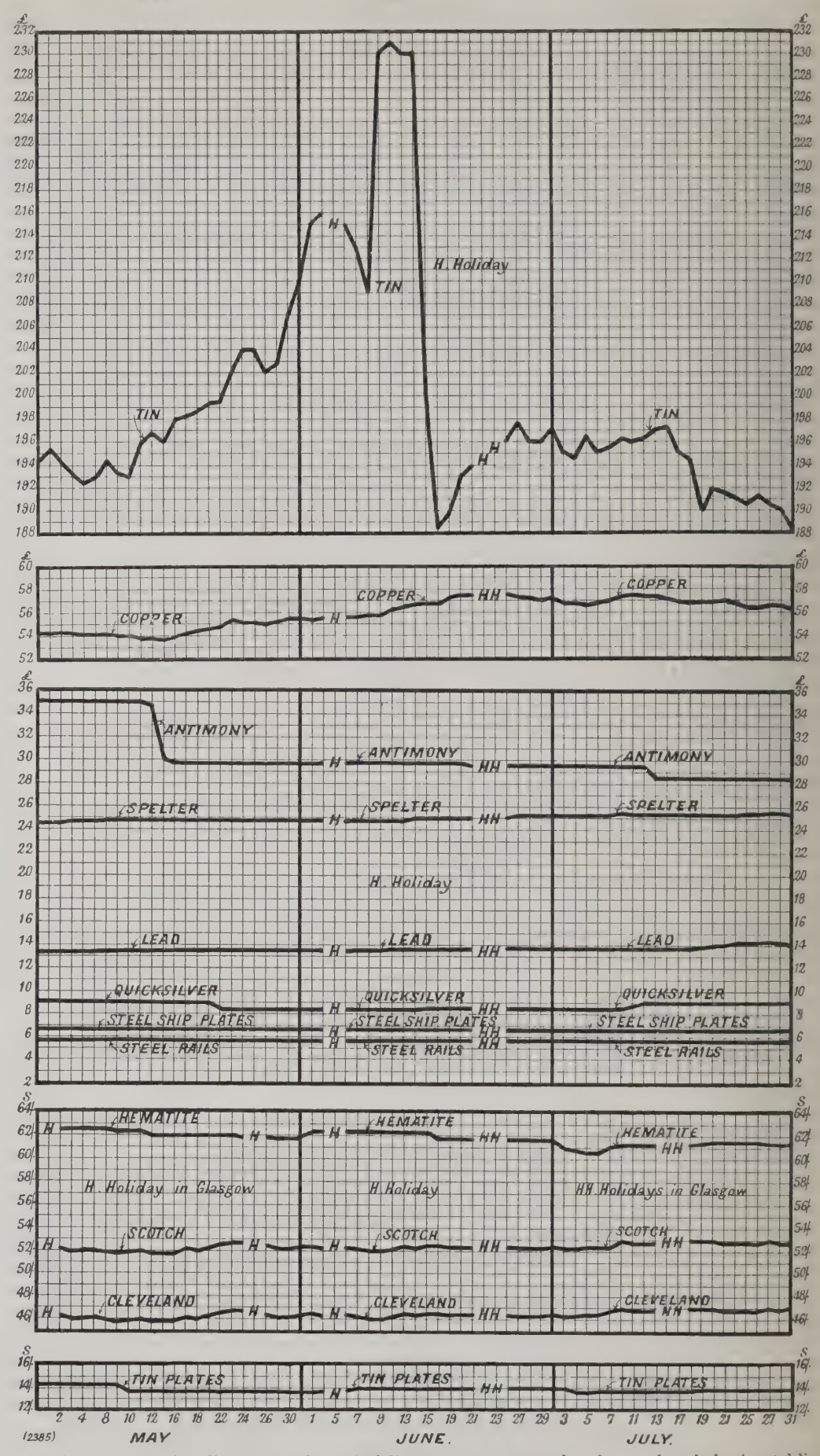
In Denmark the employees of two tramway companies (unless something unforeseen happened, of which we do not know at the time of going to press) were to go out on strike on August 1. The companies say they can go no further than they did in their last offer, and they have a number of new hands ready to take the place of the men on strike.

Anglo-American Telegraph Company.—A proposed agreement of the Anglo-American Telegraph Company, Limited, with the Western Union Telegraph Company of the United States has been settled in principle and in detail, but has not yet been exchanged. The agreement provides for a guarantee by the Western Union of 262,500*l.* per annum, payable quarterly. This is equivalent to 3¾ per cent. per annum upon the ordinary, 6 per cent. per annum upon the preferred ordinary, and 1½ per cent. per annum upon the deferred ordinary stocks of the Anglo-American Company. The negotiations with the Western Union Company have involved the Anglo-American Company in expenses amounting roughly to 3500*l.* The revenue of the Anglo-American Company in the first half of this year showed a decrease of 37,794*l.* as compared with the corresponding six months of 1910.

Road Improvement.—On Monday last a meeting was held at the Midland Hotel, Manchester, with the object of uniting the road-users of Lancashire and Cheshire. Many representatives of societies interested in the improvement of roads attended at the instance of the Roads Association of London, a society that has been in existence for several years, and represents all classes of road-users. It was resolved to establish a centre to cover Lancashire and Cheshire, with head-quarters in Manchester, to be known as the Lancashire and Cheshire Centre of the Roads Improvement Association. The committee of the centre is to be composed of representatives appointed by local road-user bodies, including railway companies and other carriers. Officers will be appointed by delegates at the next meeting, which was fixed for September 26, at 5 p.m., in the Midland Hotel, Manchester. Mr. W. E. Rowcliffe will in the meantime act as secretary.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



(2385)

In the accompanying diagrams each vertical line represents a market day, and each horizontal line represents 1s. in the case of tin-plates, hematite, Scotch and Cleveland iron, and 1*l.* in all other cases. The price of quicksilver is per bottle, the contents of which vary in weight from 70 lb. to 80 lb. The metal prices are per ton. Heavy steel rails are to Middlesbrough quotations. Tin-plates are per box of I.C. cokes.

London University.—In the Faculty of Engineering at University College, an entrance scholarship of the value of 120 guineas, instituted by a Fellow of the College, will be competed for in September next. Candidates must have passed the University of London matriculation or an examination accepted in lieu thereof.—The post-graduate courses for next session will include a course by Mr. F. Bacon on "The Photomicrographic Study of Metals;" a course by Mr. A. R. Low on "The Design and Calculation of Aeroplanes;" a course by Mr. W. J. Goudie on "Steam-Turbines;" and a course by Mr. H. P. Philpot on "Some Modern Methods in the Design of Structures."

THE "COUNTY" PETROL-AIR-GAS PLANT.

CONSTRUCTED BY THE COUNTY LIGHT, LIMITED, ENGINEERS, LONDON.

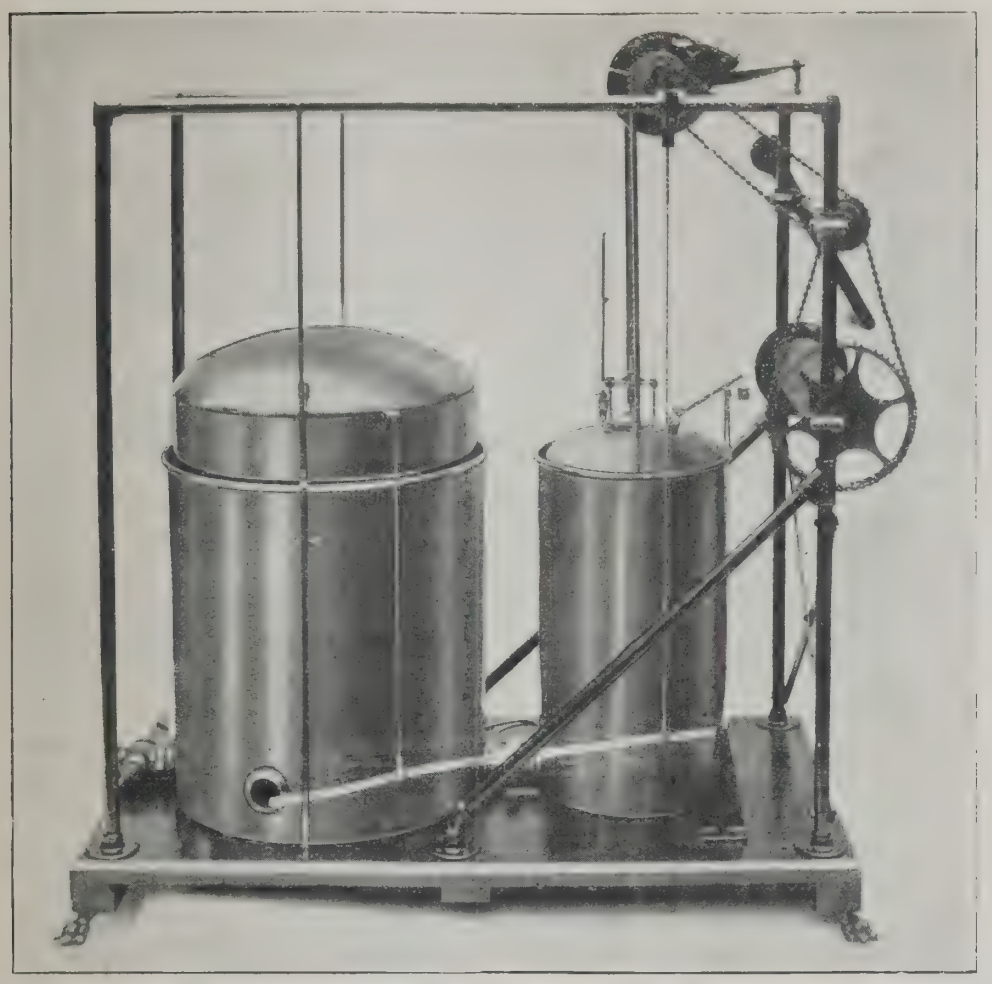
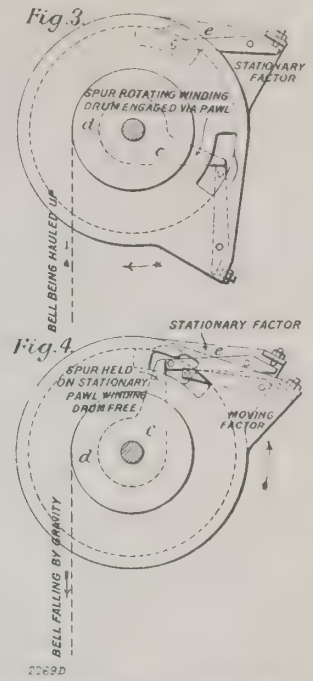


FIG. 1.



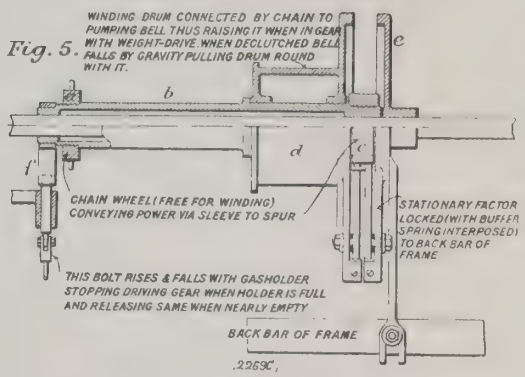
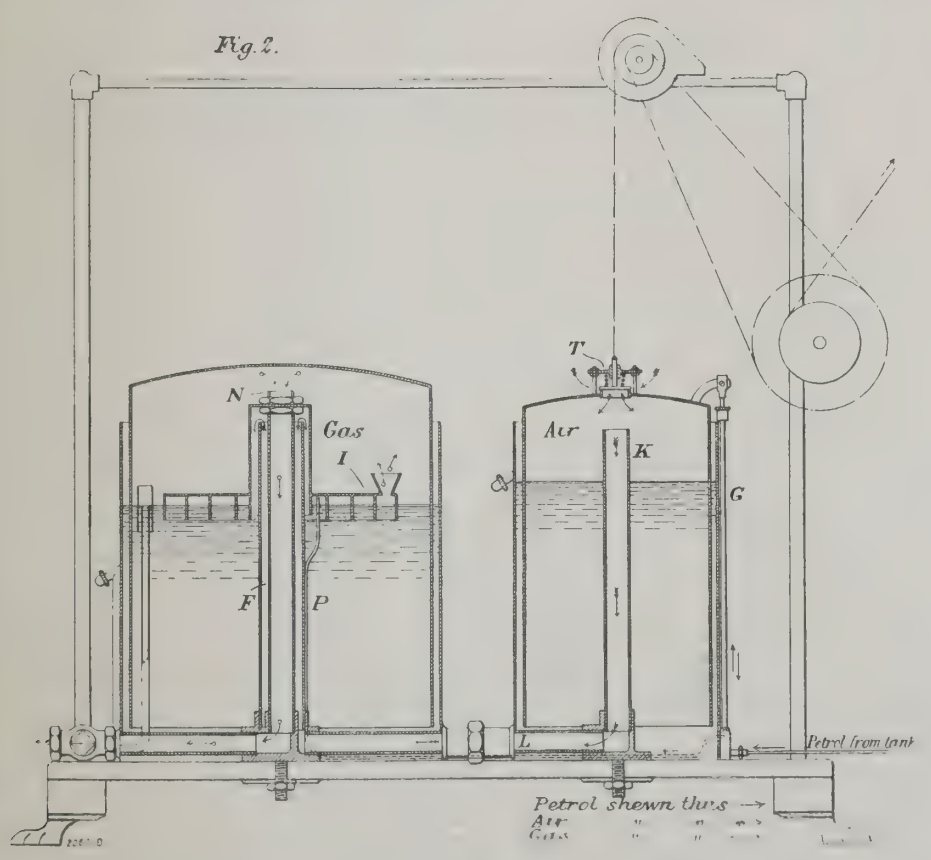


Fig. 5.
WINDING DRUM CONNECTED BY CHAIN TO PUMPING BELL THUS RAISING IT WHEN IN GEAR WITH WEIGHT-DRIVE WHEN DECLUTCHED BELL FALLS BY GRAVITY PULLING DRUM ROUND WITH IT.
CHAIN WHEEL (FREE FOR WINDING) CONVEYING POWER VIA SLEEVE TO SPUR
STATIONARY FACTOR LOCKED (WITH BUFFER SPRING INTERPOSED) TO BACK BAR OF FRAME
THIS BOLT RISES & FALLS WITH GASHOLDER STOPPING DRIVING GEAR WHEN HOLDER IS FULL AND RELEASING SAME WHEN NEARLY EMPTY
BACK BAR OF FRAME
2269C



A PETROL-AIR-GAS plant having many points of interest and novelty is illustrated in Figs. 1 to 5, above. It is known as the "County" light, and is manufactured by the County Light, Limited, whose works are at Guildford-street, York-road, S.E. The plant was designed and has been patented by Mr. E. Scott-Snell, whose paper on "Petrol-Air-Gas," read before the Society of Engineers, was reviewed on page 321 of our last volume. Before dealing with some of the special features embodied in the plant it will be well to refer briefly to its main parts and method of operation. It will be seen from Figs. 1 and 2 that the machine, in essence, consists of two bells working in water seals, and a lifting gear. The first, and smaller, of the bells acts as an air-pump, while the latter constitutes the gas-holder. Situated alongside the smaller bell is a petrol pump G, the barrel of which is fixed to the base-plate of the machine, and the plunger of which is attached to the bell. In the upper part of the bell there is an air-inlet valve T, while inside it there is a fixed vertical pipe K, open at the top and projecting above the water in the bell. This vertical pipe from the air-bell leads through a horizontal header L to an annular passage F surrounding a second vertical pipe N in the gas-bell. This annular passage communicates with a horizontal spiral chamber I, which in Fig. 2 appears in cross-section as a comb. The spiral passage is arranged so that air coming from the air-bell enters at its centre and travels forward in a path of gradually increasing radius, until it emerges into the gas-bell through the small funnel shown. Gas is taken from the larger bell down the centre vertical pipe N, and leaves the machine through the cock shown at the left-hand side. The petrol-pump G, already mentioned, communicates through a small pipe P with the spiral passage I.

In order to make the operation of the plant as clear as possible a series of small arrows has been added to Fig. 2 to indicate the directions of motion of petrol, air, and gas respectively. Plain arrows without barbs refer to petrol, barbed arrows to air, and arrows terminating in a small circle to gas. The method of working is as follows:—Assuming the gas-bell near its lower position, as shown in Fig. 2, and gas still being drawn from it, there comes a point at which, by means of a trip-gear, to be described later, the lifting mechanism causes the air-bell to be drawn up to the top of its stroke. As this takes place the valve T is pulled open and admits air to the bell, while at the same time the petrol-pump G makes an upward stroke and draws in a charge of petrol from the tank which is situated away from the machine, and to which communication is made by the small pipe shown at the right-hand side. When the bell has reached the top of its stroke the lifting mechanism is released and allows the bell to fall, by its own weight, back into the position shown in Fig. 2. On the downward stroke the air-valve T is closed by the spiral spring above it. The falling of the bell drives the charge of air through the pipes K and L, up the annular passage F and round the spiral chamber I, into the gas-holder. At the same time, however, the

descent of the pump plunger drives the charge of petrol through the small pipe P, and delivers it on to the surface of the water in the spiral chamber I. The result of this is that as the air travels through this chamber it takes up the charge of petrol, and emerges from the small funnel as gas. The gas-bell, of course, lifts as the charge enters it, and remains in its upper position until some gas is drawn off through the pipe N, on which it falls gradually until, when the lower position is reached, the trip gear causes the air-bell to be lifted again, and a new charge of gas is supplied to the bell. This cycle is repeated indefinitely, and the frequency of its occurrence depends only on the rate at which gas is being used.

There are one or two features in connection with this gas-making part of the apparatus to which attention should be directed. In the first place, it will be seen that the amount of air and the amount of petrol supplied by a single stroke of the smaller bell are absolutely constant and definite, and that a charge of air always passes over its complementary charge of petrol at the same velocity, so that a gas of uniform mixture is supplied, no matter at what rate the demand may vary. If only sufficient gas is burned to make the small bell operate once a day, its proportions will be the same as the gas that would be supplied if the machine was working up to its full capacity. This follows because a single stroke admits a volume of air fixed by the capacity of the bell, and a volume of petrol fixed by the capacity of the pump. It should further be noted that there is never more liquid petrol in the machine than is represented by the capacity of the small supply-pipes and the capacity of the pump. The actual petrol-tank is placed some distance from the machine and out of doors, so that danger from petrol fumes when filling the tank is entirely avoided. The petrol-tank is always placed below the level of the outlet into the machine, so that there is no danger from flooding. There is no float feed. The singular simplicity of the design is brought out by the fact that, apart from the valves in the pump, there is only one valve in the gas-making part of the apparatus. This is the valve T, which serves to admit air to the small bell while it is lifting. The arrangement of this valve is ingenious. It will be seen from Fig. 2 that the bell is lifted through the medium of the shank of the valve, which is accordingly pulled open by the weight of the bell itself during lifting. When the bell is at rest in its lower position, the valve is kept on its seat by a spiral spring. The weight of the bell is about 10 lb. in the smallest machine, so that the spring can be made to exert a pressure nearly up to this limit. When the valve is closed, however, the spring is acting against a pressure of only a few ounces, so that there is no difficulty in keeping the valve absolutely tight. It is made self-seating to eliminate any trouble due to lack of alignment. A further point which should be noted is that the tube which surrounds the annular passage F, through which the air is delivered to the carburettor, dips into the water of the larger drum, and so forms a perfect non-return valve, preventing any gas getting back into the air-bell.

The lifting mechanism of the apparatus is interesting. It will be gathered from Figs. 1 and 2 that it is driven only by a falling weight, and that no engine is used. The service demanded from the gear is somewhat unusual, and the conditions have been met in a very ingenious way. The falling weight gives a straight and continuous pull on to the wire rope supporting it, and that pull has to be transformed into the reciprocating motion of the bell, which must take place at irregular intervals, depending on the rate at which gas is used. Referring to Figs. 1 and 2, it will be seen that there is a barrel at the right-hand side of the machine. On to this barrel the wire rope carrying the weight is wound, and a handle fitted to the spindle of the barrel serves to wind up the weight. In Fig. 1 there is an intermediate shaft shown, which does not appear in Fig. 2. This shaft, however, is introduced simply to gear down, and does not affect the action of the gear, as shown in Fig. 2.

Referring to Fig. 2, it will be seen that there is a chain drive between the barrel and the upper shaft of the machine, and that a constant pull is exerted on the wire rope wound on the barrel, as shown by the arrow. The arrangement of the lifting-gear proper is shown in Figs. 3 to 5. The chain from the winding-barrel drives on to a chain-wheel *a* shown at the left-hand side of Fig. 5. This chain-wheel has a free-wheel device inside it, and is arranged so that when the weight is being wound up it runs free; when, however, the weight is running down, the wheel is driven by the chain, and in turn drives the sleeve *b*. This sleeve has a spur or catch *c* attached to it at the right-hand end, which can be seen in Figs. 3 to 5, while in addition there is a second barrel *d* which runs loose on the sleeve, and round which the chain connected to the top of the air-bell is wound. At the right-hand side of, and forming part of, this smaller barrel there is a flange which is termed by the makers the "moving factor" of the trip-gear. This flange is faced by another, which is fixed and does not rotate, and is called the "stationary factor." It is shown at *e* in Figs. 3 to 5. Each of these two factors carries a pawl pivoted near one end, and the arrangement is such that one or other of the pawls alternatively engages the spur *c* which is attached to the sleeve *b*. The method of operation will be best understood from Figs. 3 and 4. Fig. 3 shows the state of affairs when the bell is being lifted. In this case the pawl on the moving factor is engaging with the spur, so that the drive from the falling weight is transmitted through the chain-wheel *a*, and the sleeve and spur to the smaller barrel by way of the pawl, and so lifts the bell. A single revolution of the barrel corresponds to one stroke of the bell. When the sleeve has rotated round until the spur is nearly vertical again, the pawl on the moving factor is caught by a projecting pin on the pawl of the stationary factor, and is lifted out of contact with the spur. At the same time the spur comes in contact with the end of the stationary pawl, so that the sleeve is locked and the falling weight is unable to rotate the small barrel any further. The position of the stationary pawl at this point in the cycle is shown in Fig. 4, the moving pawl would not, however, be in the position shown in the figure, but would be resting above the pin which projects from the stationary pawl. When this state has been reached the small barrel is no longer driven and is free to run back due to the weight of the air-bell hanging on it. It accordingly does this and the moving pawl then moves back until it occupies a position below the fixed one, as shown in Fig. 4. At this stage it would appear that the projecting pin on the moving pawl would then lift the fixed pawl, so that the spur would again be released, and coming in contact with the end of the moving pawl would drive it round again, so that the cycle would be repeated. This repetition of the cycle as above actually does take place, but it is delayed for a time, depending on the rate at which gas is being used. This delay is introduced by the sliding bolt shown at the left-hand end of Fig. 5. The bolt is attached by a lever mechanism to the gas-bell, as will be seen in Fig. 1, so that it rises and falls with the bell. In its upper position—*i.e.*, when the bell is full—it fouls a projecting arm *f* which is carried by the left-hand end of the sleeve, so that it prevents the rotation of the gear, and holds it until sufficient gas has been withdrawn from the bell to cause the bolt to release the projecting arm. At this stage the pawl mechanism before described comes into play again, and the air-bell is operated. The actual position of the pawls at the moment the bolt locks the arm *f*, of course, depends on the relative settings of the spur *c* and the arm *f*. Matters are usually arranged in practice so that the spur has just started to drive round the moving factor a second time when the gear is locked by the arm coming in contact with the bolt.

There is an important feature in connection with the pawls which, for the sake of simplification, has not been mentioned in the above paragraph. As the gear is described, it might appear that it would be possible for one pawl to become accidentally freed from the spur *c* without the other being in the correct position to take up the load, with the result that the driving weights might crash to the ground and possibly do serious damage. Such an occurrence as this has, however, been foreseen and prevented in the design, by forming each pawl with a projecting pin, which runs in each case under the overhanging rim of the opposite flange, against which it works. At one part of each flange the circular contour of the rim is departed from sufficiently to allow the pawl, which is being tripped, to rise clear of the spur; at the same time the gap is not large enough to allow both pawls (one being on top of the other) to rise clear. This arrangement, which is clearly shown in Figs. 3 and 4, results in the movement of each pawl being completely constrained, so that it is impossible totally to free the spur at any part of the cycle.

The only other feature of the gear which requires mention is the buffer-arm attached to the stationary factor, and which can be seen in Figs. 1 and 5. The purpose of this is, of course, to prevent a jar when the stationary pawl catches the end of the spur. The arrangement will be quite clear from the figures. There is a further detail in connection with the air-bell which should, however, be dealt with. This is the small cock with a weighted lever handle which can be seen on the top of the bell in Fig. 1. When the bell is lifted, this cock is closed by the weight on its handle; but as the bell reaches its lower position, the handle catches a projection on the fixed outer casing of the bell, so that the cock is opened. The object of this arrangement is to give a slightly greater pull on the chain attached to the bell at the time the pawls trip each other, in order to deal with the increased frictional resistance. By opening the bell to atmosphere, the back pressure, due to forcing the air into the gas-bell, is eliminated, and the whole of the weight of the bell is available for tripping the pawls. This device results in a certain loss of air at the bottom of the stroke, but as the loss is always the same, and the bells are proportioned to allow for it, the composition of the resulting gas is not affected.

It should be said that this machine is designed to give a 6 per cent. mixture of petrol and air, which is of a non-explosive nature, so that the blowing up of the machine is an impossibility. We dealt with this question of mixture percentages in the article, already referred to, on page 321 of our last volume, so that it is not necessary to treat it further in this description. We may say that we have had an opportunity of inspecting various "County" light plants, and that they are constructed in a sound engineering way. The drums and their casings are made of copper, while the internal pipework is of brass, and very substantial. The outer frame is built up of gas-pipe in a neat and effective manner.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a list of colonial and foreign engineering projects, for some of which tenders are asked. Further data concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C. :—

Canada: The Board of Trade are in receipt of copies of Acts of the Quebec Provincial Legislature, assented to on March 24 last, incorporating the following companies:—(1) The Montreal Tramways Company, having a capital of 20,000,000 dols. (about 4,110,000*l.*), with power to acquire the existing electric railway undertakings on the Island of Montreal, and to construct tramways in the city of Montreal (see *Board of Trade Journal* of March 31, 1910, page 611). (2) The Montreal and Northern Colonisation Railway Company, having a capital of 5,000,000 dols. (about 1,030,000*l.*), with power to construct a railway from Montreal to James Bay. (3) The Montreal and South-Western Railway and Power Company, having a capital of 2,000,000 dols. (about 411,000*l.*), with power to construct a railway from Adirondac Junction to the United States boundary on Lake St. Francis, and another line from Adirondac Junction to Dundee. (4) The Richmond, Magog, and Stanstead Railway Company, having a capital of 1,000,000 dols. (about 205,000*l.*), with power to construct a railway from Richmond to Stanstead Plain. (5) The Roberval and Saguenay Railway Company, having a capital of 2,000,000 dols. (about 411,000*l.*), with power to construct a railway from Roberval to Jonquières, with a branch to St. Bruno.

Ceylon: The Board of Trade Correspondent at Colombo reports that the final estimate for the extension of the Colombo-Negombo Railway northwards along the west coast of Ceylon to Chilaw has now been approved. The length of the extension is about 27 miles, and the cost is placed at 3,932,053 rupees (about 262,000*l.*), of which 1,852,391 rupees (about 123,500*l.*) is appropriated for expenditure during the current financial year.

Russia: H.M. Embassy at St. Petersburg report the publication of the following laws:—(1) A law authorising the expenditure by the Russian State of a sum not exceeding 750,000 roubles (about 79,300*l.*) on the construction of a commercial port at Streliets Bay for the town of Sevastopol, and the survey of a branch line to connect the proposed port with existing railways. A sum of 300,000 roubles (about 31,750*l.*) is to be expended on the work during 1911. The final details as to the constructional cost of the branch line are to be presented to the Legislative Chambers by January 1 to 14, 1912. (2) A law authorising the expenditure by the State of a sum not exceeding 2,240,000 roubles (about 237,000*l.*) on the improvement of the port of Reval (see ENGINEERING, page 768, vol. xc.) by the reconstruction of the western mole, the deepening to 30 ft. of the commercial harbour, and the construction in this harbour of deep-water wharves. A sum of 700,000 roubles (about 74,000*l.*) is authorised to be expended on this work during 1911. His Majesty's Commercial Attaché for Russia (Mr. H. Cooke) reports that, according to the *Novoe Vremia*, of St. Petersburg, the newly-formed Russian shipbuilding company, with a capital of 20,000,000 roubles (about 2,111,000*l.*), the statutes of which have lately been submitted to the Russian Government for authorisation, is a sort of combine of six large Russian mechanical, metallurgical, and shipbuilding companies. These are stated to be able to supply up to 24,000 hands skilled in making mechanism and parts, such as turbines, boilers, Diesels, armour-plate, &c., for both mercantile and naval ship construction. Each of the separate enterprises concerned will work, it is stated, in its own specialities for the new company, delivering all necessary material in the rough for final finish at the large shipbuilding works on the coast of the Black Sea, formerly belonging to the Nikolaieff Works Company, which will be carried on by the new company. His Majesty's Commercial Attaché for Russia also reports that the municipal authorities of Warsaw have been authorised to contract a bond loan of 7,500,000 roubles (about 792,000*l.*) nominal for the completion of a viaduct to the Warsaw town bridge, and for continuing the water supply and canalisation works.

Servia: The *Oesterreichischer Zentral-Anzeiger* (Vienna) of July 23 notifies that tenders will be opened on August 11, at the offices of the Gemeinde Belgrad (Kanalisationsabteilung), Belgrade, for the carrying out of the eighth section of the Belgrade city drainage works. A deposit of 100,000 dinar (4000*l.*) will be required to qualify tenders. Plans and specifications governing the contract may be purchased at the above-mentioned address for 60 dinar (48s.), and the plans relating to the whole scheme for 100 dinar (4*l.*).

Italy: The *Gazzetta Ufficiale* of July 19 notifies that tenders will be opened on August 7, at the offices of the Direzione Autonoma del Genio Militare per la Regia Marina, Taranto, for the construction of submarine dams in the Mar Grande at Taranto. The upset price is put at 3,000,000 lire (120,000*l.*). Although the foregoing con-

tract will doubtless be awarded to an Italian firm, nevertheless the carrying out of the work may involve the purchase of some materials out of Italy.

Spain: The *Gaceta Oficial* of July 20 contains a notice, issued by the Ministry of Fomento, granting to the Sociedad Anónima Minas de Cala a concession for the construction of a railway from the station at Minas del Castillo de las Guardas to Minas Peña del Hierro. The rolling-stock required to open the line for traffic will be as follows:—Three locomotives, four passenger-coaches, two brake-vans, and 116 goods and coal-wagons.

Netherlands: The *Nederlandsche Staatscourant* of July 22 contains a notice, issued by the Ministerie van Waterstaat, granting to the Maatschappij voor Luchtvaart, domiciled at the Hague, a concession for the construction and working of a railway from Doldersche Weg station (on the Netherlands Central Railway) to Soesterberg.

France: The *Journal Officiel* (Paris) of July 21 publishes a law authorising the Paris city authorities to contract a loan of 240,000,000 francs (9,600,000*l.*) for the purpose of completing the Paris Metropolitan Railway. The *Diario Oficial* of June 1 contains a decree, issued by the Ministry of Industry and Public Works, authorising Don Enrique Tagle Rodriguez to draw up plans in connection with the building of a railway from Peralillo to Parronal. Twenty-two months are allowed for the surveying operations.

Uruguay: H.M. Minister at Montevideo reports that tenders are invited by the Departamento Nacional de Ingenieros for the construction of a bridge. 585 metres in length, across the River Santa Lucia. Tenders will be received at the Secretaria del Departamento Nacional de Ingenieros, Montevideo, up to 3 p.m., on December 19. A deposit of 5000 pesos (about 1064*l.*) will be required with each tender. The sum of 600,000 pesos (about 127,660*l.*) has been apportioned for the carrying out of the work. Tenders and estimates are to include original designs for the bridge to carry railway track, road, and footway. A large amount of stone and earthwork will be necessary in the construction, as the approaches to the bridge are the worn-away banks of the river. British manufacturers who propose to tender would do well, says H.M. Minister, to get immediately into communication with local contractors who could supply them with estimates for the masonry and earthworks, as individual tenders for the superstructure will not be accepted.

Panama.—With reference to the notice on page 422 of the *Board of Trade Journal* of May 25 last, relative to the grant to Mr. August Dziuk of a concession for a railway from the mouth of the Pinas River (Darien district), on the Pacific, to a point near El Real de Santa Maria, H.M. Minister at Panama now reports that the concessionnaire has deposited 10,000 balboas (about 2083*l.*) with the Government of Panama, and has been granted an extension of time, until January next, in which to submit the plans for the railway.

Brazil.—The *Diario Official* of July 2 publishes decree No. 8805, approving alterations in the plans for the construction of a section, 15 miles long, of the Goyaz Railway, the cost of which is estimated at 3,563,000 milreis (about 237,000*l.*).

United States Steel Corporation.—The unexecuted orders of the United States Steel Corporation represented an aggregate at the close of June of 3,361,058 tons. The corresponding aggregate at the close of June, 1910, was 4,257,794 tons; at the close of June, 1909, 4,057,939 tons; at the close of June, 1908, 3,313,876 tons; at the close of June, 1907, 7,603,878 tons; at the close of June, 1906, 6,809,850 tons; at the close of June, 1905, 4,829,655 tons; at the close of June, 1904, 4,136,961 tons; and at the close of June, 1903, 4,666,578 tons.

The Rödby-Femern Route.—This new proposed connection between Denmark and Germany is attracting increased attention not only in Denmark and Germany, but also in Norway and in certain districts of Sweden, and it has undoubtedly many advantages, being shorter and cheaper than the Trelleborg-Sassnitz route. The complete scheme includes, as far as the Danish side is concerned, a new direct railway—Copenhagen-Köge, a new line Rödby-Saxköbing-Orehoved, in the islands of Lolland and Falster, and a bridge across the Storström. When the route is completed the journey from Copenhagen to Germany can be reduced from 9 hours on the Gjedser-Warnemünde route and 10 hours on the Korsör-Kiel route to 5½ hours, and the fare from rather more than 20 kr. to 16 kr. The new route will entail a very material outlay, but the different works can be done by instalments without interfering with the existing traffic.

The Importation of Pig Iron into Russia.—The Russian regulations regarding the importation of pig iron, free of duty, appear to have been misunderstood, being taken to mean a general exemption from duty on pig iron, but such is not the case. The fact is that the reduction in the duty has to be specially fixed in each case, and the importer must deposit a sum with the Customs House authorities which represents the full amount of duty according to the tariff. The importer, further, has to produce a certificate from some iron works that the iron has been received by them, and it then rests with the Customs House people to refund the amount with which the duty is reduced. The object of this law is to regulate the price on pig in the different parts of the empire, the price in Harkow serving as a kind of guide, the prices in various parts of the country differing from the Harkow price according to distance and cost of transport. Thus it is generally 18 kopeks higher in St. Petersburg and 14 kopeks higher in Moscow. What may be looked upon as a kind of standard price is 55 to 57 kopeks per pood at Harkow.

FRANCIS AND TANGENTIAL TURBINES.

*Results of Experiments with Francis Turbines and Tangential (Pelton) Turbines.**

By Professor Dr. Franz Prásil, of Zurich.

[*Translated from the German.*]

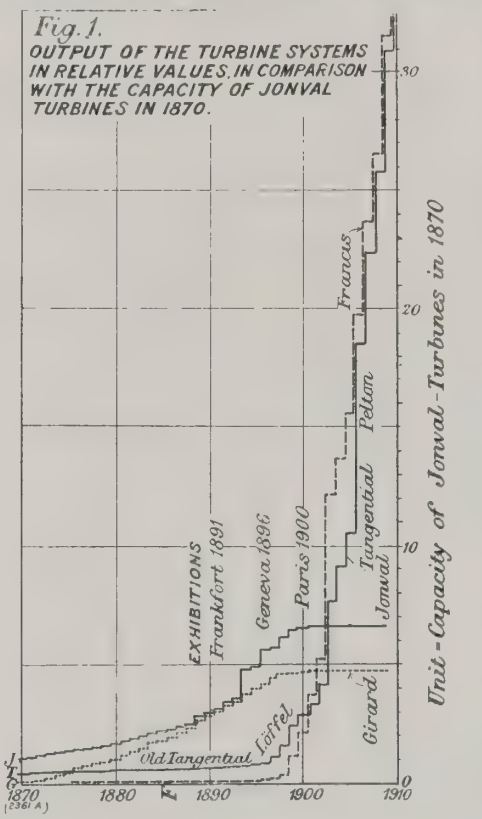
At the Paris Exhibition in 1900 the direction in which the development of the design of modern water-turbines had progressed in the last decade of the preceding century was clearly set forth: the old systems of the Jonval and the Girard turbine had almost disappeared; the Francis turbine and the Pelton wheel in the most varied forms of construction had stepped into their place, and the variety of these forms proved the importance that was attributed to these types.

At the Exhibition it was, indeed, possible to recognise the great adaptability of the two types to local requirements, as well as to the demands of the most varied industries. As, however, the exhibits were not subject to test, a quantitative judgment of the merit of the designs was not possible.

The increase in the manufacture of Francis turbines and of Pelton wheels, in comparison with that of the old types, is shown in Fig. 1, which was prepared for the Swiss catalogue of the International Exhibition at Turin, 1911. Since 1900 both types have developed in the direction of increase of horse-power per unit, so that their sizes have now reached as high as 16,000 horse-power per wheel. The Francis turbine is applied with success to falls of from 1 m. to 150 m. (3.3 ft. to 492 ft.); the Pelton wheel to falls

Fig. 1.

OUTPUT OF THE TURBINE SYSTEMS IN RELATIVE VALUES, IN COMPARISON WITH THE CAPACITY OF JONVAL TURBINES IN 1870.



of from 40 m. to 950 m. (131 ft. to 3116 ft.). In this are to be noted not only a steady improvement in the details of construction of the turbine, but also in the efficiency of the automatic governing and the safety mechanism. Particularly for modern plants with long supply-pipes and conduits; with their severe specifications of high-standard reliability in the safety apparatus, these requirements made large claims upon the skill and ability of engineers. The result has been, however, a large measure of success in the production of successful designs.

The members of the Institution of Mechanical Engineers will have an opportunity of inspecting various hydro-electric plants in Switzerland, and of having the details of their construction in this special respect explained either by the engineers in charge or by representatives of the turbine-makers. To the author there falls the agreeable task of presenting some comparative tables of the results of tests which have been entrusted to him to carry out. He has endeavoured in the tables and diagrams to follow such order and sequence as will make clear the influence of various arrangements of detail and proportions of dimensions. The experiments relate to installations which have been carried out at four works. The agreement of the results demonstrate that a condition of permanence in the development of the design of turbines has been reached, and that we are now near the limit of attainable dynamic efficiency and perfection in governing. For the sake of concentrating attention upon the matter of the analysis, the naming of particular firms has been avoided.

As an introduction to the description of the test results, some remarks are needed upon the methods of measurement employed.

A.—Measurement of Fall.

(*a*) *Direct Measurement.*—In the case of low-pressure turbines in open wheel-pits, the levels of the water in the head and tail-races were read off directly by point-gauges, their difference giving the working fall. The gauge-points must be fixed as near the turbine as possible. Each of the two graduated staves slides in a vertical guide forming part of a securely fixed wooden frame, and the metal points moving with them are brought down until they just touch the water surfaces. The zeros of the two scales are obtained by applying the points to the two water surfaces when they are still with a very small water-flow, the level-difference between these having been accurately determined by levelling instruments.

(*b*) *Indirect Measurements.*—If the water surfaces be inaccessible, a piezometer can often be applied for low-pressure turbines, on which readings similar to those above mentioned under (*a*) can be taken. With high-pressure turbines having long supply-piping and suction-tube, the pressure-fall, or fall from supply to turbine-level, can be measured by pressure-gauge, and the discharge or suction fall either direct as above or by help of a vacuum-gauge. In the case of the Pelton wheel only the pressure-fall comes into question. The positions at which the pressure and vacuum-gauges should be attached to the supply and discharge-pipes are to be as near the turbines as possible, and where as uniform as possible a pressure distribution reigns over the cross-section of the water-flow. Readings from pressure and vacuum-gauges attached at or close to pipe-bends or to the spiral casings of closed turbines are inadmissible for this purpose of determining the fall.

B.—Water Measurement.

In the tests now presented the water consumption was measured sometimes by weir and sometimes by rotating current-meter.

(*a*) *Weir Measurements.*—These were in all cases carried out with sharp-edged weirs specially built for the tests, in some cases arranged with side contraction, and in other cases without side contraction. The readings were taken with precision needle-gauges with verniers reading to $\frac{1}{10}$ mm. ($\frac{1}{254}$ in.). The calculations of the quantities were made either by the Frese formula, the derivation of which is fully described in the *Journal of the Vereins Deutscher Ingenieure* of 1890, or else directly from calibration curves obtained from rotating current-meters by the Hydrometric Bureau of the Swiss Hydrographic Department.

From the following table may be seen to what percentage the formula-calculated and the calibration-curve results agree:—

Fall over Weir.		Water Flow, Litres per Second.				Difference.	
		By the Frese Formula.		By the Calibration Curves.		Litres per Second.	Per Cent.
mm.	in.	litres.	gal.	litres.	gal.	gal.	
93.8	3.693	65	14.3	67	14.7	0.4	3.1
98.1	3.862	70	15.4	72	15.8	0.4	2.9
104.6	4.118	77	16.9	79	17.4	0.4	2.6
119.4	4.701	93	20.5	95	20.9	0.4	1.1
132.5	5.217	109	24.0	111	24.4	0.4	0.9
170.6	6.717	161	35.4	162	35.6	0.2	0.6
178.9	7.043	173	38.1	174	38.3	0.2	0.6
216.2	8.512	232	51.0	232	51.0	0.0	0.0
247.4	9.740	285	62.7	287	63.1	0.4	0.7
273.6	10.772	334	73.5	336	73.9	0.4	0.3
295.0	11.615	376	82.7	379	83.4	0.7	0.8

The weir investigated had a breadth of 1.19 m. (46½ in.), and had no side-contraction. One notes that the absolute difference is nearly constant, and is always of the same sign, so that one may conclude that either the formula or the current-meter had a constant error. For water consumptions over 100 litres (22 gallons) per second the percentage difference remains under 1 per cent.

(*b*) *Rotating Current-Meter Measurements.*—These were carried out partly by Herr Dr. Epper-Bern, Director of the Swiss Hydrographic Department, and partly by the present author or by other experimenters. The instruments used came from the workshops of Ott-Kempten, in Bavaria, and were from time to time calibrated in the Calibration Laboratory of the Confederate Hydrometric Bureau. The technical mode of using was in all cases that prescribed by the Confederate Hydrometric Bureau.

From one series of tests, in which simultaneous measurements were taken at two cross-sections, the following examples of the degree of accuracy of this mode of measurement are obtained:—

Water Consumption. Cubic Metres per Second Measured at Section.		Difference.	
I.	II.	Cubic Metres per Second.	Per Cent.
4.790	4.615	+ 0.175	+ 3.6
4.630	4.650	− 0.020	− 0.5
4.040	3.960	+ 0.080	+ 1.7
3.610	3.680	− 0.070	− 1.9
2.600	2.794	− 0.194	− 7.5

Section I. was in the smooth cement-finished part of the underground tunnel. Section II. was in the rough stone part of the discharge channel into the river (Wildbach). With such difference of kind of section, the difference between the two sets of measurements are to be regarded as small, except in the case of the last.

Another example of the comparison of simultaneous

* Paper read before the Institution of Mechanical Engineers, at the Zurich Meeting, July 26.

measurements is to be found in an article by the author, entitled "Comparative Investigations on Reaction Low-Pressure Turbines," in the Swiss *Bauzeitung*, 1905.

C.—Measurement of Effective Horse-Power.

In four tests a Prony brake was used and, throughout, minute intervals, and often by direct counting with acoustic signals of time intervals.

E.—Registration of Speed Variation with Change of Load.

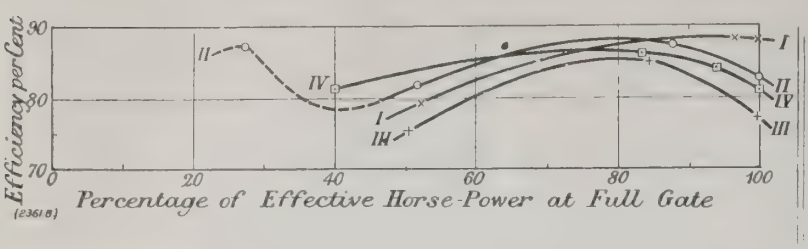
For this there was used the Horn tachograph.

H.—Results with Francis Turbines.

(*a*) *Open Arrangement.* Tables I., III., IV. (on this page). From Table I. it is seen that :—

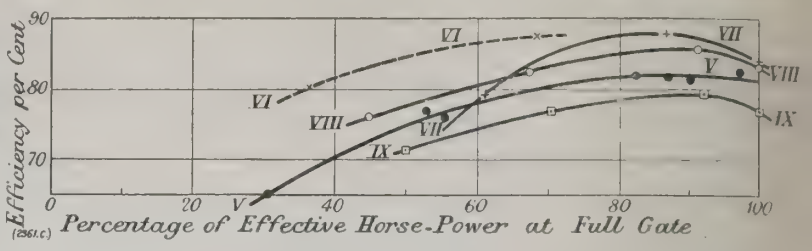
1. In turbine I. the maximum efficiency is reached at nearly full load ; but in the other turbines it is found at between 70 and 80 per cent. of full load.

TABLE I.—Efficiency of Francis Turbines in Open Wheel-Pits.



No.	System.	Fall in Metres.	Revolutions per Minute.	Effective H.-P. at Full Gate.	a = Per Cent. of Full Load. b = Per Cent. Efficiency of the Turbine.								Measurement of Horse-Power.
					a.	b.	a.	b.	a.	b.	a.	b.	
I.	Single vertical axis	4.6	100	158.3	100.0	88.1	96.8	88.6	52.7	79.4	..	..	Mechanically by Prony Brake.
II.	Single vertical axis	4.4	100	260.0	100.0	82.5	88.0	87.8	51.9	81.9	32.7	87.2	
III.	Single horizontal axis	7.0	128	434.5	100.0	76.9	84.0	85.1	50.8	75.4	..	..	
IV.	Double horizontal axis	10.4	160	1250.0	100.0	81.3	93.8	84.2	78.5	86.3	40.3	81.5	Electrically.

TABLE II.—Efficiency of Francis Turbines in Spiral Wheel-Cases.

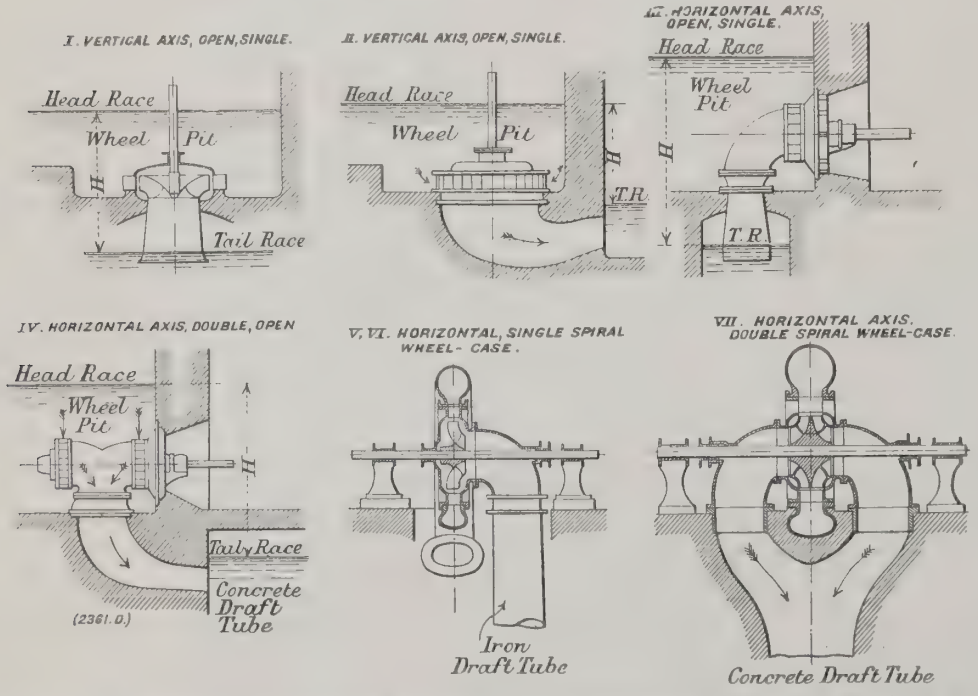


No.	System.	Fall in Metres.	Revolutions per Minute.	Effective H.-P. at Full Gate.	a = Per Cent. of Full Load. b = Per Cent. Efficiency of the Turbine.								Measurement of Horse-Power.
					a.	b.	a.	b.	a.	b.	a.	b.	
V.	Single horizontal axis	42.0	411	550	97.0	82.3	82.8	81.7	56.0	76.0	30.9	65.3	Electrically
VI.	Ditto.	64.0	400	4000	..	..	..	..	68.7	87.4	36.6	80.5	
VII.	Double horizontal axis	60.0	496	2696	100.0	78.6	86.6	87.6	56.0	79.4	..	..	
VIII.	Ditto.	87.0	490	2620	100.0	83.5	91.5	85.6	67.5	82.2	45.3	76.3	
IX.	Ditto.	147.0	601	3458	100.0	77.2	92.0	79.6	70.5	77.2	50.0	71.6	

TABLE III.—DIMENSIONS AND TEST RESULTS OF FRANCIS TURBINES.

No. of Turbine.	System.		Work Done.	DETAILS OF DESIGN. Base Data. Fall in Metres.	Water Flow. Cubic Metres per Second.	Revolutions per Minute.	Full Load. H.-P.	Runner Dimensions. Inlet. Dia. D. Metres.	Breadth B. Metres.	Number of Blades.	B/D.	Peripheral Speed, Velocity Due to Revolutions $u = D\pi n/60$.	Velocity Due to Fall $C = \sqrt{2gH}$.	Velocity Coefficient $K_u = u/C$.	TEST RESULTS. Fall in Metres.	Revolutions per Minute.	Full Load H.-P.	Percentage of Full Gate Effective H.-P. 100	90	80	70	60	50	40	Method. Water Measurement.	Measurement of Effective H.-P.
																		Percentage Efficiency.								
I.	I. & II. vertical axis ; III. & IV. horizontal axis	Single	Spinning Mill	4.6	3.000	100	142	1.25	0.300	17	1 : 4.17	6.30	9.5	0.67	4.6	100	158.3	88.1	88.5	87.5	85.5	82.2	78.0	..	Rotating Current Meter.	Prony brake
II.		Open		4.4	4.940	100	220	1.30	0.435	17	1 : 2.95	6.82	9.3	0.72	4.4	100	260	82.5	87.0	87.2	87.0	84.0	80.5	..		
III.		Single		6.6	5.400	127	372	1.30	0.495	16	1 : 2.62	8.70	11.35	0.78	7.0	128	434.5	76.9	83.5	85.0	83.5	79.7	74.5	..		
IV.		Double		10.4	11.26	172	1250	1.30	2×0.325	15	1 : 4.0	11.7	14.2	0.81	10.4	160	1250	81.3	85.5	86.5	86.5	85.0	83.5	..		
V.				42.6	1.300	428	550	0.80	0.100	15	1 : 8.0	17.8	28.5	0.615	42.0	411	550	81.5	82.0	81.5	80.0	78.0	75.0	70.5	Weir	Electrical at Generator
VI.	Horizontal axis, spiral wheel-case	Single	Electrical central station	62.0	5.000	400	3200	1.10	0.220	17	1 : 5.0	23.1	34.8	0.67	64.0	400	4000	..	..	..	87.5	86.5	84.5	81.5	Rotating Current Meter	
VII.				60.0	4.000	500	2500	0.90	2×0.0975	..	1 : 9.3	23.4	34.2	0.68	60.0	496	2696	78.6	87.5	87.5	84.5	78.0	..	..		
VIII.		Double		87.0	2.875	500	2500	0.95	2×0.110	19	1 : 8.6	25.0	41.2	0.60	87.0	490	2620	83.5	85.5	84.5	83.0	80.5	77.7	..	Weir	
IX.				143.0	2.000	600	3000	1.10	2×0.0400	..	1 : 27.5	34.2	52.8	0.65	147.0	601	3458	77.2	79.5	78.5	77.0	74.5	71.8	..	,,	

TABLE IV.—Sketch Classification of Francis Turbines I. to IX.



with wooden lining to one-half of the peripheral band, with brake-cheeks round the other half, with worm tightening-gear, and with external force applied so as to cause compressive stress in the band.

In the other tests the effective horse-power of the turbine was transmitted to the generator (dynamo), and there measured electrically, due allowance being made for the previously measured mechanical and electrical efficiency of the generator. The electrical measurements were carried out by special electrical experts by help of suitable arrangements and instruments.

D.—Measurements of Revolutions per Minute.

This was effected by mechanical hand-tachometer with

F. Measurement of Pressure Variation with Change of Load.

This was obtained by means of the instruments above mentioned for measurement of the falls.

Throughout the course of each test the observations were made as far as possible simultaneously, but at the same time independently.

G.—The Results of the Tests.

The results of the tests I. to IX., inclusive of Francis turbines, are collected in Diagrams I. to V. inclusive ; those of the tests Nos. X. to XIII. inclusive in Diagrams VI. and VII., accompanying the tables on this and the opposite pages.

2. All four turbines have an efficiency of over 85 per cent. at about 80 per cent. of full load.

3. Turbine IV. maintains greater uniformity of efficiency than the other turbines.

4. The simple turbines II. and III. have similar efficiency curves, that of III. showing throughout smaller efficiency than II.

5. Turbine II. has a second maximum efficiency at about 30 per cent. of full load.

On Table III. (above) the data of the designs are given specifying the size of turbine and its rotary speed—that is, the values on which are based the calculations of the fall, the water consumption, the revolutions per minute, and the desired efficiency ; also the wheel diameter D, the inlet breadth of wheel B, the ratio B/D, the peripheral speed $u = \pi Dn\ 60$, the theoretical speed $c = \sqrt{2gH}$, corresponding to the fall H, and finally the ratio $K_u = u/c$, which is the characteristic speed-coefficient of the turbine. Along the heading of Table III. are also given the efficiencies taken from Tables I. and II.

It is seen from this table that the wheel diameters of Turbines I. to IV. are nearly equal ; but the ratios of width to diameter B/D and also the speed-coefficients K_u are nevertheless different. In respect of this last coefficient, turbine I. is to be classed as "normal dimensioned normal speed ;" turbine IV. as "normal dimensioned high speed ;" turbine II. as "extra width normal speed ;" and turbine II as "extra width high speed."

In consequence of the equality of the diameters in turbines I. to IV., the results from them are directly comparable, and the comparison yields the following important conclusions :—

In open low-pressure Francis turbines, it is possible, even with extra width high-speed machines, to reach a maximum effective efficiency of 85 per cent. with an opening of the Fink rotary regulation gates corresponding to about 80 per cent. of full load ; while with normal speed and divided inlet passages with axially moved gates still higher maximum efficiencies up to 88 per cent. are attainable.

The appearance of a second efficiency-maximum in turbine II. appears at first difficult of explanation ; the cause, however, is masked by influences arising in connection with no-load running with varied gate-opening, and the phenomenon proves that in such wheels different stream-line forms may occur—a phenomenon which is also observed in centrifugal pumps.

In the upper row of sections on Table IV. (on the opposite page), the classes of the designs of turbines I. to IV. are shown.

forms are not presented, it is not possible to form a definite judgment upon this point.

In Table V. (below) are given the results of the tests of the governing of Turbines VII. and IX. Here it is to be noted that, in the Servo-motors of the automatic-speed and pressure-regulator, oil is used as the Servo-motor fluid, and each of the two governing plants is worked from an oil-pressure central station, in which the oil can be brought to a pressure of between 20 and 25 atmospheres. Alongside the diagrams of Table V. are placed those leading dimensions which are necessary for a criticism of the general effectiveness of the regulation, as, for example, the fly-wheel mass, the size and length of the supply-pipe, &c. It must further be pointed out that the Servo-motor of the automatic pressure-regulator of Turbine VII. is fitted with a governing gear, which is brought into action under the influence of a rise of pressure in the supply-pipe, caused by a sudden decrease of load ; while in Turbine IX. a similar governing mechanism is brought into action by a part of the Servo-motor moved by the automatic speed-regulator, and is

3. The efficiency is lower than 80 per cent. only under loads which are below 25 to 30 per cent. of the full load.

4. These definite results hold within wide limits of head and load (90 m. to 850 m. head, and 300 to 6050 horse-power) ; and it is to be noted that confirmatory results are obtained also from tests of other turbines of the same kind.

Regarding the results of the tests of the governing of Turbines XII. and XIII., set out upon Table VII., it may be noted that both turbines, as also Turbines X. and XI., are fitted with the well-known nozzles with pointed governing needles. These needle nozzles, due to Abner Doble, regulate the supply of water according to the momentary demand for power following small and gradual changes of load, by the movement of the needle which takes place under the influence of an automatic speed-regulator.

Following sudden changes in the load, very important variations of pressure arise in the long supply-pipes which accompany this design of turbine. In order to avoid these, turbine XII. is furnished with an automatic pressure-regulator with a Servo-motor similar to that of turbine IX., whose regulating mechanism is put into activity by the Servo-motor of this speed-regulator.

In Turbine XIII., the automatic pressure-regulation arising through sudden loading takes place in the following manner :—In the first instants following the decrease of load, the jet issuing from the nozzle is deflected, by the interposition of a shutter inserted between the nozzle and the wheel under the influence of an appropriate automatic regulating mechanism, for the purpose of hindering the access of the water to the wheel ; through this the supply of hydraulic energy to the wheel is diminished, while the flow of water from the supply pipe is still not decreased ; no sudden rise of pressure in the pipes can therefore take place. In the succeeding time-period the shutter is gradually withdrawn again, and the needle displaced in the nozzle as necessary for the re-establishment of normal steady condition. The insertion of the needle thus follows so slowly that no important increase of pressure can arise.

Also on Table VII. there are stated the important leading dimension data alongside of the diagrams in the same manner as on Table V. The influence of the very large fly-wheel mass in Turbine XII. makes itself apparent here also, along with the smaller variation of speed. One recognises, however, through comparison of the two diagrams upon Table VII. and Table V. that the absence of the large fly-wheel mass in Turbine XIII. is compensated for by the quickness of the governing action operated by the deflection of the jet.

It should be further mentioned that in all the turbines mentioned here the test results obtained give better values than those guaranteed by the firms who supplied the plant. The results here set forth confirm satisfactorily the proposition stated at the beginning of this paper—that the design of turbines has almost reached the limit of attainable perfection.

In regard to efficiency there is not to be expected much further advance in the future ; the problem of governing can still be considered as not yet completely solved, since there still appears in view a series of applications which will influence the further development of this problem. The electrification of railways may be mentioned as one example. But one may well express the hope, considering the experience of the results already reached, that with the help of the material and intellectual instruments now available, technical science will be able to find a satisfactory solution of these future, and perhaps often much more difficult, problems.

TABLE V.—RESULTS OF TESTS OF GOVERNING OF TURBINES VII. AND IX.

The governing of both turbines is by oil-pressure Servo-motor (relay motor).

The diagrams show the maximum change of speed with sudden charge or discharge. Observations to the left of each vertical line represent charge in kilowatts ; those to the right, discharge in kilowatts.

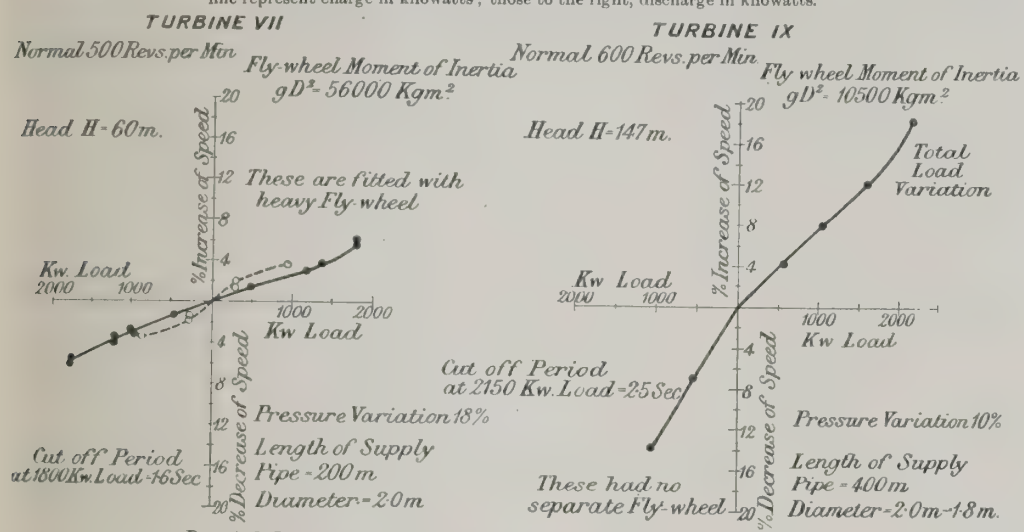
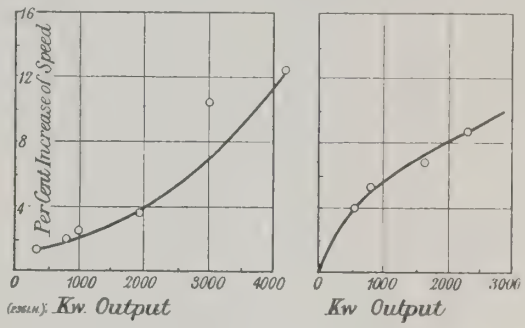

TURBINE VII
Normal 500 Revs. per Min
Fly-wheel Moment of Inertia
gD² = 56000 Kgm²
Head H = 60 m.
These are fitted with heavy Fly-wheel
% Increase of Speed
% Decrease of Speed
Kw Load
Pressure Variation 18%
Length of Supply Pipe = 200 m
Diameter = 2·0 m
Cut off Period at 1800 Kw Load = 16 Sec
TURBINE IX
Normal 600 Revs. per Min
Fly wheel Moment of Inertia
gD² = 10500 Kgm²
Head H = 147 m.
Total Load Variation
Cut off Period at 2150 Kw Load = 25 Sec
Pressure Variation 10%
Length of Supply Pipe = 400 m
Diameter = 2·0 m - 1·8 m.
These had no separate Fly-wheel
Partial Load Variation
Total " "

TABLE VII.—*Results of Tests of Governing of Turbines XII. and XIII.*

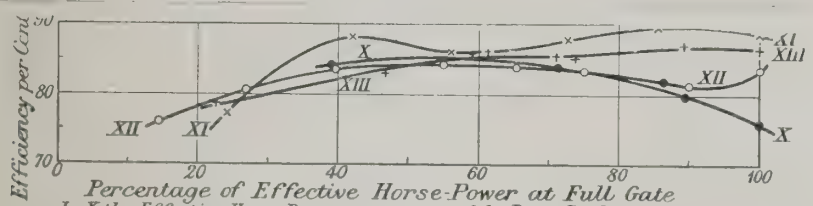
Both turbines are governed by oil-pressure Servo-motor.

Turbine XII.	*Turbine XIII.*
The turbine is fitted with automatic pressure regulation.	The turbine is fitted with jet cut-off gear.
Normal 375 revs. per minute.	Normal 630 revs. per minute.
Head H = 350 m.	Head H = 350 m.
Fly-wheel moment of inertia $g D^2$ = 55,000 sq. kg.-m.	Fly-wheel moment of inertia $g D^2$ = 13,000 sq. kg.-m.
Max. pressure variation, 1.8 per cent.	Max. pressure variation, 3.9 per cent.
Length of supply-pipe = 925 m.	Length of supply pipe = 2130 m.
Diameter = 1.35 m. - 1.05 m.	Diameter = 0.5 m.



The test with 3000 kw. load is questioned.

TABLE VI.—EFFICIENCY OF PELTON WHEELS.



In X the Effective Horse-Power was measured by Prony Brake; in the other cases it was electrically measured.

No.	Number of Nozzles.	Fall in Metres.	Revolutions per Minute.	Efficient Horse-Power at Full Gate.	a = per Cent. of Full Load. b = per Cent. Efficiency of the Turbine.											
					a	b	a	b	a	b	a	b	a	b	a	b
X.	2	90	355	326	100.0	76.0	89.3	79.7	86.5	81.6	71.4	83.6	39.6	84.2		
XI.	1	100	180	300	100 0	88.9	85.4	89.3	72.7	87.8	56.0	86.0	42.0	87.8	24.0	77.0
XII.	2	350	376	6050	100.0	83.5	89 9	81.0	75.8	82.8	55.1	83.8	27.1	80.5	14.2	75.9
XIII.	1	850	630	3710	100.0	86.2	89.4	86.9	59.2	85.2	71.2	85.1	46.7	82.9	22.3	78.5

(*b*) *Arrangement with Closed Spiral-Wheel Cases.*—The results of the tests of Turbines V. to IX. are set out on the Tables II., III., and IV., along with the important dimensions of the same arranged in tabular and graphic forms. In the lower row of sections on Table IV. their general arrangement and class of design is sketched.

From the diagrams on Table II. it may be seen that also in this arrangement the maximum efficiency is reached between 80 and 90 per cent. of full load ; but the values of the efficiency for the same percentage load differ for the different turbines of this series much more than in the previously-described series.

A direct comparison can be made between the Turbines V., VI., VIII., and IX. ; their efficiency curves have very similar general forms. From the dimension-data given on Table III. it can be recognised that the values of the efficiencies decrease as the ratio of breadth to diameter decreases. This comparison shows clearly the influence of the greater resistance of the channels of smaller flow-surface. Still, the diagrams show here also that in this style of turbine efficiencies of 85 per cent. and more are attainable.

The form of the efficiency-curve of Turbine VII. differs greatly from those of the other turbines of this series ; it is, however, similar to that of Turbine III. in the previous series I. to IV. It is to be noted that the correctness of the curve is confirmed by the tests of the governing of the different units of the installation to which Turbine VII. belongs. The apparent difference is probably caused by the form of the blades ; but as drawings of these blade-

again put out of action under the influence of a cataract. The very much less speed variation in Turbine VII. is apparent. The fly-wheel moment of inertia is, however, materially greater than that of Turbine IX. This circumstance, in conjunction with the quicker action of the Servo-motor on Turbine VII., which is indicated by its cut-off period, is the cause of the smaller variation in Turbine VII. In both cases the re-establishment of steady normal condition is reached in the time necessary for safe working under maximum-load variation following maximum-speed variation.

J.—TESTS OF HIGH-PRESSURE TURBINES.

Pelton Wheels.—On Table VI. (above) are set out in tabular and graphic form the results of tests of four high-pressure turbines—X. to XIII.—in respect of efficiency ; and on Table VII. (above) the results of tests of the regulation of the Turbines XII. and XIII. of this series are stated. The wheels of these turbines are fitted with Pelton blades. The forms of the blades certainly differ from the original Pelton shapes, and are constructed as the result of study and experience of individual turbines which have been in practical use. This variation is also partly apparent in the shapes of the efficiency-curves. The important conclusions to be drawn from these series are the following :—

1. At about 55 per cent. of full load all the four turbines show efficiencies which lie between 84 and 85 per cent.

2. The most favourable efficiencies vary between 84 and 89 per cent.

LARGE DE LAVAL STEAM-TURBINE.—The De Laval Steam-Turbine Company, Sweden, has secured the order from the Kunda Cement Works, near Reval, Russia, for a 3000-horse-power turbine direct-coupled to a three-phase generator. This is the largest steam-turbine so far supplied by the firm to Russia, and the order was obtained in the face of keen competition.

WORKMEN'S COMPENSATION CASES.

County Court.

Effect of Accident on Disease.—The liberal intention of the Workmen's Compensation Act is once more shown by the case decided by the Judge of the Workington County Court, when the widow of David Scott, employed by the Workington Iron and Steel Company, was compensated for his death, the immediate cause of which was consumption, from which the deceased had been suffering some four months prior to his death on March 6, 1911.

On July 20, 1910, Scott had been the victim of an accident which cost him the loss of an eye, and involved his long treatment at the Carlisle Infirmary, where he ultimately died of consumption. Up to the time of his death, the employers, acknowledging that an accident involved them in liability, had paid workmen's compensation by weekly payments in respect of the loss of the eye; but they refused compensation for his death, which did not appear to them to be at all connected with the accident. This was not unreasonable, but fuller examination of the medical evidence proved that the injury to his eye materially affected the man's health and lowered his vitality and contributed to the lung disease, which was the immediate cause of his death. He was a sound and healthy man till the date of the accident, and he had no predisposition to any disease. The loss of his eye worried him, and made him liable to consumption when his vitality was lowered; there was thus a direct connection between death, disease, and accident. In the Court of Appeal the principle of law was laid down that, given an accident or a disease accelerated or produced by an accident, it was not law to say that it did not come within the four corners of the Act.

Compensation by Lump Sum.—Where a workman seems to be permanently incapacitated by an accidental injury, it is often the employers' best policy to cut their loss after six months by offering to pay a lump sum. It will, however, be remembered that the Act of 1906 does not contemplate such modes of compensation. It is conceivable that a workman's half-pay during incapacity may be compensation for his injury, but rarely is the lump sum offered large enough to compensate the workman. At Weymouth County Court a firm of employers had paid weekly payments of 17s. a week for severe injuries which incapacitated a quarryman, and threatened to be lasting, if not permanent. This suggested a voluntary agreement. The Registrar refused to record it, on the ground that the sum (175*l.*) was not adequate. Medical evidence was to the effect that the workman might yet be capable of suitable light work. This opinion was doubtful, and the County Court Judge upheld the Registrar's refusal to record the agreement. The Workmen's Compensation Act does not release the employers unless the lump sum is adequate to secure the workman sufficient in a little business to be equal to half-pay during incapacity. It was argued that the quarryman, though not a business man had a smart wife who might succeed in a business which could be bought for 175*l.*

The Judge refused the employers' application because the injured man would thus be exposed to the risk of the wife's absolute failure to carry on a profitable business, and to the risk of starvation by relinquishing the claim to compensation. The employers could not, in the circumstances, be released by a voluntary agreement to redeem, and the weekly payment of half-pay (17s.) was ordered to be continued. The lump sum is a danger to the workman, who is tempted to release the employers by payment to himself of a sum which an unbusinesslike man or woman may regard as wealth, but which the Judge perceives is no adequate compensation for life-long incapacity.

Special Power of Judge to Expunge Agreement from Register.—An interesting decision was delivered by Judge Ruegg of the Staffordshire County Court, which raised points of great importance to workers in the Potteries country who are liable to serious injuries by lead poisoning in the course of their work and arising out of it. The case is no less of interest to employers and the insurance companies acting as their agents, for the application of the worker resulted in the agreement for settlement being expunged from the register under a special power possessed by the County Court Judge. According to a clause in the Workmen's Compensation Act, it is the law that "the Judge may, within six months, if a memorandum of agreement as to the redemption of a weekly payment by a lump sum or of an agreement as to the amount of compensation payable to a person under any legal disability or to dependants, has been recorded in the register, order that the record be removed on proof to the Judge's satisfaction that the agreement was obtained by fraud or undue influence or other improper means, and may make such order including an order as to any sum already paid, under the agreement, as under the circumstances he may think just."

This is a special power which County Court Judges can only exercise with very great care, for it enables them to remove from the register of the Court a memorandum of agreement which has already been recorded, and so been given the same authority as a County Court decree. This great care is called for because very often money has been had under an agreement which it would be difficult or perhaps impossible to recover from the workman. But, in a proper case, as in the present, the Judge may not hesitate to expunge the agreement from the register. The facts of this case were that a work-girl named Garner, employed by the Richards Tile Company, in September last year, suffered severe lead poisoning, contracted in the course of her work, and was paid compensation by her employers during September and October. In October, the Hanley agent of the insurance company, acting as agents for the employers, wrote to her to call on him. The girl, then certified as suffering from lead poisoning, was in bed, and too ill to attend. Her mother went in her stead, and explained to the agent that it was not possible to say anything as to her daughter's recovery, or what sum would be fair for the injured girl to accept as a sufficient sum in redemption of the weekly payments. The girl was at this time twenty-one years of age. She was entitled under the certificate to 26*l.* a year so long as her incapacity lasted. The insurance agent drove a hard bargain for his principals. He offered the sum of 25*l.* in settlement; then he offered 50*l.*, and finally 60*l.*

This sum of 60*l.* was accepted by the girl, her mother protesting, for, on repeated occasions, the mother had refused all offers when interviewing the agent on behalf of her daughter, who was too ill to attend. It is possible that the girl and her mother had the delusion common to working people that three years' earnings was the limit of the sum to which, in this case, the girl was entitled to claim (*i.e.*, 78*l.*). The judge censured the insurance agent's action, for he must have known the employers would be responsible for payment of the girl's half-pay for every week the incapacity lasted; 60*l.* was clearly insufficient, and the terms of the agreement were vitiated by misunderstanding of the girl's legal rights. The action of the doctor who gave the certificate for weekly payment was misunderstood by the girl, who imagined that when he said that she might be all right again in a year he was speaking in a quasi-judicial capacity, whereas he was giving his opinion at the request of the Insurance Company for a fee, instead of as a disinterested adviser. The employment of a medical man who had been employed in a judicial capacity and afterwards in the same case in an interested capacity was likewise unfair. The judge, when he heard that the doctor who had given the certificate for workmen's weekly compensation was the same who afterwards, to the knowledge of the Home Office, made reports of accident once a month to the insurance company, strongly rebuked the practice. It may be that the decision of Judge Ruegg in the case of Garner *v.* the Richards Tile Company may influence the making of new orders by the Home Office under the Workmen's Compensation Act.

It will be a lesson to the insurance companies that the money paid under an agreement which is set aside cannot be recoverable from the worker. Of the 60*l.* paid to Elizabeth Garner under the agreement, only 10*l.* was left, but as to repayment of that the Judge made no order. For the protection alike of the ill-informed worker, and in the interest of the employers or their insurance companies, such agreements as this ought to become impossible without the assistance of the applicant's solicitor. The unaided ignorance of the worker, which is supposed to handicap the worker's case more often than otherwise, becomes an advantage.

Scotch Appeal.

Injury Received in a Riot is not an Accident.—A labourer, who was injured in the strike riots at Bo'ness on May 31, 1910, claimed compensation from his employers, Messrs. Denholm and Co., timber merchants and shipowners, whose yardmen were on strike. To the number of 2000, strikers marched to the yards and threatened the imported labourers; a riot followed, and the applicant received injuries about the head, face, and arms, which incapacitated him for some weeks. The Sheriff Substitute held that the injuries were received by accident in the course of his employment, and awarded him 12s. 6d. a week for four weeks.

The Sheriff Substitute stated a case, and the Court of Session reversed his decision, and found the appellants, the employers, were entitled to expenses. It may be that the Sheriff Substitute was influenced by certain decisions in England and Ireland, and assumed that the injuries were received in the course of, and arising out of, the man's employment, and were the effects of an accident. In the Scotch Courts there are no decisions which justify the Court in assuming that a violent and criminal assault, or a riot, is an accident.

The dictum of Lord Macnaghten in the House of Lords has decided that the expression "accident" is to be used in the ordinary sense as denoting anything unexpected, any untoward event which is not anticipated or designed. The Scotch Courts are not bound by the decisions of English or Irish Courts of similar authority. Considering that injuries may readily be received by innocent men in the course of their employment, as the result of strikers' attacks, it is unfortunate that there is no decision of the House of Lords dealing with such a case. It is, of course, intolerable that employers should have to regard a strike and criminal offences that follow it as an accident involving compensation.

Accident due to Trespass on a Railway as Short Cut.—The widow of an overseer on the Forth and Clyde Canal appealed to the First Division against the decision of the Sheriff Substitute in her claim for compensation for the death of her husband, who, in the course of his duty, walked along the railway to Grahamstown, and was killed. The Sheriff Substitute held that the accident arose in the course of the deceased's employment, but did not arise out of his employment. A case was stated, and the Lord President affirmed the decision of the Sheriff Substitute. The man was on his employer's business, and the accident happened in the course of his employment. But he chose his own course on the railway, where he had no business. There was a safer, if longer, way by road. That he went a near cut, and exposed himself to the needless risk of being run down by a passing engine, was not an accident which happened in the course of his employment; for as the accident was not incidental to the man's employment, it was not an accident at all as understood within the meaning of the Act, for the man put himself in such a position that his death was inevitable.

CATALOGUES.

Electrical Supplies.—Messrs. Ward and Goldstone, Springfield-lane, Salford, Manchester, have sent us a copy of the 1911 edition of their catalogue of accessories for electric-light and power installations. The catalogue illustrates and states prices for a great variety of switches, circuit-breakers, fuses, instruments, water-tight electric-light fittings, conduit fittings and other wiring accessories, lamps, fans, insulators, bells, pushes, indicators, and other supplies for electrical contractors. One section of the catalogue is specially devoted to wires and cables, including flexible wires, multiple telephone cables, &c. The firm call attention to the fact that they are the actual manufacturers of these wires and cables, as well as of all kinds of switches and switch gear.

Preservation of Masonry.—A pamphlet relating to Szerelmey stone liquid—the well-known remedy for damp walls and stone decay—has reached us from Messrs. N. C. Szerelmey and Co., Rotherhithe New-road, S.E. This liquid, when applied to the surface of masonry, brickwork, &c., fills the interstices between the particles of stone and effectually excludes all moisture, to which the surface disintegration of masonry is principally due. The ordinary stone liquid is colourless and does not alter the appearance of the masonry, but modifications in colour can be effected by means of tinting paste, which can be supplied in any shade. By means of these tinted liquids a natural new appearance may be given to old masonry. The pamphlet states prices for the liquid and gives instructions for its application. Numerous illustrations of buildings treated with the material are also included.

Circuit-Breakers.—Messrs. Morris and Lister, Limited, of Carlton Works, Coventry, have sent us a copy of an illustrated price-list of circuit-breakers of the time-element type, equally suitable for direct or alternating-current circuits up to 600 volts pressure. In these breakers, which are of extremely simple construction, the main current is caused to traverse two metal strips on the switch-arm, and the expansion of these strips, due to excessive current, releases a catch and opens the switch, which is provided with a carbon break to deal with the arc. The price-list gives full particulars, including dimensions, of circuit-breakers with fixed or free handles, for currents ranging from 15 to 1500 amperes. Single, double, and triple-pole switches can be supplied (open, protected, or totally enclosed) with any of the usual accessories, such as no-voltage, reverse-current, and minimum-current releases, and, if desired, a magnetic blow-out can be fitted. They can also be arranged so as to be adjustable to open at any current between normal and 50 per cent. overload.

Driving Chains.—We have received from the Coventry Chain Company, Limited, of Coventry, a copy of their latest catalogue of noiseless driving chains and wheels. The catalogue explains the principles of these chains, points out their many advantages, and gives hints relating to their use. Numerous illustrations show the chains and their component parts, as well as several of their applications. The latter include the driving of line-shafting from electric-motors, governor drives, speed-reduction boxes for electric-motors, motor-car gear-boxes, cam-shaft drives for motor-car engines, &c. Full particulars are given of chains having pitches varying from 8 mm. to 2 in., with central or outside guide-plates; dimensions of machine-cut chain-wheels for use with these chains are also included. In order to assist in the design of cam-shaft drives, tables are given to show the possible distances between centres of shafts for $\frac{1}{2}$-in. and $\frac{3}{8}$-in. pitch chains to run tight on wheels with a two-to-one ratio. The catalogue is extremely well got up, and the information it contains will be useful to all interested in chain-driving.

Aeroplanes.—From the Aeronautical Syndicate, Limited, Collindale-avenue, West Hendon, N.W., we have received a catalogue illustrating and giving full particulars of Valkyrie aeroplanes. These machines, one of which was illustrated in our issue of March 31 last, on page 410, are of the monoplane type, and have a smaller balancing plane in front of the main plane. One of their special features is the design of the landing chassis, the skids of which are exceptionally long, widely spaced, and so shaped that the machines can descend on to much rougher ground than would be safe with other aeroplanes. Three models are made—two single-seaters for ordinary speeds and for cross-country racing respectively, and a larger machine for carrying two passengers in addition to the aviator. Very complete particulars are given as to cost, prices being stated for the complete machines, and for all parts separately, as well as for miscellaneous supplies, packing, &c. The company undertakes all classes of aeronautical work, conducts a school of flying, and also gives passenger trips; a scale of charges for these trips is included with the catalogue.

Wireless Telegraphy on the Coast of the Arctic Ocean.—Norway will not be the only country installing wireless telegraphy in the Far North; Russia is following in her wake, and proposes to erect four wireless electric stations on the shores of the Arctic Ocean—one, it is surmised, on the Murman coast, one at the mouth of the Petschora, one in the Island of Vaigatz, just inside Nova Zembla, and one in the White Island outside the mouth of the Ob. The cost of these four stations, which will bring vast areas of the Arctic Ocean within the scope of telegraphy, is calculated at some 30,000*l.* In connection with the Norwegian wireless stations at Spitzbergen and Hammerfest, these installations should prove a great boon to the Arctic trading vessels, provided, of course, that they themselves instal wireless telegraphy.

THE STRENGTH OF STEELS IN COMPOUND STRESS, AND ENDURANCE UNDER REPETITION OF STRESS.

By L. B. Turner, B.A.

(*Continued from page* 117.)

III. Endurance under Alternations of Stress. Previous Work.

The first important experimental work on the effect of repetition of stress was carried out by Herr A. Wöhler, in Berlin, and was published in 1871. In this research various irons and steels were subjected to simple tension, varying at the rate of about 60 cycles a minute between limits equal but of opposite sign, unequal of opposite sign, and unequal of the same sign. These were produced by longitudinal pull, by bending in one plane, and by bending in a plane which rotated relatively to the specimen. Wöhler's very extensive work was followed, between 1871 and 1886, by similar experiments by Spangenberg, Baker, and Bauschinger.* There have since been further experiments on endurance under repeated stress by Messrs. J. A. Ewing and J. C. W. Humphrey ;† O. Reynolds and G. H. Smith ;‡ J. C. Gardener ;§ F. Rogers ; ‖ T. E. Stanton and L. Bairstow.¶ In addition to these, Dr. Stanton** has made certain varying stress experiments in a very novel manner, with regard to the strength of rails ; but in the only experiments yet published the action was a combination of abrasion with true fatigue, and so does not concern the present less purely empirical investigation. His machine possesses points of great interest, and is capable of making true fatigue tests. Also Professor J. O. Arnold†† has produced a machine to fracture specimens by alternate bending far beyond the elastic limits. He makes certain claims for his test which are examined in relation to the present experiments later in this paper.

In addition to Wöhler's tension tests, he published a very few (nine in all) tests in simple shear, obtained by twisting the specimens. These are best examined along with the author's similar tests on similar material. It seems that these are the only experiments on varying stress other than simple tension.

It would be unsuitable here to attempt anything like a full description of the researches enumerated above. The most notable conclusions to be drawn from them are very briefly summarised below.

1. The curve whose ordinates represent the range of stress in the material, and whose abscissæ show the number of repetitions to produce fracture, is asymptotic to a horizontal straight line, whose ordinate will here be termed the "limiting endurance range," or, more briefly, the "endurance range." In the more recent experiments‡‡ the curve has been found to be almost horizontal at a million alternations of stress, so that in making endurance tests it is usually unnecessary to proceed beyond this number. Wöhler's and the other early experiments indicated a greater number of alternations before the asymptote was nearly reached. The change, as Professor Unwin remarks, is possibly due to modern improvement in the quality of the material.

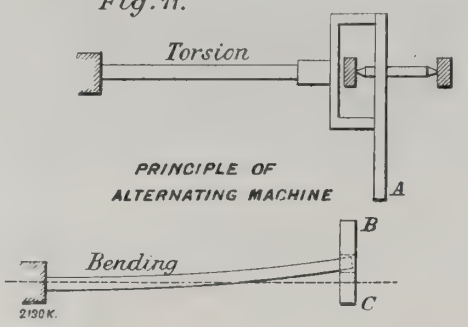
2. The number of repetitions before rupture depends, within fairly wide limits, on the range of stress, and not on the maximum stress, to which the material is subjected.§§ Thus, suppose a steel specimen endured half-a-million cycles ranging from +8 to −8 tons per square inch, it would also endure about half-a-million cycles ranging from +10 to −6 tons per square inch.

3. The limiting endurance range of stress is nearly equal to Bauschinger's "natural" elastic range.* That a bar will break under reversals of stress considerably below the ordinarily determined elastic limit is explained by Bauschinger in the following way. Consider a bar of iron or steel overstrained in the testing-machine to just beyond its then elastic limit. Such a process several times repeated may raise the elastic limit by a very considerable amount (as Professor Ewing has since more fully demonstrated). But, says Bauschinger on the strength of his experiments, this has been done only at the cost of a lowered limit for negative tension ; the interval between the negative and positive limits is unchanged. Most materials have already been treated in such a manner as thus artificially to modify their elastic limits. A bar of iron, for example, by the rolling it has undergone in its manufacture, has had its elastic limit for longitudinal tension raised. Bauschinger found that by a few applications of alternating stress, carried each time just beyond the then elastic limit, so that the material was repeatedly just overstrained, a stationary value of the elastic limit was approached. This is what he named the "natural" value, and found to be approximately half the range for unlimited reversals.†

4. Endurance is independent of the speed of alternation of stress from 60 to 800 per minute, but falls off with increased speed in the region of 2000 per minute.‡

5. Stoppage of the machine for a few hours or

Fig. 11.



days—the stress remaining steady,§ or being removed‖—does not lengthen the life. Rest does not rejuvenate.

6. Failure finally occurs by the augmentation of the slip-bands of Ewing and Rosenhain into cracks. In nearly pure iron, the cracks occur in the ferrite grains themselves, and not in the cementing medium.¶ In steels (hypo-eutectic) they appear in the ferrite rather than the pearlite.** The more completely these two equilibrium constituents are replaced by the solid solution martensite (by quenching) the greater is the limiting endurance stress.††

Experiments by the Author.

The main purpose of the present experiments is to obtain information of endurance under compound stress. Except for Wöhler's nine tests in 1871, nothing was known of fatigue under torque. Important as the problem is—every live axle, for instance, undergoes alternating compound stress—the case for strength under compound stress has been even more neglected for repeated than for steady loads. It was obvious that the experiments on static simple tension and simple shear should be repeated with varying stress.

At the same time the elastic limit has received attention. Except in the researches of Bauschinger and Stanton and Bairstow, no relation between endurance and elastic limit has been looked for. According to Bauschinger's theory of the "natural" elastic range, an annealed specimen should be in the "natural" state without being subjected to his reversed-stress treatment ; so that for annealed material the static elastic limit test would alone be sufficient to specify the strength under varying stress. This is a conclusion of the greatest practical importance. Nearly all the tests about to be described were made on annealed material, and they therefore embody a direct experimental inquiry into its validity.

The Machine.

It was decided to make the tests in simple tension and simple shear, alternating between equal opposite limits. The machine designed for the purpose does this by bending and torsion, and is unlike others in principle, in that it strains the specimens between fixed limits instead of working to a fixed stress. It is the same thing, of course, in the effect on the specimen below the elastic limit ; the principle was adopted solely because it allowed an extremely simple machine to be used. If the stress is obtained by the acceleration of a mass attached in some way to the specimen,* high and constant speed is necessary, and the machine becomes very complicated. If, on the other hand, the simpler lever mechanism of the Wöhler machines is adopted, operated from the driving mechanism through interposed spring tackle, the speed must be very slow to avoid inertia forces.

The single machine takes both specimens simultaneously, the one for torsion and the other for bending. One end of each specimen is firmly encastré to the frame of the machine, while the other end in the one case is twisted back and forth round the axis of the specimen, and in the other is forced round in a circle whose centre lies on the unstrained axis of the specimen. In the diagrammatic representation (Fig. 11), the twisting is brought about in the specimen by forcing the end A of the lever up and down perpendicularly to the plane of the paper, and the bending is caused by the rotation of the plate B C about the dotted line.

Fig. 12, page 184, is a photograph of the machine when fitted with specimens of steel tube $\frac{5}{8}$ in. in diameter, and driven from an overhead counter-shaft in the laboratory workshop. A is a lathe-bed carrying its ordinary headstock B. C is the bending and D the torsion specimen. These are each held encastré at one end in the cast-iron double bracket E. The bending specimen is held gripped in a split conical sleeve, which is forced into its seating in the gun-metal block F by the nut G. The torsion specimen is soldered into the gun-metal ends H, K. L is a cast-iron plate screwed on to the nose of the headstock B. M is a tool-steel plate in which is a hole, slightly bell-mouthed, and forming a good loose fit for the end of the bending specimen. The plate M slides in a channel in the face of the plate L, and is fixed in any position by the two screws shown. N is a gun-metal eccentric frame in which slides a phosphor-bronze eccentric sheaf, surrounding a cast-iron eccentric. This eccentric is in the form of a ring attached to the back of the plate L by the three screws whose heads are seen on the front of the plate, and which pass through slots in it. By them the eccentric is held to the plate L with any desired amount of eccentricity.

The eccentric frame N forms the end of the oscillating-lever marked A in Fig. 11. Thus as the eccentric makes N move up and down, the torsion lever oscillates through an angle determined by the eccentricity of the eccentric. The torsion lever turns about tool-steel centres held (on the axis of the specimen, as shown in Fig. 11) in the cast-iron bracket O.

The end K of the torsion specimen is held in the frame P bolted to the torsion lever. The other end is not fixed rigidly to the cast-iron bracket E ; a Hooke's joint of the diaphragm pattern intervenes. The diaphragm—a phosphor-bronze disc, with a large hole in the middle for increased flexibility—is just seen at Q. This universal joint is needed to avoid bending moment in the torsion specimen ; being of the diaphragm type, there is no backlash.

The specimens, or rather the gun-metal block F and the Hooke's joint, are fixed to the bracket E by the large nuts R, S. (S, for the torsion specimen, is only just visible.) These nuts screw on to lugs (1 in. in diameter) passing through holes ($1\frac{1}{4}$ in. in diameter) in the bracket. The holes are larger than the lugs to allow adjustment of the fixed ends of the specimens before the nuts R, S are tightened up. This provision is necessary, since the specimens may not all be quite straight.

Another view of the machine, fitted with $\frac{3}{8}$-in. solid specimens, and driven by an electric motor, is shown in Fig. 13.

When specimens are to be fitted to the machine, the eccentric, which operates the torsion lever, and the plate M, which operates the bending specimen,

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* An excellent account of the early researches is to be found in Professor W. C. Unwin's "The Testing of Materials of Construction."

† "The Fracture of Metals under Repeated Alternations of Stress." (Phil. Trans. of the Royal Society, 200A, 1902.)

‡ "On a Throw-Testing Machine for Reversals of Mean Stress." (Phil. Trans., 199A, 1902.)

§ "Effects Caused by the Reversal of Stresses in Steel." (Journal of the Iron and Steel Institute, 1905, 1.)

‖ "Heat Treatment and Fatigue of Steel." (Same volume.)

¶ "On the Resistance of Iron and Steel to Reversals of Direct Stress." (Proc. Inst. C.E., 1905-6.)

** "A New Fatigue Test for Iron and Steel." (Journal of the Iron and Steel Institute, 1908, 1.)

†† "The Fracture of Structural Steels under Alternating Stresses." (British Association Report, 1904.)

‡‡ Unwin, Reynolds and Smith, Gardener, Rogers, Stanton and Bairstow.

§§ Unwin, Stanton and Bairstow.

* Unwin, Stanton and Bairstow.

† The relation of the endurance range to the elastic limit is discussed more fully in Chapter VIII.

‡ Wöhler, 60 per minute ; Reynolds and Smith, 2000 per minute ; Stanton and Bairstow, 800 per minute.

§ Rogers.

‖ Reynolds and Smith, Stanton and Bairstow.

¶ Ewing and Humphrey.

** Rogers, Stanton and Bairstow.

†† Gardener.

* As employed by Reynolds and Smith, and Stanton and Bairstow.

are set central by the insertion of small pins which pass through holes in them into the plate L. For the bending specimen, the encastré end is then adjusted until the deflecting end (that is to be) is central in the hole in the plate M. There is very little play here, and centrality can readily be judged by the touch and the sound when the specimen is tapped with the finger. The nut R is then tightened. For the torsion specimen, the end K is first fixed in P, after which the Hooke's joint end is fixed. The specimens are then unstressed, and would not be deflected if the machine rotated.

The manner of loading the specimens is shown in Fig. 14. (The specimens in this view are $\frac{3}{8}$-in. solid rods.) For the bending specimen the screws are loosened, so that the plate M is free to slide in its channel (set vertical). The plate is drawn slightly out from its bed, and any desired load is applied to it, as shown in the figure. The plate is lightly tapped back to its bed in the channel, and the screws are tightened. While the plate is being tapped back frictional error is abolished. For the torsion specimen, the slots in the plate L are set vertical, the three screws holding the eccentric are loosened, and any desired load is applied to the eccentric frame by means of the hook attached. To abolish frictional error the three screws are taken right out, the plate L is unscrewed a little from the headstock, so that the torsion lever hangs quite free, and then it is screwed back and the three screws are put in and tightened. The specimens are thus loaded to produce the required stresses, and the machine is set to deflections corresponding to these stresses. When the machine rotates, an alternating torque is applied to one specimen, and a rotating bending moment to the other; so producing in every fibre simple alternating shear and tension respectively. The eccentric and the plate M can each be set out of centre by 1 in.

The specimens were machined for fracture to occur at a spot near the encastré ends, as described later. The occurrence of a fracture in either specimen is signalled in the following way. Referring again to Fig. 12, the block F is insulated from the bracket E by two paper washers. An electric circuit, carrying constantly a small current, includes the breaking section of the bending specimen (from the brass clamp W to the block F), and the two mercury cups in the wood block U. These cups are bridged by a bent wire carried on the wood arm T, which is lightly clamped to the torsion specimen near the breaking section, on the side away from the encastré end. When the torsion specimen is whole, the amplitude of motion of the arm T is insufficient to lift the wire from the mercury cups; but when fracture (partial) occurs, the amplitude increases, since there is no longer any considerable torque in the specimen. Thus the circuit is broken. Bending fractures, being complete, also break the circuit. When the machine was run in the workshop, the cessation of the current caused a bell to ring, whereupon an attendant stopped the machine. When it was driven by a motor, an automatic device (seen in Fig. 13) switched off the motor.

The machine was run at about 250 revolutions per minute. Revolutions were indicated by a counter fitted to the back end of the headstock.

Some of the tube specimens were tested when the machine was in the workshop. There it was run for about eight hours per working day. All the other tests were made with the motor drive. A small induction motor, consuming about 250 watts, was used, and normally ran all day and night, except for some three or four hours each morning. (This was due to a failure in the electric supply, which always occurred early in the morning.)

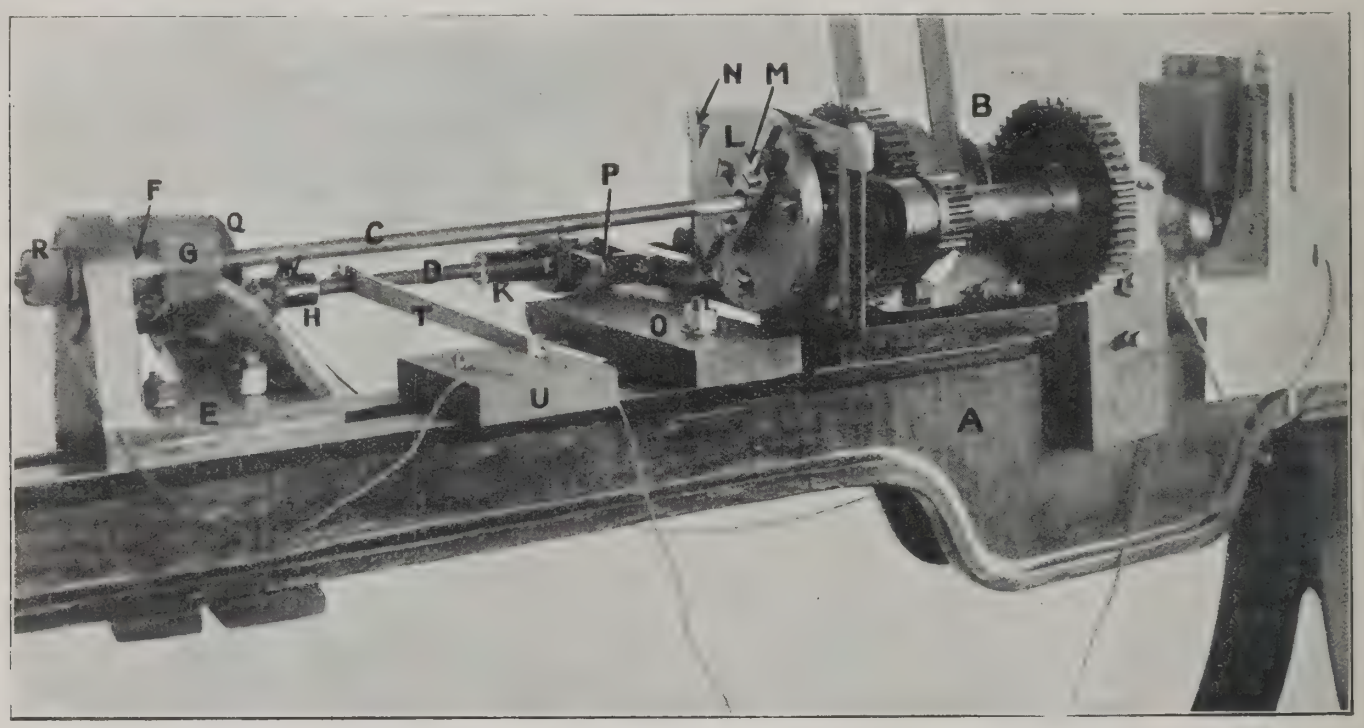


Fig. 12.

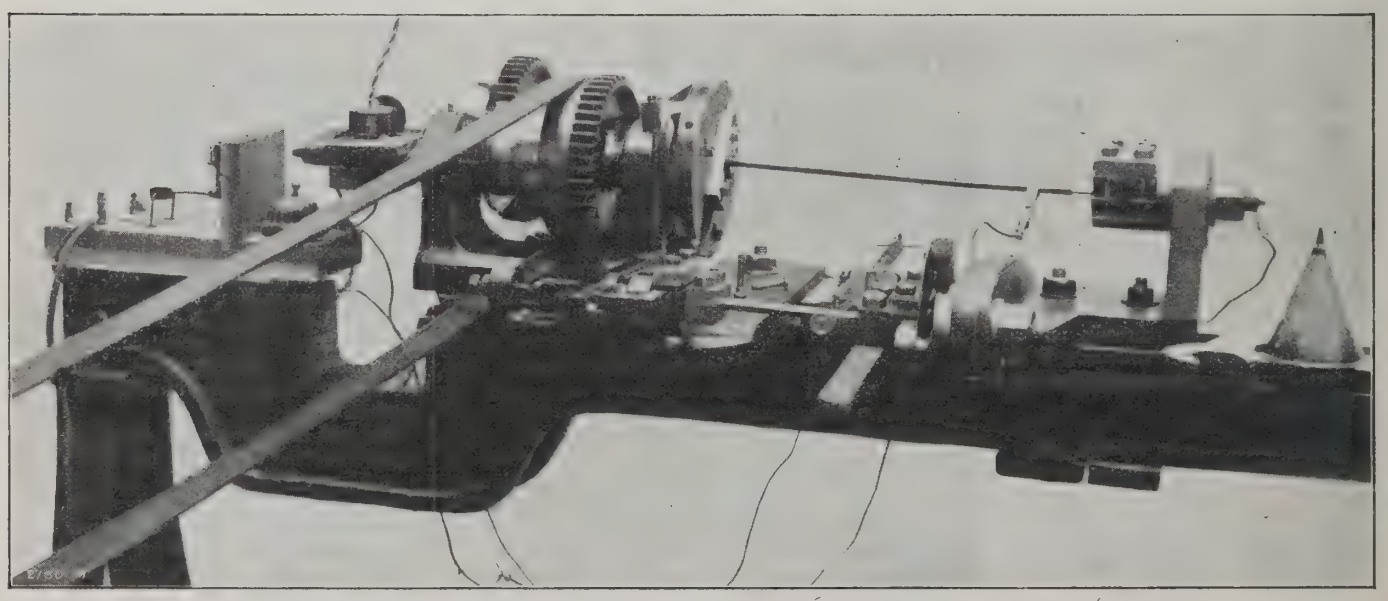


Fig. 13.

Figs. 12 and 13. Machine for Making Tests in Simple Tension and Simple Shear.

The Specimens.

The specimens tested in the machine were $\frac{5}{8}$-in. weldless steel tubes, of thickness 22 B.W.G. (0.028 in.), and $\frac{3}{8}$-in. solid rods of three different kinds of steel.

The spot at which fracture was to occur was ground up as shown in Fig. 15. The tubes were mounted on mandrels $2\frac{3}{4}$ in. long, specially ground to fit tightly, and had a small amount of material

removed. The thickness was estimated from the size of the mandrel and the external diameter of the ground section. It was impossible to obtain very accurate or uniform thickness in the tubes, but at different times four specimens were cut open and measured up with a micrometer, to check the accuracy and uniformity of the estimated thickness. It was found that the thickness round any ground section might vary by about 4 per cent. from the mean, and that the estimated thickness was greater than the true mean thickness by amounts which varied about from 0.001 in. to 0.003 in. Consequently the tabulated stresses have been calculated from thicknesses 0.002 in. less than those estimated from the mandrel diameters.

The solid specimens were all ground to the same

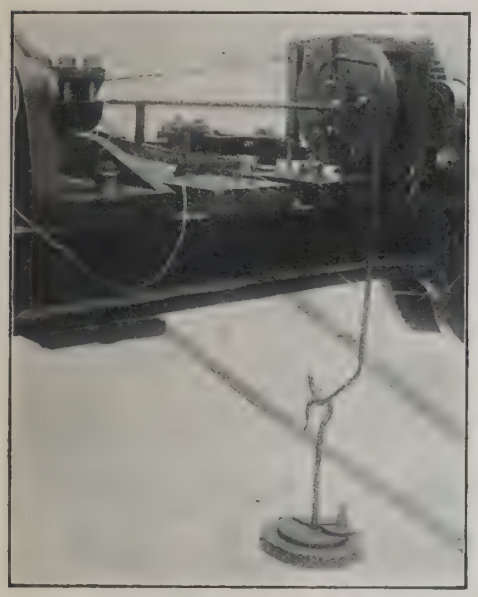
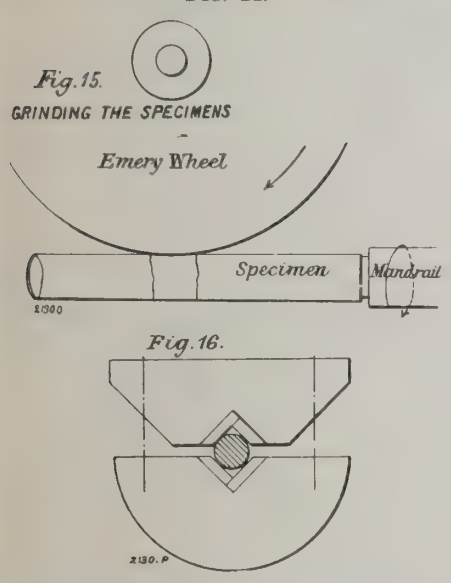


Fig. 14.



size at the breaking section. A limit-gauge was used, and metal was removed until the diameter lay between 0.329 in. and 0.331 in.

In all specimens the ground sections were polished with fine emery paper after grinding, for it was found that the scratches left by the wheel sensibly weakened specimens in torsion.

The lengths of specimens were varied somewhat during the series of tests. Roughly, they were made such as to give deflections at the plate L of the machine of not less than $\frac{1}{2}$ in. The free lengths were, roughly, as follow :—

	Bending.	Torsion.
$\frac{5}{8}$-in. tubes	19 in.	8 in.
$\frac{3}{8}$-in rods	14 in. to 15 in.	5 in. to 6 in.

With regard to the manner of gripping the specimens, the torsion tubes were soldered into the gun-metal ends for a length of 2 in. It is rather surprising that the solder held throughout a test, but close inspection showed that it did. It was found, however, that a soldered encastré grip for the bending tubes would not do, for the solder soon gave way where the tube entered the block. Hence the split sleeve grip was substituted. For the solid specimens the torsion grips were of tool steel, the top and bottom halves having semi-circular grooves of the same radius as the specimen. The bending specimen was clamped between the upper and lower right-angled grooves lined with hardened tool steel, four slight flats being filed on the specimen to bear against the four surfaces. The sketch (Fig. 16) will make this clear.

The deflecting end of the bending specimen was turned down to 0.340 in. in diameter to fit into a hardened bell-mouth steel bush fitted to the plate M.

The materials* used were :—

1. The $\frac{5}{8}$-in. tube steel, supposed to be similar to the 1-in. tubes used in the static experiments.†

2. The $\frac{3}{8}$-in. mild steel,‡ specially rolled for these experiments from a piece cut off a large crank-shaft ; ordinarily used for marine shafting and large crank-shafts.

3. The $\frac{3}{8}$-in. tool steel, as ordinarily used for making small tools ; this, a hyper-eutectic steel, was tested as having an extreme carbon content for any structural steel.

4. The $\frac{3}{8}$-in. nickel-steel,§ used where special strength is required in "axles, crank-shafts, motor work, &c." The makers state that a large quantity of similar material is used in America for bridge-building.

When specimens were annealed, it was always done before grinding. Some of the tube-steel specimens were used as supplied, and some were annealed at 760 deg. Cent. in the same manner as the 1-in. tubes of the static tests.‖ The mild steel had been annealed by the makers at 760 deg. Cent., allowed to cool in air. The tool-steel specimens were heated, several at a time, in the electric furnace¶ to 760 deg. Cent. (about 4 minutes), and were then rolled in a fire-clay tube till cold. The nickel-steel specimens were heated within an iron gas pipe in a gas muffle-furnace to 800 deg. Cent. (about 12 minutes), and were then allowed to cool in air.

(To be continued.)

LITERATURE.

Der Kautschuk und seine Prüfung. By Professor F. W. Hinrichsen and K. Memmler. Leipzig : S. Hirzel. [Price 8 marks.]

Both the authors are members of the Royal Material-prüfungsamt at Gross-Lichterfelde, near Berlin, and have for some years been devoting their efforts to the perfection of methods of rubber-testing; several of the methods and apparatus mentioned are due to them. Considerable progress has been made in this field during the last year, thanks mainly to the steps taken by the electrical institutions ; but chemical analyses of rubber cannot yet claim the reliability and accuracy of ordinary chemical analyses. After all, mechanical methods of testing are as important at least as chemical methods ; unfortunately, they afford not much more reliable information than the chemical analysis as to the durability of the materials—the point on which the electrical profession lays the greatest stress.

The octavo volume of 262 pages, illustrated by 62 figures in the text, is divided into three main sections, dealing with rubber in general, its origin, constitution, and properties, making mention also of vulcanisation and technical manufacture, with chemical analysis, and with mechanical tests. Owing to the manifold character of the rubber industry and science, literature concerning rubber is widely dispersed, and collective reviews of this kind, well brought up to date, serve a useful purpose. Optimists look forward to an age of artificial rubber. That age will certainly not come as a sudden surprise, and the authors have probably been wise in refraining from dwelling upon these researches. Rubber substitutes are only noticed in so far as they are used as adulterants. A name index and a subject-matter index are provided.

How Men Fly. By Gertrude Bacon. With fifteen black-and-white illustrations and numerous diagrams. London : Cassell and Co., Limited. [Price 1s. net.]

Only a few years ago, Professor Simon Newcomb, an authority on whose words the world relied, expressed his confident belief that a heavier-than-air flying-machine was an impossibility. We have now a lady, without any particular scientific training, coming forward to explain how the trick is done, once again illustrating the folly of prophecy. Professor Newcomb wrote something to this effect : "I consider the demonstration that no possible combination of known substances, known forms of machine, and known forms of force, can be united in a practicable machine by which men can fly long distances through the air, as complete as it is possible for the demonstration of any physical fact to be." He went on to say, by way of driving home his profound conviction : "Let us discover a substance a hundred times as strong as steel, and with that some form of force hitherto unsuspected, which will enable us to utilise this strength, or let us discover some way of reversing the law of gravitation, so that matter may be repelled from the earth instead of being attracted to it, and then, and not till then, we may have a flying-machine."

"There is every reason to believe," he concluded, "that mere ingenious advances with our present means and forms of force will be as vain in the future as they have been in the past." These are bold words, and the author easily refutes them. She says, practically, that there has been no discovery of new forces or material, and that gravitation exercises the same attraction as ever ; but that the problem has been solved by the arrival of a commonplace pair of ordinary sail-like arms, driven forward by a small high-speed internal-combustion engine. The relation between centre of pressure and angle of tilt was known, and the stability resulting from suitable construction was perfectly understood by Newcomb ; but what he failed to grasp was the swift advance of the internal-combustion engine. Newcomb did not foresee the possibility of constructing an engine whose weight should be something less than 2 kilogrammes per horse-power, and he might contend that this advance constituted a new form of force. That he and others did not foresee the direction improvement would take is the more surprising, because the efficiency of a gun depends upon the fact that it is an internal-combustion engine ; and this thought has, perhaps, in these last days suggested the possibility of the next improvement taking the form of the production of a solid explosive, whose exhaust would be entirely gaseous.

This train of thought, however, leads us too far from Miss Bacon, who, by education and descent, has easily accommodated herself to aerial locomotion. Her father taught her to regard the unstable fabric of the balloon as a secure support, and the transition to the aeroplane has been for her an easy step. It seems but right that she should be the first Englishwoman to go aloft in a heavier-than-air machine, and just as right that she, who has described so many of her experiences in the clumsy drifting balloon, should be among the first to describe the sensations that accompany achieved flight. It was two years ago, at Rheims, on a machine piloted by M. Sommer, and never intended to carry a passenger, that Miss Bacon, squeezing herself in between the back of the aviator and the very warm radiator of the engine, initiated for women the new form of locomotion. It was an historical moment, and it is well that Miss Bacon has preserved the memory of her sensations. When, after the slight jolting inseparable from the start, there came in its place "a glorious, buoyant, floating sensation without a parallel, and therefore indescribable, but delicious beyond words. I cast one glance below to make sure, but it was needless ; such a sensation could belong to but one thing in the world—flight!" Miss Bacon has made many flights since, and has noted, with true feminine appreciation, the increasing comfort that time and ingenuity have introduced into the aeroplane. The rapture and exhilaration accompanying the motion have not diminished, but the experiences vary. In an ascent in which Mr. Gilmour was the accomplished aviator, and when the aneroid, which Miss Bacon had been given to hold in order to keep her quiet, indicated an elevation of 1000 ft., "without a word of warning, he (Mr. Gilmour) leant forward, and shut the engine right off, at the same moment tipping down the nose of the machine until I almost slipped from my seat on to the floor, and down we plunged through the sky." Just for one fraction of a second, I must confess, I fairly gasped. Had the young man suddenly been seized with homicidal mania? Then, of course, I

* Analysis, &c., in Appendix II.
† See Engineering, February 12, 1909, page 204.
‡ Kindly presented by Messrs. Firth and Sons, of Sheffield.
§ Kindly presented by Sir Robert Hadfield, of Sheffield.
‖ See Engineering, February 12, 1909, page 204.
¶ See Engineering, February 12, 1909, page 204.

recollected, and I hope my voice was nonchalant and even, as I asked "Is this vol plané?"

These two extracts will serve to show that we must not expect anything very technical or scientific from the genial writer. There are those who want to know how to use the correct terms; how to translate the language of the scientific journalist and reporter into every-day English, and Miss Bacon will be found a sufficient guide. A glossary is supplied which may give courage to a lady when visiting a flying ground or aviation meeting, and, better still, the author is prepared to play the guide, pointing out the salient points in which one machine differs from another, and make intelligible the underlying principles that have guided their construction. She will explain, if need be, why a kite remains in the air, and what is the effect of the string and similar simple problems; but the more recondite questions that are not yet solved, and in which theory and practice are equally concerned, form no part of the plan of this simple guide-book. The problem of maintaining equilibrium in the air under various conditions, the question of stresses to be sustained by the different parts of the machine, are not discussed here, and we believe the author to be quite indifferent to the controversy of the sine *versus* the sine-squared law. Those who have penetrated far into the literature of the subject, or those who are capable of attacking the problems for themselves, do not need to go to Miss Bacon, and it is not for these she writes. But the man or woman in the street, who wants to gather a little information about this fascinating subject, will find here as much as he or she can readily absorb, and will admit that the information is conveyed in a way that can be appreciated.

BOOKS RECEIVED.

Die Verwaltung der Öffentlichen Arbeiten in Preussen, 1900 *bis* 1910. Bericht au Seine Majestät den Kaiser und König erstatter von dem Minister der Offentlichen Arbeiten. Berlin: Julius Springer.

The Elements of Telephony. By Arthur Crotch. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 1s. 6d. net.]

Les Explosifs Modernes. Par Paul Chalon. Troisième Edition, entière refondue. Paris: Ch. Beranger.

Physikalische Demonstrationen. Von Adolf F. Weinhold. Fünfte verbesserte und vermehrte auflage. Erste Lieferung. Leipzig: Johann Ambrosius Barth. [Price 11 marks.]

Dictionary of English and Spanish Technical and Commercial Terms used Chiefly in the Iron, Steel, Hardware and Engineering Trades. By William Jackson. London: E. and F. N. Spon; New York: Spon and Chamberlain. [Price 2s. 6d. net.]

La Navigation Sous-Marin. Par Charles Radiguer. Paris: Octave Doin et Fils. [Price 5 francs.]

Practical Dynamo and Motor Management. London: S. Reulett and Co., Limited. [Price 6d. net.]

Electricity in Locomotion: An Account of its Mechanism, its Achievements, and its Prospects. By Adam Gowans Whyte, B.Sc. Cambridge: University Press. [Price 1s. net.]

Calculation of Columns: A Practical Application of the Theory. By Theodor Nielsen. London: E. and F. N. Spon; New York: Spon and Chamberlain. [Price 4s. 6d.]

Mischen, Rühren, Kneten, und die dazu verwendeeen Maschinen. Von Dr.-Ing. Hermann Fischer. Leipzig: Otto Spamer. [Price 5.75 marks.]

The Mineral Industry of Rhodesia. By J. P. Johnson. London: Longmans, Green, and Co. [Price 8s. 6d. net.]

Gemischbildungen der Gasmaschinen. Von Dr.-Ing. G. Hellenschmidt. Berlin: Julius Springer. [Price 1.60 marks.]

Die Technologie des Maschinentechnikers. Von Ingenieur Karl Meyer. Berlin: Julius Springer. [Price 8 marks.]

Lectures on Reinforced Concrete, Delivered at the Institution of Civil Engineers, in November, 1910. By William Dunn. London: Hodder and Stoughton. [Price 7s. 6d. net.]

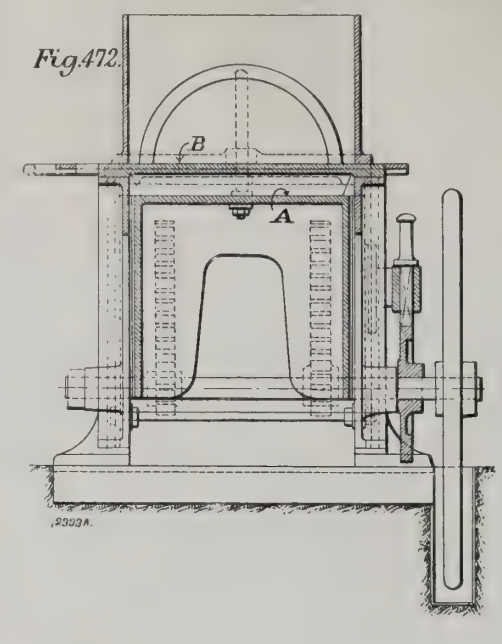
Butterworth's Workmen's Compensation Cases. Vol. IV. *Quarterly Advance Sheets* (Part II., 1911). Edited by Douglas Knocker, Barrister-at-Law. Containing complete reports of all cases entered in the lists of the House of Lords and the Court of Appeal for Hilary Term. London: Butterworth and Co., 11 and 12, Bell Yard, Temple Bar, E.C.; Sydney: Butterworth and Co. (Australia), Limited, 76, Elizabeth-street; Calcutta: Butterworth and Co. (India), Limited, 8/2, Hastings-street. [Price 7s. 6d. net.]

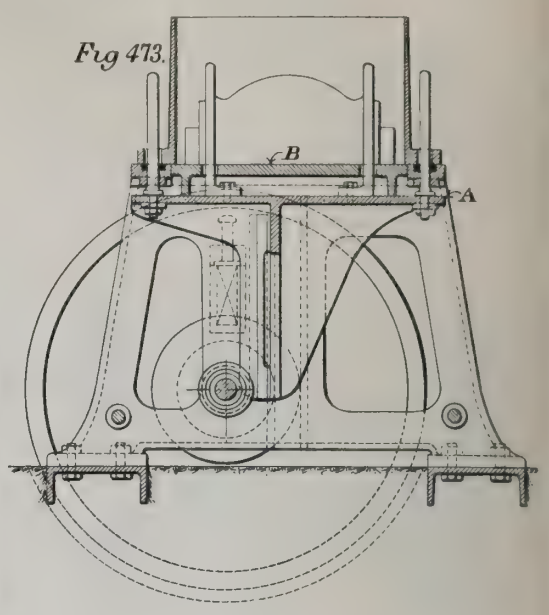
Smithsonian Institution: Report on the Progress and Condition of the U.S. National Museum for the Year ending June 30, 1910. Washington: Government Printing Office.

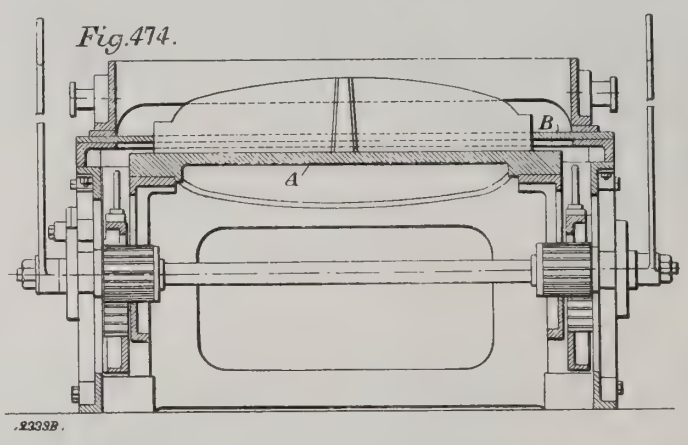
German Rails.—The exports of rails from Germany in the first three months of this year were 139,631 tons; the exports in April were 37,403 tons; in May, 51,704 tons; and in June, 28,888 tons, making an aggregate for the quarter of 117,995 tons. The aggregate exports for the first half of this year were, accordingly, 257,626 tons.

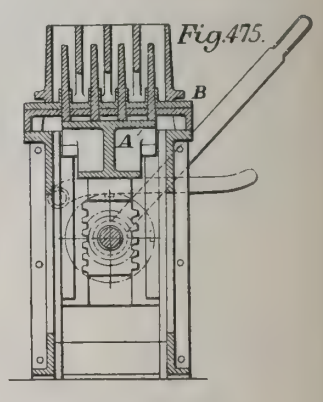
FOUNDRY PLANT AND MACHINERY.

(*For Description, see opposite Page.*)

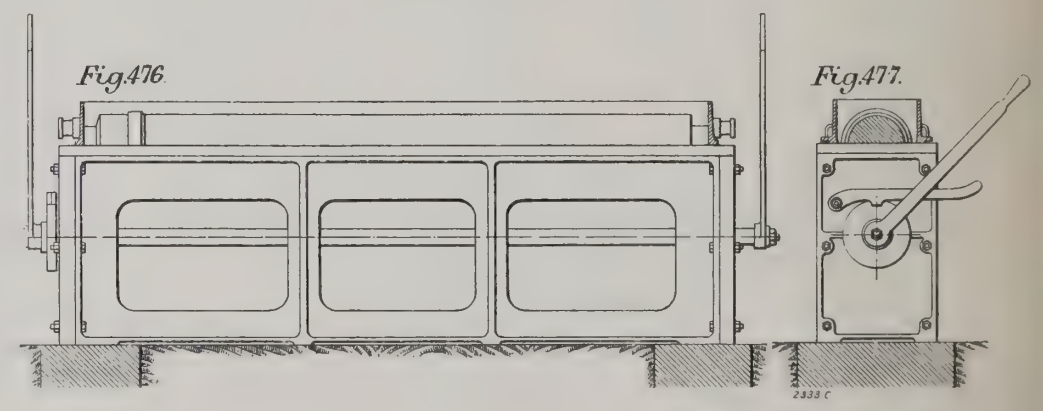




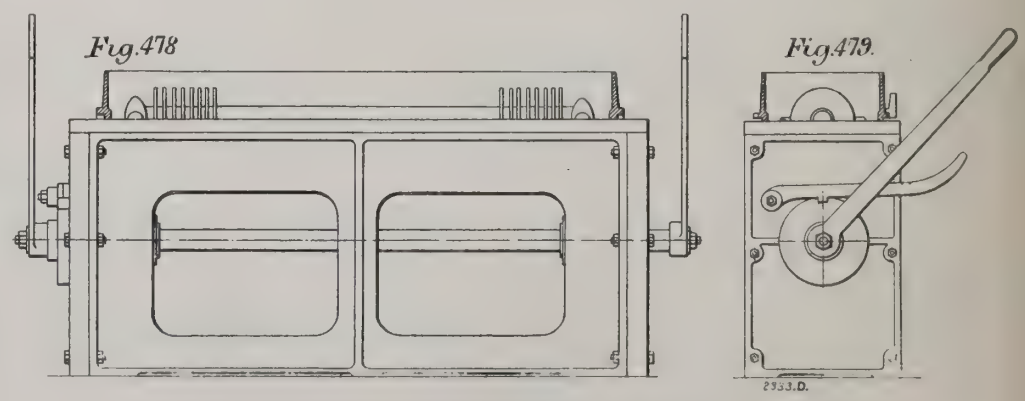




Figs. 472 to 475. Stripping-Plate Machines; the Badische Maschinenfabrik und Eisengiesserei, Durlach.

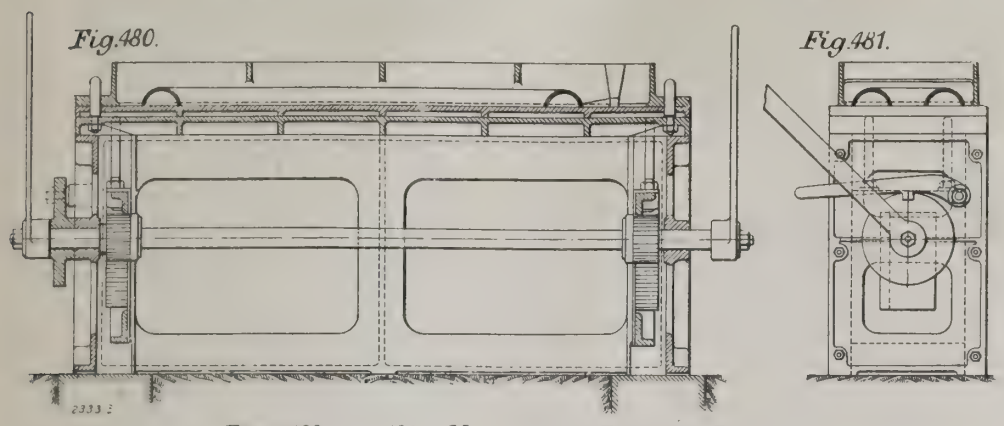


Figs. 476 and 477. Machine for Pipe and Column Work.

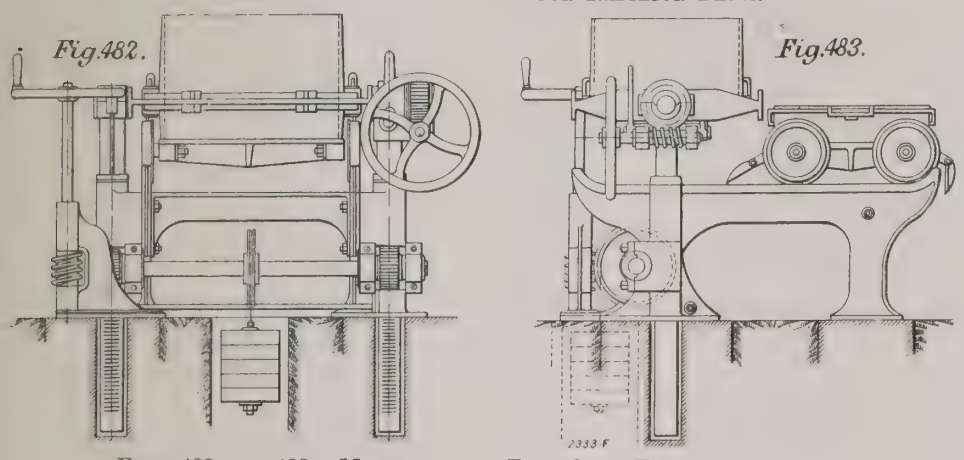


Figs. 478 and 479. Machine for Radiator Pipe Patterns.

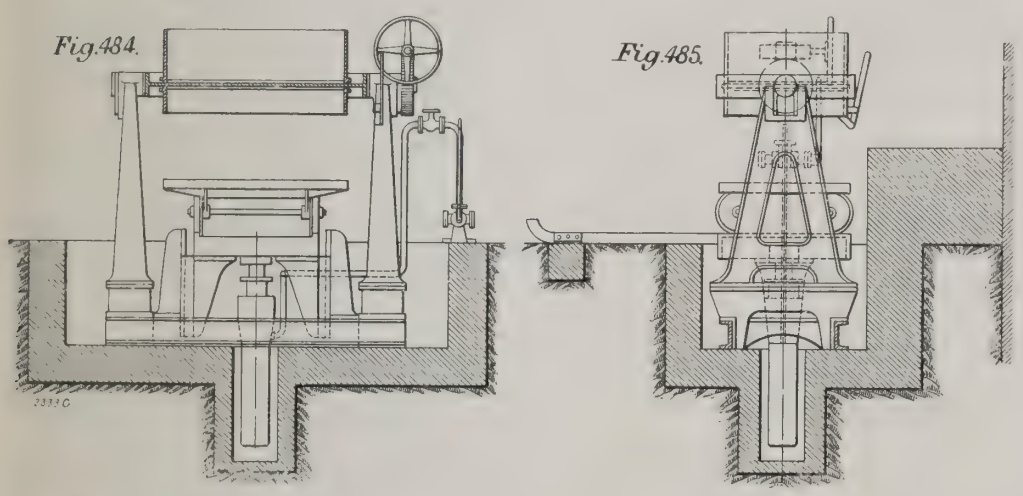
FOUNDRY PLANT AND MACHINERY.

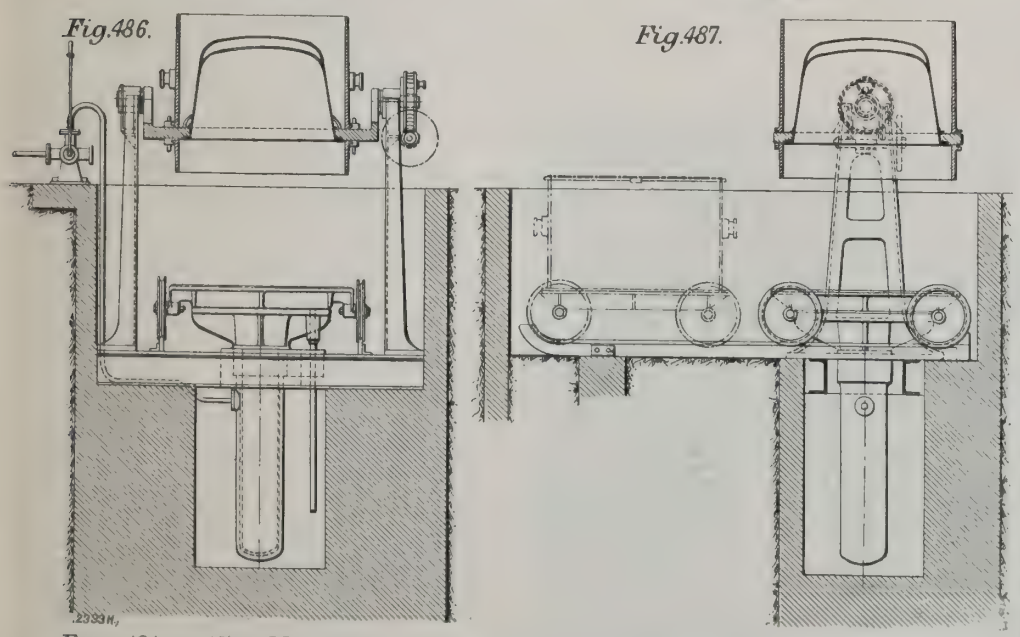


Figs. 480 and 481. Machine for Radiator Bases.



Figs. 482 and 483. Machine with Turn-Over Table and Trolley.





Figs. 484 to 487. Machines which Combine Hand-Ramming with a Mechanical Lift; the Badische Maschinenfabrik und Eisengiesserei, Durlach.

FOUNDRY PLANT AND MACHINERY. No. XXX.

By Joseph Horner.

The stripping-plate or draw-through type of machine is indispensable when deep patterns have to be moulded from. Many hand-machines of simple design are fitted thus, in large as well as small dimensions, using a combination of levers, or of levers and gears for the drawing of the pattern through the plate. A few illustrations are selected of non-turn-over-table machines of this kind, built by the Badische Maschinenfabrik und Eisengiesserei, of Durlach. The general design, modified in details to suit different classes of patterns, and also patterns in a large range of dimensions, is that of a pull-through plate A, Figs. 472 to 475, to which the pattern is attached, and the stripping-plate B, through which it is drawn. The latter is bolted to the standards of the machine and receives the moulding-box. The plate or table A is actuated by means of pinions and racks. The pinion-shaft is operated by a lever in some cases, by a hand-wheel in others. A locking device is used to retain the table A at the correct height during ramming. It consists of a notched disc on the rack-shaft, held with a pin or plunger dropped directly into a notch, as in Fig. 472, or by a lever with a projecting pin, as in Fig. 474 and in subsequent illustrations.

The examples shown are representative of the utilities of this class of machine, utilising stripping-plates. The machine shown in Figs. 472 and 473 is used for steam fittings of various kinds, of which the valve body shown is typical, being patterns with deep flanges, and box-shaped patterns generally. The machine shown in Figs. 474 and 475 is for fire-bars, and deep, thin patterns arranged in rows. Pipes, columns, stretchers, cylinders, and that class of work are done in machines illustrated by Figs. 476 and 477, to take boxes ranging from 39 in. to 170 in. in length, and in proportionate widths. The radiator-pipe patterns in Figs. 478 and 479 are mounted in two parts. The pull-through plate carries the pattern of the body of the pipe only, and this plate is provided with slits to embrace the ribs or gills. Another plate carries these ribs only, which are drawn through the slits of the pull-through plate.

The machine which is moulding radiator bases, Figs. 480 and 481, is one in which, instead of pulling the pattern downwards through a stripping-plate, the box is lifted off the pattern by the same mechanism of gears and lever as in the other examples. Four pins pass through the pattern-plate and lift the box part with its mould. The lengths of these pins are adjusted to suit different depths of lift. Here the patterns are shallow, and their convex sections provide ample taper.

Figs. 482 and 483 show a hand-moulding machine with turn-over table and work-carrying trolley. The pattern parts are attached to opposite sides of the table, which is turned over with worm gear, and the box parts are attached to the table by means of centering studs. The top part is first filled and rammed, and then the columns which sustain the bearings are raised by the hand-wheel and worm gears sufficiently high to allow the table with its box parts to be turned over, following which the other box part is rammed. The cottars are then taken out, the table rapped and lifted from the box, leaving the latter on the trolley. Afterwards the table is reversed, and a new box part placed on, &c.

One group of machines includes a combination of hand-ramming and mechanical lifting. One of these, by the Badische Maschinenfabrik, is shown by Figs. 484 and 485. Its turn-over table and trolley arrangements are in the main similar to those in the machine just shown, but the trolley-table is lifted and lowered instead of the pattern-table. This is done by an hydraulic ram; if no plant is laid down, a hand-pump may be substituted. Figs. 486 and 487 show a heavy machine of this type suitable for deep work. Other modified forms are built, and in the entire series a very large range of dimensions is secured, from boxes of about 16 in. by 12 in. up to 172 in. in length, and in numerous widths and depths.

Russian State Railways.—A special commission has been appointed to consider the replacement of 3000 locomotives of no great power upon the Russian State Railways. The replacement is to be effected in the course of the next ten years, and it is proposed to put 1200 powerful engines of a new type upon the system.

VERTICAL DRILLING-MACHINE FOR REPAIR-SHOPS ON SHIPBOARD.

CONSTRUCTED BY THE BRITANNIA ENGINEERING COMPANY (1910), LIMITED, COLCHESTER.

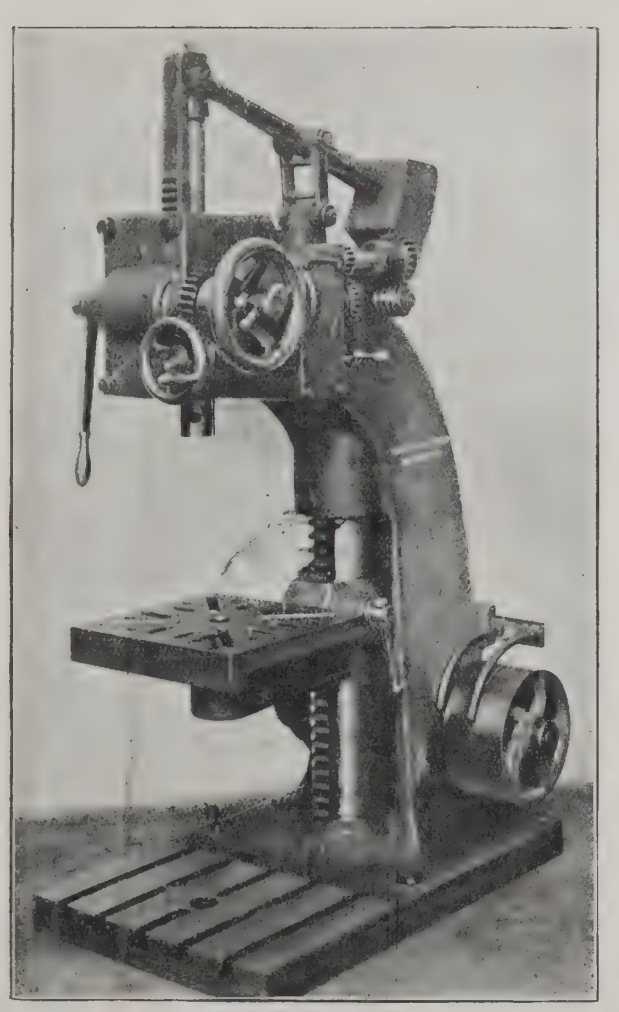


FIG. 1.

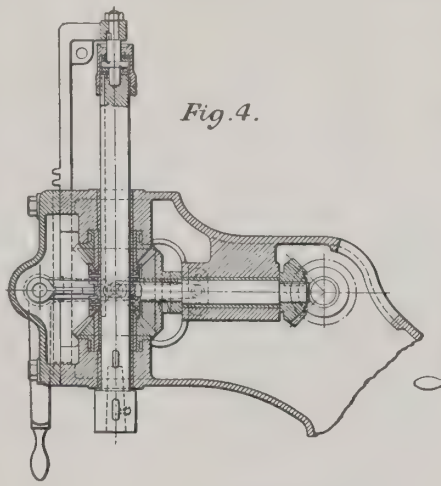


Fig. 4.

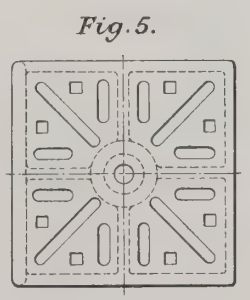


Fig. 5.

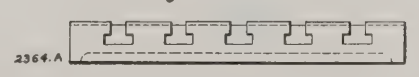


Fig. 6.

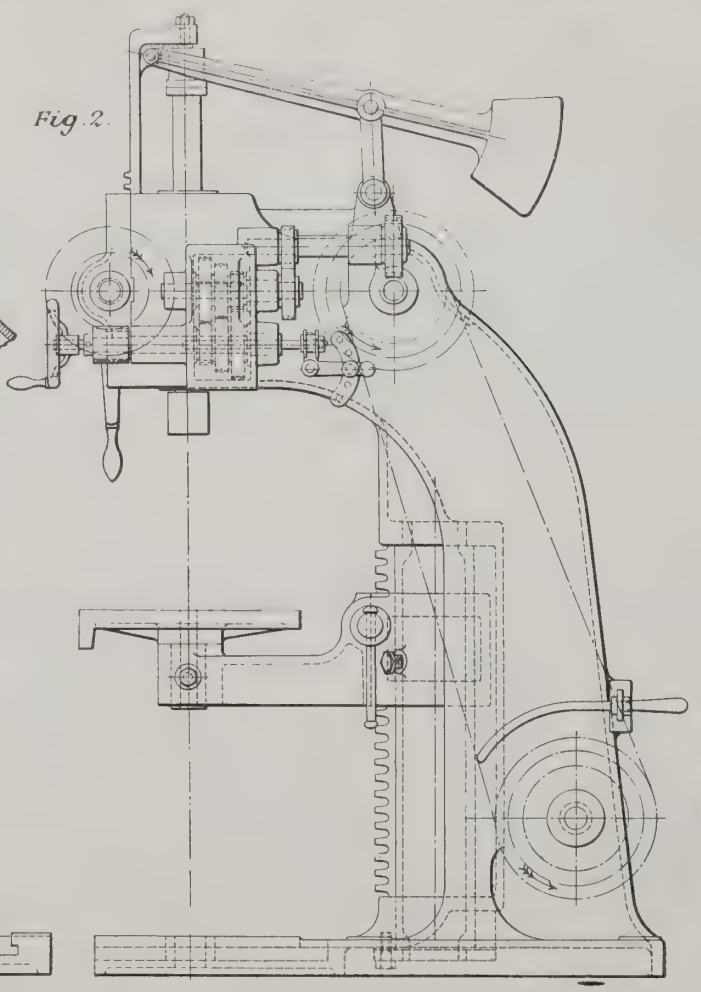


Fig. 2.

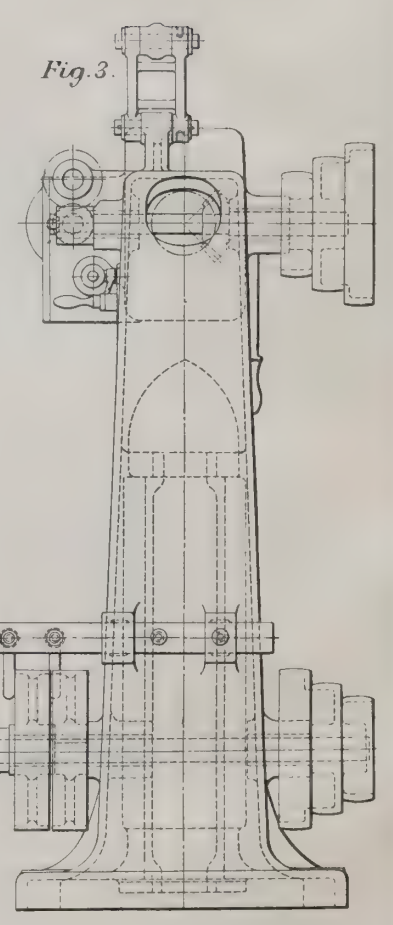


Fig. 3.

IN the half-tone engraving, Fig. 1, and the drawings, Figs. 2 to 6, herewith, we illustrate a drilling-machine constructed by the Britannia Engineering Company (1910), Limited, Colchester, and specially designed for use on board ships where the head-room is very limited. The total height of the machine, which is capable of drilling 1½-in. holes out of the solid, and of boring up to 5 in. diameter, is no more than 5 ft. when the spindle is at its highest. Fig. 2 gives a side elevation of this machine, and Fig. 3 a back elevation. A section through the head is given in Fig. 4, a plan of the table in Fig. 5, and a section through the base-plate in Fig. 6.

The machine is well up to the requirements of high-speed steel, and may be used for drilling, boring, tapping, &c. The cone pulleys are of large diameter and arranged for three spindle speeds—viz., 162, 250, and 385. The main spindle is of forged steel, 1⅞ in. in diameter, running in gun-metal bearings, provided with adjustment. It is furnished with a counterweight, and is driven by cut bevel-gearing. A clutch is provided in the head, so that the spindle may be started, stopped, or reversed from the operator's position in front of the machine. Hand instead of automatic feed may also be operated from the same position. The feeds are positive, three changes being provided. Change from one to another is instantaneous and controlled by a lever at the side of the head. A quick hand-motion for withdrawal of the spindle is also provided in connection with the hand-feed.

The spindle has a travel of 6 in., and the machine will take work on the table up to 22 in.; while if the table is swung clear and the base-plate employed, there is a clear height of 2 ft. 7½ in. between the spindle and base-plate. The table is arranged with rack and pinion vertical adjustment. It is carried on a stiff pillar, and can be swung to either side. The table-plate itself swivels on the supporting bracket. As shown in Fig. 6, the base of the machine is also finished with T-slots, so that work may be bolted to it.

PRINCE RUPERT.—A newly organised undertaking, known as the Prince Rupert Hydro-Electric Company, will control all the principal water-powers in the neighbourhood of Prince Rupert. The new company will commence with a large list of Canadian shareholders. Prince Rupert will be the Pacific terminus of the Canadian Pacific Railway.

THE PETROLEUM SPRINGS OF TRINIDAD.—The petroleum springs close to the well-known asphalt island and conveniently situated for export are now being worked, and the first tank steamer left La Brea at the end of April for New York. The Trinidad petroleum springs are expected to prove a somewhat serious rival to the springs in Texas and Pennsylvania, and tank installations are contemplated, for instance, in the Island of St. Thomas, opposite Water Island.

WIRELESS TELEGRAPH STATION FOR THE ITALIAN GOVERNMENT.—We understand from *Marconigraph* that a contract has been entered into by the Marconi Wireless Telegraph Company, Limited, and the Italian Government for the erection by the company of a 60-kw. station in the vicinity of Rome. The building, masts, and material are being supplied by Marconi's Wireless Telegraph Company, Ltd.; the erection of the masts is being carried out through the intermediary of the Italian agency. The towers will be of the Coltano type, six in number, the material used being iron and wood. Two of them are each to be 246 ft. high, and the others 147 ft. high. The towers will support a multiple wire T aerial of a total length of 1180 ft., and the surface occupied by the aerial will be about 16,800 sq. yards. The buildings will contain engine, power, battery, and operating rooms, as well as stores, waiting and staff rooms, &c. The engine-room will have a floor space of 32 ft. by 25 ft., and will contain duplicate 50-brake-horse-power Diesel engines, each driving by means of a belt a 30-kw. continuous-current dynamo. For regulating the frequency of the discharge-circuit two 32-kw. low-frequency inductances will be provided to the value necessary for the number of sparks adopted, and in addition two 32-kw. high-tension transformers will be installed to transform the alternating current by the group of generators to the required voltage for the condensers. There will be a valve receiving apparatus adapted to all wave-lengths comprised between 2650 and 6500 metres. A magnetic detector will also be provided in addition to the receiver. The station is to test to Poldhu, and will have a normal power of 32 kw. and overload up to 100 kw. We understand that the exact arrangement of the plant for this overload has not yet been settled.

ELECTRIC TRACTION IN SWITZERLAND.*

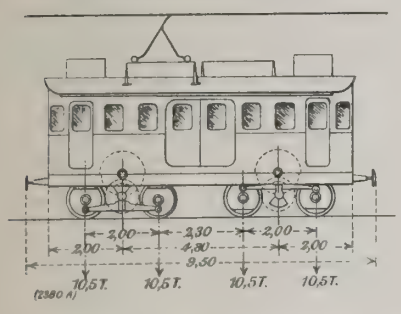
By E. HUBER-STOCKAR, of Zurich.

(*Continued from page* 127.)

Seebach-Wettingen, Figs. 22 to 28 (No. 9 on Tables IV. and V.,† to be given later).—This electric railway was not installed or operated for directly commercial purposes. It was an experiment, and, as it was technically successful, a demonstration of a then new method of electric operation of railways. The line on which the experiment was made is one which would be electrified among the very last, if all things were considered; it was chosen because of the proximity of one of its ends to the works of the M.F.O.

This experimental plant was removed after having given proof of the reason for its installation. Instead of twelve months, as fixed by agreement of November 22, 1904, between the Federal Railways and the M.F.O, it was in regular service for almost one year and a-half, mainly because the Federal Railways wanted further time to consider whether they should purchase the plant, though electric traction had no commercial reason to exist on that particular section of their system. The experimental plant has since been removed or used for other purposes. The owners of the plant have been paid for traction duties performed, and a considerable portion of their expenses in excess of receipts from traction has been refunded to them.

Fig. 22. SEEBACH-WETTINGEN SINGLE-PHASE ELECTRIC LOCOMOTIVE 500 H.P., 1905 PATTERN. (MASCHINENFABRIK OERLIKON.)



As early as at the beginning of 1902 it was proposed in a few quarters to use single-phase alternating current for electric traction instead of continuous current or three-phase alternating current. In a paper‡ read before the Zurich Society of Engineers and Architects on February 27, 1902, the author of this paper maintained that the electrification of the principal railways of Switzerland could be carried out best by the adoption of single-phase alternating current of a low periodicity of about 15 and of a high voltage, neither higher nor much lower than 15,000 on the contact line.

In a more general way, and independently of the author, Messrs. W. M. Mordey and B. M. Jenkin advocated single-phase current in a paper read before the Institution of Civil Engineers in London almost exactly at the same time (February 18, 1902).

In a few words, single-phase current methods overcome the principal limitations of continuous and three-phase current methods in their application to railway electrification generally, namely that of contact-line voltage with continuous and that by complication of contact-line construction with three-phase current. While the latter limitation is evident and simple, the former hides itself behind the great cost of plant for contact conductors, feeders and converter-station machinery and buildings, and behind the great expenses for the operation and maintenance of such machinery. Complication does, however, not limit three-phase traction directly; it limits indirectly by limiting the voltage applicable to the contact line, thus acting, though in a much higher region of voltage and in a lesser degree, as the low-voltage feature of continuous current acts.

To-day, after these considerations have become almost universal convictions in electric-traction engineering circles, all this sounds very evident. But it is not very long ago that there were no other means of persuading Governmental and railway authorities to agree with such revolutionary departures as 15,000-volt single-phase current for traction, seemingly unsafe in operation and dangerous to life, except the experiment on a large scale without any claim for reward. That is the reason why millions of money have been spent by the manufacturers of electric-railway plant in experiments, and this is the reason why the experiment on the Seebach-Wettingen section of the Federal Railways was promoted and carried out.

It was done in steps, beginning as early as 1901. First the high voltage of 15,000 volts, five times higher than the highest heretofore adopted for permanent purposes of traction (Berlin-Zossen experiment 10,000-volt three-phase) was to be shown to be practicable and safe. Next came the construction§ of single-phase traction-motors of considerable power, at that time a problem hardly touched. Then the difficult problem of telegraph, and more particularly of telephone, disturbance had to be solved practically, because in Switzerland a very great mileage of telegraphs and telephones go close alongside the railways. After that, a regular service of trains on a schedule, as is customary with steam railways, had to be performed throughout all the seasons of a year. Lastly, the electric locomotive, and the single-phase one in particular, had to be shown as being powerful, easy of operation, and flexible in speed control as a steam-locomotive, that is, capable of simply taking the place of the steam-locomotive.

The result, given by the experimental line Seebach-Wettingen, has been very satisfactory. The report of the Board of General Managers of the Federal Railways reads as follows (translated):—"After this year of operation it can be said that the system of traction has justified its trial, and that the Maschinenfabrik Oerlikon deserves high recognition of their work. The experiments carried out are of a fundamental character and have much furthered the question of electric traction, as has been shown by the great interest taken in the experiment by railway engineering circles in Switzerland and abroad. It is certainly attributable to a great extent to the work of the Maschinenfabrik Oerlikon, that, during recent times, the opinion has gained much ground that single-phase alternating current of high tension and low periodicity is the obvious form of energy for electric traction purposes on normal gauge and principal railways."

Fig. 23. SINGLE-PHASE 15,000 VOLT, 15 CYCLES. LATERAL CONTACT. SEEBACH-WETTINGEN.

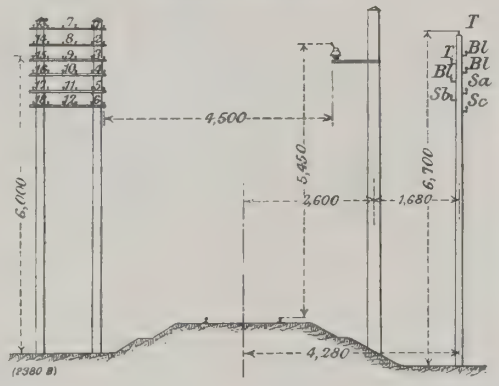


Fig. 24. OVERHEAD CONTACT. CATENARY SUSPENSION. SEEBACH-WETTINGEN.

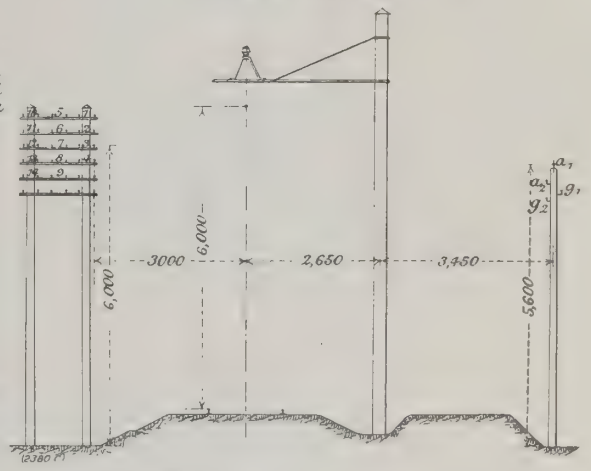
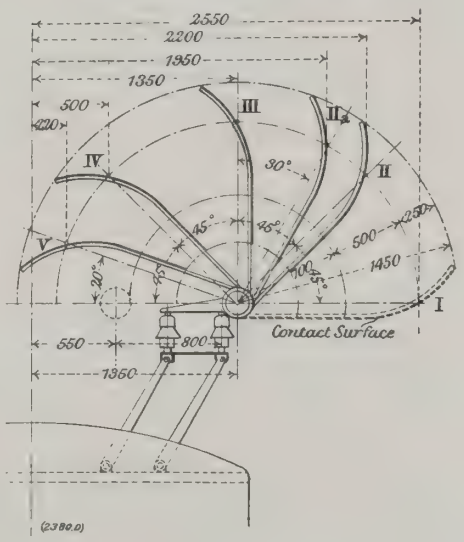


Fig. 25. CONTACT-ROD, RANGE OF POSITIONS. SEEBACH-WETTINGEN. (MASCHINENFABRIK OERLIKON.)



Neither frost nor snow nor thunder-storms have had any disturbing influence, and the high voltage has not caused any accidents for which it or the electric traction proper could be held responsible. The death took place of the stoker of a steam-locomotive in Seebach, who had climbed the driver's cabin and touched the contact-line with a stoking iron rod, in the same way that a stoker had been killed, at a voltage five times smaller, in the Simplon Tunnel service.

The power consumption per ton-kilometre was very small, though the locomotives were running on light load with the great majority of trains. It amounted to a little over 32 watt-hours per ton-kilometre measured at the high voltage end of the generating converter station. This is the lowest figure ever obtained in Switzerland in an all-year service; consequently it must be considered that the current was conducted by wires of small cross-section, and that the rail bonding was of a description otherwise considered inefficient in electric traction work.

The performance and general behaviour of the single-phase current locomotive-motors, which were at that time not only a novel thing in the art, but also, in this particular case, the most powerful ones of their kind, were as good as those of the best continuous-current traction-motors, and became the basis for the design of the motors of the locomotive for the Lötschberg Railway to be described later.

Though economy in construction of the experimental plant was aimed at, as far as seemed compatible with the success of the experiment, there were installed various types of contact line and special devices for safety and control. There were, for instance, line section switches for telemechanical operation from the station-master's cabin. Nine kilometres of the contact line were of a novel description; contact was made by a rod swivelling about a horizontal axis parallel with, and self-adjusting in, a plane perpendicular to the direction of travel. The contact-wire could therefore be placed on the top of insulators along the side of the track in a height ranging from 4 m. to 5 m., or suspended overhead about in the usual way or in any intermediate position by means of more special devices of suspension or support.

This system of a contact line has found permanent application on the Locarno-Bignasco (Valle Maggia) Railway (No. 10 on the tables, to be given later), and accounts, among other features inherent to single-phase methods, largely for the low cost of construction of that railway.

A feature inherent in this system of contact line is the comparatively low level at which the contact-wire must be placed to fully realise the advantages. The tendency now being to place the contact line high (6 m. to 7 m.) above the top of the rails, that system is not likely to be capable of a more general application.

Comprehensive Schedule of Data.

—	Locomotives I. and II.*	Locomotive III.
Electric equipment by ..	M.F.O.	S.S.W.
Mechanical part by ..	Winterthur	Borsig, Tegel.
Number of axles, all driving	4	4 (6)
Arrangement of axles ..	2 bogies	2 bogies
Total weight, complete tons	42	68 (75)
Weight of electric equipment .. .. tons	21	25 (33)
Maximum weight on single wheels .. tons	5.25	6.25
Length between buffers, metres	9500	13,700
Distance between outer axles .. metres	6300	10,100
Diameter of driving wheels .. metres	1050	1100
System of motors ..	Single-phase alternating series, voltage control of speeds. No. 1 contactors No. 2 controller	Contactors —
Voltage of motors ..	300	360
Ratio of transformer voltage	15,000 : 300	15,000 : 350
Capacity of transformers Kva.	2 × 250	2 × 500
Periodicity of alternating current	15	15
Power of one motor, one hour rating .. h.-p.	250	225
Mechanical arrangement	Motor high, single reduction gearing, counter crank-shaft below, crank-pin attaching middle of connecting rod	Motors low, totally enclosed, single reduction gear, spring suspension as usual on motor-cars
Ratio of gearing	1 : 3.08	1 : 3.72
Number of motors per locomotive	2	4 (6)
Normal total pull on tread .. .. .. kg.	3400	5400 (8100)
Normal speed per hour km.	40	45
Maximum speed per hour km.	60	60
Contact	rod and bow	rod and bow
Brakes	Pressure air.	

* Commenced running, November 11, 1905.

In 1906 the S.S.W. joined the M.F.O. in completing the experimental plant, in widening the scope of the

* Paper read before the Institution of Mechanical Engineers, at the Zurich Meeting, July 25.

† See Studer, *Schweiz. Bauzeitung*, vol. li., Nos. 15, 16, 17, 19, 20.

‡ E. Huber, *Schweiz. Bauzeitung*, vol. xxxix., Nos. 10, 11, 12.

§ A single-phase electric-motor exactly as was adopted for the locomotives Nos. I. and II. was completed and tested in the M.F.O. in July, 1904.

experiment and in carrying it through. The S.S.W. constructed the western portion of the contact line, about 12 km. on the catenary system, and added to the two locomotives Nos. I. and II., built by the M.F.O., a third locomotive of considerable power. The method of battery storage in connection with alternate-current traction was practically tried in co-operation with the Accumulatorenfabrik Oerlikon.

A regular service was performed from December 1, 1907, for a period of about one year and a-half, with a few interruptions, for the purpose of making additions. From December 1, 1907, till November 30, 1908, there have been run approximately 84,000 train-kilometres in regular public service. Before December 1, 1907, trial runs of different kinds were performed, aggregating over 18,000 locomotive-kilometres and over 27 millions of ton-kilometres.

The design and appearance of the locomotives of the Seebach-Wettingen electric traction are sufficiently explained by the illustrations on this page; it will only be necessary to give the comprehensive schedule of data which will be found in the preceding column.

Locomotive No. I. was constructed as early as 1903. With regard to the B.T.B. locomotives, type 1899, the combination of high-level motors, geared to a counter-crank-shaft below with connecting rods, was not precisely novel in electric locomotive design. In the B.T.B. locomotives, however, the gearing formed an integral part of the speed-control devices. In the locomotives Nos. I. and II. of Seebach-Wettingen they were adopted to combine high-speed motors of medium power (economical and cheap) with a low speed of travel, and at the same time to relieve the axles from all shocks from masses not entirely spring-suspended. The gears of the V-shaped spiral pattern have behaved wonderfully. By that arrangement the advantages of bogies with all wheels driving and evenly loaded are combined with those of motors accessible and open within the cabin. This arrangement is found again in the type 1910 of locomotive No. III. of the B.T.B.

The Seebach-Wettingen experiment proved the practicability of adopting high-voltage low-frequency single-phase traction on regular railways in general, the qualities of the single-phase motor as a traction motor for heavy duty, and the perfect flexibility and economy of single-phase traction motor-speed control, inherent to it and by artificial means.

One need not waste words about the ideal simplicity of construction of, and the ease and safety of, dealing with economically high voltages and large power effects in the line of contact realised by single-phase traction, though these are the chief reasons for the preference now being shown for this mode of electric traction. It must, however, be pointed out that single-phase motors have characteristic features, formerly held as a monopoly by continuous-current motors, which make them so suitable for traction.

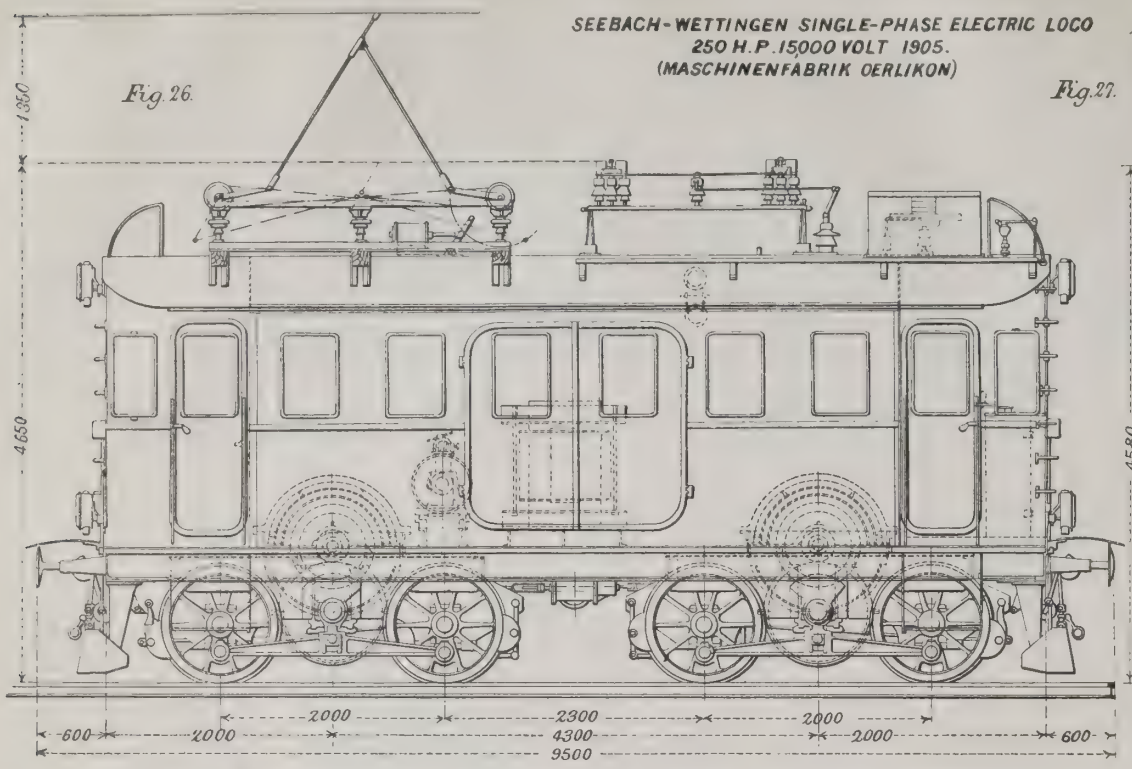
Certainly a one-speed induction motor is more attractive to the driver at first sight. It practically relieves him from a good deal of attention in maintaining speed, and prevents the possibility of making up lost time except down-hill; it removes a large part of the responsibility from the driver on to the central station attendant (for keeping voltage), and to the train-master (for not coupling on too much load). The one-speed, and to a certain extent also the multi-speed, induction motor runs faster up-hill and slower on the level, as it might safely and economically do. It runs on a hilly line for a large portion of the time either too fast or too slow, and takes either too much or too little power as is desirable for the best shaping of the load diagram at the power-station. Admittedly experienced drivers can, if the conditions are not too adverse, overcome by skill these and various other drawbacks of the induction motor to a certain extent. It is, however, obvious that a properly-designed motor, like the single-phase, though always ready to accelerate, if desired, even above its so-called normal speed, but with an inherent tendency to adjusting itself to constant power (by variation in torque inversely to variation in speed), must be beneficial to the shape of the load-line, and not disadvantageous to the traffic requirements as a whole.

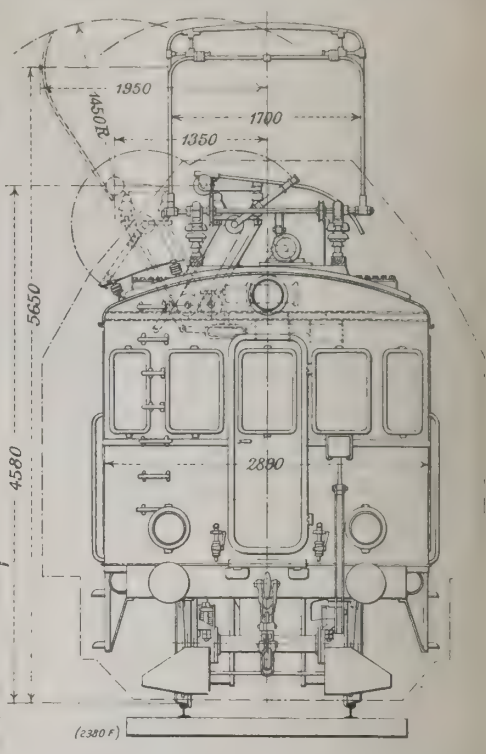
With cheap power in excess, or with a very great number of light trains running at the same time, the operative and economical importance of the flexibility of motors is greatly reduced; but those conditions do not obtain on railways in Switzerland.

The railways still to be described in this paper, and the majority of electrifications completed recently, or being planned in Switzerland and abroad, are based on single-phase current of high voltage (independent short lines 5000, long lines, lines with heavy traffic, or lines to be extended into systems, 10,000 to 15,000 volts), and of low periodicity (mostly fifteen on the European continent, twenty-five in England and America). By this the author does not mean to say that this is the outcome of the Seebach-Wettingen experiments, but that evidently, now, the conception of it is sound.

The Lötschberg electrification (No. 15 on the Tables to be given later) should be considered immediately after Seebach-Wettingen, as it is that electrification in Switzerland which was contracted for first after the Seebach-Wettingen experiment, and follows most exactly the general lines determined by that. For reasons to be given under the head of the Lötschberg, however, two other electric railways will be treated first.

(To be continued.)





The Port of Libau.—The Russian Government intends to develop Libau—the only Russian port on the Baltic which is open almost throughout the year—as a commercial port, in which respect it has hitherto been greatly neglected, the works having been almost exclusively confined to naval requirements. The cost is calculated at some 5,000,000 roubles (about 520,000*l.*). The building of elevators and other plant will be left to private enterprise.

British Trade with Australia.—According to the *Board of Trade Journal*, Mr. C. Hamilton Wickes, H.M. Trade Commissioner in Australia, who has recently been in this country under instructions, is now on his way back to Australia, and any inquiries which British firms wish to address to him should be sent to his office at Equitable Building, Melbourne. The object of Mr. Wickes's visit to the United Kingdom was to visit the principal industrial centres and to afford British manufacturers an opportunity of consulting him with regard to trade conditions and openings in the Commonwealth. During his stay Mr. Wickes visited twenty-four chambers of commerce and interviewed over 400 firms.

The late Mr. William Isaac Last.—Many people will hear with regret of the death on the 7th inst., at the early age of 54, of William Isaac Last, director of the Science Museum at South Kensington. He was educated privately, and, having a strong mechanical bent, was apprenticed in 1873 with Messrs. Hayward Tyler and Co., just when they were engaged in introducing some new specialities, such as the universal steam-pump. When barely 20, Mr. Last won the Senior Whitworth Scholarship, and, during his three years' tenure of it, carried off two first and one second prize, besides the first prize for the whole period. His scholarship was spent at Whitworth's Openshaw Works, meanwhile attending classes at Owens College. He was with the Hull and Barnsley Railway for a short time and then went out to Port Elizabeth, South Africa; but quickly realising the limited scope of the work there, he came back to England and joined the staff of the Brush Company. In 1890 he was appointed to the post of keeper for the machinery and naval divisions of the South Kensington Museum. Here his keen mechanical instinct had full play; he was instrumental in putting down a plant for showing objects in motion by low-pressure air; he reorganised the collections and endowed them with an interest and attractiveness hitherto lacking. Mr. Last's abilities were recognised in 1904, when he was appointed to succeed Major-General Festing, F.R.S., as director of the whole museum. It is sad to reflect that Mr. Last has been removed from the scene of his labours just when there is every prospect of a new building worthy of housing the science collections being erected. Mr. Last was elected, in 1886, an Associate Member of the Institution of Civil Engineers, and was frequently to be seen at the meetings. For his paper on "Setting Out the Curves of Wheel-Teeth," in 1887, the Council awarded him the Watt Medal and the Telford Premium. Mr. Last was of an unassuming disposition, but was a keen engineer, of sound judgment. He leaves a widow and three children.

INDUSTRIAL NOTES.

ON Sunday last it was announced that the London dock labourers on strike had, by the arbitration award of Sir Albert K. Rollit, gained their point, which was an increase to 8d. per hour ordinary time, and to 1s. per hour overtime. The announcement was formally made at a mass meeting of the men held in Trafalgar-square on Sunday afternoon. The questions in dispute were between the shipowners and the National Transport Workers' Federation, and the arbitration arose out of the agreement of July 27 between the Port of London authorities and their men, the questions in dispute being:—Whether, in view of the increase of pay granted by the Port authority and wharfingers, there shall, or shall not, be an increase of pay to 8d. per hour to men at present employed at 7d. per hour, and also whether there shall, or shall not, be an increase in the rate of overtime pay to 1s. per hour where such is not paid at present. This to apply only to the discharge of vessels engaged in the oversea trade, where the operation is carried on by shipowners or their contractors. The award took effect last Monday.

Unfortunately, however, this award did not put an end to the trouble at the London docks, for it was made clear by the men's leaders on Monday that, until the claims of other classes belonging to the National Transport Workers' Federation have been dealt with, the strike will continue. This intimation was very conspicuously announced at the men's meeting in Trafalgar-square by a large white banner, on which were the words: "No man to return to work unless ordered by the Transport Workers' executive." In consequence of this the London docks are at a standstill until the matter is settled. A complete settlement must, the leaders say, embrace the carmen, the lightermen, coal-porters, deal-carriers, and a section of the labourers and the engineering departments. Matters stood thus until Tuesday, when there was a meeting of the men's delegates and the representatives of the employers with the Port of London authority. Work was at a standstill among the riverside workers on Tuesday, and the effect of the strike was already felt in a shortness of sea-borne provisions in London. All work was stopped, with the exception of the removal of decaying refuse, the maintenance of the main drainage system of London, and the supply of fresh water to ships. The demand of the lightermen is for a uniform rate of pay, for hitherto there have been two rates—one for daily men and another for weekly men—and the men under the weekly arrangement have been, it is said, "manipulated" against the daily men, to the advantage of the employers.

There was no particular development of the dock strike on Tuesday, but a number of carmen ceased work. Nothing definite in the way of a settlement was arrived at. The number of carmen who had joined the strike up to Tuesday was estimated at 10,000, and processions marched during the day from Tower-hill to Victoria Docks and the Surrey Commercial Docks, committing some outrages on the way. Tuesday's conference at the Board of Trade raised some hope of a settlement. It was agreed by the owners that if the men's representatives would obtain power to settle they would try and arrange matters on Wednesday. In the evening of Tuesday the men's representatives obtained this power. In the case of the lightermen, however, their representatives continued in conference with the masters until nearly midnight, and then adjourned till the following day, as no settlement had been arrived at. The spirit of unrest appears to have become chronic among the men, and the masters are, not without cause, beginning to resent bitterly the unsatisfactory, unstraightforward methods of the men. If by those methods the masters are driven to take active steps towards the adoption of more aggressive measures, the men will in the end be the chief sufferers. The employers complain that they met those who profess to be the leaders in a conference and drew up an agreement which was signed by the representatives of both parties, to which they say they themselves firmly adhere. Although this agreement had been signed by the men's representatives, the men struck. Arbitration followed as was arranged in the agreement, and the decision went in favour of the men; but the masters were prepared to abide loyally by the award. In spite of this, however, the dockers and stevedores, who are the only men whom the shipowners themselves employ, will not return to work because other workmen have disputes. No one appears to know what the stevedores' grievances are, or whether they even have any. All that is known is that, in spite of the settlement, the men have not returned to work. Under these circumstances it will not be surprising if the masters make other arrangements quite independently of the malcontents.

Up to the time of going to press there was no improvement in the outlook; on the contrary, the trouble had spread. On Wednesday it was stated that as many as 97,000 men were idle in connection with the dockers' strike, and there is now a great shortage of meat, fruit, fish, eggs, cheese, and ice. Conferences with the coal-porters and lightermen took place, and were adjourned without settlement; every man employed in the London docks was called out; more carmen, to the number of 10,000, joined the strike; some of the Billingsgate fish-porters decided to strike, and riotous scenes occurred in many districts. These were the leading features of the day in connection with the strike.

There appears to be a great deal of unrest on the railways in different parts of the country. At Liverpool, at the beginning of this week, the trouble that had been brewing for some time developed, and the number of strikers reached about 2500, being composed chiefly of goods and passenger porters, shunters, and van-drivers. Beginning with the Lancashire and Yorkshire Railway, the strike extended to the London and North-Western Railway; on the latter railway the advice of the men's leaders has been disregarded, and the men came out without giving notice, although they are working under an agreement that does not expire till 1914.

The developments of the trouble on Tuesday were not serious, although they were calculated to increase public inconvenience, particularly to business men of Liverpool. The total number of men out on Tuesday was about 4000. Fish and fruit merchants claim to have suffered great loss. The Preston men of the Lancashire and Yorkshire Railway Company gave forty-eight hours' notice that it is their intention to refuse to handle goods coming from Liverpool.

At the time of going to press there was no improvement in the situation.

There is also trouble again on the North-Eastern Railway at Hull, for in order to support the Great Central Railway men who are now on strike at New Holland, the railway workers at Hull decided not to handle goods of the Great Central Railway Company, and 250 wagons belonging to that company were left unloaded outside the Kingston-street warehouse in Hull. A number of men on the Great Western Railway suddenly left work last week, but they returned on the advice of their leaders, and met on Sunday to draw up their demands. Among these demands are the abolition of the bonus system, and time and a quarter for all time over 60 hours per week, and an immediate increase of wages from 1s. to 2s. per week.

In Manchester 20,000 skilled and unskilled workmen have been rendered idle by the strike of the engineers' labourers. Among them are many of the employees of the Lancashire and Yorkshire Railway Company. The strikers who were out a month ago are giving trouble. When the dispute previously ended the question was the amount to be paid for overtime. On this point the masters and men cannot agree, and the assistance of the Board of Trade has again been sought.

On Monday last the National Gas-Engine Company, Limited, Ashton-under-Lyne, who employ nearly 2000 hands, closed their works on account of a strike of labourers for a minimum wage of 1*l.* per week.

The railway porters and shunters on strike at Swansea returned to work on Tuesday last on the former terms.

There now appears to be some hope that the weavers' dispute in Skipton, which has now been on for a considerable time, may be settled, for the Board of Trade has intervened with a view of arranging an agreement satisfactory to both sides. There are about 2000 workers idle in the town. The weavers declare they will not withdraw from the demand they have made, which is the Colne list less 5 per cent.

The dock labourers at Grangemouth again came out on strike on Tuesday last. The men demand eightpence per hour for day-work and tenpence per hour for night-work, and only union men to be employed. The men held a mass meeting on Monday evening last and determined to remain out until their demands were granted. The masters decline to give an advance for day-work, and also resist the demand for recognition of the right of union men to refuse to work with non-union men.

The Scandinavian labour troubles have undergone no actual change during the past week. Mediation is progressing, or rather is being proceeded with, both in Norway and Sweden; in the latter country an agreement is hoped for within a few days. In Norway nothing definite has transpired, but the prospects of a speedy settlement appear less favourable there. In Denmark the men of two Copenhagen tramway companies have gone out. They have now been formally discharged and ordered to give up their uniforms, &c. A number of new hands have been engaged and the traffic has been kept up on a limited scale.

The quarterly report of the General Federation of Trade Unions for the quarter ending June 30 last has recently appeared, and shows that the following societies were affiliated during the quarter:—The General Iron Fitters' Association, the Sett-Makers' Union, and the Spring and Doffing-Plate Makers, while the Frost Cog, and Screw-Makers have amalgamated with the Gasworkers, Brick-Makers, and General Labourers, Birmingham. The number of disputes during the quarter ended June was 157, and the number of men involved 2879, or an average of 18.33 per dispute. There was an excess of income over expenditure, the income being 8621*l.* 3s. 4d., and the expenditure 6780*l.* 12s., leaving 1840*l.* 11s. 4d. to go to the reserve.

"AVAILABLE HEAT IN STEAM BOILERS."

TO THE EDITOR OF ENGINEERING.

SIR,—I beg to correct a numerical error in my article on "Available Heat in Steam Boilers," published in your issue of June 23.

Taking as an example the case of one of Professor A. H. Gibson's experiments, it was stated that the heat required to convert the moisture in the air-supply into the condition in which it reached the chimney was about 3.4 per cent. of the heat value of the fuel. The figure ought to have been 0.5 per cent., and the effect on the boiler efficiency also about 0.5 per cent. instead of 3.5 per cent. as stated.

Kindly publish this correction.

Yours sincerely,
T. B. MORLEY.

James Watt Engineering Laboratories,
The University, Glasgow, August 1, 1911.

COLLIERY DEVELOPMENTS.—The New Hucknall Colliery Company, Limited, is about to commence operations upon what is believed to be a new large coal-field between Cuckney, Warsop, Budby, and Welbeck, and comprising in all about 5000 acres. It is expected that the top hard seam will be reached at a depth of from 600 to 650 yards. A branch will have to be constructed to connect the field with the Great Central Railway. Sinking operations at the Yorkshire Main Colliery, near Doncaster, have resulted in the striking of a seam 6 ft. thick at a depth of 915 yards. Sinking was commenced rather less than two years ago.

TECHNICAL MUSEUM IN VIENNA.—In commemoration of the sixtieth anniversary of Emperor Francis Joseph's reign, Austrian manufacturers, with the assistance of the State and the City of Vienna, have initiated a technical museum. The foundation-stone was laid on June 20, 1909, and the building, which covers an area over 20,000 square yards, and which is situated opposite the palace of Schoenbrunn, is now nearing completion. This Technical Museum is to demonstrate the development of industries and crafts in historical succession, also to do justice to the technical achievements of the present day, and to promote progress in this line by periodical exhibitions. It is to be a public educational centre, spreading the knowledge of the scientific foundations and the national economic aims of technical pursuits. A considerable stock of objects has already been secured, as several large and valuable State collections, till now dispersed, are shortly to be brought together there. Everything pertaining to technical labour is acceptable, principally tools, machines, apparatus, models, materials, methods of working, finished articles, as well as plans, designs, books, illustrations, and manuscripts. Further particulars can be obtained from the office of the Technical Museum, Vienna, I. Ebendorferstrasse 6.

"Y" OR MAYURI STEEL.—This steel, which is manufactured by the Pennsylvania Steel Company, U.S.A., is a natural alloy chrome-nickel-steel containing 1.2 to 1.5 per cent. nickel, 0.3 to 0.6 per cent. chromium, phosphorus not over 0.03 per cent., sulphur not over 0.04 per cent., manganese from 0.3 to 1.00 per cent. (ordinarily about 0.5 per cent. manganese and carbon as required). It is manufactured by the open-hearth process, and in the natural rolled or forged condition has about 10,000 lb. per sq. in. higher elastic limit, and 8000 lb. to 10,000 lb. per sq. in. higher tensile strength than carbon steel having the same amount of carbon, with the same elongation and reduction, or, with the same tensile strength, a greater elongation and reduction of area. It can be rolled, forged, or pressed into shape as easily as carbon steel, and can be as readily shaped into any form. Tests show that in the heat-treated condition it gives results practically identical with heat-treated nickel-steel of 32 per cent. nickel and the same amount of carbon. "Y" steel may be used in any place where carbon-steel is now used, and in the natural or heat-treated condition it machines well up to a tensile strength of 125,000 lb. per square inch, and about 12 per cent. elongation in 2 in. The three most widely-used grades of the steel are grade A, which is a mild steel having from 0.15 to 0.25 per cent. of carbon, and from 1.2 to 1.5 per cent. nickel; grade B, with from 0.25 to 0.35 per cent. carbon, and from 1.2 to 1.5 per cent. nickel; and grade C, which may be used for heavy classes of work, and containing from 0.35 to 0.43 per cent. carbon, and from 1.2 to 1.5 per cent. nickel. This last grade is largely used for locomotive and car-axles, heavy automobile truck-axles, forgings requiring great strength, connecting-rods, piston-rods, &c. By varying the carbon and the manganese any desired grade may be obtained. The steel can be supplied in square or round merchant bars or in 4-in. by 4-in. billets.

FOUR-CYLINDER PASSENGER LOCOMOTIVE AT THE TURIN EXHIBITION.

CONSTRUCTED BY THE SOCIETÀ ITALIANA ERNESTO BREDA, ENGINEERS, MILAN.

Fig. 3.

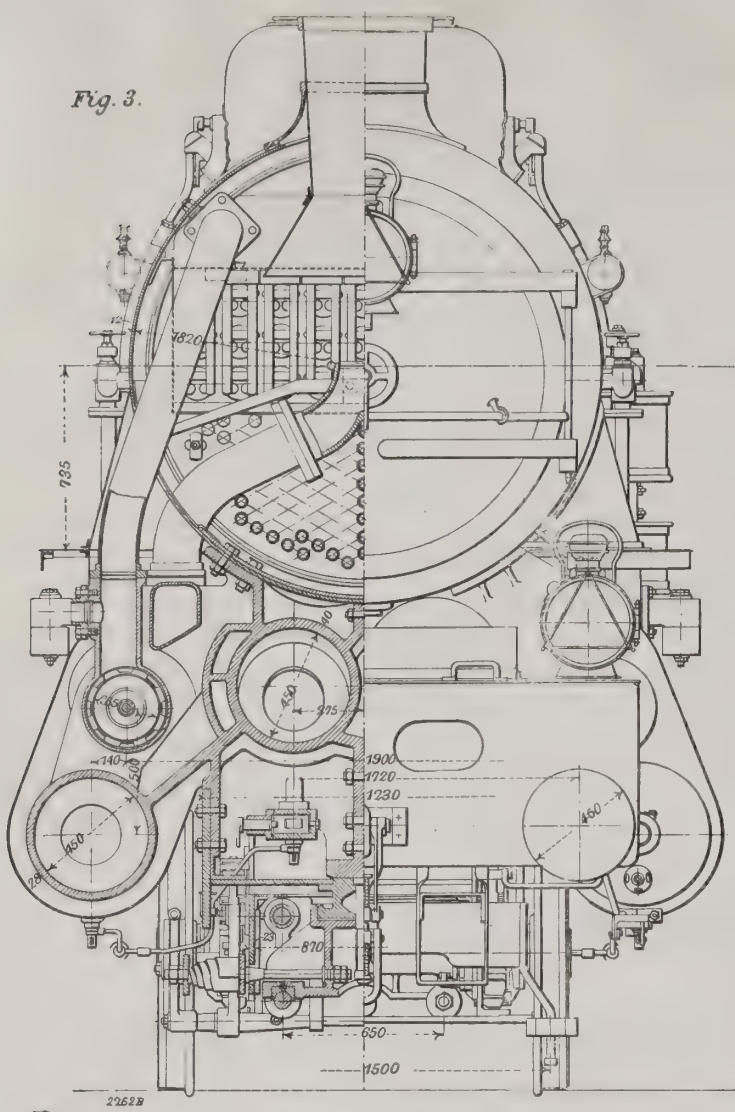


Fig. 4.

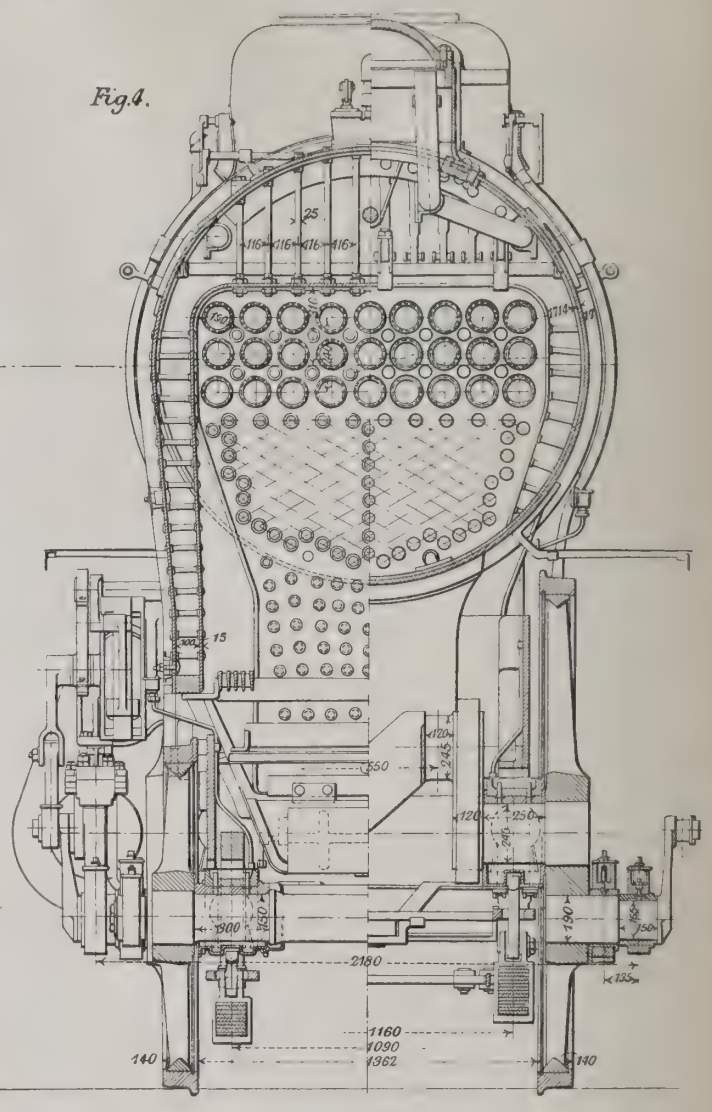
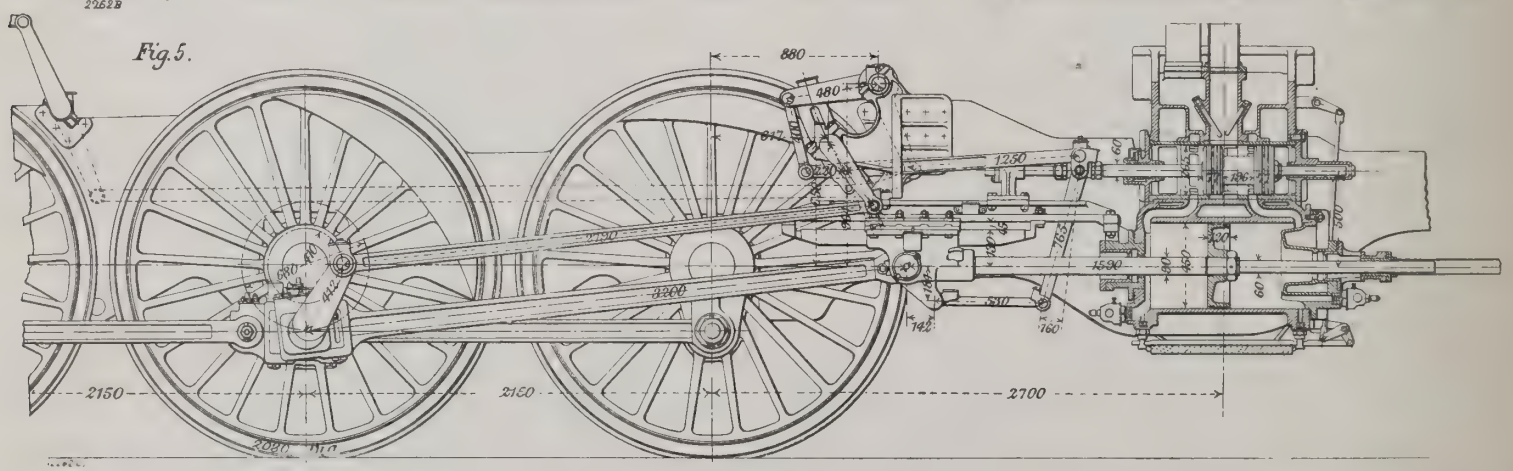


Fig. 5.



We give illustrations in Figs. 1 and 2, on Plate XXXV., published this week, and in Figs. 3 and 4, on the present page, of the first locomotive of the 4-6-2 type built for the Italian State Railways. This engine is designated on the system by the No. 69,001, and belongs to the class known as "Gruppo 690." It has been built by the Società Italiana Ernesto Breda, Milan, and is a development of a previous 4-6-0 class (Gruppo 680), being larger and more powerful, with the result that a trailing pair of wheels have become necessary. This type of engine was first developed in America, the first engine having been built in 1886 by the Lehigh Valley Railroad, at their Wilkesbarre shops, to the designs of the Strong Locomotive Company. We gave a description of this engine at the time (see ENGINEERING, vol. xliii., page 407). Since then, and more especially during the remarkable developments of comparatively recent years, the type has been widely adopted in America, and has also been introduced into many other countries.

The locomotive, of which we give general sectional elevation half plans and cross-sections, is now on exhibition at Turin. We propose in a future issue to give further illustrations of this engine, and of the tender which accompanies it, and we will therefore reserve our detailed description until that occasion. It will suffice to state here that the engine has four cylinders 450 mm. (17.71 in.) by 680 mm. (26.77 in.) stroke, driving-wheels 2030 mm. (6 ft. 8 in.) in diameter, and a boiler pressure of 170 lb. per square inch. The total heating surface is 210 sq. m. (2260 sq. ft.), in addition to which is provided superheater surface to the extent of 67 sq. m. (721 sq. ft.). The grate area is 3.50 sq. m. (37.67 sq. ft.), and the total weight of the engine in working order (exclusive of tender) is 86 tons, of which 50 tons 4 cwt. are on the driving-wheels, and available for adhesion.

INSTITUTION OF AUTOMOBILE ENGINEERS.—In regard to the information which the Institution of Automobile Engineers has collected as to the practice of the various firms in the matter of apprenticeship, the Council wish to make it clear that this information, whilst it has been tabulated for convenient reference by the staff of the Institution, is not in such a form that it can be circulated to the public generally, which is the impression which seems to have been conveyed by the previous announcement of the scheme. It is therefore desirable that parents and others should call at the offices of the Institution (13, Queen Anne's Gate, Westminster) by appointment, in order to avail themselves of this information. If this is not possible, however, advice will be given by letter.

MANCHESTER SHIP CANAL. — The Manchester Ship Canal Company reports that the ship canal revenue for the past half-year amounted to 274,419*l.*, and the expenditure to 143,936*l.*, leaving a credit balance of 130,483*l.* In the ship canal department there was an increase of 20,916*l.* in the receipts, 7889*l.* in the expenditure, and 13,027*l.* in the working profit, compared with the corresponding period of last year. The weight of merchandise, imported and exported, which paid toll was 177,564 tons greater during the first half of 1910. As the strike at the Manchester Docks did not begin until June 28, it had but little effect upon the financial result of the past half-year. The net result of the half-year in the Bridgwater department was an increase of 527*l.* in the working profit. If the Bridgwater traffic had not been seriously curtailed by the labour troubles at Liverpool during the latter half of June, there would have been a larger profit.

FOUR-CYLINDER EXPRESS PASSENGER LOCOMO

CONSTRUCTED BY THE SOCIETÀ I

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Fig. 1.

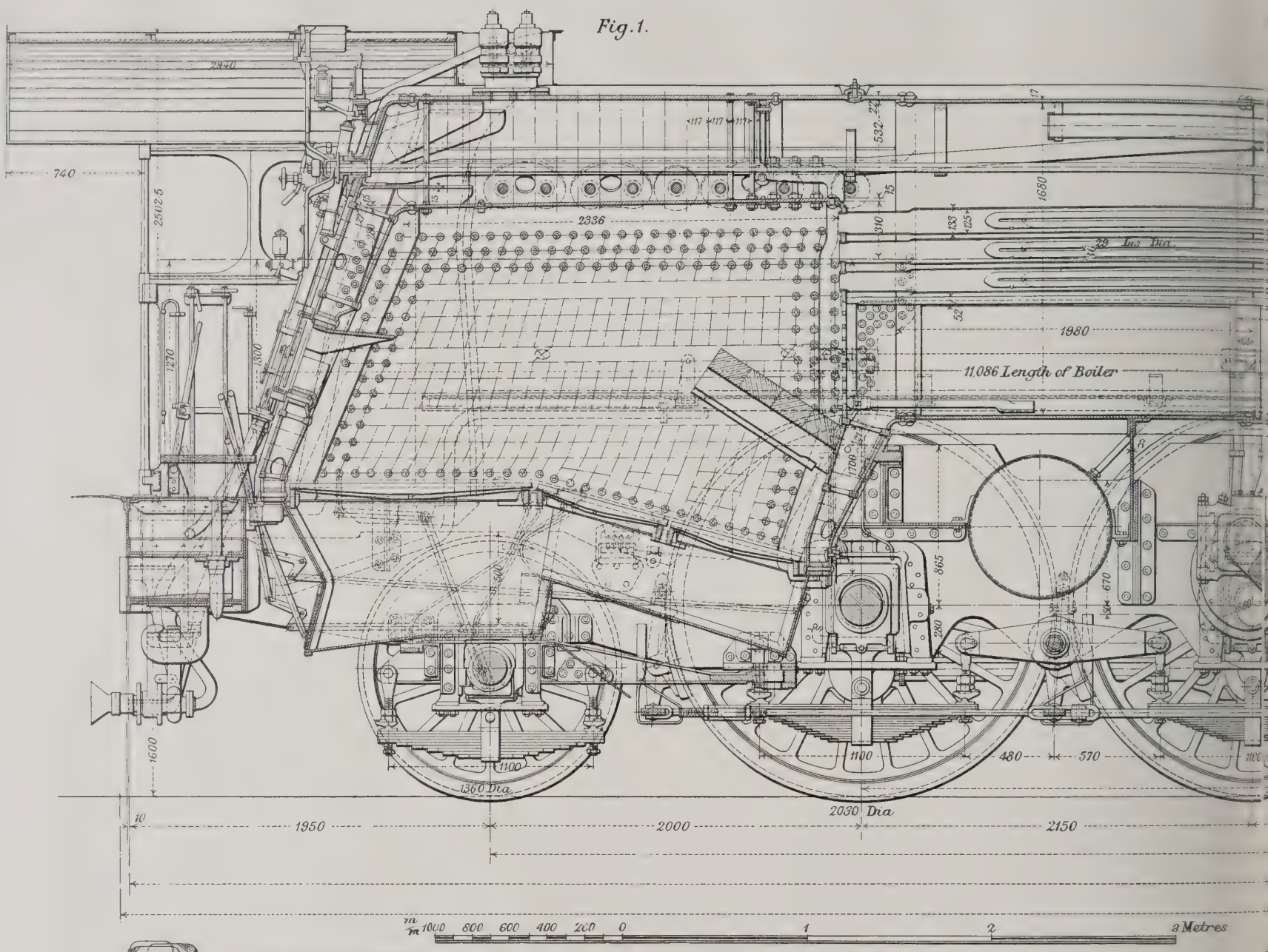
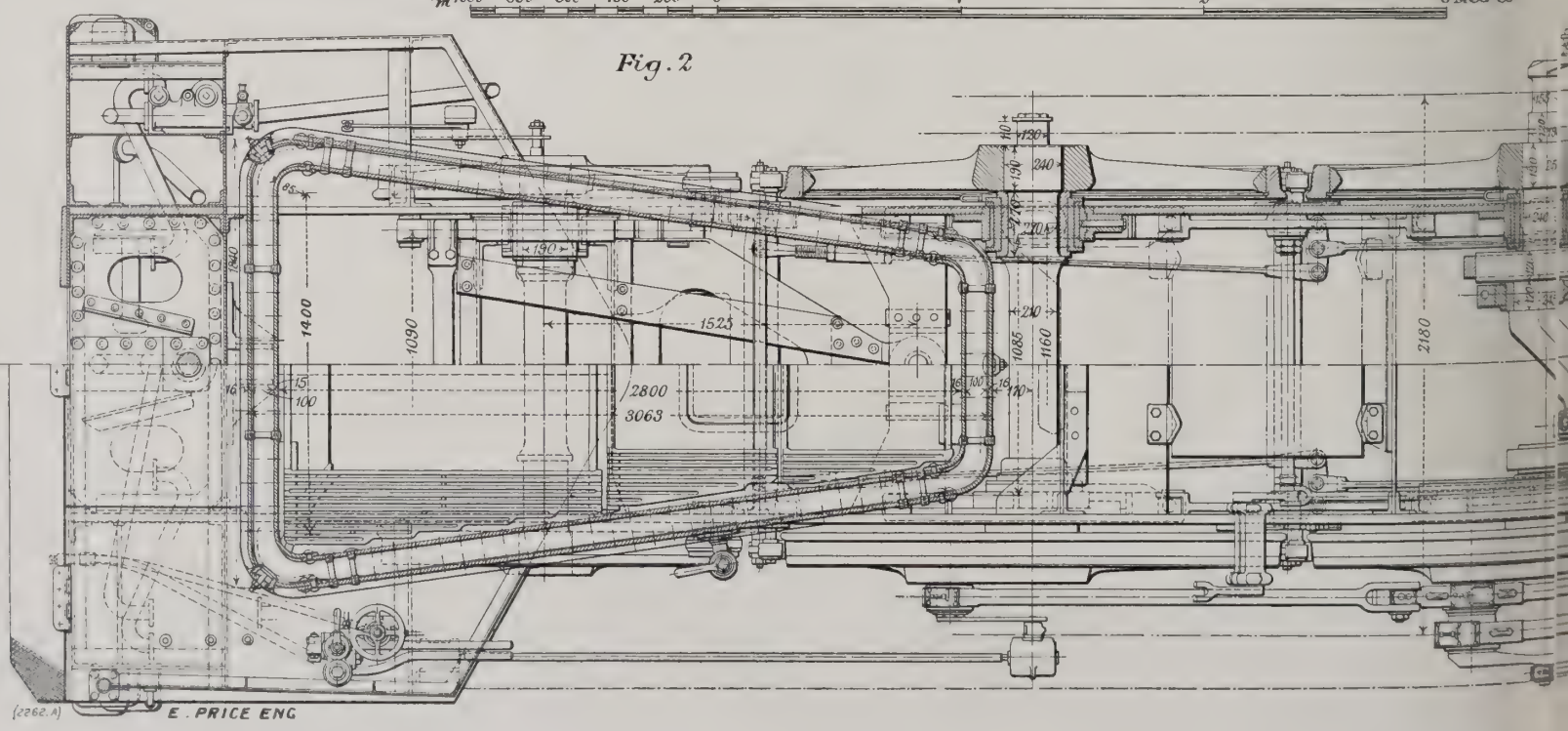


Fig. 2

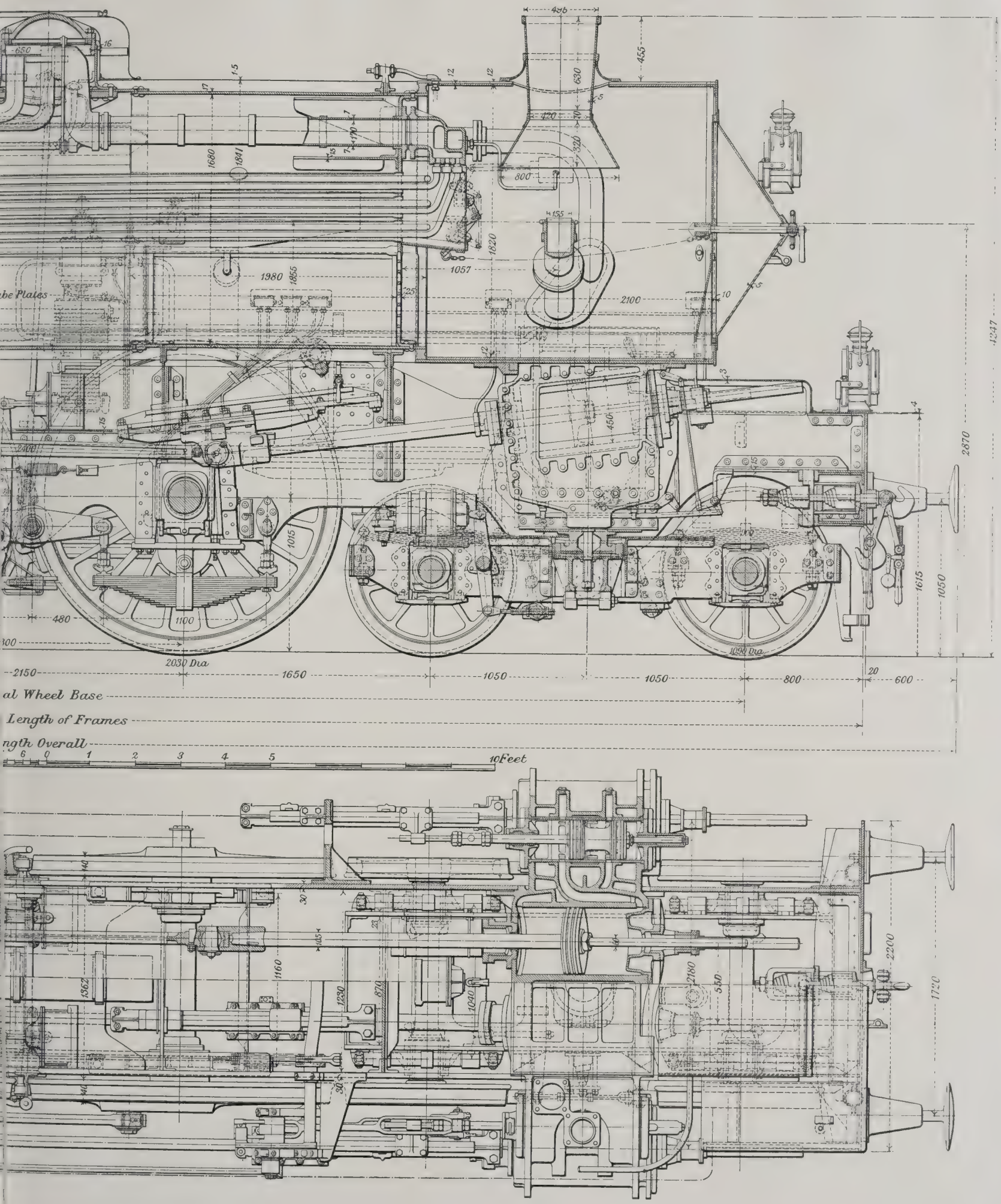


(2262.A) E. PRICE ENG

3-2 TYPE) FOR THE ITALIAN STATE RAILWAYS.

ESTO BREDA, ENGINEERS, MILAN.

192.)



RING AND DISC GRINDING-MACHINES.

CONSTRUCTED BY THE CHURCHILL MACHINE-TOOL COMPANY, LIMITED, ENGINEERS, MANCHESTER.

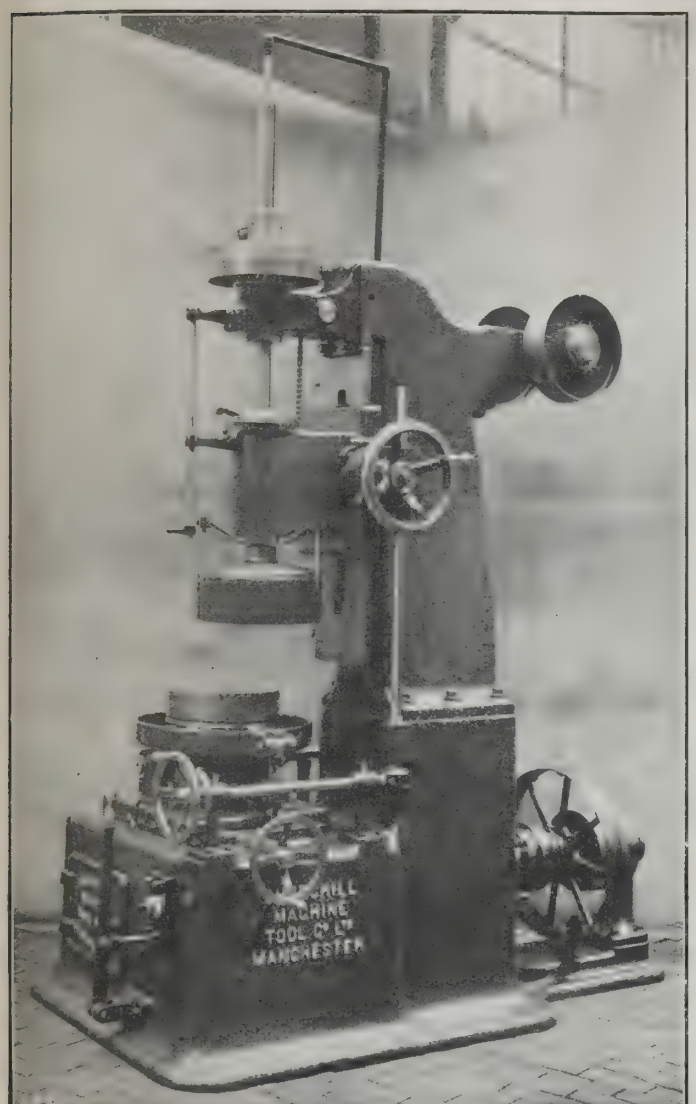


Fig. 1.

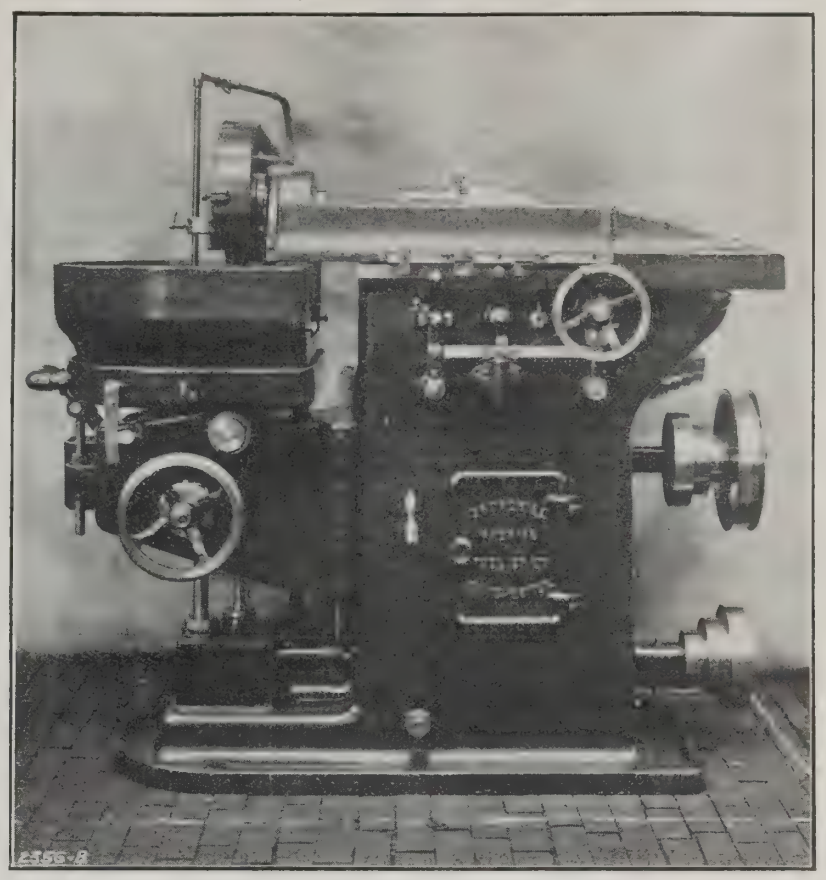


Fig. 2.

We illustrate on this page two grinding-machines of special interest. They have recently been constructed by the Churchill Machine-Tool Company, Limited, at their works at Frederick-road, Pendleton, Manchester. The machines are of somewhat similar capacity, and are each adapted for grinding piston-rings, discs, dies, and all kinds of annular surfaces, either flat, concave, or convex, but are quite different from each other in construction and method of operation.

The first machine, illustrated in Fig. 1, differs from ordinary types in that the face of the wheel is used to grind a surface instead of the edge. The wheel is mounted on the end of a vertical spindle, being held in a special chuck in view of the high speed at which it revolves. Below the wheel the work is held on a revolving table, which is made in the form of a magnetic chuck, and this table is carried on a slide adjustable crosswise, so that the periphery of the grinding-wheel can reach its centre. The wheel and its spindle are mounted on a heavy bracket which slides on the main upright of the machine, and are adjustable in a vertical direction. Quick movement of this bracket is obtained by means of a hand-wheel at the side, as shown, while in addition there is a fine adjustment with graduations reading to $\frac{1}{1000}$ in., placed in front of the machine. The revolving table carrying the magnetic chuck is made in the form of a trough, and has an adjustment of 3 deg. on each side of its zero position to allow for grinding clearances on saws, milling-cutters, &c. The table has three changes of speed to allow for different diameters of work, and can be instantly stopped without stopping the machine.

Among the advantages claimed for the machine on a large class of work are that it deals equally well with hardened as with soft metal, and that by grinding with the rim of a 12-in. ring-wheel it is possible, owing to the large cutting area and the high speed, to maintain a rate of working and a class of finish not otherwise possible. As it is essential, owing to the large area of contact between the wheel and the work, that a very adequate flow of water should be available, the vertical spindle is made hollow and its upper end is connected to the water-pump. The water is thrown by centrifugal force between the wheel and the work, both keeping them cool and washing them clear of grit. The revolving table carrying the magnetic chuck is furnished with a guard which completely surrounds the work and prevents water from splashing on to the operator. This guard is not shown in the illustration. The chuck, which is specially designed to allow for wet grinding, is energised with direct current at from 100 to 250 volts.

The machine in general is built on heavy lines to resist vibration, while it is fitted with ball-bearings throughout. The wheel spindle is of high carbon steel and has a ball-thrust, while its running bearings are independent of the driving-pulley, so that they do not take the pull of the belt. The bracket carrying the wheel is counterbalanced to facilitate movement up and down the upright. The machine is capable of dealing with work up to 16 in. in diameter.

The second machine, shown in Fig. 2, is capable of dealing with work up to 20 in. in diameter, and is in general designed for the same class of work as the other. It also is fitted with a magnetic chuck, which is frequently convenient for holding a number of small articles, such as dies or flat cutters, so that they may be operated on in batches. The machine consists of a substantial body of box-section, on the top of which is a reciprocating slide much on the lines of the ram of a shaping-machine. The grinding-wheel, 16 in. in diameter, is mounted at the front end of this slide. It is provided with a two-speed drive for an overhead countershaft. The table, carrying the magnetic chuck, is mounted on a knee-slide, and has an up-and-down motion on the main body to allow for different heights of work and for wear of the wheel. Cutting is, of course, carried out by the edge of the wheel. The work-table is 20 in. in diameter and revolves on a flat surface provided with self-oiling rollers and protected from water and grit. It can be supplied without the magnetic chuck if desired. It works in a deep pan which protects the operator from spray. Three rates of revolution are provided, driven from a cone pulley at the back of the machine. The table is arranged to swivel in order to grind concave and convex rings, an adjustment of 10 deg. on each side of the zero position being provided.

The wheel spindle is of hardened steel ground up, and runs in parallel adjustable, self-oiling, dust-proof bearings. It has a ball-thrust. The wheel is fitted with a guard to protect the operator in case of breakage. The slide is made on heavy lines to ensure steady running of the wheel, and works between flat and vee surfaces. It traverses to and from the centre of the work-table, and has both hand-feed, from the wheel shown at the right-hand side in the illustration, and also power-feed, with five changes of speed. The position of the wheel and the amount of travel are controlled by means of adjustable dogs on the side of the slide, which operate against the reversing-lever. The dogs are adjustable along a steel rack fixed to the slide, and their position can be changed while the machine is running by simply pressing a thumb-latch. In addition to the rack there is a fine screw and thumb-nut adjustment for use when grinding up to shoulders. The reversing-lever has a spring plunger, which can be drawn back when desired, allowing the slide to run beyond the reversing points without disturbing the adjustment of the dogs. The plunger automatically resumes its normal position when the slide returns. By the movement of a handle the slide can be stopped at any point of its travel. The arrangement of the reversing-lever will be clearly seen in the illustration.

The knee-slide is supported by a screw, and is fitted with ball-thrust bearings, and has a hand-wheel to elevate and depress it. The wheel is fitted with a graduated disc reading in $\frac{1}{1000}$ in. A vertical lever at the front of the machine controls the stopping and starting motion of the table by means of friction-clutches. A water-tank is carried at the rear of the main frame, which is fitted with a vertical centrifugal pump. The machine weighs approximately 40 cwt.

German Coal Exports.—Coal was exported from Germany in the first half of this year to the extent of 12,614,952 tons, as compared with 10,963,195 tons in the first half of 1910. The countries to which the principal exports were made to June 30, this year, were:—Belgium, 2,206,667 tons; France, 1,378,480 tons; Holland, 2,714,015 tons; Austria and Hungary, 4,385,207 tons; Russia, 556,051 tons; and Switzerland, 617,951 tons.

British Motor-Boat Club.—On Monday, the 31st ult., the above club held a petrol-consumption race at Cowes, the following boats taking part:—Allegro, owned by Mr. W. N. McClean; Tomoye, owned by Mr. F. C. Blake; Mimic, owned by Mr. H. Tate; and Neva, owned by Mr. E. F. Kenneth. The Tomoye proved to be the most economical on petrol, and therefore won the handsome silver cup presented by Mr. W. N. McClean. The course was a 50-mile one, and the trial was a useful one, both from a reliability and a consumption point of view. The actual quantity of petrol consumed per motor horse-power hour in each case was:—Tomoye, 0.116 gallon; Mimic, 0.144 gallon; Neva, 0.152 gallon; and Allegro, 0.153 gallon.

COMMERCIAL MOTOR-BOAT FOR CHINA.

The motor-boat which we illustrate on page 196 is of the shallow-draught tunnel stern type, her principal dimensions being 45 ft. long, 10 ft. beam, and 3 ft. 6 in. depth. She has been designed by Messrs. R. Wilson and Sons, of South Shields, and built by Messrs. Banker and Co., of Hong Kong and Wuchow, to the order of the British-American Tobacco Company.

The boat will be run by a Chinese engineer and a Chinese captain, carrying in addition two Europeans, and will be exclusively used for the sale of cigarettes at the various waterside villages on the Chinese rivers, her first run being one of 250 miles, and then 120 miles to the nearest supply base.

Figs. 1 and 2 show the engines, and Figs. 3 to 5 the boat. The hull is divided by water-tight bulkheads into four compartments. The hold and engine-room are amidships, and there is a large lazarette aft, fuel-tanks and the chain-space being forward. The galleys and lavatories are arranged on the main deck aft, and the saloon and sleeping accommodation on the upper deck. The steering-wheel and telegraph are placed well forward on the upper deck, covered by an awning. To obtain all possible deck-space a gangway is carried right along the port and starboard sides of the vessel.

The machinery consists of a 6-cylinder Djinn petroleum engine (Figs. 1 and 2), built by Messrs. Brazil, Straker, and Co., Limited, of Bristol, which develops 45 brake horse-power at 800 revolutions per minute, and a speed of 12 knots will be obtained when going "all out." No petrol is obtainable in the district, but the engine is of the firm's standard M.E. type, and runs entirely upon ordinary petroleum. The engine is fitted with cylinders cast in pairs, and the bed-plate has a solid extension carried right aft, on which is mounted the reversing-gear, which is also of the firm's own make. As regards the details generally, the ignition is by Bosch high-tension magneto, and a battery and coil-ignition as a stand-by, the distributor being driven by a vertical spindle at the forward end of the engine. The cylinders follow the company's usual practice, being supported on steel columns, which method allows all stresses to be taken up by the bed-plate. The engine is fitted with bronze pumps for cylinder cooling, forced lubrication, and fuel supply; also with a bilge-pump. These pumps are all of the plunger type, and are mounted together upon one compact pedestal, where they are driven by enclosed silent gearing and balanced eccentrics. This keeps the arrangement most accessible, and greatly reduces the athwartships space taken up.

The lubrication is forced to every bearing, including the cam-shaft bearings, and the pistons are oiled by adjustable sight drip-feeds. The oil-pump has a pressure-adjusting valve.

The fuel-pump delivers to a small reservoir which feeds the three float-chambers, each pair of cylinders having its own vaporising system. There are no induction-pipes, as the fuel, on being vaporised, passes straight into the cylinders. The fuel supply is regulated by an adjustable valve, and the engine is controlled on the throttle. The engine is extremely flexible and very lively. The system is also noteworthy by virtue of the entire smokelessness of the exhaust.

At the aft end is mounted a steel-plate control-board, on which are handily arranged the ignition, air, and throttle-levers, the sight-drips, and the lubricating-oil pressure-gauge. The starting-gear shaft is carried overhead, so that the engine can be started from ahead or aft.

The reverse gear is of the enclosed differential type, and no separate thrust-block is necessary, the arrangement for taking ahead and astern thrust being combined in the gear. Accessibility is a prominent feature, the connecting-rods and pistons being removable through the crank-case doors, whilst a few minutes are sufficient to remove the cam-shaft and valve-tappets. The valves, of course, are all on the starboard side, so that the port side is very free from gear. This is standard practice on all Djinn engines. A water-cooled exhaust branch connects the exhaust outlet, and into this the cooling water is discharged, passing thence to the silencer.

The installation of the engine was carried out by Mr. R. Wilson, Jun., in China. In connection with the Djinn engines generally, business in the company's marine department has developed so rapidly that extensions have been carried out which, with the previous marine shops, will enable the output to be increased to forty engines per week. New erecting-bays and a new test-bay, 100 ft. long, are included in the extensions, which were finished in the spring.

Winnipeg.—Local burdens are increasing at Winnipeg. In 1910 the estimated expenditure stood at 2,431,896 dols.; for 1911 the estimate is 2,981,034 dols. The estimated expenditure for 1910 was exceeded by 35,528 dols., and this amount has had to be provided for this year. It has been necessary this year also to provide for a great expansion of the water supply of the city.

NOTES FROM THE UNITED STATES.

Philadelphia, August 3.

A further general improvement has taken place in the iron and steel industry. This improvement is due more to general building requirements than to railroads; however, there are several good-sized rail orders to report, one of them being an order for 30,000 tons for the Canadian Pacific. Several orders for export have been sent to the mills. More orders are expected from Canadian sources. Structural material is more active than any other kind. Warehouse and loft-building in large cities for merchandise purposes is taking a good deal of material. The Missouri-Pacific has just ordered 6,000,000 dols. worth of equipment, including fifty large locomotives, 2000 all-steel gondola cars, 1000 steel underframe box-cars, 500 all-steel flat cars, eighteen composite baggage cars, and 17 all-steel postal cars, besides a lot of other equipment. The Atlantic Coast line is in the market for 1000 cars, of which 900 will be steel underframe cars. The Burlington is about to order 1000 dongola cars, 1000 box-cars, and 500 refrigerator cars, as well as ten engines of the "Mikado" type. The steel rails for the Canadian road are being made at Gary, Indiana. A general increase in coke production is now under way. A good deal of material is also going into apartment building in the larger cities. The general tone of the market has improved within a week. Furnace owners think that their long period of depression will soon disappear. Prices continue low, and the indications are favourable to buyers for the rest of the year. The tin-plate trust is operating to 75 per cent. of capacity, and the demand for tin-plate is gaining. The Republic Iron and Steel Company is operating nine of its ten furnaces. Immense quantities of scrap are due to arrive early in September.

Anglo-Danish Peat Industry.—The International Carbonating Company is about to introduce its process for the exploitation of peat deposits in Denmark, having made the necessary arrangements with the Aamosen Company, a Danish concern which owns the peat deposits in Sealand known as Aamosen. The Danish company has purchased additional 1930 acres peat deposits at a price of some 500 kr. (28*l.*) per acre, so that an aggregate of rather more than 2573 acres are available. Further purchases were contemplated, but the owners demanded what was considered an exorbitant price. The works will soon be taken in hand, and operations are expected to commence next summer.

Extension of the Anglo-French Telephone Service.—A new telephone cable was a short time ago laid by the Post-Office authorities in the Straits of Dover, which has now been connected to land lines from London to Paris, the facilities for intercommunication being considerably increased thereby, and speech rendered practicable between principal towns in the two countries, a thing not possible before. In order to determine the extent of the increased range, experiments have been carried out by English and French officials from a number of provincial towns on this side of the Channel. Up to the time of this extension towns north of a line connecting the Mersey and the Humber were unable to communicate with Paris, whereas now it is found possible to converse with this city from Newcastle-on-Tyne, Glasgow, and Edinburgh, and trials made from Aberdeen, involving a circuit of over 900 miles, have been successful, it being found possible in the best conditions of line and apparatus to conduct commercial speech between the French capital and the northern town. By means of these tests the Post-Office engineers will be able to determine what other towns in England can communicate with Paris, and it is expected that a list of such towns will soon be published. The new cable is fitted with loading coils, which neutralise the disturbing effects on speech transmission introduced by the insulating material necessary for such cables.

Institute of Metals.—This Institute will hold its annual autumn meeting at Newcastle-on-Tyne on September 20, 21, and 22, under the chairmanship of the Hon. Sir Charles A. Parsons, K.C.B., F.R.S., LL.D., for the local committee, and Dr. J. T. Dunn, F.I.C., as hon. secretary. The meeting will be opened at 10 a.m. on Wednesday, September 20, at Armstrong College, when the members will be welcomed by the Right Hon. the Lord Mayor of the city, Sir W. H. Stephenson, D.L., D.C.L., and the local committee, after which a series of papers will be read and discussed, Sir Gerard A. Muntz, Bart., President, being in the chair. Members will have the opportunity in the afternoon of visiting shipbuilding, engineering, metallurgical, and electrical works in the neighbourhood. A reception of members and their ladies will be held in the evening, after which there will be a conversazione in the Laing Art Gallery, by the invitation of the Lord Mayor. The following day papers will be read and discussed at a morning session of the Institute, and in the afternoon there will be further visits to works. The Tyne Commissioners have kindly placed a steamer at the disposal of the local committee for September 22, on which a trip can be made to the mouth of the river and back. The secretary of the Institute, Mr. G. Shaw Scott, M.Sc., of Caxton House, Westminster, S.W., informs us that would-be members can be elected in time for them to take part in all the functions connected with this meeting if their applications for membership are in his hands before August 15.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the market was quiet, and the dealings consisted of 2500 tons of Cleveland warrants at 46s. 9d. cash and 47s. one month, with sellers over at these prices, and at 47s. 6d. three months. The afternoon session was quite idle, and closing quotations for Cleveland warrants were easier at 46s. 8½d. cash, 46s. 11½d. one month, and 47s. 6d. three months sellers. The market had a harder tendency on Friday morning, but business was confined to 3000 tons of Cleveland warrants at 46s. 8½d. and 46s. 9d. cash, and 46s. 11d. twenty-one days. At the close there were sellers at 46s. 9d. cash, 47s. one month, and 47s. 6d. three months. In the afternoon there was nothing doing, and Cleveland warrants were quoted at 46s. 9½d. cash, 47s. 0½d. one month, and 47s. 6½d. three months sellers. On Monday the market was closed, being August Bank Holiday. When business was resumed on Tuesday morning Cleveland warrants were dull, and 2500 tons were done at 46s. 9d. cash and 47s. one month, and closing sellers quoted 46s. 9d. cash, 47s. one month, and 47s. 6d. three months. In the afternoon the market exhibited a harder tendency, but only 1500 tons of Cleveland warrants changed hands at 47s. 6d. three months. At the close there were sellers at 46s. 9½d. cash, 47s. 0½d. one month, and 47s. 6½d. three months. When the market opened to-day (Wednesday) the tone was somewhat easier, and the dealings were limited to 500 tons of Cleveland warrants at 46s. 9d. cash, with sellers over. The other closing prices were 47s. one month, and 47s. 6d. three months sellers. In the afternoon the market was again dull and quiet, and only one lot of Cleveland warrants changed hands at 46s. 9d. cash, with sellers over. The other closing quotations were the same as in the morning—namely, 47s one month and 47s. 6d. three months sellers. The following are the market quotations for makers' (No. 1) iron:—Clyde, 60s. 6d.; Calder and Gartsherrie, 61s.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 64s.; Shotts (at Leith), 62s.; and Carron (at Grangemouth), 63s.

Sulphate of Ammonia.—A strong tone continues to pervade the sulphate-of-ammonia market, and a fairly active demand exists. The current price is now quoted at 14*l.* 2s. 6d. per ton for prompt delivery, Glasgow or Leith. Shipments from Leith Harbour last week amounted to 5517 tons.

Scotch Steel Trade.—The state of affairs in the Scotch steel trade is again reported as very good this week, and although some of the plant is still idle, it is not expected to be long unemployed. Local consumers of ship and boiler-plates are taking delivery of considerable quantities, and one encouraging item worth noting is that besides some fair inquiries in circulation, makers have booked new orders for several respectable lots. Angles, however, are in no better demand, and this branch of the industry is at present rather disappointing. Light material and structural sections are in good request, and the inquiries from India for both classes of material show that a fairly large business is in prospect. The export inquiry generally is said to be very much better, as, besides the principal colonies, Japan, China, and South America, are all in the market. Prices are firm and are officially quoted without change.

Malleable-Iron Trade.—The malleable-iron trade has undergone no change since the last report, and business continues to be on the improving side. The great heat of the past week has been all against working at full pressure, but the output is considered very fair. Prices are still unchanged.

Scotch Pig-Iron Trade.—The demand for Scotch pig iron has not appreciably increased during the past week, but deliveries have been moderately good. The number of furnaces in blast was eighty-three, or three more than for the corresponding week of last year. Inquiries from the South are fewer this week owing to the holidays, but a much improved demand is expected from that and other sources in the near future. Little change can be reported in the hematite position, but there seems to be more inclination on the part of users to cover their requirements; but, nevertheless, prices are still a matter of arrangement.

Shipbuilding.—The shipbuilding returns for the month of July were, on the whole, rather below the average month's output for the year, but in all the districts the annual trades' holidays occur in July. Another factor which is still against the industry is the scarcity of suitable labour, and if this obstacle can only be overcome there is enough work on the order-books to ensure very busy times right on to the end of the year at least. The total output from the various yards in Scotland during the past month was 24 vessels, of 35,873 tons. The district figures were:—

	Vessels.	Tons.
The Clyde	18	34,358
The Forth	—	—
The Tay	1	700
The Dee	5	815
Total ..	24	35,873

The Clyde output is the second smallest for the year, and but for the cruiser New Zealand, launched at Fairfield, the figure would have been very poor indeed. The Clyde total for the year to date is now 153 vessels, of 344,218 tons, or nearly 90,000 tons more than for the corresponding seven months of last year.

British Foundrymen's Association.—The eighth annua convention of the British Foundrymen's Association was opened in the Technical College, Glasgow, yesterday (Tuesday), under the chairmanship of Bailie John King, President of the Scottish branch. After a welcome had

been extended to the visitors by Bailie Russell, on behalf of the Corporation of Glasgow, and by ex-Deacon-Convener Macdonald, on behalf of his colleagues, the governors of the Glasgow Technical College, Mr. Percy Longmuir, Sheffield, who was again elected president of the Association, returned thanks for the addresses of welcome. At the close of the presidential address, Mr. H. Pilkington read a paper on "Special Foundry Pig Iron;" Mr. R. Buchanan, Birmingham, read one on "Carbon Control in Cast Iron;" and Mr. R. R. M'Gowan read one on "Warping in Castings." A large attendance of delegates was present to-day when the second day's proceedings commenced. The president was in the chair. The papers delivered were:—"Art as Expressed in Castings," by Mr. W. F. Bagnall; "Metallography as an Aid to the Ironfounder," by Mr. John S. G. Primrose, A.G.T.C., A.I.M.M., Metallurgical Department, Glasgow Technical College; "The Crystallisation of Cast Metals," by Mr. Cecil H. Desch, D.Sc., Ph.D.; and "Notes on the Treatment of Steel Castings," by Professor A. Campion, F.I.C., Glasgow Technical College.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Returns.—It is not surprising that the returns for the coal traffic at Hull during July should show a decrease as compared with last year. The widespread unrest in the labour world generally and the shipping disturbances in particular are the chief contributory causes. The total dealt with was 472,624 tons, as against 627,024 tons in July last year, a drop of some 150,000 tons. On the year up to date, which aggregates 3,560,656 tons, there is a decrease in comparison with the same period of 1910 of nearly 360,000 tons. The decline in exports is particularly large—170,000 tons on 240,395 tons for the month. Of this trade the greater proportion was with the Baltic ports, and here also was a considerable portion—60,000 tons—of the decrease. In the output figures the Denaby and Cadeby Main Collieries, heading the list, are down on the month by about 40,000 tons.

Rolling-Mills Prosperity.—The prosperous conditions under which the rolling-mills and forges have been working during the past year are well exemplified in the results, just published, of the year's working of the Sheffield Forge and Rolling-Mills Company, Limited. After paying interest and all other charges, the net profit amounts to 15,843*l.*, out of which, with the addition of the previous year's balance, and the allowing of 2000*l.* for depreciation, it is recommended that a dividend of 10 per cent., free of income-tax, be paid. In order to meet new demands, and increase the effectiveness of their works, the company have had extensive additions made to their plant, including two new bar-mills, which will be running about September. The dividends of this company for the previous three years—1908, 1909, and 1910—were, it is interesting to note, 6, 7½, and 10 per cent. respectively.

South Yorkshire Coal Trade.—The general activity in South Yorkshire industry is largely responsible for the improved position of the hard-coal market. Collieries have received a considerable influx of orders from manufacturers, and are likely to be busy for several weeks to come. The quantities going away for shipment have also been much larger, and particularly is there a good call for best qualities. Consequently quotations are firm, and in some cases stronger. Pits are cleared of stocks so far as first-grade coal is concerned. The call for gas coal is increasing, with good shipments. Slacks are still firmly held, and difficult to obtain. A pit lads' strike at local collieries has caused some loss of working time. Coking smalls are somewhat scarce. Although in the house-coal trade the position is little altered this week, there are better prospects, due to an increase in stocking orders, including better demands from London. There are more orders from country stations, and pits are working better. Not much reduction has yet been effected in stocks. In the first-grade qualities, of which collieries are fairly well sold, prices show an upward tendency. Otherwise there is little change. Very little business was done on the Sheffield Exchange at the week-end, and the following are the latest quotations:—Best branch hand-picked, 13s. to 14s.; Barnsley best Silkstone, 11s. to 12s.; Silkstone, 9s. to 10s.; Derbyshire house, 9s.; large nuts, 7s. 3d. to 9s.; small nuts, 5s. 6d. to 6s. 6d.; Derbyshire brights, 9s. 6d. to 11s.; washed nuts, 7s. 6d. to 8s. 6d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. to 5s.; smalls, 1s. 6d. to 2s.

Iron and Steel.—The present year has been prolific in holidays, and again, this time with the Bank Holiday break, they have had a quietening effect upon trade. Although there is not much doing just now in the raw-material market, the recent long spell of quietude has apparently not been so bad as it seemed. Some fairly steady buying has been done by consumers, and this has undoubtedly operated to keep prices firmer, although it has not been sufficiently brisk to give an air of special activity to the market. East Coast mixed numbers continue selling at from 68s. to 70s. New business in common irons is not of much moment, but here again prices are steady. Lincolnshire makers who have a fair amount of contract work in hand are declining to make concessions to secure further orders. The improvement in finished iron is general, though makers are not satisfied with the prices obtained. The bar-mills have had a steady accession of orders, and are working practically full time. The demand for billets is very good, giving a favourable indication of the progress of the steel trades. Allowing for the slackness of a holiday season, the general steel trades are really very active, and slight fallings off in certain directions are not regarded with any seriousness. The armament firms in the East End have particularly heavy work in progress, not only in battleship orders for the Home and foreign Governments, but constructional work of various kinds for the large steamship companies. Makers of the smaller types of castings and forgings are not quite so busy, a fact, however, which they do not attribute to any trade depression. There are good prospects before the makers of railway rolling-stock, in view of the extensive purchasing proposals of one or two companies and the estimated requirements of others. Exports keep up very well, which means that the large number of local firms who supply steel specialities for foreign and colonial markets are actively employed. The level of prosperity is also being maintained in the numerous lighter trades.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The pig-iron trade continues very quiet, but there is a strong feeling that the autumn demand will be heavy. The time is almost at hand when buying to meet the needs of the fall of the year is usual. That there is confidence in the future is emphasised by the fact that sellers of pig iron will not entertain forward offers except at higher rates than rule for early delivery. No. 3 g.m.b. Cleveland pig iron is steady at 47s. f.o.b.; whilst No. 1 is 50s. 6d.; No. 4 foundry and No. 4 forge, each 46s. 6d.; and mottled and white iron, each 46s—all for early delivery. Sales of Nos. 1, 2, and 3 East Coast hematite pig have been made at 61s. 3d. and 61s. for early delivery, but it is declared that such transactions must have incurred a loss, and under these circumstances producers are in no great hurry to sell, as with the large and increasing consumption they look for improvement in value in the near future. There is little or nothing passing in foreign ore, and values are still based on 19s. ex-ship Tees for best Rubio. Hematite makers, however, are substituting other ores, and there is much less Rubio used than there was a year or two ago. Coke is steady, average blast-furnace qualities realising 14s. 6d. delivered here.

Stocks and Shipments of Pig Iron.—A steady decrease of stocks of pig iron in the public warrant stores has set in, the withdrawals to date this month being at the rate of close on 500 tons per working-day. Shipments of pig iron to date this month average 4430 tons per working-day, as compared with a daily average of 3004 tons to the same date last month, and 5638 tons for the corresponding part of August last year.

Manufactured Iron and Steel.—Producers of nearly all descriptions of manufactured iron and steel have plenty of work on hand, and there are a fair number of inquiries in the market, so that the position is satisfactory. Advances in values of one or two descriptions are anticipated. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s. to 6*l.* 12s. 6d.; iron ship-angles, 7*l.*; iron girder-plates, 6*l.* 17s. 6d.; iron boiler-plates, 7*l.* 7s. 6d.; iron ship-rivets, 7*l.* 5s.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; and steel joists, 6*l.*, 7s. 6d. to 6*l.* 10s.—all less the customary 2½ per cent. discount. Cast-iron columns are 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; and steel railway sleepers, 6*l.* 10s.—all net cash at works. Iron and steel galvanised corrugated sheets are 10*l.* 15s. f.o.b.—less the usual 4 per cent.

THE ITALIAN NAVY.—The Dreadnought Conte di Cavour was launched at La Spezzia on Thursday, August 3. The Conte di Cavour has a displacement of 21,500 tons, and she is 560 ft. 9 in. long by 90 ft. beam. Her engines work up to 30,000 horse-power, and she is to steam at the rate of 23 knots. She will carry 31 guns.

TECHNICAL DICTIONARIES IN SIX LANGUAGES.—The eleventh volume of this interesting series—the Deinhardt-Schlomann Series—has now appeared. It deals with the metallurgy of iron, and covers the various processes from the preparation of the ore down to the casting, forging, and rolling of the metal, including a few pages on the practical side of metallography. The book forms a welcome addition to the series; it is published in this country by Messrs. Constable and Co., Limited, 10, Orange-street, Leicester-square, W.C., and its price is 10s. 6d. net.

THE PANAMA CANAL.—The McClinter-Marshall Construction Company, Pittsburg, is engaged upon a contract for Panama Canal lock-gates. The contract for the gates runs into heavy figures—upwards of 1,000,000*l.* Some forty-six pairs, or ninety-two leaves, of mitering lock-gates are to be used in the three locks of the canal, and the contract will absorb 58,000 tons of structural steelwork and steel castings. Each leaf will consist of a system of horizontal girders, vertical end girders, frames, diaphragms, and intercostals forming its skeleton, and of a steel-plate sheathing extending from the top to the bottom on both sides of the leaf. The leaf will be swung by means of a stiff strut fastened to it at the top, and will be worked by an electrically-driven engine in the lock-well. A steel man-shaft will extend from the top of the air-chamber to the top of the leaf, and will have a man-hole at the top. In each leaf five transverse vertical frames, built in between the horizontal girders, will extend from the bottom to the top of the leaf, and these are to be made water-tight within the air-chamber. Each frame will have a man-hole cut in the web, so that free access can be had to all parts of the leaf.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Coal-loading operations were resumed more vigorously on Tuesday, but work was not in full swing until yesterday, when the collieries restarted after the holidays. Sellers have been disinclined to accept fresh business for early delivery, and prices have ruled firm for all descriptions of large and small. The best large steam coal has made 18s. 6d. to 19s.; secondary qualities have ranged between 16s. and 17s. 9d.; best bunker smalls between 9s. 9d. and 10s.; and cargo smalls between 7s. 9d. and 8s. 3d. per ton. Household coal has shown little change; the best ordinary qualities have brought 14s. 6d. to 16s. 6d.; No. 3 Rhondda large has made 17s. to 17s. 6d.; and smalls, 10s. 6d. to 10s. 9d. per ton. No. 2 Rhondda large has realised 11s. 9d. to 12s. 3d., and smalls 7s. 6d. to 8s. per ton. Foundry coke has been quoted at 18s. to 20s. 6d., and furnace ditto at 16s. to 17s. per ton. As regards iron ore, Rubio has made 18s. 6d. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Dowlais.—All departments of the Dowlais Works have been well employed, although business was interrupted early this week by the August holidays. The Goat Mill has turned out tin bars and heavy steel rails. The Big Mill has been principally engaged upon light rails for colliery and other purposes. The output of the collieries has exceeded the average.

Newport (Alexandra) Docks.—Mr. E. M. Underdown, K.C. (deputy chairman), presided, in the absence of Viscount Tredegar, at the half-yearly meeting of the Alexandra (Newport and South Wales) Docks and Railway Company. A report prepared by the general manager as to new works in course of construction, stated that the progress of the new lock entrance had been exceptionally good. The contractors had been fortunately favoured with very fine weather; the total number of shifts lost being only 43½, as compared with 77 in the corresponding period of 1910. Delay consequent upon the flooding of the works in December had proved less serious than was supposed at the time. Concrete work had been in progress on the west lock wall north and south of monolith "A," in the east side wall trench near the middle gate chamber, at the outer portion of the lock invert, and on the east wall of the outer gate chamber. The building of the quoins and levelling culverts of the west outer gate chamber, of the east middle gate chamber, and the machinery pits at the outer gate chamber, was in hand. A concrete monolith dam across the outer end of the lock was completed up to ground level by the end of February, and had since been raised to coping level. The building of the west side wall in the inner portion of the trench which collapsed in July, 1909, had been practically completed. The construction of the lock side wall in front of monolith "A" had been proceeding, the upper and lower levelling culverts had been completed, and the building of the machinery pits above monolith "E" was in hand.

Swansea.—The Swansea Town Council is considering the purchase of the undertaking of the Swansea Tramways Company. On Friday the council made a visit of inspection to the Cray Waterworks. The party's itinerary included the Morriston reservoir, a recent landslip near the pipe-line at Ystradgynlais, and afterwards visits to Nantyrwyrdd and Cray. Even after the drought the great reservoir was found to be only down 12 ft.

Pontypridd.—The passage of a Merthyr Corporation Water Bill before a select committee of the House of Commons has proved a more protracted matter than was at first anticipated. The committee decided that it would not be necessary to hear counsel on behalf of those bodies which opposed the alteration of the Bill in the interests of the Pontypridd district. Sir E. Cornwall remarked that the committee fully appreciated the case of Pontypridd. It was not within the power of the committee to extend the powers of the Pontypridd Board over the Llin reservoir, or they would have liked to do so. They would like to accept Mr. Freeman's offer to guarantee a supply for the Rhondda for fifty years, and to extend the right of the Pontypridd and Rhondda Board to construct the reservoir over that period. The committee, however, felt that, under all the circumstances, they would not be justified in making any substantial alteration in the Bill. This disposed of contentious matter, and the measure was reported for third reading.

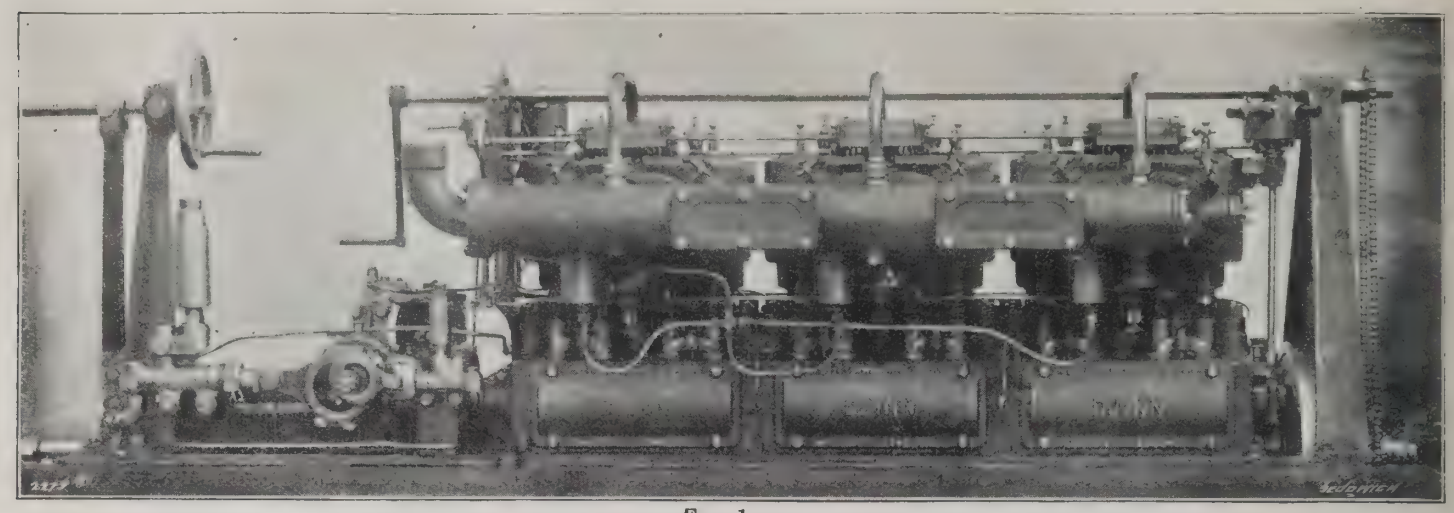
South Wales Coal.—The exports of coal from the five principal Welsh ports—Cardiff, Newport, Swansea, Port Talbot, and Llanelly—in the first seven months of this year were:—Cardiff—foreign, 9,045,496 tons; coastwise, 1,548,276 tons; total, 10,593,772 tons. Newport—foreign, 2,526,995 tons; coastwise, 382,236 tons; total, 2,909,231 tons. Swansea—foreign, 1,635,878 tons; coastwise, 155,846 tons; total, 1,791,724 tons. Port Talbot—foreign, 921,610 tons; coastwise, 85,428 tons; total, 1,007,038 tons. Llanelly—foreign, 97,164 tons; coastwise, 29,368 tons; total, 126,532 tons. The aggregate shipments for the seven months were, accordingly, 16,428,297 tons. Shipments from Cardiff, Port Talbot, and Llanelly were reduced by the labour troubles of the last few months.

CONTRACTS.—Messrs. Fraser and Chalmers, Limited, 3, London Wall Buildings, London, E.C., have, we are informed, just received an order for two Fraser and Chalmers Rateau steam-turbines of the mixed-pressure type for direct coupling to turbo-blowers for Messrs. Bolckow, Vaughan, and Co., Middlesbrough, in connection with their extensive blast-furnace works. These make, in all, twelve turbines supplied to this company.

SHALLOW-DRAUGHT MOTOR-BOAT FOR CHINA.

CONSTRUCTED BY MESSRS. BANKER AND CO., HONG KONG, TO THE DESIGNS OF MESSRS. R. WILSON AND SONS, SOUTH SHIELDS.

(*For Description, see Page* 194.)



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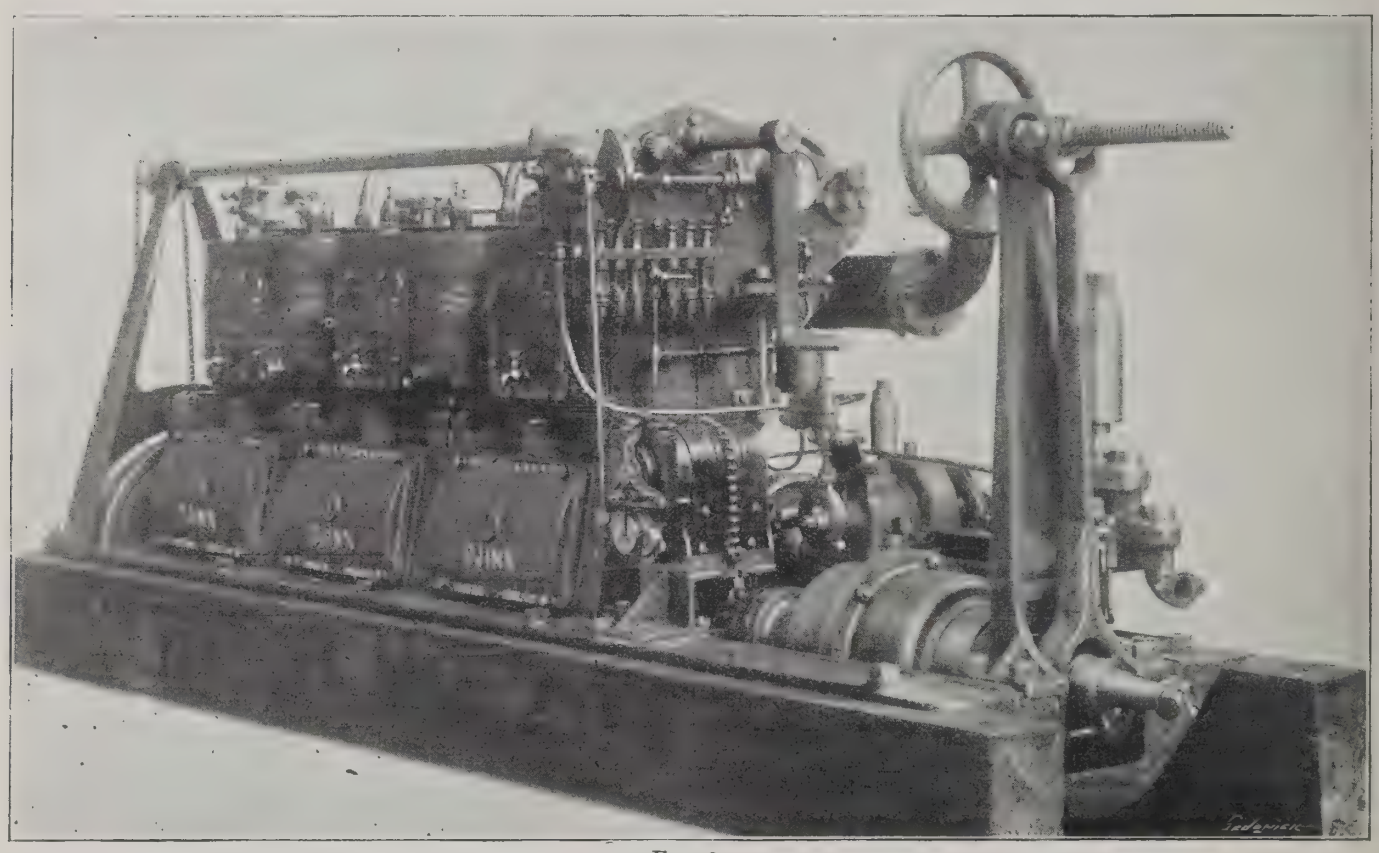

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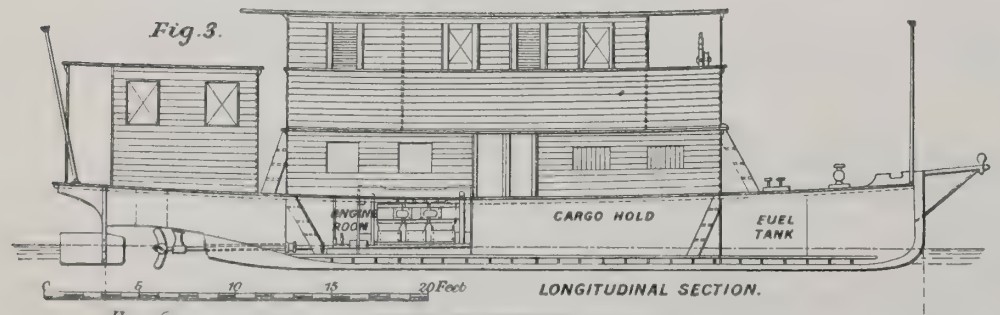

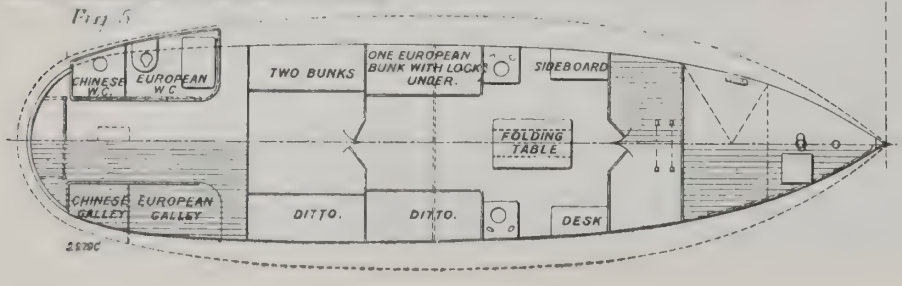

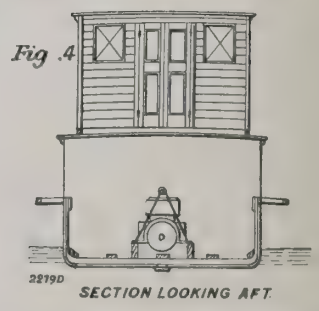

Coal in Belgium.—The imports of coal into Belgium in the first half of this year were 3,696,581 tons, as compared with 3,025,509 tons in the first half of 1910. In these imports German coal figured for 2,071,400 tons, as compared with 1,721,860 tons in the first half of 1910; French coal for 419,257 tons, as compared with 434,622 tons; British coal for 1,019,547 tons, as compared with 734,823 tons; and Dutch coal for 186,241 tons, as compared with 113,656 tons. The exports of coal from Belgium in the first half of this year were 2,585,883 tons, as compared with 2,318,050 tons in the corresponding period of 1910. France took 2,201,194 tons of Belgian coal in the first half of this year, as compared with 1,854,794 tons; and Germany 133,248 tons, as compared with 153,638 tons.

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The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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Thin paper copies	£1	16	0
Thick ,,	£2	0	6

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With a Two-Page Plate of a FOUR-CYLINDER EXPRESS PASSENGER LOCOMOTIVE (4-6-2 TYPE) FOR THE ITALIAN STATE RAILWAYS.

ENGINEERING.

FRIDAY, AUGUST 11, 1911.

THE RAILWAYS OF THE UNITED KINGDOM.

AT this time of year, and especially in such weather as that with which we have been favoured this summer, the mind turns, almost instinctively, to the contemplation of train services—that is, of course, except in the case of those who imagine that the motor-car provides a manner of transit better suited to their means or desire for luxury. The summer train service this year is not one whit behind former seasons; rather the contrary, in fact. The public appreciation of a lavish provision of "facilities" in the way of fast long-distance non-stop trains has led to the acceleration this year of several services, many of which have been conveniently arranged by methods which do not always involve increased maximum speed, but only increased average speed, a reduction of service stops, or the use of shorter routes. Judging from all accounts, this year should show exceptional activity in passenger travel. As a result of the favourable season, and the additional traffic due to the Coronation events, and the large influx of visitors coming to these shores at that time, the returns already published show very high figures; and when the statistics for the whole year come to be made up ultimately, if the normal holiday travel also be favourably affected, as it may naturally be expected it will, this year should prove even better than its predecessors.

In order to do this the returns next year will have to exceed those of last—the best so far on record—which give the number of passengers carried, exclusive of season-ticket holders, as 1,306,729,000. Not only in this respect did 1910 show a satisfactory expansion of the business of the railways, but, according to the Board of Trade returns, of which the complete report has just been issued,* in practically all forms of traffic, last year surpassed those which preceded it. The principal figures from the report are reproduced elsewhere in this issue. From them it will be seen that the paid-up capital invested in the railways of the United Kingdom amounted in 1910 to 1,318,515,000*l.*, having increased by slightly more than 4 millions sterling on the figures for 1909. The amount of authorised capital fell during the year, on account of the powers of two lines lapsing, while a third company was absorbed by another without any increase in authorised capital.

In the paid-up capital there is, as is well known, a sum included which represents nominal additions on consolidation, or conversion of stock. This amounts to about 15 per cent. of the whole sum, forming 18½ per cent. of the "ordinary" capital, 13 per cent. of the "preference" and guaranteed capital, and 12½ per cent. of the debentures and loans. The most notable feature of the year was a decrease of about one million sterling in the paid-up "ordinary" capital, as a result of the transfer of some 2,000,000*l.* from this class to preference capital, on the amalgamation of the three systems now forming the London Electric Railway. An increase of about 2½ millions in loans and debentures was partly due to an issue of debentures by the Great Western Railway.

As the result of the increased traffic and other improvements, the average dividend paid on the ordinary capital invested worked out in 1910 to 3.48 per cent., compared with 3.15 per cent. in the previous year, while the preference dividend averaged 3.51 per cent. last year, against 3.46 per cent. in 1909. As showing the manner in which the dividends are distributed, the adjoining table is rather interesting. The great percentage of the ordinary capital is represented in this table, the percentages receiving amounts not included therein being insignificant. The sudden drop of 1908 in the large dividends when practically all the capital receiving in 1907 between 6 and 7 per cent., only received between 5 and 6 per cent., was equalised in 1910 by a partial return to former conditions. The amount of capital on which no dividends are paid alters little year by year; but the return of better times is also reflected in the change which has occurred with regard to the amount of capital on which dividends of 2 to 4 per cent. are paid. Last year the greater part of this, $\frac{4}{10}$th of the total capital, received dividends nearer 4 per cent. than 2 per cent., whereas for some years previously the position had been the reverse of this.

Rate of Dividend.	Ordinary Capital, Per Cent. of Total.				
	1906.	1907.	1908.	1909.	1910.
Nil	13.9	13.6	15.4	14.6	13.7
Above 2 and under 3 per cent.	26.3	28.9	29.3	30.0	17.8
Above 3 and under 4 per cent.	12.5	8.2	11.5	11.8	22.3
Above 4 and under 5 per cent.	6.7	9 6	4.5	2.7	7.7
Above 5 and under 6 per cent.	11.9	10.6	26.7	27.6	17.4
Above 6 and under 7 per cent.	16.3	16 3	0.4	0.3	11.2

The net earnings out of which these improved dividends were paid amounted to 47,356,000*l.*, an increase of 2,222,000*l.*, or 4.9 per cent., on the year before. This was the net result of an increase in both receipts and expenditure. The traffic receipts—the highest on record—showed an increase of 3½ millions sterling, the amount being 114.2 million pounds, of which 52,759,000*l.* came from passenger traffic, and the remaining 61½ millions from goods. The passenger traffic was characterised by several exceptional features. The chief matter of note is the large rise in receipts from ordinary third-class traffic, after a considerable falling off in the previous year. This rise amounted to 1,277,000*l.*, equal to 4 per cent. of the previous year's total, and, apart from the revival of traffic, is to some extent due to the compulsory transfer to this class of much second-class traffic on the Great Western Railway when, to the regret of many of its patrons, that class was abolished on the long-distance trains on that system. The second-class traffic receipts fell during the year by 276,000*l.*, of which most is due, according to the report, to this action of the Great Western Railway. This conclusion is supported by the fact that the average receipts per second-class passenger, excluding the short-distance season-ticket holders, have in the last two years again shown a tendency to decrease. The long-distance journeys of this class are being gradually eliminated, and the receipts per passenger are now 1d. less than they were in 1908. Between the years 1903 and 1908 the receipts per passenger of this class had been nearly doubled, and yet the long-distance second-class passenger is discouraged. The receipts per third-class passenger have not changed materially for many years. They stand at 6.3d., compared with 18.1d. for the second-class traveller. The receipts from first-class traffic, and also the number of passengers of this class, have increased, but the receipts per first-class passenger have continued the upward tendency noticeable in the last few years, showing that the average length of journey is increasing, probably due, partly at least, to the fact that it is now customary to travel by preference by train for long distances, whereas a few years back it was not uncommon to make the trip by motor for the experience. Now the car is frequently taken to its destination by the chauffeur only, if, indeed, it be not trucked and conveyed thither in that manner. This, of course, is not intended to imply any decrease in the use of the motor-car for ordinary work or for excursions crowded into a short space of time, but refers rather to the periodic seasonal migrations from one part of the country to the other.

The number of third-class passengers was, of course, swelled, as were the receipts, by the transfer of the Great Western Railway's second-class long-distance passengers to this class. Some 1,720,000 more passengers were accounted for in this way, but this is a comparatively small number out of the total third-class increase of nearly 44 million. The increase of these passengers over the previous best third-class year (1908) is smaller, amounting to about 35 million. In the number of second-class season-ticket holders, the change on the Great Western Railway alone resulted in a decrease to the extent of 3093 out of a total decrease in number of 4808. The total number of season-ticket holders increased in 1910 by 3.1 per cent., the third-class holders increasing in number by 5.5 per cent. At the same time the average receipts per holder for all classes continue to improve, and the figures afford proof of the general tendency that exists to get further away from the big towns.

The receipts from merchandise and minerals in

* Cd. 5796, price 1s. 3d., published by H.M. Stationery Office, and purchaseable of Messrs. Wyman and Sons, Limited, Fetter-lane, E.C., and others, or through any bookseller.

1910 were good—from the former, in fact, the highest on record, while the latter were only slightly behind the previous best year—1907. The service of the railways, as roughly indicated by the train-miles, showed an increase of about 1 per cent. in the year. The passenger-train mileage increased 1.2 per cent , while the number of passengers increased 3.3 per cent., and the receipts 3 per cent. The goods traffic shows an even better position. For this traffic the train-miles only increased 0.5 per cent., while the tonnage handled increased 2.9 per cent., and the receipts expanded to 3.4 per cent. The goods receipts per train-mile for 1910 are the highest that find place in the returns, amounting to 95.4d., and compare with 71.06d. of ten years previously. This is an increase of 34.3 per cent. in a period in which the train-mileage has decreased 14.2 per cent., though the goods tonnage handled has increased 21.1 per cent. This affords as good a proof as is procurable of the great advances made in the economical handling of goods on British railways in recent years.

In connection with working expenses, which in 1910 amounted to 76.57 millions, having increased 2 per cent. in the year, the working ratio standing at 61.8 per cent. compared with 62.4 per cent. in 1909, the heaviest increases were due to greater expenditure under all the four chief heads : maintenance, locomotive power, repairs and renewals of carriages and wagons, and traffic. In maintenance of way the expenditure rose from 6.37d. to 6.50d. per train-mile, due to heavy expenditure on a few systems and a general increase on the part of the others. The expenditure per train-mile coming under the head of locomotive power was the same in 1910 as in 1909—namely, 11.72d., but the repairs and renewals of rolling-stock showed a large increase. The cause of this is difficult to locate, but there seems to have been an increase in this class of expenditure all round, with the exception of one only of the larger lines—the London and North-Western. The North-Eastern Railway shows the heaviest increase, as it does also the greatest expenditure on this class of work per train-mile run. It spent 8.87d. per train-mile on this work in 1910, compared with 7.98d. in 1909, but compared with only 3.27d. on the Great Northern Railway in 1910, or 3.47d. on the Midland Railway.

During the year 1910 the extent of the electrically-worked lines did not show any increase, but the traffic handled necessitated running nearly four million more equivalent car-miles than in 1909, the Board of Trade units used for traction and other purposes on these electrically-operated roads increasing by about 16 millions.

PROGRESS IN AERONAUTICAL RESEARCH.

If any idea still lurks at the back of the minds of the originators of the unhappy aeronautical experiment, known as the British Army Airship No. 1, that the exceedingly early termination of its career alone robbed them of the opportunity of proving its efficiency, such thoughts must now finally be dispelled, we think, if those concerned are open to conviction. Although we place but very little store on the value of dirigible balloons for any purpose, it is satisfactory to know that some persons, not quite so sceptical as ourselves, are at least moving in less unpromising directions than did the early military designers, who appear to have been quite ignorant of the accumulated knowledge, both practical and scientific, on the subject of the resistance offered to moving bodies in air. The later attempts of the Army aeronautical service have resulted in smaller, but much less objectionable, types of airships than the first.

Well over two years ago it was pointed out in Engineering that Italy was experimenting with an airship which conformed, as knowledge then went, to the requirements of least resistance as suggested by a consideration of stream-line flow. As far as we could discover, that airship then stood nearly alone in that this feature had been accorded a preponderating influence in the design of the gas envelope. The reason why this dirigible formed an exception to a fairly general rule was because the matter was in the hands of engineers whose scientific knowledge was as great as their practical genius. In no other country we believe were airships then constructed without palpable defects from the point of view of resistance, though in some instances other features of design may have rendered this, to some extent, inevitable. The shape of the envelope of the Army airship No. 1 was about as unfortunately chosen as it could be. It was dumpy, with a parallel length of body, and blunt ends. Very many years ago it could have been predicted that better shapes than this might have been found. Giffard's airship, of so long ago as 1852, was its superior in this respect, and since that date many dirigibles have been built in which the attempt has been made to secure a suitable form. For all the influence it had on its design, the whole of this experience, together with the knowledge derived from, and so well and easily demonstrable by, stream-line experiments, might have been non-existent when the shape of the first official attempt at a dirigible in this country was taken in hand.

Although there has long been sufficient material available from analogous work to prevent designers going so glaringly astray as then happened, within the past year or two the fund of knowledge available on the subject, strictly in connection with aeronautics, has been considerably augmented, so that there is no longer any excuse for the perpetration of like blunders, which we trust are now things of the past.

The results obtained in the aerodynamical laboratory of the Göttingen Model - Testing Institute are in course of publication in these columns. They are in general agreement with the results of tests carried out at the National Physical Laboratory in connection with the work of the Advisory Committee for Aeronautics, whose report for the year 1910-11 has just been issued.* This report is labelled "For Official Use." From past experiences, the hint conveyed by such a pertinent instruction to those most intimately concerned with the subjects dealt with would have appeared necessary, but we are pleased to think that with the present organisation such directions are superfluous. If there is anything valuable contained in the report, it will, we may be assured, be made use of by the present Superintendent of the Army Aircraft Factory and his staff.

The report contains a great variety of matter, of which some, relating to the shape of airship bodies, is of interest, since, however limited their value, if public money is to be expended on these contrivances, it is naturally advantageous that it should be spent in the most efficient manner. Various forms of body have been tested for resistance by means of models 6 in. long and 1 in. in maximum diameter, of similar shaped heads, but of different shaped tails. The diameters at $\frac{1}{2}$-in. intervals are given for the three best models in the table herewith :—

Diameter Number.	Model No. 35.	Model No. 34.	Model No. 33.
1 (head) ..	0	0	0
2	0.72	0.72	0.72
3	0.90	0.90	0.90
4	0.98	0.98	0.98
5	1.00	1.00	1.00
6	0.96	0.97	0.98
7	0.92	0.93	0.97
8	0.83	0.89	0.90
9	0.72	0.77	0.83
10	0.59	0 66	0.73
11	0.43	0.57	0.61
12	0.27	0.36	0.46
13 (tail) ..	0	0	0

While the model No. 35 gave the least recorded resistance in water, the other two models of which particulars are given (Nos. 33 and 34) are both practically rather better, as the resistance for the same net lift is less. Both these models are slightly fuller aft than in No. 35, and the advantage appears to be rather in favour of No. 34, which, according to the figures of the report, gives the least resistance for the same net lift of any of the five tested.

The body forms thus selected were all of fairly suitable shape, according to previous knowledge, and the series of tests went rather into the refinements of the subject than did those of another series intended to show by optical methods the distribution of flow round plates and models. In these latter tests, carried out in a small trough, 3 in. wide by 4 in. deep, three models were tested, one of approximately the shape shown to be best in the foregoing tests, a second of a much shorter body and blunter tail, and the third of a parallel-shaped body with similarly blunt head and tail. The latter model was somewhat of the form of the British Army airship No. 1. The photographs accompanying the report show that with the first model there was sluggish flow at the tail, but no true dead water. The means adopted of showing this was the introduction of colouring matter into the water, either in filaments or in clouds. When the latter process was used, the colouring was, of course, retained longer in the water in regions of sluggish movement than in others. At the same velocity at which the fine-tailed model was tested the blunter model showed a considerable area of dead water, or slow circulation, while the bluntest of all showed very pronounced dead water at the tail, formed of two circular eddies. This dead-water region increased with the velocity, and for the blunt model its diameter has been plotted, in the report, as a percentage of the diameter of the model, against velocities. It appears that it increased rapidly at first, from about 40 per cent of the model diameter in a flow of 0.15 in. per second, to about 80 per cent. for the comparatively large range of velocity of from 1 in. to $2\frac{1}{4}$ in. per second. There are also contained in the report some interesting photographs of small plates in flowing water which plainly show the stream-lines leaving the plate edges.

Tests were also carried out on airship models fitted with stabilising fins at the tail, and these gave rather interesting results. Models of the usual form, if left free, would turn broadside on to the air current. While it is necessary to overcome this tendency, it is, on the other hand, disadvantageous to have too strong a stabilising effect, as it interferes with the manœuvring capabilities of the dirigible. The tests were made with a model of small resistance form, but it was found that even with this type, owing to the sluggish flow near the tail, long narrow fins do not have the same effect as short fins of greater width, owing to the latter stretching into undisturbed currents. Fins extending from the point of maximum diameter to the tail, where the same diameter over the fins was retained, were also tested, but proved to be less efficient than equal area better concentrated. The effect of four such taper fins at right angles was also investigated, and it was concluded that the presence of the vertical fins had no effect upon the horizontal, and *vice versâ*, except that a subsidiary effect arises when the model's axis is not parallel with the line of flow of the current. Under these circumstances the wake oscillates from side to side of the tail, a phenomena on which it is intended to carry out further work.

Some of the other memoranda published in the report have already* been dealt with in these columns, such as, for instance, the friction of air in pipes, and the tests of the air disturbance in the shed at Teddington, in which the whirling table is run. Propeller tests have also been carried out in co-operation with Messrs. Vickers, with the result that the data obtained, in air, with full-sized propellers and with models appear to conform to Froude's law. Further work on this point is being carried out. The report of the tests of motors entered for the Alexander prize has also been dealt with in these columns. Balloon and aeroplane fabrics have received a considerable amount of attention, but we must refer readers to the report itself for information on these matters, which only remotely come within our field. Tests being carried out in connection with the Research Committee of the Institution of Mechanical Engineers deal with light alloys, with some of which tensile test results of 34 tons per square inch, combined with reasonable ductility, have been recorded. The alloy known as "duralumin" has also been tested, giving 25.7 tons per square inch for channel bars, and 30 tons for wires. The investigation is being continued to include ageing, &c.

The work of the Committee is to be extended to the carrying out of tests on full-sized aeroplanes, this having been rendered possible by arrangement with the superintendent of the Army Aircraft Factory.

In a memorandum contributed by Messrs. L. Bairstow and H. Booth the dimensional influence of square plates normal to an air-current is discussed, and the conclusion arrived at that the total force, F, on a plate normal to a current of air is given approximately by the expression :—

$$F = 0.00126\,(v\,l)^2 + 0.0000007\,(v\,l)^3,$$

where v is the velocity, and l the linear dimension of the plate. This formula, Messrs. Bairstow and

* "Aeronautics. Technical Report of the Advisory Committee for Aeronautics for the year 1910-11" (with appendices). Price 6s. Published by H.M. Stationery Office, or Messrs. Wyman and Sons, Limited, Fetter-lane, E.C.

* See Engineering, vol. xci., page 378.

Booth conclude, holds good within the limits $vl=1$, or $vl = 350$, the range covered by the experiments of Eiffel, Stanton, and Dines, on which it is based.

THE LARGE NAPHTHA-FIELDS AT MAIKOP.

The vast and prolific naphtha-fields at Maikop have during the last couple of years attracted wide attention. Foreign capital, English and German, French and Belgian, as well as Russian, has been largely invested, and the little Cossack village of Apscheronskaja, on the road from Maikop to Tuapse, has all at once sprung into a busy modern town.

Maikop is a small town in the Kuban district, at about equal distances from the north-eastern shore of the Black Sea and from the Wladikawkas-Rostow Railway. Naphtha was long ago found in the Kuban district, but the earlier efforts to exploit the deposits were either insignificant or unsuccessful. In August, 1909, however, a bore-hole of the Baku-Black Sea Company, at the Cossack of Schirwanskaja, at a depth of only 268 ft., suddenly sent forth a fountain of 210 ft. high, which the first day yielded 300,000 to 400,000 poods of naphtha, and then for a couple of days 100,000 poods per day. The fountain then caught fire, and the force of the rising naphtha was so great that a fortnight was required before the bore-hole could be closed. This occurrence, and other successful borings in the vicinity by the same company and others, demonstrated the presence of rich naphtha deposits. The news spread rapidly, and within a short time a number of companies were formed, and all likely and available land was taken up; one English company had a capital of 600,000*l.*, two rather more than 400,000*l.* each, &c. At first the more prudent Baku firms held back, but by degrees they joined in the rush, as did many small local people, and within less than a year about 1000 claims had been registered, sites within a few months rising to a hundred times their original value. The naphtha-bearing zone is somewhat narrow, but about 40 versts (25 miles) long. The conditions were admittedly favourable; the naphtha had been reached at a shallow depth, the quality was found superior to that of Baku, and the distance from the Black Sea port of Tuapse was only some 90 versts (about 55 miles).

The first results, however, were entirely disappointing. A number of companies began operations, but borings to a depth of from 630 ft. to 910 ft. gave no naphtha. The experts were anything but agreed as to where the focus, so to speak, of springs should be found. Some pronounced in favour of Schirwanskaja; others gave the preference to Ssamurskaja, to the south-east of the former place; others, again, held that not Maikop, but the Anapa neighbourhood, especially at the villages of Wosskressenskaja and Ssuworowo-Tscherkassk, was likely to prove most prolific. It would seem that between the upper strata, where naphtha, as mentioned, had been come upon, and the lower strata, where naphtha may be found, there is a layer of considerable magnitude, which contains no naphtha.

Necessary preparatory work was continued during the latter part of last year without any very eventful or hope-inspiring occurrence taking place. Still some naphtha was come upon at a depth of 1015 ft. on the Apscheron site, at Neftganaja at a depth of 476 ft., and at a depth of 1120 ft. in two places in considerable quantity, and as a result of the work done during the preceding months part of the Maikop district was, in the course of September, last year, officially declared to contain naphtha. In the middle of October, at a depth of 240 sash (about 1680 ft), a fairly prolific spring was come upon, yielding 30,000 poods (about 470 tons) in the 24 hours. In the absence of sufficient storage accommodation the bore-hole was closed, but opened for a couple of hours in November, it again gave a good yield—20,000 poods (about 320 tons) in two hours. Another fountain, from a bore-hole 44 sash (308 ft.) deep, gave a fair yield, but was closed up pending the completion of the necessary arrangements.

The work of experimental boring is being carried on with considerable energy, which is not to be wondered at, considering the large capital at stake (of English capital 5,000,000*l.* or more), but apart from the fountain at Schirwanskaja, with its yield of 700,000 poods (11,000 tons) during the 24 hours, the future of the Maikop district as an oil-field of international importance still remains an open question. The transport and other arrangements are inadequate for dealing with really large quantities. The port of Tuapse, on the Black Sea, which, as already mentioned, is at no very great distance from Maikop, has been found to be in very primitive and inadequate condition, otherwise the laying of a pipe-line to that port would have been the most natural solution; a railway to Tuapse is also being considered, but preference has been given to a pipe-line to Jekaterinodar, a distance of some 120 versts (about 75 miles), and from that place there is about the same distance to the port of Noworossijk. The fate of at least one large Russian naphtha concern, which erected large and costly plant, but whose naphtha yield became exhausted in a few years, points to some caution in connection with undertakings of this nature.

Reports from Chadyschinskaja, which was expected to prove a second centre similar to Schirwanskaja, are also somewhat disappointing, and of any really prolific yield there seems but scanty prospect, whilst some more promising borings have been undertaken to the north of the latter place. The production for 1910 of the Maikop district is put at :—

	Poods.	Tons.
Andreis	653,400	(10,500)
Ssaltzkow	572,183	(9,200)
Pressler	75,000	(1,200)
	1,300,583	(20,900)

It is hoped that when the pipe line to Jekaterinodar has been in operation for some little time, and when the Maikop fountains and pumps have started fairly running, more satisfactory figures will be forthcoming.

ATMOSPHERIC INFLUENCES ON PHOTOMETRY.

The variations of the pressure, humidity, and vitiation of the atmosphere influence the luminous intensity of flame standards to a not inconsiderable extent, and have hence been studied by various investigators. Special atmospheric conditions have to be created for this purpose, since the variations in the ordinary photometer-room are small and too much dependent upon one another. A long series of very careful observations are required to arrive at correction factors for the effects of atmospheric conditions on photometric flame standards. Messrs. W. J. A. Butterfield, F.I.C., J. S. Haldane, M.D., F.R.S., and A. P. Trotter, M. Inst. C.E., have contributed an account of recent experiments of theirs to the International Photometric Commission, which met at Zurich in July. They have made use of the caisson which the late Dr. Ludwig Mond presented to the Lister Institute for the study of the caisson disease and mountain sickness. This caisson is a boiler, 7 ft. in diameter, 7½ ft. long, built up of ⅜-in. and ½-in. plates, with dished ends, and provided with a manhole of 24 in. by 15 in. in one end. There are four spring-valves and three additional valves for controlling the air pressure from inside and outside. The pressure is raised by a compressor driven by a gas-engine. Two benches, for the photometers and for air analysis, were placed in the caisson, which has telephone communication with the outside. One or two of the observers were, as a rule, in the caisson during the experiments, and the flame standard was placed near the outlet airway, not to vitiate the air too much.

The investigation concerned the Harcourt pentane 10-candle lamp and the Hefner amyl-acetate standard. The atmospheric conditions were varied in different ways, and the original conditions restored at the end of a series, in order to check the experiments. As regards the air pressure, it is found that the luminosity of the flame increases with increasing pressure; the barometer range of the experiments was from 450 mm. to 1000 mm. (about 18 in. to 40 in.). For the range 700 mm. to 850 mm. the curve for the Harcourt lamp is nearly a straight line. Within these limits the light varies by 1 per cent. with a variation of 12.5 mm. in the air pressure; these figures entirely confirm Mr. C. C. Paterson's research of 1906-1907. At lower pressures the luminosity is much more affected. The Hefner lamp also gave a straight-line curve for the range 700 mm. to 850 mm., but it was less affected by the fluctuation in air pressure, and was about half as sensitive, an increase of 25 mm. being required to produce a change of 1 per cent. in the luminous intensity. At lower pressure, however, fluctuations in the air pressure again made a large difference, four times as large as Liebenthal found in 1895. Thus for comparisons made in towns like Johannesburg and Mexico, situated on plateaus, where the normal barometer keeps in the neighbourhood of 600 mm., considerable corrections would be required.

Some of the humidity tests were conducted in a small room of the Electric Standards Laboratory, Whitehall, by specially drying the air or by passing steam into it. A change in the temperature from 8 deg. up to 20 deg. Cent. did not in itself affect the luminosity; higher temperatures do not appear to have been tried. The luminosity of both the Harcourt and the Hefner candles decreased by about 1 per cent. for an increase of 0.16 per cent. in the aqueous vapour in the air; or 1 per cent. increase of humidity diminished the luminosity of the flame standard by 6.25 per cent. These values are intermediate between those of Paterson (6.6 per cent. for the Harcourt and 6 per cent. for the Hefner lamp), and of Liebenthal (5.5 per cent. for the Hefner candle).

The vitiation of the air, which is produced by breathing in the room and by the combustion of the flame gases, causes a deficiency in the oxygen and an excess of carbon dioxide, which affects the further burning of the flame and diminishes the luminosity. This diminution amounted to 1 per cent. for every 0.035 per cent. of carbon dioxide above the normal in the case of the Harcourt flame, and for every 0.045 per cent. of CO_2 in the case of the Hefner candle. This coefficient holds as long as the contents of CO_2 do not exceed 2 per cent.

The results of the investigations are summarised in the following correction formulæ, in which P, A, C express the normal air pressure and percentages of moisture and of carbon dioxide, while p, a, c indicate the values observed during the test. The formula for the actual luminosity I^1 expressed in terms of the luminosity I, under normal conditions, is for the Harcourt lamp :

$$I^1 = \frac{100 - \left(\frac{a-A}{0.16} + \frac{c-C}{0.035} - \frac{p-P}{12.5}\right)}{100}.$$

In the case of the Hefner lamp, 0.045 has to be substituted for 0.035, and 25.0 for 12.5.

Messrs. Butterfield, Haldane, and Trotter also conducted some experiments on the effects of variations in the atmospheric conditions on the light of gas and candle flames. These tests show that small variations in the atmospheric condition will not appreciably affect the results of comparisons between Argand and Bray gas-burners and the flame-standards mentioned, because the two classes of lamps would more or less be influenced in the same way. But in comparing electric-lamps with flame-standards, the corrections should be applied.

NOTES.

Mercury-Arc Lamp and Distilling Apparatus. An American scientist, C. Th. Knipp, has conceived the idea of converting a mercury-arc lamp into an apparatus for rapidly distilling mercury. So many electricians and physicists have to deal both with mercury and with mercury-arc lamps that his apparatus, which he first described before the New Orleans meeting of the American Association for the Advancement of Science in 1905, and which he has regularly been using for some years, will be of interest. He observed that mercury vapours condensed on the cold portions of arc-lamps, and he therefore combined a mercury-arc lamp with a receiver. The apparatus, as described in the *Physikalische Zeitschrift* of April 1, 1911, consists of two bulbs, from which three vertical tubes project downward. The one bulb is the arc-lamp, and it slopes down to the right; the other bulb is joined to the upper portion of the former bulb, and it slopes down to the left. The ends of the first bulb form pockets for the mercury electrodes, and each of these is connected by a glass tube, 760 mm. in barometric height, with a vessel which is charged with the mercury to be distilled. The one vessel is cylindrical and is provided with an overflow; it is joined to the negative pole of an induction apparatus. The other vessel, which is joined to the positive terminal and forms the chief reservoir for the mercury, is a dish whose large surface facilitates the maintenance of a suitable mercury level in the electrode pockets of the lamp. The mercury vapours pass upward into the second bulb, which acts as a receiver; they condense there,

and the mercury flows down the sloping walls of the bulb and into the third of the tubes mentioned. The upper portion of this tube is capillary, the lower portion is wider, and the lower end is bent so as to form a mercury seal. A little below the capillary portion a connection to an air-pump branches off, which is wanted for starting the operations. When the vessels have been charged so that the mercury reaches up to the electrode pockets, the pump is started until the arc is established. Mercury then begins to distil and to trickle down the third tube in drops, which continue to maintain a vacuum, so that the pump can be cut out after about 15 minutes. The distilled mercury is said to be very pure. Knipp's apparatus has a lamp bulb, 40 mm. in length, 25 mm. in diameter, and a somewhat larger receiver bulb. Worked with a current of 1 ampere at 23 volts it yields 1 kg. of pure mercury per hour.

The Velocity of Röntgen Rays.

About six years ago Erich Marx made, in the Physical Institute of the University of Leipzig, the first experimental determination of the velocity of propagation of Röntgen rays. He found that Röntgen rays travelled as fast as light rays, which had generally been assumed for general reasons. The experimental method of Marx was attacked, however, by J. Franck and R. Pohl, of Berlin, and the complicated character of the apparatus certainly justified some doubt. Marx has, therefore, repeated his determinations. The new experiments, which are described in a long contribution to the *Annalen der Physik*, vol. xxxiii., are based upon the same principle; but the apparatus is simplified, and the method is modified. The result is the same as before. Röntgen rays appear to travel with the velocity of light rays, the rate being the same within a few per cent. But Franck and Pohl again raise objections in vol. xxxiv. of the quoted journal, substantially on the same grounds. The first method was a zero method, depending upon the appearance of sparks. The advantage of this method was that details of the character of the sparks need no more be known than the observer sitting in front of a balance need know the direct connection between the load applied and the produced deflection of the beam; it is sufficient for him to see that the beam is deflected. In the new experiments a zero method is not used; the apparatus is simpler, the arrangements are more lucid, and long waves are excluded; but short waves of relatively very high energy are required, and extreme care is necessary throughout the experiments. As in the first determination, two coherent trains of waves are made to act upon each other. Hertzian waves of considerable rapidity ($\lambda/2$ = 66 cm.) are excited, and travel along a Lecher system of wires, consisting of two parallel wires with a movable bridge-piece. They first strike a Röntgen tube, and produce periodical impulses of Röntgen rays; this is the first train of waves. The other train is inductively coupled with the first. It travels along a wire to an electrode mounted in a vacuum bulb; this electrode will oscillate in synchronism with the Röntgen rays, but will lag behind in phase; the phase difference depends upon the position of the bridge. The two trains interfere with each other, and the interference is observed. Opposite the electrode is mounted, within the bulb, a Faraday cage containing an electrometer. When the Röntgen rays strike the electrode at a moment when their potential is negative, a spontaneous discharge takes place; when the potential happens to be positive, no discharge will be observed. Under the actual conditions, the current wave observed should have two maxima at the distance of 132 cm. When the bridge is shifted (the receiver remaining stationary) another similar curve will be obtained, also with two maxima; but the maxima of the second wave will appear to be displaced with regard to the maxima of the first curve. This displacement Marx finds to be equal to the distances through which the bridge has been shifted. He concludes, hence, that the velocity of the Röntgen rays is the same as that at which the electric waves travel along the Lecher wires, and the velocity of electric waves in wires is known to be the same as that of light in air. The objection which Franck and Pohl repeat is that the observed interference may merely be that of waves which travel directly through the air with the waves which pass along the wires. The Röntgen rays, they consider, need not enter into the phenomenon at all, and it is difficult without a very close study of the apparatus and of the experiments (of which a very large number were conducted) to arrive at any independent conclusion.

The Electrification of Norwegian Railways.

A committee appointed for the purpose of looking into, and reporting upon, the question of electrification of Norwegian railways has now handed in its report. The committee has examined the matter of electric traction in various countries, and strongly recommends a thorough investigation of everything connected with the electrification of Norway's railways, which seems to be favoured by several circumstances. Whilst some of the large countries had invested immense capitals in the construction of railways, and had their railway system complete for steam traction before the question of electrification arose, Norway's railway system, in spite of spirited railway building for several years, is not by a long way complete. The electric system can, therefore, be tried on new lines, where due regard can be paid to electric traction during the planning and the building of the line, without outlay on an expensive stock of steam-locomotives, &c. Besides, the less satisfactory financial results of the Norwegian railways make it particularly desirable to adopt a cheaper system, if such can be found, and, finally, Norway has in her many waterfalls a medium for generating cheap electric energy. The question of electric traction is by no means one of recent date in Norway, having been discussed for some twenty years, yet the Norwegian railway authorities have not gone anything like so thoroughly into the matter as have several other countries. Since 1892, when the purchase of waterfalls by the State for the electrification of railways was first brought forward, the State has acquired several large and small waterfalls in different parts of the country; but whether these are so situated and have such natural conditions that they are well suited for the generation of electric energy for railway traction, yet remains to be seen, and has not, so far, been fully examined into. The State railways have prepared some provisional plans and calculations for the electrification of a number of old and new railways, and the building of an electric branch line (the Myrdal-Fretheim line) to the Bergen Railway was decided upon in the year 1908. Last year the Railway Board prepared plans and calculations for the electrification of the Christiania-Drammen Railway, but beyond this the authorities do not appear to have taken any steps for the electrification of the country's railways. Of private railways with electric traction there are at present in Norway the following lines:—Hafslund-Sunnesund (transport), Christiania-Holmenkollen, Thamshavn-Lökken, Notodden-Tinoset, and Rollag-Staalheim, the last two of which are not yet quite ready. The committee holds that Norway, instead of being left behind, ought to take the lead in the matter of electric railways, and recommends a general and thorough investigation of the question of the importance of electric traction for the Norwegian railways. This investigation ought to comprise the amount of power required and the selection of suitable waterfalls; the financial aspect of electric traction for the Norwegian railways; the possibility of fixing a uniform electric equipment and system for the country's electric railways, and the possibility of joint traffic with the Swedish railways, as well as the importance of electric traction for the building of new railways as regards track and construction. It is recommended that this investigation should be left to a committee comprising experts in the domain of electricity, electric railway traction, hydraulics, and railway construction.

The Specific Heat of Water.

In the course of their investigation concerning the specific heat curves of aqueous solutions, Messrs. W. R. Bousfield, M.A., K.C., and W. Eric Bousfield, B.A., had to redetermine the specific heat of water, and this research involved a redetermination of the mechanical equivalent of heat in terms of mean calorie from 13 deg. to 55 deg. Cent. The redetermination of the specific heat of water was required, because the previous values of Barnes, Regnault and Lüdin differ by as much as 1 per cent.; their specific heats of water at 80 deg. Cent. expressed in terms of the 15 deg. calorie were 1.0014, 1.0081, 1.0113. Messrs. Bousfield used the continuous-flow method. Their thermometers could be read to 0.005 deg. Cent., and as an interval of 40 deg. Cent. was taken, an error on their part of 0.01 deg. would not vitiate their results by more than 1 in 4000. The method, which was communicated to the Royal Society in February last, was the following. A current of water was passed through a Dewar vessel, containing about 3 litres of water, and was heated in that vessel; the water entered at about 13 deg. Cent. and left at about 55 deg. Cent.; the vessel was immersed in a bath kept at the same temperature as the contents of the vessel. The electric heater and the electric resistance used in series with it for the determination of the current with the help of a battery of standard cells were of an interesting novel type. Each heater was a spiral glass tube of small bore, containing mercury, and the tube itself served as a thermometer bulb, being connected with the thermometer tube proper. This type of resistance enabled the experimenters, in their opinion, to overcome a difficulty which does not appear to have received due consideration in other researches. When a heavy current is sent through a standard resistance, the observed resistance will depend not only on the temperature, but also on the intensity of the current, because the passage of the current itself appears to induce a state of strain which may temporarily alter the resistance. That there is such a residual effect—a kind of hysteresis—in manganin standards, which persists long after the circuit has been broken, has been recognised; but there is also some influence while the current is flowing, and this latter effect—the "thermoid effect"—is generally disregarded. Messrs. Bousfield think that it will be absent in a homogeneous liquid like mercury. In making their experiments with distilled water, Messrs. Bousfield heated a weighed bulk of water from 0 deg. Cent. up to 80 deg. Cent. by stages which gave the mean specific heats over the intervals 0 to 13, 13 to 27, 27 to 55, and 55 to 80 deg. Cent.; a separate inquiry yielded the specific heat of glass. Taking all these determinations a formula was obtained containing the temperature θ in the first, second, and third power, and, according to this formula, the value of the equivalent of heat at 15 deg. Cent. would be J = 4.179. Joule's J_{15} was 4.174, that of Griffiths was 4.198, and that of Barnes 4.184. The new curve agrees best with that of Lüdin, who used the method of mixtures, and least with that of Barnes, who had applied the continuous-flow method of the authors, but with platinum thermometry. The following table shows the change in the specific heat of water with temperature according to Messrs. Bousfield:—

θ.	J.	θ.	J.	θ.	J.
0	4.209	30	4.175	60	4.203
5	4.195	35	4.178	65	4.208
10	4.186	40	4.182	70	4.213
15	4.179	45	4.187	75	4.216
20	4.176	50	4.192	80	4.217
25	4.174	55	4.198		

In this table the minimum of the specific heat lies at about 25 deg. Cent. The various observers differ also as to the temperature of this minimum. Regnault did not find any minimum at all; Bartoli and Stracciati placed it at 20 deg. Cent., Lüdin at 25 deg., Rowland at 30 deg., and Barnes at 38 deg. Cent. Messrs. Bousfield, as stated already, agree with Lüdin.

The late Professor Walthère Spring.—We regret to record the death of Dr. Walthère Spring, professor of general chemistry at the University of Liége, who died on his estate at Tilff, near Liége, last month. He secured this appointment after having been professor in Germany, where he organised the chemical institute at Leipzig. Spring first worked in the fields of organic and mineralogical chemistry, but physical chemistry attracted him more in particular. His name became generally known about 30 years ago (and was mentioned in our columns then and later), when he applied very high compression to powdered salts and finely disintegrated metals which he succeeded in coalescing and welding by the high pressure; chemical combination also seemed to result. Later he turned his attention to colloids, and in this connection also to the difficult task of preparing solutions perfectly free from dust and other contaminations. Such solutions may be optically void; that is to say, they will remain dark when illuminated by the Tyndall cone, the conical beam given by an arc-lamp and a lens. One of the last researches which the veteran scientist brought before the Belgian Academy of Sciences last year concerned this subject. He had found certain salt solutions quite clear and void in 1905, when he sealed them up, and had found others turbid at that time; five years later all the solutions were found void, and their electrical resistance appeared to have decreased; these problems cannot be regarded as settled, however. The purification of liquids was also of particular importance in his study of the colour of the sea water. Physiologists value his work on colloids highly.

STRESSES PRODUCED BY FORCE FITS.

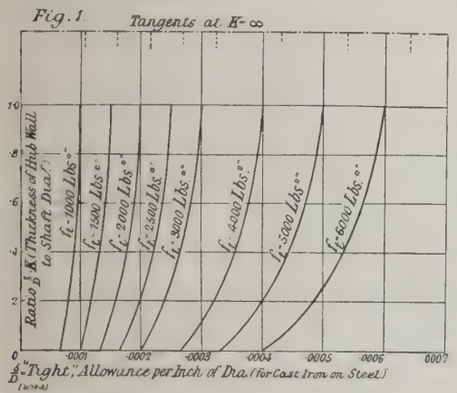
By Professor ARTHUR MORLEY.

A CORRESPONDENT recently asked the writer what should be the thickness of the wall of a cast-iron hub pressed by hydraulic power on a large dynamo-shaft with given force-fit allowances, in order to keep the bursting stress within a given limit; no text-book on design appeared to have treated the point raised. The reply may be of general interest and possibly throw some light on the reasons for which the Engineering Standards Committee decided to make no recommendations as to allowances and tolerances for force, push, and shrink fits. When hubs are forced on hollow shafts the investigation is that given in text-books for compound cylinders made by shrinkage.

For hubs forced on solid shafts,

Let

R_1 = outer radius of hub.
R_2 = inner radius of hub = radius of shaft after fitting.
$t = R_1 - R_2$ = thickness of hub-wall.
$D = 2R_2$ = diameter of shaft.
p_x = radial compressive stress per square inch at radius x ($= p_2$ at $x = R_2$).
p_y = hoop tension per square inch at radius x.
E = Young's modulus for shaft material, E^1 = ditto for hub material.
$\frac{1}{m}$ = Poisson's ratio for shaft material, $\frac{1}{m^1}$ = ditto for hub material.
δ = excess in original diameter of shaft over that of hole in hub.



From Lomi's well-known theory, in a cylinder under radial pressure,

$$p_x = \frac{B}{x^2} - A \quad . \quad . \quad . \quad (1)$$

$$p_y = \frac{B}{x^2} + A \quad . \quad . \quad . \quad (2)$$

where A and B are constants.

If u = radial displacement of a point distant x from the centre, for the solid a shaft,

$$\text{Tensile hoop strain} = \frac{u}{x} = \frac{1}{E}\left(p_y - \frac{p_x}{m}\right)$$

and

$$u = 0 \text{ for } x = 0, \text{ hence } B = 0,$$

and

$$p_x = -p_y = A = p_2 \text{ (a constant)}.$$

(It may be noticed in passing that this differs from a shaft with even a pin-hole along its axis, in which p_x varies from 0 at $x = 0$ to p_2 at $x = R_2$ and p_y varies from $-2p_2$ at $x = 0$ to $-p_2$ at $x = R_2$, a difference analogous to that of a rotating disc or cylinder with and without a small central hole.)

For the hub, taking f_t = maximum tensile stress per square inch at $x = R_2$,

$$p_x = \frac{b}{x^2} - a \quad . \quad . \quad . \quad . \quad (3)$$

$$p_y = \frac{b}{x^2} + a \quad . \quad . \quad . \quad . \quad (4)$$

At $x = R_2$,

$$p_x = p_2 = \frac{b}{R_2^2} - a \quad . \quad . \quad . \quad (5)$$

At $x = R_1$,

$$p_x = 0 = \frac{b}{R_1^2} - a \quad . \quad . \quad . \quad (6)$$

At $x = R_2$ the total hoop strain (compression of shaft + stretch of hub) is

$$\frac{p_2}{E} - \frac{p_2}{m E} + \frac{f_t}{E^1} + \frac{p_2}{m^1 E^1} = \frac{\delta}{D}$$

or

$$p_2 \cdot \frac{m-1}{m E} + \frac{1}{E^1}\left(f_t + \frac{p_2}{m^1}\right) = \frac{\delta}{D} \quad . \quad (7)$$

And at $x = R_2$

$$p_y = f_t = \frac{b}{R_2^2} + a \quad . \quad . \quad (8)$$

If δ and f_t and R_2 are fixed, (5), (7), and (8) determine a, b, and p_2, and then (6) gives R_1, and therefore t required. If f_t R_1, and R_2 are fixed, then (5), (6), and (8) determine a, b, and p_2, and (7) gives δ the allowance required.

Example.—Cast-iron hub on steel shaft D = 6″, $\delta = 0.0015\left(\text{or } \frac{D}{4000}\right)$, f_t to be 3000 lb. per sq. in. Take $m = 4 = m^1$, a choice which does not, within usual limits, greatly influence the result, and is on the safe side. Take $E = 2$ $E^1 = 30{,}000{,}000$ lb. per sq. in.

Equation (5) gives

$$p_2 = \frac{b}{9} - a.$$

Equation (7) gives

$$\frac{3}{4} \cdot \frac{p_2}{30 \times 10^6} + \frac{1}{15 \times 10^6}\left(3000 + \frac{p_2}{4}\right) = \frac{0.0015}{6} = 0.00025.$$

Equation (8) gives

$$3000 = \frac{b}{9} + a.$$

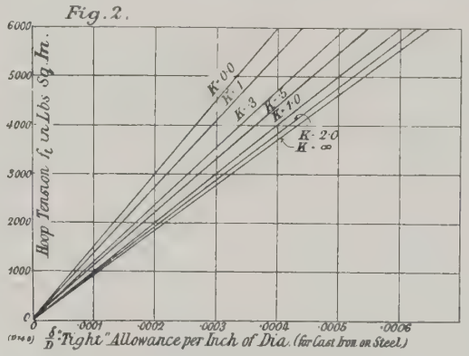
Hence

$$p_2 = 1200 \text{ lb. per sq. in.}, \quad a = 900, \quad b = 18{,}900.$$

And from (2)

$$R_1^2 = 21, \; R_1 = 4.58, \text{ or } t = 1.58''.$$

Incidentally it may be recorded that the total normal pressure on a hub 6 in. internal diameter



and 13 in. long is $6\pi \times 13 \times 1200$ lb. = 131 tons, and that this hub required 36 tons to force it on the shaft, which corresponds to a coefficient of friction of $\frac{36}{131} = 0.274$. To work to such small allowances the shaft surface would be ground dead smooth, and this coefficient would probably give a fairly accurate estimate of the torque which the combination would be capable of resisting.

The general result from equations (5), (6), (7), and (8), eliminating a, b, and p_2, is

$$\frac{\delta}{D} = \frac{f_t}{E}\left\{\left(\frac{m-1}{m} + \frac{1}{m^1}\frac{E}{E^1}\right)\frac{R_1^2 - R_2^2}{R_1^2 + R_2^2} + \frac{E}{E^1}\right\}$$

or

$$\frac{\delta}{D} = \frac{f_t}{E}\left\{\left(\frac{m-1}{m} + \frac{1}{m^1}\frac{E}{E^1}\right)\frac{(1+2k)^2 - 1}{(1+2k)^2 + 1} + \frac{E}{E^1}\right\} \quad (9)$$

where

$$k = \frac{t}{D}.$$

From this the dimensioning chart (Fig. 1) has been plotted with the above values for steel and cast iron. The previous example will illustrate its use. Taking a force-fit allowance of $\frac{1}{4000}$ of shaft diameter—*i.e.*, $\frac{\delta}{D} = 0.00025$—we read on the curve $f_t = 3000$ that $k = 0.265$—*i.e.*, $t = 6 \times 0.265 = 1.59$ in. It may also be noticed from the diagram that the hub-wall would require to be about 6 in. thick ($k = 1$) to reduce the tension to 2500 lb. per square inch. Also, that with an allowance $\frac{\delta}{D} = 0.000325$ (see tangent at $k = \infty$), no increase in t is sufficient to reduce the hoop stress below 3000 lb. per square inch.

Similar conclusions are obvious from Fig. 2, which shows another and more easily plotted form of the result (9). Fig. 2 shows very simply the variations in maximum stress in a given hub when, in additional to the nominal allowances, given tolerances (or deviations from nominal allowance) are taken into account. From either diagram it is evident that in such constructions the stresses depend more upon the fit allowance than upon the thickness of metal in the hub, and that the allowance and tolerance require careful attention.

It is interesting to speculate as to how many wheel-failures may be caused by excessive force-fit allowances or key-driving. Above stresses of 3000 lb. per square inch the ratio of stress to strain (and, therefore, E^1) in cast iron diminishes somewhat, and this diminution will to some extent modify the foregoing results for larger allowances in fairly common use; but such allowances will be ample to carry cast iron not only to the region of dangerous stresses, but to actual fracture. Ductile metals may relieve themselves by local yielding, but brittle ones have no such safeguard. Charts similar to Figs. 1 and 2 for steel hubs on steel shafts may be plotted from equation (9), which simplifies when $m = m^1$ and $E = E^1$.

HIGHER TECHNICAL EDUCATION IN SOUTH AFRICA.

By Professor BOHLE.

Historical Summary.

In dealing with the question of higher technical education in South Africa, reference must necessarily be made to the preliminary steps in the movement which took place in the Cape Colony. In 1894 the Government of the Cape Colony agreed upon a general scheme for the training of mining engineers, as devised by the South African College authorities.

This scheme provided for two years' preliminary scientific instruction, to be given at the South African College, Cape Town, or at any other of the colleges in South Africa which chose to offer the necessary equipment. The third year was to be spent at Kimberley, and the fourth year, completing the course, at Johannesburg.

The course commenced in January, 1895, at the South African College, after the council of this institution had appointed a professor of geology. In July, 1896, five students were sufficiently advanced to proceed to Kimberley.

The teaching at the School of Mines during the first two years of its existence was carried on under considerable difficulties, but by February, 1899, suitable premises were completed at Kimberley at a cost of some 9000*l*. Of this sum 2000*l*. was given by the Cape Government, 2000*l*. by the De Beers Company, and the remaining 5000*l*. was borrowed. Three separate buildings were erected: the school itself, with two large class-rooms, a laboratory, balance, furnace, and other rooms; a boarding-house, with a common room and a dining-room for the students; and a residence for the principal.

The examinations were conducted entirely by the University of the Cape of Good Hope, and consequently the courses of instruction were regulated by the University syllabuses. These examinations were three in number, known respectively as the First Mining, Second Mining, and the Final Mining. The First Mining Examination involved two years' study, and had to be passed in order to gain entrance to the School of Mines. The great majority of the students received their preliminary course of training at the South African College, but students were also received from the Victoria College, Stellenbosch, St. Andrew's College, Grahamstown, and Maritzburg College, Natal. In the earlier years students were admitted to the First Mining Examination who had satisfied the examiners at matriculation in the three mathematical subjects, and in two modern languages, but in and after 1903 no candidate was admitted to the examination for the first time unless he had passed the Matriculation Examination, or its equivalent. Having passed the three Mining Examinations, a candidate then secured the diploma of "Mining Engineer." A later provision conferred the degree of B.Sc (Mining Engineering) upon those who, in addition, passed an examination of the standard of the Intermediate Arts, in English or Dutch, or French or German.

The work carried on at Kimberley was technical in character, embracing mining theory and practice, metallurgy and assaying, mine surveying, mechanical and electrical engineering, drawing, and workshop practice. Every credit must be rendered to the De Beers Company for the generous way in which they assisted the work of the School of Mines by throwing open their mines and workshops to the students, thus enabling the theoretical instruction to be closely identified with modern practice.

Owing to unforeseen circumstances it was found that the fourth year of the course could not be provided for at Johannesburg, as originally intended. The five students who were the first to enter the course certainly spent their fourth year on the mines of the Rand, writing detailed descriptions of the various works and operations, but the only theoretical instruction imparted was a short course of lectures delivered during the vacation in the council room of the Chamber of Mines. Consequently arrangements were made whereby both the third and fourth years of the course

were carried on at the Kimberley School, the fourth-year students devoting six months of the year to practical work in various mines at Johannesburg. It was at a later date arranged that three months of each of the third and fourth years should be spent on the Rand, as it was necessary to prepare a careful description of one of the mines for the University ; but the intervention of the war, and the placing of Kimberley in a state of siege, prevented this modified arrangement from being carried out. Fortunately, owing to the previous decision of the Cape University to change the date of the examinations from July to December, the nine months during which it was found necessary to close the School of Mines did not seriously prejudice the students. They were debarred, however, from proceeding to Johannesburg, but the difficulty was met by the Cape University accepting a description of a mine other than one on the Rand.

Although the South African School of Mines was founded at Kimberley, it had all along been felt that, but for political reasons, Johannesburg would have been chosen, owing to the greater facilities which it presented. In July, 1902, an influential committee, representing the Witwatersrand Council of Education and other bodies, reported on the question of technical education, and recommended the establishment in Johannesburg of a technical institution which should provide courses in all branches of engineering in addition to mining. In October of the same year a conference was arranged between representatives of the South African College, the South African School of Mines, and this committee. Beyond emphasising the necessity of providing instruction at Johannesburg in branches of technical education connected with mining at the earliest possible date, nothing resulted from this conference. In January, 1903, however, a commission, known as the Technical Education Commission, was appointed to consider what steps should be taken to bring into existence an institution for technical education of a university character. The Commission in its report recommended, amongst other things, that temporary premises should be at once acquired to carry on the work of a mining course, on a four years' course, and also that general technical and higher education should be added. The Commission further recommended that the Government should set aside Plein-square, Johannesburg, to provide space for the establishment and growth of a technical institution which, in addition to the provision of laboratories and lecture-rooms for the use of students, might contain the public library as well as museums or art galleries, and afford accommodation for the various technical societies of the Rand. In August, 1903, an institution, under the title of the "Transvaal Technical Institute," was created by the Lieutenant-Governor, and negotiations were entered into with the South African School of Mines, Kimberley, which resulted in the absorption of that institution, in so far as the whole of its third and fourth year mining students were transferred to Johannesburg. Temporary premises were secured in Kerk-street and on Von Brandis-square, and shortly afterwards it was decided that the institute should undertake the whole of the four years' courses in mining as well as train students in mechanical, electrical, and civil engineering. These premises were found to be quite as unsuitable for their purpose as those used in the early days of the School of Mines, and after the first year a group of temporary buildings was erected on Plein-square, that site having been acquired by the Council in terms of the recommendation of the Technical Education Commission.

The foundation-stone of the new permanent buildings was laid by Lord Selborne in August, 1907, and the opening of the school took place in 1909. In addition to the professorships for mining engineering subjects, chairs were added in English, Philosophy, Classics, Law, and Biology, so that the work embraced most of what was carried on by other university colleges in South Africa.

During 1907 a Commission was appointed by the Transvaal Government to consider the question of the organisation of higher education. As a result of the report of this Commission the Government, in February, 1908, instituted university classes at Pretoria, which, as soon as arrangements could be completed, were placed under the control of the Council of the Transvaal University College—as now the institute was called, which until 1906 possessed the name of Transvaal Technical Institute—constituting the nucleus of the Arts and Science Department as distinct from the Department of Applied Science at Johannesburg. In 1910 the name of the latter was changed into South African School of Mines and Technology.

In the year 1900 the South African College transferred the matriculation classes to the South African College School, and thus the college began for the first time to confine itself to university work.

In 1902 the Senate of the South African College submitted to the Council a memorandum setting forth in detail the pressing needs of the college as regards professorships and accommodation.

The first step taken was the purchase of additional ground adjoining the college, known under the name of Bertram estates. In connection with this purchase and the developments associated with it, an appeal for funds was made to all the friends of the college, and in response a sum of 45,000*l.* was secured. In addition to this, the Corporation of the City of Cape Town offered to contribute 500*l.* a year towards the establishment of a Chair of Engineering, together with an annual sum of 1000*l.* towards defraying the interest and charges on the estate bought.

The first professor of engineering was appointed in 1903. The foundation stone of the new engineering building was laid in 1904, and the opening of the new Engineering School took place in 1905.

In 1905 the Corporation of the City of Cape Town offered to contribute 500*l.* per annum towards the establishment of a Chair of Electrotechnics. The first appointment was made at the beginning of 1906.

Courses of Study in Engineering at the South African College.

1. *Mining Engineering.*—Every candidate for admission to the mining courses shall have passed the matriculation examination of the University of the Cape of Good Hope, or the matriculation examination without Latin, the latter being replaced by a modern language.

The college gives instructions in the subjects for the first and second mining examinations of the University of the Cape of Good Hope. The complete course lasts for four years, of which the latter two are spent at Johannesburg, partly at the mines and partly at the South African School of Mines and Technology.

The subjects for the first mining examination are :—

Pure mathematics.
Applied mathematics.
Physics.
Inorganic chemistry.
Elementary geology.
Graphics.

The subjects for the second mining examination are :—

Pure mathematics.
Applied mathematics.
Physics.
Chemistry.
Geology.
Mineralogy.
Engineering design and drawing.
Graphics.

The subjects for the third year are :—

Metallurgy.
Assaying.
Surveying.
Geology and mineralogy.
Engineering.
Electrotechnics.
Engineering design and drawing.
Practice in mines and workshops.

The subjects for the fourth year are :—

Mining.
Mining economics.
Ore-dressing.
Surveying.
Assaying.
Metallurgy.
Engineering.
Electrotechnics.
Practice in mines.

The student who has passed the matriculation examination of the University of the Cape of Good Hope, with or without Latin, and also the examinations at the end of the first, second, third and fourth years, as held by the university, is granted the degree of Bachelor of Science in mining engineering. In addition to this, the South African School of Mines and Technology grants diplomas to those students who have successfully passed the examinations held by this institution.

The courses leading to diplomas at Johannesburg are carried out on the sandwich system, under which the college work is concentrated into one portion of the year, leaving the remainder for practical work in mines or workshops. This system has met with the approval of the Transvaal Chamber of Commerce, and the Association of Mine Managers of the Witwatersrand, and the latter body has undertaken to co-operate, and to place on the mines for practical training, a certain number of students recommended by the college every year.

Students who study for the first two years at the South African College must spend at least six weeks of the long vacations in workshops, such as the Salt River Locomotive Works or the college workshop.

The standards for the various examinations in mining are as follow :—

First Year.

Subjects.		Marks. Maximum.	Minimum Required.
Mathematics	First paper, 225 / Second paper, 225	450	112
Applied mathematics	Written, 250 / Practical, 100	350	87
Physics	Written, 200 / Practical, 150	350	87
Chemistry	Written, 200 / Practical, 150	350	87
Geology		250	62
Graphics		350	87
Total		2100	840

Second Year.

Subjects.		Marks. Maximum.	Minimum Required.
Mathematics	First paper, 200 / Second paper, 200	400	100
Applied mathematics	First paper, 200 / Second paper, 200	400	100
Physics	First paper, 125 / Second paper, 125 / Practical, 150	400	100
Chemistry	First paper, 125 / Second paper, 125 / Practical, 150	400	100
Geology and mineralogy	First paper, 125 / Second paper, 125 / Practical, 150	400	100
Engineering design and drawing	First paper, 150 / Second paper, 175	325	80
	Drawings	75	40
Graphics		350	87
Total		2750	1100

Third Year.

Subjects.		Marks. Maximum.	Minimum Required.
Geology	Paper / Practical	200 / 100	60 / 30
Metallurgy and Assaying	Paper / Practical	200 / 150	60 / 45
Principles of mining	First paper, 200 / Second paper, 200 / Practical	400 / 150	120 / 75
Surveying	Paper / Practical	200 / 100	60 / 50
Engineering	First paper, 200 / Second paper, 200 / Practical	400 / 150	120 / 45
Engineering design and drawing	Paper / Drawings	150 / 200	45 / 100
Electrotechnics	Paper / Practical	300 / 150	90 / 45
Total		2850	1140

Fourth Year.

Subjects.		Marks. Maximum.	Minimum Required.
Metallurgy and assaying	Paper / Practical	200 / 150	60 / 45
Principles of mining	Paper	200	60
Mining economics	,,	200	60
Ore-dressing	,,	200	60
Surveying	,, / Trial survey	200 / 300	60 / 150
Engineering	First paper 200 / Second paper, 200 / Practical	400 / 150	120 / 45
Electrotechnics	Paper / Practical	300 / 150	90 / 45
Total		2450	980

Civil, Electrical, and Mechanical Engineering.

The South African College grants diplomas in engineering to students who have successfully passed the civil, electrical, and mechanical branches according to the course selected.

Every candidate for admission to the full course for a diploma shall have passed the preliminary scientific examination for engineering, whether or not he has attended classes previously at college, or such other examination as in the opinion of the Senate is of equivalent value.

A candidate who has passed the intermediate examination in arts of the University of the Cape of Good Hope, and who has obtained in that examination 25 per cent. of the marks in each of the following subjects—mathematics, chemistry, and applied mathematics—will be excused the preliminary examination.

A candidate who has passed the first mining examination of the University of the Cape of Good Hope will be excused the preliminary examination, but it will be necessary for him to pass in English or Dutch, or French or German, at the preliminary examination, or an equivalent examination, before he is entitled to receive the diploma.

Course of Study.—Students shall be required to attend one of the regular three-year courses given, provided always that the Senate shall have power to exempt students from any part of the course on sufficient cause being shown, such exemption being duly noted on the diploma.

Students who have already taken the Engineering Diploma of the college may sit the diploma examinations in another subject in a subsequent year after at least one year's study at the college.

Examinations.

There will be a special examination at the end of each year. For this examination the marks in every subject will be awarded as follows :—One-third for the class-work of the year ; one-third for an examination on the year's work, set by the Professor, with an external examiner, who shall not be a teacher at the South African College, as Moderator ; one-third for an examination set by this external examiner on the year's work, with the Professor as Moderator ; but in the final examination in civil engineering, two theses, in addition to one written examination, will be set in civil engineering, and a trial survey in surveying. In the final examination in mechanical engineering, theses will be set in machine design and mechanical laboratory work ; in the final examination in electrical engineering two theses will be set in electrotechnics ; the theses in each subject to be set jointly by the professor and the external examiner.

The examinations will be held in the last month of the fourth term of the year, except in the case of the final examination, when the written examinations will be held in September. Where theses are set, the subjects will be given out on September 15, and each thesis must be handed in not later than November 15,

The minimum required to pass in a single subject will be :—

25 per cent. in Pure Mathematics.	40 per cent. in Engineering.
25 per cent. in Applied Mathematics.	40 per cent. in Engineering Design and Drawing.
25 per cent. in Physics.	40 per cent. in Graphics.
25 per cent. in Spherical Trigonometry and Astronomy.	40 per cent. in Electrotechnics.
	40 per cent. in Surveying.

Failure in a single subject in an examination will involve failure in the whole examination. The minimum aggregate is 40 per cent.

Honours.

For Honours the marks of the second and final examinations will be added together, and the candidate must gain not less than 60 per cent. of the aggregate marks.

Exemptions.

Special exemption is made in the case of students who have taken the degree of B.A. in the University of the Cape of Good Hope, with pure mathematics, applied mathematics, and physics as their subjects of examination, or who have passed an examination accepted by the Senate as equivalent for this purpose ; such students are excused the preliminary examination, attendance at lectures in the first engineering year, and the examination at the end of the first engineering year, provided that at, or before, the end of the year which counts as their second engineering year they pass examinations in subjects which they have not taken in the examination for their B.A. degree, or in the equivalent examination, and which are in the syllabus of the examination at the end of the first engineering year.

The Control.

An engineering committee has been formed, consisting of all professors teaching engineering subjects, a lecturer on mechanical engineering, one professor from the literature side of the college, and representatives of the engineering profession, two of whom are nominated by the Corporation of the City of Cape Town.

The duties of this committee are to supervise the engineering studies, to arrange for holding examinations, and to develop the engineering faculty in the college.

This system of control is working admirably. It keeps the college in close touch with the profession, and enables the professors to place the students after they have finished their courses.

The outside members of the profession sitting on the engineering committee for the year 1911 are :—

Mr. C. Proctor Banham, M.I.M.E., M.I.E.E., Cape Town Docks' engineer.

Mr. H. H. Elliott, A.M.I.C.E., chief maintenance engineer to the South African Railways.

Mr. H. Gearing, A.M.I.M.E., partner in Messrs. Cunningham and Gearing, engineering manufacturers.

Mr. A. S. Giles, M. Inst. C.E., M.I.E.E., general manager Cape Town Tramways.

Mr. W. J. Jeffries, engineer of the City of Cape Town.

Mr. F. E. Kanthack, A.M.I.C.E., director of irrigation for the Union of South Africa.

Mr. W. A. Legg, M. Inst. C.E., chief assistant to the Director of Irrigation.

Mr. W. F. Long, A.M.I.E.E., electrical engineer to the City of Cape Town.

Mr. J. N. Sim, technical adviser to the S. A. R. Board.

Practical Work.

All engineering students must spend the greater part of the long vacations in engineering works and attend regular college workshop classes during the session. The work in the college workshop consists of manufacturing all kinds of machines. During the year 1910 three electric motors were designed and completed by the students in addition to various other apparatus for testing purposes. During the present session a 40-horse-power direct-current machine is in hand, besides a number of small motors, dynamos, testing apparatus, &c.

Classes in electric wiring, pattern-making, and blacksmithing are held in the evenings during the winter, and are attended by nearly all the day students. The students taking electrical engineering, after having obtained their diplomas, are transferred into works in Europe, in order to provide them with a thorough practical training, and to acquaint them with modern methods and systems of manufacturing.

No difficulties have been encountered, so far, in obtaining suitable facilities for these students. In civil engineering the students have mostly found billets in Government works as junior assistants; but at present there is a scheme being considered by the Government, which will oblige civil engineering diploma students to pass through a regular two years' course of probationership, the time to be spent partly in the Irrigation Department, and partly in the Departments of Public Works and Railways.

Preliminary Engineering Examination.

The preliminary engineering examination is the entrance examination to the engineering courses held at the South African College.

For this examination a special course has been arranged, the subjects for which are as follows :—

(*a*) English.	(*e*) Chemistry.
(*b*) Mathematics.	(*f*) Physics.
(*c*) One modern language.	(*g*) Geometrical and freehand Drawing.
(*d*) Elementary mechanics.	

In the examination one paper is set in each subject, except in mathematics, for which there are two papers. The examiners are the teachers for the different subjects, with an external examiner in each subject, the latter to have the right to veto the passing of any candidate in his subject. The standard required in the examination is 25 per cent. in each subject, and 35 per cent. over all the subjects.

Before a student can enter for this preliminary engineering course he must have passed the matriculation examination of the University of the Cape of Good Hope or its equivalent. The study for an engineering diploma spreads, therefore, over a period of four years, after matriculation.

South African School of Mines and Technology.

The Johannesburg institute provides also regular courses in civil, electrical, and mechanical engineering, besides those for mining engineers.

These courses are controlled and managed in the same way as mining courses.

Civil engineering students have not yet passed through the institute, a professor of civil engineering having only just been appointed.

Up to the present the majority of students have taken mining courses.

No institutions other than the South African College and the South African School of Mines and Technology provide higher technical training ; but there is one town—Pretoria—where trades classes are held during the day. Technical evening classes are held in most towns of any size.

In conclusion, I should like to point out that the courses of study in electrical and mechanical engineering at the South African College have been arranged largely with a view of training students as far as possible in the design of mechanical and electrical plants, as well as in the running and testing of them. This will gradually produce a set of engineers acquainted with the manufacturing side of the engineering industries, and I hope that, when the students have finished their practical training in Europe, or elsewhere, some of them will, in time, commence manufacturing in South Africa. There are, of course, a good many difficulties in the way ; but the great advance made in this direction during the last few years gives rise to hope for more extended work.

The London Citizen's Year-Book.—The edition of this book for 1911-12 is revised up to May last, and contains much valuable matter. Its main object is to describe the work of the London government, including the way in which this work is carried on and its cost. It is unique in its way, because the portion devoted to the public authorities and their duties, together with things appertaining to London local life and activity, are more fully touched upon than in any publication of the same kind. Finance has had special attention given to it, London local expenditure being naturally a complicated subject. In the latter part of the book some important questions are dealt with, important because they often cause dissension between the municipal parties. Among these are London Poor Law Reform, London County Council Works Department, and Municipal Trading. There are also biographies of prominent London citizens, and nine portraits, besides maps. The book is published by Messrs. George Allen and Co., Limited, 44 and 45, Rathbone-place, London, W., the price being 1s. net.

Cast Copper.—In spite of many researches and inventions, sound copper castings of high strength and conductivity have been difficult to obtain. The fused copper absorbs gases (oxygen), and sets some of these free on cooling. The blow-holes thus produced spoil the copper ; they can be prevented by adding zinc, magnesium, phosphorus, and other deoxidisers to the copper ; but these substances also combine with the copper, and impair its electrical conductivity. E. Weintraub and F. A. Kroner, in a paper presented to the American Electrochemical Society, recommend the addition of boron, which does not combine with copper. Boron itself is expensive, though Weintraub has cheapened its manufacture. But the boron suboxide, which he discovered during these researches, which were carried out at West Lynn, Mass., in the laboratory of the General Electric Company, will answer, and he advises, in fact, the addition of 1 or 1¼ per cent. of the mixture of magnesium and boric anhydride (used for the preparation of boron suboxide) direct to the copper. Thus a cast copper of conductivity 97.5, or, at any rate, of 90 per cent., can be produced—a substitute for forged copper and alloys.

BRITISH RAILWAY RETURNS.

In the tables below are given the principal figures from the recently-issued Board of Trade report on British railways, which are referred to on page 197 :—

Mileage, Capital, &c., of the Railways of the United Kingdom.

——	1910.	1909.	Increase (+) or Decrease (−) in 1910. Amount.	Per Cent.
	miles	miles	miles	
Mileage	23,387	23,280	+ 107	+ 0.5
Of which, double or more	13,072	12,996	+ 76	+ 0.6
Track mileage (including sidings)	54,311	53,972	+ 339	+ 0.6
	£	£	£	
Capital	1,318,515,000	1,314,407,000	+ 4,108,000	+ 0.3
Amount included in the foregoing which is nominal only	197,124,000	196,681,000	+ 443,000	+ 0.2
Ordinary capital	492,080,000	493,121,000	− 1,041,000	− 0.2
Amount included in the foregoing which is nominal only	91,745,000	91,303,000	+ 442,000	+ 0.5
Receipts :—	£	£	£	
Passenger traffic	52,759,000	51,205,000	+1,554,000	+ 3.0
Goods traffic	61,479,000	59,477,000	+2,002,000	+ 3.4
Miscellaneous	9,688,000	9,492,000	+ 196,000	+ 2.1
Total	123,926,000	120,174,000	+3,752,000	+ 3.1
Working expenditure	76,570,000	75,038,000	+1,532,000	+ 2.0
Net earnings	47,356,000	45,136,000	+2,220,0 0	+ 4.9
Proportion of net earnings to capital	per cent. 3.59	per cent. 3.43	+ 0.16	
Dividend paid on ordinary capital	3.48*	3.15*	+ 0.33	

* These percentages are calculated on amounts a little in excess of the true totals.

Passengers Carried, Exclusive of Season-Ticket Holders.

——	1910.	1909.	Increase (+) or Decrease (−). Number.	Per Cent.
Number of ordinary passengers carried :—				
First-class	29,788,000	29,416,000	+ 372,000	+ 1.3
Second-class	28,148,000	30,796,000	− 2,618,000	− 8.6
Third-class	1,248,793,000	1,204,869,000	+43,924,000	+ 3.6
Total	1,306,729,000	1,265,081,000	+41,648,000	+ 3.3

Receipts from Passengers.

	1910.	1909.		
Receipts from ordinary and season-ticket passengers :—	£	£	£	
First-class	4,957,000	4,778,000	+ 179,000	+ 3.7
Second-class	3,102,000	3,413,000	− 311,000	− 9.1
Third-class	35,188,000	33,759,000	+1,429,000	+ 4.2
Total	43,247,000	41,950,000	+1,297,000	+ 3.1

Train-Mileage.

Year.	Passenger Trains.	Goods Trains.	Total (including Mixed Trains).
	mill. miles	mill. miles	million miles
1910	266.9	154.6	423.2
1909	263.8	153.8	419.2
Increase (+) or Decrease (−) mileage	+3.1	+0.8	+4.0
Increase (+) or Decrease (−) per cent.	+1.2	+0.5	+1.0

Results per Train-Mile.	1910.	1909.	Increase (+) or Decrease (−).
Receipts :—	d.	d.	d.
Passengers	47.38	46.56	+0.82
Goods	95.40	92.76	+2.64
Passengers and goods	64.78	63.36	+1.42
Expenses per train-mile	41.08	40.62	+0.46
Net receipts	23.70	22.74	+0.96

Minerals, General Merchandise, &c., Carried.

Year	1910.	1909.	Increase. Amount.	Per cent
	million tons	million tons	million tons	
Minerals conveyed	405.1	395.3	9.8	2.5
General merchandise conveyed	109.3	104.6	4.7	4.5
Total	514.4	499.9	14.5	2.9

Receipts from Goods Traffic.

Receipts from—	£	£	£	
Minerals	29,209,000	28,405,000	804,000	2.8
General merchandise	30,714,000	29,578,000	1,136 000	3.8
Live stock	1,556,000	1,494,000	62,000	4.1
Total	61,479,000	59,477,000	2,002,000	3.4

THE FRITZ ENGINEERING LABORATORY OF LEHIGH UNIVERSITY.*

By Frank P. McKibben, Professor of Civil Engineering, Lehigh University.

The Fritz Engineering Laboratory has been presented to Lehigh University by Mr. John Fritz, of Bethlehem, Pa., to enable the students of that Institution to study experimentally various problems connected with the materials of construction and hydraulics. There are four main sections in the laboratory, as follow:—(1) A general testing section, including the testing machinery and a small machine-shop; (2) a room for testing cement; (3) a room for making and storing concrete specimens, such as beams and cylinders; and (4) an hydraulic section.

The Building.—The laboratory building (see Fig. 1, annexed) is of the steel mill building type, 91 ft. wide and 114 ft. long, with a main centre aisle between two side aisles of less height and less width. The steel frame carries the roof and travelling-crane only, the side and end brick walls being carried on independent foundations. The problem to be solved in planning the building was to secure a structure of sufficient height to accommodate a vertical screw-testing machine capable of taking a specimen 24 ft. long, to secure at least two levels for the hydraulic laboratory, and to have concrete and cement-rooms, which, while in close proximity to the main testing-room, could be separated therefrom at any time in order to prevent dust from passing into the main room. At the best, cement and concrete laboratories are dusty, and should not be placed where there are testing-machines.

As ample light is of prime importance in a testing laboratory, numerous windows are provided in the side walls, end walls, and in the clerestory, and a skylight 9 ft. wide and 84 ft. long is placed in the north roof over the main aisle. Steel frames with movable sections are provided for all side and end-wall windows. The main aisle is 49 ft. 2 in. centre to centre of crane columns, and this width affords sufficient clearances on the sides of the large testing-machine which stands practically in the centre of the building. A less width for a vertical machine of the size used is not advisable; in fact, the larger the proportion of area commanded by the travelling-crane the better; but if side aisles are used, they should be at least 20 ft. wide. The section set apart in the east end of the building for the hydraulic laboratory occupies, in addition to a depressed area, 39 ft. by 54 ft. (10 ft. below the main floor level), an elevated platform of the same area 10 ft. above that level. A plan is shown in Fig. 4, page 205.

Sufficient floor area has been provided for additional equipment, such as a road-materials laboratory, a large torsion machine and an impact machine, and after these have been installed there will be ample room for future growth. Table I. shows the floor areas of the various sections.

Table I.—*Floor Areas of Sections in Fritz Laboratory.*

Section.	General Testing.	Cement.	Concrete.	Hydraulic.	Office.	Total.
Floor areas in square feet	6772	840	1320	4212	250	13,394
Clear height in feet ..	40 and 20	12	9.5	20 and 20	12	

Table II.—*Testing Machines in General Testing Section in Fritz Laboratory.*

Type of Machine.	Capacity.	Speed. Inches per Minute. Maximum.	Speed. Inches per Minute. Minimum.	Nominal Horse-Power of Motor.	Speed of Motor.
	lb.				r.p.m.
Universal	800,000	8	0.05	20	1120
,, ...	300,000	3	0.021	7.5	1120
,, ...	100 000	4	0.04	3	1700
,, ...	50,000	3	0.38†	2	1120
,, ...	50,000	3	0.38†	2	1120
,, ..	50,000	3	0.38†	2	1120
,, ...	50,000	8	0.05†	2	1120
,, ...	50,000	8	0.05†	2	1120
Tension and compression	20,000	..	..	Hand-power	
Wire-tester	200,000	..	..	Do.	
Cold bend	1.5 in. diameter bar	..	..	2	1700
Torsion	24,000 *	..	..	Hand-power	

* Inch-pounds. † Hand-power also available.

The General Testing Section.—This division (see Figs. 2 and 3) contains all testing-machines, except the briquette machines, which are in the cement section. It is so arranged that classes can be divided into small groups of three or four students each, and each group provided with a machine with which to conduct tests. Occupying the western portion of the main aisle, which is served by the crane, and which is connected to the exterior by a doorway 10 ft. wide, this general testing section is well arranged to facilitate the handling of large or heavy test specimens; for example, wagons carrying steel or concrete beams or columns to be tested are drawn into the building through the large doorway and their loads removed by the travelling-crane. This crane has a span of 47 ft. 2 in. centre to centre of runway beams, is operated by three direct-current motors, and has a safe capacity of 10 tons. In planning a laboratory in which tests on large specimens are to be made it is very important that rapidity and ease of handling should receive proper consideration, and a travelling-crane is of the greatest importance.

Equipment in General Testing Section.—Table II. shows this equipment so far as the machines are concerned, and there are, of course, a great many accessories which need not be mentioned here.

The 800,000-lb. machine is of the two-screw vertical type, capable of testing a column of 24 ft., a tension specimen of corresponding length, or a transverse specimen 10 ft. long or less. The clear distance between the screws is 35 in. Although the weighing-table is only 10 ft. 6 in. long, it is possible to test beams up to 25 ft. or 30 ft. in length by using extension girders on the weighing-table. By means of standard weights, this machine has been found to be sensitive to 50 lb.; that is, 50 lb. produces an initial movement of the scale beam at a load of 20,000 lb., or at a load of 800,000 lb., and by means of proving-levers its accuracy up to 20,000 lb. has been found to be within its range of sensitiveness.

The 300,000-lb. machine is very sensitive and accurate, and its slow speed makes it useful for general testing. Its extension arms on the weighing-table are 21 ft. long, so that a beam up to practically this length can be easily tested under a load not exceeding 300,000 lb. The top

* Paper read before the American Society for the Testing of Materials.

THE FRITZ ENGINEERING LABORATORY.

Fig. 1. The Fritz Laboratory.

Fig. 2.

THE FRITZ ENGINEERING LABORATORY OF THE LEHIGH UNIVERSITY.

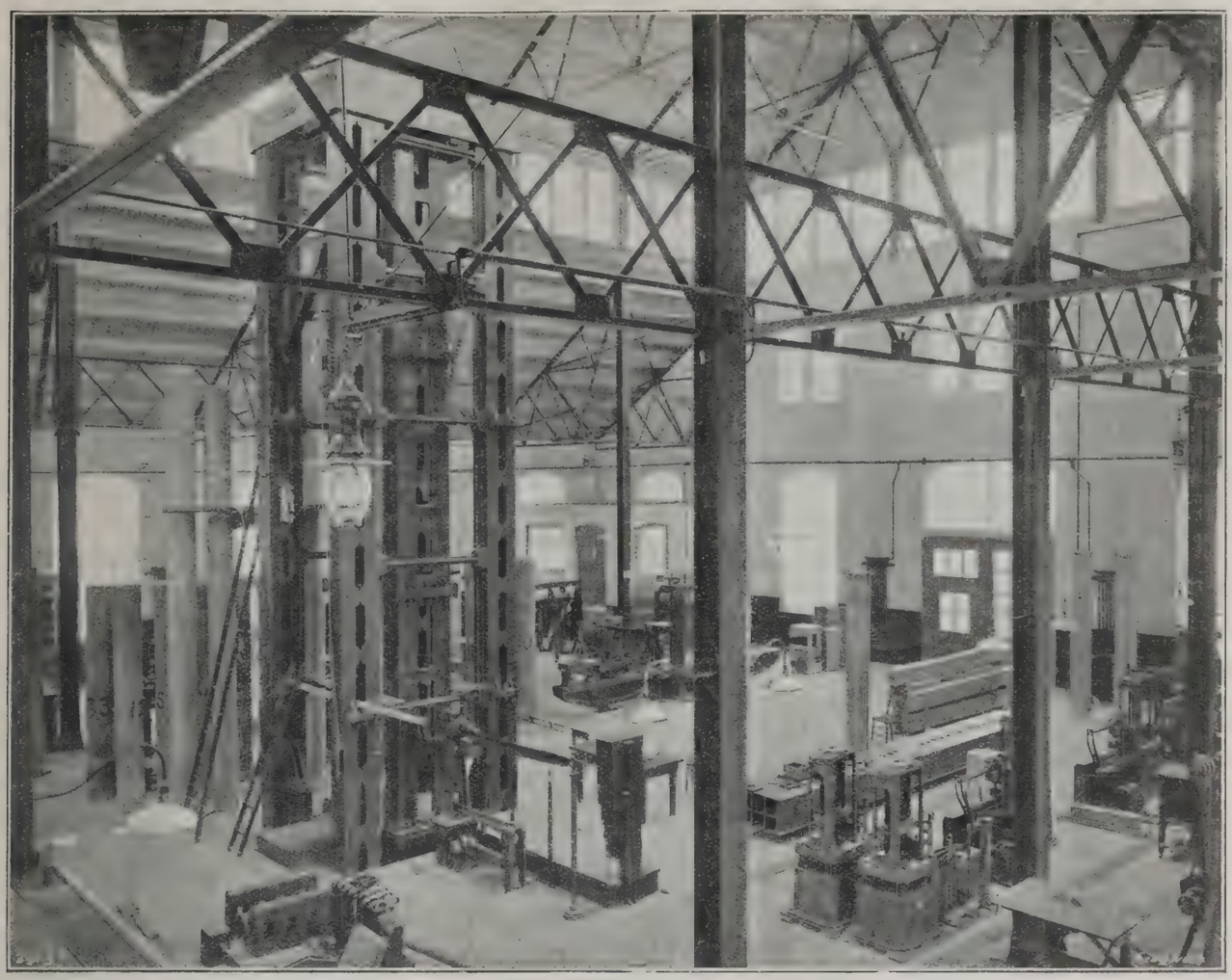
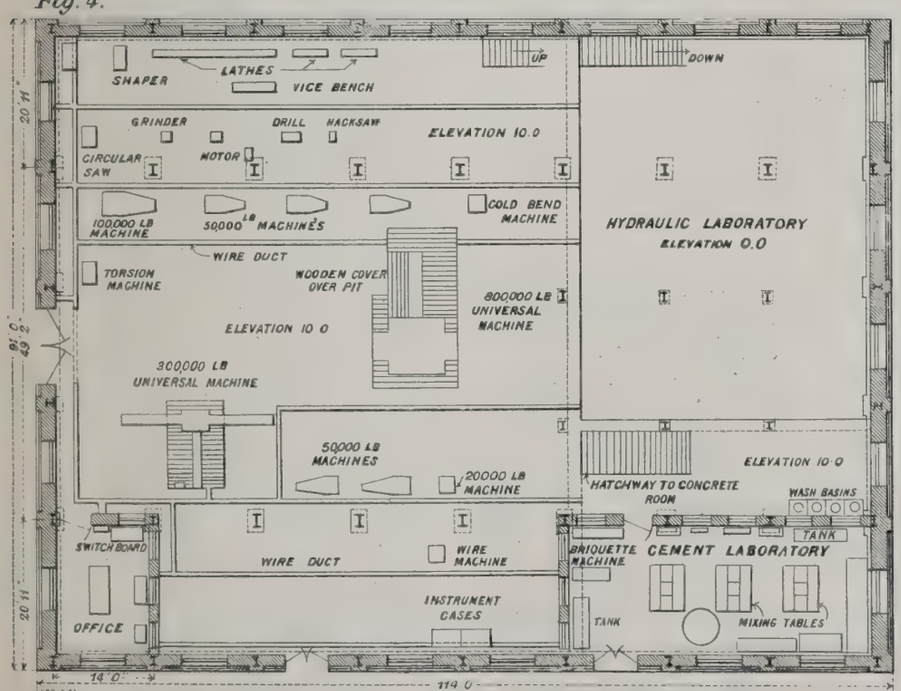


Fig. 3.

Fig. 4.



surface of the weighing-table and of the extensions is 2 ft. above the main floor, and this height has proved satisfactory. At first thought it might appear desirable to have the machine lower, with the extensions and weighing-table below the floor level, so that when not in use the extensions could be covered with steel plates or other removable flooring; but this arrangement would necessitate working in a pit when the machine is in use, and, on the whole, the position here adopted for the machine is the best possible.

The smaller universal machines are used not only for ordinary tension, compression, and shearing tests, but also for transverse tests, by placing the test specimen on Bethlehem H sections laid on the weighing-tables, the H sections thus serving as extensions to the weighing-tables. In this manner the problem of giving transverse tests to several small sections of students simultaneously is solved without having special transverse machines.

The repair-shop equipment consists of one drill-press, one high-speed lathe, two metal-turning lathes, one milling-machine, one shaper, one circular saw, one power hack-saw, and one grinder. All of these machines are belt-driven, the power being furnished by a 7½-horse-power motor.

Electric Equipment.—All electricity for lighting the building and for driving the testing-machines is two-phase 60-cycle alternating-current at 110 and 220 volts respectively, and is supplied from the University power-station. Direct-current, obtained from a local company, is used for the travelling-crane, and for this purpose is to be preferred to alternating current, and, except for the tendency to spark, the former is better for testing-machines, because of better speed-control. However, if the gearing on the machines is properly arranged to provide for a very slow speed of any 0.05 in. per minute, a rapid speed of 8 in. per minute and at least one intermediate slow speed, the alternating current is perfectly satisfactory for ordinary universal machines, and in the present instance was the only kind obtainable from the University station without the use of a rotary converter. To drive centrifugal pumps for an hydraulic laboratory water supply, direct current is much to be preferred, and although a variable-speed induction-motor can be obtained, yet the possible variations in speed are limited to such a narrow range as to prevent that nicety of speed-control obtainable with a direct-current motor. With proper gearing, therefore, either alternating or direct current can be used for ordinary testing-machines, but direct current should be used for hydraulic laboratories and for certain classes of testing-machines. The motors, of 20, 7½, and 7½ horse-power, for driving the 800,000-lb. machine, the 300,000-lb. machine, and the tools in the repair-shop respectively, are furnished with auto-starters. The motors for the hydraulic section have not yet been installed.

The Cement and Concrete Sections.—The cement-testing section occupies a separate room on the main floor level and is so planned that twelve students can work at one time. The equipment of this section consists of well-

arranged tables for making cement specimens, the ordinary storage tanks, briquette-testing machines, and all apparatus necessary for making standard cement tests.

All concrete specimens, such as beams, cubes, and cylinders, are prepared in the concrete-room, which covers not only the entire area under the cement-room, but also extends beyond this area and underneath a portion of the main testing-room, to which it is connected by a large hatchway, through which the heavy concrete specimens, such as beams, can be hoisted into the main testing-room with the aid of the travelling-crane. The equipment in the concrete section consists of a mixer, the necessary bins for sand and stone, and moulds for beams, cylinders, and cubes.

An important feature in a cement and concrete laboratory is a proper drainage system arranged to prevent pipes becoming obstructed by cement or sand. This problem has been solved by placing under the concrete-room a large concrete sump, into which all drainage must flow, and in which there is a partition or weir, over which the water passes, the sand, cement, and other matter being caught in the sump, whence it is easily removed. This arrangement is satisfactory. The hydraulic section is now being equipped.

This laboratory has been built and equipped, under the personal supervision of Mr. Fritz, by Mr. G. A. Chandler, Associate Professor D. Conkling, Mr. S. H. Ingberg, and the writer, and is a part of the civil engineering department of the University.

COMMUNICATIONS FROM THE GÖTTINGEN MODEL-TESTING INSTITUTE.*

(*Continued from page* 804 *of our last volume.*)

(4) Behaviour of Balloon Bodies when Oblique to the Air Current.

If an airship body of the usual form is placed oblique to the air current, moments are produced which tend to turn the balloon into a position at right angles to the direction of motion. The motion of the balloon in the direction of its axis is therefore unstable, unless this instability is removed by the addition of stabilising surfaces. The present investigation was designed to give information as to the forces acting on the balloon with its axis inclined to the current, and as to the effect of stabilising surfaces. In addition to the information furnished by the investigation on the question of stability, numerical values were also obtained for the dynamic lift due to inclination of the axis.

The models examined were the same three for which data have been already given in Communication No. 3. They were suspended in the same way as the curved plates of Communication No. 2 from two balances, by means of which the lift could be determined, while a third balance gave the resistance in the direction of the current. With the aid of the one movable balance, the models could be set at different inclinations to the axis of the channel, and this inclination was varied from 0 deg. to 15 deg. From the values given by the three balances the magnitude, direction, and position of the resultant wind pressure were calculated. In Figs. 13, 14, and 15, annexed, the positions of the resultants relative to the models are given for the various settings. (The models were only turned to one side out of the direction of the stream; on the other side the diagrams would, of course, be symmetrical.) The position of the resultant, far in front of the centre of gravity, shows that the air current tends to set the model at right angles to the stream. The resultant force in its different positions envelops a curve, having a cusp on the axis of the model in its middle position; it is readily seen that stability of motion is certainly obtained if this cusp C lies behind the centre of gravity G, for then the resultants for all positions of the model intersect the axis behind the centre of gravity, and always tend to turn the model into the direction of motion.

On Model III. the effect of stabilising surfaces was also examined. For this purpose it was fitted with two surfaces, each 13 cm. long by 6.5 cm. wide. In a further experiment each surface was 16 cm. long by 8 cm. wide. The distance of the centre of gravity of the two surfaces from the centre of gravity (G) of the model was in both cases 41.8 cm. In Figs. 16 and 17 the stabilising surfaces are shown by dotted lines. They are, in reality, to be understood as fixed in the plane at right angles to the plane of the drawing. As the diagrams show, with these surfaces there was very considerable displacement of the direction of the resultant force towards the centre of gravity, and even beyond it; the increase of stability is thus clearly demonstrated. The improvement in stability is still better exhibited by determining the couple about

FIG. 13. POSITIONS OF THE RESULTANT FORCE FOR MODELS I., II.

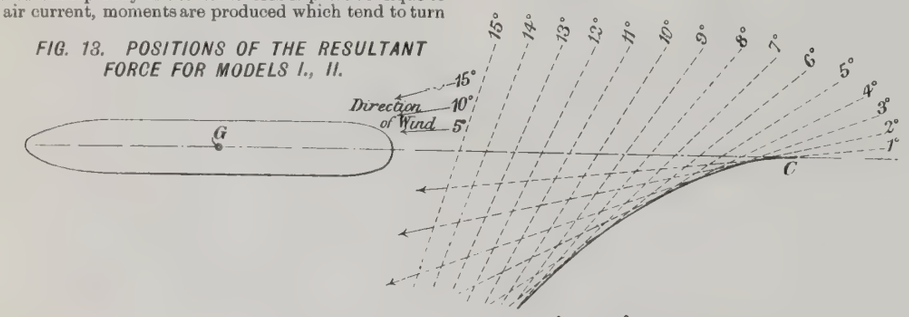


Fig. 14.

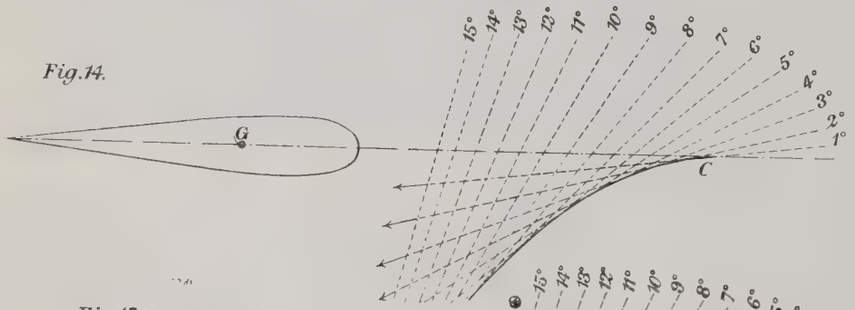


Fig. 15. POSITIONS OF THE RESULTANT FORCE FOR MODEL III.

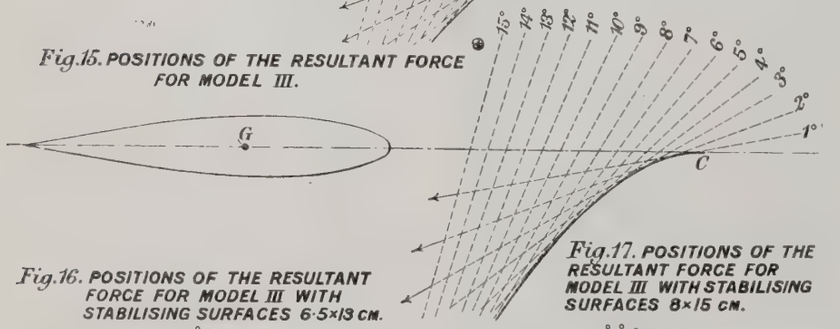


Fig. 16. POSITIONS OF THE RESULTANT FORCE FOR MODEL III WITH STABILISING SURFACES 6·5×13 cm.

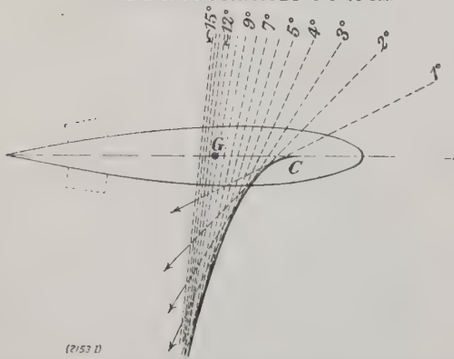


Fig. 17. POSITIONS OF THE RESULTANT FORCE FOR MODEL III WITH STABILISING SURFACES 8×15 cm.

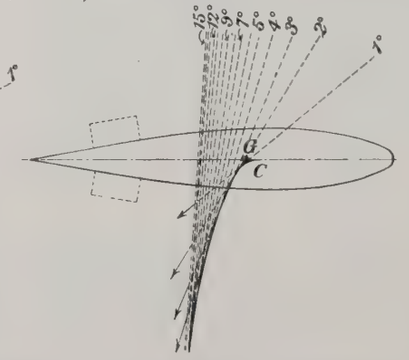


Fig. 18. TURNING-MOMENT COEFFICIENT.

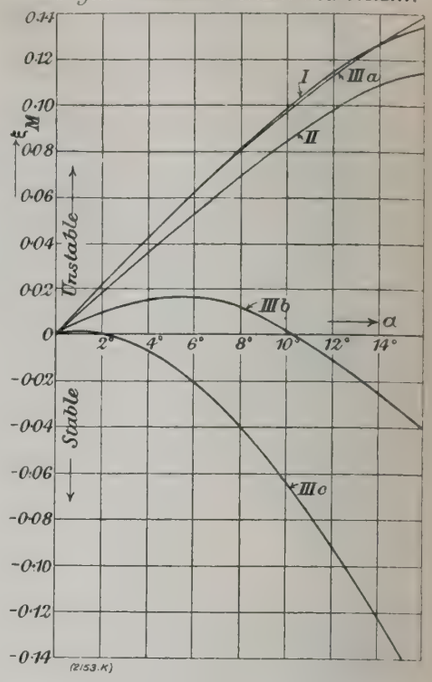


Fig. 19. RESISTANCE ('DRIFT') COEFFICIENT.

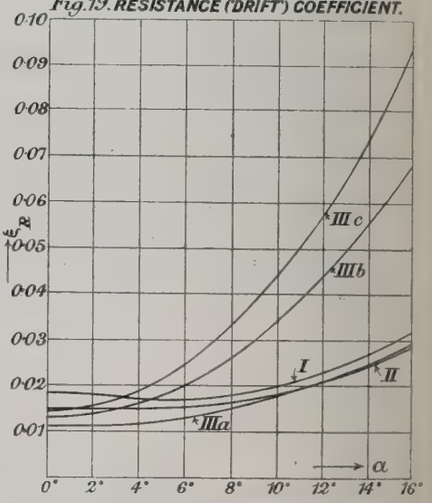
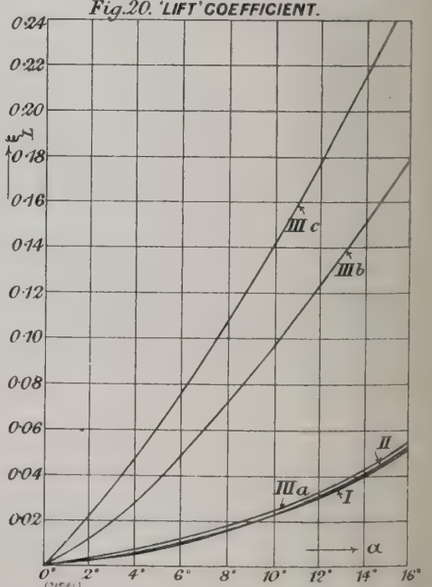


Fig. 20. 'LIFT' COEFFICIENT.



* Translated by permission from the *Zeitschrift für Flugtechnik* (Munich and Berlin: R. Oldenbourg).

the centre of gravity of the model. This couple is most conveniently calculated relative to the volume V. This may be written :—

$$M = \xi_M \cdot V \cdot \frac{v^2 \gamma}{g}.$$

(See the preceding article in the *Zeitschrift für Flugtechnik*, by L. Prandtl.) In Fig. 18 the coefficient ξ_M is plotted for the three models against the inclination. The curves III*b* and III*c* show the coefficient for Model III. when fitted respectively with the smaller and larger stabilising surfaces. This figure shows also clearly the instability of the model without stabilising surfaces and the increase of stability due to the addition of such surfaces.

The resultant of air resistances, as determined in the manner already described, were also resolved into their two components in the direction of the stream and at right angles to it, corresponding respectively to the head resistance to be overcome, R, and to the upward force giving dynamic lift L. If these forces are expressed in terms of V^2 (see the preceding article), then

$$R = \xi_R \cdot V^2 \cdot \frac{v^2 \gamma}{g}; \quad L = \xi_L \cdot V^2 \cdot \frac{v^2 \gamma}{g}.$$

The curves for ξ_R and ξ_L are given in Figs. 19 and 20. The great increase in the lift, in the case of Model III., in consequence of the addition of stabilising surfaces, is specially noticeable. This, of course, is at the same time combined with increase in the head resistance. If the increase in lift, due to the addition of stabilising surfaces, is compared with the lift on those surfaces themselves, at the same inclination to the current, it is noticeable that the increase in the total lift is very much greater than that on the stabilising surfaces alone ; it is, in fact, about 1.6 times as great.

(*To be continued.*)

WORKMEN'S COMPENSATION CASES.

County Court.

A Wife is not Necessarily a Dependant.—At Middlesbrough County Court the widow of John Chapman made a claim in respect of her husband's death, which occurred by accident while in the employment of Messrs. Bolckow, Vaughan, and Co. His wages were 1*l.* 12s. 8d. a week. His children were all grown up, and the widow claimed as the man's sole dependant. There appeared to be no defence till, on behalf of the employers, it was proved that the widow was not, as a matter of fact, a dependant at all. Although the widow was married to the deceased for twenty-three years, she was not a dependant at the time of his death, having been separated from her husband since April, 1910, on the ground that he did not contribute sufficiently to her maintenance. She was on the point of seeking a maintenance order when the man met his death by accident.

The widow claimed to be in straitened circumstances, and only occasionally received any contributions from the husband. She however, was not living by her husband's earnings, but appeared to be dependent on her sons and other lodgers. It was denied that she applied for a maintenance order. Further, as she had voluntarily left her husband and refused to return to him, and had kept herself by letting lodgings, this might have caused her the denial of "a maintenance order." Therefore the judge dismissed her claim against the employers. The fact of her being a workman's widow did not make her *ipso facto* a dependant, and the fact of dependency had to be proved. In justice to the employers, no claim should have been made upon them if the widow was voluntarily earning her own living apart from her husband. This case differed from that recently decided in the House of Lords. The widow, it is true, in the House of Lords case, had been living apart from her husband for twenty years, and was independent of her husband's earnings, having good wages as a housekeeper. Whereas in the Middlesbrough case the widow earned only a precarious living, and although she might have brought a claim against her husband in his lifetime for maintenance, she was too late in applying for it, and at his death she had no sort of claim for compensation upon her husband's employers. Her claim was therefore dismissed.

Is a Knocker-Up a Servant?—A curious claim by a knocker-up came before the Preston County Court Judge, when the question the judge had to decide was whether, as a "knocker-up," the applicant was an independent contractor or a servant.

The man, employed as a brewer, sustained injury by accident and received 6s. compensation. At the time of the accident he was, in addition to being a brewer, also in receipt of weekly earnings as "knocker-up" of some 160 fellow workmen, and he claimed to add such earnings in estimating compensation. It was, however, held by the judge that as a "knocker-up" the man was under no contract of service. He was, in fact, an independent contractor, not a servant. He did not come within the definition of a workman. The claim was therefore dismissed.

Cases like this show unhappily the absurd desire to make up a big claim against the employers which workmen too often display, as if compensation were always due to them on a generous scale, quite apart from the justice or equity of the claim, for here there was no concurrent contract of service.

The Value of an Eye.—A riveter named Ordish brought a claim against the Midland Railway Company in respect of compensation for the loss of one eye while in the company's service. The applicant had been at work in the locomotive department at 1*l.* 8s. 6d. a week.

In October he had his left eye removed at the Royal Infirmary, and in March last when an out-patient he was asked to present himself for work as a riveter. The man said he was anxious to work, but he shrank from the same employment, which would expose him to the risk of losing the remaining eye. At length it was agreed he should be paid 18s. a week as light labourer to start, the sum of compensation to be fixed by the Court at a later date. He returned to work on June 1 at a nominal wage of 18s., and was paid on an average 17s. 3d. a week owing to the works being on short time. He received full compensation during the time he had been laid up unable to work. The company had quite a number of men at work as usual in the riveting department who had suffered the loss of an eye, but the applicant in this case was afraid and thought it was unreasonable of the company to expect him to expose himself to the continued risk of total blindness. It was not right of the applicant to contend that his other work as light labourer at 18s. 6d. a week would reduce him permanently to a lower grade of employment, for other men having lost one eye had resumed their old employment at 32s. a week. There were always other light jobs, such as shop clerks and storekeepers, available where wages were 32s. and 25s. a week. The judge was of opinion that each case should be decided on its merits, and that in this case of permanent partial disablement there was no rule as to the amount of compensation to be awarded. He did not think in this case the risk of the man losing his second eye need be taken into account very seriously, as it was a trifling risk. He thought the applicant might return to his old job at his old wages, but if he preferred to avoid the risk, he thought 5s. 3d. a week compensation, in addition to the 18s. from a light job, would be reasonable. Thus, it may be estimated, 5s. 3d. a week is the value of an eye. This assumes the man will have fixity of tenure in his employment.

House of Lords.

The Course of His Employment.—This was an appeal to the House of Lords by R. Evans and Co., Limited, and the respondent was the widow of Robert Astley, in the appellant's employment as brakesman on a colliery train consisting of an engine and three trucks. An accident happened when the train was making for the company's shed. The train overtook another train, with an engine in front and a brake-van behind, and the two trains travelled with buffers touching, but not coupled. The appellant's argument was that Astley climbed upon the van, or tried to do so, for his own purpose, and that he meant to get upon the van, because in a minute or two the train would be passing the points, which he had to arrange. He would save time by alighting where the points were, and could do so more conveniently by using the steps on the brake-van, whereas there were no steps on the trucks. The error of judgment in attempting to leave the trucks for the brake caused the man's death. He was probably not larking or taking an undue risk. The man was killed by a risk incidental in its nature to the master's work ; a bonâ-fide accident happened which was incidental to the employment, and therefore the master was liable. The Court of Appeal sustained the County Court Judge's finding, the majority of the House of Lords agreed with the opinion of the Court of Appeal, and the appeal of the colliery masters was dismissed.

There seemed some reason in the argument on the master's behalf to say that the deceased was in charge of the train and abandoned his duty when he made the wrong step which he ought not to have done. There was a doubt that the accident really arose out of the workman's employment. This is a subtle distinction, but it will be noted that the majority of the judges, including the Lord Chancellor, were of opinion that the unfortunate man acted as he was employed to do, but in the wrong way.

Wife's Dependency.—A wife's dependency in very many cases that have come before the Court of Appeal has been decided in the wife's favour, even when she was not actually dependent on her husband's earnings at the time of his death. It was assumed in cases when the workman was living apart from his wife that while the husband was alive there was the possibility that the wife might return to actual dependency. Therefore it had been assumed that a wife was always in the eyes of the law a dependant, and entitled to compensation for her husband's death.

This familiar point of law has at last been reversed by the decision of the House of Lords, which disagreed with the Court of Appeal in the case of the widow of a miner named Keeling, who met his death by accident while in the employ of the Monckton Collieries, Limited. The widow was awarded 263*l.* 5s. by the County Court Judge, being the amount of the deceased's earnings for the preceding three years. On appeal to the House of Lords the award of the County Court Judge, which had been upheld by the Court of Appeal, has now been upset, and at last the view of practical common-sense has revolutionised an important point of the Workmen's Compensation Act as generally administered till now. The judgments hitherto given in the widow's favour presumed in most cases that the widow, because she had been the deceased workman's wife, was a dependant, whereas, in point of fact, this dependency was, in certain cases, a pure fiction. Mrs. Keeling, in this case, was married in 1881, and was the mother of four children. The husband treated her cruelly, and she found it impossible to live with him, and so in 1888 she left him for ever, returning to her parents, resuming her maiden name, and taking her children with her. During the whole of the ten years preceding her husband's death, Mrs. Keeling supported herself and her children by her earnings as housekeeper to a collier. During the whole time after her separation from her husband Mrs. Keeling had made no sign of any wish to return to live with him, and had never made any application to him for her support. At the time of her husband's death Mrs. Keeling was in receipt of 16s. a week from the collier, Bradford, and 13s. a week from a lodger. On the basis of partial dependency the County Court Judge awarded her compensation. He held that she had never abandoned her legal rights as a wife.

The House of Lords, whose judgment was delivered by Lord Atkinson, said the County Court Judge had not explained on what principle he had arrived at the conclusion that the respondent at the time of her husband's death was only partly dependent on his earnings.

But if the Judge's conclusion were sustained, it could only be on the ground that there was some presumption of law that a wife was, within the meaning of the statute, dependent on her husband's earnings if he was under a legal obligation to maintain her. Lord Atkinson, remarking on the fact that Mrs. Keeling for twenty years after her separation from her husband had never received a penny towards her maintenance from him, said: "It may be that in law her husband was bound to maintain her, but it is by the discharge of that obligation, and not by its mere existence in law, that a husband really maintains his wife." The common-sense, which was the crux of the judgment, was expressed by the question, "What was the pecuniary loss sustained by Mrs. Keeling on account of her husband's cessation of power to earn and to maintain her? What could be the money value to her of an obligation which her husband never acknowledged?"

The Lord Chancellor and the House of Lords agreed with Lord Atkinson's judgment, and the appeal of the colliery company was allowed. Lord Atkinson reviewed the cases in the Court of Appeal and in the House of Lords, Hodgson *v.* West Stanley Colliery, and Main Colliery Company *v.* Davies. His lordship in conclusion said: "It by no means follows that though there is no presumption that a wife is dependent upon her husband's earnings merely because of his legal obligation to maintain her, this legal obligation is to be ignored in deciding on the fact of her dependency."

Thus the fiction of a wife's legal dependency may in future be ignored. The question in awarding a wife compensation for her husband's death must be "What is the widow's actual loss by reason of the husband's death?" In such cases as the above it will be nil, and therefore there will be no claim as a dependant recognised.

The British Corporation for the Survey and Registry of Shipping.—There has just been published by this corporation, whose head offices are at 121, St. Vincent-street, Glasgow, a new issue of their "Register-Book and Rules," and it carries conviction as to the progress of the registry at home and abroad. The extent of the ramifications of the corporation is indicated by the list of surveyors at colonial and foreign ports, while the record of ships registered, and of those assigned freeboards, continues to lengthen at an increasing rate. Of greatest technical interest are the rules, which exemplify that broad spirit which is a characteristic of the Technical Committee and Chief-Surveyor, Mr. J. Foster-King, and to which we referred at length on the occasion of the twenty-first anniversary of the formation of the corporation (Engineering, vol. xci., page 283). The only alterations noticeable in a cursory examination of the rules are in details embodying the suggestion of experience. All are of practical importance to ship-owners, and indicate increased precautions in connection with fore peaks and the flat of floor forward, and in adding to the thicknesses of the tank margin-plates at the ends. Some of the boiler formulæ have been simplified, and a beginning has been made with regard to the requirements of foreign countries by printing the requirements of the Italian law in connection with the testing of engine castings for vessels to be registered in Italy.

Large Amalgamation of Water-Power Installations in Scandinavia.—Although the legislatures of both Norway and Sweden have foreseen the attempts foreign capitalists were likely to make in order to become possessed of the immense value, dormant or otherwise, which the vast supply of water-power in the two countries represents, and have passed measures so as to be able to frustrate, or, in any case control, such attempts, endeavours have not infrequently been made by foreign syndicates to become more or less directly interested in Scandinavian water-power. The success of recent electric iron-ore smelting experiments has further increased this desire for waterfalls, and a large international combine is the outcome. Under the style of the Hydraulic Power and Smelting Corporation, Limited, with a capital of 40,000,000 marks (or 2,000,000*l.*), half in shares and half in debentures, three large German electric firms (Allgemeine Elektricitäts Gesellschaft, the Siemens-Schuckert Company, and the Company for Electric Undertakings, Berlin), aided, it is understood, by the banking-house of Bleichröder, have formed a combine for the acquirement of Scandinavian water-power concerns, or shares in such. English and Scandinavian capital is also understood to be interested in the scheme, and the plan appears to have emanated from a Swedish and a Norwegian gentleman, both interested in hydraulic-power concerns, of which the Norwegian Electric Metal Company and the Tyssefaldene Company, besides the Trollhättan Electrothermical Company, are first on the list of the undertakings connected with the large new combine. The names of the further concerns to be included have not yet transpired. The Norwegian Hydro-Electric Company and its chief, Mr. S. Eyde, are outside the amalgamation. The German Press gives vent to expressions of satisfaction at the unity which, in spite of keen competition, prevails amongst the leading German electric firms when it is a question of important foreign doings ; a unity which also manifests itself in the question of prices in large transactions, in which respect this policy, however, also may have its drawbacks, especially in connection with the home consumption.

THE JAPANESE PACIFIC LINERS "TENYO MARU" AND "CHIYO MARU;" OIL-FUEL INSTALLATION.

Fig. 1. TENYO AND CHIYO MARU.
OIL STORAGE PIPING PLAN

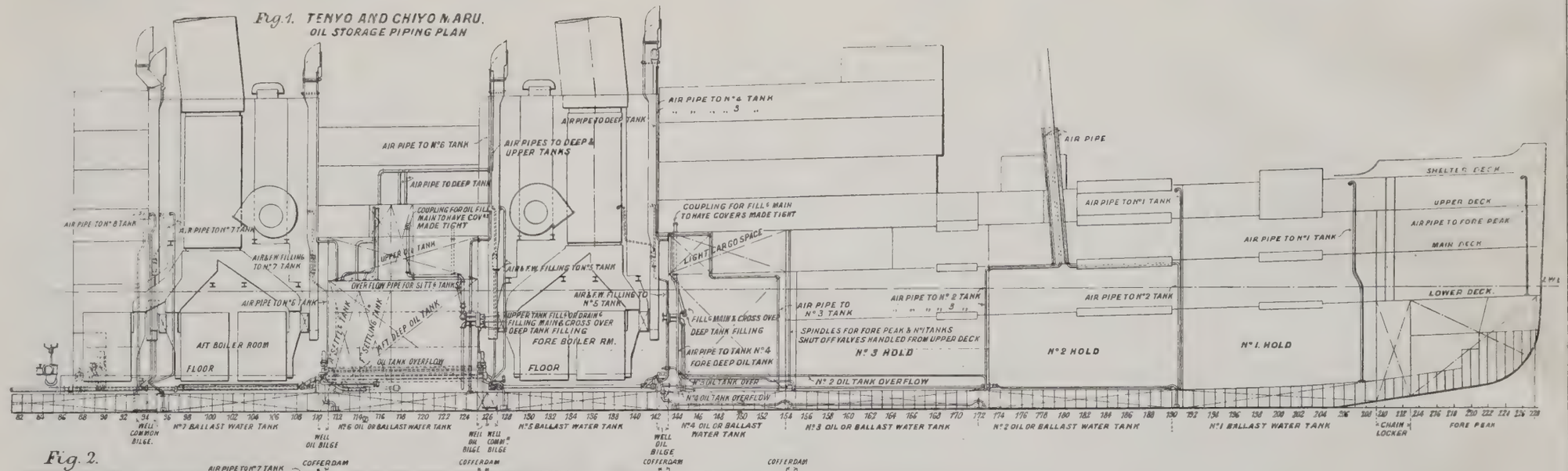
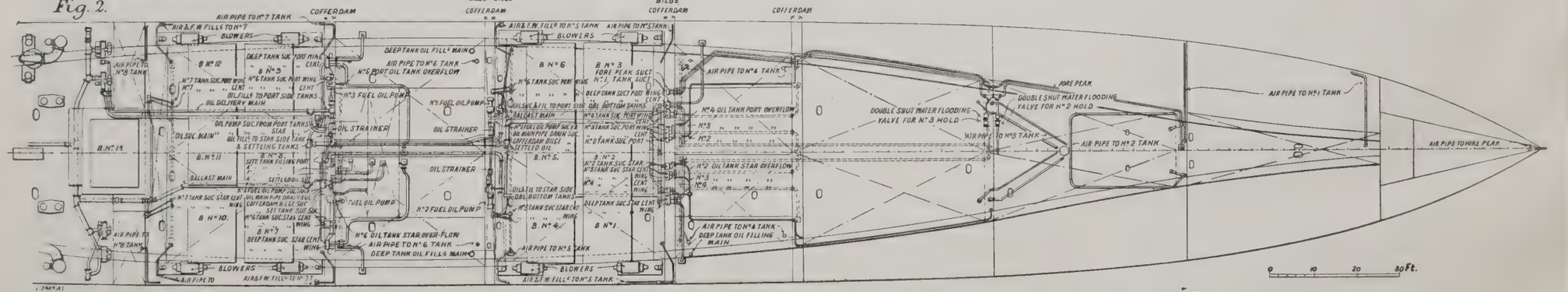

AIR PIPE TO N°8 TANK
AIR PIPE TO N°7 TANK
AIR PIPE TO N°6 TANK
AIR PIPES TO DEEP & UPPER TANKS
AIR PIPE TO DEEP TANK
AIR PIPE TO N°4 TANK
AIR PIPE TO N°3 TANK
AIR PIPE TO N°2 TANK
AIR PIPE TO N°1 TANK
AIR PIPE
AIR & F.W. FILLING TO N°7 TANK
AIR & F.W. FILLING TO N°5 TANK
AIR & F.W. FILLING TO N°3 TANK
COUPLING FOR OIL FILL MAIN TO HAVE COVERS MADE TIGHT
COUPLING FOR FILLS MAIN TO HAVE COVERS MADE TIGHT
OVERFLOW PIPE FOR SETTLG TANKS
UPPER OIL TANK
SETTLING TANK
N°7 DEEP OIL TANK
OIL TANK OVERFLOW
UPPER TANK FILLG OR DRAING FILLING MAIN & CROSS OVER DEEP TANK FILLING
FILLS MAIN & CROSS OVER DEEP TANK FILLING
AIR PIPE TO TANK N°4 FORE DEEP OIL TANK
SPINDLES FOR FORE PEAK & N°1 TANKS SHUT OFF VALVES HANDLED FROM UPPER DECK
LIGHT CARGO SPACE
AFT BOILER ROOM
FORE BOILER RM.
FLOOR
N°3 HOLD
N°2 HOLD
N°1 HOLD
N°4 OIL TANK OVER
N°2 OIL TANK OVERFLOW
N°4 OIL TANK OVERFLOW
SHELTER DECK
UPPER DECK
MAIN DECK
LOWER DECK
AIR PIPE TO FORE PEAK
CHAIN LOCKER
FORE PEAK
N°7 BALLAST WATER TANK
N°6 OIL OR BALLAST WATER TANK
N°5 BALLAST WATER TANK
N°4 OIL OR BALLAST WATER TANK
N°3 OIL OR BALLAST WATER TANK
N°2 OIL OR BALLAST WATER TANK
N°1 BALLAST WATER TANK
WELL COMMON BILGE
WELL OIL BILGE
WELL OIL BILGE
WELL COMMN BILGE
WELL OIL BILGE

Fig. 2.


COFFERDAM
AIR PIPE TO N°7 TANK
AIR & F.W. FILLS TO N°7 BLOWERS
AIR & F.W. FILLS TO N°5 TANK
AIR PIPE TO N°5 TANK
BLOWERS
DEEP TANK OIL FILLS MAIN
AIR PIPE TO N°6 TANK
N°6 PORT OIL TANK OVERFLOW
N°3 FUEL OIL PUMP
N°4 FUEL OIL PUMP
OIL STRAINER
FUEL OIL PUMP
N°2 FUEL OIL PUMP
N°6 OIL TANK STAR OVER-FLOW
AIR PIPE TO N°6 TANK
DEEP TANK OIL FILLS MAIN
AIR PIPE TO N°5 TANK
AIR PIPE TO N°4 TANK
N°4 OIL TANK PORT OVERFLOW
N°4 OIL TANK STAR OVERFLOW
DOUBLE SHUT WATER FLOODING VALVE FOR N°3 HOLD
DOUBLE SHUT WATER FLOODING VALVE FOR N°2 HOLD
FORE PEAK
AIR PIPE TO N°3 TANK
AIR PIPE TO N°2 TANK
AIR PIPE TO N°1 TANK
AIR PIPE TO FORE PEAK
DEEP TANK OIL FILLS MAIN
AIR PIPE TO N°8 TANK
0 10 20 30 Ft.

OIL-FUEL INSTALLATION ON THE JAPANESE PACIFIC LINERS "TENYO MARU" AND "CHIYO MARU."*

*Remarks on the Design and Service Performance of the Trans-Pacific Liners "Tenyo Maru" and "Chiyo Maru."**

By Professor S. Terano, Member, and Professor Baron C. Shiba, Member.

The passenger traffic on the trans-Pacific route, between San Francisco and Hong Kong, *viâ* Japanese ports, has largely increased of late years, and the long-felt need of high-class passenger steamers on the service under the Japanese flag was realised by the building of the Tenyo Maru and Chiyo Maru. They were built at the Mitsu-Bishi Dockyard and Engine Works in Nagasaki, to the order of the Toyo Kisen Kaisha; both of them were launched in 1907, and commenced running the following year. These two steamers are not only the largest yet produced in the East, and the first turbine steamers in Pacific waters, but they also present many noteworthy features in both design and appointments.

The principal dimensions are :—

		Ft.	In.
Length between perpendiculars	...	550	0
Breadth moulded	...	63	0
Depth moulded to upper deck ...	...	38	6
Depth moulded to shelter-deck...	...	46	6
Load draught (to Lloyd's summer free-board)	...	31	8
Load displacement	...	21,660	tons.
Gross tonnage	...	13,454	tons.

They are of the complete shelter-deck type, built to Lloyd's highest requirements, with promenade and boat decks covering nearly half their length amidship, thereby giving accommodation for first-class passengers. The total numbers of passengers carried are :—260 first class, 47 second class, and 816 third class. The deadweight carrying capacity is 10,330 tons, and cargo capacity 8700 tons, at 40 c.f. per ton; capacity for stores and lockers is 1400 tons, including cold storage of 240 tons.

As these steamers trade on semi-tropical routes, special care has been taken in the arrangement of state-rooms, all rooms being extra large (8 ft. by 11 ft. and 9 ft. by 12 ft.) and inner rooms avoided, except a few on the lowest passenger deck, where they have but a single berth. The ventilation throughout the steamer is assisted by 15 thermo-tanks, which can also be used for heating all living quarters in cold weather. Of the 12 watertight bulkheads, four are fitted with automatic watertight doors on the "long-arm" system.

These vessels are driven by Parsons' steam-turbines with three propellers, and have 13 single-ended boilers, 15 ft. 9 in. diameter, with total grate surface of 981 sq. ft. The mean speed attained on trial, at the draught of 24 ft. 9 in., was 20.6 knots, with shaft horse-power, as measured by a Denny-Johnson torsion-meter, of about 20,000. In ordinary sea condition they can easily maintain a mean speed of 18½ knots with twelve boilers.

One of the novelties in them is the adoption of oil-fuel, and it is the intention of the present paper to deal with details of this installation, and show the results of actual performances. The merits of oil-fuel as against coal are too well known to be repeated here, and it is only on account of the uncertainty of its supply and of its higher cost that oil-fuel has never come into more general use. Vessels burning oil-fuel are mostly restricted to those navigating in the oil districts.

At the time when the building of these two steamers was decided on the price* of coal in Japan was very high, due to the sudden increase of steamship tonnage during the Russo-Japan War of 1904-5, while in California the supply of oil-fuel was almost limitless and the cost was very moderate.* The oil-field in California is very extensive, and the yearly production has enormously increased of late years. But crude oils produced from this district are of asphaltum base, and comparatively heavy, the percentage of light oil being very low when compared with crude oils of the Eastern districts of the United States. Some of the Californian oils are too thick to be of any use except for fuel. These facts account for the abundant supply.

As it seemed in every way advisable to adopt oil for fuel, minute investigations were made with regard to the quality of the Californian oil and the methods of carrying and stowing it; also into the different systems of burning. When it was finally decided to use oil for fuel, the supply was contracted for, specifying quality as to density and flash-point. The former was fixed at 16 to 18 Beaumé, and the latter at about 150 deg. Fahr.; a higher flash-point was found an unnecessary precaution and it made the oil too expensive. The decision proved to be fully justified by the results obtained in actual service.

Double-bottom tanks are arranged to carry either oil or water ballast, but with a view to secure absolute safety, oil is not carried under boilers or engines; also, in order

* Paper read at the Jubilee Meeting of the Institution of Naval Architects, July 6, 1911.

* About 8 yen (16s. 4d.) per ton.

* 50 cents (2s. 1d.) per barrel of 330 lbs.

to avoid any probability of leakage, due to panting action, the foremost tank is not fitted for oil. The amount carried in bottom tanks is thus about 630 tons. Two deep tanks, one in front of the forward boiler-room and the other between the forward and after boiler-rooms, are constructed to carry oil; the capacity of the forward tank (extending to the main deck) is 1165 tons, and that of the upper main tank, between the upper and main decks, is 500 tons, while the lower main tank—*i.e.*, below the main deck—contains 1120 tons. There are two oil-settling tanks, built inside the main oil-tank, each of 130 tons capacity, equivalent to one day's consumption. Heavy oil is always mixed more or less with water, and can only be separated by keeping it perfectly still in the settling-tank and allowing more than twelve hours for the water to settle down at bottom of the tank, from which it can be drained off. Thus the total capacity for oil storage is 3675 tons, a quantity sufficient to run the ship for about twenty-seven steaming days at an average service speed of 15 knots, or to cover the distance of about 10,000 miles.

The supply of oil fuel is neither so certain nor so universal as in the case of coal, and this fact was borne in mind when scheming out the oil installation of these steamers. Thus deep tanks were so constructed that they could be converted with little trouble to carry coal also; all coal-holes and doors for this purpose were temporarily covered up with detachable plates securely riveted to the bulkhead plating and caulked round.

Deep tanks and double-bottom tanks are constructed according to Lloyd's requirements for oil-carrying; seams of deck, tank top, and bulkhead plating are all double riveted, and the use of red-lead putty or other packing materials for securing watertightness avoided as much as possible. Rivets connecting frame-gussets to tank-top, and also those connecting tank side-bracket to margin-plate, are countersunk headed and caulked from inside the tank.

A dry cofferdam is fitted at the front end of the forward oil-tank, extending for a length of one frame space, to keep the cargo hold clear of any leakage of oil from the tank, oil-gutters have been constructed on boiler-room sides of tanks, extending from side to side of the ship, where oil-valve boxes are placed, and any oil leaking from tank bulkheads or from pipe-joints is collected, washed down with the hose and pumped overboard at regular intervals of time. There is also an oil-well at each end of the double-bottom oil-tank, to prevent any possibility of oil leaking into ordinary ballast tanks.

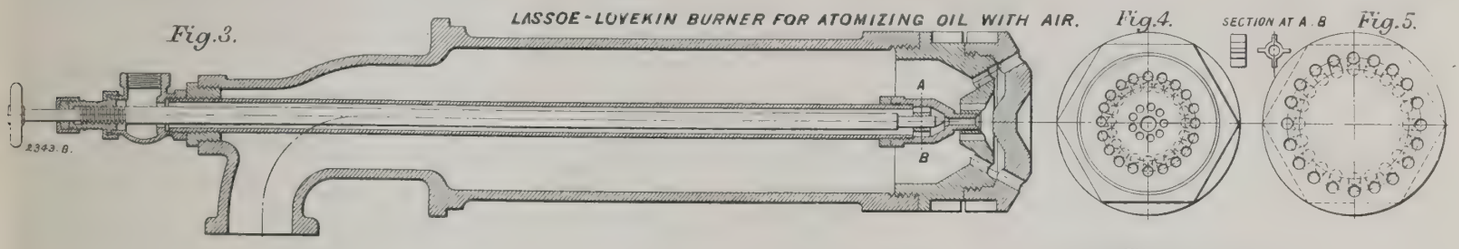
Ventilation of oil-tanks is also very carefully done throughout. The gas emitted from oil is very heavy and very difficult to remove by ordinary methods of ventilation, and as there is no danger of explosion so long as the tanks are kept perfectly tight, no ventilator pipes are fitted, except small air-pipes serving as exhausts for air in filling the tanks. When it is deemed necessary to clear the tanks, as in the case of inspection or repairs to be done to the tank, artificial means of sucking air through the oil-suction pipes are provided. For this purpose the connection can be established between one of the boiler-room blowers (fitted for supplying air to atomise the oil, as will appear later on) and the oil-suction main by means of a flexible hose. (See Figs. 10 to 12, page 210.) Clayton's fire-extinguisher is also made use of in assisting the ventilation of deep oil-tanks, and is fitted with branch pipes leading down to different depths in the tanks, thus enabling the Clayton blower to draw out gas from any desired height; only small quantities of gas can thus be dealt with.

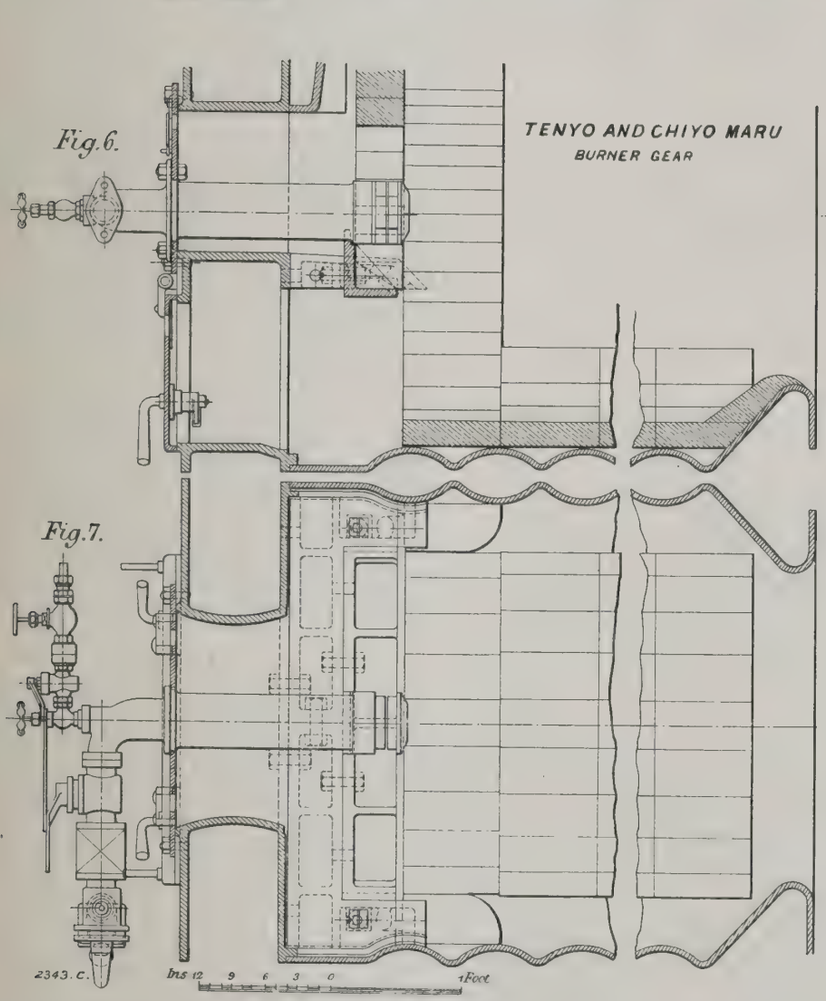
The arrangement of pipes for pumping oil is shown in Figs. 1 and 2, page 208, and, as can be seen from the plan, the tank suctions from each double bottom are led to separate valve boxes, one for each side of each tank, through which they are connected to ballast and oil-main suction. These valve-boxes are so constructed that one tank can never be connected to oil and water-ballast main at the same time, thus avoiding any possibility of oil and water mixing. There are two oil-mains of 6 in. diameter, one for each side, and they are again connected through valve-boxes to the ballast-pump suction and delivery pipes. One of the ballast donkey-pumps, 9 in. by 12 in. by 10 in., of which there are two, is exclusively used for pumping oil, being cross-connected with the water-ballast pump, with blind flanges in the middle. This pump can shift oil from one tank to another, or deliver into the settling-tanks; trim can thus be adjusted by oil ballast.

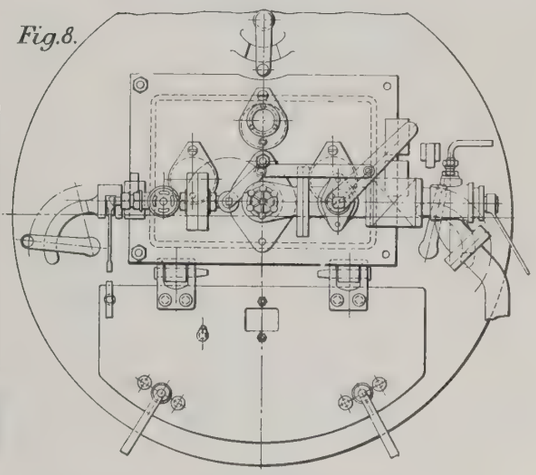
After carefully considering the different systems of burners, it was concluded that none using steam is economical for an ocean liner, as a large installation of evaporators is needed for making up the deficit of fresh water lost by atomising the oil, and fuel consumption is far greater than with other systems. Mechanical spray-burners are simple in construction, but cannot be worked satisfactorily with very heavy oil. Several experiments were made on shore with different kinds of spray-burners, using Californian fuel oil, and it was found that the burners are only workable when the oil is highly heated, which seemed to be rather objectionable in passenger steamers. Attention was then turned to burners using compressed air, and among these the Lässoe and Lovekin's was considered suitable for heavy oil, mainly for the reason that as it has comparatively large holes, the tendency to choke is less; further, its adoption of low-pressure air for atomising greatly reduces the trouble of working the air-compressors. Thus, after due consideration, Lässoe's burners were fitted in the two steamers, and their construction and arrangements are as shown in Figs. 3 to 9, above. The quantity of atomising air and oil can be nicely adjusted by cocks provided for that purpose; a small steam-pipe is led to each burner from the boiler, and this was found to be very useful for blowing out the nozzle whenever choked.

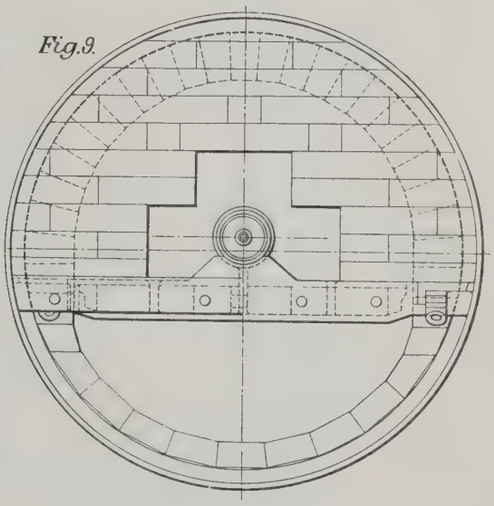
There are four duplex pumps for sending fuel oil to the burners, two arranged in duplicate, in each boiler-room, and each having dimensions of 4½ in. by 6 in. by 6 in. One is quite sufficient to supply oil to six boilers in full power.

Each pump has the following connection; —









Suction from settling-tank.
Suction from cofferdam bilge in stokehold.
Delivery to burners.
Delivery overboard.

The suction inlets of the pumps in the settling-tanks are provided with steam-heating coils, to increase the fluidity of the oil. This was found very useful, especially in winter. Strainers are provided on both the suction and delivery sides of the fuel-pumps; they are arranged in duplicate for the purpose of overhauling and cleaning. Delivery pipes from the pumps after leaving the strainers are led to the heaters and then form a ring around the boilers in each stokehold. In the ring, an escape-valve is provided, and its drain is connected to the suction of the fuel-pump.

Oil-heaters are also made duplicate, and one set is placed in each stokehold. They may be connected either in series or in parallel, and by this arrangement oil can be easily heated to any degree of temperature. In the ring, and remotest from the pump, a small pipe with valve is branched and connected to the suction of the fuel-pumps. By means of this arrangement heated oil can be passed through the whole system of oil pipings over and over again before starting the fires, and thus suitably-heated oil can be supplied to all the burners, and regular firing can be obtained at once. The arrangement of the fuel-oil pipes is shown in Fig. 10, above.

TENYO AND CHIYO MARU
BOILER ROOM ARRANGEMENT

Fig. 10.

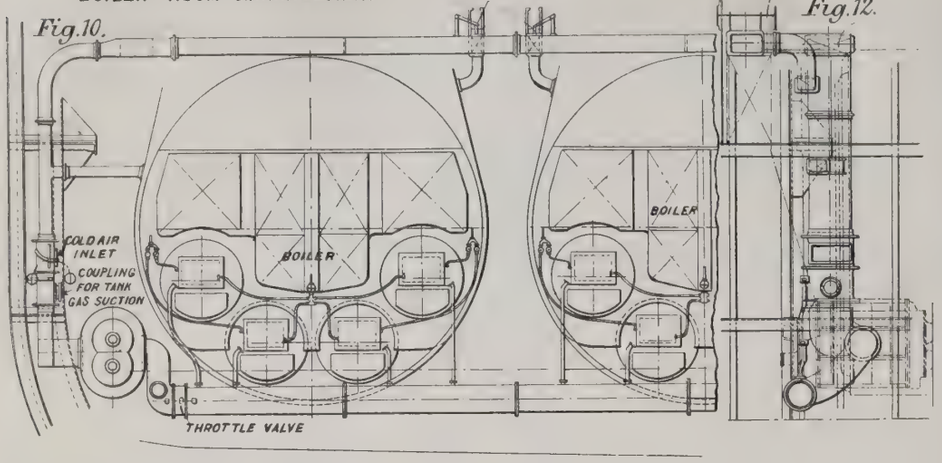
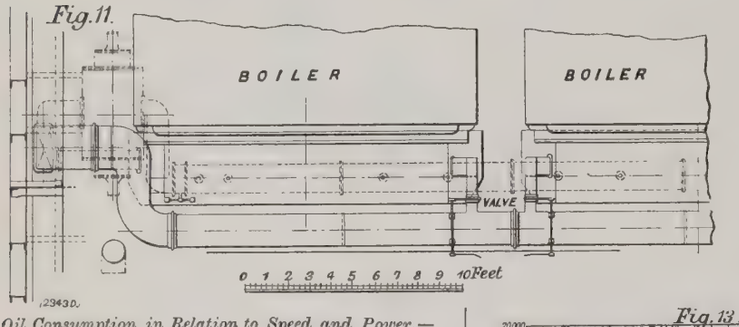


Fig. 12.

Fig. 11.



(2343 D.)

The atomising air for burners is supplied by eight blowers on Root's system. Two blowers are located in each stokehold, and have cross connections between them forming the main air duct and reservoir. At ordinary sea speeds only half the number of blowers will suffice; the other four are kept as spares. The pressure of air at the discharge of the blowers is kept at about 1½ lb. per square inch, or 3 in. of mercurial column. Better results are always obtained by atomising oil with heated air, and, with this end in view, the blowers are arranged to take the air from the Howden heater provided in the uptake of each boiler. The blowers are also made to take cold air from the stokehold directly by opening the flap-valve provided in the suction-pipe of the blower. By this arrangement the temperature of the atomising air can be adjusted to suit the quality of oil. From the main air-duct lying under the floor 2-in. pipes are led to each furnace to supply air to the burners. The arrangement of air supply is also shown in Figs. 10 to 12.

In April, 1908, the Tenyo Maru was put in service, and in the following December the Chiyo Maru. Ever since, on both ships, experiments have been conducted with the object of reaching the minimum consumption of fuel.

The following are the principal results for oil-burning, found by experience.

1. The degree of heating-desirable for the oil depends on the quality, and, in general, the best results can be obtained by heating to a little below the flash-point.

2. With Lässoe burners, the oil pressure at the burner should not be more than a few pounds above atmospheric pressure. It will be sufficient to have the pressure at the delivery of the fuel-pump just capable of passing the oil through the pipes. In the case of the Tenyo Maru and Chiyo Maru, the pressure at the delivery of the pumps varied from 15 lbs. to 20 lbs. per square inch by gauge. It was also found, with the burners, that better results are obtained by injecting oil into the furnace by the pressure of the atomising air rather than by the pressure of the oil itself, as in the mechanical spray burners.

3. The air supply to the furnace from the Howden draught-fans requires more delicate adjusting than in coal-burning. When the supply of air is deficient, dense black smoke is produced, and a heap of unburned coke is soon formed in the furnace. When the supply is in excess, no smoke is visible, but the temperature in the furnace is greatly lowered. The most economical firing is when very faint smoke is seen rising up through the funnel. In such a state of firing, in the case of the Tenyo Maru and Chiyo Maru, the air pressure in the furnace was found to be about ¼ in. This pressure is very low as compared with coal fires, where great resistance is encountered in passing air through the fire and grate.

4. Impurities of the oil form the most objectionable feature in burning, and with impure oil the consumption becomes enormously increased. When oil contains salts, a very obstructive incrustation is formed in the holes of the nozzle. This being solid salt, its removal can only be effected by passing reamers through the holes. With the nozzles choked, atomising becomes very much reduced, and consequent increase of consumption is unavoidable. Thus, when oil is used as fuel, separation from impurities is a matter of urgent necessity. The separation is most effectively done in settling-tanks, and more quickly done by heating the contents by the steam-coils therein provided.

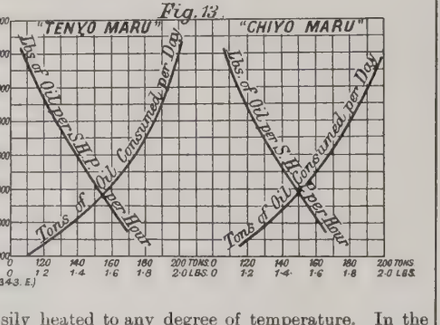
Information with regard to the consumption of fuel in the ships will be of interest. The diagrams, Fig. 13, annexed, show the relation between shaft horse-powers of the turbines and consumption of fuel. The consumption of oil in the Tenyo Maru and Chiyo Maru can be read with accuracy by the level gauges provided at the front of the settling-tanks. The daily consumptions plotted on Fig. 13 were taken from the chief engineer's log.

Another curve showing the rate of consumption per shaft horse-power per hour is drawn on the same diagram. From this curve it can be at once observed that the rate of consumption is greatly increased at reduced powers. At 18,500 shaft horse-power the consumption of oil is about 1.05 lb. per shaft horse-power per hour. This figure may be compared with the coal consumption observed on the trials made by the builders, in which case, for the same power, 1.52 lb. of the best Takashima coal were required per shaft horse-power per hour. Hence oil consumption in proportion to coal consumption is approximately in the ratio of 2 : 3.

The above was prepared for the meeting of this Institution which was to have been held last year. Since then a little more experience has been gained; this may be summarised in the following note:—

Owing to the uncertainty of supply of fuel oil in Japan and China, the owners decided, a short time ago, to burn coal at this end of the voyage; the forward battery of boilers (six in number) were therefore converted to use coal as fuel, while the aft battery, consisting of seven boilers, were still to burn oil. As ten boilers are commonly needed in ordinary service, the coal and oil-burning boilers are used in combination to suit local conditions of fuel supply. It has been found that the consumption in the case of coal-burning is 20 to 22 tons, against 14 tons of fuel oil.

Fig. 13.



(2343. E.)

Oil Consumption in Relation to Speed and Power.—"Chiyo Maru."

Voyages.	Mean Draught during the Voyage.	Displacement.	Mean Speed during the Voyage.	Consumption of Oil per Day.	Shaft Horse-Power.*
	Ft. in.	Tons.	Knots.	Tons	
Yokohama-Honolulu ..	25 7¾	16,800	15.21	141.4	8940
Honolulu-San Francisco	23 5½	15,050	17.69	185.8	15,000
San Francisco-Honolulu	26 11¼	17,900	14.43	144.9	7850
Honolulu-Yokohama ..	25 5	16,650	15.92	173.3	10,150
Yokohama-Honolulu ..	24 8½	16,050	15.18	145.7	8380
Honolulu-San Francisco	23 2¼	14,800	15.29	132.7	8150
San Francisco-Honolulu	27 0½	18,000	15.29	144.0	9190
Honolulu-Yokohama ..	25 10¼	17,000	14.45	132.0	7625
Yokohama-Honolulu ..	26 7¾	17,650	16.30	166.0	11,500
Honolulu-San Francisco	25 4	16 590	15.73	149 5	10,680
San Francisco-Honolulu	26 3½	17,380	15 04	138 5	8700
Honolulu-Yokohama ..	25 1¼	16,400	14.50	122.4	7500
Yokohama-Honolulu ..	26 0	17,150	15.04	140 3	9100
Honolulu-San Francisco	24 3¾	15,710	15.33	137.0	8480
San Francisco-Honolulu	27 4¼	18,220	15.03	129.5	8950
Honolulu-Yokohama ..	26 8½	17,700	15.08	147 5	8960

Oil Consumption in Relation to Speed and Power.—"Tenyo Maru."

Yokohama-Honolulu ..	27 0	17,950	17.20	189.5	14,420
Honolulu-San Francisco	25 7½	16,9 0	18.25	209.5	18,300
San Francisco-Honolulu	26 8¾	17,650	15.77	140.0	11,710
Honolulu-Yokohama ..	25 11	17,090	16 38	159.3	11,600
Yokohama-Honolulu ..	27 2¼	18,100	16.02	185.0	11,400
Honolulu-San Francisco	26 3¾	17,350	15.77	180.7	11,610
San Francisco Honolulu	26 3¼	17,320	15.06	141.0	8750
Honolulu-Yokohama ..	25 8½	16,950	16.34	165.6	11,460
Yokohama-Honolulu ..	26 11	17,890	15.25	145.6	9230
Honolulu-San Francisco	25 3	16,550	15.64	168.3	9650
San Francisco-Honolulu	26 8½	17,700	14.86	133.5	8600
Honolulu-Yokohama ..	26 3¾	17,350	15.50	151.3	9700
Yokohama-Honolulu ..	26 6½	17,550	14.57	158.7	8050
Honolulu-San Francisco	25 5½	16,700	15.38	189.5	8720
San Francisco-Honolulu	27 7½	17,990	14.99	155.4	8850
Honolulu-Yokohama ..	26 11	17,860	14.42	155.0	7840
Yokohama-Honolulu ..	27 8	18,060	15.03	140.1	8900
Honolulu-San Francisco	26 4¾	17,420	15.75	155.3	11,100
San Francisco-Honolulu	27 3½	18,200	14.91	138.7	8750
Honolulu-Yokohama ..	25 11¼	17,150	15.12	153.8	9000
Yokohama-Honolulu ..	26 8½	17,690	15.92	160.3	10,750
Honolulu-San Francisco	25 5½	16,700	15.11	159.5	8475
San Francisco-Honolulu	26 2¼	17,280	14.51	178.3	7880
Honolulu-Yokohama ..	25 3	16,550	15.04	138.3	8150
Yokohama-Honolulu ..	25 9½	17,030	16.10	159.5	10,890
Honolulu-San Francisco	24 4¼	15,800	15.13	143.0	8270
San Francisco-Honolulu	26 1½	17,210	14.69	144.0	8000
Honolulu-Yokohama ..	25 3½	16,600	14.78	118.0	8050

* The shaft horse-powers in the above table are taken from the trial power at the speeds tabulated, corrected for displacement; the correction employed assuming shaft horse-power to vary as displacement ⅔.

Ancient Iron Furnace Discovered in Sweden.—Professor Odelstjerna has recently been making researches at Hedesunda and Pernebo, in Sweden, in order to discover possible remains of ancient iron furnaces. The result has been very satisfactory, such furnaces having been found in both places. They were cavities or holes set with stone, and having a hard-burnt bottom of clay, mixed with slag. This kind of primitive furnace was used for the production of iron earlier in Sweden than in any other country. Those found at Hedesunda are the largest known, and it has been estimated that they were in use more than 2000 years ago.

Diameter of Small Particles and Stokes's Formula.—In a paper presented to the Deutsche Physikalische Gesellschaft (Proceedings. vol. xii., page 1025) in Berlin at the end of last year, Max Reinganum examines the conditions under which the formula of Stokes holds good. After giving a *résumé* of the critiques applied to the formula, which is used for estimating the size of particles from the rates of their movements under known forces, he describes experiments. For very small particles, such as the ions of gases, the formula would not appear to be applicable, nor would it be applicable to the metallic particles of Ehrenhaft. If the particles can be regarded as elastic spheres, similar to gas molecules, their radii should be proportional to their velocities, and not to the square root of the velocity, as Stokes taught. According to Reinganum the density of the medium should also have an influence. In "Le Radium," vol. vii., page 345, R. A. Millikan suggests another modification of Stokes's law. He produces a cloud of small particles of oil or mercury over a condenser of two horizontal plates, and lets a few particles fall through a hole in the upper plate. When the condenser is discharged and recharged, a single particle may be observed to fall and to rise again, and be watched for many hours; the air is ionised (naturally or by radioactivity), and when one or more ions join the drop, its electric charge is altered, and its speed of ascent (which depends upon the charge) alters step by step.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a list of colonial and foreign engineering projects, for some of which tenders are asked. Further particulars concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C. :—

New Zealand: The Imperial Trade Correspondent at Dunedin (Mr. W. T. Monkman) reports that there is a movement at that place for the development of Dunedin and the Province of Otago. It is hoped to expedite the completion of two or three lines of railway, the progress of a scheme for watering the dry areas, the provision of better harbour facilities, &c.

Morocco: His Majesty's Consul-General at Tangier (Mr. H. E. White, C.M.G.) reports that tenders are invited by the Special Committee of Public Works for the construction of a road, 200 metres in length, leading from the small lighthouse at Tangier to the Custom House. The estimated value of the contract is placed at 75,000 francs (3000*l.*); a deposit of 1000 francs (40*l.*) is required with each tender, to be increased by the successful tenderer to 3000 francs (120*l.*). Tenders will be received by M. le Président du Comité Spécial des Travaux Publics, Dar En-Niaba, Tangier, up to 11 a.m. on September 21. It is to be noted that the contractor must elect domicile in the neighbourhood of the works.

Spain: The *Gaceta de Madrid* of July 23 contains a notice, issued by the General Directorate of Public Works, authorising the Sociedad General de Ferrocarriles Vasco-Asturiana to lay railway lines for the purpose of connecting the Ujo-San Esteban de Pravia Railway with the harbour at the last-named place. The *Gaceta* of July 24 contains a notice, issued by the General Directorate of Public Works, to the effect that an application has been lodged by Don José Prast and García Ollalla for a concession for the construction and working of a secondary railway from Vélez Rubio to Almendricos.

Russia: The *Official Messenger* of July 21 announces that the municipal authorities of Reval have applied for power to raise a loan of 1,500,000 roubles (about 158,000*l.*) for the carrying out of public works, including water, drainage, and electric light works, the building of a hospital and barracks, &c.

Peru: El Peruano of June 2 notifies that arrangements are being made for the Amazon Pacific Railway Company to proceed with the construction of the Pucalpa Railway (see *Board of Trade Journal* of November 3, 1910, page 231). The most difficult section will be from Goyllarisquisga to Ambo, as it comprises a gradient of over 7000 ft. in 50 miles. It will take three months to prepare the plans for the first section, Goyllarisquisga to Huánuco, and two years to build this section.

IRON INDUSTRY IN SIBERIA.—The iron industry of Siberia has, so far, attained to no great importance, and the exportation of iron does not take place. There are, at present, only three iron works, the railway apparently having retarded, instead of advancing, the iron industry, the number of iron works having formerly been greater. Siberia's requirements of iron are of fair importance, but for some of the large and comparatively well populated districts, the Ural iron works or the Eastern ports are more convenient sources from which to draw the supply, the more so as Siberia's few iron works, with one exception, are located at a considerable distance from the railway, and thus handicapped in the competition. Dearth of suitable coke, and shortage of skilled hands, are further obstacles in the way of the local industry. Formerly, when the means of transport did not allow of iron being imported from abroad, the small Siberian iron works did fairly well, whereas they now only work part of the year. There are a couple of charcoal blast-furnaces, which, however, only have an average production of 8 tons of pig iron per twenty-four hours, this product being either sold for foundry purposes or used at the engineering and rolling works connected with the furnace. There is, however, reason to believe that good works could be made to pay, provided the position were favourable.

THE WORLD'S RAILWAYS. — World-wide statistics accumulate only slowly, but it is computed that, at the close of 1909, there were 625,698 miles of railway in operation on the globe. This total did not include street railways and trolley lines. The two Americas had between them 319,344 miles of completed railway, while Europe and Asia had only 266,704 miles between them. Africa had 20,829 miles in operation, and Australasia 18,849 miles. The additions made to completed railway in Europe in 1909 amounted to 2528 miles; in Asia, to 2986 miles; in Africa, to 1789 miles; in North America, to 4143 miles; in South America, to 1866 miles, and in Australasia, to 882 miles. Although North America has obtained a long lead in the matter of railways, construction on that continent is now proceeding at a reduced rate. Asia has now a by no means unimportant railway network, although there is room for great further extensions. Russia built, in 1909, 1258 miles of railway in Central Asia. In 1909 China had 5277 miles of railway in operation, of which 3050 miles had been opened in the four years ending with that date. Japan only opened out 45 miles of new line in 1909. Argentina comprises more than one-third of the railway mileage of South America, having 15,854 miles of completed line in operation in 1909. Brazil ranked second, with 13,000 miles. Cuba and the West Indies (which are included in the South American compilation) had 4340 miles of railway in the year under review. The amount of capital invested in the railways of the world in 1909 is computed at 10,320,000,000*l.*

CATALOGUES.

Electrical Supplies.—We have received from Siemens Brothers' Dynamo Works, Limited, 39, Upper Thames-street, E.C., copies of their latest illustrated price-lists of supplies for electrical contractors. These lists give particulars of ceiling-roses, lamp-holders, switches, wall-plugs and sockets, fuse-boards, insulators, electric heating-apparatus, &c.

Electrical Instruments.—We have received from Messrs. Crompton and Co., Limited, of Salisbury House, London Wall, E.C., a small price-list of moving-coil and moving-iron ammeters and volt-meters of the pedestal pattern. These instruments are in specially stout iron cases, which are gas-tight and water-tight, and are suitable for mounting direct on ironclad controlling-pillars or angle-iron frameworks.

Semi-Portable Steam-Engines.—Messrs. Ruston, Proctor, and Co., Limited, of Lincoln, have sent us a copy of a catalogue section dealing with semi-portable and under-type steam-engines. This catalogue contains a general description of both types, and also gives particulars (including capacities, weights, and principal dimensions) of each size. The semi-portables are made with single or double simple cylinders, the former up to 46 effective horse-power and the latter up to 110 horse-power. Compound engines of this type are supplied to work non-condensing and condensing for economical loads up to 77 and 92 effective horse-power respectively. Only compound-undertype engines are listed, the particulars given referring to non-condensing engines up to 135 horse-power and condensing engines up to 162 horse-power. Some information relating to the use of liquid fuel and refuse fuels, such as saw-dust, tan-bark, &c., is also included in the catalogue. Special attention is called to the durability of these engines, and a case is recorded of a portable engine which is still working after having been in use for over forty years.

Sewer Ventilating Lamps.—A pamphlet containing numerous testimonials relating to Webb's system of ventilating sewers, mortuaries, &c., has reached us from the Webb Lamp Company, Limited, 11, Poultry, E.C. In the Webb system, a pipe leading from the sewer is taken up inside a lamp-post to a suitably constructed lantern, which contains an incandescent gas-burner. The gases are drawn from the sewer by the draught set up by the gas-burner, and, being highly heated in the lantern, are both sterilised and rendered odourless before escaping into the atmosphere. Besides this duty the lamps are also useful for the purpose of street-lighting, so that this system is particularly suitable for use in urban districts. The testimonials, which are mostly from borough engineers and surveyors, are all of recent date, and refer, in several cases, to lamps which have done duty for a number of years. Several illustrations of lamps in use in different parts of this country and abroad, are included in the pamphlet. Some of these illustrations show oil-lamps employed instead of gas, in places where the latter is not available.

Electrically-Driven Rolling-Mills.—We have received from the Electric Construction Company, Limited, of Wolverhampton, a pamphlet entitled "Electrically-Operated Reversing Rolling-Mills," containing a brief illustrated description of an installation constructed by the firm and supplied to the Staffordshire works of Messrs. Alfred Hickman, Limited. The installation consists of a fly-wheel motor-generator set, comprising one motor, two generators, and two fly-wheels, each of the latter weighing 28 tons. The motor, which is shunt-wound, is driven by continuous current at 460 to 500 volts; it is rated at 2000 horse-power. The two generators supply continuous current to the two mill-motors, which drive, respectively, a 30-in. cogging-mill, and a 24-in. bar-mill. The bar-mill motor, which is directly connected to the rolls, can develop 6000 horse-power for periods of 5 seconds six times per minute, and will give a maximum output of 12,000 horse-power for 2 seconds once every hour; the cogging-mill motor is somewhat smaller. Both machines have an efficiency of 94.5 per cent. at full load, and can be fully reversed in 6 seconds. The pamphlet also describes the controlling arrangements, safety devices, and other details of this interesting and important installation, which is claimed to be the largest of its kind in this country.

Air-Compressors.—From Messrs. Alley and Maclellan, Limited, Sentinel Works, Polmadie, Glasgow, we have received a copy of the latest edition of their catalogue of air-compressors. This catalogue, which is a particularly creditable production, contains over 160 pages, with numerous excellent illustrations, bound in paper-covered boards. Besides fulfilling the functions of a catalogue, it contains much information relating to the production and use of compressed air, so that it will be valuable to all interested in this subject. The book first explains the factors which go to make the commercial efficiency of air-compressors, and then points out the advantages of two-stage compression. It next fully describes and illustrates the special features of the "Sentinel" compound inter-cooling compressors, giving prices, dimensions, and shipping particulars of belt-driven machines having capacities ranging from 35 to 8300 cub. ft. of free air per minute at pressures between 50 lb. and 130 lb. per square inch. Similar particulars are given of compressors driven by simple or compound steam-engines, the steam-cylinders being arranged vertically above the air-cylinders. Single-stage compressors are next dealt with, and full particulars of steam and belt-driven machines of this class, are given. Two types are made—one for pressures up to 60 lb., and the other for pressures up to 30 lb. The former have capacities up to 6600 cub. ft. and the latter up to 16,600 cub. ft. of free air per minute. The catalogue gives particulars of several other types of compressors and accessories, and also deals with the question of driving by electric motors and gas-engines. The last few pages of the book are devoted to useful tables relating to compressed-air work, and illustrations of other articles manufactured by the firm.

Cask-Making Machinery.—We have received from Messrs. A. Ransome and Co., Limited, of Stanley Works, Newark-on-Trent, a copy of their very interesting catalogue of cask-making machinery. The catalogue, which is bound in paper-covered boards, contains 128 pages and over 120 half-tone engravings and wood-cuts of machinery for making all kinds of casks, tubs, and barrels for liquids or dry goods. All the machines described are designed to be operated by labourers and boys, and the firm claims that a very large reduction in the cost of labour can be effected by the use of these machines, since the services of skilled coopers are not required for any part of the process of manufacture. It has also been necessary in designing these machines to avoid the great waste of wood which occurred with some of the earlier cooperage machines. With the new machines it is stated that the wastage is not greater than takes place when skilled hand-coopers are employed. The catalogue first deals with machinery for the manufacture of staves, illustrating and describing in this section saw-benches, cross-cut saws, band-saws, cylindrical saws, backing and hollowing-machines, stave-jointing machines, grooving and tonguing-machines, steaming-chambers, hydraulic stave-presses, &c. Perhaps the most interesting machines in this section are those which dress and joint the rough-riven staves, which are always of a somewhat irregular shape, and often bent and twisted. They must, however, be finished with extreme accuracy, and the methods adopted to ensure this, without wasting wood, will be of interest to both engineers and coopers. Trussing machinery is dealt with in the next section, which includes power windlasses for drawing the staves together, hydraulic and other power-driven trussing-machines and trussing-bells; some of the latter have been illustrated and described in our columns recently. Other interesting machines illustrated are the chiming, crozing, and howelling-machines employed for bevelling the ends of casks and forming the groove into which the head is fitted. In these machines the cask is held in and slowly rotated by a special kind of chuck, and is operated on by rapidly-rotating cutters at both ends simultaneously. The process, which consists of eight operations, is completed during a single revolution of the cask, which, in the case of a brewer's hogshead, takes about 30 seconds. Other machines for chiming and crozing separate staves are also illustrated. One of these is shown combined with a printing-machine and drying-oven. This machine, which is attended to by two boys, will chime, croze, and print about sixty staves per minute, and deliver them conditioned ready for trussing. The catalogue also deals with machines for manufacturing heads; hoop-punching, shearing, and riveting-machines; bung-hole-boring machines; branding and printing-machines—in fact, everything necessary to equip plants for manufacturing all kinds of casks in any part of the world is included. In addition to its utility as a trade catalogue, this publication has a considerable value as a treatise on cask-making by machinery, since it not only fully describes the machines and the methods of using them, but also contains a large amount of general information on the subject to which it relates.

THE JAPANESE CENTRAL RAILWAY.—This has been in course of construction for some fifteen years, and has recently been opened for traffic over its entire length. It is some 225 miles long, has 95 tunnels, 351 bridges, and has entailed an expenditure of 4,300,000*l.* Connecting Tokio, Kioto, and Osaka, the railway is of great strategic importance, and will also prove a vast boon to the industrial development of the country.

EVERYBODY'S POCKET CODE.—A very useful little book bearing this title has recently been compiled and published by Messrs. William Clowes and Sons, Limited, Sussex House, Fenchurch Buildings, London, E.C., and 23, Cockspur-street, S.W., which ought to prove particularly useful to a large section of the public. The primary object of its publication has been to provide a safe, efficient, and economical form of general telegraphic correspondence at a popular price and of a size easily carried in the pocket. It is compiled on the basis of half code-words of five letters each, and any two half-words may be joined together and sent as one pronounceable ten-letter word on a foreign telegraph form. The compilation of these half-words is strictly in accordance with existing regulations, and they differ from each other by at least two letters and contain no transpositions of the same two letters in the same position. The advantage claimed for this is that any mutilation by an operator of one letter, or the transposition of two in any half-word is easily detected. There are 27,000 half-words in the code, and a phrase or a portion of a phrase is indicated by each of these, and as many as 20,000 of them are said to be capable of combining with each other to form one full word sentence. Therefore, as many as four million sentences for one complete code-word can be made. It is divided into four parts: a travelling section, relating to travelling by rail and steamship; an hotel section, giving phrases and sentences relating to hotels; a shipping and forwarding section; and a banking and financial section relating to all general banking and financial business. Opposite each half code-word in each phrase is the corresponding half-phrase. Considering the enormous amount of labour the book represents the price is remarkably low, being 2s. 6d. only, or, in superior binding, 4s. 6d.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

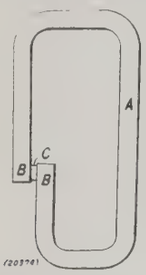
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

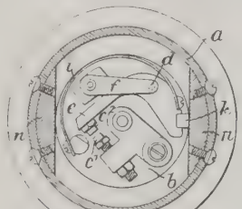
20,374/10. G. Hookham, Birmingham. Electricity Meters. [2 *Figs.*] September 1, 1910.—This invention relates more especially to permanent magnets of electricity meters. In these it is often desirable to have a narrow gap between the pole surfaces, and this gap is likely to become altered in width by the process of hardening the magnets. In order to adjust subsequently this distance with sufficient accuracy the applicant makes the magnets with the pole surfaces slightly too close together, and then springs them apart and inserts a small



block or spacing piece of non-magnetic material between the pole surfaces or adjacent parts so as to keep them open the required distance. The block or spacing piece may be inserted at one side or corner so as not to interfere with a brake disc or other device which operates in the magnetic field. In the drawings, A is the steel magnet which, in this case, is forged from one piece of steel. B, B are the polar portions, and C a block of brass inserted at one corner to keep them at the correct distance apart. (*Accepted May* 17, 1911.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

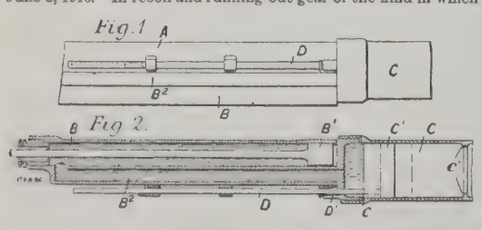
24,686/10. The Firm Robert Bosch, Stuttgart, Germany. Ignition Arrangements. [1 *Fig.*] June 22, 1910. The invention relates to interrupters for magneto-electric machines for the ignition of the charge of internal-combustion engines and is illustrated in the drawing, which shows a vertical section through the common axis of the casing *a* and disc *b*. The contact c^1 is fixed and generally insulated, and is secured to the disc *b*. A two-armed lever *e* is pivoted on a pin *d* on the disc *b*. A leaf spring *f* prevents the lever from slipping off the pin. One arm of the lever *e* carries the other contact c^2, and a spring *i* fixed to the disc *b* and to the other free arm of the lever *e* tends to press continuously the contacts c^1 and c^2 together. When in use, the



disc *b* is generally rotated, whilst the casing *a* is stationary. On the outer end of the free arm of the lever is placed a block *k* of ebonite, and on the inner periphery of the casing *a* there are, for example, two cams *n*, *n* which extend so far into the path of the block *k* that they deflect the lever from the circuit-closing position when the block on rotating strikes against the cams. According to the present invention, the operative surfaces of the cams are all formed as substantially plane surfaces tangential to the direction of motion of the lever in its positions of maximum deflection, so that the interrupter lever is more gradually deflected than in the usual constructions and the danger of fracture of the spring or other parts is avoided, and the deterioration of the contact surfaces much lessened. (*Accepted May* 24, 1911.)

GUNS AND EXPLOSIVES.

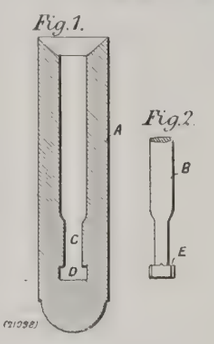
13,896/10. Sir A. T. Dawson and G. T. Buckham, London. Recoil and Running-Out Gear. [2 *Figs.*] June 8, 1910.—In recoil and running-out gear of the kind in which



the recoil-gear comprises a brake cylinder and the running-out gear comprises a compressed-air reservoir containing a floating piston, means, according to this invention, comprising a graduated scale and pointer are provided for indicating the positions occupied by the floating piston in order to enable any leakage of the liquid to be readily detected, and for this purpose the floating piston may be provided with a graduated rod working in conjunction with an index or pointer. A is the brake cylinder and B the air-compressor; these are arranged to project longitudinally in front of the air-reservoir C. The piston B^1 of the compressor is in direct contact with the liquid, communication between the compressor B and reservoir C being effected by means of a passage B^2 so that the liquid is always in contact with the floating piston C^1, which is arranged in the reservoir C to separate the liquid from the air. Parallel to the brake cylinder A is arranged the graduated-rod D, which is attached to the floating piston C^1 and passes through a gland D^1 in the wall of the reservoir C. The rod is guided in bearings attached to the brake cylinder, and one bearing is provided with a projection serving as an index or pointer with respect to the graduations on the rod D. The floating piston C^1 is limited in its movements by means of stops *c*, c^1 in the reservoir C, and the linear measurements on the rod D are so arranged in relation to the index that the distance of the floating piston C^1 from the forward or rear stops can be ascertained by inspecting the graduations on the rod. If any leakage has occurred, the position of the floating piston will vary accordingly, and can be readily detected by inspecting the position of the graduations on the rod D relatively to the index. (*Accepted May* 24, 1911.)

MINING, METALLURGY, AND METAL-WORKING.

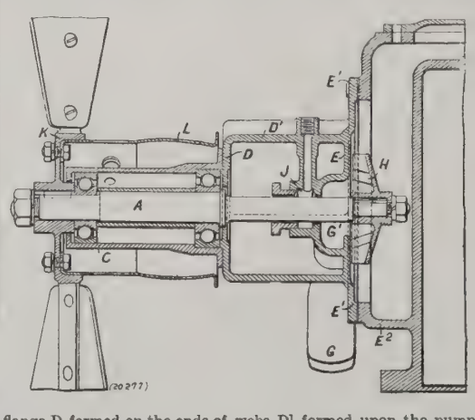
21,098/10. W. J. Caulfield, Mossend. Foundry Ladles. [4 *Figs.*] September 10, 1910.—A stopper for foundry ladles used in connection with steel manufacture comprises a block A of one piece of fireclay which embraces the end of the metal ladle-rod B, and extends upwards to form a protective sleeve for the portion of the rod which is immersed in the molten metal. A slot or recess C, enlarged at its inner end as at D, is formed in the block A to accommodate the end of the ladle-rod B.



The ladle-rod end is formed with a T-shaped head E, and is secured to the block A by rotating the rod B through an angle of 90 deg., so that the head E engages with the enlarged end B of the recess in the block A. The space between the fireclay block A and the rod B is packed with sand or other material. The portion of the metal rod B extending above the fireclay block A may be protected in the usual way by fireclay or like sleeve bricks. (*Accepted May* 31, 1911.)

MOTOR ROAD VEHICLES.

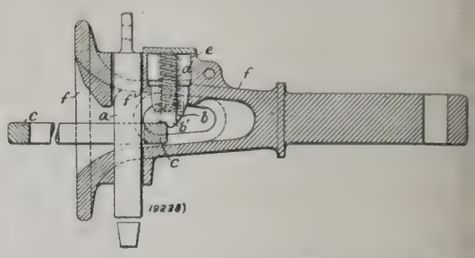
20,277/10. Albion Motor-Car Company, Limited, and T. B. Murray, Scotstoun. Cooling Arrangements. [2 *Figs.*] August 31, 1910.—In a fan and pump unit for engine cooling on motor vehicles of the type comprising a spindle carrying at one end a fan and at the other end a pump operative member, a sleeve embraces and has bearings for the spindle, and is carried on, or forms part of, the pump body, which in turn is adapted to be secured to the engine cylinder, a driving sleeve pulley for a belt being operatively connected to the fan, and embracing the bearing sleeve. The driving spindle A of the unit is carried in ball-bearings in a hollow sleeve C. This hollow sleeve C has at its rear a flange C^1, by which it is secured to a disc or



flange D formed on the ends of webs D^1 formed upon the pump body E. The pump body E has on it a flange E^1 by which it is secured to an opening in the cylinder jacket E^2, and is provided with an intake G. The pump rotor H is of ordinary form, drawing from an axial intake cavity G^1, and delivering directly to the jacket space. The pump rotor H is carried on the inner end of the spindle A, and there is provided a stuffing-box J accessible between the webs D^1 for adjustment or packing. On the opposite end of the spindle A is a spider K carrying fan blades of ordinary form, and carrying also a cylindrical sleeve L extending laterally over the bearing sleeve C, and externally surfaced for a belt, by which it, and so the fan-pump unit, is driven from the engine. (*Accepted May* 24, 1911.)

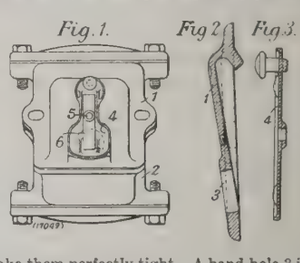
RAILWAYS AND TRAMWAYS.

19,238/10. Edgar Allen and Co., Limited, and H. H. Gunstone, Sheffield. Central Buffers. [4 *Figs.*] August 16, 1910.—In central buffers and couplings for railway vehicles, according to this invention, the means by which the coupling link may be held in a horizontal position in the buffer-head, comprise an internal round-nosed vertical plunger or ram having a curved lip placed immediately behind the coupling-pin so that the nose of the ram will, by the action of a spring inside the ram-box, bear upon the inner end of the coupling-link. Immediately behind the coupling-pin *a* is the internal round-nosed ram *b* which bears upon the inner end of the coupling-link *c*. This ram is attached to, or connected with, a vertical helical spring *d* which has its abutment in a small recess or spring-box *e* on the top of the buffer-head *f*. When the link *c* is uncoupled and withdrawn from the bell-mouthed head *f*, the flange of this round-nosed ram *b* is forced downwards on to the flange f^1, so that when a link is inserted to be coupled up, it comes in contact first with the rounded nose of this ram which is thereby forced upwards and when the link has been secured by the coupling-pin the ram



presses downwards on the end of the link to prevent it from dropping and retains it in a horizontal position. Notwithstanding the pressure of this round-nosed ram the coupling-link is sometimes, in the act of coupling, liable to be forced too far inwards, to obviate which there is formed at the bottom of the round-nosed ram *b* a curved lip b^1 which forms a stop or abutment against which the inner end of the link *c* comes in contact when forced too far inwards, so that, in the event of a shock, the inner end of the link, although under the compressing influence of the ram, is offered further resistance by this curved lip b^1 which will cause the ram to rise higher, the spring above the round-nosed ram being proportionately further compressed and the effect of the shock reduced, but on the link *c* being drawn forward until it is in touch with the coupling-pin *a* the ram *b* will return to its normal position on the top of the link as shown in the drawing. (*Accepted May* 24, 1911.)

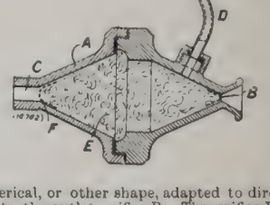
17,049/10. E. Peckham and F. S. Andrews, London. Axle Journal-Boxes. [4 *Figs.*] July 18, 1910.—This invention relates to axle journal-boxes having a casing capable of being hermetically closed to prevent entrance of dust and escape of the lubricant, and, according thereto, the main cover is adapted to be firmly secured to the journal-box casing and is provided with an opening, a pivoted cover or plate carried by the main cover being adapted to open or close the opening in the main cover, and means being provided for locking and firmly holding the pivoted plate in its closed position. The usual cover 1 is bolted to the flanged opening in the box 2, suitable packing being placed between the



joints to make them perfectly tight. A hand-hole 3 is provided in the cover through which hole the box may be filled with lubricant and packing. A pivoted plate 4 mounted on the cover is adapted to be turned on its pivotal point 5 sufficiently to cover or uncover the hand-hole; and to ensure perfect closing of the hole by the plate, pressure is brought thereon by means of a spring 6, which is so mounted as to move with, and impart, constant pressure to the plate. Further, to ensure that the plate remains in a position to cover the hand-hole, the plate is locked in this position by means of a latch or self-locking device carried at the opposite end of the plate, which latch is adapted to be received in a corresponding recess provided in the cover of the box. (*Accepted May* 24, 1911.)

MISCELLANEOUS.

14,702/10. Heenan and Froude, Limited, and W. Wheal, Manchester. Atomising Liquids. [3 *Figs.*] June 18, 1910.—This invention relates to apparatus for spraying or atomising liquids, and consists essentially of a nozzle or spray comprising a chamber filled with slag wool or other fibrous or porous material, the chamber being of conical, elliptical, or spherical shape at the outlet end, and having a small orifice at the apex or summit thereof, and into which separate supplies of water and air are forced at high and equal pressures. The casing A forming the nozzle or spray is preferably made in two parts, constructed so that they may be fastened together. The mixing-chamber may be of any shape, but the outlet portion is of conical,



elliptical, spherical, or other shape, adapted to direct the mixed air and liquid to the outlet orifice B. The orifice B is chamfered or conical externally, as shown. The air inlet C and the water inlet D are so arranged that the jets of air and liquid impinge upon each other in the chamber to assist the atomising effect of the apparatus. The chamber A is filled with slag wool or other fibrous or porous material E, the outlet orifice B of the spray and the air inlet C being preferably provided with a diaphragm F of wire gauze of very fine mesh. This helps to break up the water and assists the spraying action, and it also forms a filter and prevents any particles of dirt passing through the orifice and clogging the same. (*Accepted May* 17, 1911.)

FEED-WATER HEATING AND SUPERHEATING ON LOCOMOTIVES.—No. I.

Preliminary Remarks on Superheating.

Of the many developments which have taken place in locomotive practice in recent years, in response to the ever-increasing demands made upon the mechanical branch of railway service, probably none has been so striking as the rapidity with which the employment of superheated steam is now spreading. Although its extensive adoption is but comparatively recent, the application of superheating to locomotive work is, of course, not new, and the present movement is, in reality, a successful revival, rather than an innovation. In land and marine practice there is no longer novelty in the system, and in these directions, in which detailed trials are so much more easily conducted than in locomotive work, there are innumerable well-authenticated tests on record, showing superheating to be attended by steam and fuel economy, so that it is now-a-days broadly accepted as advantageous in principle, though it may not always be deemed expedient. Owing to the greater difficulty of carrying out complete investigations with locomotives, the position in the latter case is somewhat less well defined, though there seems now to be little reason for it remaining so.

In regard to the two other branches of steam engineering as just stated, there have existed for many years an abundance of records favourable to the system, and in order to focus ideas to some extent, brief reference may be made to some of these. It is quite beyond the province of the present article to give anything approaching a complete *résumé* of the written and spoken opinion of leading engineers as to the value of superheat of even a moderate degree; reference will be restricted to a few cases only.

Prominent among this evidence stands the work of Bryan Donkin, who, using only 50 deg. Fahr. superheat, recorded economies of 15 per cent. and more, and who was so convinced of the soundness of the principle that, many years ago, he wrote in these columns* the following words: "Among the final improvement of the land, marine, and locomotive engines, moderate superheating seems to be one of the most promising." Similarly, Willans's experience showed that from 30 deg. to 50 deg. Fahr. superheat gave appreciable economy. The oft-quoted report in the Bulletin of the Alsatian Association of Steam-Users dealt with engines, many of which were of 500 and 600 horse-power, employing superheat which ranged between 60 deg. and 120 deg. Fahr., the saving under these conditions amounting to from 12 per cent. to over 20 per cent.

Again, the Proceedings of the leading Institutions contain much evidence to a similar effect. Mr. W. Patchell's paper read in 1896, before the Institution of Mechanical Engineers, and the discussion thereon, may be cited for example. On that occasion Professor W. C. Unwin, who had been associated with important tests in Alsace, stated that all the large tests had proved engines to be more economical with superheated steam, and, referring particularly to moderate superheat, he added, "a net steam economy could be obtained of 15 to 20 per cent. by superheating; and that with a superheater added to the boiler there would be at least as great economy of coal." Professor (now Sir Alexander) Kennedy also reported economies of 22 per cent. with 65 deg. Fahr. superheat, and many another corroborative opinion besides these was also then forthcoming. While lamentably disproportionate to the mass of evidence which has accumulated on this subject, these few references must now suffice, with a final quotation from Professor Perry, who sums up the situation in saying that "every test yet made of the effect of superheating shows that it leads to greatly increased economy. From 12 to 20 per cent. increase is not uncommon when the superheating has only been about 40 to 100 deg. Fahr."

The foregoing examples all refer to stationary-engine practice, but similar facts might be adduced with regard to marine engineering. It does not necessarily follow, of course, that in locomotive work the effect should be analogous, or, as is well known, some systems, of proved value in land and marine service, have altogether failed to give a convincing account of themselves, commercially, when applied to the locomotive. The reason for this inconsistency has been due, sometimes at least, to the great difference in the conditions of work to be met, and need not imply anything in the way of a breakdown of principle. Reflection will show that, in the matter under consideration, some of the conditions affecting superheating in locomotives are favourable to the system, while others are, it must be admitted, somewhat adverse. While, in land plants, the economy of superheating may sometimes have been found to be primarily due to a reduction of the losses in the long steam mains between the boiler and engine, in others it has been shown that its value, even with only a very few degrees of superheat at the steam-chest, is traceable to improved cylinder conditions. In the locomotive the steam-pipes are usually short and well protected by the hot gases in the smoke-box, with the result that, with good design, the superheat may easily be carried as far as the steam-chest, and utilised consequently at the cylinder. It would, therefore, not be illogical to expect some measure of economy under these conditions even with a low degree of superheat, provided the efficiency of steam generation remained good, were it not that a factor, whose consideration must not be neglected, tends to offset, or at least obscure, the benefits accruing. The irregularity of the service to which the locomotive is applied, the constant stopping and starting, the variation in loading due to weather, grades and other transitory causes, have a great influence on the superheating effect realised, and the consequent advantages are not always so sharply defined as where the working conditions are uniform and favourable. It is doubtless largely due to this indefiniteness that there is such conflict of opinion as to the value of various systems giving different degrees of superheat, a point we shall revert to later.

In making any change from adopted practice it is necessary for the engineer to consider a subject in a much broader aspect than is sometimes done. Cognisance has, in fact, to be taken of all factors affecting the proposition as an investment. The determination of a point of maximum fuel or water economy is of restricted interest to the engineer, unless he can combine that knowledge with other of a financial nature, which the purely scientific man may prefer to leave untouched. The engineer's problem does not refer merely to lessened consumption, but is concerned with over-all improvement, and it is due to this very fact that so many apparently promising developments have proved abortive—the position, as an ultimate result, has not been bettered by their introduction. It is essential, of course, to consider superheating from this point, though it is seldom thus discussed, its advocates, as a rule, contenting themselves with reference to practical records of economy in supplies, and with the presentation of a few facts relating to the theory of superheated steam.

Such a discussion of the subject lacks convincing force, for two reasons. It ignores the important commercial factor, and is rendered weak because, of necessity, an unbridged gap has to be left between pure theory and the service records; for, in this matter, theory, unmodified, is misleading and inapplicable to practical conditions. It is, perhaps, natural that the greater weight should be given to practical results of a tangible nature, such as fuel and water economy, for, comparatively, they are easy to obtain and to verify. They are arrived at directly, and though the methods involved may be laborious, they are not burdened with the refinements needed in tests where the endeavour is made to push the inquiry as far as a determination of boiler and engine performance. The latter constitutes a problem of so much more complex a nature that its solution has not infrequently been abandoned, though, at the present time, if advantage be taken of general locomotive data, it may be carried far enough to lead to conclusions supporting those arrived at from experience of systems in actual use. It is true that some of the data, of which use must be made, have only been procurable on testing plants such as that at the Illinois University, Purdue, or that erected first at St. Louis, and now at Altoona on the Pennsylvania Railroad, and for this reason, arguments so constructed may still be liable to rejection, in some quarters, as of academic rather than practical interest. Nevertheless, it cannot but afford satisfaction that these data render possible deductions in fair accord with results attained in actual service.

Reference has just been made to the locomotive-testing plant at Purdue. It is to this plant that we owe the only really detailed information of the behaviour of superheated steam in locomotives, obtained until the present, on a scale large enough for the results to be considered reliable and of scientific value. Under the patronage of the Carnegie Institute of Washington, tests, commenced in 1906 by Dr. W. F. M. Goss, on this plant have been extended to embrace investigations on this subject, and the work is being continued by Dr. Goss's successor, Professor C. H. Benjamin. Reports concerning the earlier tests, issued by the Carnegie Institute, are drawn up on the commonly adopted lines, and go, fortunately, into considerable detail, though it is to be regretted that they do not venture on the discussion of the several moot points on which, in view of the theories advanced in connection with modern steam-engine research, further elucidation is so much needed. Recent investigations on the steam-engine have, while throwing light on many points, concurrently directed attention to many still indeterminate variables, so that what might have been accepted as fact some years ago is now regarded merely as the nearest to the truth at present possible; and in view of this it must be admitted the exact location of the cause of improvement of superheating still remains partly conjectural.

In the application of superheated steam in practice two systems, based on radically different principles, have to be considered. In one of these systems fuel is specially consumed for the purpose of feeding the superheater, this being really equivalent to adopting an independently-fired superheater. In the other system no fuel is specially burnt on account of the superheater, use being made simply of the heat available in the waste smoke-box gases as they leave the boiler. Both these systems are deserving of notice, though the prominence given to one has tended recently rather to overshadow the value which rightly belongs to the other. These two systems have widely different influences upon the efficiency of steam generation, and, together with this, they introduce still another complication into the discussion, for with the one system the degree of superheat may be chosen within a wide range, while in the other the range is much more restricted and the highest superheat possible considerably lower. This has a further bearing on the question, for it involves other considerations, this time concerned with the thermodynamics of the engine, in which, within certain limits, the nearer conditions can be made comparable to those of an engine using a perfect gas, the better. The whole problem thus consists in determining for the two systems the relative efficiency of steam generation and of steam utilisation, combining these two and modifying the result by financial considerations in order to bring the argument to the stage at which it may be of value to the practical railway man, to whom, as has already been pointed out, a saving is only such when an improved return on capital invested is implied.

It has just been stated that with one of the two systems the highest degree of superheat possible is a great deal lower than in the other. This is the case with the waste-gas superheater, and the discussion necessitates at the outset a decision as to what may be considered a fair figure to take as the superheat obtainable in smoke-box superheaters, utilising only the heat in the waste products of combustion. In this matter there has often been noticeable a proclivity, on the part of advocates of other systems, to use figures which can scarcely be said to do justice to these heaters. For instance, Herr R. Garbe, of the Prussian State Railways, and an energetic advocate of the Schmidt system, speaks of smoke-box superheaters as being little more than steam-driers, and supports this by taking as typical of the class a superheater which, he says, gives only 20 deg. to 30 deg. Fahr. superheat. Again, Mr. H. H. Vaughan, of the Canadian Pacific Railway, and joint inventor of the Vaughan-Horsey high-degree superheater, takes the limiting temperature as "40 deg. superheat, which is," he says, "I believe, the highest that has been claimed for the front-end superheater." Likewise Mr. F. J. Cole, of the American Locomotive Company, also the inventor of a high-degree superheater bearing his name, has committed himself to the assertion that "smoke-box superheaters operating under normal smoke-box temperatures produce only about 35 deg. to 40 deg. superheat." Destructive criticism based on such figures as these may be set aside as partaking somewhat, though possibly quite unintentionally, of bias, for though some smoke-box super-

* Engineering, vol. lv., page 418.

heaters may have given only these low degrees of superheat, it has been found quite feasible to design such an appliance to give temperatures, at the steam-chest, equivalent to superheat in the neighbourhood of 90 deg. Fahr., calculated on the temperature due to boiler pressure. Greater justice would therefore be done if a base figure were taken about twice as great as those with which critics have often been pleased to credit this system.

The remark of Mr. Coles, just quoted, incidentally raises a point on which a word or two is necessary. The term "smoke-box superheater," although now commonly applied to appliances utilising only the heat in the waste gases of an ordinary boiler, has been in the past and is still, to-day, in some connections, associated with apparatus placed in the smoke-box, with which special provision has been made to permit gases, at a higher temperature than the normal of the waste gas in a smoke-box, reaching the superheater. This has been arranged for either by means of a special large flue, or by curtailment of the length of the boiler flues. These heaters are neither waste-gas superheaters, nor high-degree independent superheaters. They constitute an inefficient attempt at compromise between the two, and have mostly been abandoned, for they possess disadvantages inherent to each class, without compensating benefits. The proper smoke-box heater is a true waste-gas superheater, which leaves the boiler-heating surface efficiency and, consequently, capacity unimpaired. With these, which will be termed hereafter "waste-gas superheaters," in order to avoid confusion, it is possible to obtain a degree of superheat of about 90 deg. Fahr.

It may be as well, before the subject is pursued further, to see whether, from facts recorded, the expectation of economy with such degrees of superheat, in locomotive work, is warranted. It has been already shown that in land and marine practice it would almost certainly follow, but, as has also been pointed out, in locomotive practice the position is not quite so clear. Though there is plenty of evidence on the point, it is in a somewhat chaotic state. This unfortunate indefiniteness was reflected in the discussion which took place last winter at the Institution of Mechanical Engineers on the occasion of the reading of Mr. G. Hughes's paper* entitled "Compounding and Superheating in Locomotives." On that occasion Mr. G. Churchward, of the Great Western Railway, said "he agreed entirely as to the general results of the percentage of saving" shown by superheating, which Mr. Hughes recorded as having been arrived at on the Lancashire and Yorkshire Railway. Now on the Lancashire and Yorkshire Railway the Schmidt apparatus then under discussion gave 270 deg. Fahr. superheat, while Mr. Churchward finds it worth while to employ superheating only to the extent of 100 deg. to 120 deg. Fahr. Bearing this in mind, it should also be noted that Herr R. Garbe, when arguing in favour of the Schmidt system, avers that "no perceptible saving is realised with less than 100 deg. superheat," implying that the process must be carried much higher before it proves advantageous; while again, in contradistinction to this attitude, it may be pointed out that the recent acquisition, by the syndicate now controlling most of the high-degree superheaters, of the apparatus in use on the Great Western Railway, suggests that, after all, there is some value in a moderate degree of superheat. Such confusion is greatly to be regretted. On the one hand, it is not to be expected that superheating to 100 deg. and to 270 deg. Fahr. will give similar results, when, as in this case, both systems are equivalent to the use of independently-fired heaters. On the other hand, Herr Garbe's statement can neither be reconciled with the position adopted by Mr. Churchward, nor yet with the recent action to which allusion has been made, in regard to the moderate degree superheater developed on the Great Western Railway by Mr. Churchward.

Incidentally it may be pointed out that the Great Western Railway possesses one of the very few locomotive-testing plants in the world, and is thus in a position to carry out careful studies on this subject. It, therefore, has at its command better means of arriving at definite conclusions than are at the command, we believe, of any German locomotive engineers. American experience on such plants tends to confirm Mr. Churchward's attitude, that moderate superheating gives appreciable, and not, as has been held, undiscernible results. The Carnegie Institute reports substantiate this, as do also numerous other reports laid at one time and another before the American Railway Master Mechanics' Association. Dr. Goss and Professor Benjamin have both reported in this sense to this body, which has, characteristically, evinced a keen interest in the movement for several years. This Association maintains a standing committee on superheating, and its proceedings contain, in the reports from this body, and in individual papers presented, with the discussions thereon, what is probably the best collection of practical data on the subject anywhere to be found. These records, covering as they do the early stages of development, are most instructive. It is difficult to summarise adequately all the information thus brought together, but it is only now a question of drawing a few broad inferences, and this may easily be done.

In the first place there are to be found many records of economy resulting with waste-gas heaters giving only 20 deg., 30 deg., and 70 deg. Fahr. superheat. There is no reason why the correctness of these records should be impugned; they emanate from sources just as reliable as do others relating to higher degrees of superheat. In the second place, it is noticeable that many systems report that they consider about 100 deg. Fahr. as the most desirable degree of superheat. This is given in the 1910 report by Mr. Churchward as the best degree, as also by the Atchison, Topeka, and Santa Fe Railroad, and the Boston and Maine Railroad; while going back a little further, records will be found of coal economy of 19 to 27 per cent. obtained with about 100 deg. Fahr. superheat on the Lake Shore and Michigan Southern Railway, and of 12 to 14 per cent. on the Boston and Maine, with an approximately similar degree. The results on these two latter systems were secured with the earlier Cole superheaters giving about 105 deg. to 110 deg. Fahr. superheat. At the 1906 Convention of the Association, Mr. Cole stated in a paper then read by him that with this superheat "a fuel saving of 17 to 19 per cent. was effected," while with regard to a later type of heater, giving 130 deg. Fahr. superheat, he said that "with this degree of temperature substantial economies in fuel and water have been obtained." Savings of 17 to 19 per cent. are, of course, very material. The fact that Mr. Cole is now advocating the higher temperatures, equivalent to 175 deg. to 250 deg. Fahr. superheat, does not, of course, in any way vitiate the accuracy of his earlier statement, and it will thus be seen that there is considerable weight of evidence in agreement with experience in land and marine practice as summarised above—namely, that economies with moderate superheat are appreciable, instead of "being imperceptible," as such authorities as Herr Garbe, in their enthusiasm for the higher degree, contend.

A third fact is brought out by an examination of the American Master Mechanics' Proceedings, principally in connection with the experience of superheating on the Canadian Pacific Railway. This company has tried several types of superheaters and a variety of degrees of superheat running to steam temperatures as high as 700 deg. Fahr. In 1906, before the New York Railway Club, Mr. H. H. Vaughan, Assistant to the Vice-President of the system, said that after experience with 160 deg. to 200 deg. Fahr. superheat they had the intention of trying higher degrees. More than four years subsequently, at the time of the Master Mechanics' Convention last year, however, the lower figures remained the standard, and Mr. Vaughan said they were then using 150 deg. to 200 deg. Fahr. superheat, adding that this was "what would be known in Europe as moderate superheat," where, in connection with the Schmidt system, it is well known, temperatures equivalent to 260 and 270 deg. Fahr. superheat are recommended. Recently Mr. Vaughan has offered in explanation of this difference the statement that this was due primarily to the fact that the superheater, which they found most practical, gave only this degree of superheat, and was not a consequence of real or supposed disadvantages of the higher degrees. This is not, of course, by any means a conclusive argument. The Vaughan-Horsey and the Schmidt types of superheaters are so similar in principle that it is not apparent why the Canadian Pacific Railway should not secure higher superheat if it thought desirable. It may be noted further that the Great Northern Railway (U.S.A.), and the Chicago, Rock Island, and Pacific Railway also both use 150 deg. to 200 deg. Fahr. superheat, and the difference thus apparent between Continental and American practice is interesting. The fact is that in American smoke-tube superheater practice it has not been the custom to carry the heater elements so far back towards the fire-box as is done in European practice. There are, however, indications of a change in this respect in America, and the latest (1911) report by Professor Benjamin on tests at Purdue on a Schmidt superheater locomotive has led Mr. Vaughan to make, for a second time, the announcement that on the Canadian Pacific Railway they intend trying rather higher degrees.

It may incidentally be remarked that Messrs. W. Schmidt, of Cassel, were recently given the opportunity of converting to the high-degree superheating system an engine on the Egyptian State Railways, and, having a free hand as regards design, installed a superheater giving about 200 deg. to 230 deg. Fahr. superheat. This last fact must clearly be indicative of one of two things: either that great uncertainty exists in the minds of the designers as to what degree of superheat an installation will, on the average, produce, or that the highest degrees are only advisable where care both in the handling of the engine on the road and in maintenance is assured. The skill and care of drivers and the excellence of maintenance is not, unfortunately, for many reasons, of a uniformly high degree throughout the world. It is unnecessary to dilate on this fact, of which the truth will be admitted by all conversant with the class of labour procurable in many countries abroad, or the traffic conditions obtaining in others. There is not any intention of laying stress here upon objections to which high-degree superheating may be open in this connection, though, without injustice, it may be pointed out that Mr. H. H. Vaughan has more than once directed attention to this need of efficient maintenance. Both before the Master Mechanics' Association in 1907, and before the American Society of Mechanical Engineers in 1907, Mr. Vaughan pointed out that a number of cases of deterioration of high-degree superheater elements had occurred, the metal losing all its nature, and being capable of being "broken in the hand." Mr. Grant Hall, superintendent of motive power, Lines West of Fort William, Canadian Pacific Railway, likewise referred, at the Master Mechanics' convention of 1908, to these failures, which are due to inefficient use and maintenance of an essential adjunct of the high-degree heater.

American practice, coupled with the fact that considerable reference will later be made to experience with an engine converted, under Dr. William Schmidt's direction, from one of the ordinary type to one giving 200 deg. to 230 deg. superheat, together with the desirability of keeping the discussion as broad as possible, and not limiting it merely to the practice of certain European countries, suggests that the figure of 220 deg. Fahr. superheat would not be an unreasonable one to take as satisfactory in connection with the high-degree superheating systems. While rather in excess of the degree till recently recommended by Mr. Vaughan, and used on the Canadian Pacific Railway, it comes within the ranges advocated by Mr. F. J. Cole and with the Schmidt system, and may therefore be considered to be fairly representative.

Before proceeding further it will be as well to point out that sight must not be lost of the fact that, in comparisons with ordinary engines using saturated steam, some knowledge is necessary of the wetness of the steam the latter class of engines consumes. The wetter the steam the more the argument will turn in favour of superheating; but since, if the discussion is to be of any real value, impartiality is necessary between the several systems, a brief discussion of known facts bearing on this point is, perhaps, permissible at this stage. For long it was the opinion—and the inference seemed justified—that a great deal of water passed over with the steam in locomotive engines.* Whatever may have occurred with the smaller boilers of some years ago, there appears now to be ground for thinking that the quality of the steam passing out of the boiler is not really so very wet. The trials on the St. Louis and the Purdue testing plants do not reveal the presence of a great amount of water, and Dr. Goss, commenting on the results at Purdue, concludes that, when the locomotive is

* See ENGINEERING, vol. lxxxix., pages 357, 396, and 431.

* See, for example, Proceedings of the Institution of Mechanical Engineers, 1896, discussion on "Value of the Steam-Jacket."

UNITED STATES DESTROYER "STERRETT" WITH CURTIS TURBINES.

BUILT BY THE FORE RIVER SHIPBUILDING COMPANY, QUINCY, MASSACHUSETTS, U.S.A.

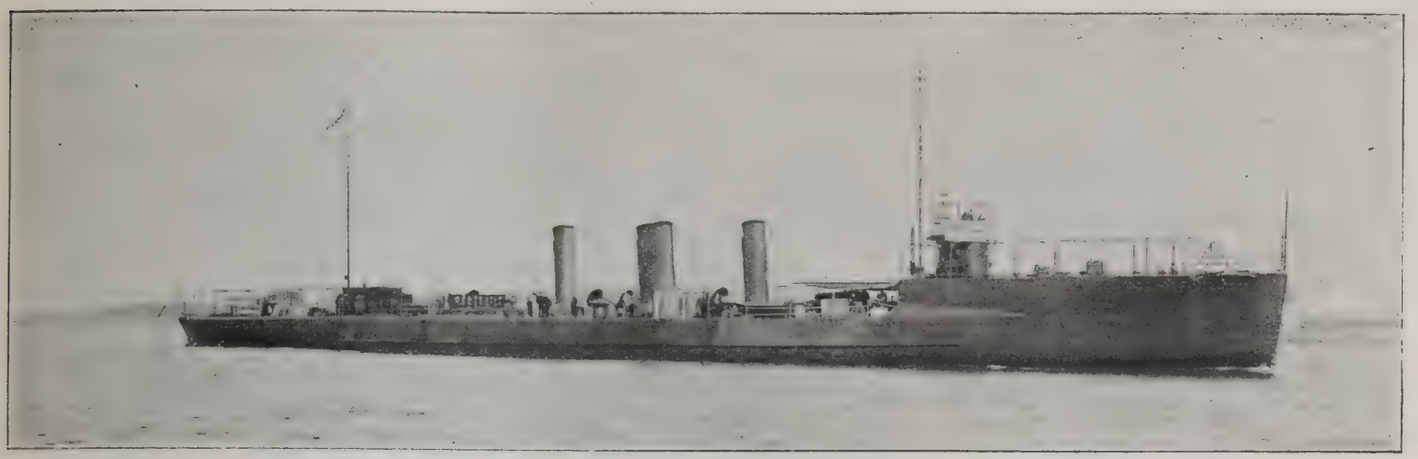


Fig. 1.

under steady load, conditions inside the boiler are quiet and water is not carried over, and that it is only when the regulator adjustment is suddenly altered to meet a greater load that the ebullition is of a sufficiently violent nature for much water to be passed over in the steam. Exceptional conditions naturally conducive to priming are, of course, now eliminated from consideration. It may be remarked that, while on a testing plant a fairly steady draw-bar pull is maintained, and the regulator may be in little need of constant adjustment, engines so tested are not, as a rule, quite so quiet as on the road, with the result that the steam bubbles would be quite as readily freed from the generating surface as in service, and this factor may be ignored, therefore, in connection with the St. Louis and Purdue figures.

The Purdue tests show a remarkable uniformity, and seldom reveal the presence of more than 1 per cent. of water. The St. Louis tests, over a wider range of conditions, showed water present to the extent of from 0.14 to 5.65 per cent., the great majority of the tests showing less than 2 per cent. The comparatively high wetness in a few tests was accounted for by priming due directly to the addition of chemicals to the water for the purpose of softening it, and these particular trials may therefore be more closely analogous to service working, in which more or less priming is often present from one cause or another, than others in which every care was taken to have the boiler and water conditions the best possible. Apparently it is on the strength of the St. Louis tests that Mr. Vaughan and Mr. Cole have assumed, in calculations, the presence of 2 per cent. or less water in ordinary saturated steam. Confirmatory of the St. Louis and Purdue tests may be cited the road trials made last year on the Atchison, Topeka, and Santa Fe Railroad, which showed in every case less than 2 per cent. of water present in the steam at the dome. Professor Hitchcock records about 2.3 per cent. moisture in road tests. M. G. Noltein, in a report to the International Railway Congress of 1910, stated that he had known instances of 2.7 per cent. of water present, but the percentage was more often in his experience below 2. The Union Pacific Railway also records 2.74 per cent. of water. General opinion seems to incline to higher figures, and with average conditions as regards water and washing out, &c., it is likely that rather more than these amounts is commonly present. On the other hand, the figure of 7 per cent., used in calculations by Herr Garbe, confessedly, by the way, an assumption, seems too high, and, if used as a basis, unduly favours superheating. One of the latest pronouncements on the subject emanates from Mr. G. Hughes, of the Lancashire and Yorkshire Railway, who has recorded the exceptional figure of 9 per cent. of water as present in the steam.* Such figures may be set aside as scarcely typical of normal working, but the amount of 5.5 per cent., sometimes selected, appears to be more fairly representative of average conditions. In view of all the evidence, it appears reasonable to suppose that the actual average amount is certainly not more than from 4 to 5 per cent., except in cases of dirty boilers or other unusually unfavourable conditions, and for the present purpose it will suffice to take the figure of, say, 4.5 per cent.

Four conclusions have thus been arrived at—viz. :—(1) That the amount of water present in saturated steam can be taken, as a rough average for the purposes of calculation, as about 4 5 per cent. ; (2) that a reasonably representative figure of high-degree superheating systems would be an average of 220 deg. Fahr. superheat ; (3) that waste-gas superheaters may be designed to give superheat equivalent to 90 deg. Fahr. or thereabouts, calculated on boiler pressure ; and (4) that appreciable economies result from superheat in the neighbourhood of 100 deg. Fahr. Based on these conclusions, it is proposed to trace as far as possible the effect of superheating on locomotive performance.

* Proceedings of the Institution of Mechanical Engineers, 1910, Part II., page 506.

CURTIS TURBINES FOR THE UNITED STATES DESTROYERS "STERRETT" AND "PERKINS."

Exceedingly satisfactory results have been obtained with the torpedo-boat destroyers Perkins and Sterrett, constructed for the United States Navy by the Fore River Shipbuilding Company, of Quincy, Massachusetts. The successful development of a turbine of any type has invariably made a heavy demand on the ability and enterprise of those responsible, and the Fore River Shipbuilding Company are to be congratulated on the exceptional resource and ingenuity they have shown in bringing the Curtis marine turbine to its present highly satisfactory position, as exemplified in the trial results of the Perkins and the Sterrett. Each of these boats is of 742 tons displacement, and is fitted with Curtis turbines driving twin screws, steam being supplied from four Yarrow-type boilers, oil fired, and designed for a working pressure of 275 lb. per sq. in., the total heating surface provided being 18,000 sq. ft. A view of the Sterrett is represented in Fig. 1, annexed. She measures 289 ft. between perpendiculars, and has a beam (moulded) of 26 ft. 4½ in., the mean draught being 8 ft. 4 in., and the displacement 743.5 tons. On the four hours' full-speed trial the Sterrett developed 12,789 horse-power at 631 revolutions per minute, and attained a speed of 30.37 knots, the water consumption, inclusive of auxiliaries, being 14.85 lb. per shaft horse-power. The Perkins was less forced, and had slightly different propellers, and she developed 11,668 shaft horse-power, attaining a speed of 29.76 knots, with a water consumption for all purposes of 14.49 lb. per shaft horse-power of the main engines. The evaporation was 10.42 lb. of water per lb. of oil consumed. The vacuum in the condenser averaged 27 in. in this case, and only 26.6 in. in the case of the Sterrett. With a higher vacuum the consumption would naturally be reduced, but with modern destroyers, having oil-fired boilers, the machinery at full power is now, in many cases, so forced that it is practically impossible to maintain a high vacuum on the full-speed trials. The Sterrett's propellers measured 6 ft. 6¾ in. in diameter by 75 61 in. mean pitch, having a projected area of 18.21 sq. ft. and a disc area of 33.82 sq. ft., the helicoidal area being 21.06 sq. ft. The uppermost tip of the blades was immersed 21.4 in. at load draught.

At 16.27 knots the turbines developed 1596 shaft horse-power, the revolutions being 298.25, and the consumption for all purposes 20.91 lb. per hour per shaft horse-power. In this trial the evaporation amounted to 11.81 lb. of water per lb. of oil. The total weight of the machinery of the Sterrett (exclusive of water) was 595,987 lb. Complete results for the Perkins are tabulated below.

Data from Official Trials.

Average speed, 12-hour runs (knots) ..	16.61	25.2	29.76
Number of nozzles open	2	7	12
Average revolutions per minute, both turbines	301.15	479.72	593.50
Average steam chest pressure (lb. abs.)	258	249	246
,, ,, quality	0.973	0.975	0 978
,, first stage pressure (lb. abs.)..	19.23	49.65	86.80
,, sixth stage pressure (lb. abs.)	2.69	7.65	
,, vacuum (in.*)	28.26	27.96	27.3
Horse-power, both turbines	1544	6456	11,668
Water rate per horse-power per hour for all purposes, closed exhaust ..	21.48	15.50	14.49

* Corrected to 30 in. barometer.

In these vessels both turbines are placed in the same engine-room, but the starboard is ahead of the port, this being necessary because of their considerable diameter and the limited distance permissible between the centres of the shafts, and other conditions of the design. In a new design now building the mean diameter of the blade path has been reduced to 63 in., the consequent reduction of blade speed being compensated for by increasing to 18 the number of stages. The smaller diameter makes it possible to fix the turbines side by side, thus reducing materially the length of the machinery-room as well as the total weight of the installation. In constructive details this new pattern is, however, substantially the same as in the case of the turbines we are about to describe.

As will be seen, the results obtained with these have been exceedingly good, and special interest attaches therefore to the details of machinery, which, thanks to the courtesy of the builders, we are able to illustrate very fully on Plate XXXVI. and on pages 216, 217, and 218.

Fig. 2, Plate XXXVI., represents a longitudinal section through the turbine, which, it will be seen, consists of 14 stages, velocity-compounded throughout, even in the case of the blading on the drum section of the rotor. The mean diameter of the turbine-blade path is, in this case, 72 in., and the length of the turbine between centres of bearings is 15 ft.

Both the ahead and astern turbines are in the one casing. The latter, which is of hard, close-grained iron, is built up of four pieces only, consisting of an upper and a lower half, each made in two parts, bolted together by circumferential flanges, as

indicated in Fig. 2. The heads are thus integral with the rest of the casing, and they are provided with lugs, to which are bolted the brackets carrying the main bearings. All the flanged joints are scraped to a fit. The turbine thus forms a unit free from risk of distortion in erection, and easily manufactured in correct alignment throughout. The whole of the interior of the casing is machined, thus ensuring the easy and accurate fixation of the various nozzle plates and stationary bucket segments. Feet, for bolting the casing to the foundation plates in the ship, are cast on the lower half of the casing, and the exhaust branch is at the top, as shown in Fig. 2. The main shaft is a high-grade-steel forging, bored from end to end, and is carried on two bearings. The forward end has thrust-collars turned on it, and the thrust-block is integral with the forward bearing, thus ensuring its correct alignment.

The ahead rotor comprises six wheels for the stages having partial admission, whilst the remaining eight stages are arranged on a drum as shown. The main steam-inlet is shown to the right in Fig. 2, and at the top in Fig. 3, and leads into a nozzle-box shown separately in Figs. 29, 30, and 31, annexed. This box has nineteen nozzles, of rectangular section, each of which, as shown in Fig. 29, is fitted with an independent shut-off valve. By closing several of the nozzles, the output of the turbine can be reduced without the loss which is involved when the power is controlled solely by throttling the steam. These nozzles, as best seen in Fig. 32, page 217, are all formed in a single bronze casting, which is bolted by machine-screws (secured from working loose by having the metal caulked into the slots) to a forged and machined steel plate, which fits on to machined seats in the nozzle-box, and forms the surface on which the shut-off valves slide, being scraped to a true surface on this face. These nozzles are cut out of the solid after casting; they are slightly divergent; the total throat area of the nineteen provided is 8.892 sq. in., and the area at discharge is 1.145 times as much. As will be seen, no portion of the nozzle is parallel, and there is reason for believing that the provision of such a parallel element, though usual in some patterns of turbines, is unnecessary, and possibly pernicious. The centre line of the nozzle makes an angle of 20 deg. with the plane of the wheel. As the shut-off valves may have to stand open for very long periods, provision is made for balancing them when open. To this end a groove, $\frac{1}{8}$ in. wide by $\frac{1}{16}$ in. deep, is cut in the valve-plate, as shown at *a*, Fig. 29, and the edge of the valve, when open, overrides this, permitting steam to enter below it, and ease it off its seat. In these nozzles the steam under full-power conditions is expanded from 246 lb. absolute down to 86.80. The theoretical velocity of issue is thus about 2080 ft. per second. These first-stage nozzles deliver the steam on to a velocity-compounded wheel, having four rows of moving buckets, the mean speed of which in the full-power trial was about 187 ft. per second.

Attention may be called to the method by which the brackets for the nozzle spindles are held in place. As indicated in Fig. 30, annexed, each is located truly by two steady-pins, and is then held in position by nuts and washers, each of which overlaps two adjoining brackets, there being a half-hole in the flange of each.

Details of the blading of this wheel are shown in Figs. 17, 18, and 23, Plate XXXVI. The bucket angle of the first row at entrance is, it will be seen, 28 deg., whilst at discharge it is 22 deg. From this it follows that the space between the buckets is narrower at discharge than at entrance, but this is in accord with the fact that the stream of fluid as it passes through the bucket tends to spread laterally, and consequently becomes thinner. It will further be observed that each successive bucket is longer than its predecessor. This is necessary, because in each bucket the fluid, besides thinning, as already mentioned, also loses velocity, and thus a greater steam-way is required at each successive set of buckets. As a consequence, the length of the last bucket is $2\frac{1}{2}$ times the width of the stream of steam as it first issues from the nozzle.

The blades, which are of extruded bronze, are all carried on foundation strips, which are illustrated separately in Figs. 10 and 11, Plate XXXVI., but the method of mounting will be best understood on reference to the reproductions from photographs of the blading, Figs. 27 and 28, annexed. The foundation-rings are strips of steel,

DETAILS OF CURTIS MARINE TURBINES.

THE FORE RIVER SHIPBUILDING COMPANY, QUINCY, MASS., U.S.A.

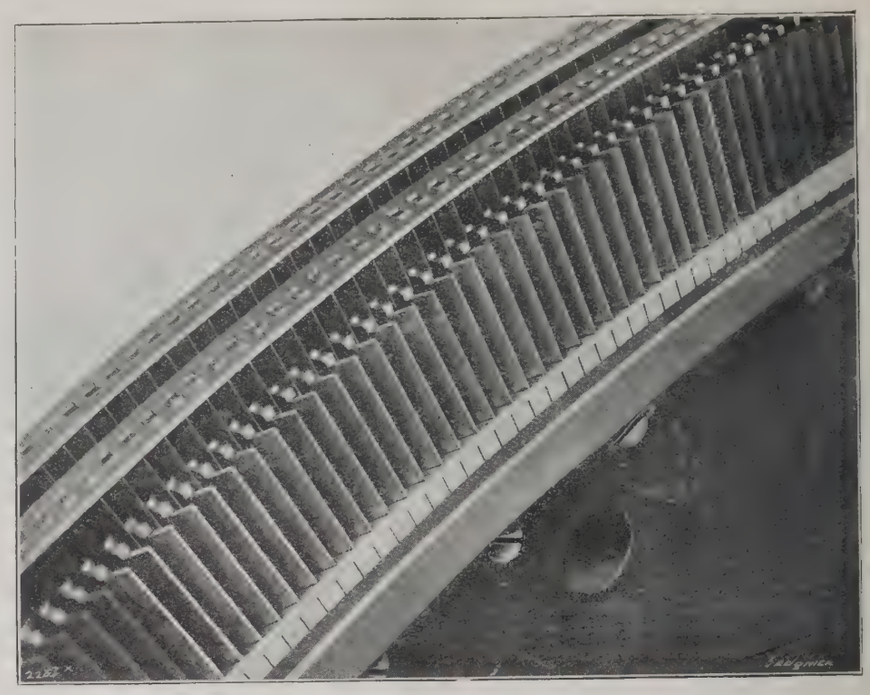


Fig. 27. Blading of Rotor.

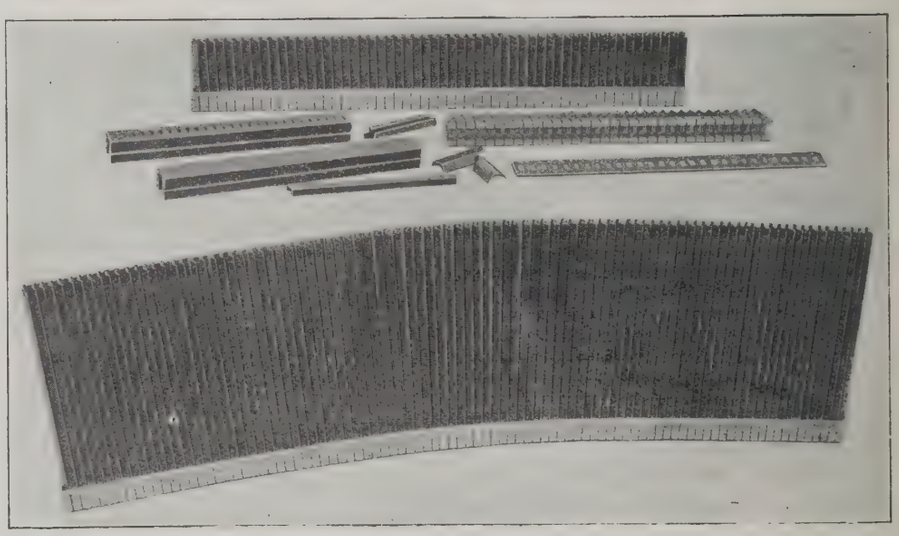
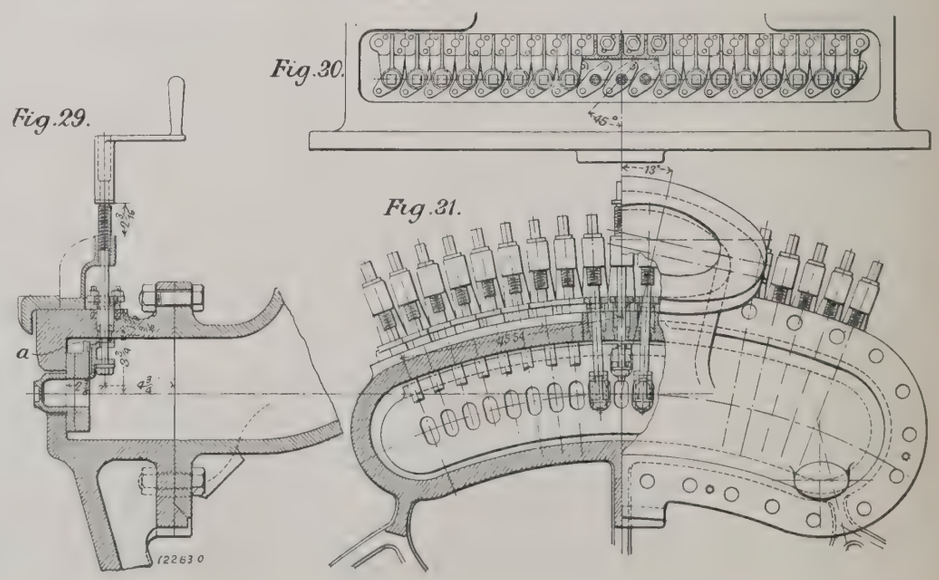


Fig. 28. Blades and Foundation Strips.



CURTIS TURBINES FOR THE UNITED STATES DESTROYERS "PERKINS" AND "STERRETT."

CONSTRUCTED BY THE FORE RIVER SHIPBUILDING COMPANY, QUINCY, MASS., U.S.A.

(*For Description, see Page* 215.)

Fig. 2.

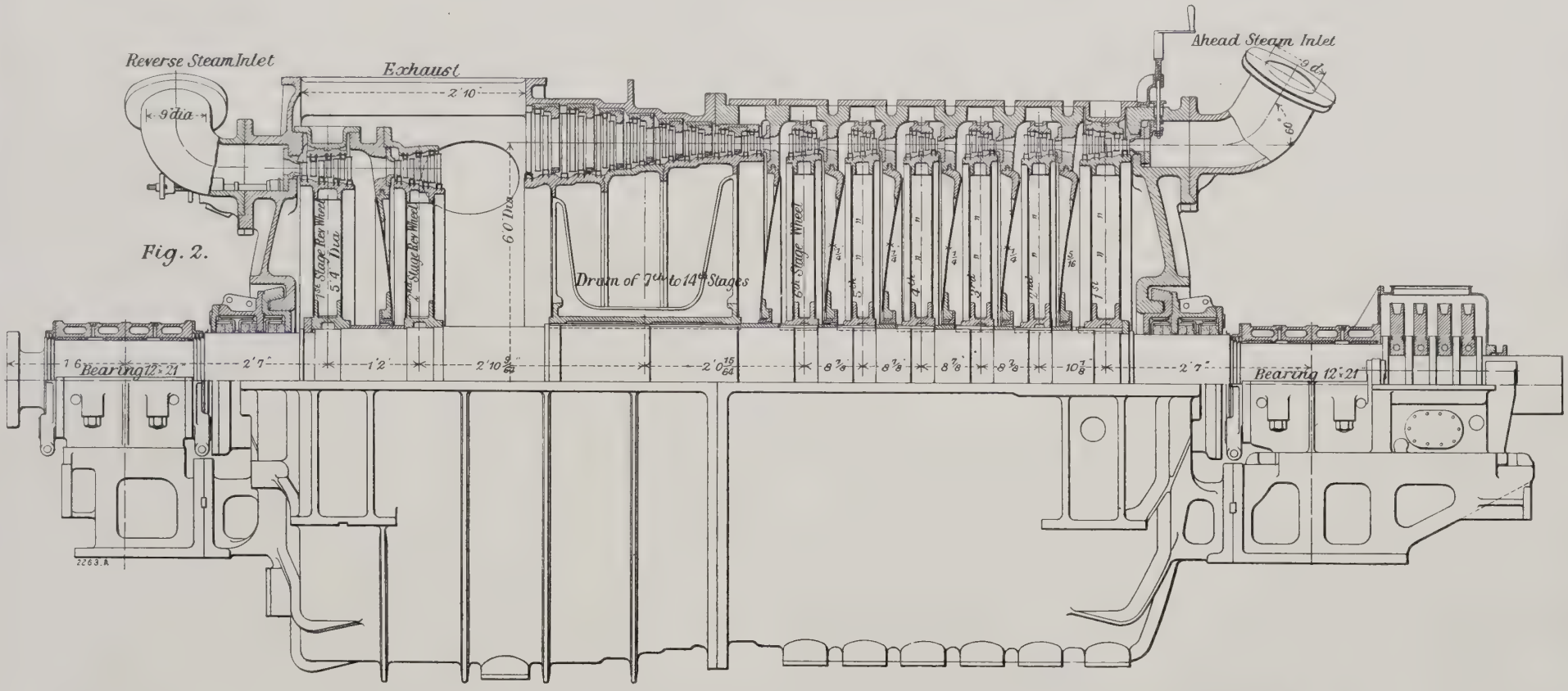


Fig. 3.

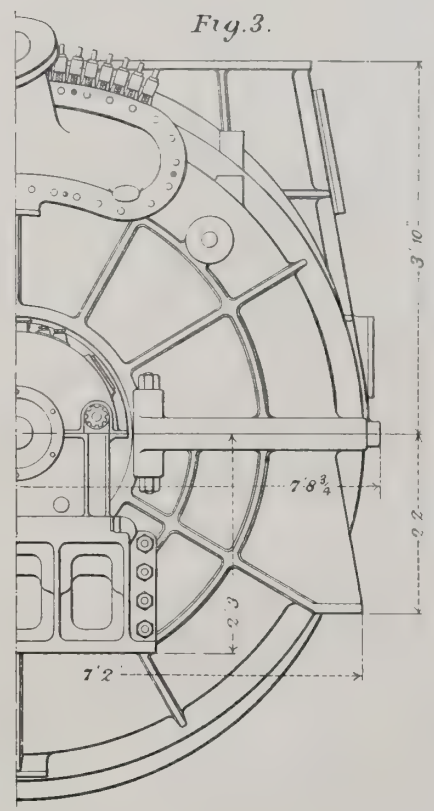


Fig. 4.

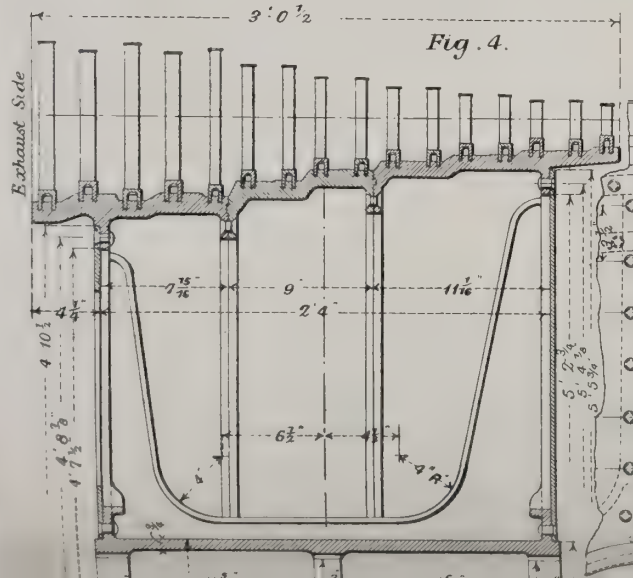


Fig. 5.

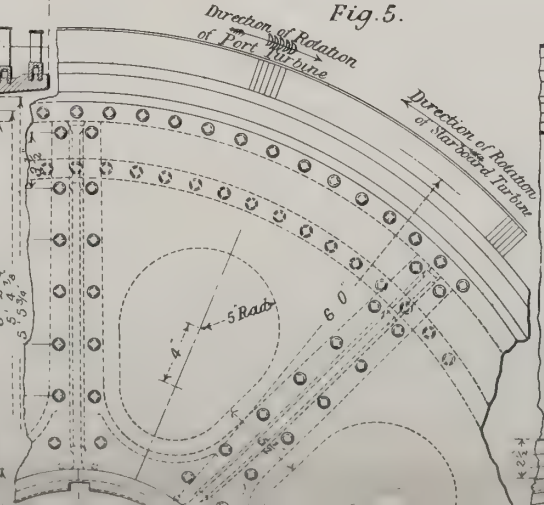


Fig. 6.

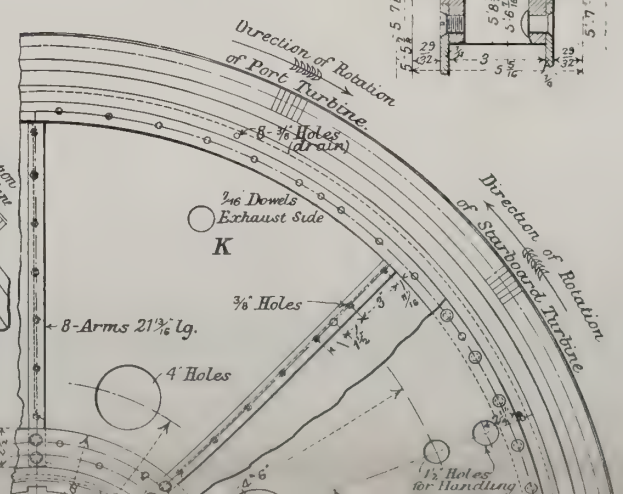


Fig. 9.

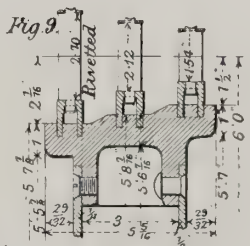


Fig. 7.

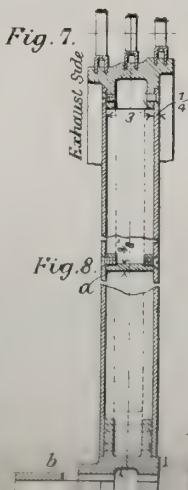


Fig. 8.

Fig. 10.

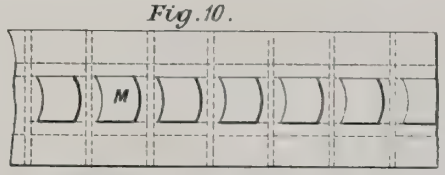


Fig. 11.

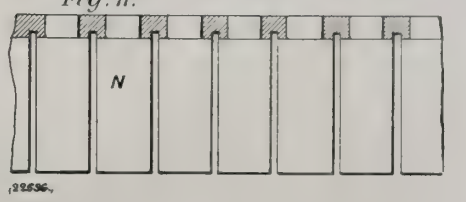


Fig. 12.

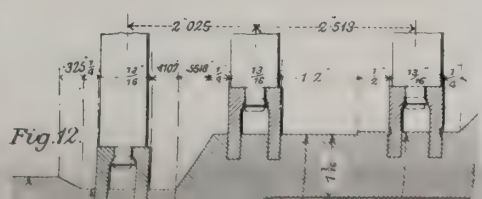
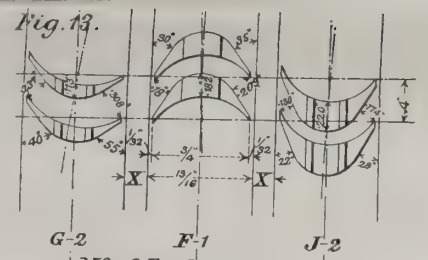
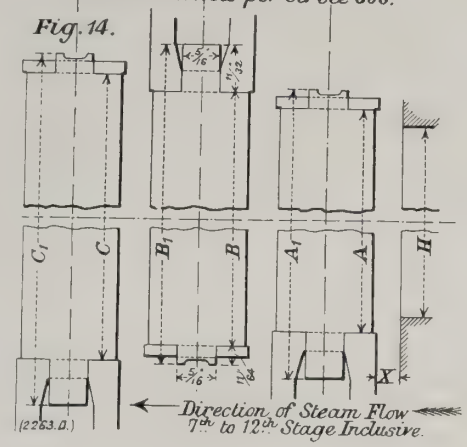


Fig. 13.



N° of Buckets per Circle 566.

Fig. 14.



Direction of Steam Flow
7th to 12th Stage Inclusive.

Fig. 15.

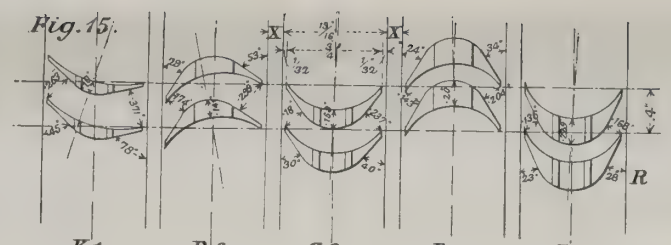
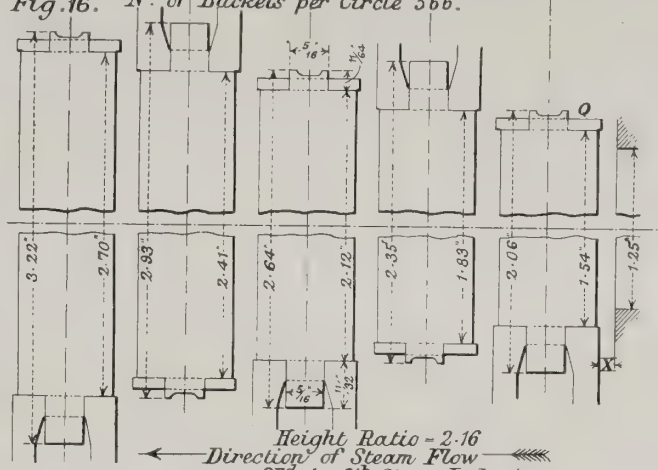


Fig. 16. N° of Buckets per Circle 566.



Height Ratio - 2·16
Direction of Steam Flow
2nd to 6th Stage Inclusive

Fig. 17.

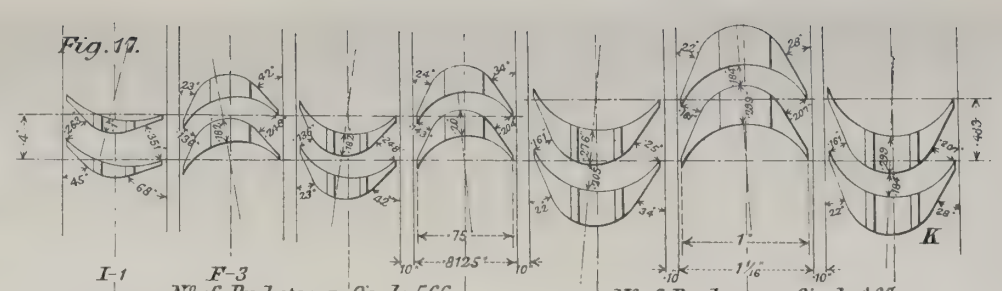
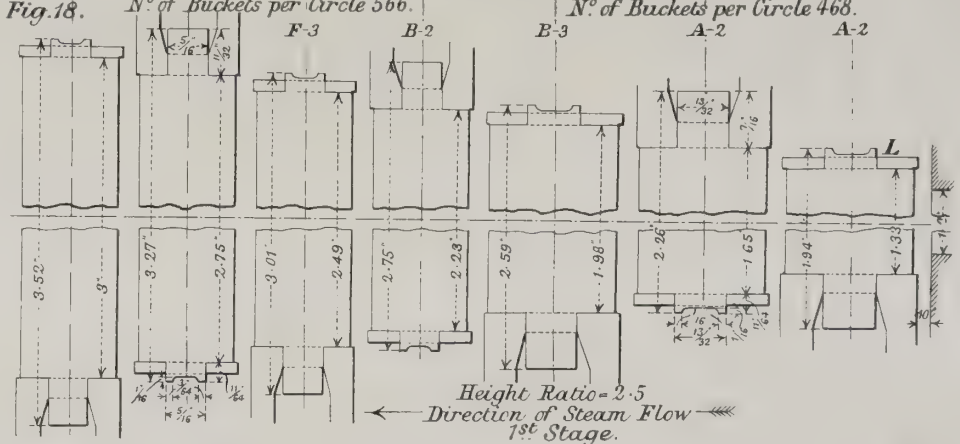
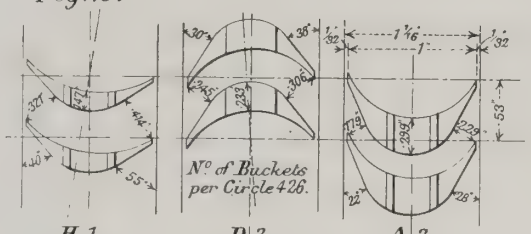


Fig. 18. N° of Buckets per Circle 566. N° of Buckets per Circle 468.



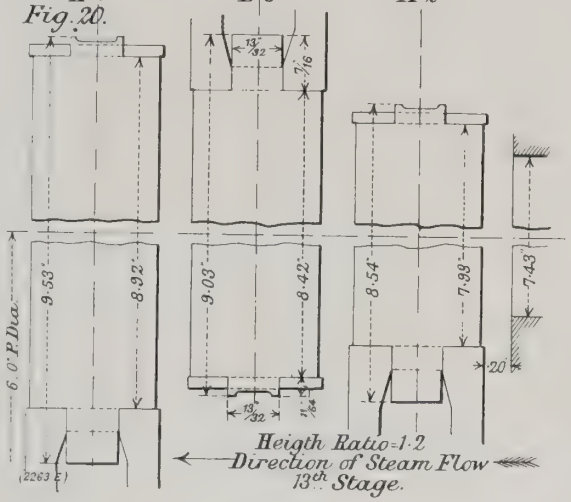
Height Ratio = 2·5
Direction of Steam Flow
1st Stage.

Fig. 19.



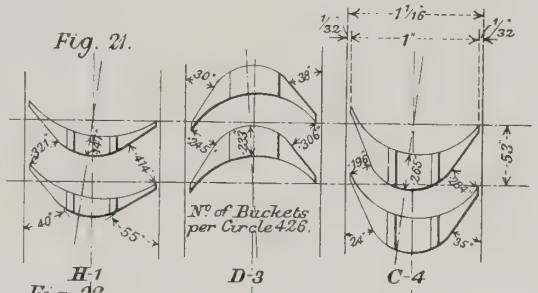
N° of Buckets per Circle 426.

Fig. 20.



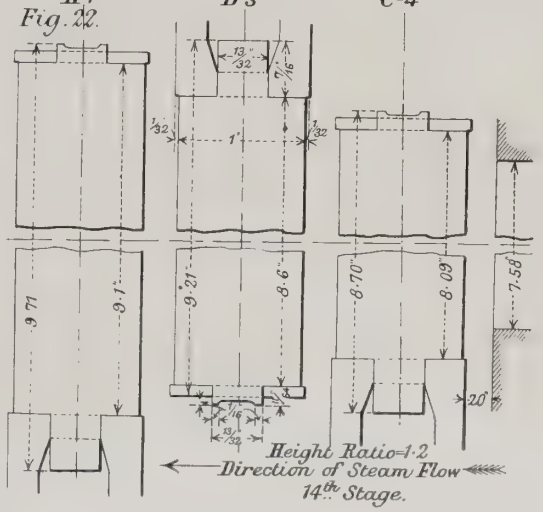
Height Ratio = 1·2
Direction of Steam Flow
13th Stage.

Fig. 21.



N° of Buckets per Circle 426.

Fig. 22.



Height Ratio = 1·2
Direction of Steam Flow
14th Stage.

Fig. 23. SECTION THROUGH RIM.

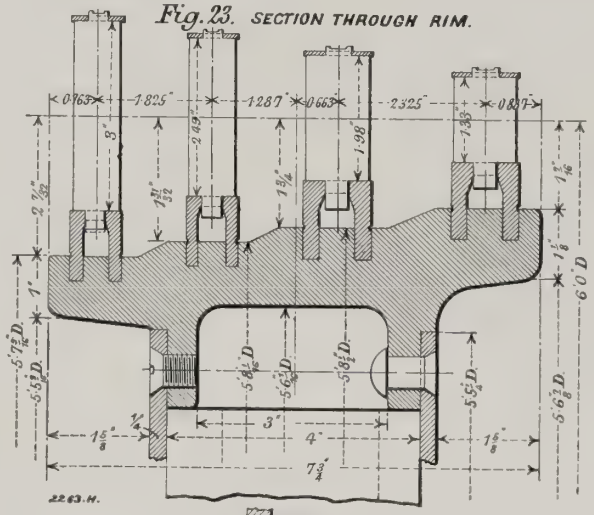


Fig. 24.

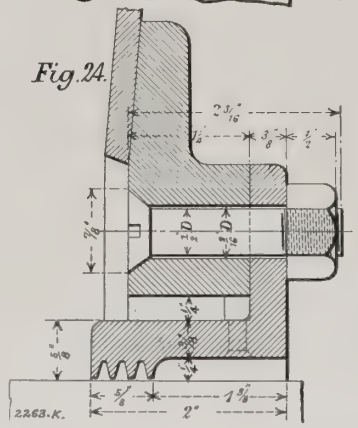


Fig. 25

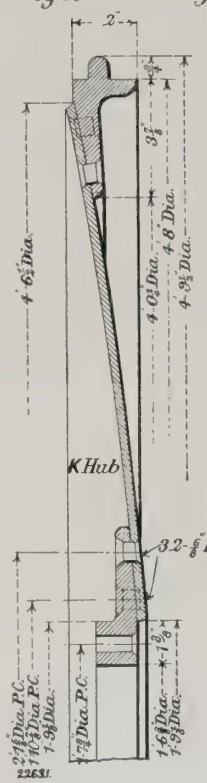
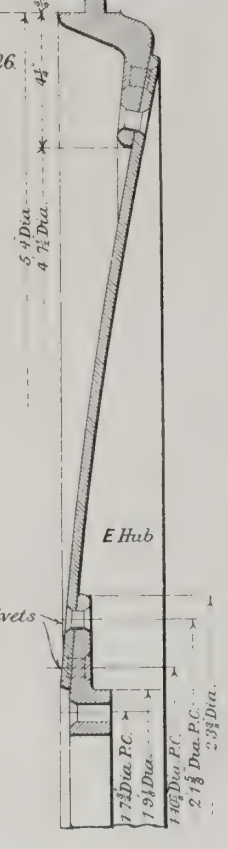


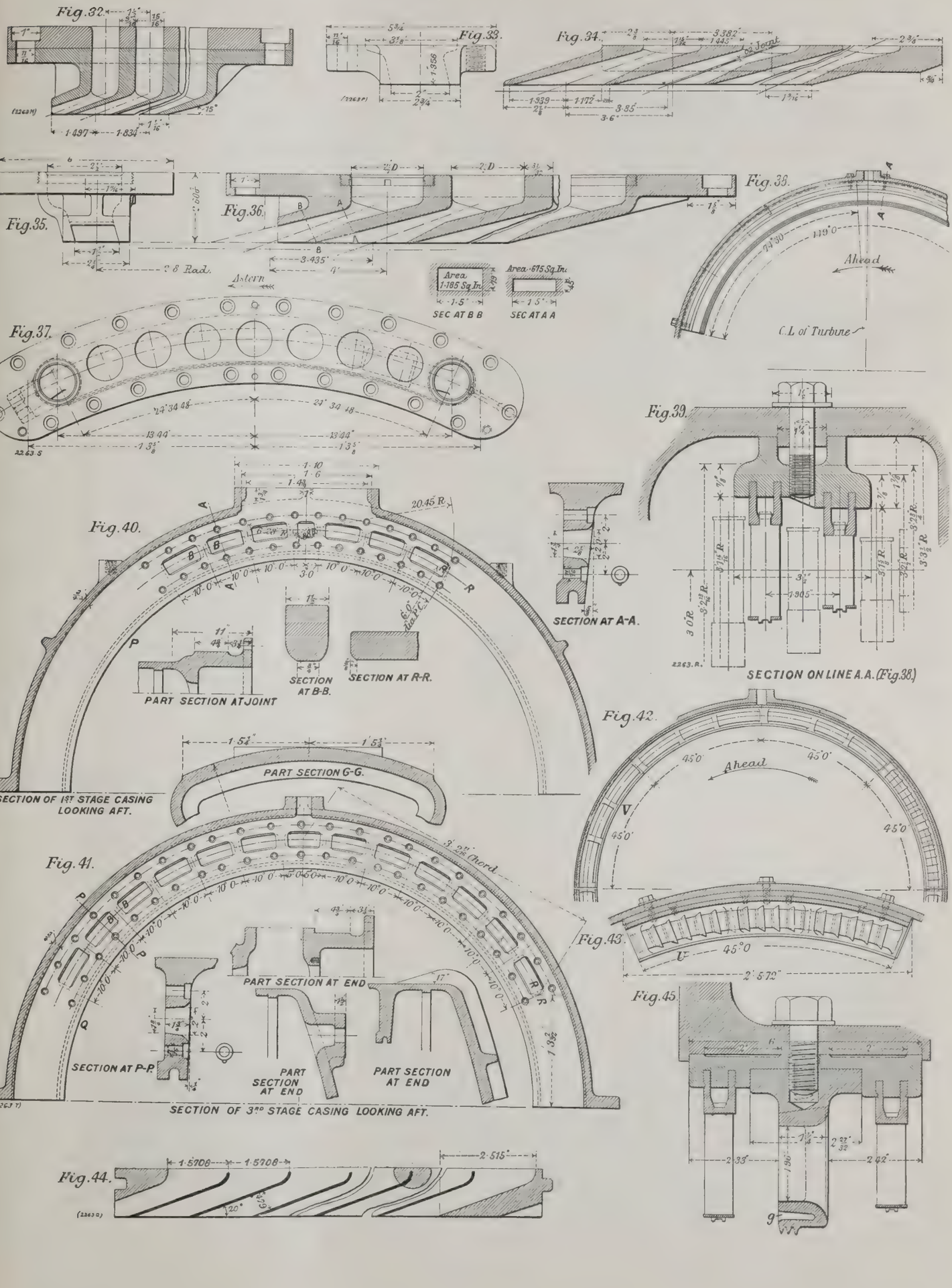
Fig 26



DETAILS OF CURTIS MARINE TURBINES.

THE FORE RIVER SHIPBUILDING COMPANY, QUINCY, MASS., U.S.A.

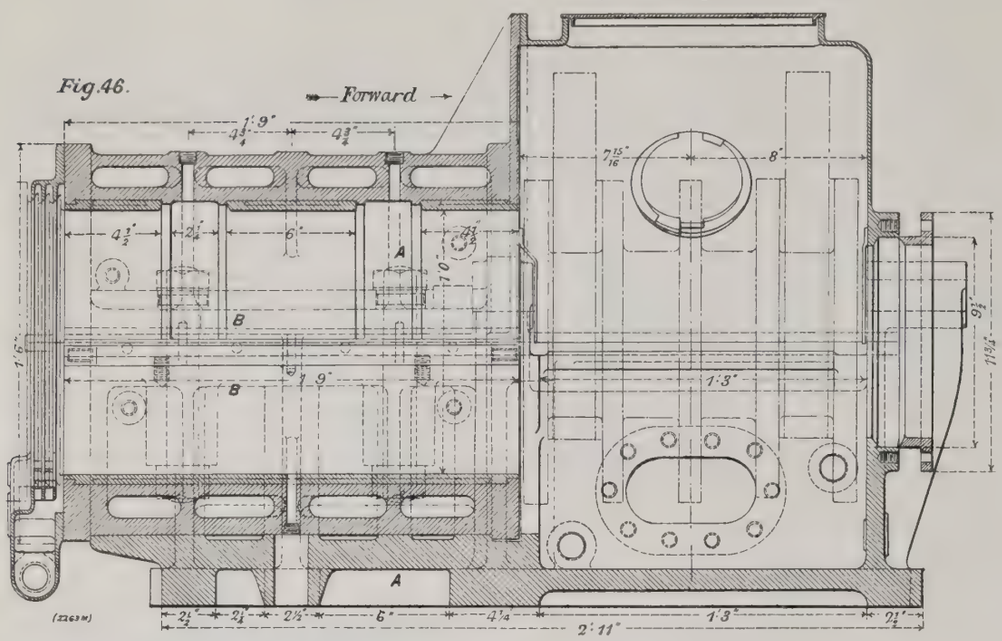
(*For Description, see Page* 215.)

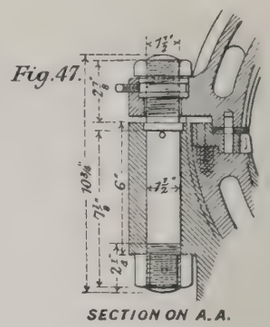


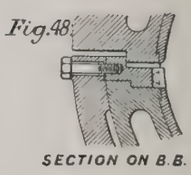
DETAILS OF CURTIS MARINE TURBINES.

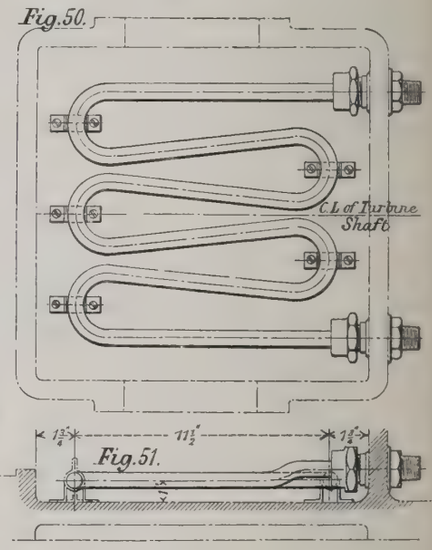
THE FORE RIVER SHIPBUILDING COMPANY, QUINCY, MASS., U.S.A.

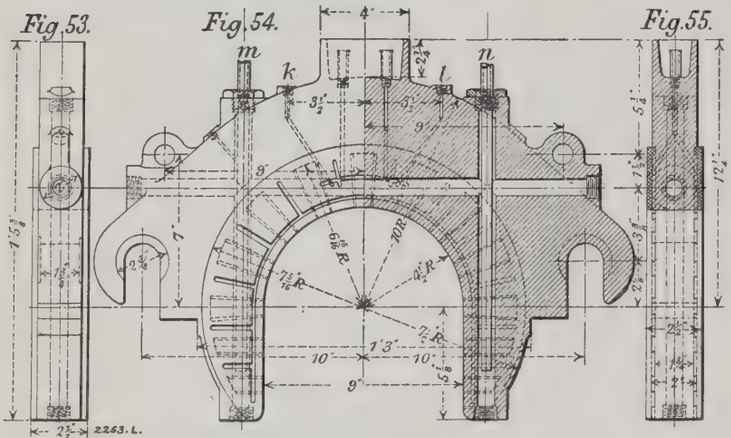
(For Description, see Page 215.)

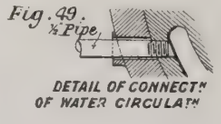


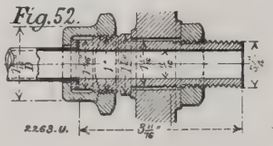


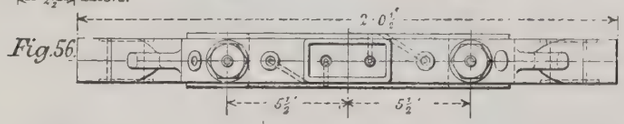


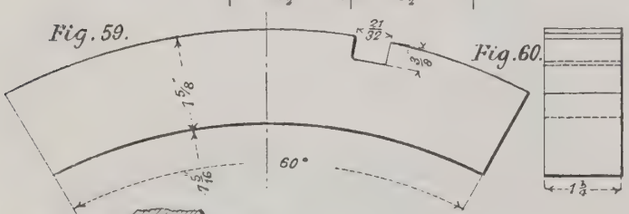


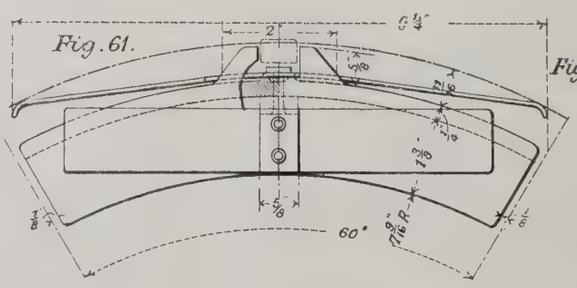


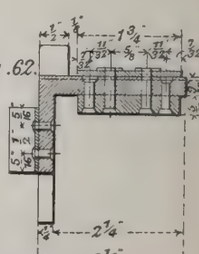


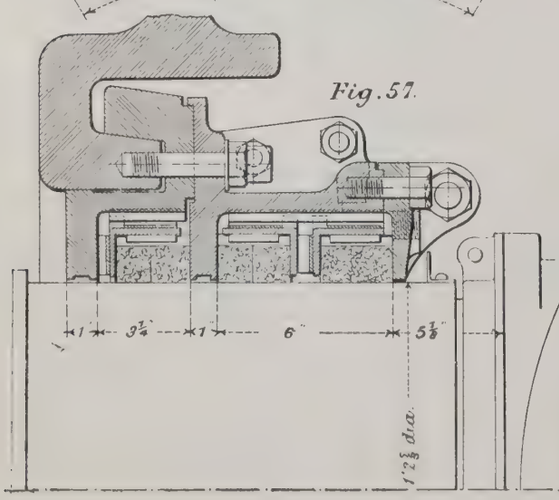


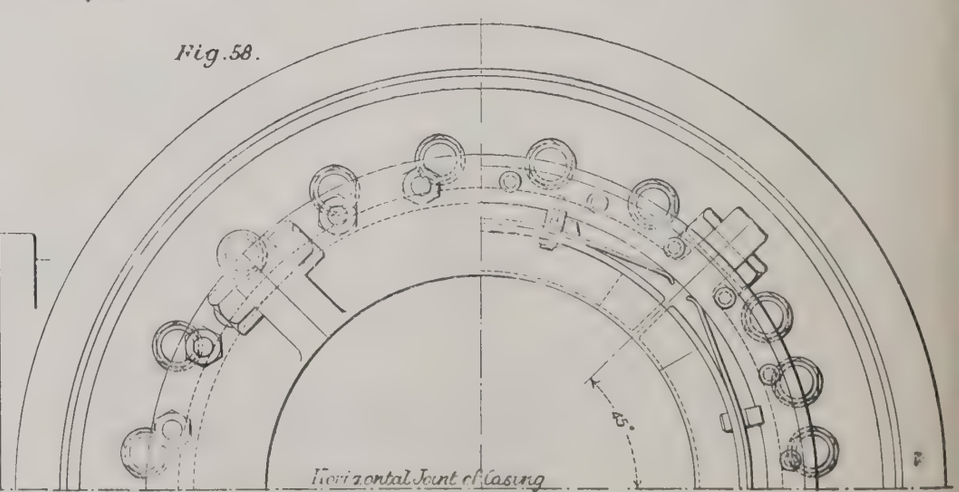












milled to a U-shape, and grooved along both sides, so that they can be secured in place on the wheel-rims by caulking the metal of the latter into these grooves. As received from the milling-machine, the foundation-rings are straight. They are punched, as shown in Fig. 10, Plate XXXVI., to receive the roots of the blades, which are secured by riveting. To enable the rings to be bent to the curve of the wheel, they are slotted, as best seen in Fig. 10, just referred to, and also in Figs. 27 and 28, page 216. The outer ends of the buckets are provided with shrouding, riveted on, as indicated in Fig. 23, Plate XXXVI. The ingenious method of assembling and mounting the blades lends itself to very rapid manufacture, since the construction of the blades and foundation strips can be proceeded with at the same time as the rotor and casing are being machined. The method of finally fixing in place is quick and simple, and experience has shown it to be reliable, the shrouded segments being very strong mechanically and very firmly held in place by the caulking.

The intermediate or stationary buckets, which are interposed between the different rows of moving buckets, so as to catch the steam discharged from the one row and direct it in a favourable direction on to the next, are also mounted on similar foundation-rings secured to steel holders, and are bolted into place. Doors for inspection purposes are provided to the rectangular openings immediately above these blade segments, and through them access can be obtained to the individual wheels, without the necessity of lifting the whole upper half of the casing. A diaphragm (see Figs. 25 and 26, Plate XXXVI.), built up of dished boiler-plating, in most cases $\frac{1}{4}$ in., but for the first stage $\frac{5}{16}$ in. thick, riveted to steel castings at the hub, and the periphery, divides off each wheel from its successor. At its circumference each of these diaphragms has a rib, which engages with a slot turned in the casing, and makes, when the pressure is on, a practically steam-tight joint. At the centre, where the shaft passes through the hub, the diaphragm is provided with a bushing of anti-friction metal, as shown to a larger scale in Fig. 24, Plate XXXVI. This bushing, it will be seen, is turned into a series of serrations, so that if a touch occurs between it and the shaft liner there is no sensible production of heat. The clearance, when hot, between this bush and the shaft liner, is 30 mils in the case of the first of these diaphragms, 40 mils for the second, 50 mils for the third, and 60 mils for the remainder. The diameter at the first diaphragm is $16\frac{5}{8}$ in. and increases in successive steps of $\frac{1}{8}$ in. each up to $17\frac{1}{4}$ in. at the last diaphragm. The bushings are held at four points only, and it will be seen that the part nearest the shaft is considerably overhung, thus giving that portion a little elasticity in case of the shaft whipping in consequence of a sudden change of load.

The nozzle openings for each stage after the first are formed by sections of nickel-steel plates fused into cast-iron ribs, as best seen in Fig. 44, page 217. These plates are bolted to ribs cast on the main turbine casing, as shown in Fig. 2. The bolts used in all these cases, it may be observed, are fillister-headed machine screws. These have proved amply sufficient, as the parts connected are subjected to a steady load only, and do not require to be held together with any extraordinary degree of pressure. The screws are prevented from unscrewing in service by simply caulking some of the surrounding metal into the slot.

Sections through the casing showing the ribs to which the nozzle-plates are screwed are represented in Figs. 40 and 41, page 217. As will be seen from the section taken at A A, the opening in the casting is bell-mouthed, so as to give the steam an easy access to the nozzles, and, as the pressure drop in all stages but the first is small, these nozzles are not divergent.

For stages 2, 3, 4, 5, and 6 the wheels carry three rows of moving buckets; their construction is shown in detail in Figs. 7, 8 and 9, Plate XXXVI. They are built up of $\frac{3}{8}$-in. boiler-plating, riveted to forged-steel rims and hubs. The latter are slotted to take a key $1\frac{1}{4}$ in. wide, and are turned to a diameter $\frac{1}{1000}$ in. less than their seats on the shaft, on to which they are forced by hydraulic pressure. Each hub has further drilled in it four $\frac{3}{4}$-in. holes to take bolts to pull off the wheel, if in any case it should be necessary. Each wheel is held in its axial position by distance-pieces, as best seen in Fig. 2, and the whole rotor is prevented from working forward by a lock-ring, which enters into a groove cut in the shaft, and is screwed to the hub of the first wheel.

These distance-pieces are checked from turning by the key, which extends beyond the wheel-hubs, and fits into a slot cut on the sleeve, as shown at *b*, Fig. 8. The distance-pieces are thick enough to mask the keys, so that the outer surface of the shaft is thus rendered quite smooth. The sides of the wheel are stiffened by eight arms or ribs riveted to the hub and slotted into a channel section with a view to reducing the weight, as indicated in the "bastard" cross-section at *a*, in Fig. 7. A view of the rim to a larger scale is represented in Fig. 9, Plate XXXVI., whilst details of the blading will be found in Figs. 15 and 16, on the same plate. The fixed intermediate rows of blades are secured as illustrated in Figs. 38 and 39, page 217.

All the "wheel" stages work with partial admission, though in the case of the lower pressure stages there are nozzles in the lower half of the casing as well as in the upper. In the case of the drum section of the turbine, however, the admission is complete. A view through the casing in this region is represented in Fig. 42, page 217, whilst Fig. 43, below, shows to an enlarged scale the method of securing in place each nozzle segment, of which eight complete the circle. These nozzle-blocks are bronze castings, and, as shown in Fig. 45, are in the first place secured by machine-screws to the forgings, on which the fixed blades are mounted, and each unit thus formed is then fixed to the casing by set-bolts.

The holder shown in Fig. 45 is that at the commencement of the drum section, and, as will be seen, it carries the fixed blades for both the seventh and the eighth stages. On reference to Fig. 2, on Plate XXXVI., it will be seen that for the succeeding stages each of these holders carries one set of fixed blades only.

Returning to the nozzle segments, these nozzles are formed by casting in division-plates, as shown in Fig. 44. Where the edge of the nozzle segment is in contiguity with the rotating drum, it is serrated, as best seen in Fig. 45. The deep slot formed at *g* is for the purpose of giving a little flexibility to the baffle in case of an accidental touch. On this drum section of the turbine there are, it will be seen, two rows of moving blades per stage. In previous drum constructions, as made by several European builders of marine turbines, this drum section has not been velocity-compounded at all, there being but one row of moving blades per stage.

The construction of the drum is well shown in Figs. 4 and 5, Plate XXXVI. It consists of an eight-armed steel casting plated at both ends. The rim which carries the blading is in three pieces, connected together by rivets passing through internal flanges, as best seen at Fig. 12, Plate XXXVI. This drum is secured to the cast-steel spider by the end-plates, which are of steel $\frac{1}{4}$ in. thick, riveted to the rim, the arms, and the hub, and at the after end this plating has large manholes through it, as indicated by the dotted lines in Fig. 5. The forward end of the drum being closed in, there is on this drum, when the turbine is at work, an end-thrust which balances that of the propeller, any residual thrust being taken by the block shown to the right in Fig. 2. Details of the drum-blading are illustrated in Figs. 13 and 14, 19 and 20, and 21 and 22, Plate XXXVI. Figs. 19 to 22 represent the blading for the thirteenth and fourteenth stages. These blades are, it will be seen, some 9 in. long, and are consequently made 1 in. wide instead of $\frac{3}{4}$ in., as in the case of the shorter blades represented in Figs. 13 and 14.

Details of the main bearings are represented in Figs. 46 and 48, page 218. This bearing has water-jacketed brasses lined with white metal. It is lubricated by oil pumped in through the two openings shown in the top half. This oil flows both ways through the bearing. That flowing aft is caught by an oil-thrower, and drained away through the opening shown at the left-hand bottom corner of Fig. 46, whilst the oil flowing forward passes into a reservoir into which dip the thrust-collars on the shaft, as indicated by the dotted lines.

Cooling-pipes (see Figs. 49, 50, and 51) are provided at the bottom of this reservoir. The surplus oil is drained off to an oil-cooler, and, after straining, is returned to the bearings. Details of the fixed thrust-collars are represented in Figs. 53 to 56, page 218. These are faced with white metal, thoroughly hammered into place. Oil for lubrication purposes is forced in through the openings at *k* and *l*, whilst cooling water is circulated through the interior of the collars by the pipes shown at *m* and *n*.

The glands at the end of the casing are packed with carbon, the construction of the gland being represented in Figs. 57 to 62. There are six carbon segments of the form shown in Figs. 59 and 60. These are pressed into contact with the shaft by plate springs, as best seen to the right of Fig. 58, being carried by metal-holders, to which the springs are riveted as indicated in Figs. 61 and 62. Plate springs are also used to put an axial thrust on the carbons and keep them in contact with their beds.

The reverse turbine is fitted at the after end of the casing, as indicated in Fig. 2. It consists of two stages only, each wheel carrying four rows of moving blades. The range of expansion in each stage is therefore large, and the nozzles, as shown in Figs. 33 and 34 and Figs. 35 to 37, have a considerable degree of divergence. Thus the throat section at A A (Fig. 36) is 0.675 sq. in., whilst at B B, the point of discharge, it is 1.35 sq. in. These nozzle-plates are bronze castings. The nozzle openings are rectangular, and are worked out of the solid. Independent shut-off valves are provided to the end nozzles in the case of stage 1, thus making it possible to adjust to some extent the total nozzle opening to the steam supply available.

In different navies the Curtis turbine is now installed, or being installed, to an aggregate of some hundreds of thousands of horse-power, and it is common knowledge that the principle of velocity compounding is also being adopted, partially at least, by builders of competing types of marine turbine. The total shaft horse-power of Curtis turbines built and building by the Fore River Shipbuilding Company for different navies is, we may add, 286,000.

BOOKS RECEIVED.

The London Citizen's Year-Book, 1911-12. *Revised to May*, 1911. *Containing Full Particulars of London's Local Authorities, Expenditure, List of Members and Officials, Elections, and Statistical and other Information on London Questions.* London: George Allen and Co., Limited. [Prices: paper, 6d. net; cloth, 1s. net.]

The Universal Directory of Railway Officials, 1911. Compiled from official sources, by S. Richardson Blundstone, Editor of the *Railway Engineer*. London: The Directory Publishing Company, Limited. [Prices: Subscription, 7s. 6d.; after publication, 10s.]

Hand-Book for Iron-Founders. London: Frodair Iron and Steel Company, Limited. [Price 2s.]

Everybody's Pocket-Code; Adapted to the Needs of all Private Individuals who may Require to Telegraph or Cable. Providing no less than 400 Million Phrases. By W. M. Saunders. London: William Clowes and Sons, Limited. [Price 2s. 6d. net.]

The Holidays; Where to Stay and What to See, 1911. London: Walter Hill. [Price 1s., or post free 1s. 6d.]

Whittaker's Arithmetic of Electrical Engineering for Technical Students and Engineers Second Edition, revised. London and New York: Whittaker and Co. [Price 1s. net.]

How to Manage a Suction-Gas Producer. By W. A. Tookey. London: Percival Marshall and Co. [Price 1s. net.]

Transactions of the Association of Water Engineers. Vol. XV., 1910. With subject index, Vols. I. to XV. and name index, Vol. XV. Edited by Percy Griffith, M. Inst. C.E., F.G.S., Secretary. London: St. Bride's Press, Limited. New York: D. Van Nostrand and Co.

Elektrizität aus Kehricht. Von Etienne de Fodor. K. Ung. Hofrat Generaldirektor der Budapester Allgemeinen Elektrizitäts-Gesellschaft. Budapest: Julius Benkö.

Theoretisches Lehrbuch des Lokomotivbaues. Die Lokomotivkraft, die Bewegung, Fuhrung, Ausprobierung, und das Entwerfen der Locomotiven. By F. Leitzmann und V. Borries. Berlin: Julius Springer. [Prices: paper, 34 marks; cloth, 36 marks.]

The Journal of the Institute of Metals. Vol. V. Edited by G. Shaw Scott, M.Sc., Secretary. London: Published by the Institute.

Railway Operating Statistics. By C. P. Mossop. London: *The Railway Gazette*. [Price 2s. 6d. net.]

Train Rule Examinations Made Easy. By G. E. Collingwood. New York: The Norman W. Henley Publishing Company. [Price 1.25 dols.]

The British Trade Book: A Survey of the Home Production and Industries of the United Kingdom, &c., and Showing the Course of British and International Commerce, with the Bearing of these Investigations upon Some Economic Questions. By John Holt Schooling (Fourth issue). London: John Murray. [Price 10s. 6d. net.]

Cost Accounts in Principle and Practice. By A. Clifford Ridgway, A.C.A. London: Sir Isaac Pitman and Sons, Limited. [Price 3s. 6d. net.]

German Coal Imports.—The imports of coal into Germany in the first half of this year were 5,245,772 tons, as compared with 5,080,680 tons in the first half of 1910. British coal was imported into Germany in the first half of this year to the extent of 4,531,117 tons, as compared with 4,314,139 tons.

TWO-STAGE COLLIERY AIR-COMPRESSOR.

CONSTRUCTED BY MESSRS. ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.

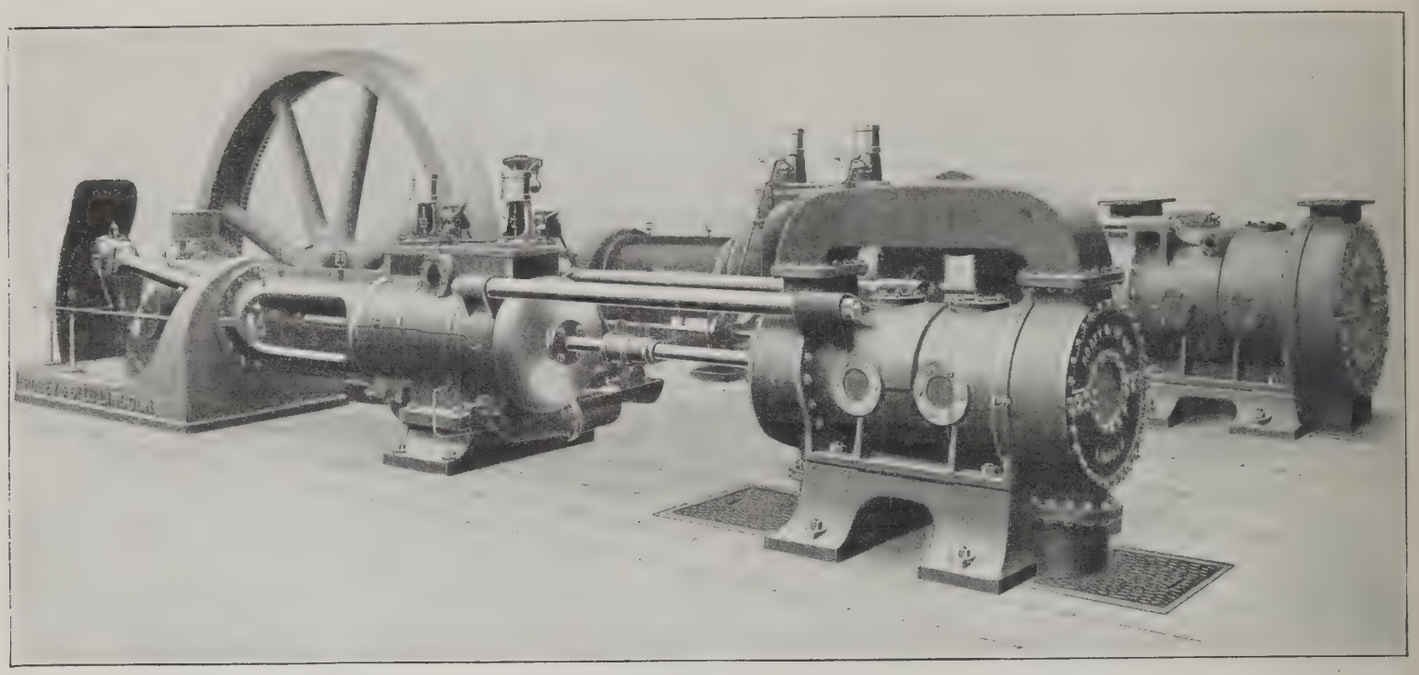


Fig. 1.

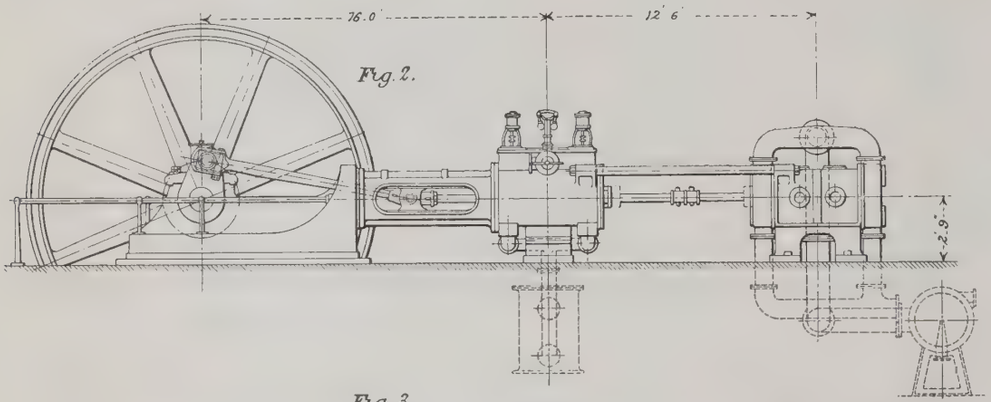


Fig. 2.

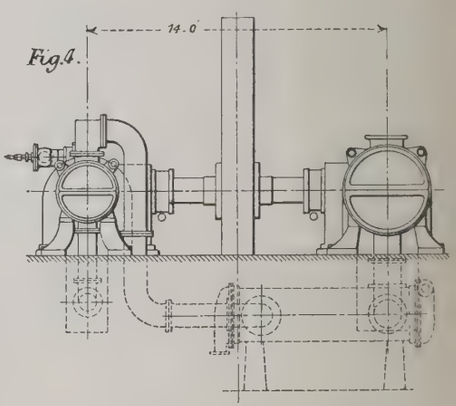


Fig. 4.

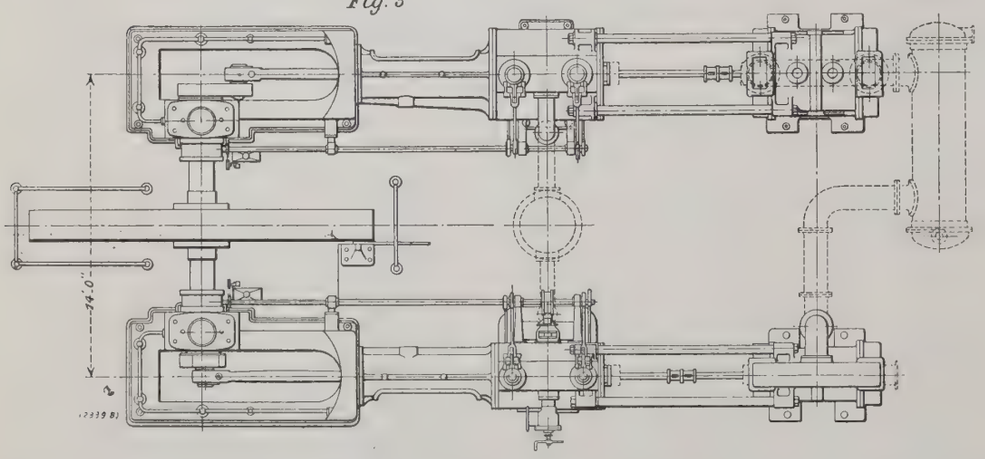


Fig. 3.

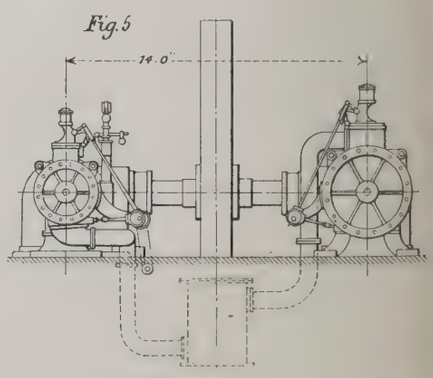


Fig. 5.

Recent accidents in collieries where electrical methods of power transmission have been installed have led to a renewed demand for air-driven machinery, for the supply of which powerful compressors are needed. On the present and opposite pages we illustrate a compressor built for this service by Messrs. Robey and Co., Limited, of the Globe Works, Lincoln. The general arrangement of the compressor in question is well shown by Figs. 1 to 5. It consists, it will be seen, essentially of a compound cross-connected steam-engine having air-cylinders arranged tandem fashion behind the steam-cylinders. The engine is designed to work with steam at 160 lb. gauge pressure, and 150 deg. superheat. The high-pressure cylinder is 19 in. in diameter by 42-in. stroke, while the diameter of the low-pressure cylinder is 35 in. As shown in Fig. 6, page 221, the admission valves are of the "drop" type, and are fitted with an automatic cut-off gear, under the control of the governor. The latter, however, merely regulates the position of a cam operating the gear, and is thus free from all positive work. The exhaust-valves, which are of the gridiron type, are below the cylinders, and are operated by eccentrics on the side shaft. The air-cylinders are arranged to complete the compression in two stages, the air from the low-pressure cylinder being passed through an air-cooler placed below the floor level, as indicated by the dotted lines in Figs. 2 and 3, annexed, before it enters the high-pressure cylinder. The latter has a diameter of 21 in. Both air-cylinders are thoroughly water-jacketed. The engine, as will be seen in Fig. 1, above, is fitted with a centrifugal governor; but provision is also made by which the supply of steam is automatically adjusted to the pressure of the air in the receiver. The valves for the air-cylinders are shown separately in Figs. 7 and 8, page 221.

As will be seen, the inlet and outlet-valves, with their seats, are complete in themselves, and are secured in the cylinder by means of the three lugs shown. The time required for examining the valves is thus reduced to a minimum, because by a special arrangement of seating the joint can be made any

DETAILS OF DROP-VALVE STEAM-ENGINE AND AIR-COMPRESSOR

CONSTRUCTED BY MESSRS. ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.

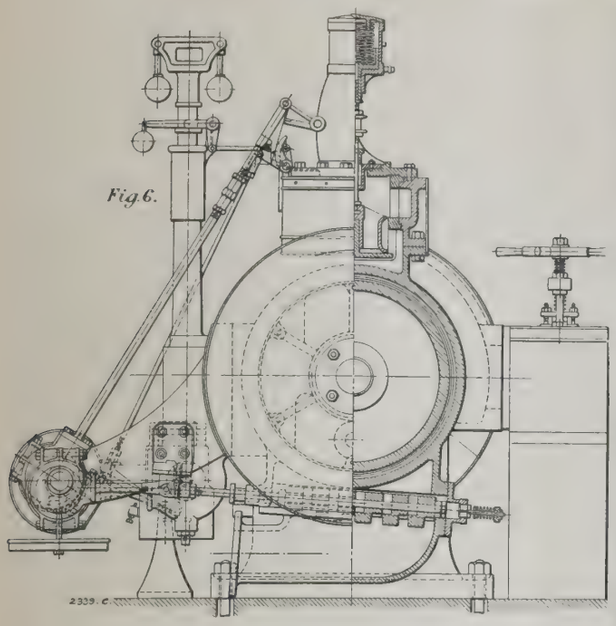


Fig. 6.

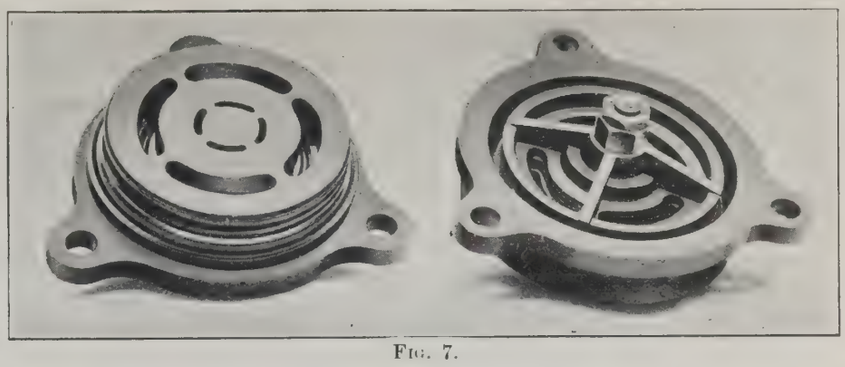


Fig. 7.

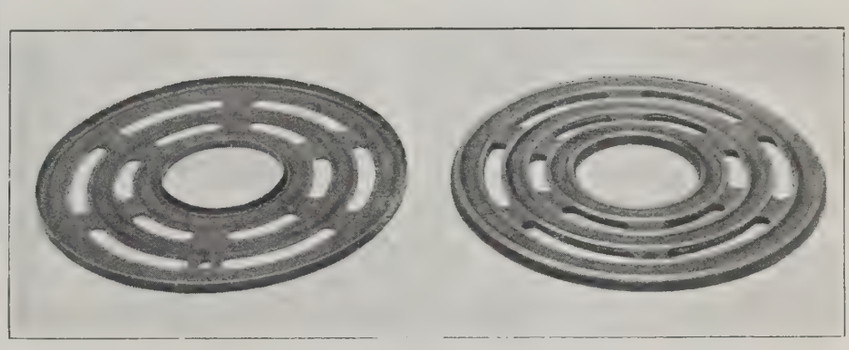


Fig. 8.

number of times without renewal, the contact being metallic. The left-hand illustration represents the inlet-valve, which is, as far as the valve is concerned, interchangeable with the delivery-valve, shown in the right-hand illustration, the only difference between the two valves being in the casing. It will be seen that the valves are multiple-ported, and require therefore only a very small lift, and they are accordingly absolutely silent in action and subject to practically no wear.

As shown in Fig. 8, the valves themselves are corrugated in form, and they are made from a special quality of mild steel, being accordingly not only extremely strong, but very elastic. The valves are held in position by means of coiled springs of square section, the springs fitting into the flanges on the outside and inside edges of the valve (as shown in the left-hand illustration in Fig. 7), and being held also at the other end by the guide-plate. By this arrangement the valve is held firmly in position on the valve-seat, but is free to move in all directions towards the guide-plate, thus rendering lubrication unnecessary. It will be seen that by this method all guide-studs or other supports which are liable to wear are dispensed with, the valves being quite free to seat themselves accurately and noiselessly at every stroke.

The advantages of a valve which has no moving parts in frictional contact, and so requiring no lubrication, are quite obvious, and as the springs used are extremely light, and are only required to support the valve and hold it against its seat, their life is practically unlimited. Valves have been carefully examined after a year's service, and absolutely no signs of any wear have been discovered, the condition being as perfect as the day the valves started work.

CURRENT RAILWAY CONSTRUCTION.

Among the more important works in hand in connection with home railway extension and development, we may state that the great Immingham Dock, promoted by the Great Central Railway Company, is expected to be ready for the shipment of coal by the end of September, the filling of the dock with water being now in progress. Hydraulic and electric power plants are almost completed ; seven coal-hoists on the south quay are also nearly ready for trial-runs, and transit-sheds and granary and other buildings are being proceeded with. As regards other works which the Great Central Railway Company has in hand, we may add that a commencement has been made with the construction of a deviation line at Keadby, in connection with a new bridge which is to be constructed over the Trent. By an arrangement with the local authorities it is proposed that this bridge shall also have a carriage-road. A junction with the Lancashire and Yorkshire system at Ashton-under-Lyne is approaching completion, and it is expected that it will be ready for traffic by the end of October. An electric line has been completed between Grimsby and Immingham, and the running of tram-cars will be shortly commenced.

The Great Eastern Railway Company is assisting the construction of a light line between Elsenham and Thaxted, but has no other works in progress.

Many of the new works contemplated by the Great Northern Railway Company remain in abeyance. In connection with sundry alterations at Finsbury Park Station, contracts have been entered into for a new down platform and a concrete viaduct over the milk-yard. A start has been made with these works. An additional track is being laid on the up-side of the main line between Corby and Essenden. A contract is in hand for the construction of a light line, eight miles in length, between Bawtry and Haxey.

The Great Western Railway, as usual, is pursuing an energetic development policy. The construction of Swansea district lines continues to make progress, and a contract is about to be let for works between these lines and the Rhondda and Swansea Bay Railway. Increasing traffic in South Wales has rendered it necessary for the company to provide additional loop lines and refuge sidings at various points on the main line, and more particularly in the neighbourhood of Port Talbot and Briton Ferry. As a necessary preliminary for the enlargement of the Newport station, a locomotive dépôt is to be removed to Maesglas. At Birmingham, the Snow Hill Station is being reconstructed and enlarged, and a goods dépôt is being provided at Moor-street Station. Additional accommodation is being provided at Paddington, and the accommodation at Newton Abbot and St. David's Station, Exeter, is also being improved.

The Lancashire and Yorkshire Railway has constructed new fish and coaling stages in ferro-concrete at Fleetwood, and additional sidings have been provided. Additional siding accommodation has also been provided at Fazakerley Junction, and bridges are in hand over Aintree-lane and the Alt. With a view to providing additional siding accommodation for coal traffic at Bankhall, a contract has been let for widening a bridge over the Leeds and Liverpool canal, and a site for the proposed sidings is being cleared. A contract has been let for a carriage-repairing shop, offices, &c., at Meols Cop, Southport.

In the course of the past half-year the London, Brighton, and South Coast Railway Company expended 120,664*l.* in equipping suburban lines for electrical working. Additional repairing-shops and sidings were proceeded with during the half-year at Peckham Rye and Norwood Junction. Some expenditure was also incurred in widening the Bognor branch on the Sutton and Cheam section. A service of electrical trains between Victoria and the Crystal Palace has worked satisfactorily.

The principal work which the London and North-Western Railway Company has at present in hand is a new relief line between Euston and Watford. The greater part of the section between Kensal Green tunnel and Harrow (about 6½ miles) has been completed, and progress is being made with the laying of the permanent way. Contracts have been let for new passenger stations at Harlesden, Stonebridge, Wembley, North Wembley, and Kenton, and the works have been commenced. A goods yard at Kenton has been opened for traffic. At Harrow new booking-office buildings on the up-side have been brought into use. Upon the section between Harrow, Bushey, and Watford (High-street), a distance of 5 miles, more than half the excavation has been removed, and two out of eighteen bridges are finished ; eleven other bridges are in course of construction, and the arches are being turned for a viaduct over the Colne, near Bushey. Nearly the whole of the earthwork involved in the widening of the Rickmansworth branch has been completed; bridges and retaining-walls have reached an advanced stage, and works at High-Street Station, Watford, have been proceeded with. Platforms, roofing, and waiting-rooms have been nearly finished at Watford Junction. Upon the Croxley Green branch, 1½ miles in length, the earthworks are well advanced and bridges have been built. A new loop-line, 3½ miles long, will be shortly commenced at Coventry ; the loop will form a connecting link between the London and Birmingham section and the Nuneaton branch. Additional lines and improved accommodation at Lichfield (Trent Valley) have been brought into use. The widening of the Trent Valley section between Armitage and Rugeley, a distance of 5¾ miles, is also in hand. Works for a branch to Holywell Town (1½ miles) are being proceeded with.

The London and South-Western Railway Company has doubled its lines between St. Denys, Southampton, and Fareham, and good progress has also been made in widening the railway between Studland-Road (Hammersmith) and Turnham Green. The re-building of the Waterloo Station has now reached the old main line, and a portion of the main-line traffic has been transferred to the new South Station. The construction of the 16-acre open dock at Southampton is now so far advanced that the dock was recently used by the new White Star liner Olympic, before she left Southampton on her first voyage to New York. The enlargement of the Trafalgar dry dock to accommodate the Olympic and her sister-ship the Titanic is also well in hand.

The Midland Railway has a deviation in hand at Lancaster, and good progress has been made with a viaduct over the Lune. The whole of the steel work of the viaduct has been commenced, and it is hoped that the deviation will be brought into use before the end of the autumn. It may be noted that during the past half-year the Midland Railway made special allocations out of revenue to the extent of 120,000*l.* for bridge reconstruction, improved signalling equipment, and carriage renewals.

The North-Eastern Railway Company is widen-

ing its line between Northallerton and Darlington, and it is re-modelling its goods-marshalling yard at Newport. New dock-gates at the entrance to the Hartlepools are almost completed, and as soon as they are ready for traffic it is proposed to undertake the reconstruction of the north entrance. New coal-staithes are being constructed at West Dunston, and appliances are being provided for bunkering coal at Middlesbrough. The river embankments of a new joint dock at Hull have been completed, and part of the quay space and storage ground has been ballasted.

The managing-committee of the South-Eastern and London, Chatham, and Dover Railway Companies is proceeding with a new harbour station at Dover, and a contract for the foundations has been let to Messrs. S. Pearson and Son, Limited.

INDUSTRIAL NOTES.

On Monday last active preparations were being made throughout the country for a great railway strike, and the activity affected both the masters and men. It was stated that Saturday would be the day on which the strike would actually commence, but nothing certain was known. Should this much-talked-of general railway strike actually occur, it would mean an unprecedented disorganisation to the industrial life of the country. If the men strike, it will be in defiance of the terms of the 1907 settlement, but they say that these terms have not been kept by the employers. However this may be, the masters held a meeting in London on Monday last, at which the general managers of all the leading railway companies in England attended. From what transpired then it seems that the companies intend to stand firm, and adhere to the terms of the 1907 settlement, to resist all demands of the men already out on strike, and to dismiss immediately any employee guilty of insubordination. The companies state that they will make no further concessions, and that the men must return to work and submit their grievances to the conciliation boards.

Matters came rapidly to a head, and on Wednesday it was announced that a general railway strike would begin on Thursday morning if the companies did not comply with the men's terms. Important meetings held at the Board of Trade on Wednesday brought no peace—only a postponement of the strike for 24 hours. The Government are making military preparations for the protection of the railways in case the strike occurs. At the time of going to press it is quite impossible to say what is going to happen ; but the companies appear to be confident that they will be quite able to carry on, at any rate, a somewhat curtailed service, as the Government have guaranteed protection for the men at work. The general situation is discussed in our leading article on page 229, and negotiations at the Board of Trade are proceeding as we go to press.

The Bristol railway men employed in the goods department of the Great Western Railway Company resolved on Sunday last to strike for higher pay and revision of hours and the abolition of the bonus system. They number, including carmen, about 600, employed at Bristol, Avonmouth, and Portishead. It will be remembered that they ceased work about three weeks ago, but were then induced by their officials to resume work pending negotiations. Since then these negotiations have been going on with the management. They appear, however, to have come to nothing. The employees of the Engineers' Department of the Great Eastern Railway Company at Grimsby have also put forward a demand for an all-round increase of 4s. per week, stating that they will go out on strike if their demands are not at once attended to.

It was with a feeling of relief that the general public learned last Saturday morning that the strike, which had for more than a week cast a dark shadow over London, was declared to be at an end, for on the previous day matters had begun to look very serious indeed, and it appeared from the general aspect of things that the aid of the military might be found necessary in order to quell disorder. Happily, however, such an alternative was avoided by an agreement between the masters and men, arrived at on Friday under the able guidance of Mr. Askwith. It was not before midnight, however, that the final decision was made known. The text of the agreement between the Association of Master Lightermen and Bargeowners and the Amalgamated Society of Watermen, Lightermen, and Watchmen of the River Thames is as follows ;—(1) Lightermen.—The day's work shall be any ten consecutive hours, commencing at 6 a.m., 7 a.m., or 8 a.m. The day's pay to be 6s.; overtime before 8 p.m. from 4 p.m. to 5 p.m., and 5 p.m. to 6 p.m. to be paid at the rate of 9d. per hour, and from 6 p.m. to 7 p.m. and 7 p.m. to 8 p.m. at the rate of 1s. per hour. Where overtime is incurred it shall follow consecutively from the day's work. Sunday pay for finishing a night's job, 6 to 10 a.m., 4s. Starting a fresh job on Sunday, 6 to 10 a.m., 6s. Full Sunday, 8s. Commencing work after 12 noon, 6s. (2) Apprentices : The hours of apprentices will in future be any consecutive ten hours per day, commencing at 6 a.m., 7 a.m., or 8 a.m. Overtime for apprentices in their 3rd, 4th, and 5th years to be 4d. per hour for the 11th and 12th hours, and for those in their 6th and 7th years 6d. per hour for the 11th and 12th hours. A night to begin after 12 hours' work, or at 8 p.m., if that time is reached before the 12 hours are completed. (3) Watchmen : The pay to be 5s. per ten hours' day from 7 a.m. to 5 p.m. Overtime to be paid at the rate of 6d. per hour up to 7 p.m. (4) Foremen and tug hands (including any member of the crew) to do only one job a night in the lighters. (5) Meal times : Reasonable time to be allowed for meals, but when working in dock or alongside ship or wharf the meal times to be the same as at the dock, ship, or wharf.

There were also some other general conditions as to the resumption of work, &c. The main points of the agreement seem to show that the men have secured a ten-hour day instead of twelve hours. For the two hours thus gained they will have overtime at the rate of 9d. per hour, the old overtime of 1s. per hour for the hours between 6 p.m. and 8 p.m. being unaltered at present, but are to come into force at once at the end of a day beginning at 8 p.m. The alteration means, it is estimated, an improvement of about 25 per cent. or more in the wages of the workpeople and a ten-hour day.

The satisfaction felt on Saturday did not, however, last long, for early this week it was found that the settlement was not universal. The majority of men concerned, of course, returned to work, but on Monday as many as 10,000 dockers remained out, and there is still widespread discontent. It was said among the men that unless their grievances are remedied the strike would be renewed. What their grievances are is not very clear. It is estimated that at the beginning of this week there were about 30,000 men and women still idle in London. It appears that there was dissatisfaction that the 1s. an hour applies only to overseas shipping, and the employment of non-union men is also a grievance.

Although London appeared at the end of last week to have at length found peace, such was not the case with Liverpool, and at the time when the former city was returning to normal conditions the latter was in the throes of very serious rioting, in which great numbers of people were injured, and a great deal of property was destroyed. Last Saturday and Sunday saw St. George's-square, opposite the Lime-street Hotel, in a state of turmoil and excitement that was only prevented from assuming far worse proportions than it did by the presence of large bodies of military and police. The shipping situation causes much apprehension, for all sense of discipline seems to have been lost by the men. They have disregarded the advice of their leaders, and the concessions they recently gained from the shipowners only seem to have made them think that they will get what they like from the employers with a little more pressure. The employers have, however, resented this, and at the end of last week they threatened to lock out the dockers on the following Monday unless the men would abide by the terms of agreement made for them. On Sunday matters grew worse, and much rioting occurred. It seems to have begun at a meeting attended by about 100,000 men, and the disorder necessitated several baton charges being made by the police. In the end the soldiers were called out, and the Riot Act was read. On Sunday evening, after large bodies of soldiers had been drafted into Lime-street, and after renewed efforts of the police, order was at length restored, and all the main streets in the heart of the city were held by the officers of the law.

On Monday, however, matters grew worse and a complete stoppage of the entire train service in and out of Liverpool seemed imminent, in addition to which it looked as though the tramway men would also join the malcontents. The threatened lock-out by the employers also came into force, which meant that the docks were closed and about 30,000 men thrown out of work. As a reply to this the men advocated a general strike, which, it is estimated, would bring out about 75,000 men.

Rioting was renewed on Tuesday, and two men were killed while taking part in an attack on a prison-van guarded by men of the 18th Hussars. The most turbulent element appears to be the Irish, but this is generally the case in Liverpool. At the time of going to press matters do not appear to have improved.

A circular letter on the subject of intimidation during trade disputes was sent by the Home Secretary to the chief constables of police forces in England and Wales. It calls the attention of the police to the intimidation and molestation of men who are willing to work, as defined in Section 7 of the Conspiracy and Protection of Property Act, 1875, and in sections of the Trade Disputes Act, 1906. It is stated that there is an idea abroad that since the passing of Section 2 of the Trades Disputes Act, which gave the right of peaceful picketing, police interference is prevented. This, however, the circular letter denies, and maintains that the enactment in question gives no protection to intimidation or to threats of violence, and that the duty of the police in dealing with these offences has not been in any way affected. It cannot, however, be said that the Trade Disputes Act has had any discouraging effect on acts of violence in connection with strikes, but rather the reverse.

On Saturday last the Glasgow municipal tramway service was completely disorganised owing to a strike of motor-men and conductors. The stoppage appears to have been very sudden, and to have taken the authorities by surprise. Within a few hours of the stoppage many cars had been wrecked or badly damaged, and about twenty men were arrested by the police on charges of intimidation and disorder. It was stated on Saturday night that there were about 2000 motormen and conductors on strike, leaving 700 either idle or on duty. In the evening the management stopped the running of all cars, which were taken into the sheds. They commenced running again, however, on Sunday, but were at once attacked.

There was more disorder on Monday, although the disturbances did not reach the pitch they did on the previous day. A large show of force had a salutary effect. A service of 300 cars was maintained during the day in the principal streets. The strike collapsed on Tuesday, and there was a procession of men to the Corporation offices with applications to resume work. It is said that the strike has cost the Corporation nearly 8000*l.*

At last it seems as though the strike of the Cambrian Coal Trust miners is near its end, after having been the cause of much misery and loss during the last nine or ten months. This conclusion was arrived at as the result of a meeting of the executive council of the South Wales Miners' Federation at Cardiff on Monday last, and on the previous Saturday. There were a number of irreconcilables at the meeting, who wished to make the strike general, as the only means of obtaining what they wanted, but they were overwhelmed by a large majority in favour of a return to work, for, it was said, a continuation of the struggle could only prove futile. The men will therefore probably return to work as soon as the pits can be got into working order. It is now open to the strikers to accept one of two settlements that have been offered to them during the last twelve months. They originally contended for 2s. 6d. per ton, but under the first agreement arrived at in October last the employers offered a cutting price of 2s. 1.3d. per ton. By the second agreement, determined on May 13 last, the same cutting price was offered, with the assurance that the average wages of the men should be maintained at the standard prevailing before the strike, that there should be no victimisation, and that points disputed in the future should be submitted to a joint committee of workmen and employers throughout the South Wales coalfield. The men will not again be given the option of refusing these terms. The strike has cost a great deal of money, and it is stated that during the first three months of its duration it cost the South Wales' Miners' Federation nearly 100,000*l.*

According to the *Board of Trade Labour Gazette*, the following was the state of the labour market in July :—

Employment in July was good on the whole, and much about the same as in June. None of the principal trades showed any marked change. The engineering and shipbuilding trades were adversely affected in some districts by the disputes in the transport trades ; and the printing and clothing trades improved and declined, respectively, owing to seasonal causes. As compared with a year ago, nearly all the principal industries showed an improvement. There was, however, a noticeable decline at blast-furnaces and in the linen, jute, and lace trades.

In the 394 trade unions, with a net membership of 769,043 making returns, 22,116 (or 2.9 per cent.) were returned as unemployed at the end of July, 1911, compared with 3.0 per cent. at the end of June, 1911, and 3.8 per cent. at the end of July, 1910.

Returns from firms employing 445,247 workpeople in the week ended July 22, 1911, showed an increase of 0.9 per cent. in the amount of wages paid compared with a month ago, and of 5.4 per cent. compared with a year ago.

The changes in the rates of wages, taking effect in July, affected 106,400 workpeople, who received a net increase of 2085*l.* per week. The principal increases affected nearly 49,000 coal-miners in Northumberland, 6000 building trade operatives in the Nottingham and Glasgow districts, 12,000 engineers in the Huddersfield, Blackburn, and Birmingham districts, and 5000 iron and steel-workers in South Wales and Monmouthshire. Amongst those whose wages were reduced were 11,500 ironstone miners and limestone quarrymen in Cleveland and Durham, nearly 7000 blast-furnacemen in Cleveland and West Cumberland, and 3000 iron-puddlers and millmen in the West of Scotland.

The most important disputes in progress during the

month were those involving about 110,000 seamen, firemen, dock labourers, and other transport workers at various ports of the United Kingdom, 12,000 coal-miners in the Rhondda Valley, 4000 pit lads and miners near Rotherham, 2400 coal-miners at Manchester, 1400 coal-miners at Wigan, 1400 iron and steel-workers at Shetton, 1000 lace-workers at Derby, 700 boiler-makers and labourers in Lincoln and district, 700 rivet-heaters, riveters, &c., at West Hartlepool, and 400 flour-millers at York. The number of new disputes beginning in July, 1911, was 66, and the total number of workpeople involved in all disputes in progress during the month was 189,108, or 72,774 more than in the previous month, and 175,014 more than in July, 1910. The total number of working days lost during the month by these workpeople amounted to 1,273,300, or 59,200 more than in June, 1911, and 1,111,400 more than in July, 1910.

Further cases dealt with under the Conciliation Act during July and the early part of August affected coal-workers, lightermen, carters, &c., in London, tramwaymen at Leeds, building-trade operatives at Bristol, plumbers at Glasgow, shipwrights and joiners at Southampton, tube-workers at Landore, and card-setting machine tenters at Cleckheaton. Settlements were arrived at as regards the coal-workers, &c., in London, the tramwaymen at Leeds, building-trade operatives at Bristol, and shipwrights and joiners at Southampton. Arbitration awards were also made in the case of the North of England coachbuilders, and matting-weavers in London, E.

The quarterly report of the Ship Constructors' and Shipwrights' Association for April, May, and June last shows a remarkable activity in shipbuilding, which brought with it an increase in the funds of the society, the income for the quarter being 15,183*l.* 1s. 9d., against an expenditure of 8271*l.* 10s. 5½d., showing a net gain to the funds of 6911*l.* 11s. 3½d., which brought the total reserve funds up to 91,455*l.* 6s. at the end of June. During the quarter there was expended on trade or dispute benefit 103*l.* 9s. 10d. ; on superannuation, 692*l.* 3s. 4d. ; on sick and accident benefit, 3706*l.* 14s. 5d. ; and on funeral benefit, 574*l.* 7s. 6d. ; making a total of 5076*l.* 15s. 1d. During the quarter 596 new members joined the society, 539 drew their transfers, and 497 replaced them, 68 members died, and 285 lapsed. This left a total membership of 22,286 at the end of June. The report contains an appreciative notice of Mr. Robert Keith, head foreman shipwright at Messrs. Harland and Wolff's, Belfast, who had on his shoulders much of the responsibility of launching the two White Star liners Olympic and Titanic.

The August report of the United Society of Boilermakers and Iron and Steel Shipbuilders shows again a steady increase in membership, the total now being 54,530. The total income for the quarter ending June 30 last was 20,165*l.* 14s. 4d., and the total expenditure during the same time was 9785*l.* 6s., leaving a balance of 10,380*l.* 8s. 4d.

The Associated Blacksmiths' and Ironworkers' Society have issued their report for the second quarter of the year, from April 8 to July 1, from which we gather that the income from all sources was 2186*l.* 6s. 8½d., and the expenditure showed a decrease of 412*l.* 15s. 9½d. from that of the previous quarter, and of 374*l.* 7s. 8½d. from the corresponding quarter of 1910. The principal items causing the decrease were unemployed benefit and sick benefits. The total expenditure in the quarter amounted to 1636*l.* 10s. 10d., leaving the capital account at 19,533*l.* 11s. 3½d., which represents an average of 6*l.* 3s. 3½d. per member. There was a slight increase in the membership for the month of July, and the income for the same time was 515*l.* 14s. 3d. and the expenditure 550*l.* 0s. 5d.

The quarterly report of the United Patternmakers' Association shows that there was a gain in the funds during the last quarter, the amount of the gain being 2704*l.*, which was almost double the gain of the March quarter. The total income for the quarter ending June was 6423*l.* The total expenditure for the same quarter amounted to 3719*l.* The total expenditure for the June quarter was 1163*l.* less than for the preceding quarter, and the total gain for the half-year amounted to 4058*l.*, exclusive of interest derived from house property investments. The prospects of the trade are good.

The monthly report of the Associated Iron-Moulders of Scotland for August does not give quite such a good report of trade as had been hoped for. The net income for the month of July, exclusive of remittances, was 1534*l.* 19s. 1½d., and the expenditure 2107*l.* 4s. 5d. The funds at the time the report was made up were 48,461*l.* 11s. 10d., as against 48,983*l.* 17s. 1½d. at the time of the last report.

Erratum.—In the "Personal" paragraph in the middle column of page 166 of our issue of August 4, line 4, for "Frodan" read "Frodair."

SPANISH RAILWAYS.

The improvement recently noted in Spanish railway property was maintained last year, and even made further progress during the twelve months. The two principal Spanish systems are the Northern of Spain, and the Madrid, Saragossa, and Alicante ; and the revenue of the Northern of Spain expanded last year to 5,338,569*l.*, as compared with 5,196,435*l.* in 1909, while the working expenses only increased from 2,345,965*l.* to 2,367,683*l.* The net revenue available for interest and dividend, accordingly, advanced last year to 3,070,886*l.*, as compared with 2,850,470*l.* in 1909. After full provision had been made for all fixed charges, the most formidable being interest and redemption of obligations, a balance of 500,588*l.* remained available for division upon the ordinary shares, and the council of administration was enabled to recommend a distribution at the rate of 3*l.* 16s. per cent. per annum. Of a final balance of 108,428*l.* remaining, after payment of this dividend, 60,000*l.* was carried to a special maintenance reserve fund, leaving 48,428*l.* to be carried to the credit of 1911. We have shown that the expenses increased last year to the extent of 21,718*l.* Savings of 106*l.* were effected under the heading of central administration, 6919*l.* under the heading of pensions, 6217*l.* under the heading of revenue control, and 1162*l.* under the heading of traction and plant. On the other hand, traffic charges increased 7857*l.* ; working, properly so-called, 27*l.* ; and way and works, 28,238*l.* The relatively moderate increase in last year's working outgoings was, accordingly, more than wholly accounted for by increased maintenance outlays. The saving of 1162*l.* under the heading of traction and plant was due to lower prices current for fuel ; the saving would have been more considerable but for an increase in the distances run by engines and larger outlays for the repair of rolling-stock. The increased expenditure under the heading of way and works was occasioned by liberal renewals of permanent way with a view to adapting more fully the company's lines to the circulation of heavier and quicker trains. The aggregate distance run by trains last year was 12,093,864 miles, as compared with 11,958,110 miles in 1910. To the increase of 135,754 miles observable in the train mileage of last year the main line from Madrid to the French frontier contributed 85,704 miles. The length of line in operation upon the system at the close of last year was 2300⅝ miles, as compared with a similar mileage at the close of 1909. To the total of 2300⅝ miles the main line contributed 568⅓ miles ; the Santander line, 86⅞ miles ; the Barcelona line, 170⅝ miles ; the Bilbao line, 155⅝ miles ; the Almanza lines, 327½ miles ; the Asturias lines, 463⅛ miles ; and sundry other minor lines, 526⅝ miles. The aggregate expenditure made by the company on capital account to the close of last year was 42,943,318*l.*, as compared with 42,803,974*l.* at the close of 1909. The most satisfactory current feature in the company's affairs is the large saving effected by it in the matter of exchange. A considerable proportion of the capital being held in France, heavy losses have been incurred in former years in the conversion of pesetas into francs for the purpose of paying interest and dividends. Last year a saving of 41,493*l.* was effected under this head, a fact which shows an encouraging improvement in Spanish general credit.

The Madrid, Saragossa, and Alicante Railway had raised at the close of last year 39,485,769*l.* upon capital account, as compared with a corresponding aggregate of 38,753,491*l.* at the close of 1909. The expenditure made on capital account at the close of 1910 was 40,255,292*l.*, as compared with 39,810,250*l.* at the close of 1909, showing an increase of 445,042*l.* In this increase tools for the company's workshops figured for 241,580*l.* The expenditure made for rolling-stock last year was 71,916*l.* ; this sum included payments made for thirty compound locomotives and tenders, twenty-eight 8-wheeled locomotives, and ten tender engines. Since the close of 1910 the company has further ordered thirty 8-wheeled locomotives to meet the continued development of traffic. The length of line worked by the company last year was 2290 miles, and the revenue collected for 1910 was 4,678,547*l.*, as compared with 4,562,397*l.* in 1909. The working expenses increased last year to 1,990,153*l.*, as compared with 1,961,902*l.* in 1909. The fixed and other charges which had to be provided for last year were 1,863,836*l.*, as compared with 1,903,108*l.* in 1909. The balance available for dividend for 1910 was accordingly 824,557*l.*, as compared with 697,387*l.* in 1909, and the dividend upon the share capital was increased to 4 per cent. per annum. As with the Northern of Spain Railway, so with the Madrid, Saragossa, and Alicante Railway, a considerable proportion of the capital is held in France, and, to make remittances to French investors, heavy losses have been sustained in former years on exchange account. These losses are being reduced, but exchange on remittances still cost the company 144,650*l.* in 1910.

The general conclusion which may be drawn from our review is that the commerce and agriculture of Spain are showing signs of increasing prosperity. Spain, however, requires a further period of political repose before she can fully participate in the activities of modern industry.

NOTES FROM THE UNITED STATES.

Philadelphia, August 9.

Within the past ten days ten large blast-furnaces in the Pittsburg district have resumed production, and during the current week two furnaces of the Jones and Laughlin Company will blow in. Crude steel stock is declining, and buyers are making inquiries for fresh supplies. This condition promises to strengthen prices at a little above the very low level of June and July. Pig iron for steel purposes promises to improve in demand, and the latest quotations show that makers are taking courage to get a little better margin. The makers of pig iron in the Southern States are also withdrawing the very low quotations of June, and they will probably hold the advance permanently. The movements of ore from the lakes until August 1 amounted in round figures to 14,000,000 tons as against 21,800,000 tons in the same period last year. The production of coke in the Connellsville region is stationary, and makers are endeavouring to prevent increase. The manufacturers of merchant bars report this week a general improvement in demand, the first that has been mentioned for several months. Both merchant bar and plate are firmer than they have been for ninety days. The plants manufacturing iron pipes are once more busy after the usual July dulness. Some Pittsburg mills are working on the largest order for riveted pipes ever placed. A contract has just been made in the Pittburg mills for 14,000 tons of material for locks on the Panama Canal. Another contract for 12,000 tons of structural material has been placed, to be furnished for the New York subway. The American Bridge Company secured the contract. Large contracts for steel plate are being placed in connection with the construction of dams in the arid regions of the West to further the cause of reclamation. These large contracts are a source of gratification to steel interests.

THE EFFICIENCY OF STEAM-TURBINES.

To the Editor of Engineering.

Sir,—In the discussion of Mr. Zoelly's paper on "Steam-Turbines," as reprinted in your issue of the 4th inst. (page 159), Mr. A. E. L. Chorlton drew a comparison between the efficiency of the simple velocity impulse turbine and the combined impulse reaction turbine. The remarks Mr. Chorlton made are, however, misleading, as he is comparing two efficiency figures calculated on an entirely different basis.

Mr. Zoelly stated in his paper (page 163 of your issue of the 4th inst.) that "with a turbine designed with entirely simple-velocity stages, it is possible to obtain an efficiency of 73 per cent." From the table of test results of the Zoelly steam-turbine (page 162) the highest thermal efficiency is 73 per cent. for the 2000-kw. 3000-revolutions-per-minute turbine at Helsingfors. This efficiency figure is based on a condition of steam behind the stop-valve, and is exclusive of the generator losses.

In his lecture, Mr. Eric Brown, in referring to the combined impulse reaction engine, stated that "the thermal efficiency of the whole set was 70 per cent." I understand that this efficiency figure is based on the steam condition in front of the stop-valve and includes all losses both of the steam-turbine and the generator. If 5 per cent. is allowed for losses in the generator, the thermal efficiency of the turbine only based on steam conditions in front of the stop-valve would be 73.2 per cent., as compared with 70.5 per cent., this being the highest figure under the same conditions in Mr. Zoelly's table referred to.

These figures demonstrate that the efficiency of the pure impulse turbine with single-velocity stages is not proved to be greater than that of a combined impulse reaction turbine, but that the contrary is the case.

It would be an advantage, when comparing the efficiencies of steam-turbines, if these were all reduced to a common basis, or if it were stated whether the steam conditions are in front or behind the stop-valve, and whether the generator losses are included.

It is only on considering figures based on identical conditions that a useful comparison of the efficiency of rival types of steam-turbines can be made.

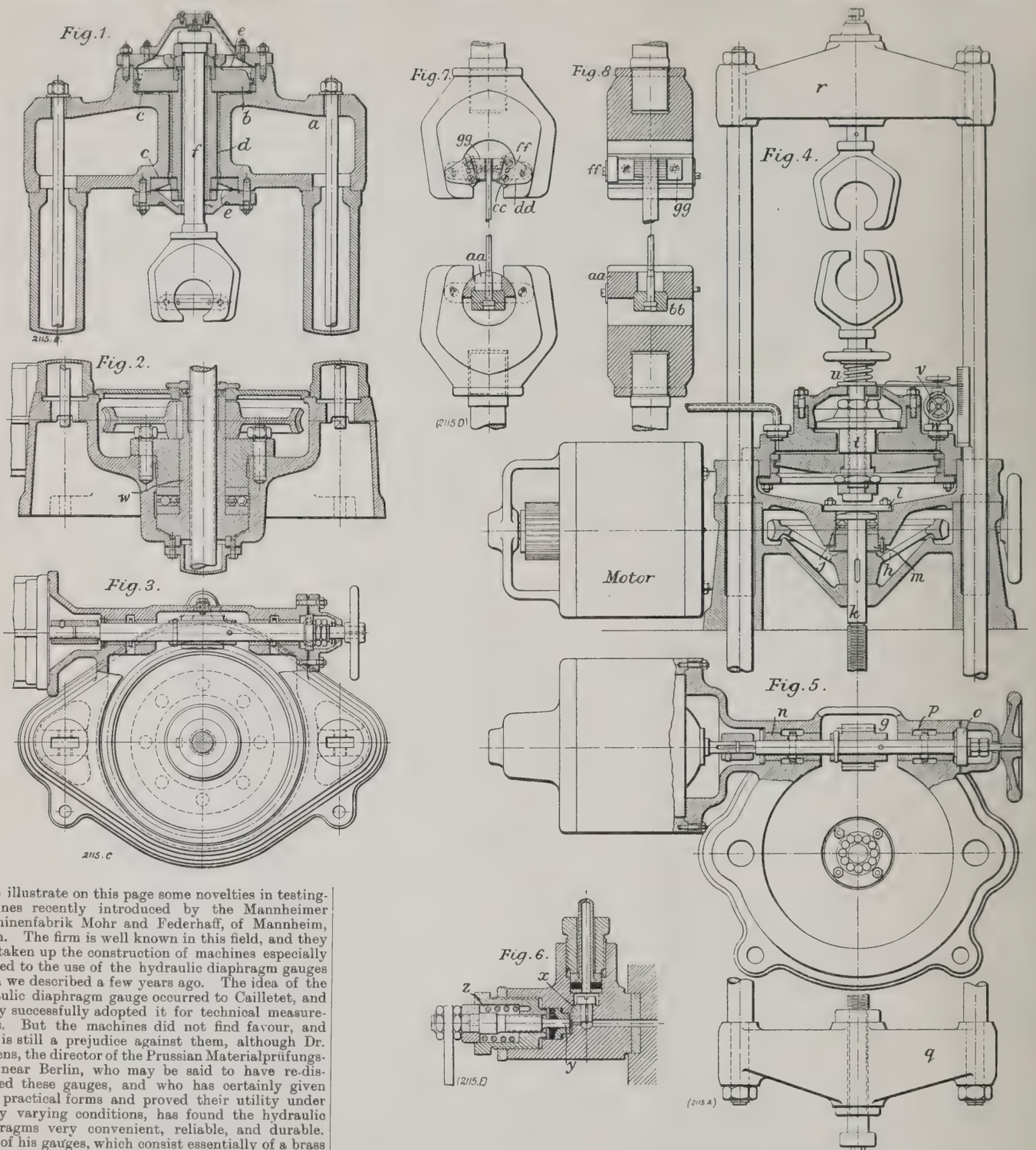
Yours faithfully,
M. G. S. Swallow.

Hartlepool Engine Works, Hartlepool,
August 14, 1911.

Small Wastes on Railways.—A somewhat amusing but instructive method of drawing their employees' attention to the effect of small wastes is adopted, according to the *Railway and Engineering Review*, by the Pere Marquette Railroad. A table has been drawn up by the company showing that for every postage stamp needlessly used the railway has to haul one ton of freight a distance of 3½ miles to recoup for this waste. For a lead-pencil the haul is two miles ; a track-spike, 2 miles ; 1 lb. waste, 10½ miles ; a lamp chimney, 10½ miles ; a station broom, 35 miles ; a lantern, 100 miles ; track-shovel, 90 miles ; 100 lb. of coal, 20 miles ; 1 gallon engine oil, 50 miles ; 1 gallon signal oil, 60 miles ; air hose, 225 miles ; draw-bar knuckle, 300 miles.

TESTING-MACHINES.

CONSTRUCTED BY THE MANNHEIMER MASCHINENFABRIK MOHR AND FEDERHAFF, ENGINEERS, MANNHEIM.



We illustrate on this page some novelties in testing-machines recently introduced by the Mannheimer Maschinenfabrik Mohr and Federhaff, of Mannheim, Baden. The firm is well known in this field, and they have taken up the construction of machines especially adapted to the use of the hydraulic diaphragm gauges which we described a few years ago. The idea of the hydraulic diaphragm gauge occurred to Cailletet, and Emery successfully adopted it for technical measurements. But the machines did not find favour, and there is still a prejudice against them, although Dr. Martens, the director of the Prussian Materialprüfungsamt, near Berlin, who may be said to have re-discovered these gauges, and who has certainly given them practical forms and proved their utility under widely varying conditions, has found the hydraulic diaphragms very convenient, reliable, and durable. Most of his gauges, which consist essentially of a brass diaphragm 0.35 mm. in thickness, covered by a rubber disc 1 mm. in thickness, remain fit after 20 million operations. That practical engineers have so far made little use of them is partly due to the fact that suitable outfits were not easily got in the market. The great advantage offered by their use is that the recording gauge is entirely separated from the test-piece, whose fracture does not affect the instrument.

Messrs. Mohr and Federhaff place the hydraulic diaphragm gauge either in the upper crosshead of the machine (Fig. 1) or in the base of the machine (Fig. 4). In the former case the test-piece and its load are suspended from the crosshead of the machine; the latter arrangement is more convenient for heavy work. Testing-machines of this type have been constructed for capacities of 50 and 75 tons. The construction of the differential gauge will be understood from Fig. 1. The piston system b moves with little play within the casing a, and comes to rest on the diaphragm c, which closes the small hydraulic chamber d. The piston need not be accurately ground; it is guided by the diaphragm e, which prevents any tilting of the piston; the bolt f, which hangs in an adjustable spherical bearing, connects the piston with the clamp for the test-piece. The hydraulic diaphragm transmits the stress over to the recording pressure-gauge. This transmission might fail for three reasons. In the first instance the diaphragm might break; in that case the piston would at once sink, and the zero of the instrument would be changed; the case is not likely to occur, and could not escape notice. Secondly, grit might get between the piston and the casing; the various diaphragms will prevent that. The third case is that the machine might inadvertently have been allowed to approach the limit of its stroke. To obviate this trouble a long magnifying pointer has been provided, which shows the position of the piston on the front of the machine and which would mark any shifting of the zero owing to slight leakage. The adjustment of the zero can easily be effected. The load can be applied by hand, by belting, or by electric power. The last-mentioned method is, on the whole, preferred by Messrs. Mohr and Federhaff, and Figs. 2 and 3 illustrate one arrangement of the electric motor and driving gear. Before referring to this gear, we will, however, describe an electrically-driven testing-machine of the second type mentioned, in which the diaphragm is mounted in the base.

Figs. 4 and 5 show, in plan and elevation, a machine of this design, for a capacity of 3 tons. The driving gear comprises several ball-bearings and other interesting features. The shaft of the electro-motor is coupled with the shaft of the worm g; h is the worm-wheel, whose motion is transmitted through the ball-bearing j to the machine spindle k; l is a holding-down plate, and m a thrust-block; the worm-shaft runs in the gun-metal bushes n, and the thrust is taken up by the double-acting ball-bearing

LINLEY'S TOOL-REST FOR LATHES.

CONSTRUCTED BY MESSRS. DARLING AND SELLERS, ENGINEERS, KEIGHLEY.

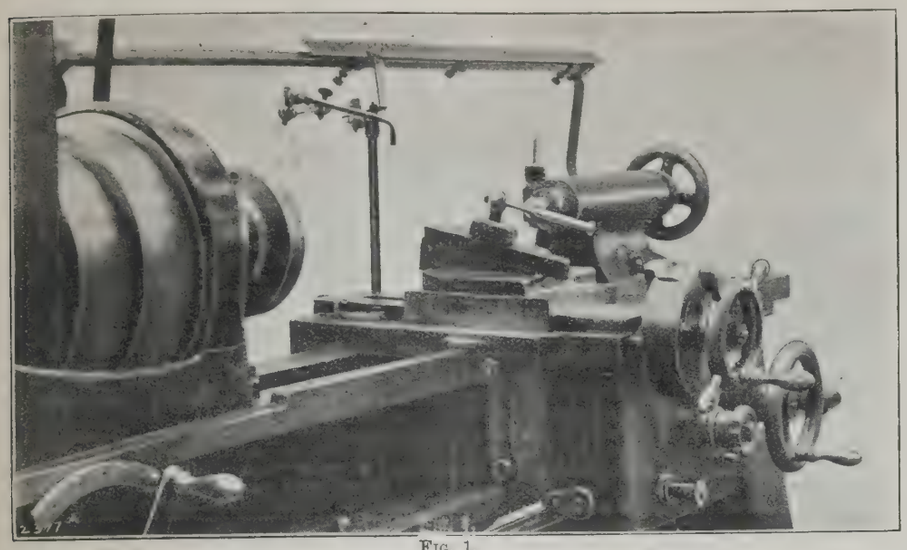


Fig. 1.

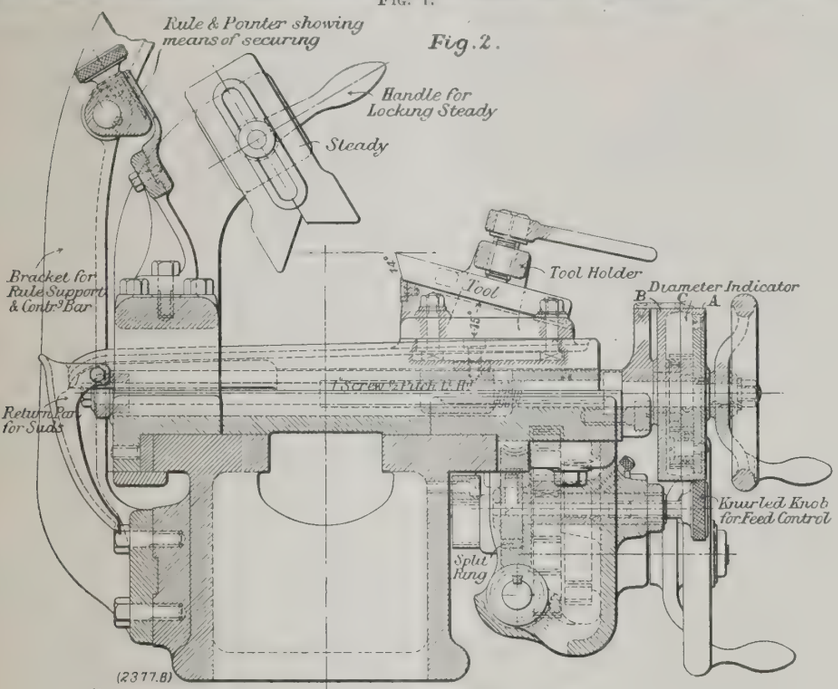


Fig. 2.

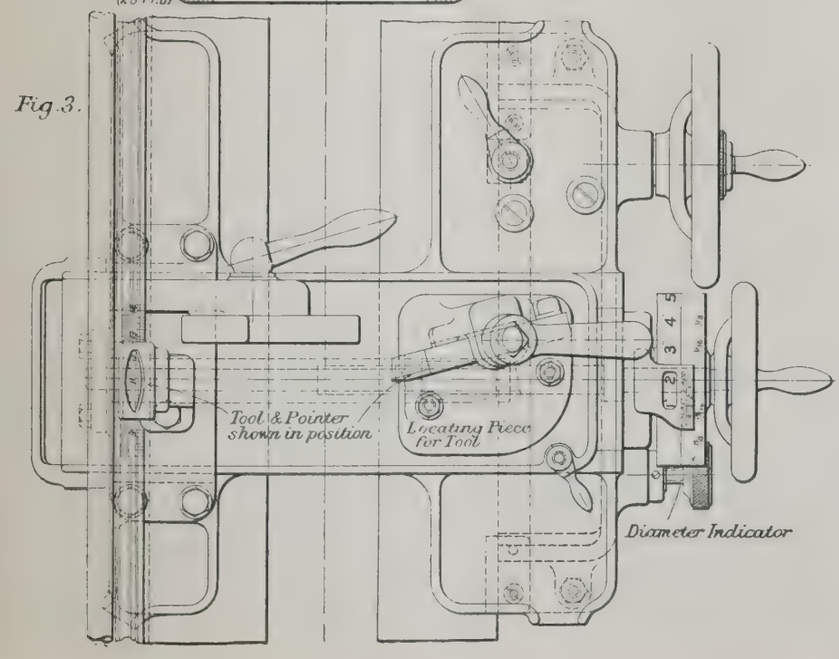


Fig. 3.

o, which is adjusted with the aid of a hand-wheel; p are ring lubricators. As the spindle turns the lower crosshead q is raised or lowered, and this motion is transmitted to the upper cross-bar r by the rods. From r is suspended the upper clamp; the lower gripper is mounted in the part t, which corresponds to the bolt f in Fig. 1, and which is forced up by the spiral spring u; the latter is controlled by the hand-wheel v. The pointer previously mentioned can be seen next to v, but the magnifying lever arrangement is not shown. How reliably such machines operate will be understood from the fact that in standardising a 5-ton machine the values read off never differed by more than 0.55 per cent. from the means, and mostly by less than ½ per cent., except in the very commencement of the test, when the load was only 200 kg. The machines, we should add, are not only designed for tensile tests; Professor Bach has adapted them to bending tests, and the firm supplies universal testing-machines fitted with hydraulic diaphragm gauges.

Figs. 3 and 4 illustrate, as already mentioned, another arrangement of the driving gear for electric motors. The motor, its coupling, the worm shaft and worm, the ring lubricators and thrust bearing are as in the case just described, except that the motor-casing is different; but the spindle is turned by the aid of a threaded bushing w and a ball-bearing.

A very essential part of the equipment, when working with hydraulic diaphragm gauges, is the relief-valve, illustrated in Fig. 6. In order to protect the pressure-gauge, on which the measurements are made, the diaphragm-gauge and the pressure-gauge must be separated from one another in the moment that the test-piece gives way. The valve x will settle firmly on its seat when a sudden fluctuation arises in the stress; the valve y, which is actuated by the crank, allows the liquid slowly to flow back from the gauge to the hydraulic gauge. The spiral spring z at once closes the valve y again as soon as the crank is let go; otherwise the device might fail owing to inadvertence. Variations in the stresses, which would result from the flow of the material when near the yield-point, will not make the valve x close; it will accommodate itself to these small fluctuations.

Figs. 7 and 8 show a new universal clamp of Messrs. Mohr and Federhaff, so designed and constructed that one bore suffices for holding round or prismatic bars, which may or may not be provided with shoulders. The essential parts are the round sliding-pieces $a\ a$ and the split seat $b\ b$, which secures axial suspension, the cylindrical parts $c\ c$, which are attached to the jaws by the aid of the plates $d\ d$, the grub screws $f\ f$, and the wedge-shaped grippers $g\ g$.

LINLEY'S TOOL-REST FOR LATHES.

An ingenious and yet singularly simple modification of the ordinary lathe slide-rest is illustrated in Figs. 1 to 3, annexed. The arrangement, which is the invention of Mr. Owen Linley, and is being manufactured by Messrs. Darling and Sellers, of Keighley, enables the dimensions of work being turned to be determined at a glance and without the use of measuring instruments of any kind. As will probably be gathered from the illustrations, the actual measuring is carried out with an indicator fixed just at the back of the hand-wheel which controls the in-and-out movement of the tool; but this indicator differs essentially from apparently corresponding indicators which are frequently fitted to machine-tools. Normally, indicators of this class have but a qualitative value, but in Mr. Linley's invention the readings are quantitative, and it is possible to read off at any time the actual finished diameter of the work which is being turned.

The value of the arrangement lies in the great saving of time that it introduces, and in the fact that it allows a large amount of work to be carried out by unskilled labour which normally requires the service of a journeyman. It is stated that an ordinary engine-lathe converted to this system is able to hold its own against a turret-lathe for many classes of repetition work, while for single jobs it frequently offers the advantages of turret-lathe working without the necessity of any preliminary setting up.

The essential feature of the arrangement consists merely in such arrangement of the tool-holder that the cutting edge of the tool is always in the same position relative to the rest, so that it necessarily follows that the indicator can be qualitatively graduated. This idea is so simple in itself that it is difficult to realise that it is new; but as the device has been accepted by the Patent Office, it may be taken that the arrangement, although so simple and effective, has not previously been recorded. The method of locating the tool is best shown in Fig. 2. Tools of a uniform thickness are used, so that their cutting edge is always at the same height above the bed of the lathe. In addition, the tools are ground in a special holder, so that they are of constant angle on their front edge. The lower part of this front edge fits against a steel stop fixed on the holder, as shown in the figure, and it is obvious that when a new tool is inserted in the machine it is only necessary to place

it against the stop and clamp it to ensure that its cutting edge shall be in the correct position, and that the diameter of any work turned by it shall be correctly shown on the indicator.

The details of the device will be clearly seen from the drawings reproduced in Figs. 2 and 3, and from the perspective view (Fig. 1). It should, however, be pointed out that the indicator shown in the outline figures is of a geared type, giving a fine reading for accurate work, and that for work of smaller diameter a simpler indicator, with one scale only, is employed. In addition to the diameter indicator, the arrangement shown in Figs. 2 and 3 is fitted with a length-indicator which enables the width of collars and stepped parts to be read off directly without measurement with a rule. This indicator consists merely of a fixed scale, over which a pointer, attached to the slide-rest, travels. The arrangement will be followed from the figures. Mr. Linley's appliance has been fitted to a number of lathes in various parts of the country, and in all cases has shown considerable saving over ordinary arrangements owing to the elimination of trial cuts, and the setting-up and stopping of the machine for measurements; while in some cases boys have been able to take over and carry out, with the same speed and satisfaction, work which required the services of a skilled turner on an unconverted lathe. In conclusion, it should be said that, by means of a modification, the system can be applied to large lathes, while it is also applicable to boring-mills, facing-heads, and chucking-reamers.

THE LAUBEUF SUBMERSIBLE BOAT.

In the earlier days of submarine navigation there existed only one type of submarine craft—the submarine proper. Later there appeared the submersible boat, which very soon had the larger number of adherents. The difference between the two types may be briefly defined. The submarine proper is cigar-shaped; it has a low buoyancy when navigating on the surface—5 to 15 per cent. only of its total displacement when completely immersed; it has one single hull, inside which are mounted all its vital parts, together with the water-ballast tanks for procuring immersion. The submersible boats, on the other hand, are built on lines very similar to those of surface craft, torpedo-boats, and destroyers; their buoyancy is comparatively high, being 20 to 40 per cent. of the total displacement; they have an outer hull which extends over the whole or over part only of the length of their inner hull, the water-ballast tanks being in the space between the two hulls. The latter type, being by far the better of the two, has prevailed in the French navy, and has been constantly improved upon, but singularly enough, it has changed its name into that of submarine, *sous-marin*, a name which, though used formerly for the type having less buoyancy on the surface, is now generally applied in France to all the craft for submarine warfare. In this brief article, however, we shall apply the term "submersible" to the boat designed by Naval Constructor Laubeuf, who was early in the field, and who has constantly advocated this type in preference to the other less buoyant one.

We illustrate in Figs. 1 to 6, on page 228, Laubeuf submersible boats of French construction. Fig. 1 shows a submersible boat navigating on the surface, Fig. 2 is a longitudinal section, Fig. 3 a plan, Fig. 4 illustrates a boat during construction, and Fig. 5 a boat being launched at Messrs. Schneider and Co'.s yard at Chalon-sur-Saône, while the double-hull arrangement is clearly shown in the diagram, Fig. 6.

From its inception in 1897 the Laubeuf type has been improved from time to time; its seaworthiness and success in attack in the course of the manœuvres carried out by the French Navy have repeatedly been proved. The Papin, among others, made a cruise of 2200 miles from September 21 to October 12, 1909, part of which was a run from Rochefort to Oran, a distance of 1230 miles, which was covered partly in bad weather and without putting into any place of call. The high degree of perfection reached in the construction of this type of craft is confirmed by the fact that no accident* which can be traced to a fault in design or build has occurred so far in actual service to any submersible boat, although the boats of this particular class, forming units of the different fleets, had accomplished, by 1910, over 14,000 immersions.

Submersible boats of the latest types on Mr. Laubeuf's plans have recently been built at Messrs. Schneider's yard at Chalon. The general arrangement of the various compartments is shown in the views, Figs. 2 and 3, which illustrate the Cb type; this craft has a displacement of 311 tons on the surface, and of 465 tons when completely immersed, the buoyancy being, therefore, 154 tons. It has a surface speed of 15 knots, and an under-water speed of 8 knots. The first compartment forward (Figs. 2 and 3) serves for taking water-ballast, and would act for neutralising a collision; a collision which would crush the forward portion of the craft would have no influence whatever upon trim and buoyancy. The second compartment, which ends forward in a thick spherical bulkhead (see Figs. 2 to 4), contains a torpedo-launching tube, a spare torpedo, and the crew's quarters. In the next compartment aft are the electric accumulators; then follow the central compartment, containing the steering-gear, the gear governing immersion, and the officers' quarters, with communication to the turret; the engine-room containing the heavy-oil motors and auxiliary apparatus; the room containing the electric-motors; and the air-compressor room, which serves also as the petty-officers' cabin. The compartment right aft is a water-ballast compartment, which is outside the thick inner hull. Four disappearing torpedo-launching apparatus are mounted on deck, where they are thoroughly protected; they are worked by compressed air from inside the boat. The armament of the boat, as will be seen, is a heavy one; the submersible has always five torpedoes ready for launching, plus a spare torpedo.

The question of habitability has been considered from the very simple standpoint according to which the power of endurance of a submersible boat depends primarily upon the power of endurance of its crew, and, therefore, upon the degree of habitability of the craft itself. When the boat is navigating on the surface, the men who are not on duty can take up stations on deck in exactly the same conditions which prevail in the case of sea-going, surface torpedo-boats, whilst a very complete system of ventilation ensures to the men on duty inside the boat a minimum of physical fatigue. When the boat is immersed, the volume of air available and the means taken for renewal are sufficient to enable the men to withstand without any trouble a period of under-water service lasting over twelve consecutive hours. The habitability of the boat is also increased by the fact that the electric accumulators are located in a separate compartment, the quarters for the officers and men being further rendered as comfortable as is possible in a boat of this class. The conditions of safety which result from the double hull arrangement and the provision of water-ballast outside the inner hull, combined with the devices for allowing the compressed air to escape, make it possible for the craft to acquire almost instantaneously a great buoyancy, thus enabling it to emerge very rapidly. The valves for operating the escape of the compressed air are all placed within sight of the officer in command. Electrically-driven drainage pumps which draw simultaneously from the various water-ballast compartments can drain these in a very short time. The safety devices include safety dropping weights, lifting tackle, and a telephone buoy.

For regulating the immersion of a submersible boat of the Cb type, the officer in command has a set of trim-indicators and three pairs of horizontal rudders—one forward, one aft, and one in front of the deck-house—by which means he is able to maintain the depth of immersion selected to within 20 in. The boat carries two periscopes, each of which gives a complete view of the whole horizon; they are raised and lowered by electric motors. Communications with the mother-ship and with sister-ships are ensured by means of submarine bells. Wireless telegraphy can also be resorted to.

The nautical qualities of the Laubeuf type of submersible boats, and the ease with which they are operated, have been fully proved in actual service. The inventor and the builders, Messrs. Schneider, are working towards improving these characteristic features still further. They have also solved two problems in this connection—*i.e.*, the one dealing with the training of officers and men in the manœuvring of submarine boats, and the other with the delivery to distant navies. They have installed, in close proximity to Toulon Bay, an establishment placed under the management of specialists for instructing crews in the handling of the craft, the plant containing accommodation for the men who follow the submarine navigation classes, and the necessary shops for the maintenance and repair of the machinery, and for charging electric accumulators. Further, the Chantiers de la Gironde, Bordeaux, which work in collaboration with the yard at Chalon-sur-Saône above referred to, have at the present time in course of construction a cargo-boat provided with a large-capacity hold to receive a submersible boat for delivering it to distant navies. This cargo-boat, the Kanguroo, is provided with water-ballast compartments; these are filled with water to enable the submersible to enter the hold reserved for it through a tunnel in direct communication with the open sea.

* The accident to the Pluviose, which was cut in two by a cross-Channel steamer travelling at a speed of about 20 knots, is one to which all classes of craft are exposed in active service. It is comparable to that which occurred with the Kambala, a Russian submarine of German construction.

Welsh Coal for Egypt.—Tenders have been invited by the administration of the Egyptian State Railways for the supply of 305,000 tons of Welsh colliery-screened steam coal.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—The pig-iron trade shows decided improvement so far as ordinary Cleveland pig is concerned, but the hematite branch continues lifeless. Brisk buying of all descriptions of pig, however, are looked for in the near future, and if labour troubles do not hamper the situation, the autumn promises to be characterised by considerable activity, for it is understood that heavy supplies are needed both for home use and for shipment There is a large and growing local consumption of pig iron. It is gratifying to hear, as emphasising confidence in the future, that buyers are offering more for forward than for early delivery. Values of Cleveland pig are higher than they have been for the past four months. Several f.o.b. sales of No. 3 g.m.b. Cleveland pig have been recorded at 47s. 7½d., and the general market rate is now 47s. 9d., whilst No. 1 has been raised to 51s. 3d., and the other qualities have advanced in proportion, No. 4 foundry becoming 47s. 3d., No. 4 forge 46s. 9d., and mottled and white iron each 46s. 3d.—all for early delivery. Quietness still rules in the East Coast hematite branch, but hopes are entertained of a change for the better shortly. Mixed numbers have again been sold at 61s. for early delivery, but as a rule sellers do not now name below 61s. 3d., which is a price below cost of production. Business in foreign ore is still at a standstill. There have been inquiries for delivery over periods next year, but would-be buyers are not prepared to pay any more for forward than for prompt delivery, and sellers will not entertain offers on such terms. Market rates remain nominally on the basis of 19s. ex-ship Tees for best Rubio. Freights Bilbao-Middlesbrough have been fixed at 4s. 6d.

Stocks and Shipments of Pig Iron.—The quantity of Cleveland pig in the public warrant stores keeps at about 600,000 tons. To-night it is just below that figure, and since the beginning of the month 769 tons have been withdrawn. Shipments of pig are on a very satisfactory scale. To date this month they average 3995 tons per working day, as compared with a daily average of 2925 tons to the same date last month, and 4046 tons for the corresponding part of August last year.

Manufactured Iron and Steel.—Producers of nearly all descriptions of manufactured iron and steel give satisfactory and encouraging accounts of these industries. Works generally are well employed, and not only have manufacturers substantial contracts made, but inquiries continue on a fairly good scale. Prospects are thus rather bright. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; and steel joists, 6*l.* 7s. 6d. to 6*l.* 10s.—all less the customary 2½ per cent. discount. Cast-iron columns are 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; and steel railway sleepers, 6*l.* 10s.—all net cash at works. Iron and steel galvanised corrugated sheets, 24 gauge, in bundles, have been advanced from 10*l.* 15s. to 11*l.* 5s. f.o.b.—less the usual 4 per cent. This is hardly so big a rise as might have been expected after the substantial advance in spelter.

The Institution of Civil Engineers; Students Papers.—The Council of the Institution of Civil Engineers have made the following awards in respect of students' papers read during the session 1910-11:—The "James Forrest" Medal and a Miller Prize to Mr. D. Hay, B.Sc. (Birmingham), and Miller Prizes to Messrs. D. A. Howell (Bristol), R. Bonner (Bristol), G. F. Walton (London), R. G. Parrott (Manchester), E. E. Farrant (London), A. C. Dean, B.Sc. (Manchester), H. W. Coales (Birmingham), A. H. Meade (London), A. C. Swales (Leeds), and H. J. F. Gourley, B. Eng. (Manchester).

The Spitzbergen Coal Deposits.—A steamer from Spitzbergen has just returned to Tromsö with news concerning the progress of coal-mining in that group of islands. The American Coal Company's installations are now complete, and, with the exception of seven hours, the electric station has supplied current throughout the winter for lighting purposes in the mines, &c., and power for the winning of about 30,000 tons of coal. This coal has been sold to various steamer and railway concerns, and a further output of 20,000 tons is expected to be obtained this summer. The coal continued to be of exceedingly good quality; there has been no labour trouble with the men, who are mostly Norwegians, with a few Swedes and Finns; seventy men returned with the steamer, but a number of these have renewed their contract from the autumn. The weather has been good, although the temperature occasionally became exceedingly low. A Swedish company has also just been formed for the purpose of acquiring and exploiting coal and other mineral deposits in the island, some very influential men being on the board. A Swedish expedition has been despatched to Spitzbergen in order to continue last summer's preparatory survey and investigations and start the working. Swedish explorers have repeatedly visited Spitzbergen and made interesting discoveries there. It is also announced that English engineers and workmen left Tromsö in the beginning of July for Spitzbergen. The expedition has its own vessel, and appears to be well equipped in every respect. Great secrecy has been observed as to the object of the expedition, only its destination being known. The Spitzbergen coal and other mineral deposits are at present attracting increased attention.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was firm in tone, but dealing was confined to 6000 tons of Cleveland warrants at 47s. 6d. three months. The closing quotations were 46s. 9½d. cash, 47s. 0½d. one month, and 47s. 6½d. three months sellers. In the afternoon Cleveland warrants were 1d. up, and 3500 tons were dealt in at 46s. 9½d. and 46s. 10d. cash, 46s. 11½d. fifteen days, and 47s. 7½d. three months. Sellers' closing prices were 46s. 10½d. cash, 47s. 1½d. one month, and 47s. 7½d. three months. On Friday morning an upward movement commenced, and Cleveland warrants were done at 47s. cash, 47s. 3½d. one month, and 47s. 9d. three months. The turnover amounted to 9000 tons, and at the close there were sellers at 47s. 0½d. cash, 47s. 3½d. one month, and 47s. 9½d. three months. Buyers of hematite offered 61s. 9d. cash and 62s. 1½d. one month, but sellers quoted 3d. more in each case. In the afternoon the market was again stronger, and 7000 tons of Cleveland warrants changed hands at 47s. 2d. cash, 47s. 3d. six days, 47s. 4d. and 47s. 4½d. one month, and 47s. 11d. three months. Closing sellers quoted 47s. 3d. cash, 47s. 6d. one month, and 48s. three months. On Monday morning a slightly easier tone prevailed, and 9000 tons of Cleveland warrants were put through at 47s. 2½d. and 47s. 2d. cash, 47s. 3d. four days, and 47s. 6d. and 47s. 5d. one month. At the close there were sellers at 47s. 2½d. cash, 47s. 5½d. one month, and 47s. 11½d. three months. The tone was firmer in the afternoon, when 5000 tons of Cleveland warrants were done at 47s. 2d. and 47s. 3d. three days, 47s. 4½d. and 47s. 6d. one month, and 47s. 11d. and 48s. three months. Closing prices were 47s. 3d. cash, 47s. 6d. one month, and 48s. three months sellers. Cash hematite was quoted at 62s. 3d. sellers. On Tuesday morning Cleveland warrants were again harder, and dealing to the extent of 3000 tons was done at 47s. 3d. cash, and 48s. three months, with buyers over. Sellers' closing quotations were 47s. 3½d. cash, 47s. 6½d. one month, and 48s. 0½d. three months. In the afternoon prices for Cleveland warrants were again firmer, and 3000 tons were dealt in at 47s. 4d. six days, 47s. 6d. one month, and at 48s. and 48s. 1d. three months. At the close there were sellers at 47s. 4d. cash, 47s. 7d. one month, and 48s. 1½d. three months. Buyers of hematite offered 62s. 1½d. cash, and 62s. 4½d. one month, and sellers quoted 4½d. more in each case. When the market opened to-day (Wednesday) the tone was strong, and Cleveland warrants were about 2d. up in price. The turnover amounted to 3500 tons at 47s. 5d. and 47s. 6d. cash, 47s. 5½d. seven days, 47s. 6d. nine days, 47s. 8½d. one month, and 48s. 2d. three months, and closing sellers quoted 47s. 6d. cash, 47s. 9d. one month, and 48s. 3d. three months. Hematite—1000 tons—changed hands at 62s. 7½d. cash, and 62s. 10½d. sixteen days, and for the month position sellers quoted 63s., and buyers 62s. 9d. In the afternoon the market was firmer, and 3500 tons of Cleveland warrants were done at 47s. 6d. cash, and 47s. 9d. one month, and at the close sellers quoted 47s. 7d. cash, 47s. 10d. one month, and 48s. 4d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde, 61s.; Calder and Gartsherrie, 61s. 6d.; Summerlee, 63s. 6d.; Langloan 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 64s.; Shotts (at Leith), 62s. 6d.; and Carron (at Grangemouth), 63s.

Sulphate of Ammonia.—Business in the sulphate-of-ammonia market is still active, and inquiries are good. The price is steady and unchanged this week, with sellers quoting 14*l.* 2s. 6d. per ton for prompt delivery, Glasgow or Leith. The amount shipped from Leith Harbour last week was 1957 tons.

Scotch Steel Trade.—The recent improvement in the Scotch steel trade continues and makers report an active demand for plates, and in one or two cases they cannot promise delivery for several weeks ahead. The home demand is good, but it is the export orders, lately booked for immediate despatch, which are the main cause of the increased activity. Angles are in better request and specifications are more plentiful. Orders for goodly quantities of thin plates have been booked during the past few days, and makers of black and galvanised sheets continue very busy. For light and sectional material generally the demand is quite satisfactory and prices are firmer, and with Canada inquiring for several thousand tons of this class of steel the outlook is very bright.

Scotch Pig-Iron Trade.—The demand for Scotch pig iron has been rather better during the past week, and a fair amount of booking has taken place. With local consumers taking large deliveries, and the export trade increasing, the present output is being readily absorbed, and stocks on hand are decreasing. Inquiries from the South are also very fair at the moment. Standard foundry iron is the subject of a moderately good demand. Hematite is little changed, although a better feeling prevails, and deliveries are reported as showing an improvement.

Malleable-Iron Trade.—A slight improvement falls to be reported in connection with the malleable-iron trade of the West of Scotland, and producers are better employed. The current price is still nominally 6*l.* per ton, less 5 per cent. for crown-bars; but several makers will not sell at that figure.

CANADIAN TIMBER.—In the Canadian census of 1891 the forest area of Canada was estimated at 799,000,000 acres. More recent estimates have reduced the area to between 500,000,000 and 600,000,000 acres, but this includes areas of timber which are not at present merchantable, and estimates of Canadian land covered with merchantable timber immediately available have now been brought down to 200,000,000 acres.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Sheffield Firms' Troubles.—It is difficult to fix any limit to the extent of the unrest in the labour world. At the recent annual meeting of Messrs. Samuel Fox and Co., Limited, Sheffield, the chairman referred to the unsettled state of affairs. Coupling this with the present tendencies of legislation as exemplified in the Insurance Bill and the Coal-Mines Bill, he expressed himself as of the opinion that these things would increase the costs of production still more and make it almost impossible for English firms to compete with other countries. The colliers employed by his company were, he regretted to say, on strike, after having repudiated an agreement approved by the men's union and the Coalowners' Association. The inadequacy of selling prices compared with the cost of raw materials was also dealt with by the chairman, who attributed to this the disappointing result of the year's working. The output had been greater, but the margin between cost and selling price had been less, so that there had been a reduction in profit.

South Yorkshire Coal Trade.—The railway strike has already interfered considerably with the local coal trade, and the normal continuance of Sheffield's industries very much depends upon what may happen in the next few days. It is stated that last week's strike would practically close the works. Dépôts are very short. The present market position of steam coal is very good, and pressure for delivery is being experienced at collieries. The activity has extended, though not in the same proportion, to the secondary qualities, and there are far fewer stocks of these on hand. In consequence much larger tonnages are being sent to the ports. Prices have moved in sympathy, and are much firmer—in many cases higher. There is a freer movement of gas-coals, bigger shipments, and larger demands from the industrial centres. Slacks remain very scarce, but it is expected that the Lancashire mill holidays will reduce the demand for a short time. Though house-coal continues to show little activity at the dépôts and much short time is being worked at the pits, improvement is now beginning to be manifested and is likely to continue. Consumers are laying in stocks, and their requirements are expected to increase gradually, especially for best qualities. Pits have still considerable accumulations, but many of them are working better. Prices are little changed, latest 'Change quotations being:—Best branch hand-picked, 13s. to 14s.; Barnsley best Silkstone, 11s. to 12s.; Silkstone, 9s. to 10s.; Derbyshire house, 9s.; large nuts, 7s. 3d. to 9s.; small nuts, 5s. 6d. to 6s. 6d.; Derbyshire brights, 9s. 6d. to 11s.; washed nuts, 7s. 6d. to 8s. 6d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. to 5s.; smalls, 1s. 6d. to 2s.

Iron and Steel.—Up to the end of last week the influence of the holidays was still felt in the iron and steel trades, so that business transactions were on the light side. This week the railway strike, which has spread from Liverpool to Sheffield, has dislocated traffic. The immediate result of this disturbance in the labour world has been to cause consumers to postpone ordering material from Sheffield, and to interfere with export business from Liverpool. A more serious aspect of the matter, however, is in regard to fuel. If a settlement is not speedily arrived at, the Sheffield works will find themselves in a very serious position. Business in pig iron has been of very small proportions though prices generally are firmly held. Only small parcels of hematite have been dealt with. Lincolnshire makers are hoping to keep up prices over the next few weeks with a view to the better business which is anticipated in the near future. There is a large demand for basic billets. In the heavy trades the armament and general shipbuilding requirements are responsible for brisk conditions, and it would be difficult to set a limit to the activities of these branches. In the ordinary steel trades orders are less numerous, but all the indications are of a steadily-growing prosperity, with but one drawback, the unsatisfactory prices for many finished articles. Also, several firms are extending their premises, a further proof of trade expansion. The export trade has not been satisfactory recently. Decreases are reported in transactions with America, the Colonies, and the Far East. A new company, associated with a well-known Sheffield concern and a Nottingham engineering firm, has just been registered to manufacture tramway "lay-outs" of manganese steel. These, it is understood, will be made in Sheffield and fitted at Nottingham. Makers of agricultural implements and parts are well engaged, and in the lighter trades, generally, activity is wide-spread.

OUR RAILS ABROAD.—The year has not moved on in an encouraging fashion in connection with our export rail trade, the shipments in July having been only 30,945 tons, as compared with 43,779 tons in July, 1910, and 60,259 tons in July, 1909.

NEW PETROLEUM FIELDS IN TURKESTAN.—On behalf of the well-known Nobel Company, in Baku, Prof. Hjalmar Sjögren, the Swedish scientist, has recently completed a survey of petroleum springs in Turkestan. The springs in question cover a vast area, which extends as far as the Chinese frontier and the Pamir plateau. Although the result of the investigations has not as yet been made public, it is believed that the new springs will not, as had perhaps been anticipated in some quarters, revolutionise the petroleum market, but they are likely to be able to supply the ever increasing requirements of large surrounding districts; China, for instance, is becoming a large consumer. The new springs may, therefore, indirectly benefit European consumers. Prof. Sjögren has apparently not finished his investigations, and he expects to proceed again to Turkestan in a short time.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The situation in the steam-coal trade is still one of difficulty in consequence of uncertain labour conditions. Prompt supplies are still inadequate to meet current requirements; and until the balance of supply and demand has been restored quotations are likely to be maintained with firmness. The best large steam coal has made 18s. 6d. to 19s. per ton; secondary qualities have ranged between 16s. and 18s.; best bunker smalls between 10s. 3d. and 10s. 9d., and cargo smalls between 8s. 3d. and 9s. 3d. per ton. The best ordinary household coal has been making 14s. 6d. to 16s. 6d.; No. 3 Rhondda large 17s. to 17s. 6d., and smalls, 10s. 6d. to 10s. 9d. per ton. No. 2 Rhondda large has brought 12s. to 12s. 6d., and smalls 7s. to 7s. 6d. per ton. Foundry coke has been quoted at 18s. to 20s. 6d., and furnace ditto at 16s. to 17s. per ton. As regards iron ore, Rubio has realised 18s. 6d. to 19s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

St. Agnes Lighthouse.—The lantern of St. Agnes lighthouse, on St. Agnes Island, has been extinguished, after having been lighted for no less than 230 years. An iron tower, 45 ft. high, has been erected on Peninnis Head, on the neighbouring island, St. Mary's. From that point on Thursday night it flashed out the new light, which is of 1¼ seconds duration every 20 seconds. The new light is produced by gas through a single mantle specially made for the purpose.

The Drought in Wales.—The water-supply question has attracted a good deal of attention in South Wales, in consequence of the prolonged drought. Fortunately, so far as Cardiff is concerned, the storage reservoirs at the Beacons, Cantreff, Llanisben, and Lisvane were all full when the dry season commenced, in the middle of May, while rainfall which occurred during the latter part of June considerably augmented the supply, over 100,000,000 gallons being added to the quantity in the reservoirs. From the end of June until the 1st inst. there was no appreciable rainfall, but from that date to the 6th inst., thanks to a heavy rainfall in the Taff Fawr Valley, the quantity stored was increased by about 40,000,000 gallons, in addition to which there was a diminution in the consumption for the time being. Had it not been for those two heavy rainfalls occurring in June and at the beginning of August, it would have been absolutely necessary to restrict the supply within the city and in the outside area. Up to the present, however, Cardiff is in the fortunate position of not having its water supply curtailed in any way. The quantity of water now in store at the four reservoirs is about 640,000,000 gallons.

Welsh Coal for Italy.—The Italian Government has been authorised by a special Act of the Italian legislature to contract with one or more Italian shipping companies for the transport of 700,000 tons of coal annually from Welsh to Italian ports for the Italian State Railways and the Marine Department. The contract, which will be for ten years, dating from July 1, 1912, will carry an annual subsidy of 12,000*l.* from the Italian Treasury. Eight steam-colliers are to be built in Italian shipyards, unless their prices are more than 7 per cent. higher than the average of the estimates of six first-class British shipbuilders.

More Welsh Coal.—The Graigola seam has been successfully struck at Hill's Colliery, Clydach, after eighteen months' boring. It has a thickness of 5 ft., and its discovery will enable Messrs. Hill to develop a large area of unworked coal.

LUXEMBOURG STEEL.—The production of steel in the Grand Duchy of Luxembourg in the ten years ending with 1910 inclusive was as annexed:—

Year.	Tons.	Year.	Tons.
1901	257,055	1906	435,285
1902	314,930	1907	444,268
1903	371,979	1908	460,676
1904	366,302	1909	535,202
1905	397,943	1910	598,310

The value of the production of 1901 was 1,226,462*l.* The out-turn of 1910 was valued at 2,998,062*l.* Finished products figured in last year's output for 376,011 tons.

OUR LOCOMOTIVE EXPORTS.—The shipments of locomotives from the United Kingdom in July this year were upon a somewhat larger scale than in July, 1910, the value being 139,002*l.*, as compared with 99,280*l.* When the comparison is extended, however, to July, 1909, the value of the shipments for that month came out at 205,747*l.* The improvement which has been observable of late is due to a better demand for our locomotives in British India. The aggregate value of the locomotives shipped to July 31 this year was 1,381,944*l.*, as compared with 1,014,959*l.* in the corresponding period of 1910, and 1,617,658*l.* in the corresponding period of 1909.

CHROMIUM STEEL AND ACIDS.—In the German journal *Metallurgie* P. Monnartz describes arrangements for preparing alloys of iron and chromium, free from carbon, by the thermit process, and also for taking cooling curves at temperatures below 1600 deg. Cent. The higher the original temperature, the coarser the resulting crystalline structures of the alloys, which are softer than cast iron, and which yield homogeneous castings. The FeCr alloys are more readily attacked by hydrochloric and sulphuric acids than iron itself (which, of course, is not free from carbon), but turn passive in nitric acid. In the ordinary laboratory air and in water they remain bright. The presence of combined carbon makes them hard and more able to resist acids; molybdenum, titanium, vanadium, and tungsten (not manganese) also render the alloys more refractory to acids while improving the mechanical properties.

THE LAUBEUF SUBMERSIBLE BOAT.

CONSTRUCTED BY MESSRS. SCHNEIDER AND CO., ENGINEERS, CHALON-SUR-SAÔNE.

(*For Description, see Page* 226.)

Fig. 1. The Vessel on the Surface.

Fig. 2.

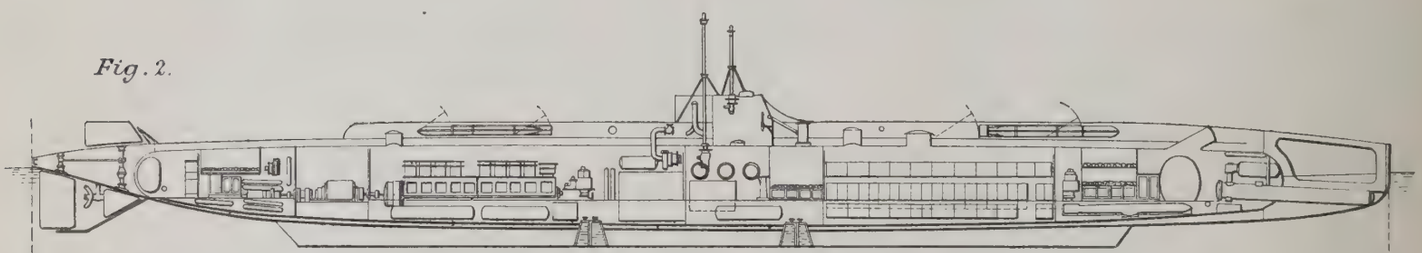
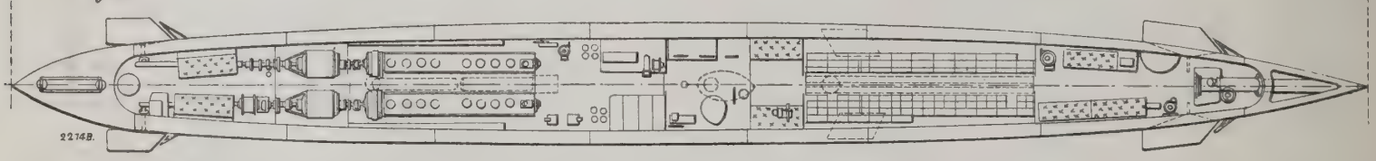


Fig. 3.



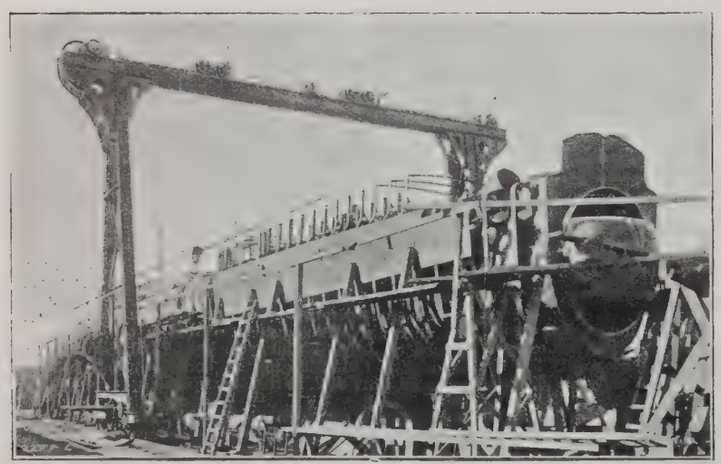
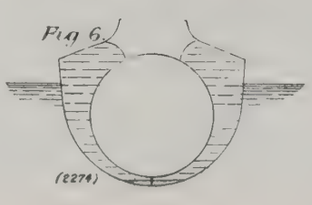


Fig. 4. The Vessel on the Building Berth.

Fig. 5. The Vessel being Launched.

The World's Gold.—The Transvaal contributed in 1910 34¼ per cent. to the gold production of the world; Rhodesia 2¾ per cent., and West Africa ¾ per cent., making the total contribution of Africa 37¾ per cent. The corresponding contribution of Australasia was 14½ per cent., in which Western Australia figured for 6¾ per cent. The contribution of the United States was 20½ per cent.; that of Russia, 7¼ per cent.; that of Mexico, 5¼ per cent.; that of Canada, 2¼ per cent.; and that of India, 2¼ per cent. Miscellaneous sources of supply made up the small balance.



A Spanish Tunnel.—A contract is about to be let for the construction of the Tosas Tunnel on the Ripoli and Puigcerda Railway. The estimated cost of the tunnel is 296,651*l.*

Saskatchewan.—A length of 1018 miles of new railway is expected to be laid this year in the Province of Saskatchewan. To this aggregate the Canadian Northern Railway Company will contribute 330 miles, the Grand Trunk Pacific Railway 340 miles, and the Canadian Pacific Railway 348 miles.

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Thin paper copies	£1	16	0
Thick „	£2	0	6

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ENGINEERING.

FRIDAY, AUGUST 18, 1911.

THE RESPONSIBILITIES OF WORKMEN.

The present labour situation owes its gravity more, perhaps, to the lack in certain quarters of that sense of responsibility which is so essential to permanent success in all business relations, than to the actual stoppage of work, serious as the latter is. The one cause appears to be reaching a permanent phase, while the other is transitory. The attitude now assumed by labour is a most serious development, which has gained impetus within the past three or four years. While we have no intention for the present of investigating the cause—we are now more concerned with effect than remedy—there can be no question that the bid for popularity by politicians generally, and the ambition of the glib-tongued labour agitator in particular, have had a demoralising effect upon the less-educated and less-skilled workers. Thus in the constructional engineering industries there was great laxity in the case of the iron-workers, who are skilled so far as their work is concerned, and are paid a high wage, largely because of the arduous nature of their occupation, but who are not considered to be so well educated as, for instance, the engine-fitter or the wood-worker. In the same way the miner, the dock labourer, and other more or less unskilled workers have listened more closely to the unscrupulous agitators than have others, and have shown a disregard for the responsibilities of their position in the producing and distributing industries. There is no doubt, too, that some labour agitators, less fortunate so far as place, power, and remuneration are concerned than the accredited labour leaders, are eager to secure preferment, and they recognise that this may be achieved by advocating more vigorous measures than are encouraged by the less demagogic trade-union leaders. The advice of the former, unfortunately, coincides with the inclination of the discontented, and, as a result, work has been light-heartedly deserted in numerous cases without the slightest regard to the interests of the nation as a whole.

The first important deduction from the prevailing condition of unrest is that there must be a fuller recognition of the value of conciliatory measures and a wider appreciation of responsibility on the part of workmen in honouring agreements which have been made with the assistance and approval of their accredited representatives. For several years great employers of labour have—in order to obviate stoppage of work—striven earnestly to ensure mutual conferences as to conditions of employment. Agreements have been entered upon instituting means for amicably settling disputes. Practically the only real difficulty in carrying out these agreements arises from the recalcitrancy of some of the men towards their executive councils. This, it will be remembered, was the cause of the trouble in the shipbuilding trade last year, and it is in a great measure the chief operating influence in connection with the disputes now going on in connection with railway, dock, and other workers.

The railway difficulty is probably the most serious, as it indicates on the part of well-educated and well-remunerated men a lack of discipline which is the more deplorable when the importance of transport to industry and to the life of the people is considered. In 1907 an agreement was entered into by railway companies and their employees at the instigation, and with the assistance, of the Board of Trade. The scheme was regarded at the time with great favour, as all questions at issue between the parties were to be settled amicably by conciliation boards. It may be that, pending a satisfactory setting to work of the machinery of the scheme—a matter involving many difficulties—delays occurred in arriving at a decision on points at issue; but this ought never to have been accepted as a reason for condemning the scheme, or for strikes, especially as the terms of settlement of all disputes have been made retrospective to the day when the first claim was made by the workmen. It is asserted that a difficulty has been the determination of some of the companies to negotiate primarily with their own men, and not through the unions. This attitude is abundantly justified by the fact that, on an average, only one-fourth of the railway workers are within the unions; the remaining three-fourths, by remaining out of the unions, obviously prefer to deal direct with their employers. If they ignored this preference, the companies would be acting unjustly to non-unionists, who are in a preponderating majority. Moreover, union officials have not always succeeded in ensuring the acceptance by the men of agreements which had been settled on their behalf by their representatives.

This has been exemplified not only in the case of some of the railways, but in connection with the London dock strike. In this latter instance the employers went farther to meet the men's claims than strict fairness justified, because it was of first importance to obviate the threatened interference with the food supply of the Metropolis. The agreement was accepted by a vote of the men, although the number voting was not great. There was general congratulation, and even His Majesty sent a telegram expressing gratification. For a time, however, the men refused to return to work, being influenced in this by self-appointed leaders. Following upon this, and encouraged by the widely expressed yet exaggerated view that London was on the verge of starvation owing to the dockers strike, and that the employers were thus at the mercy of the workers, men similarly employed in other ports put forth extravagant claims and left their work. From this stage workmen in many industries have thrown aside all sense of responsibility and have ceased work on any pretext whatever, and in some cases without any cause.

As a matter of equity, no one can prevent a man formulating what he may consider justifiable claims in connection with the terms of his employment. To carry his demands to the serious point of striking is, however, not so easily justified. But so long as human nature is as it is, such stoppages of work will be intelligible, even if not excusable. In the first place, however, ample warning should be given before such serious measures are resorted to. In any case the breaking of a contract of employment without notice should result in penalties upon the worker as well as upon the employer. The announcement on Tuesday night that the whole of the railway workmen embraced in the four railway trade unions would come out on strike within 24 hours if certain demands which they made were not complied with constituted an act which cannot be too strongly condemned. It is reasonable to assume that no complaints that could be made could possibly justify such a short-time ultimatum to the railway companies. In the case of the Great Western Railway dispute men actually left their work without any warning, and only formulated their demands after leaving their work. In view of the immense importance of the railway service and the strict legal obligations of the companies to the nation such arbitrary action ought to be punishable in some form or other, and should certainly involve civil responsibilities for damages or losses arising from such action.

The conciliatory scheme provided four years ago—even if not perfect in all respects—should certainly satisfy a great majority of the workers, and it should be given a fair trial for the period agreed upon. The present sudden ebullition of unrest is traceable to recalcitrancy more than to any other cause, and it is of vital importance that the railway companies should insist on the observance of the agreement as it stands. Any yielding under such conditions as now prevail would only result in demands being made from time to time for further concessions, and in rendering all agreements in trade disputes completely futile.

It may have been shown by experience that the present conciliation scheme has certain defects—perfection can hardly be expected in such a measure—but, as we have stated, this is no excuse whatever for ignoring it. The proper course would be to carefully formulate any objections which may be raised to it, on either side, so that these objections may be discussed, and, if necessary, arrangements be made for amending the scheme at the termination of the period to which it applies, or possibly, by mutual consent, at an earlier date.

As a rule employers scrupulously meet the conditions of such agreements, but in the case of workmen they are frequently broken. It will be remembered that in the new shipbuilding agreement penalties may be exacted from the men individually for any infringement of its provisions. That course has had a salutary effect. An alternative system is provided in the case of the

National Union of Boot and Shoe Operatives. In their case the agreement between the employers and the union includes a clause providing for "financial guarantees for duly carrying out the provisions of the agreement and existing and future awards, decisions of boards, arbitrators, or umpires," and the sum deposited by the union with the trustees for this purpose amounts to 1000*l*. At the same time it is provided that "if any provision of the agreement, or of an award, agreement, or decision be broken by any manufacturer or body of workmen belonging to the Federation or the National Union, and the federation or union fail within ten (subsequently reduced by mutual agreement to four) days either to induce such member to comply with the agreement, decision or award, or to expel them from their respective organisations, the federation or union shall be deemed to have broken the agreement, award, or decision." There is a right of claim by either organisation upon the guarantee fund "for loss sustained if work is not resumed on the morning of the fourth working day from the date on which the strike or lock-out is notified," the aim being to prevent the continuance of sectional strikes unauthorised by the authorities. If those breaking agreements, individually or collectively, were thus legally subject to penalties, responsibility on the part of all concerned would be more fully recognised.

The second direction in which the present crisis indicates the need for amended legislation is in connection with picketing. Under the Trades Union Act of 1875 it was illegal, but the House of Commons, in its wisdom, incorporated in the Trades Disputes Act of 1906 a clause to the effect that "it shall be lawful for one or more persons acting on their own behalf or on behalf of a trade union, or of an individual employer or firm, in contemplation or furtherance of a trade dispute, to attend at or near a house or place where a person resides or works, or carries on business or happens to be, if they so attend merely for the purpose of peacefully obtaining or communicating information, or of peacefully persuading any persons to work or abstain from working." This sanction of "peaceful picketing" was severely criticised at the time, as the Legislature failed to recognise the abnormal conditions under which picketing is invariably pursued. During all strikes passion runs strong, and the eagerness of the picket to prevent work carries him beyond his legal right, which is simply to obtain or to communicate information, or peacefully to persuade any person to work or to abstain from work. If one working man has the right to strike, the corresponding right to work as he wills must be conceded to another man. That fact is never fully recognised by the striker, and least of all by the picket.

What has actually occurred is that the law admitting peaceful picketing has become an excuse for forcible coercion, which the law was formulated to prohibit. It has been pointed out during this crisis by the Home Secretary that "where a crowd is so disproportionate in size to what is needed for lawful purposes as to exclude the idea of peaceful persuasion, the Act of 1906 may cease to apply." A crowd is never necessary to obtain or to communicate information; its purpose is to intimidate or coerce by a display, if not an exercise, of force. The Home Secretary further points out that any person who, to prevent another working, uses violence to or intimidates him or his wife or children, or injures his property, is liable to prosecution; and the same is the case if he follows him from place to place, or follows him, with two or more persons, in a disorderly manner. It is further pointed out that the right of peaceful persuasion only exists when the worker to be persuaded is willing to listen, and that the latter is entitled to refuse to hold any communication with the pickets if he so desires. If picketing is to be allowed to continue—and it is undoubtedly subversive of the personal right of the citizen—then each picket should be registered, carry a badge of distinction, and be responsible for any illegal act arising out of the exercise of his privilege. Moreover, the number of pickets in any given case should be strictly limited, so as to obviate that demonstration of force which has had the effect of arousing serious disturbances of the peace.

Infringement of the law of picketing is, as a rule, not the result of an act of the moment, nor is it even the outcome of sudden passion; it arises as almost a natural sequence from the deliberately-planned scheme of campaign formulated by trade unions. Unfortunately, too, the authorities have lately been remiss in their enforcement of the law so far as it is concerned with "peaceful" picketing. Of these facts many proofs could be given. It is sufficient commentary to recall that within the past few days the strikers or the leaders, in various towns, showed their approval of coercive measures by permitting certain goods to be delivered to certain clients, and withholding permission in other cases. The issue of such permits established the approval of a conspiracy for the prosecution of coercive measures which were the incentive, and ultimately the direct cause, of violent conduct on the part of strikers or others. Again, the fact that a Government department—the Post Office—even for the delivery of the mails, utilised this practice of issue of permits by law-breakers or prosecutors of acts of conspiracy, was in itself sanction of such violent measures, and a recognition of an assumed authority which should have been sternly resisted. This acceptance of a serious infringement of the common law has been a most serious mistake, and it could not have any other effect than to encourage other strikers in the same evil course.

Some Members of Parliament profess to deprecate the use of violence, saying very truly that violence tends to beget violence. It is, however, evident that the only violence they deplore is the display of force by the authorities to protect citizens in the exercise of their legal rights. It was a French judge who supported the abolition of capital punishment on the condition that "Que Messieurs les assassins commencent;" and if strikers and their leaders will themselves refrain from violence, they have nothing to fear at the hands of the police, or, *a fortiori*, from the military forces of the Crown. In labour disputes the duty of the authorities is, in the first place, to hold the lists and see that neither side resorts to violence in the furtherance of their ends; that, we are glad to note, is now the avowed and fixed determination of the Government, in the event of a railway or of other strikes. Where violence is exercised it must be stamped out vigorously. The law must be maintained, and it must be made clear—so that even the man of inflamed passion may understand—that infringement of the law carries as its inevitable sequence the punishment of the law, and, further, that the man who deserts his post at work for a real or imaginary grievance has no claim to reinstatement, particularly if this involves the dismissal of those who have chosen to continue or to take up work during the progress of the dispute.

THE DISPOSAL OF MINING REFUSE.

The satisfactory disposal of mining refuse is a matter frequently hedged about with difficulties, the greatest of which probably arise from conflicting interests. Where a certain district is given over almost entirely to mining operations, little or no trouble may arise; but where mining and agriculture are carried on over areas not far separated from each other—for instance, in the same valley or watershed—the case is different. It is then that the conflicting interests arise. These interests may not, of course, always be confined to mining and agriculture, for where manufactures are established on rivers and streams below the mines, these also may have to be considered in any legislative action that may be found necessary. In the case where agriculture and mining alone are concerned, the charge is frequently, and, no doubt, sometimes quite justly, made by farmers that the pollution of and silting up of the streams which run through their land, brought about by the effluents and tailings from mines above their property, is such as to cause material injury to the cattle that drink the water, and damage to the river channels. The extent of the damage done is often exaggerated on the one side, and the amount of pollution minimised on the other; but it is certain that in a great many cases the agriculturist has good cause for complaint, though it may not always be easy to find a remedy. Both mining and agriculture are of high importance in any country, but more particularly perhaps in a new country that is being opened up to settlers, who require as much encouragement as possible. It might be a comparatively easy matter to sacrifice one or the other, and to decide that the district should be given over either to mining or to agriculture; but it would not be policy, at any rate, in a country needing both industries, and in simple justice the rights of both must be duly considered.

A state of things similar to what we have mentioned appears to exist in some parts of Victoria, owing to the discharge of mining sludge into the rivers and streams of an agricultural district, and it is the subject of a report of the Sludge Abatement Board contained in a Blue Book recently issued by the State Government. The Board has been in existence for some time, and has, in the face of many difficulties, done some very important work and has put a stop to much of the unnecessary pollution of streams that was a cause of complaint. Its hands have, however, been somewhat tied, and it has not always been able to enforce the existing laws as promptly as required, for there are some mine-owners who seize any chance they may get to evade the law where this can possibly be done. There are, on the other hand, many mine-owners who, the Board admits, show a marked desire to obey the law, and the effort is always made by the authorities to hamper the gold and tin-mining industries as little as possible, while at the same time the farming interests are protected. During the year 1909 it was, in some cases, necessary to take legal proceedings under the Mines Act against certain offenders, while in others arrangements for the retention of debris were made without having to resort to drastic measures. At Ballarat several prosecutions took place, and fines of 50*l*. were inflicted by the police magistrate; but here in some cases a difficulty arose, for an appeal to the Supreme Court by the company fined the largest amount resulted in the conviction being set aside, it being held that the Sludge Abatement Board was a judicial or quasi-judicial body, and "should, before serving an order on any company, party, or individual, give such company, party, or individual an opportunity to state any objections that it, or he, might have to the order it was proposed to issue." This decision may have been quite right in law, but would appear to have been very bad policy, for it at once had the natural effect of rendering invalid all orders previously issued, and a fresh start had to be made by issuing draft orders, and inquiries had to be held, at which the parties on whom it was intended to serve the orders might attend, and have the chance of showing why the orders should not be served on them, or give reasons why they should be modified. The delay caused by this gave an opportunity to companies and persons disposed to pollute streams a capital opportunity for the improper discharge of large quantities of tailings into them between the times when the intention to serve the orders was known and the times when such service was actually made. In one case several thousand tons of sand were discharged into a creek during such interval, advantage being taken of a heavy rainfall at the time. The necessity of having to give the notice referred to obviously militates greatly against the efficiency of the work of sludge abatement, and it would appear to be far more beneficial if the offenders against the Act could be brought to book at once without the delay we have named being required. The decision of the Supreme Court Judge has in some cases resulted in much inconvenience and injury to settlers down stream, owing to the surreptitious discharge of large quantities of scum, but it is hoped that the offending mine-owners will eventually be brought to justice.

As previously stated, however, mining operations are sometimes falsely accused, some farmers at once concluding that when a discoloration of the streams takes place it has its origin at the mine, apparently forgetting that streams are frequently discoloured and polluted by perfectly natural causes, such as freshets, which often carry down far more material than is ever sent into the stream at one time by the mines. Thousands of cubic yards of ground may be carried into the river channel from roads, neglected banks, &c., and may attract little notice. Then, again, the fact that it does not really require very much suspended matter to colour the waters of a stream is lost sight of, so that the colour test is by no means a safe criterion alone. Water indignantly likened to "pea soup" may, on careful examination, be found to contain only a comparatively low percentage of solids, which cannot in fairness be said to cause pollution. On the other hand, there may be cases in which a similar small quantity of certain solids may be a danger or, at any rate, an inconvenience to stock. The Parliament of Victoria has therefore decided not to abolish mining in the State by insisting on complete limpidity, but has been content to allow a certain amount of solid matter to be turned into the stream, an amount which need not necessarily be reached in actual work. A very close watch has,

however, to be kept on the mines, for some of the owners do not appear to be at all inclined to accept the statement of the farmers that their tailings are injurious, some of them, indeed, going so far as to say that, in certain cases, discharges of sand are even beneficial. It is evident, therefore, that a strong and entirely independent body, to decide between the opposing interests, is the best thing for all concerned.

Of course, the pollution of the rivers and streams in question varies enormously from time to time, and it is a rather curious fact that the farmers do not appear to trouble themselves very much about the nature of the pollution, so long as the water is not discoloured. In one case that came before the Board it was stated that in a part of the Tanjil River horses refused to drink of the water, which was described as being of the colour and consistency of pea soup, but it turned out that the water had only been viewed in bulk, and no witness had taken the trouble to examine any of it in a tumbler, forgetting, apparently, that the amount of suspended matter that may make a stream look like "pea soup" is, in reality, often quite small. Great objection was taken to this water, the suspended matter in which would, no doubt, soon have settled in any vessel containing it. It appears that a pump had been erected by the Rosedale Council for the use of the inhabitants of the place for drinking and other purposes; and this pump was down-stream from a bathing place much used by the people; a doctor also had reported that the water should be boiled. Yet the country residents and the townspeople had no objection to the bathing, nor yet to cattle standing in the stream, so long as the water was not discoloured. This shows, of course, that complaints as to the harmfulness of pollutions from the mines have to be received with due caution.

In another case a sample of dirty water taken about 20 miles below some mining dredgers was produced, and on examination it was found to contain not quite $2\frac{1}{2}$ grains of solids per gallon. At this time it was stated that two dredgers were in full swing. In addition to the objections from farmers as to actual pollution, many of them maintain that they fear the effects of siltation of their flats by barren mining silt. Evidence on this point is, however, conflicting, such fears not being universally entertained. It is, of course, quite easy to understand that damage might be done in this way, but much of the sludge, &c., that is deposited has a distinct agricultural value. Analyses made by the chemist for agriculture showed that the ground of these flats for 1 ft. or so below the surface was rich in plant food, but it was not so good below that depth, though there was in it a fair percentage of certain of the compounds of a good soil. In order to ascertain the value of the mining sludge from an agricultural point of view, samples of the solidified matter were taken from the settling dams and analysed. The result for the top foot was good, but not so good for the second foot.

It seems that the worst effluent going into the river while the Tanjil Giant Company was in full swing contained on analysis 520 grains of solid matter per gallon; the river a mile below the works carrying 70 grains, and 51 miles down $2\frac{1}{8}$ grains per gallon, the appearance in bulk being very white. At another time the river 51 miles down contained $6\frac{3}{4}$ grains. As an indication, however, that this amount really indicates little so far as the mining is concerned, samples of water taken four days later from the river above the mines showed that the solid matter contained amounted to $4\frac{3}{4}$ grains per gallon, which was due to the scouring of the surface by heavy rains. The variations in the quantity of solid matter carried in these streams are very great; for instance, on one day the effluent water was found to contain 228 grains per gallon, and the river above half a grain. The following day, 14 miles below the dredgers, the matter held in suspension was half a grain per gallon, and at 35 miles and 51 miles below the results were the same.

The pollution of water by mines in agricultural districts is, however, not the only danger that farmers have to fear, as is shown by the report before us, for there is another and perhaps greater one, which requires careful watching. This is the absorption or collection of poisonous matter by the soil and vegetation in the vicinity of the mines. As proof of this, specimens of soils and herbage taken from a chemically affected area near Specimen Hill, Bendigo, were found to contain considerable quantities of deleterious matter, in one case as much as 0.105 per cent. of arsenious oxide being found in the soil and 0.158 per cent. in the herbage. Such an amount as this in herbage would prove poisonous to all stock grazing in the locality; in fact, cattle are said to have died from eating such grass. It is considered that the dangerous matter had been deposited from fumes escaping from the pyrites smelting works.

According to the Mines Act of the State, the amount of solid matter that can legally be discharged into any stream must not exceed 800 grains per gallon, and in no case has this amount, so far as is known, been passed. This 800 grains per gallon appears, after all, to be a very large quantity when we consider that stock accustomed to clear water will probably reject it until they become accustomed to it. Without filtration or clarification it is also unfit for human consumption.

As a result of their investigations, the Board are of opinion that the allowable solids per gallon might with advantage be placed at 500 grains, and not 800. They are clearly of opinion that too much attention should not be paid to discoloration of the water, as this is known to be caused by very small amounts of suspended matter; in fact, if mining operations are to be carried on at all, far higher amounts of suspended matter than will cause discoloration must be allowed. It is said, indeed, that if discoloration due to $2\frac{1}{2}$ grains per gallon, or even four times that amount, were forbidden, alluvial mining would in many cases be prohibited.

THE RAILWAY SITUATION.

Had this article been written at the immediate termination of the railway half-year there would have been little to record but a continuance of the prosperity which characterised the situation six months ago, and which there seemed every reason to believe might be expected to continue for some months to come, although, as pointed out by Mr. Wharton in his address to the shareholders of the North-Eastern Railway, there were distinct signs that the tide of prosperity had reached its full height, and might soon be expected to recede. During the concluding weeks of the half-year, he said, the steady increase in receipts disappeared, and there was also a reduction of the furnaces in blast in the district served by his line. The North-Eastern Railway, having almost a monopoly of transport in a very important industrial area, is peculiarly sensitive to trade changes, and thus the symptoms alluded to by the chairman are in all likelihood precursors to a general slackening of the currents of commerce, so that even had not new and unexpected disturbances arisen, some reduction in the traffic returns during the next six months was highly probable. As matters stand at the moment of writing, this seems now almost inevitable; but we deal elsewhere in this issue with the sudden refusal of labour in the transport trades to honourably maintain the contract they entered into with the companies four years ago. As pointed out elsewhere, the reasons given for this throwing over of the Conciliation Board are wholly inadequate and unreasonable, and are therefore presumably ostensible merely.

From the statements made by the chairmen at the general meetings of the companies, it is obvious that the National Insurance Bill will, unless the railways are scheduled out of its scope, be highly injurious, not only to the shareholders, but to many of the employees themselves. As matters now stand, railway clerks, as regards invalidity insurance, are very much better off under existing conditions than they will be under the Act; and as regards other classes of railway employee, the provident societies established and assisted by the companies provide in general greater benefits than will be secured under the proposed Act. At the same time the latter will hit somewhat hardly the most deserving class of railway investor—viz., the man who develops the industry of the country by taking risks. It is the fashion to sneer at a greed for dividends, but the expression is more telling than intelligent. The men who take the risks, and not the careful investors in debentures, mortgages, and corporation stocks, are those to which civilisation is indebted for every forward step in our interminable conflict with Nature, and it is this class on which our present system of national finance mainly imposes its burdens. In the case of the London, Brighton, and South Coast Railway, for instance, the amount taken from the ordinary shareholder for rates and taxes is more than 50 per cent. of his actual receipts, and much the same condition obtains in the case of other companies. If the National Insurance Bill passes without serious amendments, a very considerable additional burden will be placed on the shoulders of the ordinary shareholder, equivalent in many cases to a decrease of about $\frac{1}{8}$ per cent. on his dividend.

In introducing his Bill, Mr. Lloyd George said that the employers' contribution was intended to be a charge on the industry, which, accordingly, would ultimately be paid by the consumer. Since, however, the railways, in practice if not in theory, are prevented from raising rates, they will be wholly unable to transfer the charge to shippers. It has been suggested that the ordinary shareholder might obtain relief from these constantly-increasing burdens by the raising of passenger fares and such an increase is no doubt feasible. Experience shows, however, that in most cases the procedure would be highly unprofitable. Capital charges are the principal burden on a railway, and hence a high "load-factor" is conducive to large net returns. Of course, it is possible to fix fares too low, and one of the first reforms made by Sir George Gibb, when appointed to control the District Railway, was to raise the average fare from 1.67d. per passenger to 1.87d.; but the error of fixing fares too low is much less common than the reverse, as is particularly well shown by the results of recent adjustments of fares on the London, Brighton, and South Coast Railway and on the Great Eastern line. On the latter line, for instance, the reduction recently made in the suburban fares has increased the receipts in the half-year by over 26,000*l*.

The London and North-Western Railway has been able to pay 6 per cent. on its ordinary stock, which constitutes a record for the line. Another record was also broken, the capital expenditure for the year—viz., 344,037*l*.—being the lowest in the history of the company. Most of this has been attributable to the Euston to Watford widening. Both passenger and goods traffic for the twelve months exceeded all previous returns, and on Coronation day the Company finished its 5000th locomotive. The goods earnings amounted to 10s. 9.44d. per train-mile, a figure unprecedented on this railway, and no doubt largely due to the keenness shown in cutting down unprofitable mileage, since during the half-year one million tons more of merchandise were carried on a train-mileage less by 40,000. The earnings per passenger train-mile were only 4s. 3.69d. The Midland Railway has also had a good half-year, but the most interesting matter brought forward at their meeting was the proposal to take over the London, Tilbury, and Southend line.

The Lancashire and Yorkshire Railway Company are able to make the best distribution for a period of eleven years, the gross receipts being 95,000*l*. more than in the corresponding half of 1910. The number of passengers carried was 31,229,544, being an increase of 1,134,423. Of this total about one-half is attributable to the electrified lines. This fact well shows the popularity of the frequent service and relatively high speeds which are attainable only with electric traction. The electrification of a portion of the Brighton line has had similar results, where the whole of the loss to the trams has now been made good. From 1904 onwards till the electrification of the South London line in 1909 there was a continuous diminution in the number of passengers carried. There has since been a rapid increase, which is certain to be accentuated so soon as the electrified lines to the Crystal Palace are in full working. This is not possible at present, since the supply of current available is insufficient, but the enlargement of the generating station from which the electricity is purchased is being rapidly pushed on with, and by the end of the year it is hoped that electric traction will be available for running the trains between London Bridge and the Palace. As matters stand the additional receipts from the electrified lines are 30 per cent. of the total increase. The statement that the company has now recovered its loss to the tramways, is, perhaps, not wholly justified. No doubt, to some considerable extent, passengers who formerly patronised the trams have been attracted back to the railways, but the tramway returns make it evident that to no small extent the increase in the receipts has been largely due to the creation of fresh traffic, by providing attractive facilities for it, in

the shape of frequent and relatively fast services. It is, however, interesting to note in this connection that the North-Eastern Railway Company, in spite of the success which has attended the electrification of their lines on the north of the Tyne, do not consider that it is as yet advisable to adopt electric traction on the Newcastle to South Shields line, although the traffic here is very intense.

A noticeable feature of the railway accounts is the poor direct return from the steamboats. Thus in the case of the Brighton line, for instance, the loss on the steamboats for the half-year was 3644*l*., but in spite of this the services are being improved. The Newhaven, the latest of the turbine boats in the Dieppe service, has a speed of 24 knots, and can make the trip in 2¾ hours. Another, the London, will also soon be ready. Both these boats are owned in France, but the Brighton Company intend shortly to build another themselves. With these high-speed boats and with the completion of the Pontoise line, avoiding Rouen, the time from London to Paris will be reduced to seven hours, or about half an hour less than by the best of the existing services by the short sea route.

What steps the South-Eastern and Chatham Railway combination will take to make good the threatened diversion of traffic have not yet been announced, with the exception of the decision to build a new turbine steamer, in addition to that just put in service The provision of these cannot, however, substantially reduce the duration of a passage which already lasts but some 60 minutes or so, and it is hardly probable that the already excellent train service between Calais and Paris can be greatly speeded up. Hence, if any improvement is to be affected, it is, as the Americans says, "up to" the railways on this side of the Channel, on which the best trains are booked at the liberal rating of 1 hour 40 minutes for a distance of under 78 miles. Possibly the bridge reconstructions referred to at the general meeting may have been undertaken with a view to speeding up this service, and the proposed straightening of curves at Tonbridge will also be useful in this regard. The combined companies, it was announced, have decided to concentrate their shops for repairs and construction at Ashford, the Battersea works being abandoned. This decision is, of course, in accord with precedents for some years past, as company after company has been dismantling its branch shops, and we note that the North-Eastern Railway is also about to abandon locomotive building at Gateshead and execute all such work at Darlington.

At the Great Northern Company's meeting the chairman announced that about 171,000*l*. would be spent during the next half-year in widenings to the main line and in the construction of new lines at Finsbury Park and between Corby and Essenden. It is also intended to work a light line from Lincoln to Skegness, which will shorten the distance between the latter resort, and Yorkshire and Lancashire, by about 10 miles in distance and one hour in time. Several of the Great Northern locomotives, we learn, are to be fitted with superheaters as an experiment, and the results will certainly be awaited with interest.

There have been somewhat bitter complaints from passengers on the North-Eastern Railway against the delays which have arisen from the introduction of a more rigid system of ticket inspection. That this was necessary is, however, very conclusively shown by the chairman's statement that over 30,000*l*. per annum is collected from passengers travelling without tickets or with tickets available for a part of the journey only. In view of the infrequency with which season-tickets are inspected in the London district, it is highly probable that frauds are equally prevalent here.

Unquestionably the most noteworthy feature of railway history during the past decade has been the gradual rehabilitation of the various underground services. Three years ago the Metropolitan Railway had but 18,000*l*. available for dividend; now the sum is 61,424*l*. The receipts from passengers, goods, and parcels have all increased. To facilitate the clearance of the trains from stations central doors are being fitted to the electric cars, which have hitherto had doors at the ends only. At Neasden new turbine generators are being installed; one of these is already at work, and is showing a substantial economy over the old double-flow machine which it replaced. The automatic signalling system has now been completed from Willesden Green to Neasden, and extensive improvements are in progress at Baker-street Station, over which it is ultimately intended to erect a large hotel.

In the case of the District Railway, again, the improvement effected has been phenomenal. For the first time for twenty-seven years the first preference shares have received their full dividend, which from the year 1900 to 1909 was stopped altogether, whilst at the same time arrears on prior stocks were accumulating. The last of the arrears on the guaranteed stock will be paid off in the next half-year, thus reducing the prior charges by 6250*l*. The improvement has been mainly due to a judicious expenditure of fresh capital in improving the services, and this is still being proceeded with. Fifty-one new cars were ordered last year, and this number is to be further augmented, the money necessary being secured by the issue of prior lien bonds. The second preference shares still receive no return. The widening between Ravenscourt Park and Acton is being rapidly completed, and is expected to be ready for use in November next. In conjunction with the London Electric Railways, the company have purchased the Lot's-road power-station.

The Central London Railway have carried over 20 million passengers in the half-year, but this was a reduction of 658,609 as compared with the corresponding half of 1910. The decrease is attributed to the motor-bus competition. Of these motor-buses there is a one-minute service eastwards from Lancaster Gate. Twelve months ago 162 omnibuses passed this point in four hours, but the number has now risen to 205, carrying about 5200 passengers. At certain times of the day eight omnibuses going citywards pass the Oxford-street Station in one minute, and 240 in the hour, these vehicles having a seating capacity of 8160, or about one-half of the full capacity of the railway. Probably improved traffic will result from the completion of the Liverpool-street extension, which will be opened in about six months' time.

The pioneer of the tube lines—viz., the City and South London—reports a record half-year, carrying more passengers than ever and more per train. The gross receipts accordingly rose by 5040*l*., of which, however, 1850*l*. was directly attributable to the non-recurrent traffic arising from the Coronation. This line is handicapped by the low commercial speed of its trains, which is but 13½ miles per hour, as compared with 17 miles on the other tubes, and 20 miles on the electrified portion of the London, Brighton, and South Coast Railway. The directors have, therefore, sanctioned experiments, by which it is hoped to reduce by five or six minutes the time between termini.

An agreement to electrify the East London line has finally been reached, and as soon as parliamentary sanction is obtained the work will be put in hand. A service of twelve trains per hour is proposed. The current required will be purchased from Lot's-road.

ELECTROLYTIC DESTRUCTION OF REINFORCED CONCRETE.

An interesting contribution to the discussion on the electrolytic destruction of reinforced concrete, which Messrs. C. E. Magnusson and G. H. Smith raised at the Chicago Convention of the American Institute of Electrical Engineers last June, was made by Mr. Harry Baker and Professor W. L. Upson on behalf of two students of the University of Vermont, Messrs. O. J. Olgiati and H. Roberts. We dealt with the experiments of Magnusson and Smith on page 174 of our issue of August 4, and will to-day confine ourselves to the distinctive features of the experiments of Olgiati and Roberts.

These researches deserve attention because electrodes of iron and of carbon were embedded firmly or loosely into the concrete cylinders and tested with direct or alternating currents in duplicate experiments, the circuit comprising blocks of different kinds, and further dummy blocks of concrete without electrodes. Collapsible iron electrodes, consisting of sheet iron, rolled up with filter paper interposed between the layers, and tubular iron electrodes filled with oil, in order to determine the temperature rise, were also used. The concrete blocks were placed in water. The thermal electrodes penetrated right through the block of concrete, and the connection with the current lead was made outside the block, so that there was only heating, and no electrolysis through the mass of the concrete. By these means it was possible to estimate, in how far mere thermal expansion of the iron accounted for the cracking of the concrete. For the electrolytic tests the current was introduced in a different way. The electrode, a piece of iron piping, was either embedded entirely in the block, the pipe ends being plugged, or the one end of the pipe was allowed to project, and the other end was brought flush up to the surface, which was covered by a layer of pitch. Copper rings were pushed over the cylindrical surface of the block, and the insulated leads were attached to these copper rings. In the case of the completely embedded electrodes the current travelled from a set of rings through the concrete to the iron, and out again through the concrete to another copper ring, fixed over the upper portion of the block which projected above the water. When the electrode itself projected out of the block and the water, the second wire was joined to the upper end of the electrode, and several blocks were, in both cases, coupled in series in this way.

The concrete blocks were made of ironclad Portland cement, a sand which does not appear to have been particularly suitable, and broken stone. The currents, both direct and alternating, were either of 0.1 ampere or of greater intensity. When the direct weak currents were turned on, some material appeared to be washed out of the ferro-concrete blocks, gas was liberated, and the surface of the block gradually became covered with a rusty deposit. The apparent resistance of the concrete would rise, until a crack developed after perhaps fourteen days, and would then decrease. Weak alternating currents produced neither gassing nor corrosion. But when the alternating currents were raised to 3 amperes, which caused a temperature rise in the electrodes to 45 deg. Cent. (113 deg. Fahr.), the blocks split in ten hours. The collapsible electrodes behaved like the others, except that they held out longer under direct currents, apparently until the rusting had proceeded so far that further expansion was prevented; strong alternating currents did not cause splitting, evidently because, in the absence of rusting, the thermal expansion remained unimpeded.

The carbon electrodes burst the blocks under direct currents very much like iron electrodes; there was gassing and a thick black mush was forced out from the badly-corroded carbon anode; some compounds seemed to have been formed between the carbon and the concrete.

In the case of the loose carbon electrodes a decided odour of chlorine was sometimes noticed, which was probably due to the salt in the carbon; the carbon was again corroded, but no splitting took place, showing that the loosely-embedded electrode had room enough to expand during its corrosion. Alternating currents did not do any harm to blocks containing carbon electrodes.

In a final series of tests sets of twenty-two small blocks were made up of the four kinds of electrodes, tubes, collapsible sheet iron, loose and firm carbons, and of dummy blocks; the blocks were immersed for three weeks before testing, then submitted to electrolysis, and finally crushed in an Olsen machine, two at a time at progressive intervals, in order to ascertain whether the weakening of the concrete was gradual or sudden. The conclusions may briefly be summed up as follows. Mere thermal expansion will destroy ferro-concrete, when produced by electric currents of high density; the currents may be alternating or direct, and their direction is immaterial in the latter case. Such thermal disruption may result in a few hours owing to leakage of direct or alternating currents. Weak currents, insufficient to act thermally, cause corrosion, because iron oxide is formed at the anode surface, and penetrates into the concrete at a rate depending upon the porosity of the concrete, the current intensity, gas pressure, &c.; the oxygen seems to be due to the electrolysis of water, and not to be taken up from the concrete. The progressive corrosion of the iron is not accompanied by any gradual reduction in the strength of the concrete, but the gas pressure may hasten disruption. Disruption will ensue also when the anode is not of iron (but of carbon), because oxidation and expansion are the chief causes of the trouble.

These latter conclusions, which concern carbon electrodes, and also the experiments made with collapsible sheet iron, have no direct importance for the engineer. The engineer wants a concrete which is firmly bound up with the iron, such that the iron will impart its mechanical strength to the concrete. Scientifically, however, these experiments are valuable, because they demonstrate the correct-

ness of the assumption, that it is the expansion accompanying thermal or electrochemical effects upon the core in concrete that has to be guarded against. Large leakages of direct or alternating current may lead to structural failure within a few hours. Small leakages of alternating currents may sometimes be disregarded ; yet much depends upon the shape of the current waves, as we know from other researches. With small leakages of direct currents, an insidious, slow undermining of mechanical strength must be feared. There is little danger in any case, as long as the concrete is kept dry. But moisture finds its way into everything, and a sharp look-out should be kept for stray electric currents. The electrician knows how to maintain an effective electric survey. As regards the prevention and the cure of the rusting of iron in concrete and in general, the most recent researches have not placed new resources at the disposal of the engineer.

THE MANUFACTURE OF DRAWN TUNGSTEN FILAMENT LAMPS.

Electric lighting, probably more than most branches of applied science, has been remarkable for the number of radical developments which have from time to time modified its practice and scope. The introductions of the carbon-filament lamp, the Nernst lamp, the flame arc, the vapour lamp, and the metal-filament lamp mark a series of stages in its progress which in their basic and far-reaching character it would be difficult to parallel in any other art. These various introductions have in each case modified the whole practice and outlook of electric lighting, and, in particular, have greatly increased its efficiency. The new forms of lamp have, in some cases, naturally introduced new difficulties and problems, but these have usually formed but the starting-point for further improvement, and the latest development in our list—the metal-filament lamp—forms an example of this. These lamps possess such superior efficiency as compared with the carbon lamps, from which they are a development, that on their introduction they met with immediate success. None the less the moulded filaments from which they were made were extremely fragile, and this fact probably hampered their progress to some extent, rapid though it was. This weakness, however, was from the first an object of attention to the lamp-makers, and during the last few years great improvements in filaments have taken place. These improvements have now culminated in one of the important steps characteristic of electric lighting, and a process has now been developed by which tungsten can be drawn into wire so that wire filaments can now be made which actually are wire, and are no longer built up of particles of metal fused together.

The first introduction of the manufacture of drawn tungsten filaments into this country has been made by the British Thomson-Houston Company, Limited, which has equipped a series of shops at their Rugby works for this purpose. We had an opportunity of inspecting these shops on the 16th inst., and found them of a very complete and workmanlike character. The process of actually drawing the tungsten into wire is a secret one, and no details are available for publication ; but we propose to describe the various processes which go to the making up of the lamps, as they are of a very interesting character, and differ in many particulars from the practice of other makers. Before dealing with the details of manufacture, it should, however, be said that the drawn tungsten, which we had an opportunity of examining, is quite remarkably strong, and that at a first trial there is difficulty in breaking it with the fingers. Advantage is taken of this strength in the design of the lamps, as, instead of building the filaments up of a number of short lengths of wire, joined together at the points of support, as was the method when a squirted filament material was used, the filament is now made up of a single length of wire simply looped round the supporting wires. This arrangement has the advantages over the old one that the whole filament is free and capable of adjusting its various parts for equal tension, while, as there are no joints, but a single continuous conductor, no question arises of one length of filament reaching a higher temperature than another owing to slightly shorter length and consequently higher resistance, which is an always-present possibility with the jointed system. The effect of a length of filament running at a higher temperature than its neighbours is, of course, to shorten the life of the lamp, as its career is determined by that of its shortest-lived member. It should, perhaps, be said that in the older method of manufacture the so-called squirted filaments were made up by mixing the tungsten, in the state of powder, with a binder, squirting the mass through a die, and afterwards electrically subjecting the formed filament to a high temperature, which vaporised the binder and fused the particles of tungsten together.

The manufacture of the lamps is divided up into a number of detail processes, each of which is carried out by one or more girls, working on a piece-work basis. As is almost universal in modern factories, the work, beginning at one end of a shop, gradually progresses forward to the other end, receiving its necessary operations and manipulations from the successive girls, who each deal with one detail or process only, and in such an order that the whole progress is continually forward, from the raw material at one end to the finished lamp at the other. The work, being of a small and delicate nature, is well adapted to girl labour, and can for most of its processes be carried out while the operators are seated at benches. A view of one of the shops, showing the exhausting apparatus in the foreground, is given in the illustration on this page. This view is characteristic of the whole of the shops, and gives a good idea of the general conditions under which the lamps are manufactured.

The Lamp-Exhausting and Testing Department of the British Thomson-Houston Company at Rugby.

The glass of a finished lamp is made up of three originally separate parts, which may be considered to be the starting point of its manufacture. These are, firstly, the bulb, which is blown with the sealing end closed and a wide opening at the end which finally carries the cap ; secondly, the small flanged tube which carries the conducting-wires from the cap to the filament ; and, thirdly, the glass supporting-stem which carries the radial steadying-wires for the filament. The third of these parts is simply made from lengths of glass rod by a girl who holds them in a blow-pipe flame and forms the small swelled-out parts, on to which another girl in a later operation fuses the radial steadying-wires. Before the fixing of these wires, however, the supporting-stem is fused to the second glass part—*i.e.*, the tube which carries the leading-in

wires. This process is carried out on a horizontal wheel, attended to by two girls, and arranged with some half-dozen supports round its circumference, on which the two glass parts can be set. There are two blow-pipe flames playing on two of the supports at all times, and as the wheel is rotated into any one of its six positions which are determined by stops, the glass parts carried by it are moved into position under the flame in turn. The two girls feed the machine with the two independent glass parts, one of them setting the leading-in wires in position before the parts reach the flames to be fused together, and the other closing the glass tube on to the wires, when it is semi-molten, and so forming what finally becomes the closed end of the lamp. The radial steadying-wires before mentioned are fused into the glass supporting-stem after the process just described has been carried out.

The next operation is the winding of the filament on to the radial supports and the connecting of it up to the leading in wires. This is carried out by hand, the tungsten wire being supplied to the operator on a reel, from which she cuts off a measured length, handling it with small pliers, and winding it around the supports to form the filament of the finished lamp. The leading-in wires are in the form of very small copper tubes, and the operator who winds the filament connects it to these tubes by simply inserting it into their ends and closing them with her pliers. No other form of connection beyond this mechanical one is used. The connecting wires have, of course, a small length—about $\frac{1}{8}$ in.—of their length made up of platinum at the point where they pass through the glass. The fusing of the internal glass stem and tube carrying the filament, to the bulb, is carried out on a machine fitted with blow-pipe flames and corresponding very nearly with the machine, previously described, on which the stem and tube are fused together; but before this process is carried out, the bulb receives a preliminary treatment by having an exhausting-tube fused to the centre of its spherical closed ends. The hole for the reception of this tube is made by a small flame impinging on the end of the bulb.

After the assembling of the filaments and their holders in the bulbs, the only process, apart from the fixing of the caps, is the exhausting of the lamps. This is carried out by means of rotary pumps, the lamps being mounted on machines in batches of six at a time. The first exhaustion is carried out by a general pump which serves all of the machines, the lamps being finally treated by further pumps, of which one is fitted for each three machines, and which are backed by and exhaust into the general pump. The insides of the exhaustion tubes, which are fused to the bulbs, are painted with a solution of red phosphorus, and at the moment before the bulbs are sealed up this phosphorus is heated and vapourised so that it carries away any injurious last products from the interior of the bulbs and leaves an almost perfect vacuum. The machines are fitted with heated chambers, and the exhausting is partly carried out with the lamps at a high temperature.

The lamps are made alive, and receive a first test before leaving the machines; and in order to ensure that the current shall not be put on to them too soon, an ingenious induction-coil arrangement is fitted which can be connected across the bulbs in such a way that if the vacuum is not yet sufficient to make it safe to switch on the lamps, a gaseous discharge takes place through them which directly indicates their state to the operator. The last process before the fitting of the caps is the ageing of the lamps, which is carried out by subjecting them to 25 per cent. over-voltage for a quarter of an hour. This eliminates all weak and doubtful examples. The over-voltage which the lamps will stand is remarkable, and we had an opportunity of seeing four 115-volt lamps run at 230 volts, and a 115-volt lamp run at 300 volts, in all cases without rupture of the filaments.

THE TURIN INTERNATIONAL EXHIBITION.

In an article published in April last* we announced the opening of the Turin Exhibition, and reviewed briefly the development of Italian industries during the last fifty years, since the declaration of Italy's unification. The present Exhibition was organised with the object of celebrating the unification of the country and demonstrating to the world at large the progress made by national establishments in the manufacture of all classes of products. The Valentino Park, Turin, where the exhibition is being held, is an ideal site; it is easily reached from every part of the city; it contains a number of groves affording a most welcome shade in the present torrid heat; the River Po, flowing through the grounds, gives an agreeable freshness; while the wooded hills to the east and south-east form a magnificent setting to the whole. The Exhibition is laid out on both banks of the river; on the left bank it extends from the Corso Vittorio Emanuele II. and the Umberto I. bridge as far as the Cinta Daziaria, and on the right bank as far as a suburb called the Pilonneto.

The right bank, commencing from the Umberto I. bridge, is covered by a number of separate pavilions, which contain the displays made by the Argentine Republic, by Uruguay, Equador, and other South American States; by Brazil, in a separate pavilion; Belgium, France, Germany, the United States, Siam, and Servia. These displays include a large variety of specimens and exhibits representative of the industrial, agricultural and mineral products of the several countries, all most tastefully arranged. This portion of the exhibition will attract its fair share of visitors; we do not propose, however, to deal with it in the present article.

The display made on the left bank of the river, commencing at the entrance on the Corso Valentino, is of greater interest to engineers, since it contains the exhibits made by the Royal Italian Navy; the building containing Italian, French, Swiss, and German electrical exhibits and displays relating to professional teaching; the building containing machinery in motion, which latter communicates with the British pavilion; while further south is the Italian Public Works building, leading to the heavy metallurgical section and the building containing the locomotives and railway rolling-stock.

Among the most attractive exhibits from the engineering point of view are those which are contained in the building covering the machinery in motion above referred to. This building adjoins the British section; its extreme southern end is set apart as a power-station for the production of current for general distribution for power and lighting throughout the Exhibition, with the exception of the Royal Italian Navy pavilion, the British Section, the Swiss and French electricity displays, and the Pilonneto, which are self-contained, as we shall show further on. Power-stations at exhibitions may be said to afford an excellent illustration of the development in engine design and construction, as the progress made in this particular branch can easily be gauged by a comparison of the prime movers on view at the time with those which were shown at previous exhibitions. In this respect the Turin Exhibition is instructive, inasmuch as it affords, to a greater extent even than several other recent Continental exhibitions, an indication of the prevailing ideas in engineering practice. It contains three heavy-oil engines, two steam-turbines, one vertical and one horizontal steam-engine, which take the load alternately. The illustration is very aptly completed by the prime movers which make the Italian naval pavilion, the British section, and various other displays self-contained, as stated above.

The largest exhibit in the power-station in the Machinery Building is that made by Messrs. Franco Tosi, Legnano, who show a 600-horse-power four-cycle Diesel engine, having four cylinders 535 mm. (21 in.) in diameter, with a 770 mm. (30.3 in.) stroke, direct coupled to a three-phase 45-ampere 6400-volt alternator, running at a speed of 150 revolutions, built by the Tecnomasio Italiano Brown, Boveri, and Co. In this engine the compressed air is supplied by a Reavell air-compressor driven from the Diesel engine-shaft and mounted on an extension of the engine-foundation plate. The compressor has four cylinders, placed radially round the shaft at angles of 90 deg., two of these cylinders being low-pressure, one being a medium pressure, and the fourth compressing the air up to the required pressure of 60 atmospheres (850 lb. per sq. in.). The air-compressor is water-cooled. The compressed air is delivered to two receivers, one of which comes into play on starting the engine; they are connected to a third, smaller receiver for the fuel injection. The liquid-fuel pump is located close to the governor which acts directly upon it; the fuel suction is effected by a piston operated directly from the vertical shaft of the governor by means of an eccentric. This piston has a fixed travel; a second piston, smaller in diameter, operates the suction valve, the opening of which is controlled by the governor.

Messrs. Franco Tosi also exhibit a 5000-horse-power Brown-Boveri Parsons (Tosi) steam-turbine, running at a speed of 1500 revolutions, and coupled to a Ganz three-phase 4200-kw. 6400-volt 50-period alternator. The turbine exhausts into a surface condenser underground. The same firm show, further, a 600 to 800-horse-power horizontal compound tandem engine, running at a speed of 125 revolutions, direct-coupled to a three-phase 6400-volt 60-ampere alternator, built by the Savigliano Electric Company. The high-pressure cylinder of this engine is 500 mm. (19.7 in.) in diameter; the diameter of the low-pressure cylinder is 850 mm. (33.5 in.). The steam distribution is by double-beat valves on the Lentz principle. The engine works condensing, the jet-condensing plant being underground, together with that for the turbine. Messrs. Franco Tosi had intended exhibiting also a 1000-horse-power Diesel engine; the alternator to be driven by that engine is in place at their stand, but the engine could not be completed in time.

Close to the stand just dealt with the Maschinenbau A.G., vorm. Ph. Swiderski, Leipzig, exhibit a 1200-horse-power normal, and 1500-horse-power maximum, radial turbine, of the Eyermann type, running at a speed of 3000 revolutions, coupled to a three-phase 6400-volt 750-kw. 50-period Brown-Boveri alternator. The turbine works in conjunction with a Westinghouse-Leblanc condenser underground. The Swiderski Company also exhibit a 500-horse-power vertical steam-engine, with Lentz valve distribution; this is a two-cylinder compound engine working condensing and direct-coupled to a three-phase alternator, built by the Savigliano Electric Company, of similar characteristics to the above.

The Società Italiana Langen and Wolf show a 500-horse-power four-cycle vertical Diesel engine, running at a speed of 250 revolutions, coupled to a 220 440 volt continuous-current generator constructed by Messrs. Ganz, Budapest.

The largest Diesel engine in this section, and also in the whole Exhibition, is that shown by Messrs. Sulzer Brothers, Winterthur. This is a vertical four-cylinder two-cycle 1000 to 1200-horse-power engine, running at a speed of 150 revolutions, direct-coupled to a three-phase 6400-volt 80-ampere 50-period alternator, built by the Savigliano Electric Company. We may remark that Messrs. Sulzer build on the two-cycle principle all their Diesel engines for powers exceeding 600 H.P. The cylinders of the engine exhibited are 500 mm. (19.7 in.) in diameter, with a 750-mm. (29.5 in.) stroke, each cylinder developing 260 H.P. A fifth crank works a combined air-pump, which supplies the air for scavenging and that for the charge. The air-pump supplying the air for the charge is a three-stage pump; a separate cylinder supplies the air for scavenging. The oil-fuel supply to the cylinders is governed automatically according to the load on the engine; the air supply for scavenging is also governed automatically, and varies in quantity with the charge. The engine at the stand in Turin is provided with an electric motor which drives a toothed pinion made to mesh with the gear cut inside the flywheel rim for barring round. The Sulzer set, like the other sets—except that of Langen and Wolf above referred to—supplies a 6400-volt three-phase current which, with the similar current proceeding from the other engines, is transformed down for power and lighting, at various points which are distributed as required. The lighting throughout the Exhibition, with the exception of that of the building containing the Tosi, Sulzer, and other sets, is by three-phase current, the lamps being run in series. A part of the grounds in the neighbourhood of the monumental bridge across the river and the monumental fountain is lighted by lamps in series upon the 6400-volt circuit.

The water for cooling the cylinders of the Diesel engines in the power-station is taken from the town mains. The condensing water for the horizontal and vertical steam-engines and the steam-turbines above referred to is taken from the river, and is pumped up by a set of pumps located in a small building on the river bank. This building

* See Engineering, vol. xci., page 556.

contains one set formed of a high-speed, 160 to 200 horse-power Sulzer Diesel engine, running at 375 revolutions, driving by an elastic coupling a Sulzer centrifugal pump having a capacity of 300 litres (66 gallons) per second, against a head of 40 m. (130 ft.). There is besides, as a stand-by, an electric set consisting of a Brown Boveri 180-horse-power 500-volt motor supplied by a transformer located in the same building, which takes the 6400-volt current coming from the power-station, the motor driving by an elastic coupling a centrifugal pump having a capacity of 400 litres (88 gallons) per second, against the same head of 40 m. The two pumps deliver into a reservoir having a capacity of about 750 cub. m. (165,000 gallons) placed close to the power-station, and from which the various condenser pumps derive their supplies.

The Franco Tosi turbine, as above stated, is connected to a surface-condenser, and all the condensed steam proceeding from the turbine goes to a receiver, from which are fed the Tosi steam boilers referred to further on. The cooling water proceeding from the cylinder jackets of the Sulzer Diesel engine is delivered into a tank, from which are fed the Babcock and Wilcox boilers, also described further on, the feed-water being supplied to the boilers at a temperature which varies between 30 and 50 deg. Cent.

The Exhibition Committee ensure the liquid fuel supply to the Diesel engines in the power-station. This fuel is contained in an underground reservoir having a capacity of about 90 cub. m. (19,800 gallons) located between the Langen and Wolf Diesel set and the Babcock and Wilcox steam-boilers. From this receiver, each Diesel-engine exhibitor takes the oil fuel he needs. Messrs. Sulzer, for example, have a tank mounted on brackets supported on the columns of the building, above their engine, and containing sufficient oil fuel for a 16-hours' run, which tank they fill by means of a small electric pump which draws from the underground reservoir. From this tank the oil fuel passes down through filters to the engine cylinders. Close to their oil-fuel tank Messrs. Sulzer have mounted their cooling water-tank, from which the water runs down to the cylinders and valve-gear. The other Diesel-engine exhibitors have a very similar arrangement.

We may state here that the oil used has a specific gravity of at least 0.93, at which minimum it enters Italy at a comparatively very low duty in virtue of an agreement with Roumania.

Messrs. Sulzer Brothers draw the air supply for their Diesel engine from a vertical pipe which opens outside the roof over their stand, and which is carried down underground to the engine, the air passing, on its way, through a series of air-filters, and thence to the cylinders. The exhaust from the four cylinders escapes through a silencer outside the roof of the building. The other Diesel engines draw their air supply from inside the building, but exhaust also outside the roof.

The switchboard, built by the Savigliano Company, is to the rear of Messrs. Franco Tosi's horizontal engine; it has seven panels, one for each Diesel engine, steam-engine and steam-turbine, all the mains, leads, and connections being under ground To the rear of the switchboard are mounted four Tosi multi-tubular boilers with superheaters, divided into two sets, their total heating surface being 1808 sq. m. (19,375 sq. ft.). One of the sets is provided with furnaces for burning coal; the other is built for burning oil-fuel, and is fitted for this purpose with the Körting furnace and oil-spraying device. The oil fuel has the same specific gravity as that used in the Diesel engines—0.93 to 0.95; it is, in fact, taken from the underground reservoir above mentioned. It is drawn from the reservoir by two steam-pumps placed directly in the rear of the switchboard, one of the pumps acting as a stand-by, and is delivered under pressure to the pipes, which carry it to the atomiser, flowing on its way through a tubular heater with steam circulation, in which the oil is raised to a temperature approaching that of vaporisation; the oil is heated generally to a temperature of 150 deg. Cent. An air chamber is in connection with the device, and its capacity is sufficient to secure a regular flow for the oil.

The oil-pipe system ends for each boiler in five spraying devices, which are fitted into the bottom part of the front furnace-plate. The oil-fuel supply to the boilers is regulated simply by acting upon the steam-valve of the oil-pump; any one of the five spraying devices can also be cut off at will. With feed-water at 50 deg. Cent. the oil-fuel consumption amounts to about 1 lb. per 13 lb. of water evaporated, the steam produced being superheated to 300 deg. Cent. In some cases the steam production has reached 14.5 lb. per pound of liquid fuel, using feed-water at the temperature named. The Tosi boiler set, which is coal-fired, is fitted with the Underfeed Stoker Company's automatic grate. Both sets are connected to a chimney built up of steel plate. The boilers are fed by two "Duplex" pumps, built by Messrs. Tosi, and fitted with a feed-water heating device supplied with the exhaust steam from the pumps.

There are also two Babcock and Wilcox boiler sets, which can work in conjunction with the Tosi boilers, or independently. The installation has a total heating surface of 1148 sq. m. (12,370 sq. ft.), and a total superheating surface of 224 sq. m. (2410 sq. ft.). The boilers are fitted with automatic stokers, which are supplied with coal from the coal-stores above the boilers, the coal supply being ensured by a small bucket-conveyor, which also removes the ashes in the usual way. The boilers are fed by two Worthington pumps.

The power-station in the Machinery-in-Motion Building is served by an 18-ton travelling trestle-crane which runs on a track on the floor-level, built by the Savigliano Company. There is further a 15-ton overhead travelling-crane by the same company, and a 20-ton one by the Deutsche Maschinenfabrik, which can serve the whole of the building, besides the power-station.

(To be continued.)

NOTES.

A Tension-Meter for Wire Stays in Flying-Machines.

Rupture of wire stays has been one of the most potent causes of fatal disaster to the courageous pioneers engaged in solving the problem of aerial navigation. The adjustment of such stays is always made by skilled mechanics, who to the best of their ability equalise the tension in each. Experience shows, however, that even with the greatest care it is impossible to secure any satisfactory approximation to a uniform loading of these all-important components of a modern aeroplane; and to meet the demand for some more reliable method for securing an equalisation of the strain on such stays, Captain F. Largier has devised a simple tension-meter, which he describes in a recent number of *Le Génie Civil*. The apparatus consists essentially of a couple of knife-edges mounted on a resonance-box in such fashion that the distance between the two edges can be adjusted at will. By means of two suspension springs the knife-edges are maintained in contact with the wire the tension of which is to be measured, and this wire is then struck lightly with an ordinary lead-pencil so as to throw it into vibration and cause it to emit a musical note, which is reinforced by the resonance-box. The pitch of the note thus obtained may, for practical purposes, be considered as depending solely on the distance between the two knife-edges and on the stress in the wire. Hence by adjusting the distance between the knife-edges until the wire vibrates in unison with a standard tuning-fork, the actual tension in it may be read from scales graduated once for all on the instrument. The apparatus in question has been utilised by its inventor to measure the tensions in the different stays of a French military aeroplane. These had been carefully adjusted to the best of the ability of the mechanic, but the tension-meter showed that actually the stress ranged from a minimum of 6.35 tons per sq. in. up to a maximum of 15 tons per sq. in. Captain Largier considers that there would be no difficulty in applying his instrument to measure the tension in the stays during actual flight, and suggests as one method of doing this that the note sounded should be recorded on a phonograph, in which case the pitch could be determined at leisure.

Radiations in the Bulbs of Glow-Lamps.

In a communication recently presented to the Paris Académie des Sciences, L. Houllevigue describes some peculiar light effects observed in glow-lamps with carbon filaments which will not have escaped notice, but which do not appear to have been studied before. When a glow-lamp is joined to a circuit of excessive potential, a bluish glow fills the bulb for a little while after the current is switched on. The phenomenon is only visible or distinct for a short time—rarely more than a minute—though the lamp will continue to burn. The greater the excess potential, the more rapid will be the extinction. The spectroscopic examination shows that mercury vapours are present. When a magnet is brought near the bulb, the glow becomes concentrated in the tube of force which passes through the filament. The suggested explanation does not explain the action of the magnet. Electrons emanating from the filament in all directions are supposed to ionise the residual mercury vapour, which would then produce a spectrum; the magnetic field should cause the electrons to gather in a helix; but the special experiments made by Houllevigue do not conform to this view. He fitted a bulb with a lateral tubular projection, facing the loop of the carbon filament, and connected the bulb to a Gaede pump, by means of which he maintained the air pressure at less than 0.001 mm. of mercury for hours; at the entrance to the side tube he placed a diaphragm 6 mm. in diameter. The filament was for a 50-volt circuit. When the voltage was gradually raised to 80 volts the glow was seen to fill the bulb. Suddenly it would traverse the diaphragm and enter into the tube, in which it would attain a length of 7 cm. The length of the luminous column would increase with a rise of temperature and with an improvement in the vacuum; when a little air was admitted, the column would shorten temporarily, but would become longer again, probably because the air was being absorbed by the carbon. When the magnetic field was applied to this bulb, it was found that the magnet always shortened the length of the column; the direction of the field had no influence. Experiments with tungsten filaments did not show the phenomenon. It would seem to us that electrons, though they may ultimately suffice to explain everything, are not alone concerned in the glow. Mercury vapour as such is invisible, unless illuminated by ultra-violet radiations, which cause it to fluoresce; the presence of air and some other gases interferes with this fluorescence, as J. Franck and W. W. Wood have demonstrated.* There is always gas retained by the filaments, and the nature of the gases may change with the filament material.

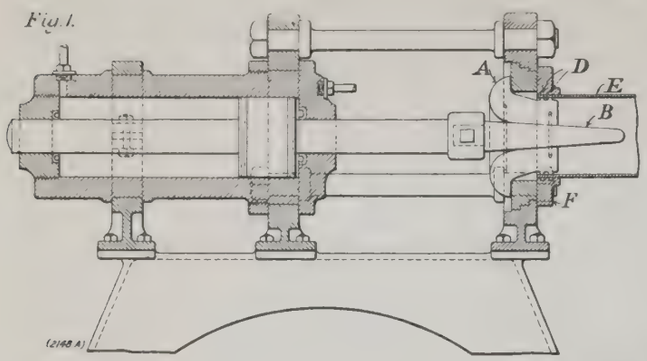
Scandinavian Labour Conflicts.

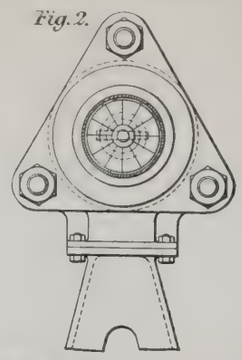
In spite of repeated negotiations, the mediators have not yet succeeded in bringing any of the Scandinavian labour conflicts to an end. The most serious trouble—the Norwegian lock-out, which affects some 32,000 men, and which, failing a speedy termination, is likely to be extended so as to affect 50,000 men—is causing much bitterness on both sides. It seems to be more a question of who is to have the upper hand than one simply of wages, and both sides are determined not to give in, and are well prepared for a protracted conflict. The men have strike funds stated to amount to between 3,000,000 kr. (166,600*l.*) and 4,000,000 kr. (222,200*l.*), and the employers do not seem to expect any peace before this fund has been spent. Both sides hold that their vital interests are at stake, and as far as the employers are concerned the time is considered rather a favourable one, inasmuch as trade is somewhat dull both in the mining and the cellulose industry. The lock-out naturally fosters Socialistic propaganda, and some of the Socialist leaders have been attacking King Haakon in somewhat unrestrained language, because he wisely refrains from interfering. In the meantime the mediators continue their endeavours, but the proposals hitherto brought forward, and the meetings held, have proved unsuccessful. In Sweden the position has for several weeks been wanting in clearness; there has been no lack of proposals and negotiations, but they have so far led to no agreement. It is thought by many that the conflict will gradually collapse. The masters rejected the last mediation proposal, whilst the men were disposed to acquiesce. Count Hamilton, the Civil Minister, has in vain attempted to mediate. In Denmark the tramway strike nominally continues, but the men admit they have lost, in more ways than one, and that they have acted very foolishly. They refused the mediation proposal to postpone the strike for a week, and did not accept the company's offer that they should return to work on the improved terms, which they had refused up to a certain date. The result is that the companies have engaged other men and that the traffic is gradually being resumed

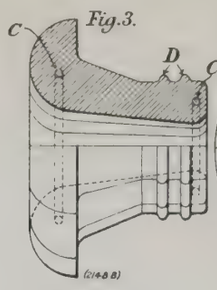
* See Engineering, vol. xli., page 730.

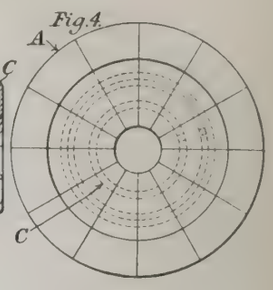
THE PATTERSON-ALLEN PIPE-FLANGING MACHINE.

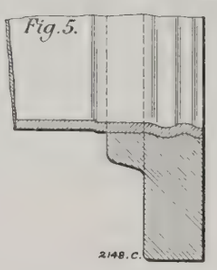
CONSTRUCTED BY THE PATTERSON-ALLEN ENGINEERING COMPANY, LONDON.

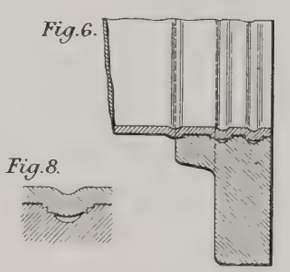


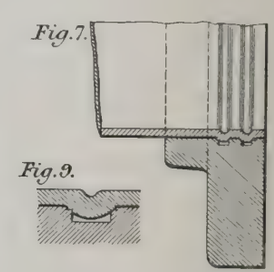












to its full extent. The companies have left one fifth of the situations free, and for these they are willing to re-engage some of the old hands, but on less favourable terms; with regard to this negotiations are still progressing. The Danish and Norwegian masters' organisations have prohibited the employment of Swedish labour during the existing conflicts, a step which does not affect the locked-out Swedish hands, but Swedish labour generally.

THE LATE MR. RICHARD HOWSON.

We regret to have to record the death, at an advanced age, of Mr. Richard Howson, well known in connection with the development of the iron industry on the North-East Coast. Mr. Howson was at one time or another closely connected with changes in practice which have had an important influence on production. He was born at Giggleswick, in Craven, on February 3, 1821, and was educated at Giggleswick Grammar School, at which his father, the Rev. John Howson, was second master for over forty years.

At the age of eighteen Richard Howson was apprenticed to Messrs. Nasmyth and Gaskell, at the time when James Nasmyth was developing the steam-hammer, and young Howson spent much of the ensuing four years in close connection with this work. In 1843 he was sent out to Sweden on business for the firm, taking over, in fact, a large steam-hammer, the first to be exported from this country. After the completion of the installation of this hammer, Howson remained in Sweden for some years, being engaged as a draughtsman, mostly in the design and construction of cotton-mills. On his return to England, after a sojourn abroad of about five years, he fulfilled several engagements as a draughtsman, finally becoming interested in the development and introduction of the vertical type of blowing-engine, which ultimately replaced the old-fashioned beam type. During this part of his career he worked at the Canal Foundry and Engine Works of Messrs. John Stevenson and Co., Preston, Lancashire, of which, in 1862, he was appointed manager.

His success in this connection resulted in his appointment in 1866, by the late Sir B. Samuelson, to the position of constructive engineer and engineering manager of the Newport Iron Works, Middlesbrough, where he almost entirely reconstructed the plant and carried out many extensions. In 1872 Mr. Howson started in private practice as a consulting engineer, being retained in that capacity also by the Newport and Ferryhill Works. He travelled a good deal abroad, visiting Austria, Italy, France, the United States, and Canada, making reports on iron and steel manufacture in those countries, to Messrs. Samuelson and Co. He became interested in mechanical puddling, and, working in conjunction first with Mr. Thomas and subsequently with Mr. Samuel Godfrey, Mr. Howson designed and patented mechanical revolving puddling furnaces, of which the last, produced in collaboration with Mr. Godfrey, proved itself the best machine of this type devised till that time. Owing, however, to the development of the Bessemer steel process, this type of machine was never widely used.

Mr. Howson was elected a member of the Institution of Civil Engineers in 1888. He was one of the original members of the Iron and Steel Institute, and took a considerable interest in the work of that body. From the time of its foundation to 1896 he read six papers before the Institute, besides making other contributions to its proceedings. His first paper he read at the first meeting of the Institute in 1869; it was entitled "The Siemens-Martin Process of Manufacturing Cast Steel." In 1872 he read before the Institute a paper on "The Rotary Puddling Furnace," designed by himself and Mr. Thomas. His next contribution was a paper in 1876 on "Welding Iron." In 1877 he read a paper bearing the simple title of "Welding." Again, in the same year, he read a paper on "Mechanical Puddling," descriptive in particular of the furnace which he and Mr. Godfrey had produced. In 1883 he read a further paper before the Institute, on this occasion under the title of "Blast-Furnace Economy in Relation to Design." In 1886-7 he was president of the Cleveland Institute of Engineers, when he took for the subject of his most interesting address "The Conservation of Force, and Some of Its Possibilities."

With regard to Mr. Howson's intimate connection with attempts to improve the puddling process by mechanical means, it may be of interest to note that his grandfather, Thomas Howson, was associated in business with Henry Cort, the inventor of the puddling and rolling processes, and was also related to him by marriage.

Mr. Richard Howson died at Middlesbrough on the 2nd inst., having attained, therefore, to the age of ninety.

THE PATTERSON-ALLEN PIPE-FLANGING MACHINE.

We illustrate above a machine which has been designed for the purpose of fixing flanges on the ends of pipes by the cold extension process. Its action will be clearly understood on reference to our engravings, which show the apparatus in longitudinal section in Fig. 1, and in end elevation in Fig. 2. Apart from the hydraulic cylinder and ram, about which there is nothing special, the parts of the machine to which we wish particularly to allude are the hollow tapered steel die A and the tapered plug B on the end of the hydraulic piston-rod. It will be seen, on reference to Figs. 3 and 4, which are enlarged views of the die A, that this portion of the machine consists of a number of segments, twelve in all, which are arranged in a circle and held together by the springs C. The larger end of this built-up die is so shaped that it forms a shoulder, the purpose of which is clearly shown in Fig. 1, and at the smaller end beads or ribs D are formed, which, when the tapered plug or arbor B is forced into the die, expand outwards at right angles to the line of thrust of the part B. When used the die is placed inside the pipe, E, that requires fixing into the flange F, and by means of hydraulic or other pressure the arbor B is forced forward, the result being that the segments of the die move outwards, and the material of the pipe is squeezed into grooves cut in the flange, and remains there in the form of corrugations, making a perfectly tight joint. Several forms of flange joints made by this method are shown in Figs. 5, 6, and 7, the actual joints of Figs. 6 and 7 being shown, to a larger scale, in Figs. 8 and 9 respectively.

It will be noticed that in Figs. 6 and 7 the pipe is expanded tightly into the cylindrical portion of the flange, but not into the bottom of the grooves; the reason for this is, that with steel and iron pipes it is found that a stronger and more permanent joint is made when a certain amount of play is allowed in the grooves. Fig. 5 represents the type of joint found most suitable for pipes made of copper and the other more ductile materials.

Among the advantages belonging to this method of fixing flanges, it is claimed that it requires no skilled labour, and that practically any material, even including cast iron, may be used for the flanges, and that tubes and pipes lap or butt-welded can be flanged. The machine is expeditious; the time required for flanging does not exceed more than two minutes for any diameter, and for small pipes up to 3 in. in diameter considerably less time is said to be required. Experiments have shown that one man can finish from 250 to 300 8-in. flanges per day without any assistance. The machine may be used for all diameters from 2 in. up to 20 in. by simply changing the dies, which operation requires only a few minutes.

The tightness of the joints made by this machine is, we understand, perfect, tests having been carried out where several sections of pipes flanged together were, twice daily for one week, submitted to a steam test of 250 lb. pressure per square inch, the steam being superheated to from 700 deg. to 800 deg. Fahr. without showing any signs of distress or leakage at the joints, although the pipes were found to have bulged perceptibly under the heat and strain. The same sections were also submitted to an hydraulic pressure of 3000 lb. per square inch, and at the same time vibrated by mechanical means, without in any way affecting the joints. Tests were also made with crude and refined petroleum, gasolene, and hot tar, under various pressures and temperatures, without any signs of failure. In this apparatus no accumulator is interposed between the pressure-pumps and the hydraulic cylinder, the pressure being automatically controlled by a pump-governor to suit the various sizes of flanges dealt with. The machine is made by the Patterson-Allen Engineering Company, 2, Budge-row, London, E.C., who are also the patentees.

The United States Navy.—The Atlantic fleet of the United States now consists of twenty-one battleships and four armoured cruisers. The fleet is the most powerful muster of warships ever placed under one command by the United States. It has involved the country in the heavy outlay of 36,250,000*l*. Next year two more battleships—the Wyoming and the Arkansas—now building, will be added to the fleet at a further cost of 2,126,368*l*.

Diamonds at High Temperatures.—Cornelio Doelter, who has for some years been working on the electrolytic or electronic conductivity of solids, salts, and minerals, &c., has determined the conductivity of diamonds between 880 deg. and 1290 deg. Cent. in an atmosphere of hydrogen or of nitrogen. The specimen was a plate 1 sq. cm. in area and 1 mm. in thickness. The resistance was 58 800 ohms at 950 deg. Cent., but fell to 370 ohms at 1220 deg.; it rose then to 930 ohms at 1260 deg., and decreased once more to 590 ohms at the maximum temperature applied, 1290 deg. Cent. Somewhat similar phenomena had been observed in quartz, and they are not suggestive of a really uniform substance; in the case of quartz, some electrolytic effect would, of course, be possible. In other experiments Doelter, whose account appears in the Vienna *Monatshefte der Chemie*, heated diamonds in hydrogen, nitrogen, chlorine, and carbon dioxide up to 1550 deg. Cent., and failed to observe any conversion of diamond into graphite; there was some brownish-black discoloration, probably a corrosion effect leading to the formation of amorphous carbon, but no formation of graphite, which has often been assumed.

11,000-H.-P. TURBINE; NECAXA POWER-STATION, MEXICO.

CONSTRUCTED BY MESSRS. ESCHER WYSS AND CO., ENGINEERS, ZURICH.

Fig. 1.

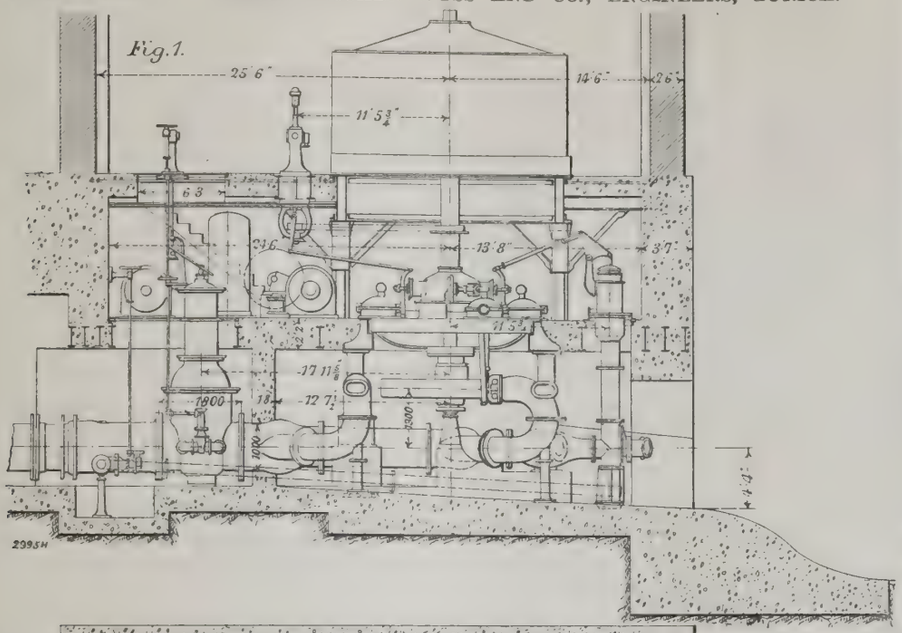
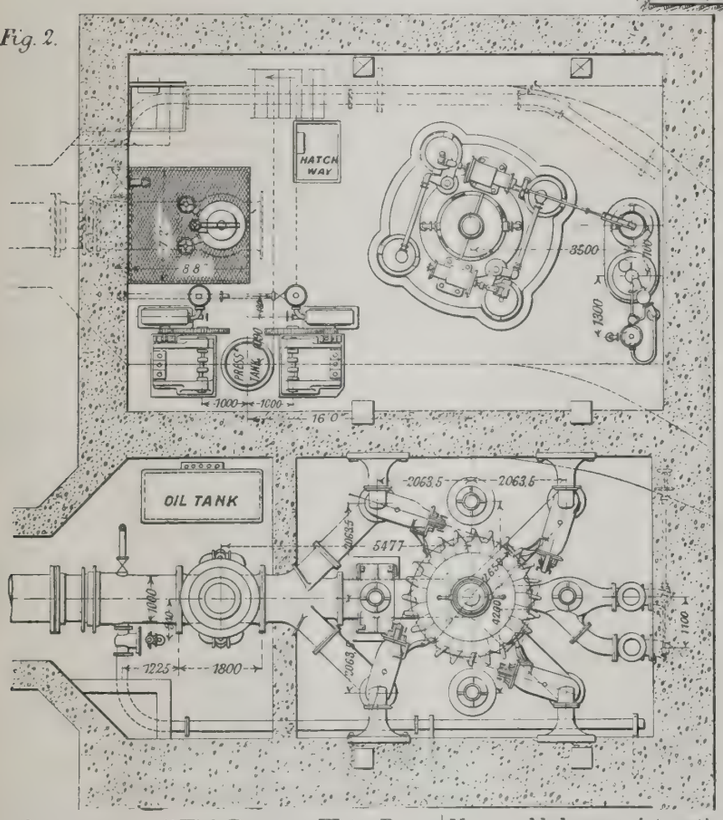


Fig. 2.



In the paper on "High-Pressure Water-Power Works," read by Mr. L. Zodel at the Zurich meeting of the Institution of Mechanical Engineers, and reproduced on page 239 of this issue, a detailed description is given of the hydro-electric power works at Necaxa, Mexico. In supplement to the illustrations in the paper, reproduced on pages 239 and 240, we give above an elevation and plan and section of the 11,000-horse-power turbine which will assist our readers in following Mr. Zodel's description, particularly of Fig. 4 of his memoir, showing the turbo-generator set partly in elevation and partly in section.

NITRO-CELLULOSE POWDER FOR NAVAL PURPOSES.

In Engineering of May 20, 1910, vol. lxxxix., page 649, we wrote on the subject of "Nitro-Cellulose Powder for Naval Purposes," indicating the disadvantages of this type of powder when compared with nitro-glycerine types of powder for warships. Our article was translated into Portuguese and appeared in the January number of the *Revista Maritima Brazileira*. The translator, Captain Alvaro Porto, of the Brazilian Navy, added some interesting information gained from experience on the ships of the Brazilian Navy, which are of great interest, as they establish the fact that the Brazilian authorities are quite satisfied with nitro-glycerine powder, and have adopted what is known as $C.SP_2$ powder, which seems to be a powder of the nitro-glycerine type with a somewhat less percentage of nitro-glycerine than cordite M.D., and contains also, as a stabilising agent, a small percentage of an alkali. The alkali seems, so far as can be gathered, to be bi-carbonate of soda. Captain Porto's comments are valuable, as the climate of Brazil, especially on the sea coast, probably affords as good a practical test of the stability of a propellant powder as it is possible to find anywhere in the world.

Captain Alvaro Porto's commentary is as follows :—

With respect to double-base—*i.e.*, nitro-glycerine-nitro-cellulose—powder, no other navy has had more experience in its use than ours, and this has been of the greatest credit to this class of smokeless powder, especially in regard to its great stability. In a climate such as ours, very hot in the summer and very unsettled in the winter, it is wonderful that cordite can be kept in such a perfect state for thirteen and fifteen years, stored in sheds on land, and on board ships whose magazines are not provided with refrigerators. For about eighteen years we have used cordite, without ever having had the least trouble with it; we have never given it the care demanded in other navies. Cordite has, so far, been treated by us just as a black powder, and subject always to high and variable temperatures—on land between 20 deg. and 34 deg. Cent., and on board to 38 deg. Cent., sometimes for months and years consecutively. In spite of these conditions of neglect, which have put the cordite to such a severe proof, we have only to record one disaster in eighteen years—viz., that of the Aquidaban in 1906. This disaster, however, far from proving a discredit to the cordite, must be considered by experts in explosives, and by those who know how the disaster occurred, as a proof of the stability of this powder. Under the conditions of the storage of that particular lot of powder during eight years, any other, especially a single-base powder (to judge by the United States regulations for testing nitro-cellulose powder), would long before have decomposed, and entered into spontaneous combustion.

When the incidents of the occurrence are examined, I am certain that experts will find it almost incredible that the stability of that powder should for so long withstand such a tremendous trial. I was in charge of the artillery of the unfortunate battleship eight months before the disaster happened. For some months I had occasion to observe daily that the temperature in the magazine for the stern turret, where the disaster happened, was 32 deg. Cent. when the ship's boilers were not in use, and 45 deg. Cent. when one or more boilers were being employed. The temperature, in this latter event, went so high that it was impossible to keep the hand for even a few seconds upon the power-cases, and during practice firing I was obliged to change the magazine hands every 20 minutes to avoid their fainting. Not less than 9 tons of cordite and some 2 tons of black prismatic powder for the 203-mm. guns in the stern turret were kept stored in this magazine for eight years. Not only was the temperature maintained for all that time above 30 deg. Cent. continually, but there was also the sharp variations of temperature caused by the alternative working of the boilers of the vessel, and frequently in the space above the roof of the magazine there was a temperature of 52 deg. Cent. One boiler was almost always twice a week kept working, either for the derricks or for the movement of the turrets. These very trying conditions continued, as I have already said, for the space of eight years, and under such circumstances it was not surprising that the cordite stored there could stand it no longer. Beyond the daily observation of the temperature in that magazine, which constituted one of the greatest worries of the Commander, Serra Pinto, there was also under observation, weekly, some of the cordite kept in a bottle, which I myself had the care of; it was stored under the same conditions as in the powder-cases.

A short time before leaving the ship, some eight months before the disaster occurred, these sticks of cordite showed a hard yellowish surface, full of cracks, and proving brittle on the slightest bending, whilst the material of the cartridge-bags had turned yellowish. On opening a box a very strong smell was noticed, causing headaches to the crew; in fact, there were all the signs of powder in a forward stage of decomposition. The conditions of the magazine storage continued to be the same, and even then the disaster only occurred eight months after, showing how slow is the progress of the phenomena in this class of powder, which would have given time for preventive measures being taken had we had a service well organised in inspection and vigilance. Already on account of the high temperature observed daily, and of the appearance of the cordite sticks, I never felt safe in firing with the 203-mm. guns with the service charges of cordite, especially as I had lately returned from the Armstrong works, where I learned that charges of powder should never be fired at a temperature higher than that at which the charges had been fixed in the polygon, if it was desired to keep the pressure normal. An excess of temperature caused, naturally, an increase of pressure, and consequently variations in shooting and a waste of ammunition, especially at that time, when the graduation of the sight-strips could not be automatically altered, and, what is still more important, a greater erosion of the bore, carrying with it a shortening of the life and accuracy of the gun. For curiosity's sake I fired three rounds from one of the 120-mm. forecastle guns, using, however, cordite stored in the forward magazines, which were cooler, and whose sticks of cordite were of better appearance. In the second and third rounds I used "crusher gauges," and was surprised to find a pressure of 19.2 and and 19.4 tons per square inch, whereas the guns had been designed and charges fixed for a normal pressure of 15 tons. This excess of pressure could soon have been verified without the use of the crusher, for, beyond the violent recoils observed, the firing-tube was so damaged that the striker and its spring were scored by a strong escape of gas coming through the head of the tube. Here was the natural consequence of packing a smokeless powder for such a long time in magazines, not provided with refrigerators, in high and variable temperatures, although such precautions were in use in other navies at the time. Therefore, if this powder (when packed in magazines in which the temperature did not exceed 35 deg. Cent.) were so altered, what could be expected in the case of the 203-mm. gun using powder from the after magazine? We were courting a disaster, as we were abusing the stability of the cordite, treating it as if it were a black powder. Of course, the disaster came. What it proved, however, was not any bad quality of the cordite, but that it is a powder that satisfies perfectly the conditions of our climate and also those of our Navy.

It is true that its ballistic qualities sensibly altered under the conditions in which it was stored; but this could

not help being so, seeing that that is a property inherent in all modern smokeless powders, and we know that the charges were fixed in the polygon at 26 deg. Cent., while here they were continually kept at higher temperatures than the above. From this it is easy to comprehend the excess of pressure that the increase of temperature gave, and such has been observed in all our firing exercises, on which occasions we always have suffered damages to the firing-locks, split tubes, pierced caps, and violent recoils, affecting the mountings, &c. It is a pity, however, that until to-day these facts should have been attributed to the quality of the explosive material, when we well know that the fault was solely due to our bad treatment of the cordite, leaving it always lying in high and varying temperatures. Let us give the powder a rational treatment, and let us make the guns always work with a normal pressure, and we shall not experience any more of the damage already mentioned.

To appreciate the meaning of the excess of pressure produced by our treatment of the cordite, suffice it to say that all our guns are tested in the polygon with five rounds, obtaining in two of them a pressure 25 per cent. greater than the normal, and on these occasions the parts of the breech mechanisms have always functioned perfectly, pierced caps and split tubes being of very rare occurrence, being observed only in guns known as "high velocity guns," when the test pressure has reached from 30 to 32 per cent. above the normal pressure. If, however, in Brazil these mechanisms fail, the cause is in the bad treatment of the cordite, which, like all other smokeless powders, should of necessity be kept at low and suitable temperatures—say between 15 deg. and 20 deg. Cent. Just lately I had occasion to know the result of an examination at 135 deg. Cent. of a lot of cordite made ten years ago for 240-mm. guns, which had always been kept stored in a shed where the internal temperature was the normal of our climate. The analysis demonstrated a beginning of chemical action, and, what is still more curious, a great excess of humidity, thus presenting the necessary conditions for decomposition. In spite of its ten years of age, we could have availed ourselves of this lot of powder if we had first, by means of crusher-gauges, ascertained the necessary alteration in weight of charge to compensate for differences in pressure, and if we had dried the powder for a few days at constant temperature. Here we have another example of cordite ten years old. I think, however, that this lot has already existed long enough, and should now be destroyed. Its stability has already resisted ten years of neglect. If we use this lot of powder in our guns, damages to the breech mechanism will occur, projectiles will burst prematurely in the bore, and the continuous excess of pressure will eventually cause heavy erosion. Under such circumstances can we blame the powder? We still have in stock other lots made some thirteen years ago, and still there is no sign of rank decomposition.

It is clear that all the above facts are not any excuse for our not establishing a vigorous system of inspection of smokeless powders, and that we must not rely alone upon the good stability of cordite. Such an inspection should be made every three months, however good the conditions of storing may be, seeing that decomposition of a powder is not only due to high and varying temperatures, but may also depend on the care observed during all the processes of manufacture and the careful choice of ingredients. As regards the above, I may cite an example of the decomposition of a lot of cordite for the 240-mm. guns, independent of the conditions of storing, which was discovered soon after the disaster to the Aquidaban, when all the lots were submitted to an examination.

We have seen that the powder on board the Aquidaban resisted eight years' ill-storage; we know that that of the 240-mm. gun is 10 years of age and does not yet show any sign of decomposition; and we have in stock many lots 12, 13, and even 14 years old, which do not show signs of free decomposition. Yet, notwithstanding the above, the particular lot to which I am referring, under the same conditions of storage, showed signs of decomposition at the end of three years.

Let us now consider the new C.S.P.$_2$ powder, also a double-base powder with about 20 per cent. of nitroglycerine and 1 per cent. of bicarbonate of soda. As we have only had this powder for two years in Brazil, I cannot give any example of its stability over a long period of time, but I shall content myself by referring to the magnificent trials realised in England by experts in such an important and difficult subject. It is a cooler powder than the M.D., with far greater stability, and it conformed with all the other necessary conditions of proof with our 186-mm. guns, which were proved in the polygons at Ridsdale and Silloth. Besides this, the "silver vessel test" at 80 deg. Cent. fully confirmed that C.S.P.$_2$ remained in a perfect stable condition during 5120 hours at a temperature of 80 deg. Cent. (this was in a ground-up state, which makes the test all the more severe). The C.S.P.$_2$ still continues to be stored by us on land under the same conditions as cordite, and it is for this reason that it will undergo eventually the same treatment, and be able, like cordite, to demonstrate its great stability. So far our only experience is as follows:—1. For two years some C.S.P.$_2$ for the 101-mm. guns of the destroyers Para and Pianby has been stored in magazines with canvas covering, with the temperature equal to that of the day; and the last analysis, taken in October, shows that it was found in magnificent condition under the test at 135 deg. Cent. 2. A sample of C.S.P.$_2$, placed, from February, 1910, to October of the same year, in a magazine for the 120-mm. ammunition, on board the Minas Geraes, where the temperature was never lower than 33 deg. Cent., was tested, and found in a perfect state.

There are some who consider the C.S.P.$_2$ undesirable, because it includes in its composition a small percentage of bicarbonate of sodium. There are others who admit that the stability of C.S.P.$_2$ is good, but that, owing to the bicarbonate of sodium, once decomposition is started, it goes on so rapidly that there is no time for remedial measures to be taken. There are others who complain of the C.S.P.$_2$ powder because it is a powder that demands a normal temperature, not exceeding 21 deg. Cent., for preserving it in good condition. I must confess to being somewhat at a loss how to answer these ingenious technical quibbles; and as this article may be read by "amateurs," I will limit myself to pointing out, firstly, that all smokeless powders have to be kept at low and constant temperatures if it is desired to retain their stability and give accuracy of fire; secondly, some C.S.P.$_2$ subjected to the "silver vessel test" at 80 deg. Cent., only showed signs of the beginning of decomposition after a space of 5120 hours. (M.D. cordite stands this test for about 1800 hours, Mark I. cordite for about 600 hours, and nitrocellulose powder for about 150 hours.) It is also well to remember that in England the M.D. cordite, and formerly Mark I. cordite, is ordered to be maintained at the normal temperature, on land and on board ship, of about 15 deg. Cent.; in Germany the powder is stored at a temperature not exceeding 20 deg. Cent.; whilst in the United States the nitrocellulose powder must be kept below 18 deg. Cent.

In all well-organised navies, especially in the German, English, and North-American, when a temperature of 30 deg. Cent. is registered in a magazine for four weeks, and if the normal temperature cannot be then ensured, all the powder lying in the magazine is immediately disembarked, and subjected to a rigorous examination (*vide* the circular of the English Admiralty of 1901, and regulations of the American Bureau of Ordnance). If it were only the C.S.P.$_2$ that required a normal and constant temperature not exceeding 21 deg. Cent., why then should all the navies, which, so far, have not adopted this powder, use refrigerators, even to the point of not admitting the existence of a magazine in a warship not provided with artificially-cooled magazines. We should already be weary of the continual repetition of evidence demonstrating that the alteration of the ballistic conditions of a smokeless powder is due to its being stored for months in magazines where the temperature is high, or, at any rate, superior to that employed in the polygon (26 deg. Cent.), and which naturally is responsible for the wear of the gun, and for the damage to the parts of the breech mechanism, firing-tubes, &c., and even responsible for the premature bursting of projectiles in the bore. For example, a projectile of forged steel for the 305-mm. gun must be accepted in the ballistic test if it fulfils certain conditions, one of which is that the pressure in the gun must not exceed 19.8 tons per square inch—*i.e.*, not greater than 1.8 tons above the normal pressure of 18 tons. On the other hand, a projectile of cast steel for the same gun is accepted in the same test, if the pressure in the gun does not exceed 19 tons—*i.e.*, 1 ton greater than the normal (18 tons). Thus, if we keep M.D. cordite, C.S.P.$_2$, or nitro-cellulose powder, in a magazine in which the temperature is maintained for many weeks or months above 26 deg. Cent., it is certain we shall get, in the gun, a pressure much greater than the normal, and, therefore, we shall not have the necessary margin of safety with the projectiles. It is a well-known and well-observed fact, embodied in a practical formula, that each 5.6 deg. Cent. above 26 deg. Cent. (the temperature of the charges fired in the polygon) produces an increase of 0.8 tons of pressure in the case of the 305-mm. guns, the powder having been only 48 hours under the influence of the said temperature. If, however, the powder is not stored under suitable conditions, it is easy to imagine the possibility of excesses of pressure and consequently the likelihood of serious accidents. I regret that I cannot here give the actual measurements of the 305-mm. guns after firing five times with charges of M.D. and C.S.P.$_2$ with normal pressures, and the measurement of this gun using charges producing a pressure of 1.5 tons above the normal.

However, in the first case the wear at the commencement of the rifling reached 0.006 in., and in the second case—*i.e.*, with higher pressures—0.039 in., covering a zone of about 5.5 calibres. It is also a fact that the accuracy-life of a gun is directly dependent on the good condition of the powder.

As regards other faults prematurely attributed to C.S.P.$_2$, it is sufficient to refer to the German method of testing and the "silver vessel test" at 80 deg. Cent., to enable us to state that they are unfounded. As up to the present no Brazilian expert has had occasion to experiment with this powder for any length of time, or to make any serious study of its stability, no evidence is forthcoming from this side; but it does not seem possible that the Armstrong and Chilworth Companies, in the face of their business relations with our Government, and of their own reputation as gun-makers and manufacturers of powder, would have advised us to adopt C.S.P.$_2$ if it was not a more stable and less corrosive and a cooler powder than cordite Mark I. and M.D. cordite. If the German method of testing inspires confidence, we may quote here the result of the examination made, in the Piquete factory, of the C.S.P.$_2$ powder for the 101-mm. guns of two destroyers, packed for nearly two years in a shed, where the internal temperature is the same as the external temperature.

Coloration of the test paper	35 minutes
Appearance of nitrous vapours ...	45 ,,
Explosion	5 hours

It is well to add that this powder was kept in cartridge-bags, packed in wooden boxes, just as they came from England. What would have happened if these cartridges had been made from a one-base powder of the nitro-cellulose type we may guess by reading the North-American (U.S.A.) powder specifications. This does not mean that it would be advisable to continue to store the C.S.P$_2$ packed in wooden boxes not properly closed, nor that the charges should be allowed to remain uncared for. What we must do, is to give the C.S.P$_2$ all the care that is demanded by any other modern smokeless powder, to acquire confidence in the C.S.P$_2$, because it is good, safe, and very stable, and in this way we may profit by its many advantages as a cooler powder than the M.D. cordite, and, finally, to imitate other navies in the manner of packing smokeless powder, giving it suitable treatment, and exercising a rigorous vigilance over it, with the idea of guaranteeing the safety of those who live on board of our warships, and the preservation of our guns, as well as in the interests of the public purse.

Here we can opportunely quote an extract from the "Annual Report of the Chief of the Bureau of Ordnance" of 1908, of the United States Navy:—

There is, undoubtedly, an inherent tendency for nitro-cellulose powder to decompose when stored at the high temperature frequently found in ships' magazines. While we have no instance of even a minor explosion, the Bureau has been put to great expense by having to replace powder which showed doubtful, if not low, stability. A system of magazine refrigeration to keep temperatures uniform at from 65 deg. to 70 deg. Fahr. (18.3 deg. to 21.1 deg. Cent.) would result in trebling the life of powder on board ship. Moreover, magazine cooling will virtually remove the danger of explosions from spontaneous combustion, which danger, in the light of the Jena, and other disasters, must be recognised, will tend to improve the accuracy of firing, through the more uniform ballistics obtainable, and its cost will be partly, if not wholly, offset by the lesser expense of re-working. The general adoption of magazine refrigeration is, therefore, recommended."

Incandescent Gas-Mantles.—The discovery made some little time ago that ramie is much more effective than cotton for the construction of incandescent gas-mantles, because the separate fabric of the yarn employed remains fairly wide apart and presents a larger glowing surface, has led to an increased lamp efficiency. It is now reported, according to the *Journal of the Royal Society of Arts*, that experiments with artificial silk show that the fibres of this material maintain their individuality to an even greater extent than ramie, and the mantles themselves are said to be much more elastic, supple, and durable. The Deutsche Gasglühlicht Company, of Berlin, has been doing a great deal of research work on these lines, and it is said that they intend shortly to place a new mantle on the market, the essential difference of which from existing types lies in the fact that it is made of artificial silk. It is claimed for it that it is specially adapted for street lighting, and for all purposes where high-pressure gas is employed.

British Trade in Russia.—According to the *Board of Trade Journal* the following information is supplied in a report from Mr. C. Blakey, British Vice-Consul at Kharkov, Russia, and relates to the trade of that district. The value of the imports into Russia during 1910 shows a continued increase over the preceding three years, which is a satisfactory proof of the prosperity of the country and its growing importance as a market for British goods. But analysis of the statistics shows that the *rôle* played by the United Kingdom is not so good as would appear at first sight. It is seen that, as compared with Germany, the imports from the United Kingdom comprise a greater proportion of raw and semi-manufactured material, such as salt fish, tallow, coal, and cotton, whilst the imports from Germany comprise a large share of machinery and finished articles. Many British goods might find a sale in Russia if the retailer, quite apart from the wholesale agent, would take an interest in them. A feasible way out of the difficulty would be, it is said, to open in the larger towns retail-shops selling British goods. Amongst the goods to be sold in this way might be boots, woollen cloths, gloves, underwear, linen goods, scents, soaps, drugs, Sheffield ware and sporting requisites. Such stores exist in Moscow. The United Kingdom can compete both in quality and price, and if the trade were properly organised, a demand for our goods can be created. The Russian market would have done largely without sewing-machines, typewriters, cash registers, harvesting machinery, patent medicines, &c., if the trade organisations had not taught the public the utility of these goods and made their purchase convenient. Advertisements will not of themselves divert to the United Kingdom a trade held by competing firms on the spot. In the heavy engineering trade, and more particularly in electrical engineering, the Germans have shown more enterprise than the British. They have branch offices under their own management with experienced engineers at the head, a staff of suitable men, and branch factories in Russia to supply parts of contracts that cannot profitably be imported. They have thus established a reliable trade, while the British remain dependent upon the good will of their agents. In the trade in machine-tools, flour-milling machinery, agricultural machinery, and portable engines German firms have a large share. The trade in electrical machinery and in semi-portable engines is entirely in their hands. In steam-engines they do a good trade and hold a high reputation. So it is in other classes of heavy goods. Mr. Blakey is fully assured that the British manufacturer could well compete in everything but electrical engineering if he were as well served by a sales department in Russia as is his German rival.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE publish below a list of colonial and foreign engineering projects, for some of which tenders are asked. Further information concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C. :—

New Zealand: According to the *Otago Witness* of June 7, the engineer-in-chief has recommended the execution of the following works at the port of Gisborne :—Breakwater extension, 60,000*l.*; mole construction, 40,000*l.*; dredging, 50,000*l.*; jetty or wharf construction (including railway connection), 20,000*l.* The scheme is to provide accommodation for vessels drawing up to 26 ft.

Egypt: With reference to the notice on page 112 of our issue of July 21 relative to the East Port Breakwater at Alexandria, H.M. Consul-General at Alexandria (Mr. D. A. Cameron) reports that the municipality of that place invite tenders for the construction of the Kaid Bey branch of the breakwater. Tenders will be received by the President of the Municipal Commission, Alexandria, up to noon on January 16, 1912. A deposit of 8000*l.*E (about 8209*l.*) is required with each tender. Particulars and plans may be obtained from the Technical Office of the Municipality, Alexandria, on deposit of 5*l.*E (about 5*l.* 2s. 7d.). The following information is from the report by the British Vice-Consul at Port Said (Mr. T. D. Dunlop) on the trade of that district in 1910, which will shortly be issued :—The Government are advancing to the Port Said Municipality funds to undertake the long-desired drainage scheme, and it is expected that this much-needed work will be begun in 1912. The cost will be about 150,000*l.* The contract is being arranged by private tender.

Turkey: According to the *Borsen Zeitung* (Berlin) of July 29, the Special Commission appointed by the Turkish Ministry of Public Works to discuss a comprehensive scheme of railway construction has now submitted its report. It is proposed to carry out surveying operations for the construction of the following sections of railway :—(1) Pristina, Prizrend, Divra, Mat, San Giovanni di Medua, with a branch to Scutari in Albania; (2) Monastir, Perlepe-Gradsko, Istib, Kotchana, Bulgarian frontier; (3) Karaferia, Elassona, Greek frontier; (4) Monastir, Resne, Ochrida, Gortcha, Kolonia, Leskovik, Janina, Tchamlik; (5) a branch line from Resné to Divra. It is stated that the Uskub, Khalkandele, Gostivar, San Giovanni di Medua section has been abandoned by the Government owing to technical difficulties. For the construction of the above-mentioned lines it is proposed to raise a loan of 20,000,000*l.* or 30,000,000*l.*

Crete: With reference to the notice on page 339 of our last volume, relative to the proposed construction of a light railway 75 miles long from Candia to Messara, the British Acting-Consul-General at Canea (Mr. E. C. D. Rawlins) reports that tenders are invited by the Cretan Government for a fifty years' concession for the construction and working of the line. Payment is to be made to the contractor in a loan to be issued for an amount sufficient to pay the cost of the works. Interest at 4 per cent., and a sinking fund by which the amount will be payable in 60 years, are guaranteed. The customs of Candia are offered as security. Tenders will be received by the Commision du Pouvoir Exécutif, Canea, up to November 6. A deposit of 200,000 francs (8000*l.*) is required with each tender.

Netherlands: The *Nederlandsche Staatscourant* of August 2 publishes a decree, issued by the Ministry of Waterstaat, declaring the necessity for constructing a railway from Metslawier to Anjum. The petition in respect of this railway has been submitted by the Noord-Friesche Locaalspoorwegmaatschappij. The *Staatscourant* of August 4 publishes the terms of an agreement entered into between the Ministry of Waterstaat and the Eerste Drentsche Stoomtramwegmaatschappij, domiciled at Hoogeveen, for the construction of two sections of railway, one from Hoogeveen to Niew-Amsterdam, and the other from Erm to Ter Apel *vid* Emmen. The undertaking will be supported by a system of State and Communal subsidies.

Switzerland: The *Feuille Fédérale Suisse* of August 2 publishes a decree granting to the municipal authorities of Eriswil an eighty years' concession for the construction and working of a railway from Huttwil to Eriswil, a distance of 1½ miles. The cost is estimated at 500,000 francs (20,000*l.*).

Russia: The *Official Messenger* of July 27 publishes the text of laws providing certain sums for railway construction as follows :—From Kariemsk to Biankino, on the Trans-Baikal Railway, 3,059,615 roubles; constructional work on the Amur Railway, 642,365 roubles; Ekaterinburg to Tiumen, on the Perm Railway, 1,773,490 roubles; a section to connect up the Yaroslav-Rubinsk and Uroch-Archangel lines, 467,302 roubles; the construction of a station at Omsk, 1,714,933 roubles. (Rouble = 2s. 1⅓d.).

Brazil: The *Diario Official* of July 11 publishes a decree (No. 8804) approving the plans submitted by the Itabapoana Railway Company, for the construction of a section of line, nearly 10 miles long, from Antonio Caetano to Bom Jesus de Itabapoana. The cost is estimated at 680,462 milreis (about 45,000*l.*). The *Diario* of July 12 publishes a decree (No. 8815) approving the plans submitted by the São Paulo-Rio Grande Railway Company for the construction of a line, 64 miles long, between Jaguariahyva and Colonia Mineira. The cost is estimated at 6,035,000 milreis (about 402,000*l.*).

Uruguay: The *Diario Oficial* of June 28 publishes a decree authorising the executive authorities to arrange for the carrying out of surveying operations with the object of drawing up plans for improving the rivers Olimar, Cebollatí, San José, Santa Lucía, Yi, Tacuarí, Tacuarembó, Arapey, Queguay, and Daymán. A sum of 200,000 pesos (about 42,500*l.*) will be set aside for the above-mentioned purpose. Two years are allowed for preparing the plans.

HIGH-PRESSURE WATER-POWER WORKS.*

By L. ZODEL, of Zurich.

[*Translated from the German.*]

IN selecting this as the subject of the present paper, it is not the intention of the author to lay down rules and principles which govern the design and construction of high-pressure water-power works, but rather to review the progress made in such plants in recent years and to endeavour to bring forward the relative merits of different designs for different purposes. Keeping this object in view, reference will be made to a number of modern plants, short descriptions of which will become necessary in this paper in order that members may be acquainted with the particular conditions governing those plants, although many may be already familiar with the characteristics of some of them. Illustrations in the way of slides will form an important part; they will show that hydro-electric stations, of all things, lend themselves the least readily to hard and fast rules; it by no means follows that what has shown itself satisfactory in one case will be equally satisfactory in another. Engineers of every branch will be represented on work of this kind, and surveyors, architects, miners, railroad men, besides engineers of the mechanical and electrical professions, have to work hand in hand in order to secure the best results. In some cases geologists and even weather prophets have to be consulted.

The utilisation of high-pressure water-powers represents the latter portion of the wonderful and rapid development which has occurred in hydraulic works during the last twenty years. This is largely owing to the fact that such powers are necessarily in mountainous districts, and may be at some considerable distance from thickly populated centres where a demand exists for power, lighting, traction, and industrial work. Therefore comparatively low falls were more in use until the question of long-distance high-tension electrical transmission could be looked upon as a sound technical and commercial proposition. This has only been satisfactorily solved within the last few years.

At the Frankfort Exhibition of 1891, a power transmission at Laufen-on-the-Neckar, over the then extraordinary distance of 175 km. (108 miles), was brought into actual use and proved that transmissions over still greater distances were equally possible and were only a question of time. This laid the foundation stone for present-day high-tension electrical transmission. But at that time only a couple of hundred horse-power were dealt with, and it required much hard work, with innumerable tests and many failures, before the thousands or even hundreds of thousands of horse-power could be transmitted safely, within the requisite economical limits, over distances exceeding 200 km. (125 miles).

It is necessary to divide water-powers into three classes—namely, low, medium, and high head. Certainly there is no well-defined limit, but for general convenience we may call low-pressure plants those with a head of from 1 to 10 m. (32.8 ft.) or to perhaps 15 m. (49 ft.); medium-pressure those from 10 to 100 m. (328 ft.); and high-pressure those over 100 or 200 m. (656 ft.). The water-turbine builder has a much sharper and more precise distinction. He calls low-pressure plants those in which the turbines are placed in open flumes; medium-pressure those in which the turbine is placed in closed casings (such as pipes, drums, spirals, &c.); and high-pressure those in which impulse-wheels are employed.

It is also possible to classify such plants according to the volume of water utilised. Thus with the same head a station might be termed medium-pressure or high-pressure, according as the discharge utilised was large or small. A plant with, for example, 100 metres head and a very large volume of water, say 20 cub. m. (716 cub. ft.) per second, would be considered one of medium head, because a closed reaction-turbine having a draught tube would be employed; yet the same head with only 1 cub. m. (35 cub. ft.) per second, would certainly constitute a high-pressure plant, for impulse-turbines would be installed. High-pressure plants usually work out considerably cheaper than low-pressure for the same power, but a long transmission line may so increase the capital outlay on the former that a low-pressure station nearer the consumer is preferable. All such questions must be carefully worked out for the particular case in hand.

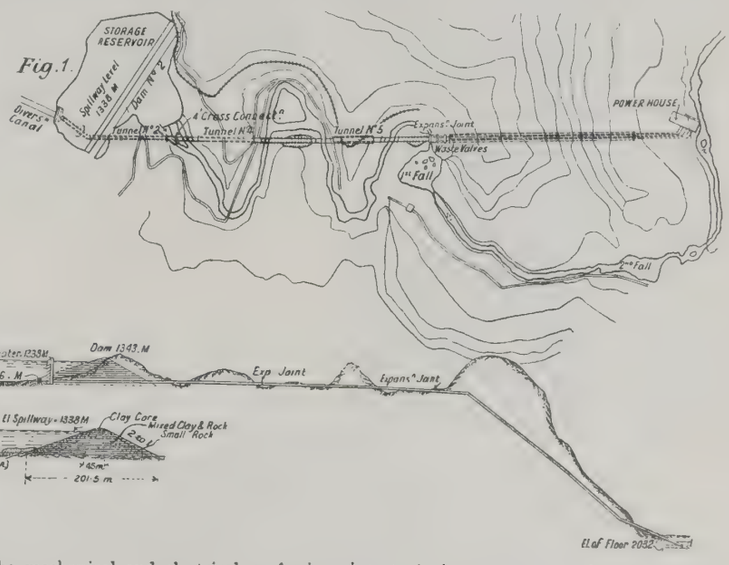
A very great advantage possessed by high-pressure plants over low-pressure, and shared to a large extent by medium-pressure also, is the readiness with which the irregular flow of rivers may be regulated to supply a constant-power demand by means of storage reservoirs and weirs. With these it becomes possible to utilise the whole of the rainfall of a district and to store the water till required by the power-consumer. Thus we may say that such storage plants are by far the more rational proposition. Storage, however, increases the cost of a station very considerably, and the amount of such storage must be limited to such capital charges as will be borne by the plant as a paying concern. The greater the head of water the more rational will a storage reservoir be, since the same quantity of accumulated water will represent a proportionately larger store of energy.

Questions of national economy and of political or even strategic importance are often served by water-power stations, besides the immediate interests of the promoters of the scheme. This is especially the case in countries such as Switzerland, which have no coal or other natural fuel, and have to depend on foreign States for their supply; hydro-electric stations represent the foundation of their industrial security and independence.

Many large high-pressure stations, with both natural and artificial storage reservoirs, have been built within the last few years all over the world. Some of these will now shortly be brought to the notice of members, reference being more particularly made to the pipe-lines and conduits carrying the water from the lake or river to the turbines. For it is exactly to these pipe-lines that too little attention is usually devoted. Many people, and not a few engineers, consider that the pipe-line is a secondary part of an hydraulic-power plant, so long as the thickness of the pipe allows a good factor of safety against the pressure, and a continuous line has been laid over the ground from the intake to the turbine. Hence it is that pipe-lines are often built by engineers who are experts in the choice of material and in the manufacture of a pipe, but who do not understand the essentially important functions which a complete pipe-line, and especially a high-pressure pipe-line, has to fulfil. The general arrangement, the relative dimensions of different parts of the pipe-line, the methods of anchoring and placing of fixed points, are all such important factors that they can only be properly determined by the turbine-builder, because on them depends to a very great extent the proper working of the turbine, and hence the success of the whole plant.

The Necaxa Power Works (Figs. 1 to 4).*—The works of the original Necaxa power-station of the Mexican Light and Power Company have been fully described in various technical journals and will no doubt be familiar to members. During the last two years, however, very great enlargement of the plant has taken place, which is of such interest as to justify a description in this paper. A short account of the old works will, however, be necessary so as to recall the main features of the station.

The Mexican Light and Power Company was founded by Dr. Pearson in Montreal, in the year 1902, for the purpose of developing the water-power of the Necaxa and neighbouring streams in the State of Hidalgo, and of transmitting the power a distance of 150 km. (93 miles) to the city of Mexico and to other towns. The magnitude



* Paper read before the Institution of Mechanical Engineers, at the Zurich Meeting, July 26.

* On page 237 further illustrations of the 11,000-horse-power turbine are given.

HIGH-PRESSURE WATER-POWER WORKS; NECAXA STATION, MEXICO.

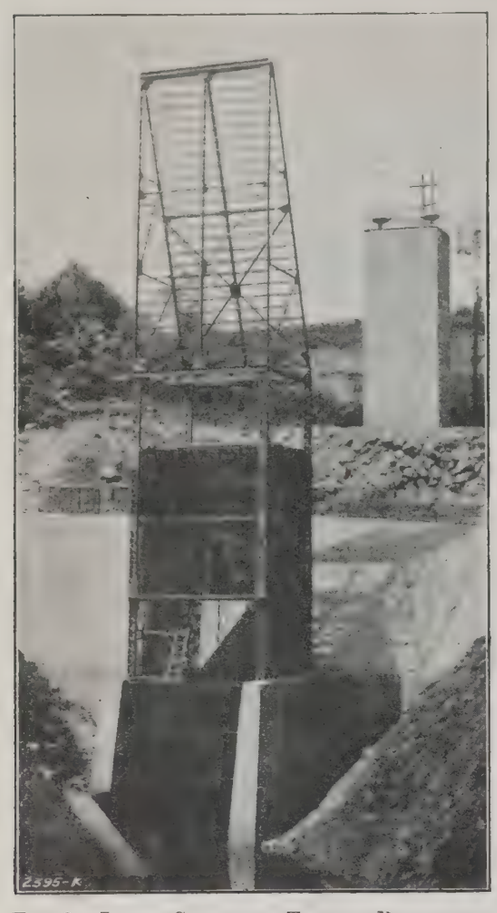


Fig. 2. Intake Screens at Tenango Reservoir, and Entrance to Tunnel at Lake Necaxa.

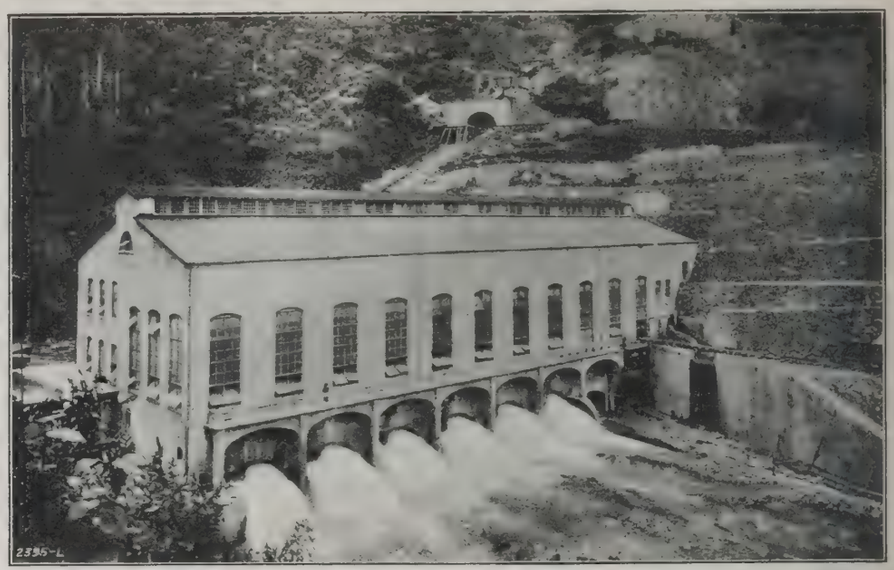


Fig. 3. Six 11,000-Horse-Power Turbines in Operation, and Excavation in Progress for Two 16,000-Horse-Power Units.

Fig. 4.

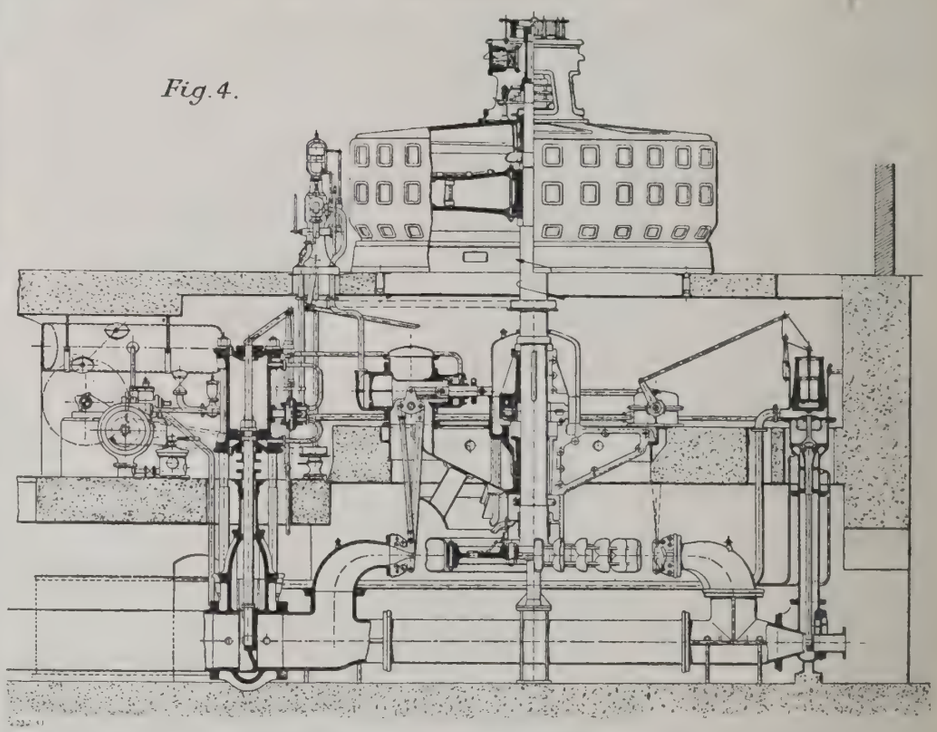


Fig. 4. 11,000-Horse-Power Turbine and Generator. (*See also page* 237.)

of the work undertaken by this company may be judged by the fact that the share capital interested is 16,000,000 dols., and that the total funds at its disposal are brought up to nearly 30,000,000 dols. by issues of bonds.

The Necaxa River flows over an extensive plateau of the Mexican table-land, and at one part of its course descends abruptly in a series of falls for a height of over 400 m. (1312 ft.) into a deep valley. This head is utilised for the power-works. The first part of the scheme, which was commenced in 1903, consisted of the construction of a large earth dam above the falls, to form a storage reservoir which supplied the power-station with water for about 50,000 horse-power. This station was in operation by the end of 1905, but the final completion of the dam was delayed until this year by the collapse of the inner face, owing to the thrust of water collected within the dam when the reservoir was empty. This accident interfered with the working of the power-station for some time. The maximum height of the dam is 60 m. (197 ft.), greatest length 390 m. (1279 ft.), and the greatest breadth 290 m. (951 ft.) at the base; it required a total volume of 1,600,000 cub. m. (2.08 million cub. yards) of material to complete. A puddle core was employed and much of the material was sluiced into place hydraulically. The capacity of the Necaxa reservoir is 45,000,000 cub. m. (1590 million cub. ft.). An earth dam was selected as the type most suitable for the volcanic nature of a country periodically liable to earthquakes.

The plan in Fig. 1 (page 239) shows the general lay-out of the plant. Two large feeder-pipes of 1.82 m. (6 ft.) diameter start from the intake tower, situated in the lake beyond the dam, and pass through a tunnel which emerges below the dam wall. These two feeders are made of riveted plate and are laid, on concrete pedestals, partly in cuts and partly in tunnels, to a receiver-pipe of 7 m. length and 2.5 m. diameter, under a pressure head of 54.2 m. (177.8 ft.). From this receiver the six high-pressure pipes descend in a tunnel through the cliff to the power-house. Sluice valves are provided at the receiver to control each pipe, and air-pipes are laid from behind the valves on each high-pressure line up the hill at the entrance to the pipe-tunnel to a height above that of the reservoir level. The six pressure lines are laid in two parallel tunnels; they are composed of welded pipes of 781 mm. (30.7 in.) outside diameter and have a thickness varying between 10 mm. and 22 mm. (0.39 in. and 0.87 in.), with a total length of 735 m. (2411 ft.) to the turbines. The maximum static head is 432 m. (1417 ft.).

The turbines were Escher Wyss and Co.'s impulse-wheels designed for a net head of 360 m. to 390 m. (1181 ft. to 1279 ft.) to generate 8200 horse-power at 300 revolutions per minute. They are arranged with vertical shafts, which also carry the generator rotors, and are supported by an oil-pressure thrust-bearing. Three-throw oil-pumps connected to an air-vessel supply pressure-oil to the bearings and governors. A pressure-relief valve is fitted to each turbine to prevent shocks in the pipe-line.

Having thus recalled to mind the conditions of the original plant at Necaxa, the author will proceed to describe the extensions, which are now in part completed and in part still under construction.

The company have greatly increased the water available by diverting the Texcapa, Tenango, Nexapa, and Xaltepuxtla rivers into the Necaxa reservoir by means of an extensive system of tunnels through the dividing ridges. The catchment area has thus been raised to 400 square kilometres (154 square miles), and can shortly be further increased by another 200 square kilometres (77 square miles) by bringing in the large Laxaxalpan stream. The additional storage volume required has been obtained by the construction of a series of earth dams of very great size, forming on each of the streams reservoirs with capacities as follow:—

Texcapa Reservoir	...	18	million cub. m.
Tenango ,,	...	43	,, ,,
Nexapa ,,	...	15.5	,, ,,
Necaxa ,, (first completed)	}	43	,, ,,
Total	...	119.5	,, ,, = 4220 mil. cub. ft.

Thus the present storage capacity of the combined system is nearly 120,000,000 cub. m. Further schemes provide for an ultimate development of the Los Reyes, Laguna, and other reservoirs which would bring up the total capacity to over 300 million cub. m., and at the same time considerably increase the catchment area.

As a first step towards the enlargement of the power-house plant the company decided to increase the capacity of the existing six 8200-horse-power turbines to 11,000 horse-power each, by fitting new runners and new nozzles, Fig. 4 (see also page 237). This was successfully carried out, and is an interesting case, since the velocity of the water in each of the six pipe-lines supplying the six turbines was thereby increased to 5.5 m. (18 ft.) per second. This is an exceptionally high figure, but was not found to be injurious in any way. The capacity of the station thus became 66,000 horse-power.

The next step was the erection of two new units of 16,000 horse-power each, built by Escher Wyss and Co. They are similar in design to the old machines, and are supplied with water through a new pipe-line system which has been just recently erected. A new low-pressure feeder-pipe starts from the intake tower in the Necaxa reservoir, and joins with another feeder which is arranged to draw water directly from the conduit, Fig. 2, connecting the Tanango and Necaxa basins. Inter-connecting valves are arranged between these feeders, as the illustration shows. The new feeder is laid, in cuts and tunnels parallel to the first, to a receiver, from which the two new pressure pipe-lines descend in a separate tunnel to the power-house. The two high-pres-

HIGH-PRESSURE WATER-POWER WORKS; RIO DE JANEIRO STATION.

Fig. 5. The Spillway.

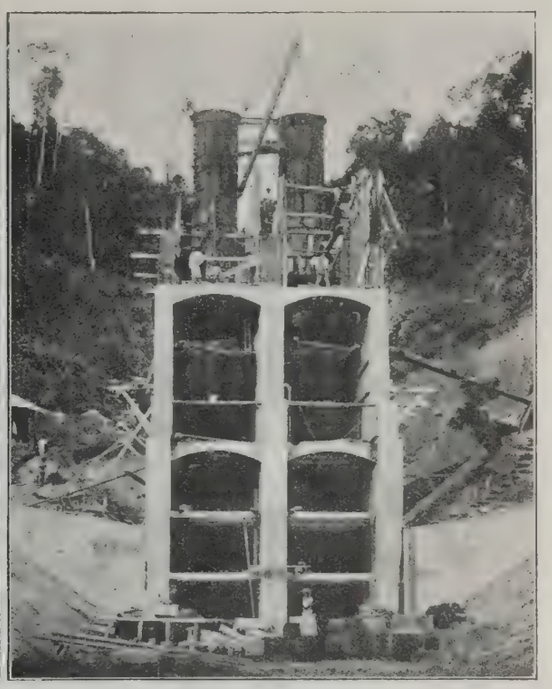


Fig. 6. The Water-Tower for Intake in Course of Construction.

Fig. 7. The Siphon.

Fig. 8. Power-House and High-Pressure Pipe-Line.

sure pipes are arranged in four sections of 1160 mm., 1100 mm., 1075 mm., and 1040 mm. (about 46 in., 43 in., 42 in., and 41 in.) diameter respectively, having a total length of about 680 m. (2230 ft.). The maximum velocity in these pipes is 4.7 m. (15.4 ft.) per second. The new pipe-line system is thus almost a completely parallel construction with that first built, and is in every way similar, though on a considerably larger scale. The capacity of the power-station is now 98,000 horse-power.

Rio de Janeiro Power Plant (Figs. 6 to 9).—The power works of the Rio de Janeiro Tramway, Light and and Power Company, which now supplies the entire city, having a population of 812,000, with light and power, is situated on the Lages River, at a distance of 80 km. (50 miles) from the metropolis. The useful watershed comprises an area of 500 sq. km. (193 sq. miles), all of which lies within 100 km. (62 miles) from the coast, and has an average, though irregular, tropical rainfall of 1500 mm. (59 in.) a year. The Rio des Lages pursues a course through a tortuous valley, having a very slight fall for a great distance, and then suddenly descends in a succession of falls and rapids a height of over 300 m. (984 ft.) in a distance of only a few kilometres. This gives a very favourable situation for a hydro-electric station combined with a storage reservoir. The natural flow of the Rio des Lages varied between a minimum of 2 to 2½ cub. m. (70 to 88 cub. ft.) per second, and a maximum of 600 cub. m. (21,190 cub. ft.) per second, with an average of 13 cub. m. (460 cub. ft.) per second, which is sufficient for 40,000 horse-power continuously, with a head of 310 m.

An artificial storage reservoir, with an area of 18.6 sq. km. (8 sq. miles) and mean depth when full of 11.34 m. (37.2 ft.), has been formed by building an arched concrete dam across the narrow valley above the place where the rapid fall begins. Granite rock was quarried near the site of the dam. Fig. 5, above, illustrates the completion of the spillway along the crest of the dam wall, the particulars of which are as follow :-

Maximum height of dam	42 metres
Thickness at base	27 ,,
Radius of dam (mean)	150 ,,
Length along crest	220 ,,
Length of spillway	135 ,,
Elevation of spillway above the sea..	404 ,,
Volume of concrete in dam	60,000 cub. m. (78,470 cub. yd.)

This lake is the largest artificial reservoir formed by a dam wall at present in existence. It has a total volume of 222 million cub. m. (7840 million cub. ft.), and a total useful volume of 204 million cub. m. (7206 million cub. ft.)

HIGH-PRESSURE WATER-POWER WORKS; RIO DE JANEIRO STATION.

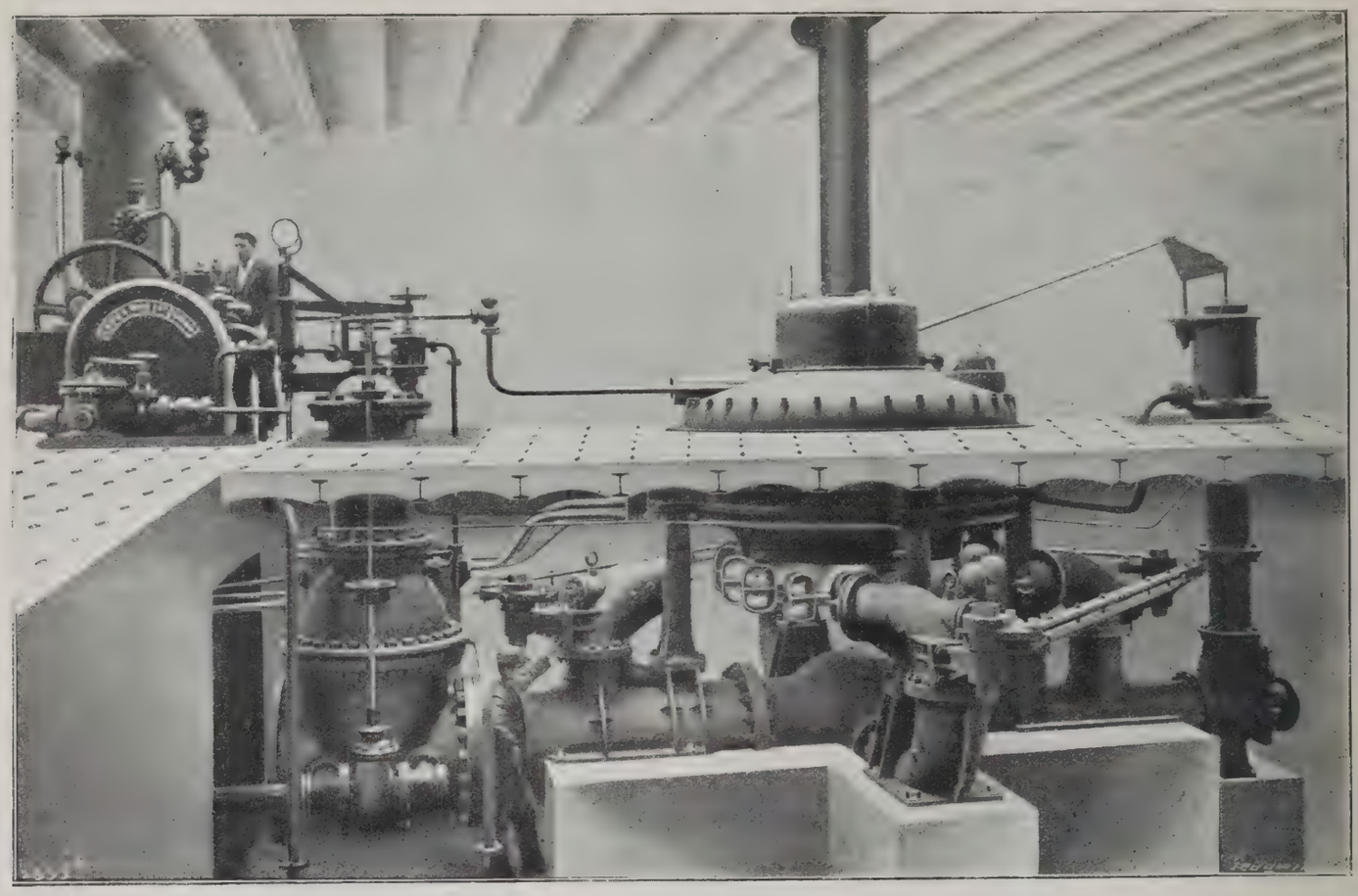


Fig. 9. 9000-Horse-Power Turbine and Governing Gear.

obtained with a maximum variation of water-level of 19 m., which represents the difference in elevation of the water intakes. The length of the lake is 27 km. (17 miles), and the total circumference about 220 km. (137 miles), owing to the extremely tortuous character of the contours. The steep sides of the valley gave an excellent site for the dam, which is thus of very economical proportions for the water-storage volume obtained.

The power-house is situated at an elevation of 94 m. (308 ft.), giving a gross maximum head of 310 m. (1015 ft.). The loss of head by friction in the feeders is reckoned at 6.6 per cent., so that the maximum net head at the turbines becomes 290 m. (952 ft.). The difference in the head when the reservoir is full and nearly empty is less than 6 per cent.

The water-tower for the intake at the reservoir, seen in Fig. 6, is arranged in three levels, each provided with screens and gates 9 ft. by 12 ft., so as to draw the water from the surface at all levels of the lake. A separate intake is arranged for each of the two 8-ft. feeders passing from the reservoir, so as to make each half of the system perfectly independent.

The pipe-line has a great similarity to that of Necaxa, and is made in two sections, consisting of two upper low-pressure pipes and of six main high-pressure pipes for the lower portion leading to the power-house. Connection is made between these sections by means of a receiver-pipe, which serves the purpose of a penstock chamber in power works, having an open conduit to convey the water to the pipe-lines. This upper system of pipes consists of two independent riveted steel feeder-pipes 2435 mm. (8 ft) in diameter, with a total length of 1684 m. (5530 ft.). These are an interesting feature, as at Necaxa, in that they replace the open flume or conduit, which up to the present has been the more usual construction, but would have caused considerable difficulty here. The steel feeder-pipes have the great advantage that, being under pressure, they utilise the full head obtained at all times in the reservoir. They are built of plate varying in thickness from 6.4 mm. to 16 mm. ($\frac{1}{4}$ in. to $\frac{5}{8}$ in.) and are under a maximum pressure-head of 56.78 m. (186 ft.). The average fall of the pipes varies from 0.15 per cent. to 9 per cent.; they pass through three tunnels with lengths of 187 m., 88 m., and 436 m.; a valley is crossed by means of an inverted siphon 131 m. long and 29 m. deep, shown in Fig. 7, page 241. At about half-way between the intake and the receiver, at the exit of the third tunnel, each pipe is provided with an 8-ft. stand-pipe, 16 m. (52 ft.) high, open to the atmosphere, and carried above the spillway level, for the purpose of equalising any pressure oscillations due to water-hammer. The two feeders each connect to a receiver-pipe under a pressure-head of 57 m. at elevation 347 m., and a second pair of stand-pipes 8 ft. in diameter are taken up the side of the hill to the same height as the other two, in order to equalise pressure oscillations at this point; they may be seen above the valve-house. A valve-house is provided, enclosing the two receiver-pipes and containing a 2435-mm. (8-ft.) sluice-valve on each feeder, a 1525-mm. (5-ft.) valve between the two feeders, and 915-mm. (3-ft.) valves at the top of each pressure-pipe leading from the receivers to the power-house. The latter valves can be closed by little Pelton-wheel turbines, supplied with water from the receiver and started by solenoids actuated from the power-house, so that water can be quickly shut off from the 915-mm. (3-ft.) pipes in cases of emergency.

Three lines of high-pressure 915-mm. (3-ft.) pipes start from each receiver, and each of the six lines connects to a 9000-horse-power turbine. A seventh pipe-line of 305 mm. (1 ft.) diameter passes from both receivers to drive the exciter turbine sets. The main high-pressure pipe-lines have a thickness of from 10 mm. to 26 mm. (0.4 in. to 1.02 in.) and are 670 m. long; the pipes are lap-welded steel in 10-m. lengths, with flanged ends held together by loose rings. A 150-mm. (6-in.) stand-pipe, carried above the spillway level, is provided on each high-pressure pipe-line just behind the sluice-valves next the receiver, so that the whole arrangement with the pressure receivers approaches the conditions of an open penstock chamber, and has been eminently satisfactory. The whole pressure system is divided into two completely separate and self-contained units, and this provides great safety in operation. The velocity of flow in the pipes is 4.4 m. per second.

The power-house illustrated in Fig. 8, page 241, is constructed entirely of steel and concrete, and is 72 m. long, 29 m. wide, and 24 m. high; 2500 tons of steel were used.

The six turbines are impulse-wheel machines, built by Messrs. Escher Wyss and Co., with vertical shaft and four needle-nozzles symmetrically arranged round the cast-steel wheel-disc, which has an effective diameter of 2120 mm. (84 in.), and is provided with eighteen cast-steel buckets. They are designed for a head of 273 m. to 290 m. and generate 9000 horse-power at 300 revolutions per minute. An oil-pressure thrust-bearing supports the turbine and generator rotors, which amount to 40 tons dead-weight. These bearings are supplied with pressure-oil by three-throw pumps, which also feed the turbine governors. A pressure-relief valve is arranged to limit rise of pressure in the pipes to 10 per cent. on throwing full load off the turbine. Two exciter units of 400 horse-power each are provided.

The generators supply three-phase current at 6000 volts and 50 cycles, which is stepped up through transformers to a line voltage of 88,000 for transmission to Rio de Janeiro, the distance being 88.5 km. (55 miles).

Up to the present time, turbines developing a total of 54,000 horse-power have been installed, and sanction has just been given for a further increase of two units of 19,000 horse-power each.

(To be continued.)

Wireless Telegraphy, Norway-Spitzbergen.—The wireless telegraph installations in Spitzbergen and along the west coast of Norway are now being proceeded with, and are, partly at least, expected to be ready late in the autumn. Besides the station in Spitzbergen, there will be one in Finmarken, either at Ingö or Hammerfest, and one at Bergen. In due course the question of a powerful station at Christiania will be considered.

The Institute of Marine Engineers.—In connection with the above Institute, an award of 2*l.*, in books or instruments, or towards the payment of class fees, is offered to apprentice engineers throughout the kingdom for the best essay on the subject, "Improvements in Workshop Practice in respect to Machinery and Fitting." This is in addition to the essay competitions promoted by the Council of the Institute for different sections of membership. The paper must be the sole work of the competitor, and is to consist of approximately 2000 words. It must be signed with a *nom de plume* (the name and address of the writer being also enclosed in a sealed envelope, with the *nom de plume* written on the outside), and it must be delivered to the Secretary, Institute of Marine Engineers, 58, Romford-road, Stratford, London, E., not later than September 1.

Metallic Strontium.—According to the Journal of the American Chemical Society, metallic strontium can be obtained by fusing pure strontium chloride in a hemispherical iron cathode vessel. This allows a low anode current density and avoids overheating. After applying a current of 125 amperes and 40 volts for seven hours, 76 grammes of metal can be removed in small lumps up to 3 grammes in weight. The metal is removed from the mixture by crushing on an iron plate and then sifting away the chloride. On analysis it is found to contain about 98 per cent. of metallic strontium, which is a light metal with a silvery lustre when cut, gradually becoming yellow, and finally white and non-lustrous. It is softer than calcium and can be cut with a knife. It alloys with iron, and hydrogen and nitrogen unite with the heated metal. The specific gravity is 2.55, and the specific heat 0.0742, corresponding to an atomic heat of 6.5. The iron alloy is rather hard, and decomposes water. This alloy contains 23 per cent. of strontium.

CATALOGUES.

Wood-Working Machinery.—Messrs. Walter Newbold and Co., 10, Arthur-street West, London Bridge, E.C., have sent us a copy of a pamphlet giving prices and particulars of circular-saw benches, band sawing-machines, planing and moulding-machines, and several other wood-working machine-tools.

Milling-Machines.—A well-printed and illustrated booklet entitled "A Milling-Machine Analysed," has come to hand from Messrs. Alfred Herbert, Limited, of Coventry. This booklet deals very thoroughly with the design and construction of the firm's No. 9 and No. 12 horizontal milling-machines, illustrating and fully describing all their important details, and calling attention to their special features.

Box-Nailing Machines.—Messrs. Matthew Wylie and Co., 57, Robertson-street, Glasgow, have sent us a copy of an eight-page sectional catalogue of box-nailing and cleating-machines. Those illustrated are capable of driving from four to twelve nails in a straight line, or by means of a side-arm attachment some of the nails may be driven in a line at right-angles to the other. With this attachment the bottoms and lids of boxes may be nailed in two operations. The machines can also be fitted with a device for clinching the nails when required for nailing on battens.

Gas-Engines.—From Messrs. Russell, Newbery, and Co., of Altrincham, near Manchester, we have received a catalogue in which particulars are given of a new design of vertical gas-engine which they are making. The engines are suitable for electric lighting and other work. The catalogue gives a general specification of the engines, which are made in standard sizes from 12.5 to 200 brake horse-power. They are suitable for either town or suction-gas.

Reinforced Concrete.—A booklet dealing with reinforced-concrete construction, using their special form of reinforcing-bars, has reached us from the Grip Steel-Bar Company, Limited, Exchange Buildings, 6, St. Mary's Gate, Manchester. The bars employed are octagonal in section, and have wedge shaped projections on four faces, the projections being arranged so as to resist a pull in either direction. The booklet gives some general notes on reinforced-concrete work, including information on beam calculations, foundations, columns, and floor slabs. Numerous examples of warehouse and other buildings, bridges, retaining walls, and other structures using "Grip" steel bars as reinforcement are illustrated.

Nuts for Packing-Glands.—A new form of nut for stuffing-box glands has recently been placed on the market by Messrs. Princeps and Co., Matilda-street, Sheffield. These nuts are fitted with a flanged ring, capable of sliding in the nut proper, a spring being placed between the two parts. The flanged ring, which bears on the gland, slides freely over the stud, so that when the nut is tightened up, the pressure exerted must be transmitted by the spring. The object of the device is to prolong the life of the packing material by preventing undue pressure from being put on the gland. The nuts can be used with both fibrous and metallic packings on engines and steam-hammers; they can be fitted without making any alterations to the stuffing-box.

Steam-Traps, Pistons, Metallic Packings, &c.—Messrs. Lancaster and Tonge, Limited, of Pendleton, Manchester, have lately issued a booklet illustrating and describing the various specialities they manufacture for use in steam-power plants. The booklet first describes the firm's well-known steam-traps of the float and bucket types, and deals with their applications. Particulars are also given of steam-dryers of the central-tube type. The next section relates to pistons and piston-packings, and, besides fully describing the firm's products, contains some useful information on the design of these important details. Similar particulars are also given of metallic packings, which the firm manufactures in several different patterns for the piston-rods and valve-rods of steam-engines, &c. The booklet also mentions that the firm make all kinds of machine-moulded wheels.

Weighing-Machines for Conveyors, &c.—Messrs. Samuel Denison and Son, Limited, of Leeds, have sent us a copy of a booklet relating to the Blake-Denison machine for automatically weighing and recording the quantity of materials passing over conveyors of any type, either level or inclined. The machines are made to deal with loads up to 1000 tons per hour, running at speeds up to 600 ft. per minute. In addition to recording the aggregate tonnage passed over the conveyor, the machines can now be provided with a time-tonnage recorder. This device, which can be operated electrically at any distance from the weigher, produces the time-tonnage record on a paper chart, and thus enables the fluctuations in the output of the installation to be checked for each shift. The pamphlet also illustrates and describes machines for weighing slowly-moving railway trucks, and others for weighing the loads on aerial railways, ropeways, telpher lines, &c.

Steam Motor-Vehicles.—A catalogue describing their "Overseas Special" steam commercial motor-vehicles has been issued by the Sheppee Motor Company, Thomas-street, York. These vehicles are suitable for the transport of goods or passengers, and, as their name implies, have been specially designed for use abroad. They are intended to carry a load of 2 tons at a speed of 18 to 20 miles per hour. The engine has two double-acting cylinders, with mushroom valves, and is rated at 35 to 40 horse-power. It is supplied with highly superheated steam from a flash boiler heated by a paraffin burner. The exhaust from the engine is condensed and returned to the boiler, so that the vehicle can travel very long distances without replenishing the supply of water. Another important feature is the high clearance between the road and the chassis. This is not less than 18 in. at any part. The wheels are of steel, and are fitted with solid rubber tyres. Prices are stated for the chassis, and for different types of bodies.

Reinforced Concrete.—We have received from Messrs. Edmond Coignet, Limited, 20, Victoria-street, Westminster, S.W., a record of reinforced-concrete constructions carried out on the Coignet system. After giving a brief general description of the system, and pointing out its advantages, the book gives particulars, with illustrations reproduced from drawings and photographs, of a number of warehouses, factories, business premises, and other buildings (large and small) erected by the company, or their licensees, in this country and abroad. The next section deals with piles, foundations, marine work, &c., and contains particulars of wharves, piers, and other structures of this type. A third section is devoted to bunkers, silos, water reservoirs, tanks, and pipes, while the remainder of the book illustrates examples of road, railway, and foot-bridges. This publication, which cannot fail to prove interesting to engineers, architects, and others, clearly shows the adaptability of the Coignet system to a very wide range of work.

Paraffin and Petrol Motors.—A copy of their illustrated catalogue of marine and stationary motors has reached us from the Parsons Motor Company, Limited, Town Quay, Southampton. The catalogue gives full particulars, with prices, of engines ranging from 7 to 180 brake horse-power, separate types being made in each size for use with paraffin and petrol. Some new sizes are listed in this catalogue for the first time. Prices are also stated for marine sets, complete with reversing gear, propeller, shaft, &c., and instructions are given for installing and running these sets. The catalogue also gives full particulars of the Parsons reversing gear, clutch, water-cooled silencer, and other accessories and spares, each item being priced clearly and definitely. Numerous illustrations of yachts, fishing-boats, motor-boats, and other vessels fitted with Parsons motors are included in the catalogue. The firm also manufacture engines for stationary work, and prices for these are stated. The illustrations show some of the numerous purposes for which these stationary engines are employed.

Water-Ejector for Compressed-Air Mains.—We have received from the "Ejecta" Valve Company, 110, Cannon-street, E.C., a circular illustrating and describing a valve for automatically ejecting the water which accumulates in compressed-air mains. The apparatus consists of a gun-metal valve-chamber containing a needle-valve operated by a copper float. Above the valve-chamber, and in communication with it, is a small cylinder containing a piston, to which the valve is directly connected. Dry compressed air is admitted to the top of this cylinder, and the valve-chamber is connected to the mains in such a manner that the water which accumulates in the system drains into the chamber. When a sufficient quantity has collected the valve is lifted by the float, and the water is forced out by the air pressure. After this has occurred the pressure in the valve-chamber being less than that above the piston, the latter descends and closes the valve. The apparatus is small in size and simple in principle and construction. It will work under any pressure without adjustment, and is said to ensure the delivery of absolutely dry air to the machinery.

Steel Castings from Mild-Steel Scrap.—From the Dartium Syndicate, Limited, of 28, Basinghall-street, E.C., we have received a copy of a booklet giving complete working instructions for the production of steel castings and tool-steel, in any ordinary brass or iron foundry, from mild-steel scrap. According to this process, the steel scrap, together with a varying quantity (generally about 10 per cent.) of a metallic compound known as "Dartium," is placed in a crucible and fused as rapidly as possible. The steel is allowed to boil or work for a few minutes, after which a small quantity of pure metallic aluminium is added, when the metal is ready for pouring into the mould. The booklet describes the process and deals with the method of making patterns and moulds, as well as with the process of annealing the castings. The latter operation, although not always necessary, is generally desirable to remove strains set up during cooling. For this purpose it is usually sufficient to raise the casting to a red heat and allow it to cool slowly; but when specially soft and ductile castings are required, the annealing time varies from one to fourteen days. When thoroughly annealed, the castings are stated to be quite equal to mild-steel forgings in strength and ductility. A charge of 1s. is made for the booklet.

Oil-Engines.—From Messrs. Ruston, Proctor, and Co., Limited, of Lincoln, we have received a copy of their catalogue, section L, illustrating and describing fixed and portable oil-engines for refined or crude petroleum. The catalogue gives full particulars, including weights and principal dimensions (in English and metric units) of fixed engines having outputs ranging from 3 to 92 brake horse-power when running on refined oil. The oil consumption of these engines, using refined Russian petroleum, varies from 0.93 lb. per brake-horse-power hour in the smaller sizes to 0.55 lb. in the largest sizes. Full particulars of standard portable engines from 3½ to 25 brake horse-power are also included. The firm also make small portable engines particularly suitable for farmers, as well as a special light type for export to countries where transport is difficult and costly. The catalogue contains numerous half-tone engravings of fixed and portable engines, showing some of the latter driving centrifugal pumps. Illustrations of compressed-air self-starters for the stationary engines are also included. Another circular dealing with a new type of stationary engine, specially designed for use with crude oil, has also reached us from this firm. These engines, which can be operated with any kind of crude or residual oil, are made in five sizes, ranging from 20 to 50 brake horse-power.

Apparatus for Sterilising and Treating Air.—From Messrs. W. J. Fraser and Co., Limited, 98, Commercial-road East, London, E., we have received a pamphlet describing Robertson and Rintoul's apparatus for sterilising and treating air. The apparatus is used for the bacteriological purification of air in hospitals, breweries, &c., and also for removing noxious vapours arising from manufacturing processes. It consists of a chamber containing a large number of horizontal rods spaced a few inches apart and interlaced with fibrous threads. Over these threads runs a liquid, the nature of which varies according to the purpose for which the apparatus is being used. Air from a blower enters at the bottom of the chamber and passes upwards among the saturated threads, on which the organisms are collected and destroyed by the liquid. The makers claim that this apparatus, while presenting an extremely large contact-surface, offers but little resistance to the passage of the air, and does not alter its degree of humidity. Results of tests made on a steriliser 1 ft. 6 in. square by 5 ft. high are included in the pamphlet. With this apparatus passing 18,000 cub. ft. to 20,000 cub ft. of air per hour, only one organism developed on a Petrie dish exposed to the sterilised air for forty-five minutes, whereas, on one exposed for the same time to the air before treatment, over 1000 organisms were counted.

Water-Softeners.—Messrs. Ashwell and Nesbit, Limited, Barkby-lane, Leicester, have issued a pamphlet relating to their "Eradica" process of water purification. The plants dealt with are suitable for domestic and industrial purposes. One of their most important features is the definite measuring and mixing of the crude water and reagents in exact proportions. Several different types are illustrated. In one of them the measuring apparatus consists of a tilting vessel, having a large central compartment, into which the crude water is delivered, and two smaller compartments by the side of, and in connection with, the large one. When the tank is full it tips over, the water from the large compartment running into the reaction tank, while that from the two small compartments is led to the lime and soda solution tanks respectively, from which it displaces the proper quantities of these solutions. The displaced solutions mix with the crude water and run into the reaction tank, from which the softened water passes to a filter, whence it is drawn off for use. Another type of softener illustrated and described uses dry chemicals in the form of powders, which are accurately measured by a device operated by a tilting vessel. The catalogue also deals with the utilisation of exhaust steam for heating and softening water required for boiler-feed and other purposes, illustrating and describing the "Nuconomiser" open-type heater for this duty.

Electric Welding-Machines.—A pamphlet dealing with the Prescot electric welding-machines has been issued by British Insulated and Helsby Cables, Limited, of Prescot, Lancashire. These interesting machines, which were fully dealt with in ENGINEERING, vol. lxxxvii, pages 69, 135, and 208, are intended to replace riveting in the manufacture of sheet-iron goods and hollow ware. They comprise a step-down transformer, the primary of which is supplied with alternating current from the mains. From the secondary a heavy current at a low potential is led to the welding electrodes, which are constructed of copper and are water-cooled. The shape of the electrodes depends upon the nature of the work to be done; in a spot-welding machine they are bluntly pointed. The two plates to be joined are placed between these electrodes, which are then brought down into contact with the plates, so that the current passes through the latter and rapidly heats them to welding temperature. The electrodes are then closed down further, so as slightly to penetrate the surface of the heated plates and force them into intimate contact. In this way plates ranging in thickness from 28 S.W.G. to 7 S.W.G. can be most effectively connected. The pamphlet gives full particulars, with prices, of spot-welding and seam-welding machines, both types being made in several different sizes and patterns, all of which are illustrated with examples of work done by them. Tests showing the great strength of welds made by these machines are also illustrated.

GOLD.—The imports of gold into the United Kingdom in May were 4,610,063*l.*, as compared with 3,010,427*l.* in May, 1910, and 2,768,228*l.* in May, 1909; and in the five months ending May 31, this year, 18,011,741*l.*, as compared with 15,763,795*l.* and 15,516,175*l.* in 1910 and 1909 (corresponding periods). The great bulk of our gold supplies is still derived from South Africa, the receipts from that quarter in the first five months of the last three years having been as follows:—

Colony.	1911. £	1910. £	1909. £
Rhodesia	1,014,650	1,080,172	948,355
Cape Colony ..	7,690	7,710	13,680
Natal	260,629	173,239	141,125
Transvaal	13,654,806	11,703,420	11,770,677
Total	14,937,775	12,964,541	12,873,837

British India ranks second as regards gold deliveries made to the United Kingdom, our receipts from that quarter to May 31, this year, having been 973,308*l.*, as compared with 1,008,704*l.* and 970,558*l.* Australian gold supplies appear to be continuously declining; they only amounted, to May 31, this year, to 486,632*l.*, as compared with 636,932*l.* and 799,819*l.*

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

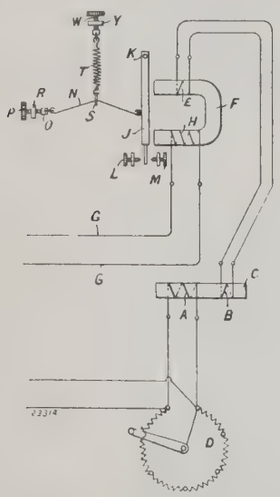
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

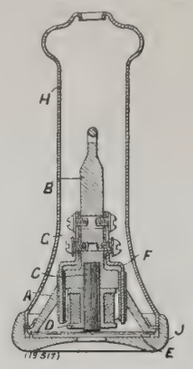
ELECTRICAL APPARATUS.

23,314/10. W. J. Poole, Glasgow. Voltage and Current Regulation. [1 *Fig.*] October 8, 1910.—Electric pressure and current regulators of the electrically-controlled type are usually controlled by a relay consisting of an electro magnetic device so operating a contact-making device as to cause the latter to take up and remain in a predetermined position, while the value of the current regulated remains normal, and move to other determinate positions instantly with change in value of the current being regulated. According to this invention, a subduing or damping device is provided, comprising two solenoid coils upon one core, one coil being in circuit across the terminals of a controlling rheostat or the like, or in series with the exciting circuit of the generator field, or its exciter field, and the other coil being in circuit with a third coil about the magnet of the relay device, or about a polarised core co-acting with that magnet, with or without a spring operating through a device, such as a toggle-linkage, to control the movements of the armature of that magnet. The electrical subduing device shown consists of two separate solenoids A, B, wound on a laminated iron core C, common to both coils. One, A, of the coils is connected across the terminals of the regulator rheostat D, the apparatus which varies the strength of the current in the field-circuit of the generator being controlled (or if a separate exciter is used, across the main terminals or the rheostat terminals of the exciter). The other coil B is connected to a similar coil E wound on the core F, which forms the magnetic circuit of the relay, and has a relay coil H connected to the generator by conductors G. Now it is evident that the current in A will vary with the potential across the terminals of D, and will be at a maximum value when all the resistance of the rheostat D is cut in, and at a minimum value when all the resistance is cut out. But the value of the current strength in A will have no effect on the circuit of B, E, and, therefore, no effect on the action of the relay, as long as there is no sudden change. Should this change occur, however, and occur quickly, there will be a corre-



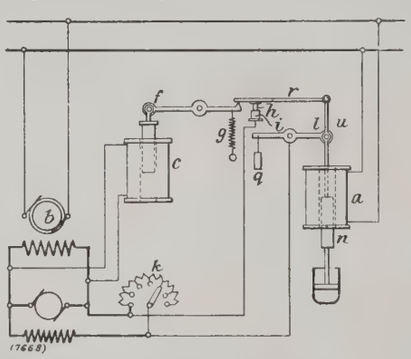
sponding increase or decrease of the magnetic flux in C. During the period of increase a current will be induced in C and also round B and E in a given direction. During the period of decrease an induced current will also flow round B and E, but in the opposite direction. The coils B, E are connected in such a way that the flux in F, which is generated by E, always tends to oppose the increase or decrease of the normal flux generated in F by the magnetising coil H of the relay. Now the flux due to E is proportional to the current strength in B, and this current is inversely proportional to the time rate of flux changes in C set up by changes of the current value in A, and the value of this induced current is not proportional to the instantaneous value of the current in A, but is inversely proportional to the time in which any change in the value of the current strength in A takes place. The device therefore is one which only subdues the action of the relay, and therefore of the regulator, when the strength of the current controlled by the rheostat of the latter tends to change in value too quickly, the degree of subjugation being inversely proportional to the time taken to bring the change into effect. The armature J of the electro-magnet F is, as usual, mounted upon a pivot K and has a contact piece co-acting with two adjustable contact screws L M in circuit, as usual, with the rheostat-operating device (not shown). The mechanical damping or subduing device consists of what amounts to an adjustable toggle-link device and is in the form of a flexible band N of steel, for example, anchored at one end to the back of the armature J, and at the other end to a shackle O on the end of a screw P adjustable in a bracket R. At about the centre of the length of the band N is a stirrup S, to which is attached one end of a helical spring T adjustable in a bracket Y. By adjustment of the screw P the modulus of the band N as a toggle-linkage may be adjusted to the ratio of the variation in pull of the magnet F upon the armature J, while by the screw W the spring T may be adjusted in strength to the force exerted by the magnet F upon the armature J. (*Accepted May* 31, 1911.)

19,517/10. M. S. Conner, Salford. Telephone-Receivers. [5 *Figs.*] August 20, 1910.—In a telephone receiver which employs an electro-magnet instead of a permanent magnet for producing the necessary magnetic field, a hollow iron case of truncated cone shape, whose smaller end is extended to form a stem B, and whose larger end is outwardly flanged, is fitted with a core C of iron wires. The core receives a coil D, which serves the dual purpose of exciting the electro-magnet and causing the diaphragm E to vibrate by means of the undulatory voice current flowing in its circuit. The ends of the coil are attached to connections F, which pass through the case A to insulated terminals G, mounted on the stem B. The diaphragm E is supported by the outer flange of the case A, and this case is placed in a con-



taining case H, and clamped in position on the ear-piece J, which at the same time clamps the diaphragm to the case A, an insulating ring being interposed if required. The magnetic circuit from the core to the periphery of the diaphragm is thus through a considerable mass of iron, giving a low reluctance. Although the case A, as described, is convenient, other shapes may be used, and different methods of mounting and clamping the diaphragm may be adopted, or the containing case may be dispensed with. (*Accepted May* 31, 1911.)

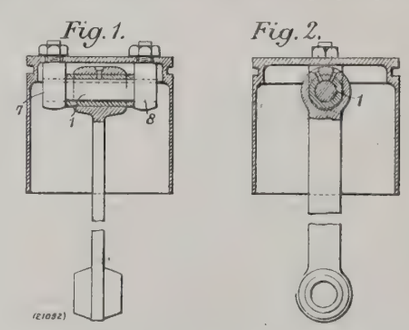
7668/11. Allgemeine-Elektricitats Gesellschaft, Berlin, Germany. [2 *Figs.*] March 26, 1910.—In a potential regulator for electric generators of the Tirrill type, means, according to this invention, are provided whereby the movements of a relay energised by the exciter potential, and a relay energised by the generator potential, are transmitted to the movable contact in such a manner that the movement of the contact is composed of two components proportional to the movements of the two relays. The contact *i* is a fixed contact, whereas the contact *h* is movable. The lever *r* which carries the contact *h* lies with the free left end upon the arm of the lever *f* carrying a knife projection, which arm is set into rapid periodic vibrations by the coil *c*. The other end of the lever *r* is hinged to the rod *u* connected with the core *n*. The lever *l* serves as connection with a weight *q* for the balancing of the core *n*. The spring *g* engages



with the lever *f*, and has its other end secured to a fixed point. As in the known Tirrill regulator the core *n* alters the height of its position according to the load on the generator. When, for example, the potential of the generator *b* assumes less than its normal value on account of increased load, then the core *n* sinks down in the coil *c*, and with it the end of the lever *r*. In this way the contact of the contacts *h* and *i*, in spite of the left end of the lever *r* being raised by the tractive force of the coil *c* is retained and for so long until the exciter potential increased by the short-circuit of the resistance *k* again establishes the normal generator potential. At this moment the core *n*, in spite of its somewhat altered position of height, is again in equilibrium, and the opening and closing of the contacts *h* and *i* is now affected at a somewhat higher position of the knife—that is to say, at a higher tension of the spring *g*. (*Accepted May* 31, 1911.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

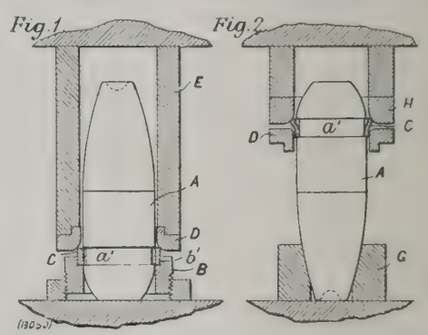
21,092/10. W. J. Lloyd, Birmingham. Pistons. [2 *Figs.*] September 10, 1910.—A piston for an internal-combustion engine of the type used on motor-cars has the gudgeon-pin, upon



which the top of the connecting-rod works, suspended from, or otherwise attached to, the underside of the piston head, and in close proximity thereto through the medium of two shanked eyes and snugs. The invention dispenses with the usual two snugs which support the gudgeon-pin, and are usually arranged about half way up the interior of the piston. The method of mounting the connecting-rod in accordance with the invention consists in employing two eyes 7, 8, each of the eyes being provided with a screwed shank, which is passed from the underside of the piston through a hole in the head to the exterior thereof, and is secured by a nut screwed on to the projecting end of the shank. The gudgeon-pin 1 is formed in one with, or is otherwise secured to, one of the eyes before the latter is secured to the head of the piston, and the other end of the gudgeon-pin 1 is adapted to enter the hole in the other eye before the latter is secured to the head of the piston, so that there is no possibility of the gudgeon-pin getting loose and rocking in the eyes. A bush is secured to the interior of the eye of the connecting-rod to work on the gudgeon-pin. Owing to the snugs being dispensed with, the interior of the piston may be bored deeper than heretofore and its sides made much thinner. (*Accepted May* 31, 1911.)

GUNS AND EXPLOSIVES.

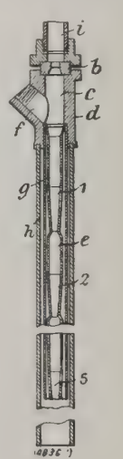
13,050/10. H. Stanbridge, Sheffield. Projectiles. [3 *Figs.*] May 30, 1910.—The copper or other metal bands or rings of projectiles are attached in position by placing the base of the projectile A in a block B having a recess b^1 half the width of band and of the same diameter or a little smaller. The bottom of such recess and the bottom of the groove a^1 in the projectile correspond. The band C is slipped over the projectile and placed in the recess b^1 and a die D having an internal diameter slightly larger than the desired finished diameter of the band is placed over the projectile and rests on the band. The die has a convex lead or radius calculated to mount and press inwards the band on the



die being forced down by a sleeve E placed over the projectile. The sleeve fits the projectile and has a recess for centering the die and keeping it true. The die is now forced down until it meets the block B and half the band or thereabouts is closed in, the die being fast on the band. The head of the projectile is now placed in a cup or block G to centre it and a die H nearly or quite the desired finished size of band, is forced down over the half of the band projecting, and as the downward push is continued it gradually pushes off the die D and leaves the band in its place. In some cases a final die or dies can be pushed over to further decrease the diameter of the band. (*Accepted May* 31, 1911.)

HYDRAULIC MACHINERY.

4836/11. W. J. Frame, Glasgow. Hydraulic Suction Apparatus. [4 *Figs.*] December 21, 1910.—Hydraulic jet suction apparatus has, according to this invention, an eduction tube provided with a series of truncated cones communicating with one another, the throats of the truncated cones gradually enlarging towards the final outlet. The water, under pressure, passes from the tube *i* through the diaphragm *b*, and issues as a jet of spray which passes across the space *c* of the suction chamber *d* into the eduction tube *e*, which latter has a series of conic



contractions therein which form truncated cones 1, 2, 3, 4, and 5. *f* is the suction branch of the suction chamber, *g* is a tube enclosing the eduction tube, and *h* a tubular protecting casing. The diaphragm *b* is made with an orifice therein having a sharp edge, the surface surrounding the orifice being preferably flat. The opening has a parallel wall or part extending for a short distance, and then diverges. The parallel part may be of any length, provided it is less than about the least transverse dimension of the entrance opening. (*Accepted May* 31, 1911.)

German Electrical Industry.—The Germans, it is well known, push their foreign trade in this branch with exceeding skill and energy, and with good results. Thus the German Oversea Electricity Company, which has a capital of 90,000,000 marks, last year had gross profits of 21,696,656 marks, against 17,631,155 marks for the previous year, the net profits being respectively 14,689,043 marks and 11,332,456 marks, the writings-off for the two years being respectively 4,420,795 marks and 2,861,362 marks, the dividend for both years being 10 per cent.

THE STEAM-TURBINE.

THE theory of the Parsons steam-turbine has long constituted a problem in applied mathematics of considerable difficulty, which has been aggravated by the scantiness of reliable data, such as might serve not only to check the results of calculation, but also to suggest new methods of attack.

In some regards, indeed, the electric-lighting reaction turbine is but badly adapted for research purposes, since, in point of fact, it is generally so constituted as to be three or four distinct turbines arranged in series, and, though the efficiency of the whole set can be determined with much accuracy, it has not proved easy to deduce with precision the individual efficiency of the several components. With marine turbines, however, where the high-pressure and the low-pressure turbines drive separate shafts, this source of uncertainty is avoided, but, on the other hand, the measurements of power being made by torsion-meters are less reliable than those effected electrically. Further, the turbines being supplied with non-superheated steam, the initial "dryness fraction" is a little doubtful. These drawbacks, notwithstanding the trial data of marine turbines, certainly seem to throw most light on reaction-turbine theory, and the conclusions set forth below have, in the main, been based on a careful analysis of the results obtained in the trials of various battleships and large Atlantic liners.

In a series of articles which appeared in ENGINEERING during the autumn of 1906 a method of treating the compound reaction turbine was explained, which, whilst correct in principle, was cumbrous to apply, and, further, in the then dearth of experimental data, the values of certain important coefficients had to be assumed. Moreover, in developing this method reliance was placed on the then accepted theory of "loss by hydraulic shock." This introduced what has since been proved to be a needless complication, as recent experiments have shown that this theory is largely erroneous and almost wholly inapplicable to turbine practice.

The first indication of this fact appeared on analysing, about three years ago, the results of some very carefully conducted experiments, in which a series of impulse wheels, having different bucket angles, were tested under identical conditions and through wide ranges of speed. From the efficiency realised, after correction for wheel friction, it was possible to deduce the loss by bucket friction. According to the accepted theory this should have been least when the tangent to the bucket curve at entrance was parallel to the flow, of the steam, taken relatively to the moving bucket. Actually, however, it turned out that, in certain cases, the loss by bucket friction was, under this condition, considerably higher than when the wheel was run more slowly. A partial explanation of this result was afforded by Professor Rateau's experiments on the pressure of air on inclined planes, of which a description appeared in ENGINEERING, September 17, 1909. The accepted theory of hydraulic shock has, it will be remembered, been based on the following considerations:—Suppose a flat plate to stand at right angles to an air current. Then from symmetry it is obvious that air will flow over each and every edge of the plate. Next take the case of a flat plate such as A B, Fig. 1, exposed to an air current the velocity of which is represented in magnitude and direction by C D. Then C D can be resolved into a component C E parallel to the plate, and a component E D perpendicular to the plate. The former produces a flow of air solely over the trailing edge of the plate, but the normal component, it was assumed, would, just as if it acted alone, produce a flow over every edge, and so far as the production of velocity in the direction C E was concerned, this "normal component was destroyed." Hence, whatever the angle θ (see Fig. 1), it was held that some portion of the air would escape over the leading edge just as it would were actual gases theoretically perfect fluids. Experiments made with fairly large values of θ confirmed this theoretic conclusion, but Professor Rateau found that when θ was less than about 25 deg. none of the flow took place over the edge A. It is perhaps only fair to experimenters in aeronautics, such as Sir Hiram Maxim, to state that this conclusion had been previously reached by them.

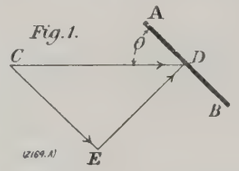


Fig. 1.

Following these experiments by Professor Rateau, an article, published in the *Zeitschrift des Vereines Deutscher Ingenieure* on September 11, 1909, by Professor Donat Banki, of Budapest, described some experiments made with apparatus specially designed to test the importance of hydraulic shock. This consisted of a pair of horizontal discs, between which could be clamped two straight radial guides, the angle between which was adjustable. A glass window was provided in one of the discs, through which the flow could be observed. Water under pressure issued from a cock, in a direction parallel to one guide, and flowing along it, was diverted by the other. The fluid thus met this movable guide under conditions which, according to the previously-accepted theory, would lead, in turbine practice, to a large loss of its kinetic energy. Actually, however, the loss proved to be very small, even when the angle between the guides was as little as 90 deg. Of course, in this experiment it has to be observed that the fixed guide prevented any flow of the water save in the intended direction, and nothing analogous to this is provided in turbine practice. On the other hand, however, the effective angle between the first element of a turbine bucket and the fluid actuating it never approaches 90 deg. in ordinary turbine practice, and Banki's experiments may thus be taken as confirming those of Rateau, and also the conclusions reached from an analysis of the turbine tests already mentioned. One is thus led to the conclusion that the ordinary theory of loss by hydraulic shock is inapplicable when considering the losses of energy in turbine buckets. In impulse-wheels these losses are, nevertheless, large, as Professor Rateau has shown in his experiments, described in ENGINEERING, December 10, 1909, page 804. His figures have been confirmed by Dr. Briling, in a series of experiments originally published in the *Zeitschrift des Vereines Deutscher Ingenieure*, and of which a short account was given in our issue of April 29, 1910, page 552.

The fact thus established, that the true bucket loss* is nearly independent of the bucket speed, greatly simplifies the theory of the compound reaction steam turbine, and enables its rational design to be reduced to a few simple formulæ the coefficients for which can be read direct from certain curves calculated once for all.

It will probably be more satisfactory to many of our readers if we give these formulæ at once and explain their application before giving a description of the long and somewhat tedious investigations by which they have been derived, and of the experimental data from which the coefficients involved in the complete theory have been determined.

As is well known, the blades of a Parsons turbine of the standard type are divided into a series of groups, in each of which all the blades are identical in height and form. From group to group the blade heights increase in a geometric ratio, which very commonly is $\sqrt{2}$, or 1.41, whilst in other cases it is $\sqrt[3]{2}$, or 1.26. Less frequently the ratio in question has been made equal to the $\sqrt[3]{4}$, or 1.587. In practice the nearest even $\frac{1}{8}$ in. is taken for the blade height. If, for instance, the blade height in group 1 is $\frac{7}{8}$ in., then the second group will have a blade height of $\frac{7}{8}$ in. $\times$ 1.41 = 1.25 in. nearly, whilst the blade height in the third group will be $\frac{7}{8} \times (1.41)^2 = 1\frac{3}{4}$ in., and so on. Similarly, if the common ratio had been $\sqrt[3]{2}$ instead of 1.41 the blade height in the second group would be $\frac{7}{8} \times 1.259 = 0.98$, say 1 in. In the third group it would be $\frac{7}{8} \times (1.259)^2 = 1\frac{3}{8}$ in. nearly, whilst in the fourth group it would be $\frac{7}{8} \times 2 = 1\frac{3}{4}$ in. A complete turbine commonly consists of twelve groups when the blade-height ratio is $\sqrt{2}$ to 1, and of fifteen groups when this ratio is $\sqrt[3]{2}$ to 1.

The number of rows of blades per group is kept constant, and within each group it is the standard practice to set the blades so that the least distance between two adjacent blades is one-third the pitch.† It has been accordingly usual to assume that the actual area available for flow is one-third the area of the annulus between the drum and the casing. This would correspond to angle of discharge equal to 19 deg. 27 min. Actual measurement of the direction of discharge, by a method of which particulars will be given later, gives, however, a slightly different result.

Experiment confirms theory in showing that the flow fills the full annulus, and that no deduction must be made for the space occupied by the blades. One other result has, moreover, been established by actual experiment—viz., that the leakage

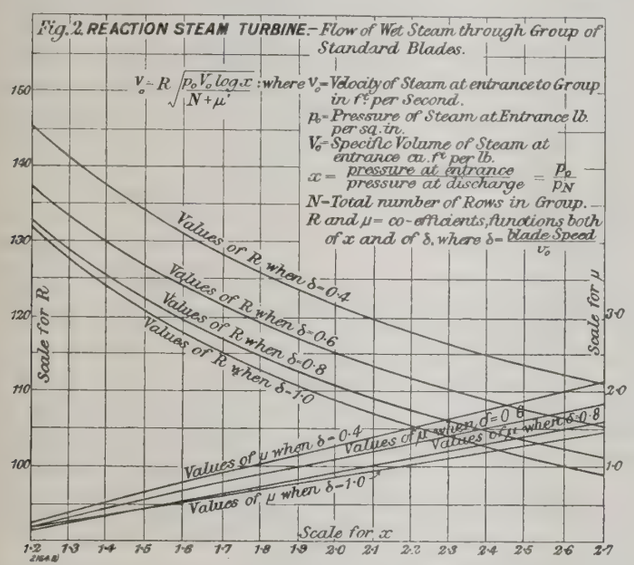


Fig. 2. REACTION STEAM TURBINE.—Flow of Wet Steam through Group of Standard Blades.
$V_o = R\sqrt{\frac{p_o V_o \log x}{N+\mu}}$ where V_o = Velocity of Steam at entrance to Group in ft. per Second.
p_o = Pressure of Steam at Entrance lb. per sq. in.
V_o = Specific Volume of Steam at entrance cu. ft. per lb.
$x = \frac{\text{pressure at entrance}}{\text{pressure at discharge}} = \frac{p_o}{p_N}$
N = Total number of Rows in Group.
R and μ = co-efficients, functions both of x and of δ, where $\delta = \frac{\text{Blade Speed}}{V_o}$
Values of R when δ = 0·4
Values of R when δ = 0·6
Values of R when δ = 0·8
Values of R when δ = 1·0
Values of μ when δ = 0·4
Values of μ when δ = 0·6
Values of μ when δ = 0·8
Values of μ when δ = 1·0
Scale for R
Scale for μ
Scale for x
150
140
130
120
110
100
3·0
2·0
1·0
1·2
1·3
1·4
1·5
1·6
1·7
1·8
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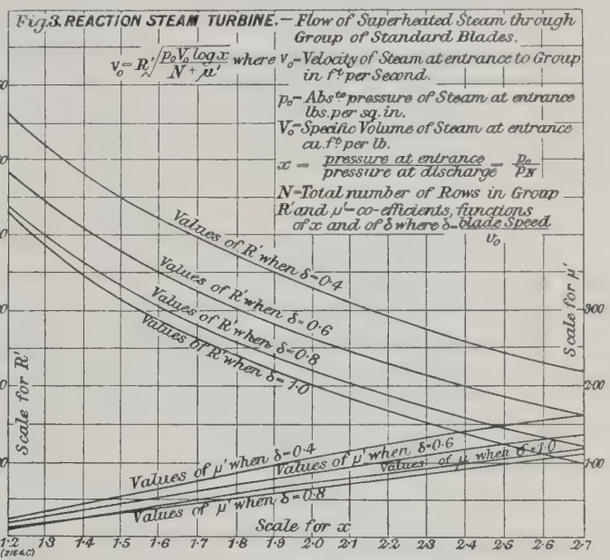


Fig. 3. REACTION STEAM TURBINE.—Flow of Superheated Steam through Group of Standard Blades.
$V_o = R'\sqrt{\frac{p_o V_o \log x}{N+\mu'}}$ where V_o = Velocity of Steam at entrance to Group in ft. per Second.
p_o = Abs^te pressure of Steam at entrance lbs. per sq. in.
V_o = Specific Volume of Steam at entrance cu. ft. per lb.
$x = \frac{\text{pressure at entrance}}{\text{pressure at discharge}} = \frac{p_o}{p_N}$
N = Total number of Rows in Group
R' and μ' = co-efficients, functions of x and of δ where $\delta = \frac{\text{Blade Speed}}{V_o}$
Values of R' when δ = 0·4
Values of R' when δ = 0·6
Values of R' when δ = 0·8
Values of R' when δ = 1·0
Values of μ' when δ = 0·4
Values of μ' when δ = 0·6
Values of μ' when δ = 0·8
Values of μ when δ = 1·0
Scale for R'
Scale for μ'
Scale for x
150
140
130
120
110
100
3·00
2·00
1·00
1·2
1·3
1·4
1·5
1·6
1·7
1·8
1·9
2·0
2·1
2·2
2·3
2·4
2·5
2·6
2·7

* The efficiency of the wheel, of course, diminishes rapidly as the speed falls to nearly zero, but the loss of energy is then mainly loss by "carry over."

† In one important marine installation this fraction has been made equal to $\frac{1}{4}$, but no advantage has resulted

over the blade-tips cuts straight across, and is not appreciably deflected by the main flow through the blades. In other words, the direction of the leakage flow is axial.

Premising the foregoing, it may be stated that if p_0 denotes the absolute pressure* in pounds per square inch of the steam as it flows into a group of a compound-reaction turbine, and V_0 the corresponding actual specific volume of the steam in cubic feet per pound, whilst p_N and V_N denote the same quantities on discharge from the group, then the fundamental equation in reaction-turbine design may be written—

$$v_0 = R\sqrt{\frac{p_0 V_0 \log x}{N + \mu}} \quad . \quad . \quad (1)$$

Here v_0 denotes the "nominal" velocity of flow of the steam into the group taken in feet per second; x the ratio $\frac{p_0}{p_N}$, and N the total number of rows of blades in the group, both fixed and moving. R and μ are two coefficients which vary both with x and with δ, the latter being the ratio of blade speed to steam speed at entrance; that is, $\delta = \frac{s}{v_0}$, where s is the blade speed in feet per second. The values of R and μ can be read direct from the curves reproduced in Figs. 2 and 3, the former being used in the case of wet, and the other in the case of superheated, steam. As will appear later, the form of equation (1) is based on theory, whilst the values of the coefficients are determined by comparison with actual test data.

By the "nominal" velocity of the steam at entrance is meant the velocity with which the steam would flow through the first row of blades did no expansion take place within these blades. Thus, if Ω be the actual area in square feet available for flow, and w the weight of steam passed per second, v_0 is defined by the relation

$$v_0 = \frac{w V_0}{\Omega}.$$

From a mathematical standpoint it is convenient to consider v_0 as the velocity of discharge of the steam from an imaginary row of blades anterior to row No. 1. It is also convenient to call v_0 the velocity of the steam at entrance.

Experiment shows that with a blade height ratio equal to $\sqrt{2}$, that x for the first group has the value 1.41, whilst with a blade height ratio equal to $\sqrt[3]{2}$, x has the value 1.29. Again, s is very often about 0.5 v_0, or, in other cases, 0.6 v_0. It is not often much less than 0.4, save when marine turbines are running at low powers.

Putting

$$\delta = 0.4, \text{ and } \rho = 1.41,$$

we get, taking R and μ from Fig. 2,

$$v_0 = 52.92\sqrt{\frac{p_0 V_0}{N + 0.60}},$$

and

$$v_0 = 47.08\sqrt{\frac{p_0 V_0}{N + 0.38}},$$

where

$$\delta = 0.4, \text{ and } \rho = 1.29.$$

Similarly for

$$\delta = 0.5, \text{ and } \rho = 1.41,$$

we have

$$v_0 = 51.38\sqrt{\frac{p_0 V_0}{N + 0.53}},$$

whilst with

$$\delta = 0.5, \text{ and } x = 1.29,$$

we get

$$v_0 = 45.71\sqrt{\frac{p_0 V_0}{N + 0.31}}.$$

Similarly putting

$$\delta = 0.6, \text{ and } x = 1.41,$$

gives

$$v_0 = 50.10\sqrt{\frac{p_0 V_0}{N + 0.46}},$$

whilst

$$\delta = 0.6, \; x = 1.29,$$

leads to

$$v_0 = 44.58\sqrt{\frac{p_0 V_0}{N + 0.28}}.$$

As a matter of experience, as will be shown by trial data taken from several tests of turbines, the ratio of the initial pressure at entrance to a group to the pressure on discharge from the same group is nearly constant for a Parsons turbine designed with the blade heights increasing in geometric ratio from group to group. In fact, the pressure decreases in very nearly the same ratio as the blade heights increase, and this circumstance makes it possible to employ numerical tables for rapidly fixing the general dimensions and steam consumption of a Parsons turbine of the ordinary type. A table of this kind is given below, and is based on a value for $p_0 V_0 = 455$, which is a fair mean for present-day boiler practice. Thus, with steam at 200 lb. absolute the product $p_0 V_0$ is 458, whilst with $p_0 = 150$ we get $p_0 V_0 = 451$.

Table I.

$v_0 = \frac{w V_0}{\Omega}$ = velocity of steam at entrance to group.

N = Total Number of Rows in Group (Both Fixed and Moving).	$x = \frac{p_0}{p_N}$ = Pressure at Entrance / Pressure at Discharge = 1.29.			$x = \frac{p_0}{p_N}$ = Pressure at Entrance / Pressure at Discharge = $\sqrt{2}$ = 1.41.		
	Blade Speed / v_0 = δ = 0.4.	Blade Speed / v_0 = δ = 0.5.	Blade Speed / v_0 = δ = 0.6.	Blade Speed / v_0 = δ = 0.4.	Blade Speed / v_0 = δ = 0.5.	Blade Speed / v_0 = δ = 0.6.
	ft. per sec.	ft. p. sec	ft. per sec.	ft. per sec.	ft. p. sec	ft. per sec.
4	482.1	469.7	459.7	528.6	517.1	508.2
6	398.8	388.2	379.4	440.0	430.7	422.3
8	347.7	338.3	330.5	385.5	376.9	369.0
10	312.3	303.7	296.6	347.2	339.2	338.1
12	285.9	277.9	271.4	318.5	310.9	303.6
14	265.2	257.7	251.6	295.9	288.7	282.3
16	248.4	241.5	235.7	277.5	270.7	264.6
18	234.5	227.9	222.4	262.1	255.7	249.8
20	222.6	216.4	211.2	249.1	242.9	237.3
22	212.5	206.4	201.4	237.8	231.9	226.5
24	204.5	197.8	193.0	227.9	222.2	217.0
26	195.6	190.1	185.3	219.2	213.7	208.7
28	188.3	183.2	178.8	211.4	206.1	201.2
30	182.3	177.1	172.8	204.4	199.2	194.5
32	176.6	171.6	167.4	198.0	193.0	188.4
34	171.4	166.5	162.4	192.2	187.3	182.8
36	166.6	161.8	157.9	186.9	182.1	177.8

The table shows, for example, that if there are 24 rows of blades in a group, and the pressure in front is 1.41 times the pressure on discharge from the group, then v_0 the velocity of the steam at entrance is 222.2 ft. per second if the blade speed is half the steam speed, and 217.0 ft. per second if δ. on the other hand, is raised to the value 0.6.

If the ratio $\frac{p_0}{p_N}$ is 1.29 instead of 1.41, then the velocity v_0 for the same group of 24 blades will be 197.8 ft. per second for $\delta = 0.5$, and 193.0 ft. per second if $\delta = 0.6$.

If the value of p V were constant from end to end of the turbine, a second group of 24 blades, with the same velocity at entrance as before, would for the case first taken again reduce the pressure in the ratio of 1 to 1.41, so that two groups, of 24 blades each, would, in the conditions stated, halve the pressure. Actually, of course, the product p V is not constant, but diminishes as the expansion proceeds, according to a law which may be expressed, with sufficient accuracy, as $p V^\gamma$ = constant, where γ has a value greater than unity In the Parsons turbine, however, this reduction of the product p V, due to the expansion of the steam, is, in some cases, partially compensated for by the fact that a less weight of steam passes through the blading at the high-pressure end of the turbine, since the leakage at the high-pressure dummy is greater than at the intermediate dummy, and this again is greater than the leakage loss at the low-pressure dummy.

(To be continued.)

New York State Barge Canal.—From the most recently issued report by the State engineer and surveyor of the State of New York it appears that of the contract work, amounting to 14,518,030*l.*, there was completed up to July 1 last work valued at 6,232,700*l.*, and that the portion done in June represented a sum of 288,896*l.*

Cement in Russia.—Owing to the increased activity in the building trades throughout the Russian Empire there has sprung up a considerable demand for cement, and there is some difficulty in obtaining the necessary supplies. In spite of the shortness of the supplies in most places, there are, however, large stocks in certain localities, but the agents in many cases are simply holding them back, with the natural sequence of higher prices. This policy is being publicly denounced. The production (and the consumption) is very small, amounting to $\frac{1}{30}$ barrel per inhabitant, against Germany's half-barrel per head.

THE STRENGTH OF STEELS IN COMPOUND STRESS, AND ENDURANCE UNDER REPETITION OF STRESS.

By L. B. Turner, B.A.

(*Continued from page* 185.)

Tube-Steel Results.

Special interest was felt in the experiments on the tube steel, owing to the static tests which had been made on the 1-in. tubes of the material. It seems, however, that such tubes are not satisfactory as specimens in experimental work of this nature. We have seen that the 1-in. tubes did not give very uniform results (thus necessitating a large number of tests); after they had been used, other batches of 1-in. tube were obtained, and were found to vary astonishingly in their elastic limit properties; the $\frac{5}{8}$ in. tubes show similar lack of uniformity.* Their behaviour in the annealed condition is rather more satisfactory than when not annealed.

Static tests in pull and torque were made on the unground body of the specimen, after it had been used in the alternating machine.

Fig. 17, page 247, shows the endurance curves for the unannealed specimens, and Fig. 18 for the annealed. The ordinates are the extreme values of the alternating stress (simple shear or simple tension) reached at the breaking section; the abscissæ are the revolutions to fracture,† or, if the specimen was removed unfractured (shown so :—O—>), the revolutions till the removal. The stresses are calculated on the assumption that the material remains elastic while the load is being applied; they, therefore, are not the true stresses in the highly-stressed, quickly-breaking specimens.

Table IV. contains the elastic limit and endurance results for the tubes.

Table IV.—*Tube Steel* (*Lb. per Sq. In.*).

	Simple Tension.		Simple Shear.	
	Elastic Limit.	Endurance Stress.	Elastic Limit.	Endurance Stress.
Not annealed	50,000	33,000	29,500	16,000
Annealed	31,000	29,000	17,000	16,000

In the annealed specimens, the limiting endurance stress is only slightly less than the elastic limit, for both tension and shear. This in accordance with the Bauschinger theory. The shear theory is not far from accurate for both static stress and alternating stress. These are results which would be of immense importance if the tests from which they are obtained were more uniform. Fortunately the other materials tested were of more reliable quality.

5. Mild-Steel Results (Fig. 19).

The mild steel gave results very similar to those of the tube steel. But the material was admirably uniform, both in its behaviour under static and under alternating stress. The smoothness with which the points lie about the endurance curves is a testimony at once to the good quality of the steel, and to the satisfactory working of the alternating machine. The high stresses to which the tension tests are carried are for the purpose of the Arnold test, discussed later.

Table V.—*Mild Steel.*

	Lb. per Sq. In.
Simple tension:	
Elastic limit	42,300
Endurance stress	40,000
Simple shear:	
Elastic limit	24,000
Endurance stress	22,000

This steel is considerably stronger in static simple shear than the shear theory would indicate. It is interesting to see that its behaviour under alternating stress is very similar; in each distribution the endurance stress is slightly lower than the corresponding elastic limit, being such as to make the shears rather closer for the alternating than for the static stress.

Tool-Steel Results (Fig. 20).

The tool steel showed itself much less uniform than the mild steel, and behaved very differently under the alternating stresses.

* It is convenient to denote pressures in pounds per square inch by p, and pressures in pounds per square foot by P.

* These tubes even varied in diameter and thickness, a fault very little evident in the 1-in. tubes.

† In comparing these with other experiments, it should be remembered that one revolution equals two reversals of stress.

TABLE VI.—*Tool Steel.*

	Lb. per Sq. In.
Simple Tension:	
Elastic limit	67,000
Endurance stress	50,000
Simple Shear:	
Elastic limit	38,400
Endurance stress	38,000

Although such a high carbon steel (1.25 per cent.), containing, therefore, structurally free cementite and no structurally free ferrite, the shears at elastic limit were slightly more equal in the two stress-distributions than was the case for the mild steel, consisting of ferrite and pearlite. But whereas for the mild steel the strengths to endure alternating stress are but little different from the elastic limits in static stress, the tool steel is remarkably weak to resist alternating tension; while in shear, on the other hand, its endurance stress is equal to the elastic limit. Consequently, for the alternating stress, the shears are so far unequal that the maximum tension hypothesis would be closer than that of equal shears. The great discrepancy between the endurance and the elastic limit simple tensions is in contradiction, of course, to the Bauschinger theory as applied to this material.

The only previous tests in repeated compound stress—viz., Wöhler's nine torsion-tests — were made on material probably very similar to our tool-steel. It was called "Krupp's cast-steel axles," and had an ultimate strength varying in five tests between 41.8 and 49 tons per sq. in.; the mean figure is equal to 102,000 lb. per sq. in. The ultimate strength of the present tool steel was 107,000 lb. per sq. in. Wöhler's results for this material are given in Table VII. :—

TABLE VII.—(*Wöhler*).* *Krupp's Cast-Steel Axles.*

Endurance Stresses.
Pounds per Square Inch.

	Max. Stress.	Min. Stress.
Simple Tension	51,000	0
	30,000	−30,000
Simple Shear	41,000	0
	23,500	−23,500

* From Unw n, page 350.

For alternations between equal opposite stresses, Wöhler's figures are thus: 30,000 and 23,500; and the author's for tool steel, 50,000 and 38,000. The ratio is almost the same for the two materials. As Wöhler's was in all probability a hyper-eutectic crucible steel, this result is very interesting. Two steels of the same class in carbon-content, although unequal in endurance strength, yet fracture according to the same critical stress distribution. It is regrettable that no comparison of elastic limits can be made.

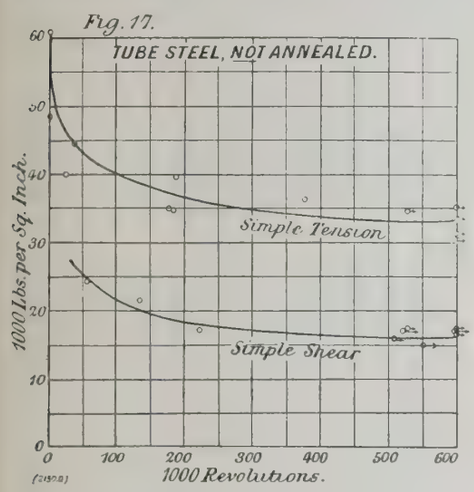
NICKEL-STEEL RESULTS (FIG. 21).

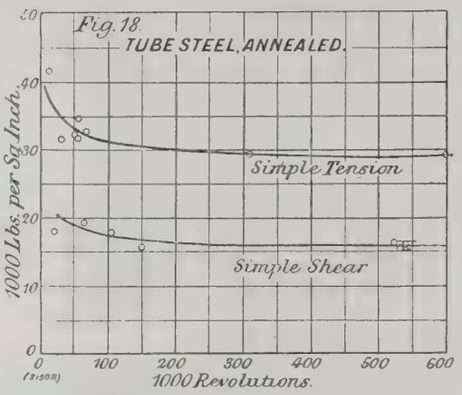
This material, as an example of the numerous "fancy" steels introduced for structural use in recent years, is an important inclusion in the series of tests. Its uniformity was satisfactory, although not so striking as that of the mild steel.* to see what effect the annealing produced. The dotted curves in Fig. 21 show that annealing distinctly, though not very greatly, lowered the endurance stresses. In the testing-machine the elastic limit was somewhat raised, and the yield-point lowered, by annealing; the two points coinciding in the annealed specimens.

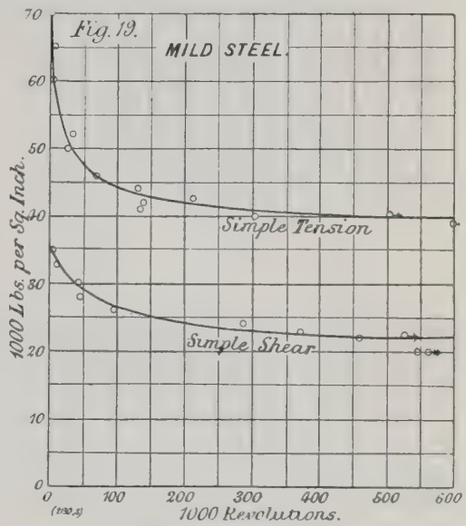
COLLECTED RESULTS.

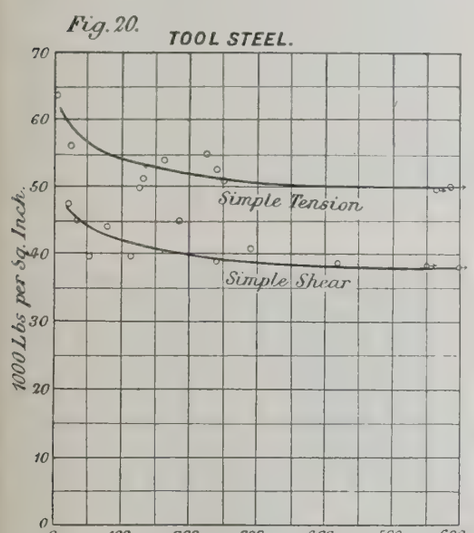
In Table IX., various figures for the materials tested in the alternating machine have been collected together for purposes of comparison.

Comparison of rows 1 and 3 shows that in all the steels the elastic limit shear in simple shear never exceeded the elastic limit shear in simple tension by more than about 14 per cent. So that the shear theory of elastic limit, as a rough working rule for purposes of design, would not be a very bad one. Row 11 shows that the elastic limit in simple shear is a tolerably good index of the limiting endurance stress for simple shear; row 10 shows that for simple tension the equality is not well maintained, the tool and nickel-steels being particularly weak (in comparison with their elastic limits) to withstand alternations of simple tension. Consequently comparison of Rows 2 and 4 shows larger variation in the maximum shears for the endurance stress than for the elastic limit. If we except the tool-steel, however, the endurance shear in simple shear never exeeds the endurance shear in simple tension by more than about 17 per cent. (the nickel steel being responsible for the largeness of this figure).









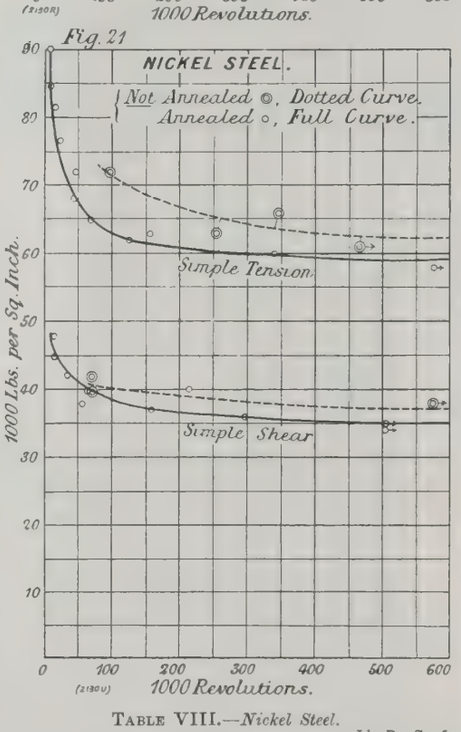


TABLE VIII.—*Nickel Steel.*

	Lb. Per Sq. In
Simple Tension:	
Elastic limit	81,200
Edurance stress	59,000
Simple Shear:	
Elastic limit	40,800
Endurance stress	35,000

Here the shear theory is accurate for the static tests, but the endurance stresses drop below the elastic limits, and, as with the tool-steel, considerably more in simple tension than in simple shear.

A few tests were made on the bar "as rolled,"

* Repeated stress experiments generally, from the nature of fatigue, are apt to give points on the endurance curve which do not lie very evenly about the mean curve. As the same effect would be produced by experimental imperfections of machine and method, it is pleasing to light upon some materials, in the course of the research, which, although treated in the same manner as the rest, yet yield results of good uniformity. The mild steel is such material, as far as regards the machine. The nickel steel endurance curves tend to show that the annealing process was satisfactorily uniform; for although annealing did affect its behaviour, and although it is a material susceptible to heat-treatment, the points for the annealed specimens lie very fairly evenly about the curves.

TABLE IX.—*Units: Inch, Pound.*

	Kind of Test.	Kinds of Steel. Tube (Anneal.)	Mild.	Tool.	Nickel.
	Simple tension:—				
1	Elastic limit	31,000	42,200	67 700	81,200
2	Endurance stress	29,000	40,000	50,000	59,000
	Simple shear:—				
3	Elastic limit	17,000	24,400	38,400	40,800
4	Endurance stress	16,000	22,000	38,000	35,000
5	$E \times 10^{-7}$	2.62	2.91	3.01	2.89
6	$C \times 10^{-7}$	1.16	1.18	1 15	1.15
	Testing machine:—				
7	Ultimate strength	55,200	61,400	107,000	108,000
8	Elongation on 8 in. p.c.	24	29	9	14
9	Contraction of area ,,	65	69	39	36
	Endurance stress :— Elastic limit				
10	Tension	0.89	0.95	0.74	0.73
11	Shear	0.93	0.90	0.99	0 86
	Endurance stress :— Ultimate strength				
12	Tension	.52	0.65	0.47	0.55

For the two ordinary low-carbon structural steels, the shear criterion would provide the engineer with a sound working rule for static and for varying loads; the greatest safe range of stress being taken equal to the static elastic range of the material. For the other two steels, the shear theory would be good enough as regards the static loads, but would lead to dangerously high varying tension or unnecessarily low varying shear.

Similar experiments made on a variety of ordinary

mild steels would probably show similar results to those obtained with the two such steels here tested. If this were so, the Bauschinger theory and the shear theory would be demonstrated to be approximately true for this class of steel. The double obscurity wherein the designer now gropes would give way to an understanding enabling him, for the first time, to attempt the rational design of a crank-shaft.

The Arnold Test.

At the British Association meeting in 1904, Professor J. O. Arnold described a machine designed to make alternating bending tests of a novel kind. The specimens are in the form of $\frac{3}{8}$-in. square rods. One end is firmly encastré, while the other is bent backwards and forwards through a constant distance in one plane until the specimen breaks. The bending force is applied by an oscillating plate A, through a hole in which the free end of the specimen B passes (Fig. 22). This end of the specimen—4 in. from the fixed end—is deflected

Fig. 22.

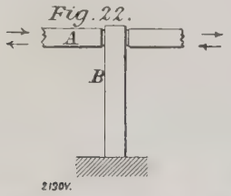


Fig. 24.

to $\frac{9}{16}$ in. or $\frac{3}{4}$ in. on each side, thereby much overstraining the specimen, which breaks after a very few thousands of alternations.

It is asserted that the number of alternations before fracture is a measure of the capacity of the material to withstand fatigue; and Professor Arnold makes the astonishing and unsupported claim:—"This method of testing—which practically carries out the almost impracticable Wöhler test in one or two minutes—. . ."

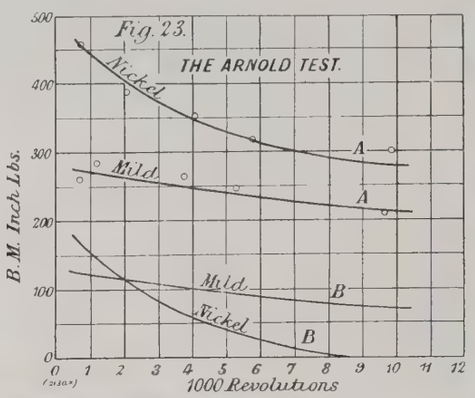
More recently the test has been advanced in Engineering.*

In the writer's experiments with alternating tension, it was easy to extend the tests to investigate this claim. This has been done with the mild and nickel-steels.

Both these materials underwent complete plastic yield at the elastic limit, and the specimens in the alternating machine were of the same size. Consequently the amount of overstrain in each specimen is proportional to that part of the applied bending moment which is in excess of the bending moment just producing limit of elasticity. Now in Arnold's machine practically the whole of the deflection corresponds to overstrain; hence his method is to apply equal overstrain to the different materials. If, therefore, two specimens are tested in the writer's machine, being given equal amounts of plastic bending moment (*i.e.*, bending moment in excess of that just producing elastic limit), the ratio of revolutions in the two cases is claimed to be a measure of the relative endurance strengths.

In Fig. 23, A, A are curves relating applied bending moment with revolutions to fracture. B, B are the same curves, with the ordinates reduced by the respective elastic limit bending moments for the two materials.

Fig. 23.



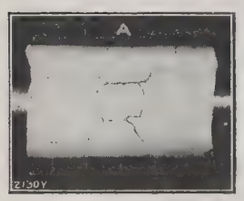
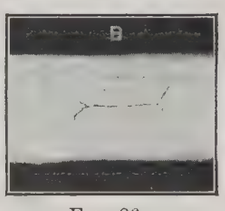


Fig. 25.



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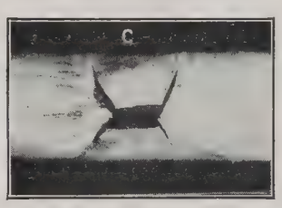


Fig. 27.

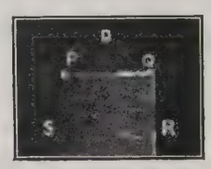


Fig. 28.

Fig. 29.

Fig. 30.

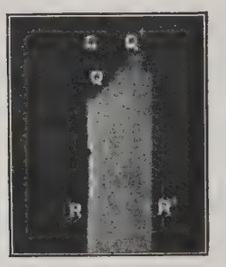


Fig. 31.

Fig. 32.

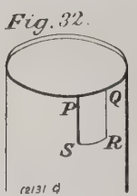


Fig. 36.

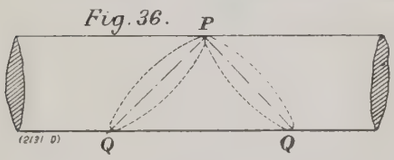


Fig. 37.

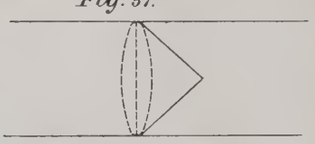
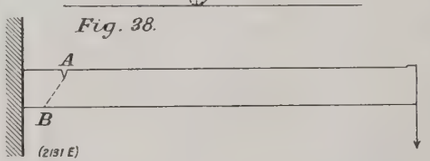


Fig. 38.



To justify the claim for the Arnold test, the abscissæ of the intersections of a horizontal line with the two curves B, B would have to be in the ratio of the limiting endurance stresses—(viz., Nickel / Mild = 59,000 / 40,000). With the present curves, this could only be so for one such horizontal line; showing that with these materials the results claimed could only be obtained by using one particular amplitude of deflection of the specimens in the machine. No special care seems to have been exercised in choosing this amplitude, and different values have been used in different experiments.

The test may very likely give useful information, but it does not supply that of the Wöhler test—viz., the limiting endurance stress.

Form of Fracture under Alternating Stress.

As evidence for and against particular hypotheses of elastic breakdown, the inclinations of surfaces of fracture have sometimes been adduced. For example, a characteristic form of fracture of mild steel stretched to destruction in the testing-machine is the truncated cone (Fig. 24), indicating, it is urged, that breakdown occurs over the plane of maximum shear. The validity of such a contention is highly doubtful, even if it refer only to the ultimate strength, and to apply it to the problem of the elastic limit is quite illegitimate.

But with fracture by fatigue the case is very different. Here the stress may never have exceeded the (primitive) elastic limit, and it is well known that, even when the stress variation has not involved change of sign, the fracture is always of an entirely brittle nature. The dimensions of the specimen are the same before and after the fracture has occurred. In failure by fatigue, therefore, the surface of severance is an entirely relevant factor in the investigation of the stress distribution which produced the breakdown. Furthermore, if the surface of fracture is clearly defined, we have therein a short cut towards establishing or disproving our hypothesis. Suppose, for example, we are testing the shear theory, and we find in a single specimen that the fracture occurred in a plane of maximum shear; at once we have a piece of evidence complete in itself. There is no necessity to compare fractures under various kinds of

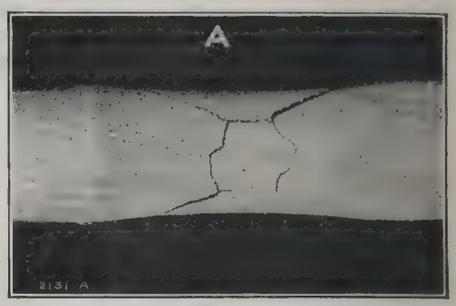


Fig. 33.

Fig. 34.

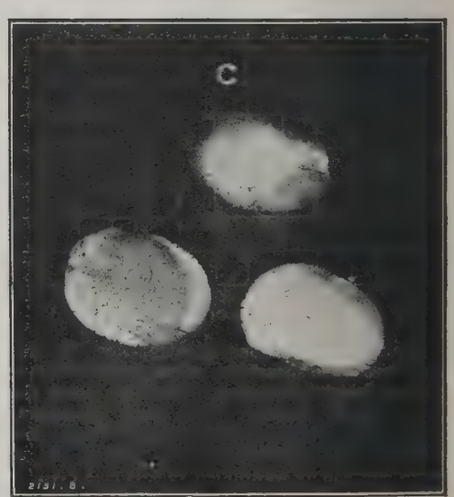


Fig. 35.

* J. O. Arnold, "Factors of Safety in Marine Engineering," Engineering, vol. lxxxv., pages 543, 565, and 598 (April 21 and May 1, 1908).

stress distribution. The single test on the single specimen shows that the fracture took place by reason of the greatest shear.

In the present experiments various typical photographs of the fractured surfaces were taken, and these we will proceed to consider.*

Tube-Steel (Figs. 25 to 31, A—G, Page 248).

The failure of the tubes under alternating torque was invariably by the occurrence of one or more longitudinal cracks, which, in the course of a few more alternations, split at the ends into forked branches. This is shown in A and B (Figs. 25 and 26). C (Fig. 27) shows the effect of allowing the machine to continue to run, and is of no evidential interest. The vital point is the manner in which the fracture begins; after it has begun the stress distribution is unknown. Here, then, the fracture always chooses a plane of maximum shear. The direction of the crack shows this very closely; for the value of the shear only falls to 95 per cent. of the maximum for a plane inclined as much as 9 deg. to the longitudinal direction.

In the bending specimens the severance was completed round a ring normal to the axis, and the broken edges showed a marked tendency to incline to the axis of the tube. D (Fig. 28) is a photograph of a strip P Q R S cut from a broken specimen (Fig. 32).

The inclination of the edge P Q is not the same all along, but suffers a sudden change from inwards to outwards. D is the outside surface P Q R S of the strip, and E (Fig. 29) is the inside surface $P^1Q^1R^1S$. The two corners P P^1 and Q^1 Q of the strip are shown in magnified side view in F and G (Figs. 30 and 31), so that the slopes may be measured. They are about 54 deg. and 45 deg. The mean of these—48.5 deg.—corresponds to a shear only about 1 per cent. less than the maximum (at 45 deg.).

Thus examination of the form of fracture of the tube specimens confirms the result obtained by comparison of stretches—viz., that the shear theory is closely followed.

Mild Steel (Figs. 33 to 35, A—C).

The torsion fractures of the mild steel (solid) specimens were similar to those of the tubes. There was this unimportant difference: that whereas in the tubes usually only one—hardly ever more than two—longitudinal cracks appeared, here several cracks were distributed round the specimen. A (Fig. 33) shows the surface cracks of a typical torsion fracture. B (Fig. 34) shows the ends of the two pieces of a specimen in which the severance was completed; it shows the ridge formation corresponding to the branched cracks on the surface. The longitudinal cracks on the surface are seen to be the intersections of the surface with fracture planes containing the axis and a radius.

The bending specimens broke across more or less plane surfaces normal to the axis. A group of three is shown in C (Fig. 35). A slight lip formation was sometimes observable at the edges.

The stress results and the torsion fractures are concordant in support of the approximate truth of the shear theory; but the bending fractures are not obviously in agreement. Rather does it seem at first sight that they would support the maximum tension theory, seeing that the surface of separation is approximately one over which the tension is a maximum and the shear zero. But we must bear in mind that, as remarked before, it is the incipient stage of fracture which concerns us—*i.e.*, the manner in which the fracture begins at the surface; and it may be that the inequality of distribution of stress across the section will mask the significance of the fracture. For suppose that when the tension of the fibre through P (Fig. 36) is a maximum, it begins

Fig. 39.

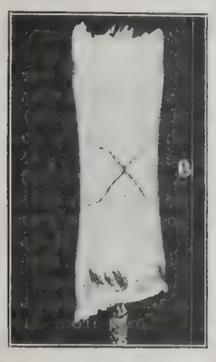


Fig. 40.

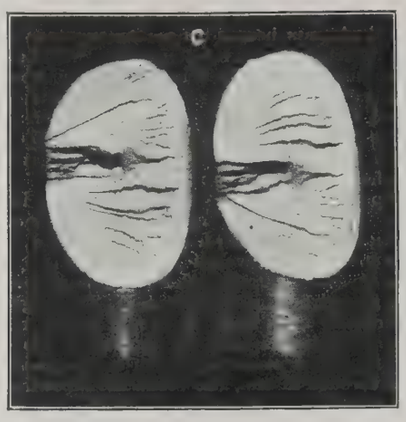


Fig. 41.

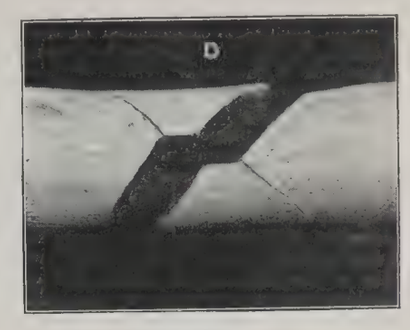


Fig. 42.

Fig. 43.

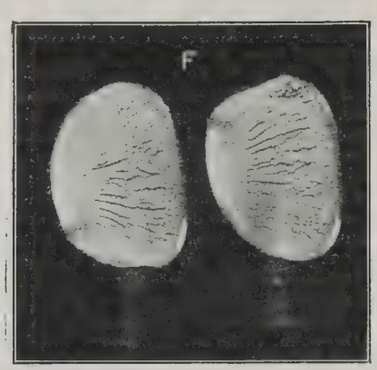


Fig. 44.

Fig. 45.

Fig. 46.

Fig. 47.

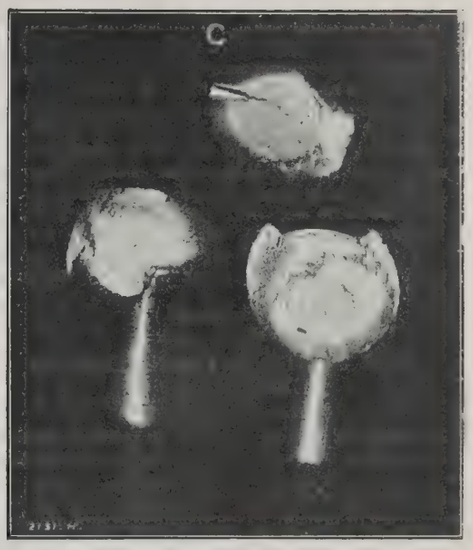


Fig. 48.

* The specimens appear white in some of the photographs, because a thin layer of whitewash was sometimes applied in order better to show up the cracks.

to give way. If the shear theory applies, severance occurs across a plane at 45 deg. to the axis, and of all such planes symmetry would indicate one whose trace on the paper is P Q. At the next instant, if P still supports its share of the bending moment, it is the turn of a neighbouring fibre P^1 to suffer the greatest tension, and for this there is a plane $P^1 Q^1$ situated with regard to P^1 as P Q is to P. And so the shear theory would give us a weakening of the material, a preparation for fracture, near the outside of the specimen, over a conical surface, as in Fig. 37.

But now suppose the fibre at P actually gives way. There is then something of the nature of a tearing action, such as is experienced in the beam at the point A in Fig. 38. And we do not suppose, on the strength of the shear hypothesis, that the beam would fracture along the plane A B.

Owing then, to this tearing action, we may not say that a fracture perpendicular to the axis is evidence for the maximum-tension theory; on the other hand, a tendency towards a lip formation at the edges points away from this theory.

The significance of the torsion fractures is not depreciated in the same manner, if only for the reason that here the surface crack is itself sufficient indication of the plane of fracture. Nor are the tube-bending fractures so subject to this criticism; for in them the stress is almost uniform from outside to inside, and the fracture is likely to be a true fatigue failure rather than a tear.

Tool Steel (Figs. 39 to 45, A—G).

Here also the torsion fracture nearly always showed the significant longitudinal cracks, usually one or two in number. After a crack had appeared, the final severance tended to take place across one plane, instead of several, as in the mild steel. Examples are given in A—F (Figs. 39 to 44). Sometimes, as illustrated by E and F (Figs. 43 and 44), it was not possible to detect any initial longitudinal failure; but that such may be present, though very little evident, is shown in B (Fig. 40). G (Fig 45) is a torsion fracture of a specimen which had undergone severe overstrain before being put into the alternating machine, and which finally broke with 125,000 revolutions at a nominal shear of 32,000 lb. per square inch. It is included only as a freak case.

The bending specimens gave uninteresting fractures similar to those of the mild steel.

Nickel-Steel (Figs. 46 to 48, A—C).

This material gave fractures closely resembling those of the mild steel. The torsion specimens showed rather more peaked and rugged ends, and the bending specimens exhibited more pronounced lip formation at the edges (Figs. 46 to 48).

Reviewing the evidence from the form of fracture, we see that the shear theory is supported by torsion and bending specimens of the tube steel, and by torsion specimens of all the other steels. The tool steel was the only one in which some torsion specimens showed no sign of fracture by shear; and it is noteworthy that this steel is the only one for which the maximum endurance shears in simple tension and in simple shear are very unequal. (See Table IX.)

(*To be continued.*)

THE TURIN INTERNATIONAL EXHIBITION.

(*Continued from page* 235.)

In the article which appeared in our last number we described the power-station for the production of current for general distribution, located at one end of the building which also contains the machinery in motion. This building communicates, by a colonnade gallery to the rear of the Prince Amadeus statue, with the Electricity, Switzerland, and Professional Teaching Pavilion. In this last-named pavilion the exhibits illustrating professional teaching are all arranged in a gallery which runs round the four sides. The ground floor is occupied by Swiss mechanical and electrical exhibits, and by machinery displays shown by various European countries. The portion of the ground floor on which are the Swiss mechanical exhibits is supplied with alternating current for power and lighting by two engine sets. One of these is by the Schweizerische Locomotiv-und Maschinenfabrik, Winterthur; this is a 150-horse-power, three-cylinder, vertical, four-cycle "Winterthur" Diesel engine, running at a speed of 190 revolutions, direct coupled to a 500-volt, 145-ampere, three-phase, fifty-period Alioth alternator. The oil fuel is stored outside the building; the quantity required for a period of activity of the engine is contained in a tank above the stand, the oil fuel running down to the engine through filters. The cooling water taken from the town mains flows back to the river. A switchboard in close proximity provides the necessary connections. We may add here, in passing, that the stand of the Winterthur Works also contains a horizontal 50-horse-power Diesel engine running empty at 200 revolutions; a 5-horse-power heavy-oil engine, in which ignition is effected in the usual way, by a bell which is heated before the engine is started, the fuel ensuring its remaining hot while the engine is running; this engine drives a centrifugal pump for illustrating its working at the Exhibition. The stand further contains a four-cylinder vertical 250-horse-power gas-engine, for a speed of 250 revolutions; and a 25-horse-power horizontal gas-engine, neither of them shown running.

Opposite this is the stand of Messrs. Bächtold and Co., Steckborn, containing a three-cylinder vertical four-cycle 150-horse-power engine, running at a speed of 190 revolutions, and driving by a belt, at a speed of 750 revolutions, a Meidinger 240-volt 240-ampere 50-period alternator. This engine runs alternately with that of the Winterthur Works above mentioned—day on, day off. The oil-fuel supply takes place also from an overhead tank and through filters; the stand has its own switchboard.

The current throughout this Swiss Section is distributed for power at 500 volts, and for lighting at 240 volts; according as either of the two engines is running, part of its current supply is transformed up or down.

Messrs. Bächtold also show, at a standstill, a 55-horse-power 200-revolution horizontal gas-engine, with its suction gas-producer; also a small 6-horse-power 250-revolution vertical petrol-engine.

The building with which we are now dealing also contains a Boulte Larbodière and Co. self-contained set, formed of the boiler, engine, and dynamo. The engine develops 180 horse-power at a speed of 420 revolutions. The steam pressure at the slide-valves is 14 kg. per sq. cm. (199 lb. per sq. in.). The steam consumption—temperature of the steam, 320 deg. Cent.—is stated to be 4.6 kg. (10.138 lb.) per horse-power hour. The boiler has a grate area of 0.90 sq. m. (9.68 sq. ft.), and a heating surface of 32 sq. m. (344 sq. ft.); its normal steam production at 320 deg. Cent. is given as 700 kg. (1540 lb.) per hour. The engine drives a continuous-current Labour dynamo which supplies a 220-volt current for the power required in the French Section on the ground floor of the building.

Another interesting prime mover is that exhibited by Messrs. Paolo, Kind, and Co., Turin, in the Naval Pavilion. This important pavilion contains a magnificent display of large and small calibre naval guns, ship's models, models of cabins and general naval material made by the Royal Italian Navy. The building is lighted by a 100-effective-horse-power heavy-oil, internal-combustion, directly reversible marine motor, designed and built by Messrs. Kind. This motor runs at a speed of 375 revolutions. It has four cylinders 180 mm. (7.08 in.) in diameter, with a 250 mm. (9.84 in.) stroke. The engine has a total weight of 3000 kg. (6600 lb.), including the flywheel, air vessels, silencer, and fittings. It measures in height above the floor level 1.57 m. (5 ft 2 in.), and 2.77 m. (9 ft. 2 in.) in length outside bearings. Its fuel consumption is given as 250 grammes (0.55 lb.) per effective horse-power hour. When the engine is running under its normal load, it can be reversed in 3 seconds. All speed changes, reversing, stopping, &c., are effected by acting on one single hand-wheel. The engine is direct coupled at one end to a continuous-current dynamo. On the other it drives a shaft which runs outside the pavilion wall into a concrete tank, the shaft being fitted at the end inside the tank with a propeller, by means of which the rapid reversibility of the engine is clearly illustrated.

The British Section, as already stated, is self-contained. The current it requires for power and lighting is generated by Messrs. R. Hornsby and Sons, Limited, and by the Campbell Gas-Engine Company, Limited. Messrs. Hornsby have put down for this purpose two horizontal suction-gas engines of 100 horse-power each, fitted with the new Hornsby variable governor, and driving each by belting a 275-ampere 220-volt continuous-current dynamo built by the Lancashire Dynamo Company. The engines are started by a small petrol-motor. The Hornsby gas-producers are outside the pavilion.

Messrs. Hornsby's engines run alternately with those on a neighbouring stand, exhibited by the Campbell Gas-Engine Company, Limited. This company have put down for supplying light and power to the section a 120-horse-power horizontal suction-gas engine driving an 80-kw. "Phœnix" dynamo by a laminated leather belt. They have also a vertical four-cylinder 150-horse-power gas-engine direct coupled to a 100-kw. "Phœnix" dynamo; and a vertical four-cylinder 290-horse-power gas-engine direct coupled to a 190-kw. "Phœnix" dynamo. These engines are driven from a suction-gas plant located in proximity outside the pavilion, designed for working with inferior fuel, such as anthracite peas and coke breeze. The Campbell Gas-Engine Company's starting set consists of one of their 6½-horse-power lampless oil-engines, direct coupled to an air-compressor, which delivers air at a pressure of 200 lb. per square inch into a steel receiver; compressed air is taken from this receiver for starting the engines.

Both the Hornsby and the Campbell Company's electric sets are connected to a switchboard put down by Messrs. A. Reyrolle and Co., there being a panel for each of the two firms.

Apart from the above engines, the Campbell Gas-Engine Company exhibit close by a 12-horse-power portable oil-engine of their latest "lampless" type; a 16-horse-power stationary engine also of their "lampless" type; and a 35-horse-power high-compression crude-oil engine.

The portion of the Exhibition at the extreme southern end, at a place called the Pilonetto, is lighted by a 100 to 140-horse-power oil-engine, designed and built by the Fiat Company, and direct coupled to a continuous-current dynamo. This is located in a room, which was to contain also a 1000-horse-power engine of the same type, also by the Fiat Company; this latter engine, however, could not be completed in time.

The above is a brief description of the installations exhibited, which serve as prime movers for a large variety of machines and for current supply for lighting purposes.

Apart from these, there are several engines which run empty for demonstration purposes. We have already referred to a few of the latter when reviewing the engines running for current supply. Among the others forming individual exhibits, we may, in the first place, mention the Humphrey pump, exhibited at work in the Machinery Hall, building. This pump was built by the Tecnomasio Italiano Brown Boveri, to plans supplied by the Pump and Power Company, Limited, London. It is an improved four-stroke cycle pump, and was designed to deliver 8600 gallons per minute when working with producer gas of only 110 B.Th.U. per cubic foot. For the purposes of the Exhibition the pump is being run on illuminating gas, and is giving an output of over 11,000 gallons per minute, equal to 16,000,000 gallons per day. The height of lift is made variable by means of an adjustable weir, over which the water pumped flows in a cascade into an artificial rock-work pool, from whence the water is returned to be pumped over and over again. The width of the weir is 3 metres (9 ft. 10 in.), and the enormous quantity of falling water makes a very fine display, so that there is always a crowd of interested spectators round the exhibit.

The pump differs chiefly from the one exhibited at Brussels last year (see Engineering, vol. xc., page 124) in that the water-valves are placed in the vertical portion of the pump just below the combustion-chamber, also the play-pipe is much shorter; in fact, the horizontal part of the pipe which connects the bend at the base of the pump to the bend at the bottom of the water-tower is only 25 ft. 6 in. long. The whole arrangement is therefore very compact. The explosion-chamber is 3 ft. 9 in. in diameter, and 5 ft. high. It is fitted with an improved arrangement of exhaust, admission, and scavenging-valves. The play-pipe is just under 3 ft. in diameter, and the pump is intended to run at about 13 complete cycles per minute.

One of the chief uses to which it is intended to put this type of pump in Italy is for land drainage work, and a demonstration was recently given at the stand before Signor Pasini and other well-known engineers for land-drainage plants A two

day's test was made with the object of showing whether long and hard leaves, such as are usually carried by the water in drainage canals, would affect the working of the pump. The test was fully successful and gave complete satisfaction to the gentlemen present; the large quantity of leaves fed into the suction-tank did not in the least affect the working of the pump.

The Tecnomasio Italiano Brown Boveri have acquired the sole licence to manufacture Humphrey pumps and compressors in Italy, and their works at Milan are able to cope with any size of installation of this type likely to be required.

Another interesting display in the machinery building is that made by the Societá Anonima Italiana Koerting, Sestri Ponente, who show a 7.5-horse-power, valveless two-cycle petrol-engine, the speed of which is 450 revolutions. It has a cylinder 178 mm. (7 in.) in diameter and a 190-mm. (7.5-in.) stroke. They also exhibit a four-cycle, heavy-oil, 6-horse-power engine at a speed of 325 revolutions, with hot-tube ignition; the cylinder is 175 mm. (6.9 in.) in diameter, with a stroke of 280 mm. (11 in.). They show further a 40-horse-power producer-gas engine, fitted with the Koerting valve for maintaining the mixture constant. A special feature of their stand is a 75 horse-power, eight-cylinder, petrol-engine, weighing 200 kg. (440 lb.) for a dirigible balloon The most interesting engine of the Italian Koerting Company's display is a 70-horse-power, heavy-oil, four-cycle, horizontal engine, of the Diesel type, which is shown coupled by belting to a water-pump. It runs at a speed of 190 revolutions; its cylinder is 345 mm. (13.6 in.) in diameter, with a 680-mm. (26.8-in.) stroke. The fuel consumption amounts to 190 grammes (6.7 oz.) per horse-power hour, when running normally under full load. The company claim the following advantages for this engine above those of what we may call the pure Diesel type. A chamber in which the fuel-pump delivers the oil fuel is in constant communication with the interior of the cylinder, the air injections taking place only at the moment of ignition. In this way the fuel-pump has only to overcome the pressure existing in the cylinder, and as it delivers oil in the chamber at the moment when the piston is on the suction stroke, it runs against the atmosphere pressure alone, instead of against a pressure of 50 atmospheres (710 lb. per sq. in.), as in the other engines. The company have further done away with the needle-valve which is met with in the engines of the pure Diesel type; the needle-valve has to withstand the 50 atmosphere pressure, and to remain in contact with the cylinder and with the high temperatures that rule inside it; in the engine under notice, the valve is at a distance from the cylinder, the oil-fuel chamber being between them. The engine at the Turin Exhibition runs most smoothly and with great regularity. The pump to which it is coupled delivers at normal speed 17 litres (3.7 gallons) per second at a pressure of $11\frac{3}{8}$ atmospheres (against a head of 385 ft.).

In the same building, and close to the Franco Tosi power-station, the Maschinenfabrik Augsburg-Nurnberg display several units. These include a stationary single-acting 100-horse-power Diesel engine of the Vogel M.A.N. system, and a Nürnberg 300-horse-power heavy oil marine engine. The former is a vertical engine which works on the four-cycle principle, and has a speed of 215 revolutions. It drives by belt transmission a continuous current dynamo. Its fuel consumption is given as 195 grammes (6.88 oz.) per horse-power hour.

The 300-horse-power marine engine is designed for driving the propeller shaft direct; it has six cylinders and runs single-acting on the two-cycle principle. Its speed is 300 revolutions; this speed can be reduced to below 100 revolutions. Reversing is by compressed air and takes but a few seconds from full speed ahead to full speed astern. The trunk of the pistons is enlarged at the lower end, to form a second piston which works in an air-cylinder and supplies the air needed for scavenging out the spent charge; the arrangement also acts as a guide, the cross-head pin being in the lower end of the piston. The engine-frame carries on each side a longitudinal receiver which extends along the six cylinders; these receivers act as inlet and discharge-chambers for scavenging. The exhaust taking place through ports and being governed by the piston, each cylinder has only a fuel, a scavenging-valve and a starting-valve. The cam-shaft lies above the cylinders. The engine is reversed by a hand-lever. For stopping, the lever is placed in its central position; when it is worked to the right or to the left, it leads to an automatic starting of the engine for ahead or astern running. The same lever also serves to regulate the oil fuel supply, and to vary thereby the work of the engine. The fuel pumps are in a casing at the front end of the engine frame. The engine is provided with forced lubrication. The company guarantee a maximum oil-fuel consumption of 220 grammes (7.76 oz.) per horse-power hour. The engine exhibited weighs, inclusive of accessories and fittings, 50 kg. (110 lb.) per horse-power; the castings are almost exclusively of cast iron.

Close to this stand, the Dinglersche Maschinenfabrik A.-G., Zweibrücken, exhibit, a 30-effective-horse-power horizontal crude-oil engine, having a cylinder 290 mm. (11.42 in.) in diameter, with a stroke of 450 mm. (17.72 in.), and running at a speed of 210 revolutions. They also have, adjoining this, a small horizontal steam-engine, the cylinder of which is 225 mm. (8.86 in.) in diameter, for a stroke of 350 mm. (13.78 in.), running at a speed of 225 revolutions, and developing 38 to 60 effective horse-power when taking steam at a pressure of 9 atmospheres (128 lb. per sq. in.) at the inlet-valve. Also a two-stage air-compressor, having cylinders 360 mm. and 450 mm. (14.17 in. and 17.72 in.) in diameter, for a 400-mm. (15.75-in.) stroke, and a speed of 150 revolutions; it has a capacity of 550 cub. m. (19,420 cub. ft.) of free air per hour. The Dingler engines in question run most smoothly.

On the opposite side the Sächsische Maschinenfabrik vorm Rich. Hartmann A.-G., Chemnitz, have put down a 200-horse-power horizontal steam-engine on the Van den Kerchove pattern, which drives several machine-tools which they exhibit in the same stand.

(To be continued.)

LITERATURE.

A Dictionary of Electrical Engineering. Edited by H. M. Hobart, B.Sc., M. Inst. C.E., M.I.E.E., M. Am. I.E.E. Two vols. London: The Gresham Publishing Company. [Price 35s. net.]

The compilation of a dictionary of electrical, or any other sort of engineering obviously presents some difficulties. If the book sets out to be a dictionary, it is in no way to its credit if it finishes by becoming an encyclopædia; while, at the same time, if it restricts itself too closly to bald and brief definitions, it is likely to be of little value either to those acquainted with its subject, or those ignorant of it. Mr. Hobart, in his two volumes, has avoided either of these extremes, and the general scheme of his dictionary is probably as workmanlike and useful a compromise as it is possible to get. In general the definitions given are brief, but, where necessary, there has been no hesitation in dealing with matters in articles of a page or two. As examples, the reference "battery cut-out" has been disposed of in a few lines, as what is practically a mere definition is sufficient in this case to explain the meaning of the term. On the other hand, the matter dealing with "primary battery" runs to two pages. This is quite reasonable, as while it would, no doubt, be quite possible to dispose of the reference with a brief definition, it is doubtful if such a definition would be of the slightest use to anyone likely to look it up. This balance and sense of proportion seem to be well preserved throughout the volumes.

There is no difficulty in finding inconsistencies in a work of this class, which, from its very nature, is more or less of a compromise throughout, and we have no wish to raise trivial points. A matter affecting the system of the work, and which is likely to force itself to the notice of those who use it to any extent, should, however, be noticed. The reference under "primary battery," which we have already referred to, illustrates it. Under this reference there appear sub-headings dealing with special cases of batteries, such as the Bunsen, Grove, &c. This appears a reasonable system of arrangement and the one that, on the whole, is likely to be most useful to users of the work. It is not adhered to consistently, however, and even in the reference we are dealing with there is no description of the Daniell battery, but only a reference to the description of it which appears elsewhere under the heading "cell." There is no obvious reason why, if any particular cases of batteries are going to be described under the general heading, all should not be so treated, and the double arrangement is likely to lead to loss of time. Another example of the same sort occurs in connection with the entry "speed-indicator or tachometer." Electrical instruments of this class are described under the general heading, but in addition there are separate articles dealing with liquid tachometer and vibration tachometer. It should be said that this inconsistency is not likely to debar a user from finding any entry he requires in the dictionary, as the system of cross-references is really admirable. None the less, it is not clear why the inconsistency has been introduced.

In the preparation of the work Mr. Hobart has had the assistance of a number of experts in different branches of electrical practice, and the various definitions and articles are clearly and well written. The line illustrations scattered throughout the books are well chosen, and assist greatly in the understanding of the various matters dealt with. There are, however, a number of process-block plates whose purpose is not clear. Many of them illustrate the interior of generating-stations and cognate subjects, and it is not obvious that they are properly in place in a dictionary, or that they add to the value of the work in any way. The volumes are well printed and bound, and should form very useful works of reference for all interested in electrical matters.

BOOKS RECEIVED.

Up-to-Date Air-Brake Catechism. By Robert H. Blackall. Twenty-Fifth Edition, entirely revised, enlarged, and re-set. New York: The Norman W. Henley Publishing Company. [Price 2 dols.]

Practical Instructor and Reference-Book for Locomotive Firemen and Engineers. By Charles F. Lockhart. New York: The Norman W. Henley Publishing Company. [Price 1.50 dols.]

Fighting-Ships, 1911. Founded and edited by Fred. T. Jane. London: Sampson Low, Marston, and Co, Limited. [Price 21s. net.]

Results of Observations made at the Coast and Geodetic Survey Magnetic Observatory at Sitka, Alaska, 1907 and 1908. By Daniel L. Hazard. Washington: Government Printing Office.

Gesetzmässigkeiten in der Statik des Vierendeel-Tragers nebst Verfuhren zur unmittelbaren Gewinnung der Einflusslinien duren Reihenbildung. Von Dr.-Ing. Ludwig Freytag. Munich and Berlin: R. Oldenbourg. [Price 1.60 marks.]

Pumping Machinery: A Treatise on the History, Design, Construction, and Operation of Various Forms of Pumps. By Arthur M Greene, Jr. New York: John Wiley and Son; London: Chapman and Hall, Limited. [Price 17s. net.]

The Ventilation of Electrical Machinery. By W. H. F. Murdoch, B.Sc., M.I.E.E. London and New York: Whittaker and Co. [Price 3s. net.]

Theorie und Praxis der Grossgasindustrie. Von Rudolf Mewes. I. Band, I. Halfte. *Geschichtliche Entwicklung der Prinzipien der Mechanik und Physik-Grundgesetze der Thermodynamik.* Leipzig: H. A. Ludwig Degener; London: Williams and Norgate. [Price 18s.]

Ministero di Agricoltura, Industria e Commercio. Carta Idrografica d'Italia. Reno, Lamone, Fiumi Uniti, Savio, Marrecchia, Foglia, Esino, Potenzo, Chienti, Tenna, Aso. Ed. Altri Minori. Rome: Tipografia Nazionale di G. Bertero, E.C., *via* Umbria. [Price 5 lire.]

Publications du Laboratoire de Guiche. Vol. I. Essai d'Aérodynamique du Plan. Par Armand de Grammont, Duc de Guiche. Paris: Hachette et Cie.

The Corrosion of Iron and Steel. By J. Newton Friend, Ph.D., D.Sc. London, New York, Bombay, and Calcutta: Longmans, Green, and Co. [Price 6s. net.]

Modern Practice in Mining. Vol. IV. The Ventilation of Mines. By R. A. S. Redmayne, M.Sc., &c., H.M. Chief Inspector of Mines, &c. London, New York, Bombay, and Calcutta: Longmans, Green, and Co. [Price 6s. 6d. net.]

Accountant's Library. Vol. XIV. Engineers' and Shipbuilders' Accounts. By F. G. Burton, F.S.A.A., Second edition. London: Gee and Co. [Price 3s. 6d. net., post free 3s. 9d.]

Transactions of the American Society of Civil Engineers. Vol. LXXII., June, 1911. New York: Published by the Society.

Transactions of the American Institute of Mining Engineers. Vol. XLI. *Papers and Discussions of* 1910. New York: Published by the Institute.

The Deinhardt-Schlomann Series. Technical Dictionary in Six Languages. Vol. XI. *Metallurgy of Iron.* By William Venator and Dr. Colin Ross. London: Constable and Co., Limited; Munich and Berlin: R. Oldenbourg; Paris: H. Dunod and E. Pinat; St. Petersburg: K. L. Ricker; Milan: Ulrico Hoepli; Barcelona: Libreria Nacional y Extranjera. [Price 10s. 6d. net.]

The Royal Navy List and Naval Recorder, July, 1911. London: Witherby and Co. [Price 10s.]

The Ten Republics. An Introduction to the South American Series in Porter's Progress of Nations. By Robert P. Porter. With twelve maps. London: George Routledge and Sons, Limited. [Price 1s.; cloth, 2s. 6d.]

HIGH-PRESSURE WATER-POWER WORKS.*

By L. Zodel, of Zurich.

[*Translated from the German.*]

(*Concluded from page* 242.)

Tyssedalen Station (Figs. 10 and 11).†—Power works of very special interest have been recently erected in Norway, and of these one will be mentioned by reason of the difficult work carried out on the pipe-line. This is the power-plant at Tyssedalen, near Odda, in the Hardanger Fjord on the west coast, where 33,600 horse-power are now utilised, and transmitted to carbide, cyanamide, and other factories at Odda, a distance of about 6 km.

The source of power is the Tysse River, on which is the famous Skjeggedahlsfos, one of Norway's most beautiful waterfalls. Below this fall is the Ringedals Lake, which provides an ideal natural storage reservoir for the power works at an elevation of 435 m. (1426 ft.) above, and at 3.5 km. (2.17 miles) distant from the fjord, at whose edge the power-house is situated. This lake has an area of 5.5 sq. km. (2.22 square miles), and has now been tapped by a regulating tunnel of 6 sq. m. (64.5 sq. ft.) area at a depth of 16.5 m. (52 ft.) below the normal level; by this means a useful storage capacity of about 80 million cub. m. (2825 million cub. ft.) has been obtained by allowing the level to be drained to this depth during the winter months, when the flow of the river is at a minimum. A dam has also been constructed to raise the water-level by 13.5 m. (44.5 ft.) to a maximum elevation of 448.5 m. (1470 ft.), and the useful storage volume is thus 170 million cub. m. (6000 million cub. ft.). The catchment area of 378 sq. km. (146 sq. miles) is sufficient, with the ample rainfall in this mountainous district, to give about 100,000 horse-power.

The regulating tunnel from the Ringedals Lake discharges into the little Vetle Lake, immediately below, which forms a second small regulating basin on the river, whose level is adjusted by a needle dam. A tunnel of 3410 m. (11,200 ft.) length starts from this lake and passes through the mountain to the penstock chamber, from which the pipe line leads down to the power-house. This tunnel is driven through granite for the whole of its length, the work having been carried on simultaneously from thirteen adit levels, and completed within two years. The rock was left rough inside the tunnel, the cross-section being nowhere less than 9.5 sq. m. (102 sq. ft.).

The penstock chamber is cut out of the solid rock to a depth of about 15 m. (49.3 ft.), and the tunnel emerges into the bottom of this at an elevation of 397.5 m. (1303 ft.). The sill of the overflow of the penstock is at elevation 413 m. (1353 ft.), and the maximum possible water-level due to the head in the tunnel is 415 m. (1360 ft.).

Two pipe-lines of 1600 mm. (63 in.) diameter connect with this penstock chamber through a short tunnel, and are fitted with sluice-valves of 1200 mm. (47 in.) diameter placed in a valve-house at the exit. Flap valves are also arranged over the end of the pipes in the chamber in such a way that the chains which hold them open may be released by electric current from the power-house, in case of accident to any part of the plant. The intake would then be closed immediately by shutting the flap. The usual air-pipes are fitted to prevent the formation of a vacuum on emptying the pipe-line.

The two pipe-lines already installed are arranged in three sections of 1200 mm., 1100 mm., and 950 mm. (47 in., 43⅓ in., and 37½ in.) diameter respectively, and have a thickness varying between 7 mm. and 23 mm. ($\frac{9}{16}$ in. and $\frac{7}{8}$ in.). The total length is 720 m. (2360 ft.). They are made of single and double-riveted pipes. The illustrations show the difficult character of the erection of this pipe-line, the difficulties being further increased by the necessity of carrying out a large part of the work during the winter months, the erection period being between August and March. All workmen had to be slung with ropes over the face of the rocks, and the pipes reach an inclination of 55 deg. to the horizontal, as seen in Fig. 11, above. The pipes were secured by means of H-girders let into the cliff at the steepest part, and by massive masonry anchorage blocks built into the rock at convenient points, and reinforced with steel bars and tie-rods to hold the pipes perfectly rigid. Fig. 10, above, shows clearly one of these anchorages, and the method of hauling the pipes up a steep portion of the mountain.

Straight portions of the pipe-line on less steep gradients are supported by masonry pedestals with a bearing of oil-soaked paper, to facilitate small longitudinal movements due to expansion and contraction, which is taken up by expansion stuffing-box joints, placed at the top of straight sections of the line. A valve is fitted at the bottom of each pipe-line with a safety-plate so arranged as to break in case the pressure in the pipes should rise above 50 per cent. in excess of the normal. In such case the sluice-valve behind the safety-plate could be slowly closed by hand, or the flap-valves over the pipe-line end in the penstock chamber could be instantly closed and the pipe allowed to empty itself of water, when a new safety-plate would be fitted and the line refilled. This safety-plate has been fitted to many high-pressure pipe-lines, and is a surer means of safeguarding the pipes in case of unforeseen disturbances than the spring safety-valve sometimes employed, although it causes greater inconvenience if it should come into action. The pipe-line water velocity in the lower portion is 4.7 m. (15.4 ft.) per second.

The distributing pipes and the branch pipes for the exciter-turbines are laid along the power-house. The two pipe-lines each feed three Escher Wyss impulse-wheel turbines of 4800 horse-power maximum output, running at 375 revolutions per minute, with a net head of 384 m. (1260 ft.), and a seventh machine is held in reserve. These are machines with horizontal shafts and a single-needle nozzle; they are provided with pressure-relief valves for relieving pressure oscillations in the pipe-line. The generators work in parallel directly on to the 12,000-volt transmission line of 6 km. length to Odda.

The whole station was built in the very short period of slightly over two years from the end of 1905 to March 1908.

An enlargement of this station is now being made, and a third pipe-line with three zones of 1550 mm., 1400 mm., and 1250 mm. (61 in., 55 in., and 49 in.) diameter is being erected to supply two turbines of 13,500 horse-power each. There was a question whether these new units should be arranged with horizontal or with vertical shafts, but the present-day preference for the former prevailed, and they were ordered with the horizontal arrangement. The increase in power of each unit from 4800 to 13,500 horse-power clearly illustrates the tendency towards large units characteristic of modern turbine development. A better efficiency is thereby secured, and the cost per horse-power installed is also diminished:—

Thus this station has now
- 7 × 4,800 = 33,600 h.-p. installed.
- 2 × 13,500 = 27,000 h.-p. being erected.

giving a generating total of ... 60,600 h.-p.
and exciters ... ... 400 ,,

or a grand total of ... ... 61,000 ,,

The plans for the enlargement of the station include seven new sets of 13,500 horse-power each, of which the two now being built are but the first instalment. When these are finally erected, the station will have a capacity of over 125,000 horse-power, and the generating-room will be 150 metres long.

Brusio Power Works (Figs. 12 to 16).—A typical high-pressure power-station in Switzerland is that of the Kraftwerk Brusio Company, which utilises the water-power of the Poschiavino river in the Poschiavo Valley in the Canton Grisons, on the south side of the Alpine Chain between the Bernina Pass and the Italian frontier near Tirano. About 55,000 horse-power are developed, the greater part of which is transmitted to the industrial districts of Northern Italy over a transmission line of 150 km. (93 miles) length. The total head available is about 1000 m. (3280 ft.), and this is used in two stages. The upper lies between the Lago Bianco on the Bernina Pass and the Lago di Poschiavo, giving an effective head of 600 m. (1970 ft.) for the Robbia station; and the lower

Fig. 10. Tyssedalen Station; Position of Main Anchorage.

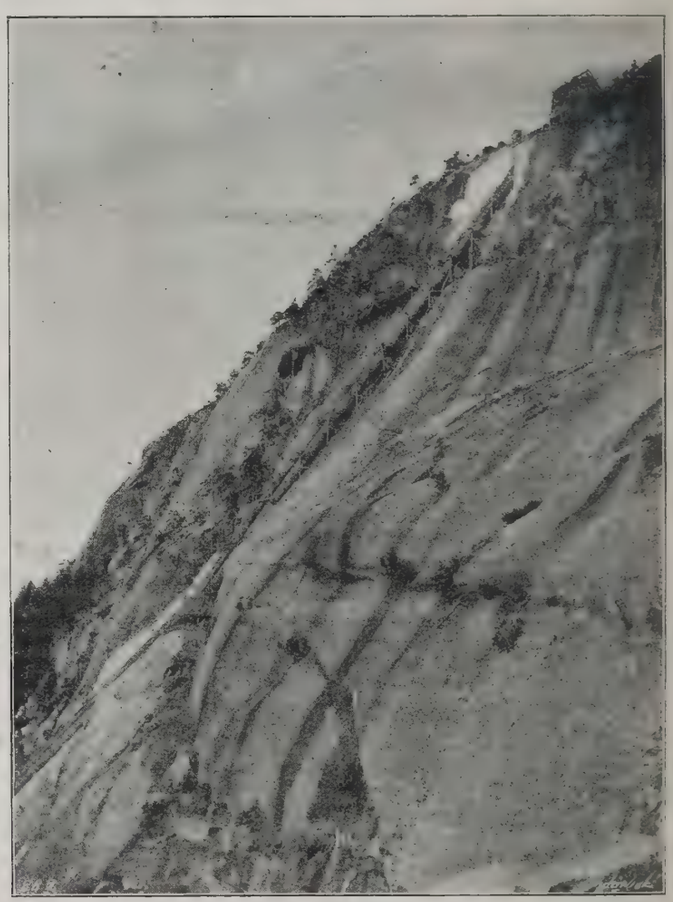


Fig. 11. Tyssedalen Station; Portion of Pipe-Line.

* Paper read before the Institution of Mechanical Engineers, Zurich Meeting, July 26.

† This station was fully illustrated and described in Engineering, vol. lxxxvii., pages 405 and 443.

is between the Poschiavo Lake and the Italian frontier at Campo Cologno, where the head obtained is about 420 m. (1375 ft.). The lower station was built first, and will be first referred to here.

The Campo Cologno Station.—The minimum average volume of water available from the Poschiavino river has been found to be 7.5 cub. m. (264 cub. ft.) per second during a run of 12 hours, and this quantity is equalised by the Lake of Poschiavo, which acts as a natural storage basin of 2 sq. km. (1.25 square miles) area. A variation in level of 8.4 m. (275 ft.) is allowed by the concession, and this is obtained partly by tapping the lake below its normal level, and partly by raising the level with sluices built across the outlet. This gives a regulating volume of about 15,000,000 cub. m. (530,000,000 cub. ft.). The elevation of the lake is between 956 m. and 964.4 m. (3160 ft.), and is about 435 m. (1428 ft.) above the power-house. The intake from the lake is effected by means of a siphon leading into the shaft from which the tunnel starts. The tunnel has a length of 5250 m., with a gradient of 1 : 500, and leads the water into the penstock-chamber (Fig. 12, above), excavated out of the rock, and from which the five pipe-lines descend to the power-house; a sixth, shown on the illustrations, is provided for. The chamber is of such a depth that the tunnel remains full for a distance of 1½ km. when the plant is not working, so that sufficient water is always available for starting up the turbines; superfluous water passes to waste down an overflow situated in the tunnel. This penstock-chamber is provided with screens over the pipes and with means for periodically cleaning them. Flap-valves are fitted over the ends of the pipes, and are supported when open by a chain connected to a hand-winch in such a way that it can be released by a solenoid actuated from the power-house in the same way as at Tyssedalen station, and the valve allowed to fall over the end of the pipe in cases of emergency. A small hand-valve is fitted for filling the pipe-line, and the main flap-valve can then be raised by the winch-gear. At a little distance below the penstock a valve-house is built, containing sluice-valves which are able absolutely to close any pipe-line, and have the usual air-pipes immediately behind them reaching to above the spillway level.

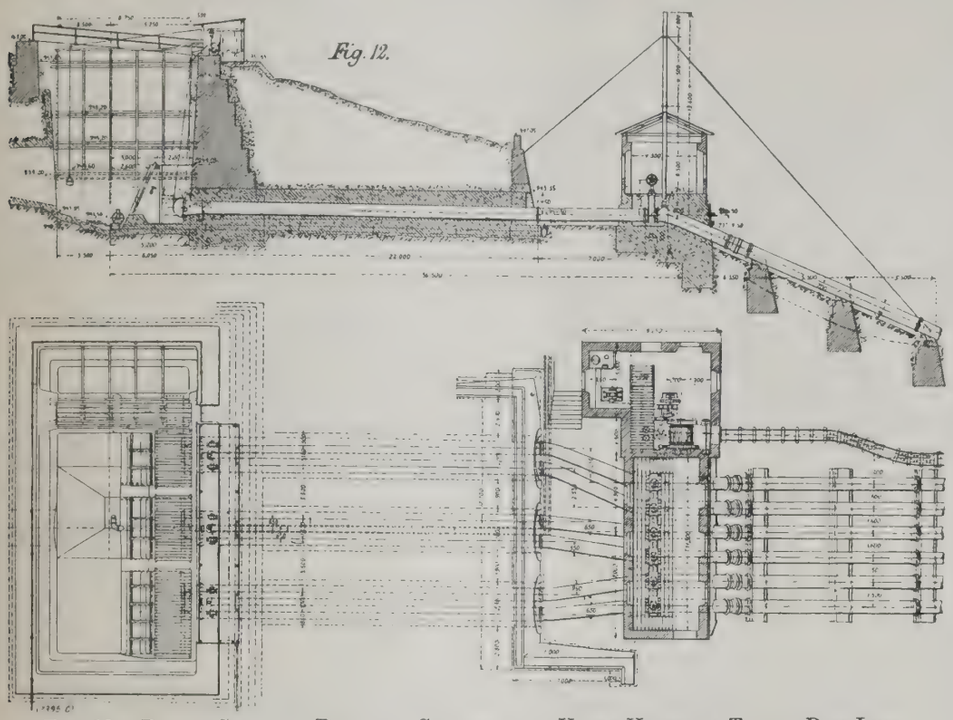


FIG. 12. BRUSIO STATION; PENSTOCK CHAMBER AND VALVE-HOUSE AT TOP OF PIPE-LINE.

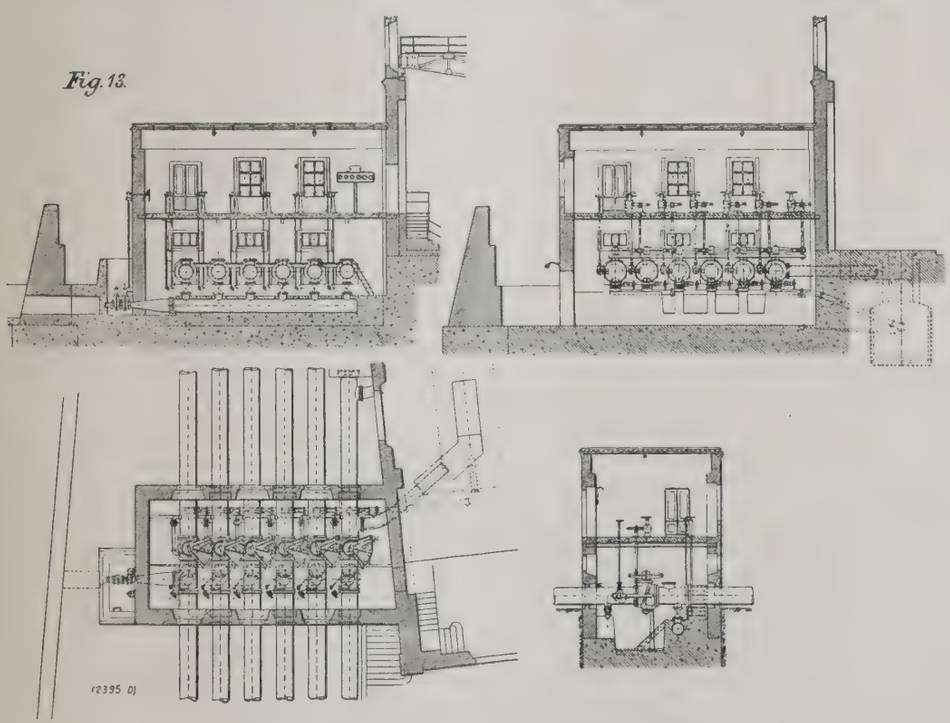


FIG. 13. BRUSIO STATION; LOWER VALVE-HOUSE.

The five pressure pipe-lines now erected have a length of 981 m. from the valve-house to anchorage No. X., or, including the distributing pipes, have a maximum length of 1124 m., and consist of three zones of different diameters. The upper section is of riveted steel pipes 870 mm. (34 in.) in diameter, while the middle and lower sections, seen in Fig. 15, page 256, are of lap-welded steel plate of 830 mm. and 790 mm. (32.5 in. and 31 in.) diameter respectively. The thickness varies from 6 mm. to 23 mm., and the length of each pipe is 12 m. In straight sections the pipes were each bedded on masonry pedestals, while very heavy reinforced concrete anchorages were provided at all angle points, one of these (No. X.) near the power-house having a total weight of 3300 tons.

Each pipe is arranged to feed at least two main turbines, and the velocity of the water in the lower section is normally 3.36 m. per second; the loss of head by friction is about 14 m. or nearly 3½ per cent. Expansion joints are arranged at the top of each straight portion of pipe-line.

Adjoining the power-house is a valve-house, Fig. 13, on this page, containing a main throttle-valve on each pipe-line operated by gearing from the floor above; by-pass valves are provided, and drain-valves behind the throttle-valves for the purpose of emptying the water from the entire pipe-line system into the tail-race in case of stoppage of the plant.

The different pipe-lines have been connected together by means of branches to a common communication pipe laid transversely beneath them, and in front of the throttle-valves in the power-house. This pipe serves to equalise the flow in the main pipe-lines, and at present feeds the distributing-pipe to the end two turbines of the power-house, since the sixth and last pipe-line is not yet erected. This is a convenient arrangement for connecting the various pipe-lines of a plant together in a case when they would be otherwise quite separated. At the end of this cross-pipe on the side towards the river, a valve with the usual safety-plate has been fitted, so as to break, should the pressure in the pipe-line system accidentally rise above 50 per cent. excess of the normal. A sluice-valve has been inserted behind this valve so that the opening may be closed by hand, in case the plate should break, and in order to prevent undue waste of water.

Each pipe connects up to two main turbines. The exciters have an independent distributing pipe connected to three of the pipe-lines; they can be run off any of these at will. A plan of the arrangement of the power-house is shown in Fig. 14 on the next page.

Twelve main turbines are installed in the power-house, which is situated close to the Poschiavino River. They are Escher Wyss impulse tangential machines fitted with horizontal shaft and single needle-nozzle, with the exception of two Girard turbines which are now out of date, and will shortly be replaced by the tangential type. Ten turbines are of 3500 horse-power, and two, which were put in at a later date, of 4600 horse-power, all designed for 400-metre head and 375 revolutions per minute. Four exciters, of 250 horse-power each, bring up the total power to 45,000 horse-power. Fig. 16, on page 256, illustrates the main turbines. Below the needle-nozzle in this figure may be seen the pressure relief-valve fitted to each machine. All the machines are directly coupled to the three-phase generators, which run in parallel at 7000 volts tension and 50 periods per second. Most of this power is transmitted at 7000 volts across the Italian frontier to the transformer station of the Compagnia Lombarda, 500 yards distant, and there stepped up with oil-cooled transformers to a tension of 50,000 volts for the long-distance transmission system to the sub-station at Lomazzo, which supplies Como and the neighbourhood of Milan. A small portion of the power is used locally for the Bernina Railway and for power and lighting purposes in the Poschiavo Valley. During the daytime the whole station is under full load, but only a small part of it is kept running at night.

Very shortly after the completion of the Brusio Station, the demand for power grew so rapidly that the company was obliged to erect a second station to utilise the upper portion of the head to be obtained in the Poschiavo Valley. On the summit of the Bernina Pass are two lakes, known as the Lago Bianco and Lago Nero, while on the west side of the valley the Cavagliasca stream descends from the glaciers of the Piz Palü. The Lago Bianco has an elevation of 2230 m. (7330 ft.), that is, 1260 m. (4135 ft.) above the Lago di Poschiavo. The waters of the Cavagliasca have been impounded for the Robbia power-station, and the Lago Bianco, which discharges into it, has been dammed up so as to act as a storage-reservoir over winter months when the stream is frozen. Thus it was possible to obtain a head of 600 m. (1970 ft.) at the power-station, which is situated above the village of Poschiavo, and to ensure sufficient water to generate about 7000 horse-power. Three turbines of 3500 horse-power are therefore intended for the station, of which two are now installed and one is on order. The net head is 580 m. (1900 ft.), and the machines work at 500 revolutions per minute driving generators which are run in parallel with those of the Brusio plant. A single pipe-line of 600 mm. (23.5 in.) diameter supplies the turbines, and the velocity of flow with 7000 horse-power running is 4 m. per second.

The turbines of this plant are fitted with the new deflecting nozzle operated by an oil-pressure governor. Similar machines are installed at the Adamello Hydro-Electric Power-Station, which is a plant of exceptional interest.

The Siagne Station, Figs. 17 and 18, page 257.—The River Siagne rises in the Alpes Maritimes province of South-Eastern France to the north of Cannes, and is used, by reason of its clear spring water, to supply the town with drinking water from an intake near the village of St. Césaire. The power-station is situated immediately above this intake, and utilises a fall of about 348 m. (1142 ft.) of the Siagne. The water is taken from a weir on the upper reaches of the river by a conduit and tunnel to a balancing reservoir above the power-house, partly blasted out of the rock and partly formed by a large retaining wall. The Siagne discharges an average volume of about 3 cub. m. (105 cub. ft.) per second at the intake weir, and thus, with the fall of 348 m. (1142 ft.), provides

an absolute output of 14,000 horse-hower. The Compagnie de l'Energie Electrique du Littorale Méditerranéen has developed this power by means of five units of 2000 kw. maximum each, of which one is held as a reserve.

The Saigne power-station provides a specially interesting and most instructive case of high-pressure pipe-lines, and has demonstrated in a most drastic manner what the consequences of incorrect design can be. The original pipe-line had to be abandoned after a few months' running on account of unsatisfactory working of the plant, and an entirely new pipe-line had to be built on totally different principles, in spite of the fact that the chief dimensions of the pipes were perfectly correct and amply sufficient for the conditions of head and discharge, and moreover were not altered in the second pipe-line.

Two parallel pipes were provided, each 900 mm. (35.4 in.) diameter, built of single pipes about 6 m. long of riveted plate of from 4 mm. to 25 mm. thickness, the individual pipes being riveted together *in situ*. The pipes rested on masonry pedestals and closely followed the surface of the ground, so that the pipe-line consisted of a large number of inclines and angles in every direction. Fig. 17, on page 257, clearly show how the two pipe-lines were brought down to the power-house. About 40 m. vertically above the latter they formed a kind of distributing-pipe from which the connecting-pipes branched off to the turbines. Above this distributing-pipe the pipe-lines rose at a very steep angle, in places almost vertically, to a point 90 m. below the intake. From this point they turned to the left, and led for a considerable distance at a very slight gradient to the penstock chamber.

The principal faults in the arrangement of this line were as follows :—

(1) Too great a length of the upper portion, under low pressure, with pipes of small thickness, whereby a continual working or respirating phenomenon became apparent in this part of the pipe-line.

(2) Insufficient fixing or anchoring of the pipes in the lower portion of the line, and a most curious position of the distributing-pipe, in which very harmful vibration, combined with displacement of the pipes, could take place on sudden variations of water velocity or shocks in the pipe-line ; this might easily lead to a burst, especially in the case of riveted pipes.

(3) Unsuitable dimensions of the connecting-pipes between the distributor and the turbines, with their length too great and their diameter too small, resulting in considerable accentuation of the pressure variations.

Each pipe-line formed one single rigid piece from top to bottom, and no provision was made for expansion and contraction, such as the insertion of expansion joints. Expansion due to temperature changes in an exposed pipe-line is, however, unavoidable, and if no arrangements are made to allow of longitudinal motion, then additional stresses will be set up in the pipe walls that will be difficult to foresee, and will cause resultant stresses which may under certain conditions have a fatal effect.

It must be mentioned here that French engineers in general build pipe-lines on this principle—that is, without expansion joints—and that a large number of such high-pressure pipe-lines are now in continuous operation in France. This design must nevertheless be characterised as irrational, especially in view of the demands made at the present day on the pipe-line of a central station with continually and rapidly changing water velocities.

Shortly after starting up the works a burst occurred about the middle of one of the pipe-lines, probably owing to some such sudden variation in the pipe velocity. A longitudinal riveted joint was torn open for a length of 2 m., and the water suddenly streamed with such velocity from the gap that a large part of the upper section of the pipe was completely flattened by the vacuum which was produced, in spite of large air-pipes at the penstock-chamber. Exhaustive investigation led to the final decision to replace the entire existing pipe-lines by others over a quite different route.

The new line has been in continuous operation since the spring of 1908. It consists of two parallel pipe-lines of almost the same dimensions as the old, but differs therefrom in that it passes straight down the side of the mountain from the penstock-chamber to a point about 30 m. to 40 m. above the power-house, when it turns round and passes towards the latter through a tunnel.

The upper part of the pipe-line was made as short and as steep as possible, and the lower arranged longer in proportion. The whole line is divided into six straight sections ; the angle points between them are formed into main anchorages (fixed points) of solid concrete masonry into which the pipe bends are rigidly bedded. An expansion joint is placed below each fixed point. The intermediate concrete pedestals supporting the pipe-line are laid at a uniform distance of 7.90 m. apart.

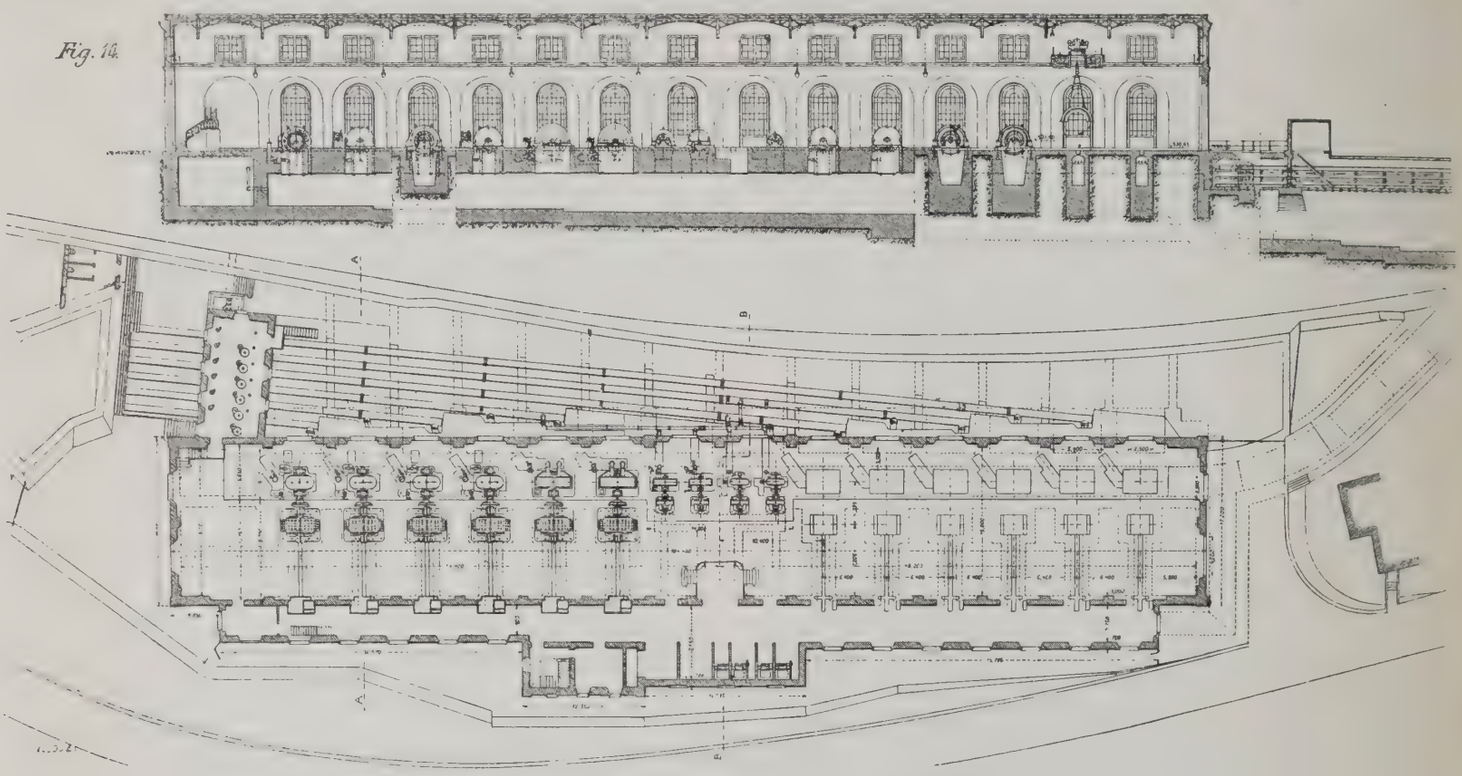


Fig. 14. Plan and Section of Brusio Power-Station.

Fig. 18, on page 257, is a view of the lower part of the pipe-line near to the tunnel entrance, showing two fixed-point anchorages. The upper of these anchorages has the pipes completely grouted in, the lower is treated as an intermediate fixed point on account of its short distance from the upper, and the pipes are only bolted down to the concrete foundation. The next main fixed point below the preceding, and at the same time the last on the line, is situated in the tunnel which emerges at the power-house. This main anchorage takes up the whole thrust of the pipe-lines, and the horizontal continuation of the latter, which extends along the power-house wall to feed the turbines, has free ends.

Quite short conical pipes of 400 mm. to 500 mm. (15¾ in. to 19¾ in.) diameter connect each main pipe to the five turbines, and are fitted with sluice-valves so that the latter may be run separately from either pipe-line. In normal running the two pipe-lines are thus connected together, and pressure variations due to any one generating unit distribute themselves over the cross-section of both pipes ; they can also be isolated at any time when required, or either pipe-line may be shut down and all the turbines kept running on one only.

In fact the station was run at first from one new pipe-line alone without difficulty, while the second was being erected, the object in doing so being to minimise the time during which the plant was kept idle after the accident to the old line.

These pipe-lines were also riveted together *in situ*, the upper portion, up to 13 mm. (½ in.) thickness, being of riveted pipe, and the remainder of pipes lap-welded by the water-gas process. The total length of the pipe-line is 876 m. (2870 ft.) composed of three sizes of pipes of 950 mm., 900 mm., and 850 mm. (37½ in., 35½ in., and 33½ in.) diameter respectively. The thickness varies between 7 mm. and 22 mm.

Each pipe is fitted at the penstock-chamber with an automatic hydraulic stop-valve, also arranged to be operated electrically from the power-house by means of a solenoid. This automatic hydraulic valve can be set to close at any desired maximum discharge of water ; if for any reason the discharge exceeds the limit, the intake opening closes at once.

The whole erection of the new pipe-line was finished in six months. The result, as compared with the old pipe-line was as expected. The extraordinary surges and resonance effects of the pressure shocks, especially the visible movement and trembling of the pipes, completely disappeared. No disturbance or irregularity could be observed in the pipe-line, even with severe and sudden load variations during running.

The five 2000-kw. (max.) machines installed in the power-house run at 375 revolutions per minute. The turbines are Escher Wyss and Co.'s impulse wheels, of 2800 horse-power maximum output, having each one regulating needle-nozzle. They are fitted with automatic speed-regulators and pressure-relief valves, both operated by the pipe-line water, which is exceptionally clean and could therefore well be used. The rigid coupling which connects turbine and generator is arranged as a fly-wheel to increase the rather small fly-wheel effect of the generators, in view of the exceedingly close governing guarantees required.

The Siagne power-station is used as one of the hydro-electric plants which feed the high-tension system supplying power to Nice and Cannes.

Conclusion.—The water-carrying system of a high-pressure hydraulic-power scheme consists of two parts : the low-pressure part to cover most of the horizontal distance between the lake or river intake and the power-house, and the high-pressure part to give the operating head for the station. The high-pressure pipe-line represents one of the most costly items of the plant, and is therefore made as short as possible by taking the low-pressure conduit to the nearest advantageous point above the power-house. There are two main types of this conduit : that in which water flows under pressure and that with water flowing freely in an open flume. Both these types have been illustrated in this paper. The former may be further sub-divided into :—(1) the pressure-tunnel arrangement leading to a deep penstock-chamber, as in the case of the Tyssedalen and Brusio installations ; and (2) the low-pressure feeder-pipe arrangement connecting to a receiver with a stand-pipe, as at Necaxa and Rio de Janeiro. Both of these systems allow of the total head available at any time in the reservoir to be utilised, even with large variations in water-level.

The type of conduit with open flume cannot, however, utilise any head in the reservoir, and this must be lost. In the case of a long conduit, a balancing reservoir must also be constructed to provide for any sudden increase in the load, since the open flume will not draw a greater volume of water to supply a greater demand, as happens automatically with the pressure conduit. This case is illustrated in the Siagne power-station. Another example is the well-known Kinlochleven plant of the British Aluminium Company in Scotland. The choice of the arrangement of conduit most suitable for a power scheme depends entirely on the particular conditions of the works, and no rule can be laid down.

The best proof of the great interest now taken in water-power development works by mechanical and all engineers lies in the list of visits to large modern hydro-electric stations given in the programme to be followed by the

members of this Institution, which is honouring Switzerland with its summer meeting this year.

Members of the Institution of Mechanical Engineers are indeed the representatives *par excellence* of steam and steam-power. Water-power, the "white coal" of the mountains, will hardly be of much importance in their own country, compared with that all-powerful "Black Queen of energy" of which they have in abundance; but it may indeed play a very great part in the development of the resources of the vast Colonial Possessions included the British Empire.

"STRESSES PRODUCED BY FORCE-FITS."

To the Editor of Engineering.

Sir,—Having read Professor Morley's "Stresses Produced by Force-Fits" in your issue of August 11, I beg to mention that his statement that the subject does not appear to have been treated before is not quite correct. The whole question was thoroughly sifted in an article on gun-building written by me, and published in your paper of November 26, 1909, on page 709, Figs. 33 and 38. Any existing relationships between "force-fit" (shrinkage), maximum tensile stress on hub, compressive stress in shaft, normal pressure p_2, different moduli of elasticity, and Poisson's ratio $\frac{1}{m}$, were then examined by means of graphical procedure, a method which generally appeals more to the engineer than calculation.

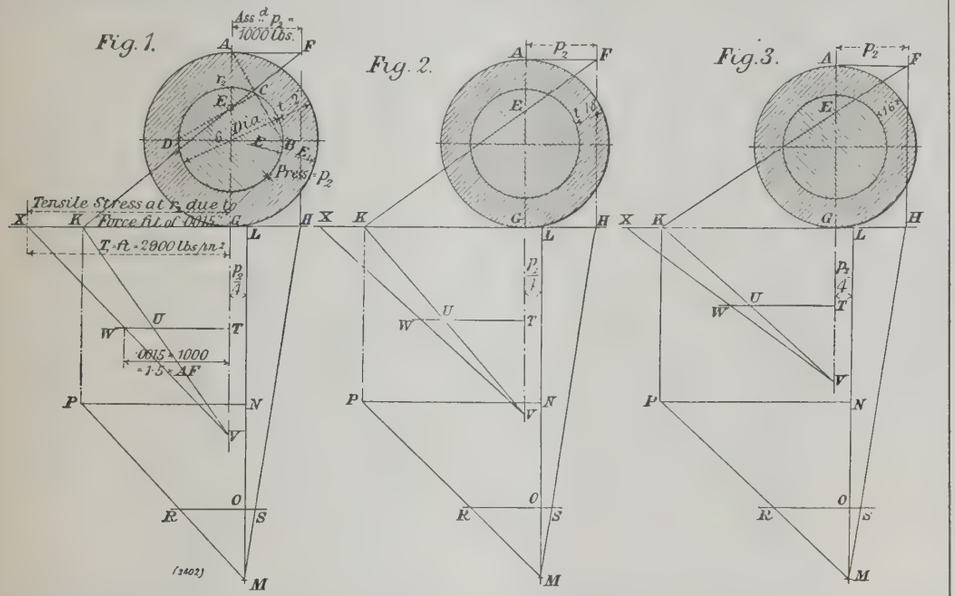


Fig. 1.—Assume thickness t of C.I. hub to be 2 in., draw shaft and hub diameters to any convenient scale:—Join AB, cutting arc Dr_2 B at C. Join CD, cutting AG at point E. (This point E is same point as that marked "h" in Fig. 1 of A. Bremberg's article on page 567 of Engineering, October 29, 1909.) From A set off AF = unity, representing a normal pressure of 1000 lb. acting between shaft and hub. Join FE, and produce cutting line KH at K. Project F to H on line KH. Set off $GL = p_2/m$, and as $m = 4$ in this case, then $GL = p_2/4 = \frac{AF}{4}$. Set off $LM = \frac{E}{1{,}000{,}000} = 30$, and $MN = \frac{E_1}{1{,}000{,}000} = 15$, to any convenient scale, and to same scale set off MO = diameter of shaft (6 in.). Through N and O draw PN and ROS parallel to KH. Project K to P on PN. Join PM and HM, cutting RS at R and S respectively. Then the number of units (AF) in RS is equal to thousandths of an inch in the "force fit" which would produce a normal pressure AF of 1000 lb. Through any point T on line AG produced draw TW parallel to KH. From T set off TU = RS, and TW = force fit of 1.5 thousandths = 1.5 AF. Join KU and produce, cutting GT produced at V. Join VW and produce, cutting KH or KH produced at X. Then GX represents, to same scale as AF, the maximum tensile stress of hub due to "force fit" of 0.0015 in.—*i.e.*, a stress of 2900 lb. per sq. in., which shows that thickness of wall must be reduced to obtain stress of 3000 lb. per sq. in.

Fig. 2.—Reduce thickness of wall to 1.8 in. Proceeding as directed in Fig. 1, GX now shows a tensile stress of 2950 lb., which indicates that wall should be further reduced to about 1.6 in.

Fig. 3.—Reduce thickness of wall to 1.6 in. Proceeding again as per Fig. 1, GX now shows tensile stress of 2995 lb. per sq. in., and therefore the problem is solved. Graphical solution gives ext. rad. of hub = 3 in. + 1.6 in. = 4.6 in., against 4.58 as calculated.

N.B.—If Poisson's ratio should be different for the two materials, the $\frac{p_2}{m_1}$ would be added to the extreme left of KG, and the $\frac{p_2}{m_2}$ deducted from extreme right of GH; Point M would be on line AV produced, and the rest of the procedure would remain unaltered.

The problem given in Professor Morley's article is:—"To find the outside radius of a cast-iron hub forced on a steel shaft 6 in. in diameter, against a force-fit allowance of 0.0015." Maximum tensile stress on hub to be 3000 lb. per square inch; modulus of elasticity—C.I. hub—15,000,000 lb. per sq. in., and shaft 30,000,000 lb. per sq. in. Poisson's ratio = $\frac{1}{4}$.

According to Professor Morley, the maximum tensile stress on hub = $p_2 \times \frac{R_1^2 + R_2^2}{R_1^2 - R_2^2}$, in which

p_2 = normal pressure between shaft and hub,
R_1 = outer radius of hub, and
R_2 = inner radius of hub.

The graphical treatment of the above problem, worked out according to Figs. 33 and 38, in the article of November, 1909, is enclosed herewith. Yours truly,

A. Bremberg
(of Messrs. Wm. Beardmore and Co., Ltd., Glasgow).
Parkhead Forge Rolling Mills and Steel Works,
Glasgow, August 17, 1911.

"PROGRESS IN AERONAUTICAL RESEARCH."

To the Editor of Engineering.

Sir,—In the final paragraph of an article on "Progress in Aeronautical Research," appearing in your issue of August 11, a reference is made to a memorandum by Messrs. Bairstow and Booth in the Aeronautical Committee's report for 1910-11. The memorandum deals with the effect of dimensions and speed on the air resistance of square plates. As this is a subject in which I am greatly interested, I beg to submit the following remarks upon the memorandum:—

The latter proposes the following approximate formulæ:—

$$F = v^2 l^2 [0.00126 + 0.0000007\ v\ l],$$

where F is the total force on a square plate of side l feet, moving normally to its surface at a velocity of v feet per second. This formula may be put in another form—viz.,

$$k = \frac{F}{v^2 l^2} = 0.00126 + 0.0000007\ v\ l,$$

where k is the coefficient of resistance.

It will be noticed from the formula for k that if v is constant, k increases in value with increase in l—a result strictly in accordance with experimental results. On the other hand, if l is constant, the formula shows that k increases with v—a result not in accord with experimental results. Dr. Stanton's experiments on square plates of 1.77-in., 1.33-in., and 0.886-in. sides show a steady decrease in k as the speed increases. His results for a plate of 0.443-in. side are irregular, which is probably due to the fact that errors in observation are relatively greater for such a small plate. So far as I remember, Dr. Stanton's experiments on large square plates of 5-ft. and 10-ft. side show k to be practically constant for the speeds of wind observed, and from the appearance of his plotted results there seems to be an indication of a decrease in k at the highest speeds. Dines's experiments on a plate 12 in. square give $k = 0.00167$ at 21 miles an hour, and 0.00135 at 40 miles an hour. Finally, Eiffel's experiments, which are referred to later, show generally that k diminishes as the velocity of each particular plate is increased.

Your article states that the proposed formula is based on the results obtained by Stanton, Dines, and Eiffel, but on looking up the memorandum I find it is based principally upon Eiffel's experiments with falling plates.

There are one or two objections to this mode of experiment, but the most serious objection is that the plates were not falling at constant velocity, but with an acceleration, which, for the smaller plates throughout and for larger plates for the earlier portion of their descent, was nearly equal to the acceleration due to gravity—viz., 32.2 foot-seconds per second.

The memorandum states that the effect of acceleration is small, but the reasons for this statement are not given. In another part of the memorandum it is stated that if the volume of air accelerated with the plate is taken as $2\ l^3$, the corrected results agree more closely with the proposed formula.

So far as I am aware, systematic experiments on the accelerated motion of plates in air have not yet been carried out. Beaufoy's results with square plates of 21-in. side, moving through water at 2 ft. per second, show that the volume of water accelerated with the plate is about $12\ l^3$, and that this volume increases with the velocity. This increase with velocity appears to be borne out by Eden's experiments on balloon models in water (pages 48 to 51 of the Report), in which the dead water behind model C increased very appreciably with the velocity. Again, the Aeronautical Report, 1909-10, page 175, states that Riabouchinsky, experimenting with an apparatus formed of two leaves which opened and shut with accelerated motion, found $k = 0.885$ (metric units), against 0.682 for uniform motion. Finally, Eiffel, in his book, "Resistance de l'Air," page 2, gives to scale the stream-lines around a square plate of 50-cm. edge moving with a velocity of from 10 to 15 metres per second. The volume of "dead air" at the back of the plate (which is only a part of the total volume of air which is accelerated with the plate) is considerably in excess of $2\ l^3$.

In view of the above results, one is forced to the conclusion that the effect of acceleration on resistance is treated far too lightly in the memorandum, and is probably such as to render the basis of the proposed formula totally unreliable.

But even if the effect of acceleration is small, as the memorandum supposes, the question remains whether the results obtained by Eiffel with his falling apparatus are precise enough to deduce a formula of this sort. I believe they are not.

Eiffel's method of experiment is now well known. An apparatus carrying the plate fell along a vertical wire, the only vertical forces acting on the apparatus being the weight, the pressure on the experimental plate, and the resistance of the supporting apparatus. For the same speed the latter may be taken as constant whatever the size of plate. The velocities for each plate were taken after falls of 20, 40, 60, 80, and 95 metres—the latter being 90 metres for the largest plate—and from the circumstances of the experiments one might logically expect that for the same fall the velocity of the plates would gradually decrease as the size increased.

Only one experiment was made with the smallest plate ($\frac{1}{16}$ square metre), and four out of the five velocities recorded are appreciably less than for the next size of plate ($\frac{1}{8}$ square metre). The velocity at 95 metres fall is manifestly incorrect. A comparison of the times taken in falling the various heights shows that this smallest plate took appreciably longer to fall than the $\frac{1}{8}$ and $\frac{1}{4}$ square metre plates. The results for this plate are therefore unreliable. The memorandum states that "Eiffel's observations for the largest plate (1 square metre) are not so numerous as for the other plates, and less weight therefore attaches to them." These observations were more numerous than for the smallest plate, but a comparison of the results obtained in the two experiments for this plate leads one to the same conclusion as the memorandum.

Three experiments were made with the plate of area $\frac{1}{2}$ square metre, and the three results for each particular fall differ by from 8 to 16 per cent. Two experiments were made with the plate of area $\frac{1}{8}$ square metre, and these show a closer agreement, the largest difference being 8 per cent. Three experiments with the $\frac{1}{4}$ square metre plate also agree fairly well, the greatest difference being 6 per cent., but even for this plate the three results for 95 metres fall appear incorrect when compared with circular and rectangular plates of the same area.

A careful examination of Eiffel's detailed results for square plates forces one to the conclusion that they are not sufficiently precise to form the basis of such a formula as is proposed. This is quite apart from the effect of acceleration, of which there is little information. That available is totally opposed to the assumptions in the memorandum.

It is interesting to note on page 54 of the Report that the results of experiments on a model and full-sized screw show that the law of similarity (Froude's law) holds good. This has long been recognised for ship propellers. The writer believes that the same law will be found to be true for square plates moving normally to their surfaces.

I am afraid, Sir, this letter will take up much of your valuable space; but my excuse must be that the subject treated is one which is becoming increasingly important in connection with aeronautical research.

I remain, Sir, yours faithfully,
A. W. Johns, R.C.N.C.
104, Huron-road, Upper Tooting, London, S.W.,
August 17, 1911.

THE EFFICIENCY OF STEAM-TURBINES.

To the Editor of Engineering.

Sir,—I observe in your issue of the 18th inst. a letter from Mr. M. G. S. Swallow, of Hartlepool, regarding some remarks I made on Mr. Zoelly's paper, read before the Institution of Mechanical Engineers at the meeting at Zurich.

I am afraid Mr. Swallow's letter leaves me with the feeling that he has endeavoured to explain away the efficiency of the compound turbine, as given by Mr. Eric Brown at his lantern lecture, being less than the straight impulse-turbine as given by Mr. Zoelly.

Though I had the pleasure of listening to Mr. Brown, I was not aware that he included in his thermal efficiency that of the dynamo. It would be a most unusual thing to do so. Mr. Zoelly, in his paper, did not limit the maximum efficiency of the impulse-machine to 73 per cent., but stated that more than that can be obtained.

The use of compound velocity-wheels is open to all makers, for it is known that they are a cheaper construction. That they are also less efficient must be well recognised by Mr. Zoelly, for he has resisted all attempts to lower the efficiency of his turbine by their introduction.

Yours truly,
Alan E. L. Chorlton.
Salford Iron Works, Manchester, August 22, 1911.

INDUSTRIAL NOTES.

At the end of last week the railway traffic of the country was much disorganised, but the disorganisation varied greatly on different railways and in different localities, some of the companies having comparatively little trouble in continuing their train service, while others had to alter their time-tables very largely. The estimate of the number of railwaymen on strike ranged from 200,000 to 230,000, the former being probably the more correct estimate of the two. In many parts of the country trains were held up, more particularly in the North, and with the exception of the London and South-Western Railway all lines appear to have been affected. There was also a considerable amount of dislocation on the Underground and Metropolitan Railways. All of the principal London stations were guarded by the military, while large bodies of troops were despatched to various unsettled parts of the country, the total number being, it is estimated, about 50,000. In the Midlands and Wales signal-boxes were seized and trains stoned; indeed, acts of violence were reported from all over the country. It was announced on Friday, in the House of Commons, by Mr. Lloyd George, that Parliament would sit the following Tuesday, instead of being adjourned till October 28. The shortage of supplies due to the strike was seriously felt even at the end of last week, and it is stated that in the Middlesbrough district the furnaces at the ironworks had to be damped down owing to the shortage of fuel. It is also stated that the German shipping lines have reaped a rich harvest owing to the strike in Liverpool, and the Kaiserin Auguste Victoria left Southampton on Friday last for New York with every berth occupied, the last berth being, it is said, sold for 170 guineas. In London there was threatened a shortage in the milk supply, and a great many children are said to have died of dysentery.

Considering the aspect of things on Saturday last, the men having broken the agreement of 1907, and estranged the public by their refusal of the Government offer of an inquiry by a Royal Commission into their alleged grievances, the strike was foredoomed to early failure. Few people, however, expected such a sudden collapse as took place late on Saturday night, and was announced all over the country on Sunday. When, on Monday, more was known as to the lines on which peace was said to have been secured, the first feeling of thankfulness gave place to one of fear that the great fight had only been delayed. In the northern parts of the country the men wanted no settlement such as had been arranged, and preferred to fight to the bitter end.

The terms of the settlement arrived at on Saturday and signed by the Board of Trade were (1) The strike to be terminated forthwith, and the men's leaders to use their best endeavours to induce the men to return to work at once; (2) All the men involved in the present dispute, either by strike or lock-out, including casuals, who present themselves for work within a reasonable time to be reinstated by the companies at the earliest practicable moment, and no one to be subjected to proceedings for breach of contract or otherwise penalised; (3) the Conciliation Board to be convened for the purpose of settling forthwith the questions at present in dispute so far as they are within the scope of such Boards, provided notice of such questions be given not later than fourteen days from the date of this agreement. If the Sectional Boards fail to arrive at a settlement, the Central Board to meet at once. Any decision arrived at to be retrospective, as from the date of this agreement. It is agreed that for the purpose of this and the following clause "rates of wages" includes remuneration, whether by time or piece; (4) steps to be taken forthwith to effect a settlement of the questions now in dispute between the companies and classes of their employees not included within the Conciliation Scheme of 1907 by means of conferences between representatives of the companies and representatives of the employees who are themselves employed by the same company, and, failing agreement, by arbitration, to be arranged mutually or by the Board of Trade. The above to be a temporary arrangement pending the report of the Commission as to the best means of settling disputes; (5) Both parties to give every assistance to the Special Commission of Inquiry, the immediate appointment of which the Government have announced; (6) Any question which may arise as to the interpretation of this agreement is to be referred to the Board of Trade.

The Government have given an assurance to the railway companies that they will propose to Parliament next session legislation providing that an increase in the cost of labour due to the improved conditions for the staff would be a valid justification of a reasonable general increase of charges within the legal maxima, if challenged, under the Act of 1894.

The names of the members of the Royal Commission appointed to inquire into the working of the railway conciliation scheme, which was agreed to by the railway companies and the representatives of the unions, were announced by Mr. Asquith in the House of Commons on Tuesday last. They are the following:—The Right Hon. Sir David Harrel, K.C.B., K.C.V.O. (Chairman), who was Permanent Under Secretary for Ireland, 1893-1902, and who is a member of the Board of Trade Court of Arbitration; Sir Thomas Ratcliffe Ellis, secretary of the Mining Association of Great Britain and the Federated Coal-Owners' Association; Mr. Arthur Henderson, M.P., member for Barnard Castle division of Durham since 1903, and chairman of the Labour Party in the House of Commons 1908-1910; Mr. Charles Gabriel Beale, of the firm of Beale

HIGH-PRESSURE WATER-POWER WORKS.

(*For Description, see Page* 252.)

Fig. 15. Pipe-Line and Main Anchorages; Brusio Station.

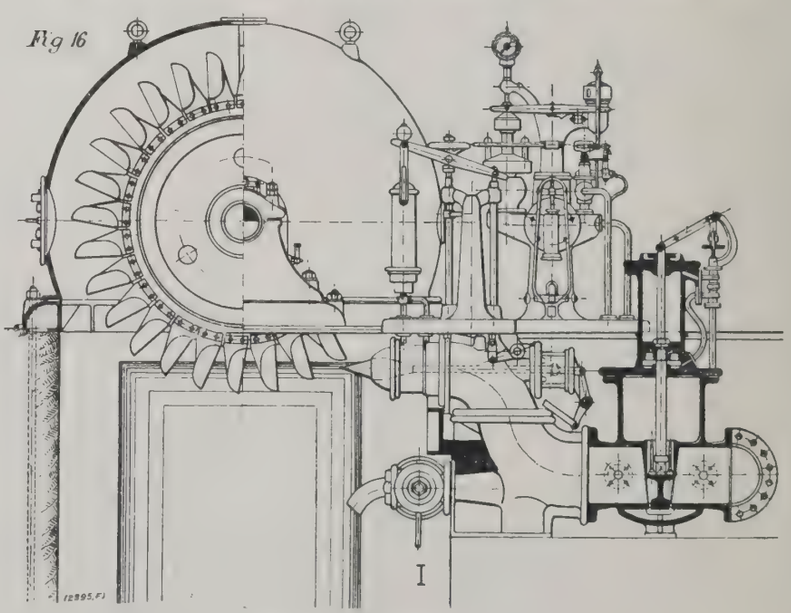


Fig. 16. Generating Turbines; Brusio Station.

HIGH-PRESSURE WATER-POWER WORKS; SIAGNE STATION.

(*For Description, see Page* 252.)

Fig. 17. Lower Part of the Old Pipe-Line near Power-House.

Fig. 18. Anchorages on the New Pipe-Line.

and Co., of London, solicitors to the Midland Railway Company; and Mr. John Burnett, chief Labour correspondent to the Board of Trade 1893-1907, secretary to the Labour Commission 1891-1894, and formerly general secretary of the Amalgamated Society of Engineers 1875-1886. The secretary will be Mr. J. J. Wills, of the Labour Department of the Board of Trade.

While the agreement was being drawn up in London, rioting and disturbances continued in the provinces, being attended in Wales with loss of life. At Llanelly the soldiers were compelled to fire on the crowd, killing two men. Fresh disturbances followed, and the mob set fire to the goods-shed and also some trucks. Some cylinders of explosives, stored in one of the trucks, blew up and killed seven persons, besides injuring many others.

The strikers in Manchester rejected the London agreement, considering that they had been betrayed. At a meeting held at the Grand Theatre on Sunday afternoon a resolution put to the men, recommending them to accept the agreement, was rejected by an overwhelming majority. On the North-Eastern Railway also many men resolved not to return to work, although the strike had been officially settled. The men of Newcastle resolved that an eight-hour day and 2s. per week advance, and a minimum wage of 22s. per week, should be included in the terms of settlement. The case of the North-Eastern Railway was not included in Saturday's settlement, as the men of that company were not parties to the conference. The general manager stated on Sunday that as their men left work without any grievances, the company were not allowing them to resume work except as might be required, and the whole situation would be laid before the board. There appears to be a recalcitrant spirit among all the men on the North-Eastern Railway, and on Monday the men refused to return to work. The directors met at York and decided to reinstate the men on the terms of Saturday's agreement, subject to the conditions that the men should return to duty at once and work amicably with non-unionists. The men, however, were not disposed to accept this decision, and referred the matter to the National Executive. At Newcastle, Tyne Dock, and Hull the men also decided to remain out. Some rioting has occurred in Darlington.

Late on Tuesday night a report came from York that the dispute had been settled, and that the executive had advised the men to return to work. This was the outcome of an interview between Mr. Butterworth, the general manager, and the representatives of the men.

In Liverpool chaos still reigned at the end of last week. There is great suffering among the poor, as the price of food has again advanced. On Friday night the city was in semi-darkness, on account of the failure of the electric supply, the men from the power-station having become affected. The streets were, however, relighted when the trams were stopped, and the station was afterwards worked largely by amateurs. On Sunday night it was stated that after a full meeting of the strike committee it had been decided that the transport workers, other than railway passenger service men, must not resume work pending further negotiations.

On Monday it seemed as though matters were now settling down, for with the return of the railway men to work it was announced that the dockers' strike was ended. There was in the evening, however, another deadlock, because the tramway committee refused to reinstate 250 strikers, on account of which the strike committee ordered the dockers, carters, &c., to remain out. The Home Secretary was requested by the Lord Mayor not to relax the military and naval protection which had been afforded the port. The Lord Mayor also suggested that legislation was needed in order to deal with picketing and intimidation during strikes — rather a useless hint to a Government that has done so much to strengthen the pickets' hands by the passing of the Trades Disputes' Act. What makes the matter complicated is that the non-union men who remained loyal outnumber the union men, and threaten to come out if the strikers are taken back, while the railway men say that they will commence another strike if the union men are not reinstated.

On Wednesday afternoon, Mr. Tom Mann (chairman of the Strike Committee), Mr. Cotter, (secretary of the Stewards' Union), Mr. Bromley (organising secretary of the Associated Locomotive Engineers and Firemen's Union), left London for Liverpool in order to start another national strike if the 250 tramwaymen who went out on strike are not reinstated. Up to the time of going to press the result of their visit is not known.

On Friday last it was announced for the second time that the dock dispute was ended, and we can now only hope that a satisfactory settlement has really been arrived at. The mutual arrangement between the contending parties appears to have been due to a conference held at the Home Office, under the chairmanship of Mr. John Burns, President of the Local Government Board, who accepted the office of arbitrator on certain points that may arise in the working. The settlement states that it is to be final, and that no fresh points are to be raised after the signature. The following are the main points of the agreement:—The settlement is to be on the lines of the agreement of July 27, and the subsequent award of Sir A. Rollit, except as expressly modified. Questions affecting stevedores are to be dealt with under the existing award. Men employed for discharging vessels on the over-sea trade are to be engaged outside the docks, and questions arising on this point are to be referred to Mr. John Burns, or an arbitrator appointed by the President of the Local Government Board for the time being. (The Port of London Authority, however, are not affected by this clause.) Transport workers will not demand that either foremen or tally-clerks shall be members of their federation. It is acknowledged that some little friction may be experienced in getting to work, but it is not likely that any serious trouble will arise.

The miners of the Rhondda Valley are again restive, and occupied themselves on Monday last at Porth by passing the following resolution:—"That we call upon the South Wales Federation Executive Council to ask the Miners' Federation of Great Britain Committee to take immediate action to establish a minimum wage for all persons employed at the collieries, and, failing this, we call upon them to take immediate action to secure a minimum wage for working in abnormal places." The object of the Rhondda men

is to get a general stoppage of the collieries in Great Britain, and if they cannot effect this, then a complete stoppage of the collieries in Wales. They were promised that, at the conference of the Miners' Federation of Great Britain to be held in October, the following motion would be discussed:—"That a general stoppage be declared throughout the Federation area for the purpose of securing for all colliery workmen a definite guaranteed wage." It is thought that the men of the Rhondda Valley, who number about 12,000, may take drastic action. The feeling among the men appears to be that it is only by following the action of the seamen and railwaymen that they can hope to have what they want.

There has been a renewal of serious rioting in Wales this week, the mining valleys of Monmouthshire, Ebbw Vale, Rhymney, and Tredegar being principally affected, and looting was carried out on a large scale. There were also lively scenes in Darlington on the North-Eastern Railway, and men in charge of wagons laden with goods were violently assaulted by gangs of ruffians.

The Amalgamated Association of Tramway and Vehicle Workers have issued to the "people of London" a "manifesto" detailing the grievances of the London County Council tramway workers, and demanding a meeting of the Highways Committee and Conciliation Board for the consideration of these. It is stated that the inaction of the committee has brought the men "to the end of constitutional action;" but no threat is made. A little patience will influence public sympathy.

FOUR-CYLINDER PASSENGER LOCOMOTIVE; ITALIAN STATE RAILWAYS.

In our issue of the 11th inst. we gave* a two-page engraving (Plate XXXV.) and other illustrations of a new class of engines built recently by the Società Italiana Ernesto Breda, of Milan, for the Italian State Railways. These illustrations comprised a longitudinal sectional elevation, half plans and cross-sections, and details of the cylinder and valve gear of this type of engine. These drawings we now supplement by another two-page engraving (Plate XXXVII.) and other illustrations on page 260. The following are the chief particulars of this locomotive and its tender:—

Engine:

Diameter of the four cylinders	450 mm. (17.71 in.)
Stroke	680 ,, (26.77 ,,)
Diameter of driving-wheels	2030 ,, (6 ft. 8 in.)
,, bogie-wheels	1090 ,, (3 ,, 7 ,,)
,, trailing-wheels	1360 ,, (4 ,, 5½ ,,)
Working pressure	12 kg. per sq. cm. (170 lb. per sq. in.)
Grate area	3.50 sq. m. (37.67 sq. ft.)
Heating surface, fire-box	16 sq. m. (172 sq. ft.)
,, tubes	194 ,, (2088 ,,)
,, total	210 ,, (2260 ,,)
Superheating surface	67 ,, (721 ,,)
Weight, empty	78,800 kg. (77 tons 11 cwt.)
,, on driving-wheels	51,000 kg. (50 tons 4 cwt.)
,, in working order	87,300 kg. (86 tons)

Tender:

Diameter of the eight wheels	1095 mm. (3 ft. 7 in.)
Water capacity	20 cub. m. (4400 galls.)
Fuel ,,	8 tons
Weight, empty	21,600 kg. (21 tons)
,, in working order	49,600 kg. (48 tons 16 cwt.)

Engine and Tender:

Total length	22,275 mm. (73 ft.)
,, weight in working order	136,900 kg. (134 tons 16 cwt.)

A characteristic of this new "Pacific" locomotive of the Italian State Railways is the form of the grate, which is of two different widths, the front end being made narrower than the after end (see Fig. 2, Plate XXXV.), to enable the front portion of the fire-box to fit between the wheels of the rear coupled axle, while the after part, of greater width, extends over the trailing-wheels. This form of grate, but with a somewhat different method of connecting the two widths, had already been used by the Paris-Orleans Railways, and also by the South of France Railways. It was applied to the Belgian State Railway locomotives of type 12 (2-4-2 Columbia), the first of which was shown at the Antwerp Exhibition in 1894. This grate was designed by Belpaire, who, in 1884, applied it first to a locomotive of type 6 for the Belgian State Railways. We gave an illustrated description of the locomotive No. 12 of the Belgian State Railways at the time (see Engineering, vol. lviii., pages 293 and 321).

As for the other details, the locomotive we illustrate is built on the standards of the Italian State Railway; it is fitted with a Schmidt steam-superheater, and with a feed-water purifier of the Gölsdorf system. The boiler tubes are smooth, there being 27 having a diameter of 125 mm. and 133 mm. (4.9 in. and 5.2 in.), and 155 having a diameter of 47 mm. and 52 mm. (1.8 in. and 2 in.). The distance between the tube-plates is 5.8 m. (19 ft.). The boiler shell has an average diameter of 1.68 m. (5 ft. 6 in.); the centre of the boiler is 2.87 m. (9 ft. 5 in.) above the rail level. The theoretic draw-bar pull is 13,060 kg. (28,784 lb.) maximum. The locomotive is provided with the following accessory apparatus:—A quick-acting Westinghouse compressed-air brake; a steam heating apparatus on the Haag system, for the train; a Zara throttle, with balanced valve; a Flaman speed-recorder; a Leach sand-box; a Coale safety-valve; a Michalk lubricator; and a Gölsdorf feed-water strainer. Figs. 13 to 16, on page 260, show respectively the leading bogie, the trailing Bissell track, and two views of the cylinders and valve-chests.

The tender is with two trucks, of a type adapted for high speeds, imported into Italy from America with the locomotives "F. S. Gruppo 666" and "Gruppo 720." Its design is clearly shown by Figs. 9 to 12, on Plate XXXVII.

At the Turin Exhibition the locomotive is shown at the head of the "modern train" which is exhibited by the Italian State Railways. It was built by the Breda Company in six and a half months only.

* See page 192 *ante*.

THE LATE MR. F. H. MOLLETT.

We regret to record the death, on the 20th inst., at his residence at Surbiton, of Mr. Frederick Herbert Mollett, who was known to a wide circle of engineers from his connections with eminent firms of consulting engineers and contractors.

Mr. Mollett was born in 1846, and had reached the age of sixty-five in May last. After a general education he was articled, during the years 1865 to 1868, to Mr. F. T. Turner, M. Inst. C.E., engineer to the London, Chatham, and Dover and allied railways, which were then in course of construction, remaining afterwards with him, as assistant, until Mr. Turner's retirement in 1870. For the next two years he was occupied in preparing parliamentary plans, working surveys, and details of various tramway schemes, including schemes for London and Dublin, water works, and drainage, &c. This variety of work he carried out for Mr. T. Hennell, M. Inst. C.E., Mr. J. Kincaid, M. Inst. C.E., and Mr. J. Newton. Subsequently he was employed by Mr. Thomas to superintend the preparation of parliamentary plans for the Cornwall Minerals Railway, and he was afterwards in charge, as resident engineer, of the construction works in the Fowey district of this line. This occupied his attention until 1875, when he was engaged under Mr. (afterwards Sir) Wm. Shelford, M. Inst. C.E., as chief assistant, in making the working surveys, and designing works, &c., on the the Louth and East Coast Railway. His work for Mr. Shelford also included parliamentary work in connection with other tramway and railway schemes. During the years 1877-79 Mr. Mollett practised on his own account, being connected during part of that time with the parliamentary work, and subsequently with the construction, of a short railway in Wales. In 1879 he returned to Mr. Shelford as chief assistant, and was engaged on the preparation of the parliamentary and working plans for the Hull and Barnsley Railway. Subsequently he superintended the preparation of the contract drawings, &c., for this line, and acted as superintendent of the construction works and of later extensions.

In 1887 Mr. Mollett joined the staff of Messrs. Sir John Hawkshaw, Son, and Hayter (now Messrs. Hawkshaw and Dobson), as resident engineer, under Mr. Dobson, on the Buenos Aires new harbour works, for which that firm were consulting engineers. He subsequently joined Messrs. C. H. Walker and Co., Limited, who were the contractors for that work, and continued with them until the spring of this year, as advising engineer. During this period the firm have been engaged on many large contracts, as, for instance, the Southern Dock for the Buenos Aires Great Southern Railway, the Bermuda Breakwater for the British Government, Rio Harbour improvements, and the Transandine Summit Tunnel, &c. He was elected an associate member of the Institution of Civil Engineers in 1872, and was transferred to the class of members in 1887.

THE LATE MR. W. HODGSON.

The death is announced as having occurred, on the 20th inst., of Mr. William Hodgson, M. Inst. C.E., who was connected with a good deal of construction work on English railways.

Mr. Hodgson was born in 1851, and in 1874 was articled to Mr. J. T. Crossley, M. Inst. C.E., remaining with him until 1877. During part of that time he acted as assistant resident engineer on the work in connection with the construction of the Nottingham and Melton Railway of the Midland Company. In 1879 he acted as assistant resident engineer for the work at the Poplar Dock of the Midland Railway, being engaged in the design and construction of this work, and also of work connected with St. Pancras, until the end of 1880. At the close of that year he acted as resident engineer on the construction work for the Tottenham and Hampstead north curve on the Midland, under Mr. J. Underwood. In 1883 he became resident engineer on the Market Harborough new line and works for the Midland Railway, including alterations on the London and North-Western Railway. He became an associate member of the Institution of Civil Engineers in 1878, and a full member in 1886.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was firm, and 7000 tons of Cleveland warrants changed hands at 47s. 5d. and 47s. 5½d. cash, 47s. 8½d. and 47s. 10d. one month, and 48s. 3d. and 48s. 4d. three months. Closing sellers quoted 47s. 7½d. cash, 47s. 10½d. one month, and 48s. 4½d. three months. Hematite amounting to 2000 tons was done at 63s. 7½d. three months. In the afternoon the market was the turn easier, and 2000 tons of Cleveland warrants were done at 47s. 6½d. cash and 47s. 9½d. one month, and at the close there were sellers at 47s. 7d. cash, 47s. 10d. one month, and 48s. 4d. three months. Hematite—2000 tons—changed hands at 63s. 2d. and 63s. 2½d. one month, with buyers over at the latter figure. On Friday morning Cleveland warrants were steady, and the business amounted to 3000 tons at 47s. 6½d. cash, with buyers over, and sellers at 47s. 7d. For the other position sellers quoted 47s. 10d. one month and 48s. 4d. three months. Hematite was stronger, and 1000 tons were done at 63s. 3d. one month, with buyers over. The afternoon session was quiet, and dealings were limited to 1000 tons of Cleveland warrants at 47s. 9½d. one month. Closing sellers quoted 47s. 7d. cash, 47s. 10d. one month, and 48s. 4d. three months. On Monday morning the market was quiet, and 2000 tons of Cleveland warrants were done at 47s. 9d. cash, 48s. one month, and 48s. 1½d. October 6. Sellers' closing prices were 47s. 8½d. cash, 47s. 11½d. one month, and 48s. 5½d. three months. Hematite was quoted at 63s. 3d. cash sellers with buyers at 63s. 3d. one month. In the afternoon Cleveland warrants were weak, and the turnover consisted of only 1500 tons at 47s. 7d. cash and 47s. 9½d. one month. Closing prices were 47s. 7d. cash, 47s. 10d. one month, and 48s. 4d. three months. Hematite was steady with sellers at 63s. 6d. one month. On Tuesday morning a better tone prevailed, and Cleveland warrants were put through at 47s. 7½d. cash, and 47s. 10d. one month, with sellers over at 47s. 7½d. cash, 47s. 10½d. one month, and 48s. 4½d. three months. The turnover was only 1500 tons. Sellers of hematite quoted 63s. cash. The afternoon session was dull and quiet, and dealing was confined to 500 tons of Cleveland warrants at 47s. 7d. cash, with sellers over. For the other positions there were sellers at 47s. 10d. one month, and 48s. 4d. three months. Hematite was quoted by sellers at 62s. 10½d. cash and 63s. 9d. three months. When the market opened to-day (Wednesday) the tone was dull, and Cleveland warrants were 1d. down. The turnover amounted to 5000 tons at 47s. 6d., 47s. 4½d., and 47s. 5d. cash, and 47s. 5½d. nine days, and at the closing the prices were 47s. 6d. cash, 47s. 9d. one month, and 48s. 3d. three months sellers, buyers offering 1d. less. Sellers of hematite quoted 62s. 10½d. cash. In the afternoon the market was quite idle, and no dealing was recorded. Sellers' closing quotations for Cleveland warrants were 47s. 7d. cash, 47s. 10d. one month, and 48s. 4d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde, 61s. 6d.; Calder, 61s. 6d.; Gartsherrie, 62s.; Summerlee, 64s.; Langloan, 63s.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 64s.; Shotts (at Leith), 63s.; and Carron (at Grangemouth), 63s. 6d.

Sulphate of Ammonia.—A fairly steady tone still prevails in the sulphate of ammonia market, and the price to-day is quoted without change at 14*l.* 2s. 6d. per ton for prompt delivery, Glasgow or Leith. The amount shipped from Leith Harbour last week was 2325 tons.

Scotch Steel Trade.—A healthy tone prevails in the Scotch steel trade this week, and makers are all busy. The probability of having to shut down plant owing to the trouble with the railway men is now practically past, and raw material is now coming freely to hand. Specifications for ship-plates for home consumption are plentiful, while the demand from South America, India, and Japan is also extremely good. Some orders for boiler-plates have just been secured, and angles and sectional steel makers report an increased business. No falling-off has taken place in the demand for black and galvanised sheets and producers are exceedingly busy, while the prices for the former are up by about 12s. 6d. per ton. For structural steel a good inquiry prevails. Prices all round are firm.

Malleable-Iron Trade.—The malleable-iron makers in the West of Scotland report that business is rather better this week, but supplies of raw material are not coming to hand as freely as they require owing to the strike at the docks. The prospects are better and prices are the turn higher than was recently reported.

Scotch Pig-Iron Trade.—The demand for the ordinary qualities of Scotch pig-iron still continues, principally on home account, with a fair inquiry for export. Foundry iron is also in request, and good deliveries are going through. Hematite has taken a turn for the better, and quite a lot of booking has been done at from 64s. to 64s. 6d. per ton, with buyers for forward lots over at these quotations.

FOUR-CYLINDER PASSENGER LOCOMOTIVE (4 6 2 TYPE) AND TENDER FOR THE ITALIAN STATE RAILWAYS.

CONSTRUCTED BY THE SOCIETÀ ITALIANA ERNESTO BREDA, ENGINEERS, MILAN.

(*For Description, see Page* 258.)

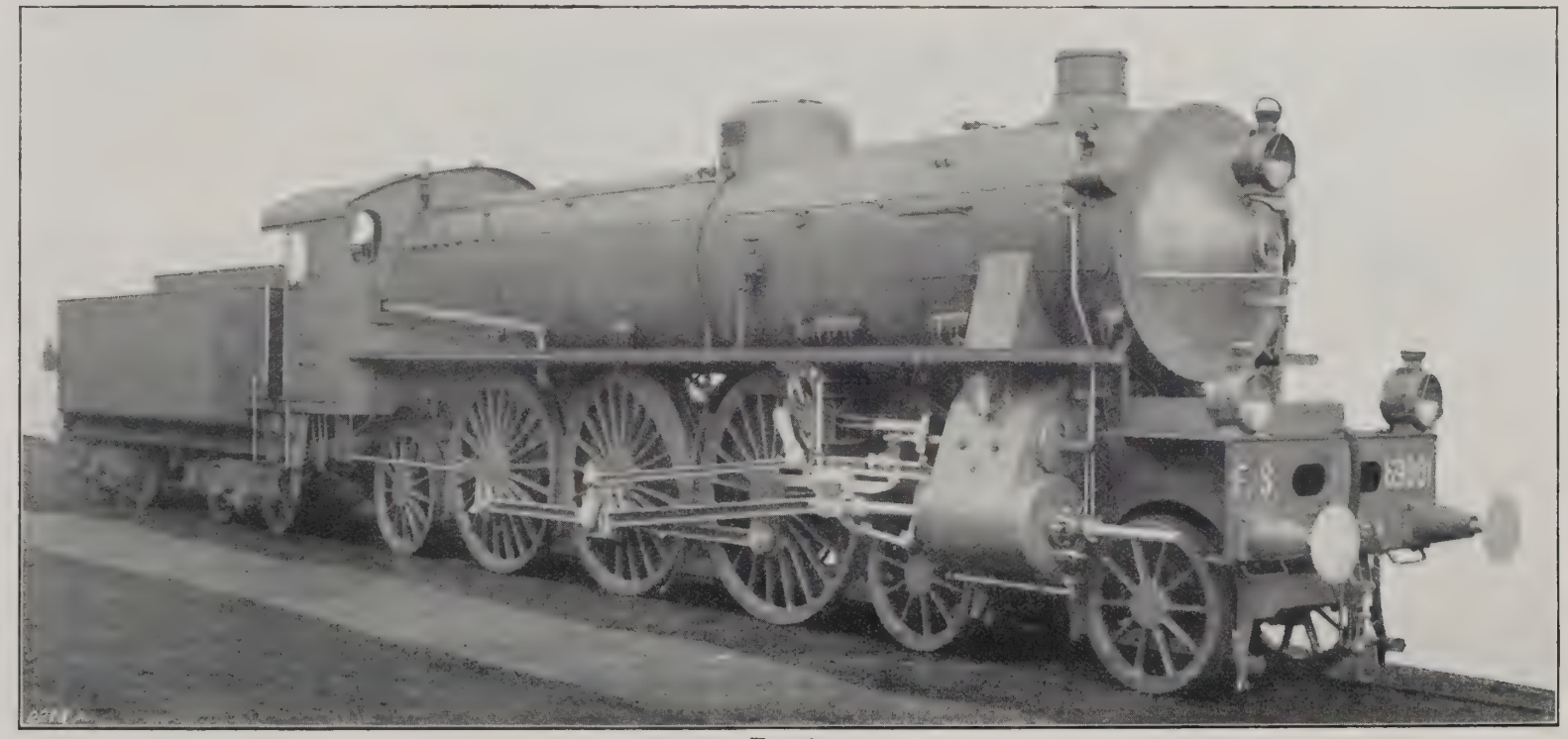
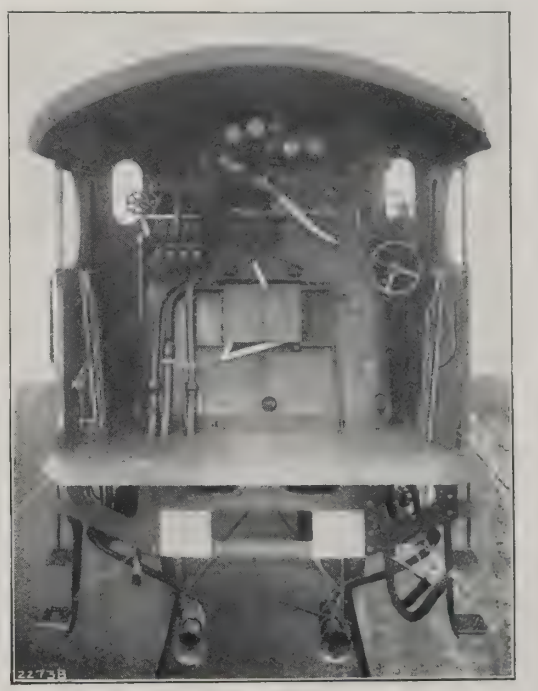


Fig. 6.



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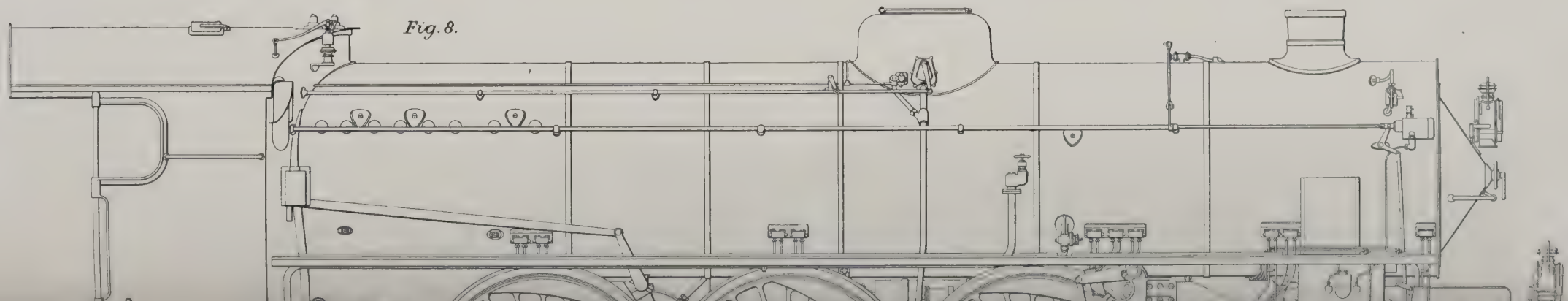

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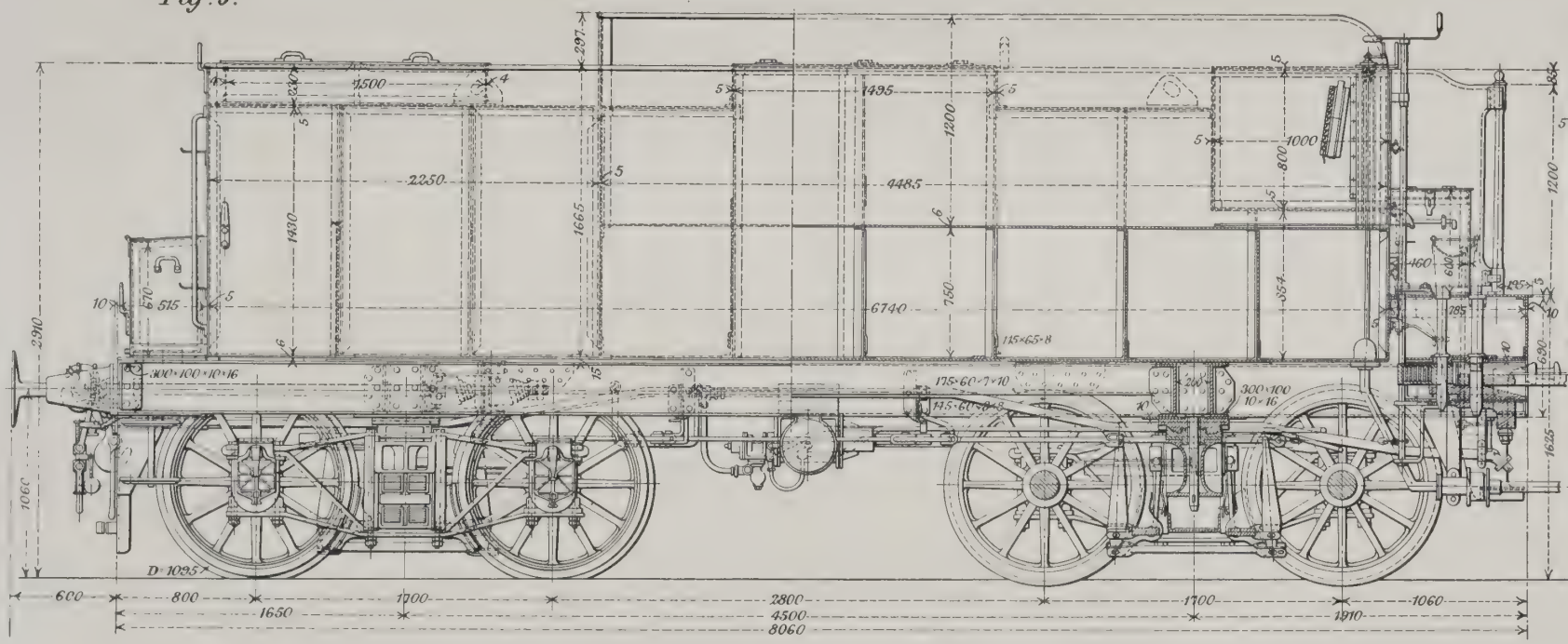

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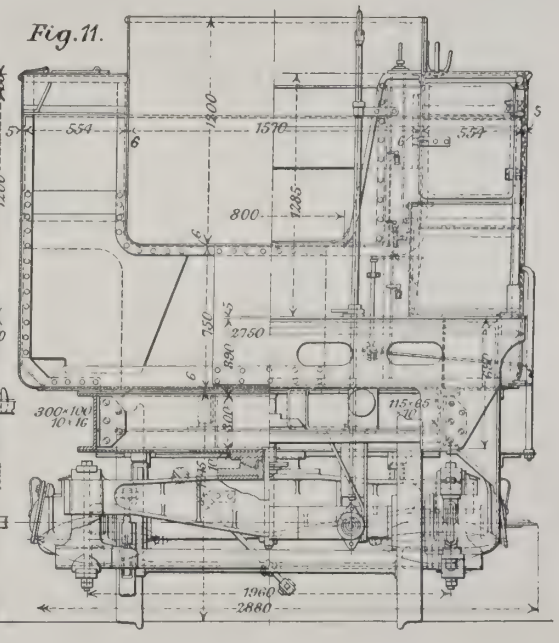

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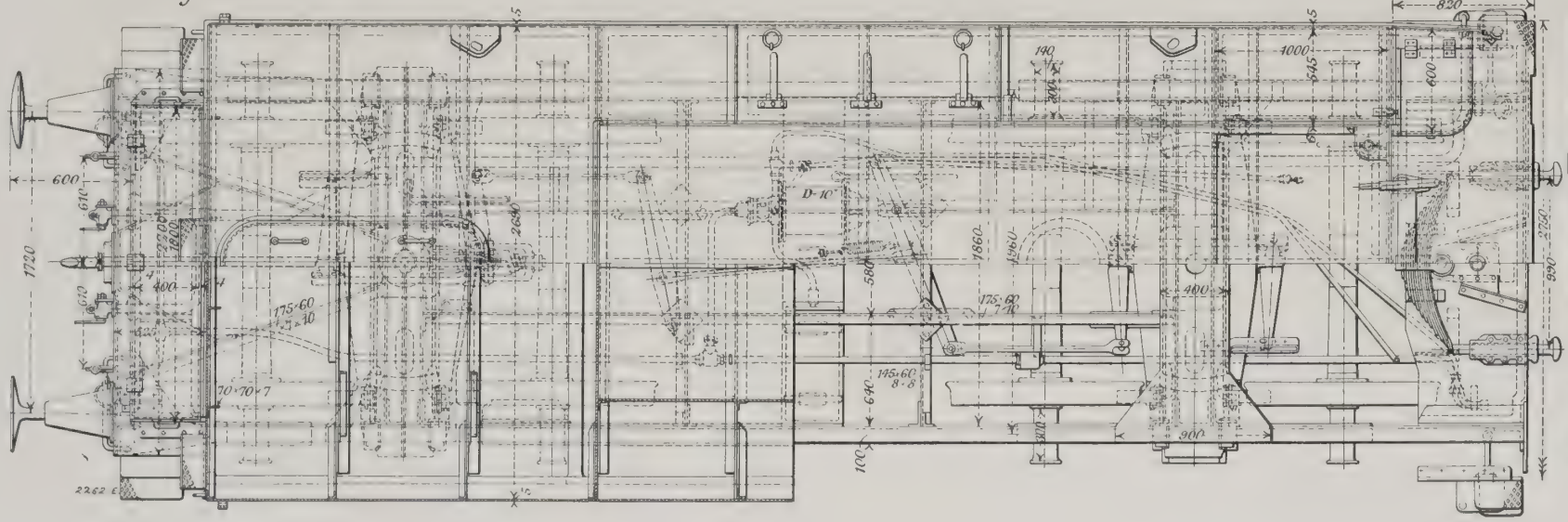

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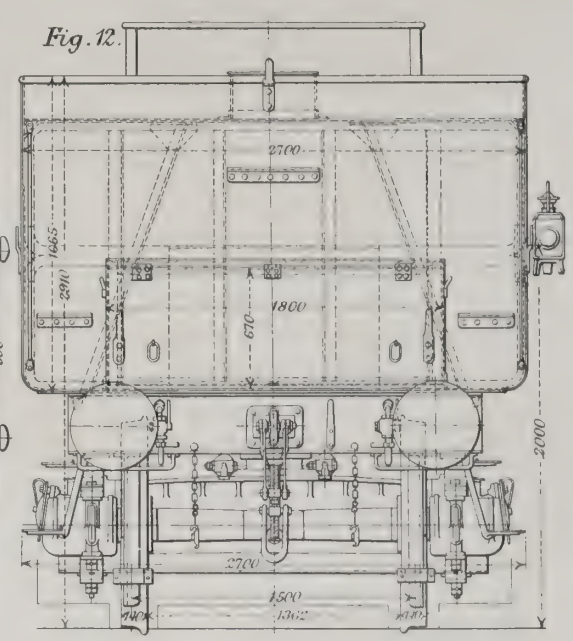


NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Effects of the Strike.—Since last Wednesday the condition of the Sheffield industries has been bad. At the week-end many works were shut down, and large departments in others had to cease work, all on account of a shortage of fuel. Had the railway strike lasted much longer local trade would have been brought to an absolute standstill. The head of one of the large firms which was compelled to close down communicated with the Prime Minister, the Home Office, and the Board of Trade, pointing out that men willing to work were unable to do so on account of the strike, and posted up a notice at the works to similar effect.

South Yorkshire Coal Trade.—The good influences which during the past few weeks have had such a beneficial effect upon the steam-coal trade still obtain. Demands both for shipment and industrial consumption have been large, and tonnages consequently brought up to a level which will compare satisfactorily with those recorded last year at the same time. Prices are stronger, and coal-owners are expecting the shipping season to close well. The pressure of orders for gas-coal has been considerable both on home and export account. The house-coal market has been rather quiet, but a more lively demand from London is reported, resulting in a reduction of stocks. With the end of the heat-wave, and the drawing-in of the summer season, business is expected to be active in the immediate future. The strike caused almost a cessation of business on the local Exchange at the week-end, and prices remained unaltered. They are:—Best branch hand-picked, 13s. to 14s.; Barnsley best Silkstone, 11s. to 12s.; Silkstone, 9s. to 10s.; Derbyshire house, 9s.; large nuts, 7s. 3d. to 9s.; small nuts, 5s. 6d. to 6s. 6d.; Derbyshire brights, 9s. 6d. to 11s.; washed nuts, 7s. 6d. to 8s. 6d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. 3d. to 5s. 3d.; and smalls, 2s. to 3s.

Iron and Steel.—The Sheffield industries, in a metaphorical sense, are beginning to breathe again. The railway strike was a sort of hand at their throat; without fuel and raw materials to consume, production had to cease. With something like a normal flow of supplies they may be expected quickly to be in full swing again. Speaking generally there is abundance of work, and orders held over and deliveries suspended are likely to result in extreme pressure for some time. The raw material market kept very firm throughout the trouble, and hematite producers, though officially quoting recent prices, are asking more for forward deliveries. Billets are firm and bars are in about the same position, the South Yorkshire Bar Iron Association having decided at their last meeting to maintain the 6*l.* 15s. figure. Since business transactions during last week were so small the general industrial position in Sheffield is about the same. It is obvious that the majority of firms will have suffered financially, particularly in regard to foreign orders, which may quite conceivably have been diverted on account of unsettled industrial conditions here. The strike was particularly unfortunate in that this year, contrary to the usual experience, the month of August has found the Sheffield manufacturers with pretty full order-books. At this time in an ordinary year a week's stoppage would not have been of nearly so much moment. From the employers' view solely it might have been profitable to have closed departments rather than have kept machinery running for an inadequate amount of work.

THE ROYAL SANITARY INSTITUTE.—This Institute announce a series of lectures and demonstrations for sanitary officers; of lectures to assist school teachers and other students entering for the examinations in hygiene in its bearing on school life, and for women health visitors and school nurses; and of lectures for candidates preparing for the examination for inspectors of meat and other foods. These lectures commence in September and October next, and further data concerning them can be obtained from Mr. E. White Wallis, secretary of the Sanitary Institute, 90, Buckingham Palace-road, S.W.

GOODS TRAIN BRAKE TESTS.—Tests of continuous goods train brakes were made on July 10 and 11 on the Orléans Railway between Vierzon and Royat by the Engineer-in-Chief Sabouret, in the presence of the Comité de l'Exploitation Technique des Chemins de Fer. The trains were: One of twenty-eight carriages, total weight 350 tons, on an incline of 25 : 1000; one of sixty carriages, total weight 880 tons, on an incline of 15 : 1000; one of eighty carriages of 1130 tons weight, on an incline of 5 : 1000. The results were very satisfactory, although the speeds were raised to 50 km. and 55 km. per hour. One train was run down an incline of 25 : 1000, 600 metres in length, without putting on counter steam, the usual French practice. The experiments have been described in *Le Génie Civil*. Goods train braking has seldom been applied in Europe so far on trains of more than forty carriages, although it is common practice in the United States. The reason is that the American coupling practically makes the whole train a continuous whole, which is gradually brought to a standstill without violent knocking of the carriages against one another. In order to avoid these shocks, the locomotive and tender and the front part of the train could, in the French experiments, be braked independently of the rear; this was achieved with the aid of a double valve at about one-fifth the train-length. The front part is first put under a slight brake pressure; the remainder of the train is then braked; when the train is very long a second double valve is provided. The experiments were conducted with brakes of the Westinghouse, Wenger, Lipowski, and Knord types, all of which could easily be fixed on goods carriages.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—What with the annual local holidays, and the unfortunate railway strike, the Exchange here might almost as well have been closed this week, for very few traders have put in an appearance, and business has been practically at a standstill. Now that the serious labour trouble is over, however, very considerable activity is confidently looked for. Most of the blast-furnaces have had to be damped down, owing to difficulty in obtaining adequate supplies of coke and limestone, due to the railway stoppage. Some forty furnaces have been damped or put on slack blast, but they will quickly be put into operation again. Values of pig iron are strong. No. 3 g.m.b. Cleveland is fully 47s. 9d. f.o.b., whilst No. 1 is firm at 51s. 3d.; No. 4 foundry, 47s. 3d.; No. 4 forge, 46s. 9d.; and mottled and white iron, each 46s. 3d.—all for early delivery, higher rates being asked on forward account. A rather better account is given of East Coast hematite pig iron, and consumers are understood to be in need of supplies, so that buying at an early date is anticipated. Mixed numbers are said to be obtainable from some second hands at 61s., but makers, as a rule, will not quote below 61s. 3d., and some producers are inclined to hold out for a higher figure, declaring that the foregoing quotations are unremunerative. There is still no business passing in foreign ore, and market rates remain nominally based on 19s. ex-ship Tees for best Rubio. Coke prices have been very high for immediate delivery, owing to scarcity due to difficulty of transit owing to the railway strike, but affairs are rapidly becoming normal again. For delivery over the last quarter of the year, average blast-furnace coke has been sold rather freely at 14s. 6d.

Stocks and Shipments of Pig Iron.—Stocks of pig iron show little alteration. To date this month 725 tons of Cleveland pig have been taken from the warrant stores, where the stock remains about 600,000 tons. Stores in makers' yards are stationary. Shipments of pig are on an excellent scale; up to to-night they reached this month 73,139 tons, as compared with 60,924 tons to the same date last month, and 70,722 tons for the corresponding part of August last year.

Manufactured Iron and Steel.—Manufactured iron and steel works are closed, as is usual during the local race week, and consequently these two important branches of the staple industry have not been inconvenienced by the disastrous railway strike. Quotations all round are firm. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron girder-plates, 6*l.* 17s. 6d.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; and steel joists, 6*l.* 7s. 6d. to 6*l.* 10s.—all less the customary 2½ per cent. discount. Cast-iron columns are 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; and steel railway sleepers, 6*l.* 10s.—all net at works. Galvanised corrugated sheets are 11*l.* 5s. f.o.b.—less the usual 4 per cent.

MONUMENT TO THE LATE J. AUGUSTIN NORMAND.—A statue of the late J. Augustin Normand was unveiled on Sunday last, the 20th inst., on the Place du Vieux Marché, Havre, in the presence of a large concourse of local authorities and personal friends. M. Normand passed away on December 11, 1906, and in the obituary notice which we gave at the time (see ENGINEERING, vol. lxxxii., page 806) we referred both to the work which he had carried out and to his charming qualities and unvarying courtesy. The fact that his native town has raised a statue to his memory less than five years after his death, affords a proof that the value and geniality of the man are fully appreciated. British naval architects were represented at the ceremony by Sir William H. White, K.C.B., Mr. S. W. Barnaby, and Mr. John Gravell.

JAPANESE RAILWAYS.—The following information, sent us by the Commercial Intelligence Branch, Board of Trade, is from the report by the British Acting Commercial Attaché for Japan on the trade of that country in 1910, which will shortly be issued:—In last year's report attention was drawn to the boom in schemes for light railways and lighting companies. The number of new proposals for undertakings of these descriptions and extensions of existing ones has increased during 1910. In August a light railway law was put in force. The object of this law is to enforce proper control over the promotion of schemes for constructing light railways, and also to encourage the construction of such lines in order to connect minor centres of trade and production with the existing lines of railway. The nationalisation of the railways has had the effect of checking private enterprise in this direction, while the State is unable to spare funds sufficient to meet the demands for railway extension. Consequently it is hoped that this law will attract private capital to the construction of light railways. A more powerful fillip to this industry was given by the news of the Government's intention to introduce into the Diet during the 1911 session a Bill for granting subsidies to light railways. This Bill was passed by the Diet. The date of its coming into force is not yet fixed. It should be repeated here that, on account of the financial standing of some of these undertakings, it is advisable for British merchants to do business with them only through firms or representatives in Japan, as the latter are in a position to ascertain whether contracts can safely be accepted.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Work has been generally, but not quite completely, resumed at the docks. Many collieries have been unable, however, to resume operations, in consequence of an absence of empty wagons. Under these circumstances coal prices have ruled firm for both large and small. The best large steam coal has made 19s. to 19s. 6d. per ton; secondary qualities have ranged from 16s. 6d. to 18s. 6d. per ton; best bunker smalls from 10s. 9d. to 11s. per ton; and cargo smalls from 8s. 9d. to 9s. 6d. per ton. The best ordinary household coal has been quoted at 14s. 6d. to 16s. 6d. per ton; No. 3 Rhondda large has made 17s. to 17s. 6d. per ton, and smalls, 10s. 6d. to 10s. 9d. per ton. No. 2 Rhondda large has been quoted at 12s. 3d. to 12s. 6d. per ton, and smalls, 8s. to 8s. 6d. per ton. Foundry coke has brought 18s. to 20s. 6d. per ton, and furnace ditto, 16s. to 17s. per ton. As regards iron ore, Rubio has realised 18s. 6d. to 19s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Newport Bridge.—The re-building of Newport Bridge was discussed at considerable length at a special meeting of the Town Council on Tuesday. Mr. Alderman Canning, in bringing up a report of a joint committee on the matter, recommending that a new bridge 60 ft. wide be built of ferro-concrete (with the alternative of parapets in Cornish granite), and that engineers be invited to submit designs and estimates, dealt with the question of the stability of ferro-concrete. He said he had had some experience as engineer to the Newport Gas Company of that material, having laid long floors in the retort-house carrying a weight of 300 lb. per sq. ft. In the four years of the life of those floors there was no deflection or vibration at all. The fact that the Government was the largest user of ferro-concrete was also a significant point. After a long discussion, it was agreed that, with a view to giving additional time for the preparation of designs, the Council should abandon the idea of going to Parliament next session. The time for sending in designs and estimates was extended to December 30 next, and a Bill will be promoted in the following session of Parliament. Subject to this extension of time, the scheme was approved.

Gloucester Wagon Company.—The report of the directors of the Gloucester Railway Carriage and Wagon Company, Limited, states that the revenue from wagon rents has been well maintained; but that, owing to unprecedented competition, a loss on the manufacture of rolling-stock has occurred. The directors accordingly regret that they are unable to recommend any further dividend for the past year. They propose to take 10,000*l.* from the reserve fund; and after deducting the loss, to carry 2134*l.* forward to next year's account. The usual charges for depreciation of land, buildings, machinery, and wagons, amounting to 11,464*l.*, have been provided for. The directors report that there is now a great improvement in trade; there are orders upon the books at remunerative prices, and they look forward with confidence to satisfactory results in the coming year. The company now repairs and maintains 24,572 wagons, including those belonging to it.

New Slip at Pembroke.—Messrs. Relf and Sons, Plymouth, who have been entrusted with a contract for a patent slip for destroyers at Pembroke Dockyard, have commenced work. The original estimated cost of the slip was 14,000*l.*, which was, however, increased to 22,000*l.* last year, 500*l.* being expended on surveys and other preliminary work. Messrs. Relf's tender was 17,695*l.* About 13,500*l.* is to be expended during the current financial year.

The Ebbw Vale.—A remarkable state of affairs exists at the works of the Ebbw Vale Steel, Iron, and Coal Company, Limited. The company alleges that it is impossible for it to compete in bars and billets against German and American terms, and that the foreign producers are determined to undersell the company by at least 5s. per ton in any case. On the other hand, other causes are alleged to be at the root of a stoppage of work, by which nearly 4000 workmen have been thrown idle.

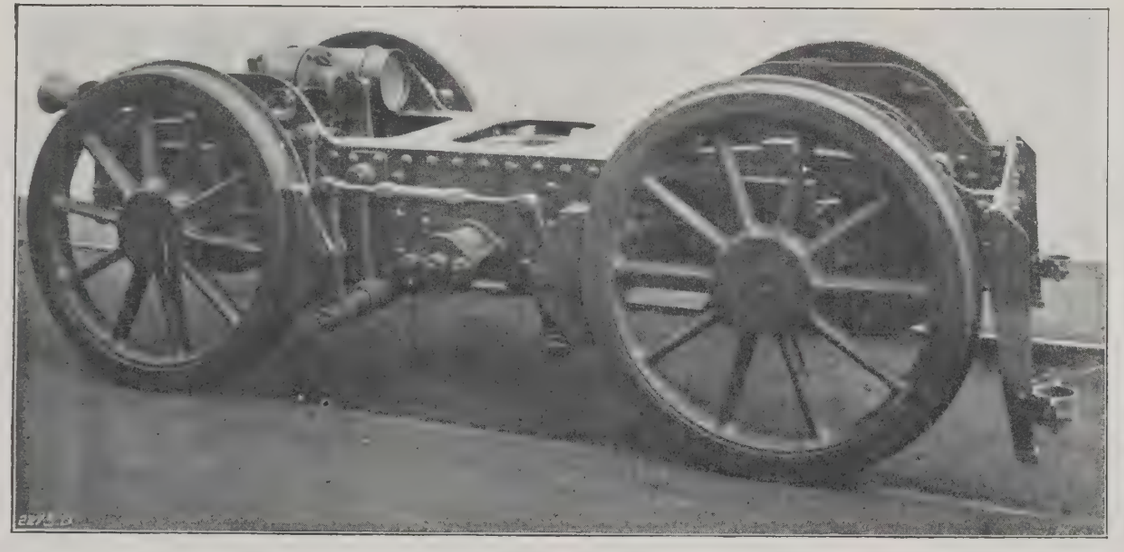
ILLUMINATING GAS FROM SEWERAGE.—According to a paragraph in *La Technique Moderne* the Municipality of Brünn, Austria, have decided to filter the town sewerage and to distil the solid residue for obtaining illuminating gas. Analyses made at different periods from 1906 to 1909 show that at Brünn 1 cub. m. (220 gallons) of sewerage yields on an average 1666.4 grammes (3.7 lb.) of solid residue. The yield in gas of the latter amounts to 23.8 cub. m. (840 cub. ft.) per 100 kg. (220 lb.) of solid residue; the gas has a calorific value at least equal to that of coal-gas, and gives a better light than the latter.

ELECTRIC POWER FOR BURGOS, SPAIN.—The hydro-electric power-transmission plant for the supply of electricity for the town and district of Burgos, in Spain, from the River Ebro, was opened last March. A company—"El Porvenir de Burgos"—was established in 1906, and at present two turbines, each of 600 horse-power, are being driven by the water of the Ebro River; the feeding-conduit has a length of 2 miles, and crosses the Ebro once. The turbines are of the Francis type with horizontal shafts and spiral casing, provided with a servo-motor, an oil-pump, and a Harburg pendulum regulator. They run at 600 revolutions, and were built by the E.A.G., late Kolben and Co. Three-phase currents are generated at 3300 volts and 50 periods. Current, at 30,000 volts, is transmitted to Burgos, more than 30 miles distant, where the tension is again reduced to 5000 volts, and at the distributing stations to 120 volts.

DETAILS OF FOUR-CYLINDER PASSENGER LOCOMOTIVE (4-6-2 TYPE) AND TENDER; ITALIAN STATE RAILWAYS.

CONSTRUCTED BY THE SOCIETÀ ITALIANA ERNESTO BREDA, ENGINEERS, MILAN.

(*For Description, see Page* 258.)



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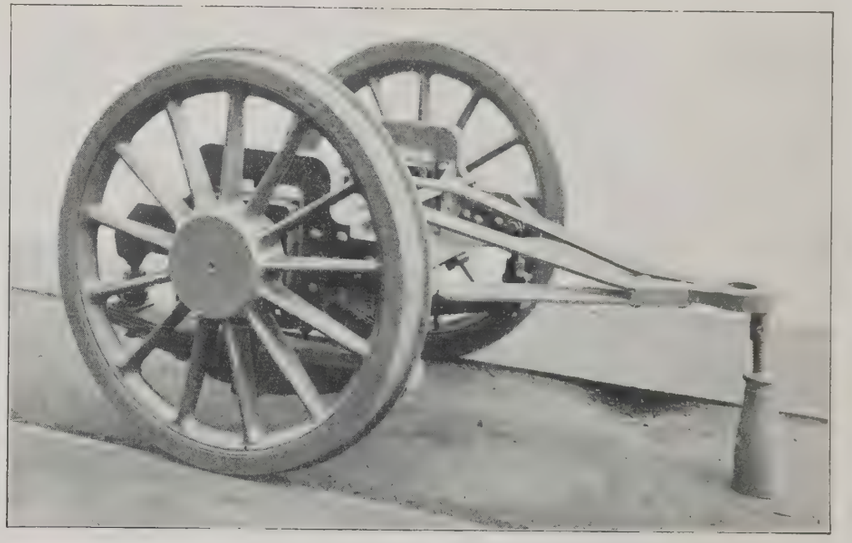

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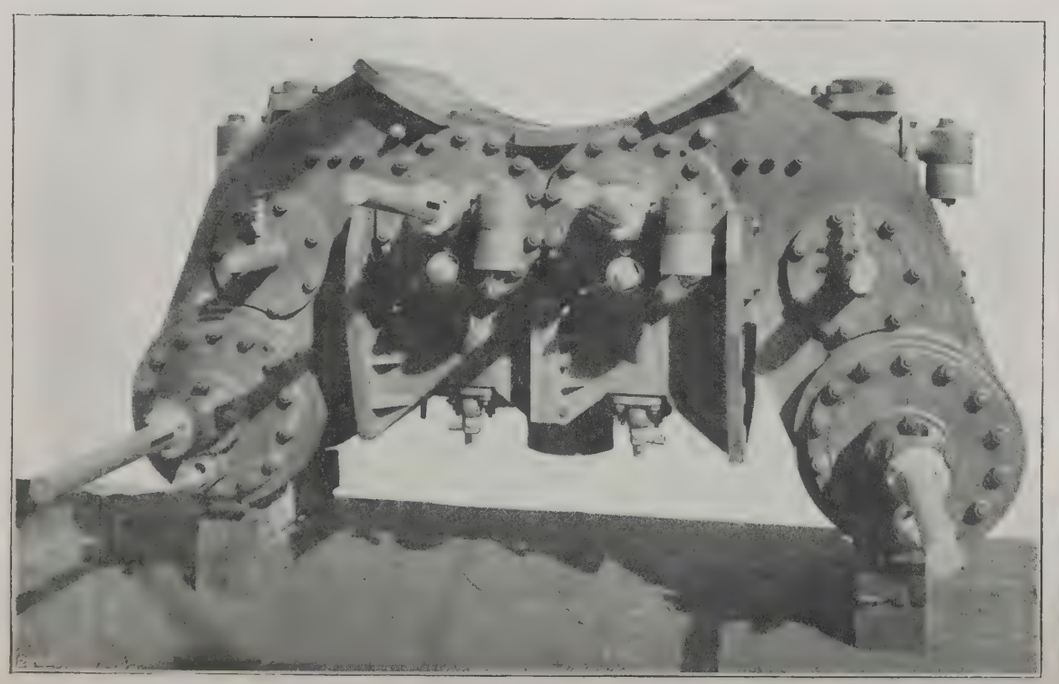

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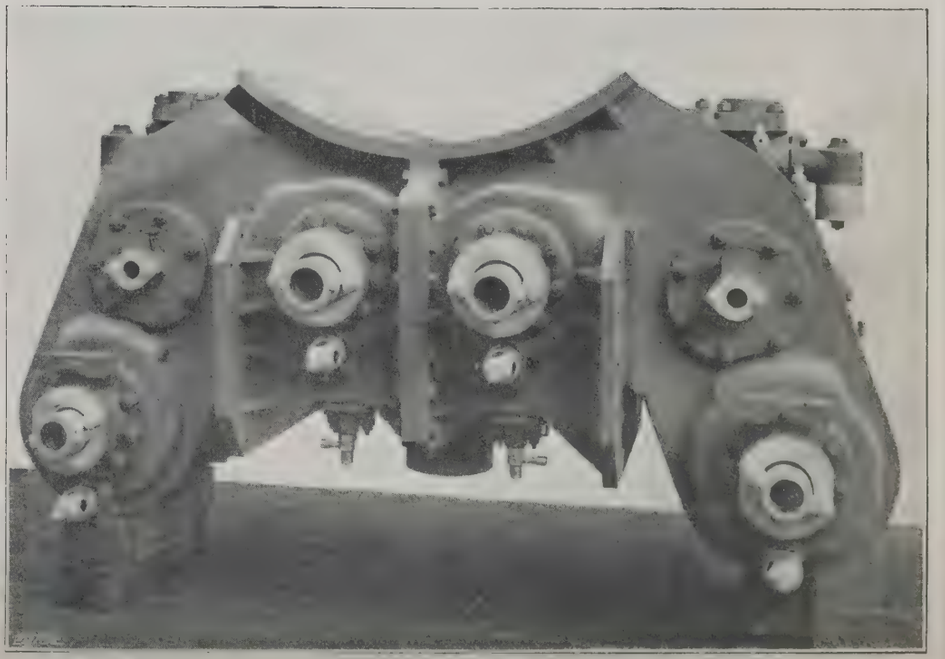

Fig. 16.

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With a Two-Page Plate of a FOUR-CYLINDER PASSENGER LOCOMOTIVE (4-6-2 TYPE) AND TENDER FOR THE ITALIAN STATE RAILWAYS.

ENGINEERING.

FRIDAY, AUGUST 25, 1911.

THE RAILWAY STRIKE; ITS CONSEQUENCES AND LESSONS.

The short-lived strike of the railway workers, with its attendant series of outrages, has already had great effect, and is destined to have still more influence in the future. We do not refer so much to the meeting of representatives of the railway companies and of the men's unions, whereby a truce was arranged: such conferences between contending parties are helpful, even if not always effective, in the settlement of disputes. Nor do we even regard as of first consequence the appointment of the Commission of Inquiry to investigate the working of the Railway Conciliation and Arbitration Scheme of 1907, and to report what changes, if any, are desirable, with a view to the prompt and satisfactory settlement of such differences as may arise. This commendable step, with its potentialities for ensuring permanent agreement, could have been brought about without a cessation of work. The greatest direct consequence, and the one which may have far-reaching results, is that public opinion has been awakened and educated as to the methods of trade unionism, the barbarism of strikes, the tyranny of picketing, and the general resulting loss, in a way which is impossible with strikes in any other industry. Employers have often fought at great expense for the maintenance of principles of equity, for the honourable fulfilment of agreements come to by accredited representatives of employers and men, and against internal dissension within unions. Such strikes, too, have been attended with similar tyrannical and outrageous behaviour by pickets and strikers generally as has characterised recent disputes. But these industrial conflicts have not touched the social life of the people—they have not been so widely and intimately prejudicial to the interests of the individual; and thus the great mass of the people have not been brought in direct contact with trade-union methods, or with the growth of that spirit of revolt against all the foundations and fabric of social life, with its common rights, responsibilities, and rewards—a revolt which is so foreign to the British nation that the names of syndicalism and sabotage by which it is designated have had to be imported.

It has been recognised by the public generally that the strike was tyrannical, and that those responsible completely disregarded the interests of the people; that, however, can be said of nearly all strikes. In this instance only twenty-four hours were given to the railway companies to consider and concede demands which were not clearly enunciated. That within two days an arrangement was effected under which the men returned to work proves conclusively that had adequate time been given there would have been no need whatever for work to cease. We admit that several circumstances may indirectly have conduced to the acceptance of the arrangement by the men's representatives. There was not that complete paralysis of the nation through the entire stoppage of railway traffic which the union leaders anticipated. This was not due to any lack of effort on the part of those leaders. The response by the men did not meet expectations. The railways succeeded in maintaining a moderately good general service. The public showed commendable patience, and even assisted the railway companies in many ways—a fact which proved that the strikers had alienated sympathy. Even the "bears" on the Stock Exchange were unable to foster an alarmist selling of railway stock. The members of the Government, and especially the Home Secretary, showed unprecedented decision and firmness in the employment of troops to maintain order. As it was there was a widespread tendency to lawlessness and outrage, and there was general satisfaction when the terms of a truce were arranged.

To call the arrangement a "settlement" is a misnomer, and the claim of the men's representatives that it is a great victory is only understandable when it is remembered that trade leaders and agitators have to maintain their popularity with their men by subterfuge in thought and extravagance in language. They "saved their face" by being able to say that the railway companies had at last met the representatives of the men's unions. This, however, does not mean that the unions are to be recognised under the Conciliation and Arbitration Scheme of 1907. That is matter for arrangement by the Commission of Inquiry. As the unions had called a strike, the Government induced the railway companies' representatives to meet these unions, and certain arrangements were made for the withdrawal of the strike order. At the same time it was arranged that steps were to be taken for the convening of conciliation boards to settle pending disputes, decisions to be retrospective, and, further, that disputes with men not included within the conciliation scheme should be considered by conferences between representatives of the company and "representatives of their employees who are themselves employed by the same company," and, failing agreement, by arbitration to be arranged mutually or by the Board of Trade.

There is here no indication of recognition of the unions by the employers, and when the subject comes before the Commission of Inquiry, there are possibilities of trouble. The only railway which recognises the unions in the way now demanded in the case of all companies—viz., the North-Eastern Railway—has had more trouble in connection with their conciliation scheme than all the others, and last week's strike was in their case protracted long after its cessation on other lines. Their traffic receipts for last week showed a decrease of 50,000*l.* when compared with the corresponding week last year, notwithstanding general trade expansion now. The more persistent and intensified friction thus experienced where trade unions are recognised cannot be regarded as a mere coincidence, and certainly does not support the claims of the trade unionists that trouble would cease on the other lines were the union delegates to conduct negotiations instead of the representatives of the workers of each respective railway. There is the significant fact, too, that not one-fourth of the railway workers are members of the union.

The clause in the terms of truce which caused the greatest trouble and awakened and educated public opinion most was that in reference to the re-instatement in work of men who had come out on strike. It was agreed that the men should be reinstated by the companies "at the earliest practicable moment," and that no one was to be "subjected to proceedings for breach of contract, or otherwise penalised." We have always contended that if there be a right to strike, there is a right to work, and similarly, if the striker is not to be penalised, no more should the man who continues in work. If a man, by continuing at work and refusing to strike, wins promotion, is he to be robbed of that advantage when the striker chooses to return? This is one of those phases of trade-union tyranny to which we are glad that public attention has been so prominently directed. The public have praised the loyalty of the men in remaining at work, and have raised subscriptions to acknowledge this loyalty. The companies, too, have granted bonuses. But a grave injustice would be done if any man who has proved his reliability by continuing at work does not profit permanently by remaining in the position to which he was promoted, provided his efficiency is not in question. Reliability is an essential characteristic in all affairs of life, and in none more so than in railway service. As an example, there is the case of an engine-driver and fireman who backed a locomotive on to a Continental train in a London station, and, before striking, waited until all was ready for the train to depart. The guard's signal for beginning the journey was met by the driver and fireman leaving the locomotive; and yet, according to trade-union methods, such men are to be welcomed back to their former posts the moment they elect to return to duty, while the loyal men who have stepped into the breach are to be penalised by being denied the promotion they have won by devotion and loyalty. It is important to note that the agreement stipulates for reinstatement at "the earliest practicable moment," which surely means when there is a vacancy. This is but fair to all concerned. Any other course would be a strong incentive to break agreements illegally. If men strike without due notice they ought to bear the penalty of their acts, and it is to be regretted that the law has not been enforced against such infringement of agreements in some salutary cases in order to establish the existence and the justice of such legal provisions as to relations of employer and employed.

The strike should put an end to the view that there can be "peaceful picketing." In the House of Commons on Tuesday last, Mr. Lloyd George, who was largely responsible for the passing of the

Trades Disputes Act of 1906, under which peaceful picketing was legalised, described the procedure of "peaceful persuasion" during the railway strike. At Llanelly, last Saturday, a train arrived at the Union Bridge. "A large number of persons had congregated to watch the proceedings; some of the most daring men immediately jumped on the foot-plate of the engine, and a fierce struggle ensued, the driver was badly hurt, blood oozed from his head, bricks were thrown, and the officer went and tried to persuade the strikers to refrain from further disturbance; he shook hands with them, and while thus engaged bricks and stones were thrown." After this narration of facts, Mr. George asked: "Where is the peaceful character of these proceedings?" This peaceful picketing was the prelude to the tragedy during which so many were killed and injured. Again, Mr. Winston Churchill, who was also an advocate of the Bill in 1906, stated that, even in the forty-eight hours during which the strike lasted, "riots occurred in four or five places, and minor riots occurred in twenty or more places. There were six or more attacks on railway stations, and a very great many on signal-boxes all along the line. I need not enlarge on the peril of driving people out of the signal-boxes at a time when even a few trains were running. There were nine attempts to damage the permanent-way, of which we have a record at present, or to wreck trains, or to tamper with points. There were a great number of cases—almost innumerable—of attempts to stop trains and to stone them. I do not suppose the people of this country realise that those are a class of offences that the law says are punishable with penal servitude up to penal servitude for life. There were many cases of telegraph and signal wires being cut, there were in several places gross instances of incendiarism, and in two cases in South Wales, at any rate, of wholesale looting by persons previously with good records. That is an amazing feature in the recent disturbances." We make no comment on the laxity which permits the culprits in these outrages to escape being sent to penal servitude or otherwise suitably punished. It cannot be accepted that these outrages were not part of the plan of campaign of the unions responsible for the strike. The labour leaders in the House of Commons—Mr. Ramsay Macdonald, Mr. Keir Hardie, and others—played the contemptible part of actually condemning the Government for interfering with the course of the strike proceedings and for employing troops to safeguard the nation from such outrages.

A policeman on his beat or a soldier on sentry duty can be no menace to the peace-abiding citizen. A striker who intended to obey the law could not be incensed by the employment of troops to protect property. The real objection to the Government's measure was the fear—or rather the certainty—that the prevention of intimidation to the men willing to work, and of the destruction of property whereby the railway companies and the public were to be terrorised, would defeat the aim of the strikers. And what was this aim? It was to paralyse the nation, to stop all passenger traffic at a season when a great proportion of the population were from home on holiday, and prevent their returning, to stop food supplies, and to preclude factories from obtaining the materials essential to the maintenance of their industries. As Mr. Winston Churchill put it in the House of Commons on Tuesday, "Had the strike proceeded for a week on the lines apparently intended there must have been practically a total cessation of industry. Every one would have been thrown out of work. Every mill, every mine, every factory must have been closed. The wages for the household would have ceased. Had the stoppage continued for a fortnight it is, I think, almost certain that in a great many places to a total lack of employment would have been added absolute starvation." Speaking of the great industrial area comprised between Liverpool, Newcastle, Hull, and Birmingham Mr. Churchill went on to say:—"In that great quadrilateral which, I suppose, must contain anything between fifteen and twenty millions of persons, intelligent, hard-working people, who have raised our industries to the forefront of the world's affairs, it is practically certain that a continuance of the railway strike would have produced a swift and certain degeneration of all the means, of all the structure, social and economic, on which the life of the people depends. If it had not been interrupted it would have hurled the whole of that great community into an abyss of horror which no man can dare to contemplate." Had "peaceful picketing" been permitted this result might have been achieved, but the Government which legalised it prevented it by the force of military. Even so, the troops were at times hindered because the magistrate, being a trade unionist, was intimidated, and afraid to read the Riot Act. Here also is a reason for amendment of the law. Should not the commandant of the troops in such a case have power to read the Riot Act and take action?

The use of the military was imperative. It should not be lost sight of that before this "one of the most menacing industrial strikes with which this country has ever been confronted," to quote Mr. George, serious breaches of the law occurred at Liverpool and elsewhere, where the labour unrest originated. It was necessary to maintain the railway transit of food supplies, and thus the railways had to be protected. The Government would have been guilty of treason had they waited until the mischief had been done. It was a case in which the necessity for preventive measures was most urgent. If the rioting was the work of hooligans, why did the Labour leaders in the House of Commons on Tuesday protest so unpatriotically against the use of military on the plea that it was taking sides against the strikers. The attitude of such Members is not even justified by the fact that their election to the House last year was valiantly supported by those members of the Government whom they now condemn. They now learn the lesson that a Minister of the Crown may take a different view on the election platform from that necessary to the fulfilment of his oath of office to his Sovereign, however reprehensible such inconsistency may be. "The Government," to quote the Home Secretary, "took sides only with the public; we could not look on impartially and allow their vital interests to be affected; we became, and must always become in such circumstances, active partisans of the food supply."

This and other promises for the future are satisfactory in view of the fact that the "settlement" for the present only means that parties to the dispute, "without abandoning their intentions," to quote the Premier, "have agreed to the immediate investigation of the case by an impartial tribunal." There may be fervent hope, but there cannot be any certainty, that a lasting peace will result from the deliberations of the Commission of Inquiry, to the composition of which we refer in our "Industrial Notes." We have no intention of entering into any consideration of the claims of the men. These have not yet been formulated. The conciliation scheme needs modification, since it is, like much of our recent legislation, most hasty and immature in its provisions and machinery for application. Before the Commission of Inquiry the facts will be elucidated, and we are sure that many ludicrously exaggerated statements by the men will be corrected. Misconceptions of the situation will also be explained. We doubt not that the railway companies will accept every suggestion of the Commission which is at all reasonable, but there must be some surety that such conditions as are accepted by employers and workers will be faithfully fulfilled, and this guarantee must be associated with penalties in some form or other as indicated in our leading article in last week's issue.

The solution of the difficulties to be dealt with is simplified so far as the Commission is concerned, by the promise of the Government to propose in Parliament next session legislation providing that an increase in the cost of labour due to the improvement of the conditions for the staff will be a valid justification for a reasonable general increase of charges within the legal maxima, if challenged, under the Act of 1894. But this promise raises very important issues. Increased freight rates must augment the cost of production, and to this extent must increase the difficulties of our manufacturers in competing in foreign markets. Any such handicap must thus certainly add to the number of unemployed workers. But, as has been proved in many ways, the labour leader's business is to agitate, and not to promote industrial prosperity, a task of which he knows little and apparently cares less.

SEISMOGRAPHIC DETERMINATION OF THE VIBRATIONS OF RAILWAY-BRIDGE PIERS.

The Bulletin of the Imperial Earthquake Investigation Committee of Japan, dated Tokyo, June, 1911, contains a detailed account of some vibration measurements which Professor F. Omori, well known in the field of seismography, conducted on two railway-bridges of a new line which connects Kyoto with the naval port of Maizuru. The two bridges, the Shichima-gawa and the Takaya-gawa (which we will designate as the S bridge and the T bridge), are both near the town of Ayabe, and the tests were made in July, 1910, previous to the opening of the line. Trains consisting of two tender engines (sometimes one engine only) and two empty wagons were sent up and down this line at speeds ranging from 3½ to 23 miles per hour. Each of the engines weighed, in working order, 78 tons. In some tests a train of the two engines, one brake-van (10.4 tons) and eight wagons, seven of which were loaded with 20 tons of rails each, was also run over the bridge. The report abounds in figures concerning velocities, periods, and amplitudes of the vibrations; but Professor Omori does not enter into the dynamics of the problems at all.

Both the bridge structures comprise heavy trusses supported by high masonry piers resting on firm soil. The tallest pier of the T bridge has a height of 82½ ft. and supports the fixed end of a 200-ft. deck truss, to which is attached one end of a 70-ft. plate-girder. The tallest pier of the S bridge has a height of 82⅛ ft.; it supports the roller ends of two 200-ft. deck trusses, to which 40-ft. plate-girders are attached. The depth of a truss is 28 ft. The T bridge truss weighs 155 tons, the girder weighs 27½ tons; the S bridge truss weighs 183 tons, and each girder 9½ tons. The measurement of the pier motion was made with the portable horizontal vibration-recorder, which Professor Omori had used in previous tests on two piers only 20 ft. and 30 ft. in height, but requiring well sinkings to depths of 65 ft. and 95 ft. in unreliable soil. The two horizontal pendulums register with a magnification of 30 in ink on white paper. By transverse component of the pier vibration Professor Omori understands, in the customary terminology, the vibration in a direction normal to the pier plane—namely, parallel to the length of the bridge—and by longitudinal component the vibration in a direction parallel to the pier plane—namely, normal to the length of the bridge. The natural periods of the heavy masses of the vibration-recorder were from 2 to 3 seconds, much longer than the natural periods of the pier. Another instrument recorded the horizontal and vertical oscillations of the trusses.

The T bridge has a total length of 350 ft., and consists of one 200-ft. deck truss and three 70-ft. plate-girders. The truss in question rests on the tallest pier, as mentioned, and on the other (Kyoto) end on an abutment 46 ft. in height. The horizontal vibration-recorder was set up on the top of the tall pier, which has at that level a section of 7 ft. by 24 ft., widening downwards to 17½ ft. by 30½ ft. The single rail-track is on the top of the truss, and thus 28 ft. above the pier top, and the horizontal and vertical vibration-recorder was placed on the track-level in the middle of the truss. Twenty experimental runs were made. In the vertical vibrations of the truss three principal periods $t_1 = 0.19$ second, $t_2 = 0.26$ second, $t_3 = 0.40$ second, could be distinguished, when the two engines and wagons were running, and only two principal periods of 0.25 second and 0.36 second with one engine and two wagons. These figures express means; the 0.40 second period was the most frequent and pronounced. The amplitudes of the vertical vibrations seemed to increase with the velocity of the train, up to 6.3 mm.; still greater amplitudes would probably have been obtained with long goods trains, which have an accumulative effect on the vertical component.

On the top of the pier vibrations in the horizontal components were distinctly registered when one or two men were running over the truss; the longitudinal movement lasted in the latter case 30 seconds, but its amplitude was smaller than that of the transverse component, which rose to 0.063 mm. When one engine was sent slowly over the truss track, the movements of the two components set in almost at the same moment, and lasted 96 (transverse) and 111 seconds (longitudinal). The maximum transverse movement of a little more than 1 mm. was observed with up trains to Kyoto at speeds of 9 and 23 miles per hour in vibration periods of about 0.33 second and 0.40 second. The greatest longitudinal vibrations hardly exceeded half a millimetre; the respective periods were 0.18 second and 0.25 second, and the speeds of the down trains in this case 7 and 15 miles per hour. The ratio of maxi-

mum transverse to longitudinal movement varied between 1 and 4. This ratio would depend upon the vertical vibrations of the bridge truss. For, if we imagine the points A, O, B, P to be in a straight line, and a source of disturbance to be at O on A B, then P would describe two movements, first backward and forward in resonance with O, and, secondly, in a line at right angles to O P at a period of about half that of O. The movement of a truss or girder would be maximum in the middle of the truss; it would vanish towards the extremities, and would be communicated to the adjacent piers as a horizontal movement in a direction normal to the pier-faces. These assumptions were also confirmed by Professor Omori by measuring the movements of the ground caused by a gas-engine.

The brake effects on the pier were remarkable, even when the train (as a rule of one engine and two wagons) was stopped at low initial velocity, not exceeding 6 miles per hour. At the moment when the engine was brought to rest a sudden displacement (a one-sided jerk) in the transverse component was recorded which was often much more striking than the vibration during the running of the train; the curves of the longitudinal component in most cases did not indicate the braking and stopping moment at all. The transverse component showed an average first displacement of 0.32 mm., measured in the one direction of the ordinate only (and therefore equivalent to a vibration of double that magnitude), and a second somewhat smaller movement more of a vibratory character, of mean amplitude 0.42 (measured in both directions of the ordinate). If a heavy train had been stopped on the bridge while running at high speed, the pier might have failed. The direction of the first displacement of the brake effect was always the opposite to that in which the train was running. Thus trains passing over a bridge seem to push the spans and piers along with them through a small range, and to cause the pier to bound back when the engine is brought to a standstill. The mean period of the brake vibrations was about 0.32 second, equal to the vibration supposed to characterise the proper oscillations of the pier. It is interesting to note that Sir Benjamin Baker, many years ago, pointed out, with special regard to the old Tay Bridge, that some railway piers might prove too slender transversely and might fail when trains were stopped on them.

The diagrams of the pier motion further indicated that the pointer of the transverse component was deflected from its zero position during the passage of a train over the truss of 200 ft., and that this deflection attained its maximum when the train was at the middle of the truss. The longitudinal component did not show any such effect. This movement Professor Omori ascribes to the tilting of the top surface of the pier on which the recorder was mounted. The inclination of this surface was calculated at 11.5 seconds of arc, with a single engine passing over the truss.

The second bridge, the Shichimi-gawa, also single track, has a total length of 629 ft., and consists of four plate-girders each 40 ft. in length, two trusses each of 200 ft. length, and one plate-girder, supported by two abutments and six piers. The two trusses rest with their roller ends on the eighth tallest pier, 82 ft. in height; the total height from foundations to track is 114⅓ ft.; the girders are joined to the other truss ends. The instrument was mounted on the top of this pier. Fifteen experiments were made, including seven stopping tests, mostly with the heavy train mentioned above. The pier is, as in the case of the other bridge, about twice as wide as thick; but the ratio of the maximum transverse to the maximum longitudinal movement varied only from 0.47 to 1.36; the pier thus moved 1.4 more in the longitudinal than in the transverse component, and behaved abnormally. The pier is for some reason very rigid in the transverse direction, and the effects on the pier of stopping a train were slight, the maximum vibrations amounting to 0.11 mm. only, although the heavy eight-wagon trains were stopped at velocities up to 16.4 miles per hour. The bulletin is illustrated by diagrams of the curves; but there are none referring to these heavy trains on the S bridge.

The just-mentioned features and Professor Omori's conclusions do not appear quite in harmony with his introduction. He first stated that there was no well-sinking, because the river-beds were hard, and there is no explanation of the different behaviour of the two piers; we may think of different subsoils, but there is no mention of borings. He concludes that the case of the Takaya-gawa is typical also of cases in which the river-bed is made up of a soft, muddy stratum of great thickness, and in which the piers are always shaky, notwithstanding the considerable depths to which the wells are sunk. Such a pier would move both with its own natural period and with the period of the vertical motion of the truss which it supports. The Shichimi-gawa, on the other hand, is an example of exceptionally small transverse pier motion, which is not affected by the vertical vibration of the trusses, and hardly affected by the stopping of the train.

The periods of the observed transverse and longitudinal vibrations, Professor Omori continues, were about 0.2 and 0.4 second, and thus much shorter than the periods of destructive earthquakes, which would be 1 or 1.5 seconds. With regard to earthquakes, the piers would hence be "short columns," liable to be fractured at their base, while high brick chimneys would be "tall columns," with natural periods longer than the seismic periods, and liable to break at about two-thirds their height. Since further the longitudinal components were by no means insignificant in the case of the two piers under consideration, the piers themselves might be cracked in directions parallel to the bridge axis, and at right angles to it, by destructive earthquakes.

THE BRITISH ASSOCIATION MEETING.

Next Wednesday, August 30, the British Association will assemble at Portsmouth, on its first visit to this town and naval port. Considering that almost all the important towns of the United Kingdom have entertained the British Association, and that the other ports on the south coast have not refrained from offering hospitality to the scientists, the reticence of Portsmouth might excite comment. Various reasons may be assigned for it. In the first instance, preliminary negotiations may be opened, but sometimes will not proceed very far, because dates and other circumstances will not fit. Then Portsmouth is neither conspicuous as a seat of learning nor as a manufacturing centre, and its commanding position as a naval port does not particularly qualify it to welcome an Association which, though British in name, is renowned for the generous hospitality which it tenders to scientists from all parts of the globe. For some reason or other the meetings on the south coast have not attracted large gatherings, moreover. The first Plymouth meeting of 1841 was attended by 981 persons, the second, of 1877, by 1229 members of all classes. At the first Southampton meeting of 1846 only 857 members entered their names, and at the second meeting of 1882 the attendance numbered 1253. The Dover meeting of 1899 attracted 1409 members, comprising a fair contingent from Boulogne, where the French sister association was assembled at the same time. The Brighton meeting of 1872, attended by 2533 members, stands out among the rather small meetings mentioned, which, it must be remembered, did not mark any periodical want of popularity of the Association; for the preceding and succeeding meetings attracted more members in each case.

It is not easy to say why Brighton should have proved a more popular meeting place than the other towns of the South. Things may have been different thirty years ago. But learning, industry, scenery, and historical associations did not distinguish Brighton in particular, and it is accidental features that account for a great deal in such cases. Portsmouth, it may be assumed, will not follow the Brighton lead, but will have to be satisfied with a moderate attendance, such as most meetings have seen of late. People are gradually becoming a little tired of conventions and large meetings, which involve very hard work to the organisers, and often bring little satisfaction to them, especially in scientific respects. What is good and satisfactory is accepted as a matter of course, and any shortcomings in the arrangements, caused in many cases by the indecision or unpunctuality of members, are duly grumbled at. There is, it will be acknowledged, no longer a need for a general association for the advancement of science in the sense of eighty years ago, when the British Association was inaugurated at York. Yet the Association continues to maintain its unique position as the body which affords the best opportunity for intercourse and exchange of ideas between scientists of all classes. The astounding development of the many various domains of research has, in fact, accentuated the importance of an association which aims at counteracting the dangers of specialisation; and it is a fortunate feature that the British Association has always been in a position to invite distinguished scientists from abroad. In order to prevent scientists working in different fields from drifting apart and from following too exclusively their own tracks, the Association encourages joint meetings and discussions, though it has had to increase the number of its sections in the course of time.

Sir William Ramsay is the President Elect. It may be presumed, therefore, that radioactivity and the nature of the elements will be touched upon in his address. Three or four years ago Sir William startled the scientific world and the meeting at Dublin by describing alleged transmutations of elements under the influence of radium emanation. Those experiments were repeated and not confirmed by others, who suggested various possible sources of error, and some further information on those features is certainly desirable.

We gave an outline of the programme of Section G, Engineering, in our issue of July 21. We will merely say now that aeronautics, oil-engines for marine propulsion, superheated-steam engines, and suction-gas plant, as well as radiotelegraphy, will be discussed, while papers will be read on tramway-rail corrugation, electrical ship-driving and steering, and on other subjects. Professor J. H. Biles will preside over Section G.

Part of the proceedings of Section A, Mathematical and Physical Science, will be in common with Section G. The presidency of Professor H. H. Turner will encourage astronomers to present communications, and Mr. A. S. Eddington will open a discussion on stellar distribution and movement. Another discussion, on the principle of relativity, will be opened by Mr. E. Cunningham. Professor Petterson will speak on great boundary waves and other tidal phenomena; Professor Vegard, of Christiania, on auroræ; Professor A. Watson on sound waves, and Professor Bragg on the corpuscular nature of radiation.

The Chemical Section, B, in which Professor J. Walker will take the chair, will discuss the part played by enzymes in the economy of plants and animals in joint meetings with Section K, Botany, and with Agriculture (so far a sub-section of K). This discussion is to be opened by Dr. Frankland E. Armstrong. Another discussion on colloids and absorption phenomena, to be opened by Professor Feundlich, will deal with subjects of which the technical importance is now becoming understood; Professor Trouton will refer to absorption in Section A. The discussion on indicators will also concern allied subjects. Of miscellaneous papers offered we mention communications by Professor Barus on the diffusion of gases through water, by Mr. P. V. Bevan on absorption spectra of metallic vapours, by Professors W. H. Perkin and W. J. Pope on optically active systems not containing any asymmetric atom, and Dr. W. Lewis on the compressibility of mercury. Reports on electric steel furnaces and insolubility are to be presented by Professor McWilliam and Dr. J. V. Eyre.

On the programme of Section C, Geology, in which Mr. A. Harker will preside, we notice a joint discussion with Section E, Geography, on sub-oceanic river-valleys around the British Isles. Colonel C. S. Close will be President of the Geographical Section, which is also going to discuss the airmen's requirements in connection with papers by Captain Bertram Dickson and others. In Section F, Economic Science and Statistics, the President, the Hon. W. Pember Reeves, will raise the subject of land taxation, while Mr. Waxweiler, of the Institut Solvay, at Brussels, will discourse on variation of wages; Mr. W. J. Hinton will speak on the merchant service.

Sections D, Zoology, President, Professor D'Arcy Thompson; H, Anthropology, President, Dr. W. H. R. Rivers; I, Physiology, President, Professor J. McDonald; K, Botany, President, Professor E. E. Weiss; and the Sub-Section K, Agriculture, Chairman, Mr. W. Bateson, will, perhaps, be all the more interesting to the engineer, because discussions like that on totemism (Section H) take him away from his professional cares; but we shall not be able to notice their proceedings.

Portsmouth has a population of 232,000 according to the latest census. Ever since 1295

the borough has returned two Members of Parliament. Sixty years ago the borough only occupied a small portion of the island of Portsea, and that portion was enclosed in walls and gates, through which it was difficult to gain access after sunset. Thirty years ago the boundaries were enlarged, and they include now Southsea, as well as the arsenal and dockyards. So far as possible special facilities will be offered to members for visiting the dockyards, the gunnery school on Whale Island, and the Vernon, the ship for torpedo and radiotelegraphy instruction. The Isle of Wight and the New Forest are near by—and also near to London—and in spite of this circumstance and of the absence of industrial works, members will probably regret not to have more time at their disposal to visit things worth seeing, while also attending the sections.

The reception-room will be in the Connaught Drill Hall. Sir William Ramsay's presidential address and the evening discourses—by Dr. Leonard Hill, on the physiology of submarine work, and by Professor A. C. Seward, on links with the past in the plant world—will be delivered in the Town Hall; and three of the sections, comprising A and G, will meet in the Municipal College. These three buildings are close to one another, and also close to the town railway-station. The chemists will have rather a long journey from the reception-room to their meeting-hall, which will be a secondary school near Fratton Station.

Next week we shall begin our report on the meeting and the sectional proceedings, noticing the President's address and the proceedings of Section G in the first instance.

THE ROYAL ENGINEERS OF THE TERRITORIAL FORCE.

The importance of the engineer services to the efficiency and well-being of an army in the field can hardly be over-estimated. Modern inventions and methods of warfare all tend to magnify the *rôle* assigned to the engineer. The more science is brought to bear upon, and adapted to, the service of war, the greater is the part played by the technical corps of an army. It is, however, often not thoroughly appreciated how all the specialised branches of the army, artillery, engineers, medical corps, and even cavalry, are designed and used really in the service of infantry, "the pith and strength of battle." The infantry is the arm which has ultimately to decide the conflict, and to fight and win or lose battles. The *raison d'être* of the other branches of the Service is to cover, protect, and assist the infantry when and where required, and to enable it to maintain the position taken up, or, if necessary, to perform similar duties during a retirement.

Each arm—cavalry, artillery, and infantry—has a power peculiar to itself, yet is dependent to a greater or less extent upon the co-operation of the other arms. They all require and rely on the assistance of the Royal Engineers, whether in the arrangements for camps and bivouacs, building and demolition of bridges, communications, provision of entrenchments and fortifications, to name a few of the duties devolving upon the engineer corps.

General Sir John French, G.C.B., Inspector-General of the Forces, in the course of his address to the cadets at his recent official inspection of the Royal Military Academy at Woolwich, especially emphasised the increasing importance and greater necessity of the services of a highly-skilled corps of Royal Engineers, under modern practice and conditions of war. The British Army at present is allotted a smaller proportion of engineers than is the case in many of the great foreign armies. During the South African and Manchurian campaigns the necessity of highly-trained and efficient engineer services was more marked and realised than ever before. Whilst the great principles of war remain, as always, immutable, modern weapons and conditions have revolutionised the practice; and consequently the art of the engineer, and, indeed, of all the so-called scientific or technical services, is called upon to an extent not previously contemplated. The Territorial Army is an integral part of the Empire's defences, as our military forces are now organised. We desire to direct the attention and interest of engineers in civil life to the Royal Engineers of the Territorial Force.

The organisation of the Territorial Force is that of an army intended for war. It provides for fourteen divisions, with the proper number of corps and army troops. A division at full strength consists roughly of 20,000 officers and men. To each division is allotted its quota of Royal Engineers, in accordance with the establishment, known as the Divisional Engineers, consisting of two field companies and a telegraph company. In addition to the Divisional Engineers, whose headquarters are situated in various parts of the country, there are wireless, cable, and air-line telegraph companies. These latter may be said to be divided into five groups—one group in each of the London, Northern (Leeds), Scottish (Glasgow), Southern (Birmingham), and Western (Liverpool) commands. There is a balloon company, with headquarters in London, and a railway battalion at Crewe. The force further includes fortress engineers, and works and electric light companies, situated in different parts, and electrical engineers in London.

In the monthly army list, published by authority, and obtainable through any bookseller, price 1s. 6d., will be found a complete list of the various Royal Engineer units of the Territorial Force, with the addresses of the various headquarters and names of officers serving. It will be seen that a complete organisation has been worked out and established, and that opportunities exist for engineers to assist in the defence of the country by serving in the Territorial Army, and particularly in the Royal Engineers branch of that force.

Now it seems clear that officers of the Royal Engineers in the Territorial Force ought to be engineers in civil life, apart from any military training, or at least ought to have had a sound engineering training. The regular Royal Engineer officers are the most highly-trained and carefully selected of all the officers of the army. We understand that in the Territorial Royal Engineers large numbers of the commissioned ranks are without any engineering training, or experience, in civil life, obtained directly from following some branch of engineering or any of the allied vocations.

We realise the difficulty there is in obtaining a full supply of suitable candidates for commissions in all branches of the Territorial Force. We admire the energy and patriotic spirit of those who, having no connection with engineering, hold commissions in the Territorial Royal Engineers. Under present circumstances, no doubt, without them the force could not have been raised. In our opinion, however, it is a *sine quâ non* that if the Territorial Engineers are to approach and maintain the required standard of efficiency they should be officered by men with engineering training in civil life. In some few instances we believe commanding officers of engineers insist on some engineering or allied qualification on the part of candidates they recommend for commissions under their command. This course, instead of being the exception, ought to be the rule. An ample supply of men with the necessary qualifications is available; nobody can seriously dispute this. Anyone sufficiently interested may, by application, obtain a very good knowledge from the manual of military engineering and certain drill-books, and up to a certain point may make himself a good officer. But he is not and cannot pretend to be either an engineer or an engineer officer in the proper sense. It would be easy to enlarge at length on the subject and point out many reasons why Territorial Royal Engineer officers ought, from every point of view, to have had some training and experience to fit them for their duties other than that obtainable on the Stock Exchange, in a lawyer's office, or other spheres of life totally removed from anything connected with engineering, buildings, or allied employments. We have not, however, space to do more than draw the attention of engineers to the matter. Most men have friends in the Territorial Force, and it is a simple matter, for anyone who will take the trouble, to find out full particulars.

The question of expense is sometimes a difficulty, but it is often exaggerated. The pay and allowances received when in camp will more than cover the annual expense incurred. On first joining probably an expenditure of 20*l.* to 25*l.* will provide all that is necessary in the way of uniform, &c., at any rate, for the first few years of service. After, say, a couple of years or so, a few extra pounds may be expended to make the kit more complete. The old extravagant methods and notions that existed in many volunteer regiments, and the constant drain on the pockets of officers in subscriptions to various regimental institutions, suppers, &c., are things of the past. Of course, a few regiments still exist in which it is somewhat expensive to hold a commission, but they are decidedly few, and even in these expenses have been reduced from what they were in volunteer days. Much useful information to anybody thinking of applying for a commission in the Territorial Royal Engineers, or any other branch of the force, is contained in the *Regulations for the Territorial Force and for County Associations*, 1910, obtainable for 6d. from any bookseller. Conditions of service, particulars as to pay, training, necessary uniform, with much other information, together with a copy of the Territorial and Reserve Forces Act, 1907, are included in this official publication.

Any candidate for a commission can obtain any particulars he may wish for from the secretary of his County Association, or from the adjutant of a local corps. A man who is thinking of applying for a commission will probably know some officer who will advise him, or tell him, how to set about it. In the event of his not knowing any Territorial officers, he should make an appointment to see the Secretary of the County Association, or the adjutant of the corps or regiment in which he wishes to apply for a commission. The adjutant will give any information, and explain the regulations and conditions of service, and arrange for an interview with the colonel or officer commanding. If the latter, after making inquiries about the candidate, considers him suitable, he will, when a vacancy occurs, recommend him for a commission, which, in the ordinary course, he will then receive.

No member of the Territorial Force can be compelled to serve, unless he volunteers to do so, outside the United Kingdom of Great Britain and Ireland. He must attend the minimum number of drills per annum laid down, which, in the Royal Engineers, is forty-five before the end of the first year of service, and fifteen in subsequent years, and he must also go into camp with his unit once a year for not less than eight days, and not more than fifteen days. If, however, some real and *bonâ-fide* reason arises why he cannot attend camp, the officer commanding can, in his discretion, grant leave of absence, and this is never in practice unreasonably withheld. During camp training all ranks receive Army rates of pay and allowances. A second lieutenant Royal Engineers draws 15s. 1d., increased to 17s. 1d. when he has passed for promotion to lieutenant; a lieutenant, 18s. 4d.; and a captain, 1*l.* 5s. 8½d. a day; but to be eligible to draw pay and allowances the minimum number of drills for each year must have been completed before going to camp. A drill consists of one hour's instruction, and any number of drills up to three may be performed in one day.

Before promotion to the rank of captain, the officer must attend a course of one month's duration at the School of Military Engineering at Chatham. This course may, however, if necessary, be spread over two years, a fortnight being taken at a time. Travelling expenses to and from Chatham are paid, and the officer receives the rate of pay and allowances, at Army rates, of his rank whilst attending the school of instruction. Further, if he passes a satisfactory examination at the termination of the course, an outfit allowance of 20*l.* (in addition to pay, &c.) is granted, which goes a long way to meet the expenses incurred in buying uniform immediataly upon receiving his commission.

In the event of great national emergency, and after the Army Reserve has been called to the colours, the King may issue a proclamation embodying the whole or part of the Territorial Army. In this event those called upon would be obliged to respond or be treated as deserters. The proclamation would not take effect if both Houses of Parliament presented a petition praying that the force should not be called up.

Arrangements are made whereby an officer who has temporarily to change his place of residence can be attached to a local corps for the performance of the necessary drills, or in the event of the change being permanent, can, when a vacancy occurs, exchange into another corps, provided the various commanding officers concerned approve the transfer. In the event of an officer having to go abroad, and wishing not to relinquish his commission, he may be seconded for four years from the termination of his first year's absence, if recommended by his commanding officer. If residing in a British Colony, or in Egypt, the officer may, on being recommended, be attached to a regular or local corps, for not more than two years in succession, for the purpose of carrying out any portion of his annual training. All officers of the Territorial Force are

interested in and enjoy the work. Many are very keen and efficient, and devote much time to their military duties and education. The attendance required by the regulations is not enough to make a good or useful officer. The great majority do far more than the minimum laid down. These men find they can do it and choose to do it, and it is therefore difficult to believe that, with few exceptions, others cannot do likewise. Instead of a shortage of officers, there ought to be a list of candidates waiting for commissions in the Territorial Force, and particularly in the engineer branch. All ranks of the Territorial Army are, under the Act of 1907 constituting the force, exempt from jury service.

THE UNIPOLAR DYNAMO AND MERCURY CONTACTS.

The advance of the steam-turbine has drawn attention to the unipolar dynamo. The direct-current dynamo in itself is acknowledged to be a very perfect machine. But direct-current dynamos require very careful and somewhat expensive design if they are to be run at steam-turbine speeds, and hence the recent endeavours to construct a high-speed dynamo which may directly be coupled with a steam-turbine, and which will yield direct currents without necessitating any commutating devices. Those endeavours have, indeed, not ceased since Faraday, in 1831, made a disc of copper spin between the poles of a horse-shoe magnet. The magnetic flux through the disc, parallel to its axis, set up an electromotive force between the central portion of the disc and its circumference, and when one brush was made to bear against the axis and another against the circumference, a current was obtained. Faraday himself improved his machine, and many scientists followed in his footsteps. They all, however, confined themselves to laboratory apparatus, until George Forbes, in 1884, devised real unipolar dynamos.

As the electromotive forces which such machines will generate are in essence low, high speeds are necessary, and with the speed, the mechanical difficulties to be overcome, increase. Difficulties are caused notably by the axial thrust, to which the discs or drums become exposed when the magnetic field does not remain rigorously symmetrical, and by the sliding contacts between the brushes or other devices and the rotating parts. The new contribution to these problems which we wish to notice in this article concerns a unipolar dynamo of the Laval turbine type fitted with mercury sliding contacts. The research was conducted by Boris Ugrimoff, of Moscow, now lecturer on electrotechnics at the Moscow Technical High School, when working under Professor E. Arnold at the Technical High School of Karlsruhe for the purpose of taking his degree, and his doctor dissertation was published by Julius Springer last year.

This dissertation is interesting in two respects. Dr. Ugrimoff first gives an able review of the many, often ingenious, unipolar dynamos which have been proposed and constructed, and then proceeds to his own researches. A few of these suggestions dealt with have assumed practical shape, and it may be news to some of our readers that the General Electric Company of Schenectady has, since 1905, been building the unipolar generators of Jakob Noegerath, yielding up to 2000 kilowatts. The Noegerath drum is of the cage type, the circumference being set with rods or bars of copper which are joined to slip-rings at both their ends; the brushes rest on the slip-rings. With circumferential speeds of 125 metres per second the wear of the metal brushes and rings is heavy. This has been brought out in the discussions of the American Institute of Electrical Engineers. The losses due to friction first increase, and finally decrease again when the speed is raised; the apparent contact resistance diminishes when the current density is raised, as E. Arnold, himself the originator of a unipolar dynamo, demonstrated long ago. The Noegerath dynamos can bear temporary heavy overloads and short circuits as well as had been expected. But there seem to be eddy current and hysteresis losses, which C. P. Steinmetz, Elihu Thomson, Wait, and others have attempted to overcome by other designs. Wait went back to a disc armature, which he provided with spiral grooves. Esnault-Pelterie attempted to rotate the brushes as well as the rotor. Seidener proposed, in 1904, to fix two discs of the Laval turbine type on the shaft of a turbine in such a way as to balance the axial thrust by the opposing fields—an old idea, of course, which had occurred to George Forbes previously. But the turbine-wheel dynamo was a novelty, though Beringer had a peculiar idea, which reminds one of the steam-turbine in a different manner. He meant to keep a liquid conductor in rapid spiral circulation within a magnetic field by the aid of turbine steam.

The liquid conductor, mercury, and the Laval disc are the essential features of Ugrimoff's researches. He uses the mercury as a sliding contact, however. This is not original, of course, as Ugrimoff was aware. But when he first attempted to let a steel disc cut at high speed through a ring trough filled with mercury, which the centrifugal force was to hold in the trough, the mercury was jerked out and evaporated. He therefore made a steel disc having an annular furrow on the one side of its rim, as if the rim had been bent over all round the rim on the one side. Mercury was poured into this furrow after the disc had been set spinning, so that it filled the annular trough, and knives were dipped into this trough. The first knives were mere blades; but they oscillated, and the hatchet shape was adopted for the knife. The disc had a diameter of 520 mm. (20.4 in.), and in later experiments of 620 mm. and 700 mm. (24.4 in. and 27.6 in.), and with speeds of 3050 revolutions per minute the spirting and evaporation of the mercury, and the mercury waste, again became very troublesome. Furrows of different depth and width were tried, and oil was poured over the mercury; but the oil formed a mercury emulsion, which was saponified and burnt at higher speeds. Then water-cooling was resorted to, the drops of water being introduced first just in the rear of the knife, and then an inch or so in front of it. A very good cooling was obtained; for the temperature of the emulsion which collected in the casing of the disc, and which was passed through a filter in order to regain the mercury, did not exceed 29 deg. Cent. at a speed of 4630 revolutions per minute.

The shapes of the trough and of the knife are matters of importance, as the detailed account of the many experiments shows. The approved blade is a piece of steel like a hatchet, bounded by three arcs and fastened to a holder. The front edge is sharpened to a wedge, and the lower edge was first sharpened in the same way; it was found, however, that it was better to make the body of the blade fairly thick, and to provide it with a shoulder near the lower rim, so that only the thinner portion of the knife, itself of uniform thickness again, would really dip into the mercury when at rest. During the movement the mercury would creep up the knife, up to the shoulder and above it, and a corresponding furrow would be left in the mercury, bounded by thin walls of mercury which the air currents would atomise. This arrangement best overcame the troubles, when the mercury trough had a depth of 25 mm. (wheel diameter 700 mm.), and the knife dipped into the mercury to a depth of 2 mm., leaving 1 mm. or 1.5 mm. lateral clearance between the knife surfaces and the walls of the trough, which had a width of 5 mm. This clearance should be small; the knife thickness was 3.75 mm. in its body (thinner knives caused more loss of mercury), and only 1 mm. or less in the lower portion below the shoulder. With these dimensions the mercury wave set up by the knife did not rise to a height exceeding 20 mm. At speeds of 5000 revolutions per minute the air temperature within the casing did not exceed 35 deg. Cent. (95 deg. Fahr.), while the temperature in the filter would rise a few degrees higher.

One section of the dissertation deals with the hydrodynamics of the cooled mercury contacts. During these experiments currents of 70 amperes and less were passed through the knife-contact, and on special tests the intensity of these currents was raised to 400 amperes for half an hour. It is rather surprising that the mercury temperature in the filter and the air temperature in the casing did not rise above 32 deg. Cent. during part of these experiments, and not above 43 deg. and 37 deg. Cent. (109.4 deg. and 99 deg. Fahr.) as extremes, nor the (estimated) contact resistance to more than 0.03 ohm; the casing, which was built up of cardboard and cotton, may have favoured a good natural ventilation.

We need not describe in great detail the dynamo which Ugrimoff constructed at Moscow after these researches, because it hardly represents the solution of the problem. The machine was designed to give about 80 kw. at 40 volts and 8000 revolutions per minute; owing to various reasons these aims were not quite realised, though the designer did not spare expense nor preliminary tests of various kinds. It must be said, however, that it is difficult to ascertain the dimensions and chief data in spite of the many tables and curves of his dissertation. The disc is of steel containing 0.52 per cent. of carbon, 2.88 per cent. of nickel, and 2.82 per cent. of chromium, supplied by Messrs. Krupp, and dynamically balanced by the Maschinenbauanstalt Humboldt; magnetic tests of the steel were made with a Koepsel apparatus, and mechanical tests conducted at Charlottenburg. Neither the diameter of the disc (presumably 700 mm.), nor its weight are stated; the belt pulley had a diameter of 80 mm., and the belt speed was sometimes 36 m. per second; the maximum dynamo speed reached 7225 revolutions per minute. Both sides of the rim are provided with annular mercury troughs, the two troughs being oddly enough not of quite the same dimensions, for the sake of further experiments; perhaps the hydrodynamic investigation mentioned was not begun when the disc was ordered. The disc turns about its horizontal axis between the two (unequal) halves of the stator, which practically consists of two blocks of steel bolted together. The blocks have the appearance of massive dished ends of a boiler.

The rotor turns in the plane of the junction of the two blocks, which does not appear recommendable, and between the two annular field-coils, which are on the rotor side protected by a brass cover and rubber packing against the moisture and mercury vapour which might penetrate into them from the trough. The mercury and water-pipes and knife-holders are next to these brass plates. Those parts of the stator which serve as poleshoes are solid to a depth of 7 mm., and then perforated radially in various planes in order to stop the reaction magnetic flux. Although the author had much to say on the difficulties of the axial thrust, he first attempted to dispense with an automatic balancing device, after having balanced the rotor at 7225 revolutions, and he hoped to adjust the position of the axis while at rest. This answered for one month, when one of the coils failed, while the coils were coupled in parallel. No serious damage appears to have been done. But the author adopted a thrust-bearing with bushes split into an upper and a lower half, coupled in such a way that the two bushes would tend to move in opposite directions. The core of this bearing, which is on one side only of the rotor, is water-cooled. Some bismuth coils were also wound on the shaft to effect a balance; the resistance of bismuth varies with the intensity of the magnetic field in which it is placed. These means and the provisions for lubricating and cooling the two bearings (not counting the one thrust-bearing) appear to have given satisfaction. In the dynamo the temperature rose to 51 deg. Cent., and in the thrust-bearing to 55 deg. Cent. at the maximum speed of 7225 revolutions per minute.

Direct efficiency tests were not made, but the various losses were estimated at different speeds, and a maximum efficiency of 81 per cent. was deduced at full output—75 kw. the armature reaction is described as negligible. The author claims that he has constructed a unipolar generator which would feed metallic filament lamps, which may directly be coupled with a steam-turbine, and which is more simple and less expensive than a direct-current dynamo. The sliding mercury contact and the cooling device continued to answer when the mercury was being cut at a linear speed of 270 metres per second. He admits, however, that four knives were needed at full load, and that a knife did not hold out longer than 10 or 15 hours at the outside. He adds that the knives are quite cheap, and can be replaced while the machine is in motion, which is a bold statement. He contemplates building a double machine with two discs. That would obviously offer advantages.

ABRASIVES FOR DIFFERENT CLASSES OF WORK.

There is little doubt that the wonderful accuracy of many modern machines of precision, as we know them, would at any rate have been exceedingly difficult of attainment, if not practically impossible, but for the various processes of grinding now in vogue. The demand for high-class finish and minute limits of error have stimulated in a marked degree experimental research, in order to discover the best materials to use in grinding operations. The variety

of abrasives now employed makes a knowledge of the different purposes for which they are suitable necessary, and a careful study of their nature very important; for one kind, well suited to operations on certain materials, may be quite inapplicable to others. It is because of this varying adaptability that emery, which for a long time was almost the only abrasive known, proved very inefficient when the modern steel alloys came into use.

In a paper read early this year by Mr. George N. Jeppson before the Society of Automobile Engineers at New York City, some interesting particulars are given on this point, and serve to show that great care is often required in order to select the best abrasive for certain classes of work, not only as regards its cutting properties, but also the ease with which it lends itself to proper bonding. Not only has the size and hardness of the grains to be considered, but also their temper or toughness. Emery is a natural abrasive with a percentage of about 67 of aluminium oxide, about 15 per cent. ferric oxide, and 8 per cent. of magnetic iron. Like emery, corundum is also a natural abrasive, but its quantity appears to be limited, and it also lacks uniformity. Where good, however, it is efficient on soft and heat-treated steels. It has a percentage of about 91 of aluminium oxide. Among artificial abrasives that known as alundum may perhaps be placed at the head. It is a product of the electric furnace, is made from bauxite, a hydrate of alumina, and it contains a high percentage of crystalline aluminium oxide. It is by many engineers considered the most efficient abrasive on steel, and its quality is well under control. It contains 91.25 per cent. of aluminium oxide, 2.5 per cent. of ferric oxide, 1.75 per cent. of silica, 4.35 per cent. of titanium oxide, 0.25 per cent. of calcium oxide, and 1.25 per cent. of magnetic iron. There is, however, a special alundum made, which may be considered the most efficient known material for grinding all kinds of specially hard and tough steel. It contains a very high percentage of aluminium oxide, this being as much as 99.17 per cent. The other constituents are ferric oxide, 0.65 per cent.; magnetic iron, 0.15 per cent.; and silica, 0.16 per cent. Materials such as hardened tool-steels require an abrasive which is hard enough to penetrate the surface ground, and tough enough to remove the chips without breaking off or dulling too quickly, and such qualifications appear to be possessed in a marked degree by alundum.

Following this material comes carbide of silicon, or what is commonly known as carborundum, the great chemical differences between the two abrasives being that, whereas in alundum the percentage of aluminium oxide is very high, in carborundum it is very low, silicon forming the greatest constituent of this material. The actual chemical constituents of the carborundum are: silicon, 67.5 per cent.; combined carbon, 28.57 per cent; aluminium oxide, 0.85 per cent.; ferric oxide, 2.06 per cent.; silica, 1.08 per cent.; titanium oxide, 0.13 per cent.; and free carbon, 0.44 per cent. It is, as is well known, made in the electric furnace from coke and sand, and is the hardest abrasive in use. It is found particularly suitable on cast iron, chilled iron, and brass. A finished surface may generally be obtained by its use, but in cases where a high finish is required it may be employed for the roughing operation, and the finish added by an aluminous wheel. Carborundum wheels have, however, the drawback in some cases that the diamonds used for truing them wear rapidly, and Mr. Jeppson gives an instance in which an alundum wheel and a carborundum wheel had 25 cuts of $\frac{1}{1000}$ in. taken off each of them with the same diamond, and after careful weighing, the ratio of wear on the diamond was alundum 1 to carborundum $4\frac{1}{2}$.

Coming to the subject of bond, which is a very important one, many things have to be considered. Not only is the function of the bond to hold the particles of the wheel together, and to give a proper factor of safety at its specified speed, but it must be possible to vary its tensile strength to suit the work it has to do. If the bond is such that it retains the cutting particles so long that they become dulled, the wheel will not have a high efficiency, whereas if the bond be not strong enough to hold the cutting particles, they may be pulled out before the proper amount of work has been done. For different classes of work also the bond will depend on the speed, the area of the wheel on the work, the vibration of the wheel spindle, or of the work, &c. The different kinds of bonding processes generally used are the vitrified, the silicate, the elastic and rubber processes, and each of these has its proper field. The vitrified bond is made of fused clay, can be made in a greater range of hardness than any other, and is not affected by heat or cold. It gives more clearance between the particles than any other, because it does not completely fill the voids between the grains, and is suitable for all kinds of grinding except where the wheel is not thick enough to withstand side pressure, as it lacks elasticity. As regards moisture, the silicate bond is not so stable as the one to which we have just referred; it allows less clearance between the grains, and has a range of hardness below that of the vitrified bond in the harder grades. It also lacks elasticity, and is not suitable for very thin wheels. It is composed of clay fluxed by silicates of soda at low temperatures. The third bond that we have mentioned completely fills the voids between the grains, being composed of shellac and other gums. It has, however, a limited range of grades, but has a high tensile strength and elasticity, and can be used where very thin wheels are required. The rubber or vulcanite bond is similar in nature to the one just mentioned, and its uses also are somewhat limited.

The conclusions arrived at appear to be that the abrasives emery, corundum and alundum, in which crystalline aluminium oxide is the cutting constituent, are superior to carbide of silicon on metals of high tensile strength, such as alloy steels, high and low carbon steel and wrought iron, while metals such as cast and chilled iron are best ground with carborundum wheels. The fact that carborundum, which is harder than emery, corundum, and alundum, should be less efficient on steel has puzzled many people, but the reason is that the property of toughness is lacking in carborundum, or, in other words, when grinding steel the property of which is high tensile strength, the cutting tooth is broken off close to the bond, and the grinding has then to be done on a surface largely composed of bond, and the wheel glazes quickly. Carefully prepared curves show a rapid rise in the horse-power required at the beginning of a test of both carborundum and emery wheels, the test-piece being 0.25 carbon steel 2 in. in diameter and 24 in. long; though with the emery-wheel the rise was not nearly so much as with the other abrasive. Although the emery loses its cutting teeth, it does not seem to do so to the same extent as the carborundum wheel, and not so much that the bond is reached. A curve plotted from tests with an alundum wheel is more consistent, as the properties of toughness and hardness in this material are so combined as to make it the most efficient abrasive for steel that we at present have. Our knowledge of abrasives is, however, by no means complete, and the importance of grinding having reached the position it now has, it is very likely that we shall see considerable advances made in the near future.

NOTES.

The End of the Scandinavian Labour Conflicts.

The Norwegian labour conflict, quite contrary to general expectation, may now be looked upon as ended, inasmuch as the two mediators, M. Halvorsen, one of the Presidents of the Norwegian Parliament, and Pastor A. Eriksen, have succeeded in bringing about an agreement between the two sides, or rather their representatives. The agreement has to be accepted finally by masters and men, which it is expected will be done. On the news being announced from the chair in the Storthing, the members showed their appreciation of the result by rising. King Haakon sent the two mediators a letter of thanks for the satisfactory result of their labours. The lock-out commenced on July 8, with 15,000 men, and on July 15 it was extended, and then comprised 32,000 men, who consequently have been out of work for more than six weeks. So far the men's organisations have paid out 1,330,000 kr. (73,888*l.*), and the wages lost represent an aggregate of about three times that amount; the loss to the men is thus at least 4,500,000 kr. (250,000*l.*). The negotiations have been carried on with much secrecy, nor has anything so far been made public about the nature of the agreement, which affects workers in mines, electric stations and the Christiania nail factories. One of the points—minimum wages in the mining industry—is understood to be referred to arbitration. Negotiations are still pending in the cellulose, wood-pulp, and paper industries, where the tariffs expired on August 20. In Sweden the lock-out has dwindled down to some 6000 men, and the masters appear to be acting independently of their associations, carrying on work with organised as well as unorganised workers. In Denmark the cause of the tramwaymen has been completely lost, the old employees have been beaten, and situations and the right to pensions, &c., have been lost by all, with the exception of, perhaps, some 10 per cent., whom the company has consented to take back on reduced terms. It is difficult to point to a more telling example of what harm foolish and irresponsible leaders may bring upon misled employees.

Insurance Against Strikes.

The question of insurance against strikes, or losses caused by strikes, has for some time been attracting considerable attention in various countries, and the occurrences of the past few weeks are likely further to increase the interest in such insurance. The underwriters at Lloyds have done a very considerable business during the past ten days: but no general system of strike insurance has been organised. The subject is being prepared and investigated by committees and experts in different countries, but Finland was first in the field to begin this branch of insurance in a rational manner. The Finnish employers have formed a company to carry on this form of insurance, with the object of protecting its members against losses caused by total or partial cessation of labour, whether the cause be strike or lock-out. The insurance can be effected in two ways, (*a*) for a sum fixed by the amount of the ordinary working expenses, and 6 per cent. interest per annum upon the value of stocks of raw material, of half-finished, and, in some cases, of finished goods, or (*b*) 6 per cent. of the calculated annual value of production. Ordinary working expenses comprise the expenses necessary for the working of the concern, salaries to the directors, office clerks, technical staff, and other permanently engaged workers, besides the keep of horses, rent of premises, &c., further premiums for fire and other kinds of insurance, and, finally, rates and taxes. The compensation is calculated in accordance with the actual expenditure entailed during the period work is stopped. When stoppages of work extend over three days, members affected by the stoppages are entitled to compensation, provided that their attitude in the dispute has been sanctioned. The compensation is as follows:—When the insurance is effected according to the first of the above-mentioned methods, compensation at total stoppage of work is paid upon the amount of the insured sum proportionate to the duration of the stoppage. At partial stoppage of work compensation is paid in proportion to the extent and nature of the stoppage. When the insurance is effected under the second method compensation is paid equal to such a portion of the insured amount as is represented by the reduced value of production. The company's members pay an annual premium which is a calculated percentage of the insured amount and a guarantee is paid on joining which amounts to twice the amount of the premium. Additional guarantee obligations may arise under certain conditions, and the members are responsible for the obligations of the company up to the extent of these amounts.

Electrolytic Copper Free from Arsenic.

An interesting research on the electrolytic deposition of copper from impure sulphates containing arsenic and antimony is published in a doctor dissertation, recently presented by a Chinese student, Ching Yu Weng, to the Columbia University of New York. Arsenic and antimony are common impurities in sulphate lyes; both these metals are precipitated with the copper, which they render brittle, and they favour tree-formation. In his investigation Weng makes use of ordinary impure sulphate, sometimes containing considerable amounts of the two metals, and of this solution and various "addition agents," substances added in order to prevent the deposition of the arsenic and antimony. Taking, in the first instance, the ordinary electrolyte, Weng noticed that the copper began to become distinctly contaminated with arsenic and antimony when the arsenic content of the bath reached 1.5 per cent. When, however, the As content was 6 per cent., the arsenic itself acted as preventive addition, provided that the bath was heated to 50 or 60 deg. Cent.; when the bath temperature was 40 deg. Cent. or less,

it required the presence of at least 8 per cent. of arsenic in the bath to secure the preventive effect. The peculiar phenomenon may be due to a hydrolysis of the arsenic sulphate in the bath, subject to certain temperature and concentration conditions; the hydrolysis would yield arsenious acid (which would not travel to the cathode, and would thus not be deposited) and sulphuric acid. As regards inorganic addition agents, common salt (NaCl) acted best, hydrochloric acid was also fair, sodium sulphate less so, aluminium sulphate improved the deposit slightly, aluminium chloride proved less advantageous. In this effect, again, temperature and arsenic concentration had their influences. Of organic compounds, gelatine and tannin had a decidedly beneficial effect, as they have in many electrolytic baths, though the gelatine at the beginning of the electrolysis seemed to favour the formation of small fern-like growths. Peptones were distinctly injurious. By far the best results were obtained with the addition of both common salt and gelatine, about 0.01 or 0.02 per cent. of each of them. Some of the observations which we have noticed are not novel, of course, but the recognition of the peculiar behaviour of arsenic, to act as its own preventive at certain concentrations and temperatures, is probably new, though a good deal of what the chemists discover in refineries is not published. The research does not really explain some of the observations. Professor E. F. Kern, under whom Weng conducted his investigation, is inclined to ascribe the beneficial effect of the inorganic salts to their metallic ions and to their reducing action. But one does not see on these grounds why sodium chloride is so much more effective than the sulphate, and the action of the organic compounds remains obscure, in spite of the many varied researches on this subject. The colloidal nature of these compounds is certainly essential, but that recognition does not explain the phenomena.

Personal.—Messrs. Trollope and Sons and Colls and Sons, Limited, of London, have added an engineering department to their organisation for the design and construction of structures in reinforced concrete and steelwork. The offices of this department are at 5, Coleman-street, E.C.—The Hayes (Universal) Printing Machinery, Limited, Works-road, Letchworth, Herts, have taken over, as a going concern, the business hitherto carried on by Messrs. Hayes, Reynolds, and Co., at the Hall Works, Stratton-road, Shirley, Southampton. The Southampton works have been removed to Letchworth.

Contracts.—The Yorkshire Boiler Company, Limited, Leeds, have received an order from the Hull and Barnsley Railway Company for two of their Yorkshire boilers 17 ft. long by 6 ft. 6 in. in diameter, for a total guaranteed hourly evaporation of 10,000 lb. They are also at present completing an installation of two of their 24-ft. by 7-ft. 6-in. boilers for the Edinburgh Ropery and Sailcloth Company, Limited, Leith, the guaranteed hourly evaporation of the two being nearly 20,000 lb. The company are also fixing a Yorkshire boiler 18 ft. by 8 ft. for the Kendal Corporation Electricity Works. This boiler will give an evaporation of between 7000 lb. and 8000 lb. of water per hour.

Motor-'Buses in Paris.—In a recent communication to the proceedings of the Société des Ingenieurs Civils, M. Marriage states that when the horse 'buses in Paris are finally eliminated, the city will be served daily by 800 motor vehicles, with 240 more in reserve. The daily capacity will be 50 per cent. more than with the horse 'buses, which had sufficient seating capacity to transport 128 millions of passengers per annum. The largest garage is at Clichy, and can accommodate 128 vehicles, seventeen over pits. The daily consumption of petrol at each garage ranges from 4 to 8 tons. It is stored in tanks under the pressure of an inert gas and there are pipes to the points of supply. This arrangement enables the tanks on the vehicles to be filled very rapidly.

Iron and Steel Institute: Italian Meeting.—We are informed that his Majesty King Victor Emanuel has graciously consented to become the patron of the reception committee which has been formed by the Associazione fra gli Industriali Metallurgici Italiani in connection with the arrangements for the October meeting of the Iron and Steel Institute in Italy. His Excellency G. Giolitti is acting as the president of the committee, which includes the Marquis di San Giuliano, Secretary of State for Foreign Affairs; Professor Nitti, Secretary of State for Agriculture, Trade, and Commerce; Signor E. Sacchi, Secretary of State for Public Works; Sir Rennell Rodd, the British Ambassador at the Italian Court; and the mayors and members of the municipal councils and the members of Chambers of Commerce, universities, and technical associations in each city to be visited. The arrangements for the meeting, which promises to be one of exceptional interest, are being carried out under the superintendence of Mr. G. E. Falck, president of the above-mentioned Associazione, with the assistance of Mr. A. Casalbore, secretary, and Dr. L. Gaddi, technical secretary.

BOILER EXPLOSION AT NORTH LOPHAM.

A formal investigation under the Boiler Explosions Act, 1882, has been conducted by the Board of Trade, at the Corn Hall, Diss, with regard to the cause and circumstances of an explosion which occurred on December 23, at the Grange Farm, North Lopham, owned by Mr. G. W. Gale. The Commissioners were Mr. A. A. Hudson, K.C., barrister-at-law (presiding), and Mr. G. Fullerton Bell, consulting engineer. The inquiry was conducted on behalf of the Board of Trade by Mr. George C. Vaux.

Mr. Vaux, in opening the proceedings, stated that the parties to the investigation were Mr. William Womack, coachbuilder, and owner of the exploded boiler; Mr. George Wm. Gale, farmer, and Mr. Ambrose Stevens, traction-engine owner, North Lopham, all of whom were legally represented. The makers of the boiler, the explosion of which, Mr. Vaux said, formed the subject of that inquiry, had not been traced, but its construction was attributed to a firm called Woods and Co., of Stowmarket. This company was reconstructed in 1907, when all the papers and documents were destroyed, and none of the members of the old firm were now carrying on the business. The boiler, which was a small one of the vertical type, was believed to be at least 13 years old, one of the fittings bearing the date 1898. It included a glass-water gauge, a safety-valve capable of registering up to 70 lb. on the square inch, and a steam-pressure gauge of Schaffer's make, graded up to 120 lb. About 12 years ago the boiler was bought from Messrs. Woods and Co. by Mr. J. B. Marchant, a farmer, who used it for five or six years, up to about 1905, when he retired from business. It was then sold to Mr. Robert Baldwin, farmer and dealer, of Diss, and had been worked, or looked after, by his son, Mr. George Baldwin. In January, 1908, leakage appeared to have started, and the boiler, along with the engine, was sent to Messrs. E. Youngs and Co., Diss, for repairs. That firm tested the fire-box by hammering it, and found that it was getting thin and needed repairs. New tubes were fitted and other work done, including the renewal of four studs in the fire-box, after which the boiler was tested up to 120 lb. per square inch by hydraulic pressure. The firm appeared to have warned Mr. George Baldwin that the fire-box was getting thin, and he replied that it was proposed to use the boiler only at a low pressure, and principally for preparing food for cattle. In September, 1909, one of the tubes was expanded by Messrs. Youngs, and about that time Mr. George Baldwin went to Australia, where he was now living. After his departure his father, Mr. Robert Baldwin, attended to the boiler until his death, in June, 1910. His property was sold by auction in September, 1910, and the boiler, with an engine, was "knocked down" to Mr. Hayward, the landlord of the Cherry Tree Inn, Eye, for the sum of five guineas. Mr. Hayward subsequently sold both boiler and engine for 8*l.* 10s. to Mr. Ambrose Stevens, a traction-engine owner, who, in his turn, resold them to Mr. William Womack, coach-builder, for 10*l.* There was no warranty or stipulation as to the working pressure. The boiler was then conveyed by Mr. Gale to his farm at North Lopham, as Mr. Womack was not ready to use it and, therefore, lent it to Mr. Gale on the understanding that he should have it when wanted. It was cleaned out, connected with the engine, and was then used for grinding corn and cutting chaff. The spring-balance safety-valve was set to blow off at a pressure of 50 lb. on the square inch. It did not appear that any proper examination or test of the boiler had been made before it was set to work. Steam had been got up on four or five occasions, and again on the morning of December 23, when the boiler exploded, the explosion being of a very violent character. The fire-box ruptured, an opening being formed measuring 21 in. by 14 in., through which the contents of the boiler rushed, with the result that the boiler was lifted from its seat, and thrown over on to its side. A portion of the barn was blown down, and the roof displaced by a falling chimney. Mr. Gale, Mr. Stevens, and the latter's engine-driver—a man named Maiden—were all in the barn at the time. Maiden was somewhat scalded, but the others escaped injury. It was stated that Maiden had no business on the premises, but was merely an onlooker.

Mr. Vaux concluded his lengthy statement by saying that an engineer-surveyor from the Board of Trade, who had examined the boiler after the explosion, found it in a very wasted condition, the plates of the fire-box along the line of fracture being considerably reduced in places by corrosion, and no thicker than a knife-edge.

Mr. Vaux then called a number of witnesses.

Mr. John Marchant, of Southholt Park, Eye, retired farmer, said that he bought the boiler from Mr. Woods, of Stowmarket, twelve years ago, and for five years used it for chaff-cutting and grinding, but never worked it at more than 50 lb. pressure. Mr. Woods wrote him that it was equal to new, and would work easily at 50 lb. In October, 1905, witness sold the boiler to Mr. Robert Baldwin.

Mr. Thomas Stockings, foreman in the employ of Messrs. Woods and Co., Stowmarket, said he had been connected with the old firm for forty years. The papers of the old company were destroyed, but he could say that the boiler was not made by Messrs. Woods, and the present firm did not make or sell the type of boiler which had exploded.

Mr. William Baldwin, farmer, Palgrave, stated that the boiler was used on his late father's farm for preparing cattle food.

Mr. John Base, engineer, and manager of the engineering department of Messrs. E. Youngs and Co., Diss, deposed to the boiler being repaired by his firm in 1908, when they found the fire-box very thin, and the attention of Mr. George Baldwin was called to its weak condition. They advised him to have a new fire-box put in, but he did not consent, and they warned him that it would be unsafe to use it at a working pressure. The boiler was tested by hydraulic pressure to 100 lb., but witness did not consider that a test of hydraulic pressure was worth much without the hammer test.

Mr. Clement Gaze, auctioneer, Diss, deposed to selling the boiler, with an engine, at the sale by auction of the late Mr. Robert Baldwin's effects. The boiler and engine were then running, and more than fifty persons were present at the sale.

The Commissioner remarked that the engine was sold as in good working condition, and it looked as if the boiler had been thrown in.

Mr. Gaze replied that when the boiler was sold steam had been got up, and it was running, but he could not tell the pressure at which it was then working, though 60 lb. was mentioned.

Mr. Vaux said if a man saw a boiler working at a certain pressure at the time it was sold, he was entitled to think it would work at the same pressure for some months, at any rate. It was only fair to Mr. Stevens, who would be called, to try and get outside evidence as to the exact pressure at which the boiler was worked at the sale.

Mr. Edward Hayward, landlord of the Cherry Tree Inn, Eye, stated that he bought the boiler and engine at the sale, and afterwards sold them, with a chaff-cutter, to Mr. Stevens for 8*l.* 10s. He gave 6*l.* 17s. for the things.

Another witness, a man named John Howlett, said that when employed by the late John Baldwin, he was in the habit of working the engine and boiler. The safety-valve used to blow-off at 80 lb. The boiler was running up to within a week or so of the sale, and also on the day of the sale. He had worked it many times at 70 lb., and was quite satisfied. No one had told him what pressure to work at, and he went by his own ideas. He ran it the day of the sale, and it was watched by a large number of persons who entered the building where it was sold. Some people asked him if it was "all right," and he replied that he was not afraid to drive it any time. He had had a knowledge of boilers and engines since the year 1870, but he had not been apprenticed to the engineering trade.

Mr. George Gale, farmer, North Lopham, said he had seen the boiler at work on the late Mr. Baldwin's premises, and after it was removed to his farm he used it for grinding purposes. He had a knowledge of boilers, and, many years ago, attended to one which was examined periodically. When the boiler was brought to his premises he consulted, as a friend, Mr. Ambrose Stevens, an engine-driver and owner, of North Lopham, as to the boiler and its fitness for his work, &c., and Stevens offered to attend to it and fix it up for witness. The morning the boiler burst the safety-valve was set at 60 lb., but when he came to the barn, about half-past eleven, he screwed it back to 50 lb., merely because he thought they did not require all the steam. The explosion occurred at 12.15, and, shortly before, he had looked at the gauge and saw that it registered 47 lb. pressure.

Mr. Ambrose Stevens, to whom the last witness specially referred, was subjected to a long and searching examination as to his association with the boiler. He was, he said, about two yards from the boiler when it burst, but escaped unhurt. He was an owner and driver of traction engines, and had had to do with engines for forty-five years. In 1882 he owned an engine and thrashing machine himself. He did not insure his boilers, and unless they needed repair they were never examined. Personally he never examined a boiler, although he had had eight or nine, and he never knew any one else who had his boilers examined. Witness did not sell the boiler to Mr. Womack, but merely bought it for him, and the 30s. he made on the transaction he did not look upon as profit, but for taking the boiler down and putting it up again. With regard to his connection with the boiler, witness said he saw the boiler at Mr. Baldwin's sale, and as there were no cracks, and all seemed right, he was satisfied with it. It had previously been tested by hydraulic pressure up to 120 lb., and therefore he thought it was good enough. The pressure required for the work to be done on Mr. Gale's farm would be about 60 lb., and he believed that the boiler would be quite safe at 70 lb. or 80 lb., at which pressure he heard it had been working. He set the valve at 50 lb., or, perhaps, 55 lb., and when the boiler had been working a few days he never saw the gauge at more than 60 lb., and then the valve was blowing off. On the day of the explosion the valve was blowing at 30 lb. to 40 lb., and shortly before the boiler burst the gauge was showing something like 40 lb. He had not told Mr. Gale that the boiler was safe for 60 lb. pressure.

The President asked witness if he knew that Mr. Gale and Mr. Womack relied upon his judgment as an engineer. Witness, in reply, said he was not an engineer, but was known as a "handy man." He admitted that the parties named were relying on his experience with boilers and engines.

The President asked whether witness knew that the boiler had been repaired. Witness replied that he had been told that new tubes had been inserted, and that they practically "patched up the old wreck," or something of that sort, and "made as good a job as they could."

The President: After this explosion, did you not think that it was necessary to examine and test the boiler in some way?

Witness replied that he did not think of it.

The President: Are you prepared to drive an old wreck?

Witness: Not if I know it. The boiler had been repaired after they said it was a wreck.

The President: What induced you to set the boiler to work after that expression had been used to you?

Witness: I thought the boiler was sound.

Mr. Base here remarked that he did not remember making any such statement to Mr. Stevens as had been quoted before the explosion occurred.

Mr. Stevens replied that the conversation took place when he went to Diss after the auction to remove the boiler. He knew of no boilers in the district which were periodically subjected to examination and test.

Mr. Henry Voss, engineer-surveyor to the Board of Trade, handed in a report and sketches of the boiler, which he had, he said, examined after the explosion. There were the usual fittings, including a safety-valve loaded with a lever and Salter spring-balance capable of registering up to 70 lb. on the square inch. The explosion was of a very violent character. The fire-box ruptured, leaving an opening measuring about 21 in. horizontally by 14 in. vertically, through which the contents of the boiler rushed. The reaction caused the boiler to be lifted from its seat and to make a half revolution on its axis. The boiler, generally, was in a very wasted condition, and the fire-box was so badly deteriorated that there was no doubt that had it been examined by any competent authority the boiler would not have been allowed to work, and the explosion would have been averted. At the line of fracture the fire-box was not more than a knife-edge in thickness.

This concluded the examination of witnesses, and Mr. Vaux then addressed the Court and submitted a list of questions on which he asked for judgment.

The Court then adjourned to the following day, and, on resuming, the President inquired the price of a second-hand vertical boiler like the one with respect to which they were inquiring. Mr. Base replied between 30*l.* and 40*l.* if the boiler were in good condition; and Mr. Vaux mentioned the sum of 25*l.*

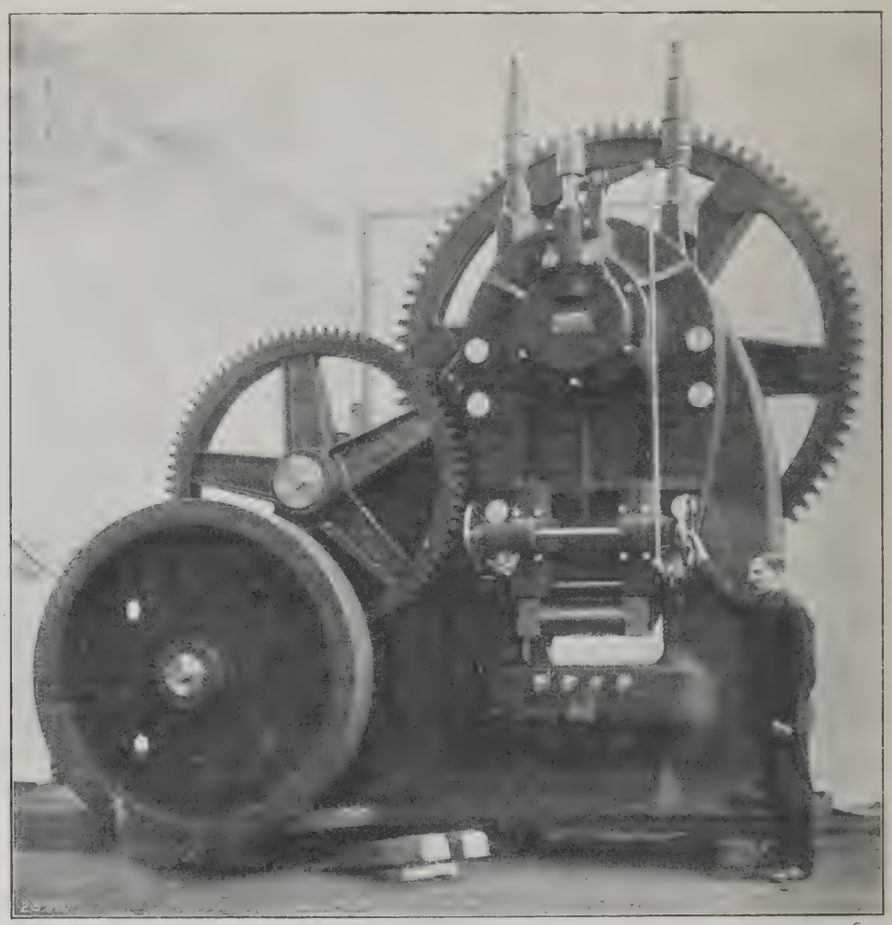
The President then very fully and carefully reviewed the evidence, and proceeded to deliver the judgment of the Court. He said the evidence disclosed a most extraordinary story, for it showed most utter recklessness and negligence in the management of boilers. On September 27 the boiler and engine were put up for sale, and steam was got up without any regard to the strength of the boiler. The place where it stood was crowded with people, and if an explosion had taken place, it must have caused the death of many persons, besides injuring others. It was now known that the boiler thus put up for sale was worthless for any pressure, and the inquiry had shown that it had been stated by an engineer to be a "wreck," which had been patched up. Dealing with the various sales and re-sales of the boiler, the President pointed out that the witness Womack had admitted that he knew nothing about boilers, and depended upon what he supposed was the knowledge possessed by the witness Stevens, who had had experience with traction engines, but had small knowledge of boilers, and whose evidence as to his own boilers was remarkable. He said he never had them examined except when they needed repair, and that he never knew anyone who did have his boilers examined. This, then, was the man on whom Mr. Womack relied. Other persons were concerned in the matter who knew nothing about boilers. Mr. Stevens had been told by Mr. Base that the boiler was a "wreck," and patched up, and one would have thought that, having had that opinion from an engineer, he would have been particularly cautious in dealing with the boiler, and the Court could not help thinking that he had some doubts as to its soundness, because when it was got to work he shifted the weight on the safety-valve about from time to time, according to what the boiler had to do. It was fairly clear that when the explosion occurred the valve had been set at 60 lb. by Mr. Stevens, which, after what Mr. Base had told him, was a most reckless proceeding. The explosion was due to severe corrosion, the plate of the fire-box being only $\frac{1}{32}$ in. thick, and on the line of fracture the thickness was that of a knife-edge merely. As to the question of responsibility, which the Board of Trade had submitted for the judgment of the Court, it was clear that Mr. Womack was not responsible for anything which had taken place; he had no knowledge of boilers, but was guided by the advice of Mr. Stevens, and he lent the boiler to Mr. Gale, who also was acting upon Mr. Stevens' advice. With regard to Mr. Stevens, the President said, he was fairly responsible for the explosion, for, although he had been told the boiler was a wreck, he never submitted it to any proper examination or test. With regard to Mr. Gale, the Court did not think he was altogether free from blame, for no one was free from blame who worked a second-hand boiler without having had a proper examination made of it. The Court, however, were not able to form any definite opinion as to the extent of his responsibility. He and Mr. Stevens were apparently close friends, and seemed to have worked boilers and engines together. Mr. Gale knew what Mr. Stevens had learned about the boiler, but his responsibility was not very great. He had had some knowledge of boilers, and he must or ought to have known that he should have had this boiler thoroughly examined.

In conclusion, the President said that the judgment of the Court was that Mr. Stevens was seriously to blame and must pay to the Board of Trade the sum of 20*l.* towards the costs and expenses of the inquiry. No order would be made against Mr. Gale.

The President further remarked that Messrs. Youngs and Co., who had called Mr. Baldwin's attention to the unsafe condition of the boiler when it was repaired, should have done something to prevent its being worked, to the great danger of a number of people who were attending the auction sale. Mr. Base, Messrs. Young's foreman, stated that this occurred three years ago, and the boiler had been in the hands of other engineers since that time.

ELECTRICALLY-DRIVEN BLOOM-SHEARS.

CONSTRUCTED BY THE STAHLWERK OEKING A.-G., DÜSSELDORF-LIERENFELD.



The Stahlwerk Oeking A.-G., of Düsseldorf-Lierenfeld, have recently made and supplied to several Continental firms electrically-driven bloom shears of the type we illustrate above. The machine shown in this view is capable of cutting blooms 5.9 in. by 7.5 in., while a similar machine is built for cutting blooms of 6.5 in. square, cold, or 10¼ in. square, hot. The shearing pressure of this machine is equal to 45 kilos. per sq. mm., and exerts a total force of 1300 tons.

The slide is balanced by carefully set springs, which ensure smooth working and absence of shock. The blades make twelve strokes per minute. The slide is also arranged with adjustable guides, so that wear can be taken. The machine is driven direct by 90-horse-power electric-motor through a raw-hide pinion. To protect the motor against shock a patent elastic "Bamag" clutch is provided. The machine has a height of 14.76 ft., and covers a floor space of 14.75 ft. by 16.14 ft., its total weight being about 55 tons.

Two flywheels are fitted, of a weight of 3 tons each, keyed to a shaft of forged nickel steel, the shaft running in gun-metal bearings with ring lubricators. The large spur-wheel has a diameter of 10.17 ft., and a weight of 6 tons, and the cam-shaft has a weight of about 2½ tons, with a diameter of 18 in. The body of the machine, the slide, the slide-cover, as well as all gear-wheels, are made of best open-hearth cast steel. All gear-wheels are cut from the solid; the shafts and pinions are made of best forged steel.

A holding-down attachment is placed in front of the blades, which can easily be raised or lowered to ensure a flat cut and to preserve the blades. The adjustable stop (length gauge) is solidly connected with the machine, and allows of very rapid working. The stop can easily be turned over out of the way if not required for the particular work in hand.

In front of the blades is a set of electrically-driven live rollers (not shown on this illustration) which automatically bring the blooms to the blades. These rollers are built into a self-contained carriage, the frame of which is made of cast steel. This carriage runs on rails, and can be removed if not wanted.

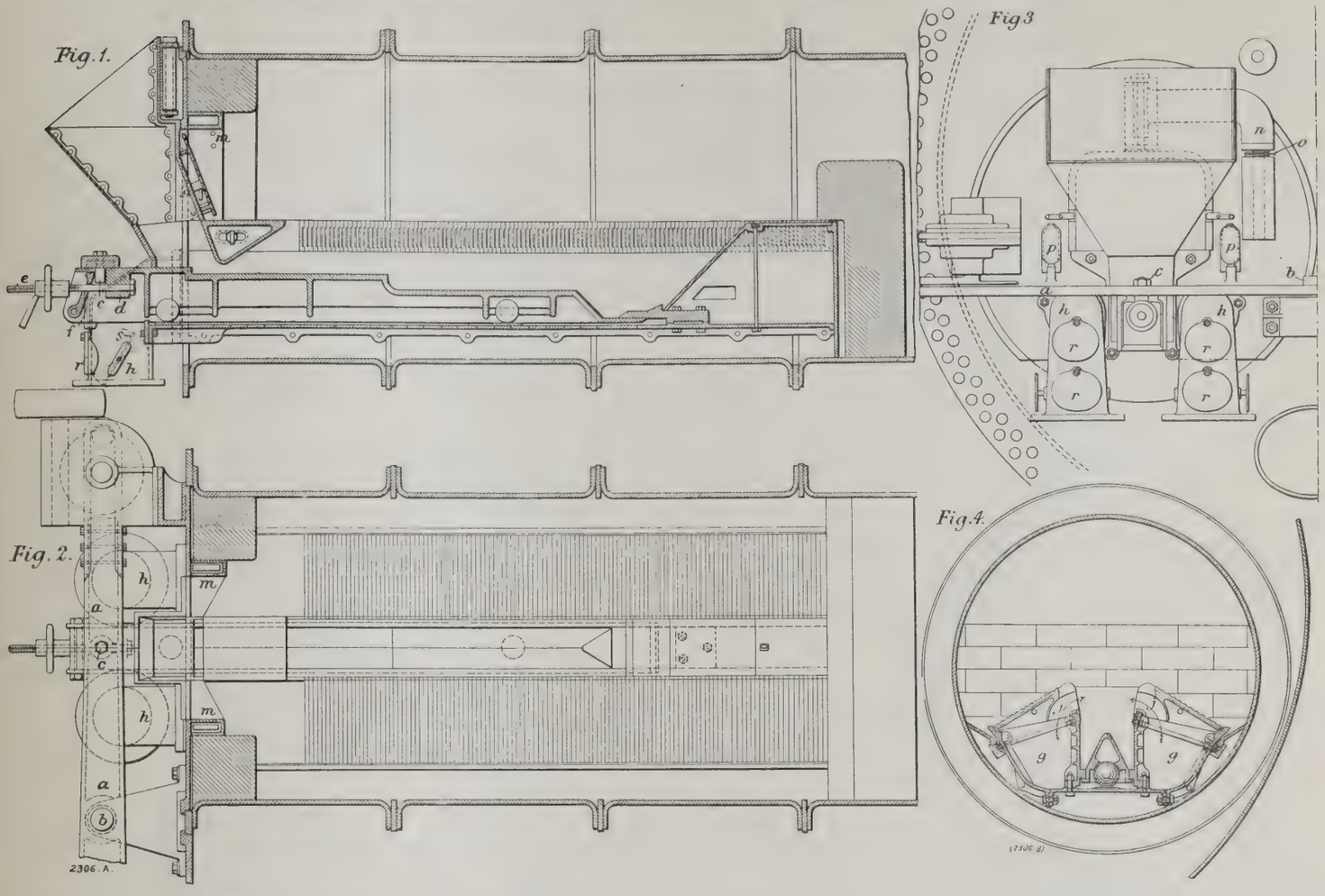
In order to prevent damage to the machine by overstrain, the driving-shaft is fitted with a safety "shear-pin" clutch, which gives way should blooms of dimensions exceeding the capacity of the tool be put through the blades The starting is effected by a clutch coupling, operated by a hand-lever, but the stopping is done automatically when the slide reaches the highest position. This construction avoids the risk of making a false cut, and is safe for the workman, besides allowing him the free use of both hands; if desired, however, the work may be continuous.

Artificial Reservoirs and the Drought.—The great value of large artificial water-basins, closed by dams, has been demonstrated during the recent long droughts. The valley of the Roer, or Rur—on the left bank of the Rhine, not to be confounded with the Westphalian Ruhr, on the right bank of the Rhine—had been suffering severely from droughts, as well as from floods. There are now nine big dams in this district, the largest of which, the Urft Dam, we described in our volume lxxxiv., on page 740. The drought of this summer was as severe over there as here; but there has been no serious trouble, thanks to the artificial reservoirs, and the experience of this summer will strengthen the supporters of further schemes for the creation of large basins.

The Institution of Mining Engineers.—The twenty-second annual general meeting of the members of the Institution of Mining Engineers will be held at Cardiff, on Wednesday, September 13, 1911, at 10.30 a.m., in the Lecture Theatre of the South Wales Institute of Engineers, Park-place. The members will be welcomed to the city by the Lord Mayor of Cardiff, and the President of the South Wales Institute of Engineers. The members and visitors will dine together on Wednesday, September 13, at the invitation of the South Wales Institute of Engineers; and on Thursday, September 14, at the invitation of the Monmouthshire and South Wales Coal-owners' Association. Arrangements have been made for visits to places of interest, to works and collieries, and for other excursions, on September 13, 14, and 15. The following papers will be read, or taken as read, at the meeting on September 13:—(1) "The Reduction, Control, and Collection of Coal-Dust in Mines," by Mr. Sam Mavor. (2) "A Rope-Driven Coal Cutter," by Mr. William Maurice. The following papers, which have already appeared in the Transactions, will be open for discussion:—(*a*) "A Flame-Test for the Estimation of Oxygen and Black-Damp in Naked-Light Mines," by Dr. J. S. Haldane, F.R.S. (*b*) "An Experiment on the Effect of Reversing a Main Air-Current," by Mr. James Bain and Dr. J. S. Haldane, F.R.S. (*c*) "Notes on Contrivances Designed to Prevent Overwinding, with some Instances of their Failure," by Mr. W. H. Pickering and Mr. Granville Poole, H.M. Inspectors of Mines. (*d*) "The Otto-Hilgenstock Direct-Recovery Process and its Application," by Mr. Ernest Bury.

THE "CLIMAX" UNDERFEED STOKER.

CONSTRUCTED BY MESSRS. B. R. ROWLAND AND CO., LIMITED, ENGINEERS, REDDISH.



A STOKER of the underfeed type has recently been introduced by Messrs. B. R. Rowland and Co., Limited, of Reddish. The design is such that it can be applied to existing boilers with the minimum of fitting and without the necessity of drilling holes in the boiler-plates. Moving parts are reduced to the smallest number, and provision is made for the reduction of friction and the ready access to the grate for cleaning and repairs, &c.

Reference to the illustrations annexed, which show the stoker arranged for firing a Lancashire boiler, will make the construction clear. Fig. 1 is a longitudinal section through one grate, Fig. 2 a plan of one flue, whilst Figs. 3 and 4 are respectively an end elevation and a section through the grate.

The drive is effected through a worm gear mounted in a dust-proof casing carried on the front plate of the stoker, power being transmitted by a belt pulley. A clutch is arranged on this pulley, so that the stoker can be thrown out of gear as desired.

The worm-wheel drives a disc-crank, the pin of which engages in the slotted end of the rocking-lever *a* ; this lever oscillates round the fulcrum *b*, carried on the front plate of the stokers, as shown in Fig. 2. Two pins *c*, fixed in the lever, engage with lugs *d* on the feed-rams, and so give the necessary motion for forcing the coal to the grate.

An arrangement is provided whereby the amount of travel given to the ram may be varied. This is clearly shown in Figs. 1 and 2. A screwed spindle *e*, fixed in the driving lug of the ram, is provided with a sleeve-nut fitted with a hand-wheel and locking-nut, which nut engages with a hinge-piece *f*, carried on the ram. The driving-pin *c*, on the rocking lever, which gives motion to the ram, engages with the lug on the inward stroke, and with the hinge-piece on the outward stroke ; thus, by travelling the hand-wheel outwards, a lost motion is given, enabling the stroke of the ram to be adjusted from 4 in. to 0 in., according to requirements.

The rams are of simple design, as will be seen from the illustrations, and in order to reduce friction they work on cast-iron balls, which run on adjustable paths. The coal, which is fed into the hopper on the front of the stoker, is carried forward in the trough by the reciprocating action of the ram, and flows over on to the sloping bars of the grates, and it is claimed that a very even distribution of the fire is obtained. Two air-ducts *g*, shown in Fig. 4, are formed one on each side of the trough, into which air is led through the valve-boxes *h*, placed at the front of the boiler. The tops of the air-ducts are formed by the fire-grates, which are so arranged that part of the air passes between them through spaces *j* at the top of the trough, as indicated by arrows, these spaces forming a series of tuyeres. The remainder of the air, of course, passes through the grates, which are formed of thin bars closely set. A hollow casting *m*, shown in Figs. 1 and 2, is fixed inside the door ; this is in communication with the air-ducts, and a series of holes supply above the fire air, heated in its passage through the casting, thus tending to prevent the formation of smoke.

In order to facilitate the cleaning of the grate, the hopper is made to swing clear of the front on the hinged arm *n*, while to allow for the unequal expansion of the hopper and furnace front, this arm is mounted on a spring *o*, which prevents undue strains being set up. On each side of the grate, inspection and raking-doors *p* are fitted. Ashes finding their way through the grate into the air-ducts can be removed through the doors *r* provided in the air-valve boxes, and shown in Figs. 1 and 3 ; using the upper door, the ashes are raked forward, and the air-valve *s* being closed, they fall through the lower door. Coal-dust or ash, finding its way past the lower edge of the rams, falls through holes, formed in the bottom plates of the troughs, to the space beneath, which space, being open at the front, enables this dust to be swept out. Since, however, the vertical position of the ram can be readily adjusted by means of the plates upon which the balls carrying the ram run, and to which reference is made above, it is found that a very small amount of coal finds its way past the bottom of the ram.

This stoker, to which the makers have given the name "Climax," is manufactured under Mr. W. R. Wills's patents, and has much to commend it in the simplicity of its design. From independent inquiries we have made it would appear that the working of the stoker is very satisfactory, even when using a very small coal of low grade (about ½-in. mesh with 17 per cent. of ash) ; and the cost of repairs, owing to the simplicity of construction, is remarkably small.

ELECTRIC TRACTION IN SWITZERLAND.*

By E. HUBER-STOCKAR, of Zurich.

(*Continued from page* 190.)

Seethalbahn (No. 12 on Tables IV. and V.†).—As is seen from Tables IV. and V., this railway is of an exceptional character, as it appears really to be a normal-gauge street railway of considerable length, and traffic of both kinds.

The electrification at present completed is an actual one with regard to the steam operation, having reached an age of thirty-seven years. The very fact of so large a portion of the track being laid on public roads and the main street of a number of villages has, apart from the heavy grades of a section more recently added, brought about the abolition of steam in favour of electricity. Steam traction could not keep pace with the development of the districts traversed, and appeared to be incapable of securing to the railway that share of through traffic to which it can be considered entitled with regard to its terminating in a centre like Luzern at the one end, and at Wildegg, a station of the main line Brugg-Olten (Zürich-Bern) at the other end.

In fact, the Seethalbahn is a regular normal-gauge railway with a great length constructed on large public roads, which are used chiefly for agricultural traffic. It must therefore be considered in this paper, quite apart from the particular interest it presents, as a normal-gauge single-phase alternate-current electrification of considerable magnitude. The electric plant for the entire electrification is by B.B.C.

Power is obtained from the power-station at Beznau, of the Beznau-Löntschwerk, by transmission of, to begin with, 1000 to 2000 horse-power in the shape of three-phase current of 8000-volt tension and a periodicity of 50. In one sub-station at Beinwil, not far from the middle of the line, this three-phase current is converted by machinery

* Paper read before the Institution of Mechanical Engineers, at the Zurich Meeting, July 25.

† We complete Tables IV. and V. on pages 270 and 271, the first parts of each having been published with the first section of the paper on page 127 *ante*. The whole of Table VI., giving further details of the railways, is given on page 272 of this issue.

into single-phase current of 5000-volt tension and a periodicity of 25, fed directly into the overhead contact line without any intermediate transformer sub-stations.

The contact-line is 5.500 to 6.000 m. above the rails on sections private to the railway company and 7.000 m. on public roadways.

According to the programme of the electrification there will be run, in both directions together, twenty passenger trains of 67 tons (stopping at way-side stations) and 74 tons (faster), besides four freight trains of 162 tons total weight. On sections on public roads the speed of passenger trains will be 35, on private tracks 45, and on the maximum grade of 3.7 per cent. 24 to 31 km. per hour. The speed of freight trains will be 35 km. throughout, except on the maximum grade, where it will be 17 km. to 20 km. per hour. All trains are moved by one motor-car each. Multiple-unit control is, however, provided, and heavier trains thus made practicable.

As trains of more considerable weight are not expected, electric locomotives have not appeared desirable apart from a little electric shunting-engine at Hochdorf station. It is, however, evident that at any time a service of locomotives and heavier trains can be organised by the addition of electric locomotives without changing the nature of the operation of the railway.

With the data on hand the author is able to give the following description of the motor-cars and their equipments—eight passenger, two freight; the figures are approximate:—

Total weight of motor-cars	42 to 45 tons
Number of axles	4 (in two bogies)
Number of motors	4, single reduction, enclosed, usual spring suspension
System of motors	B.B.C., single-phase, with voltage control of speed (multiple unit plan)
Ratio of gearing	1 to 3.68 (passenger), 1 to 4.85 (freight motor-cars)
Periodicity of current ...	25
Voltage on contact-line ...	5500 to 5000
Voltage of motors	200
Number of transformers on board car	2
Power of one motor... ...	100 horse-power
Total power on board ...	400 horse-power
Electric lighting and heating (voltage 100)	Brakes, pressure-air

The electric service of the Seethalbahn may be considered representative of the local and suburban service of principal railways, which, while operating trains of any weight for long-distance traffic with powerful locomotives, organise their local and less heavy suburban traffic with motor-car trains or even single motor-cars of the type similar to that of the Seethalbahn. The voltage of 5000 on the contact-line would, according to present knowledge, not be adopted in the case of a railway of greater length, possibly prospective only, but a voltage of 10,000 to 15,000. In the case of the Seethalbahn, the adoption of 5500 to 5000 volts for the contact-line was economical, and convenient at the same time, for particular reasons. The power required by the trains, even near the extremities of the line, is too small to cause inadmissible losses in the contact-line. Therefore sectionising of line, transformer sub-stations, and intermediate high-tension distribution were not necessary. If, however, instead of three-phase current, single-phase current of proper periodicity had been obtainable from the works at Beznau, it is certain that this current would have been conducted to two or three transformer sub-stations on the railway line. These two or three transformer sub-stations would have been a most satisfactory proposition in many respects, cheaper in cost of plant and operation than the one station at Beinwil with converting machinery; but this was excluded by the nature of the current obtainable.

This observation will call attention to the desirability of the generation of electric alternating current specially for traction purposes and of the unification of periodicity. Differences in the voltage of different power-stations do not signify, as they can always be dealt with by means of transformers at an advantage, all things being considered. But radical differences of periodicity cannot be overcome except in an expensive way.

*Martigny-Orsières,** Figs. 29 to 33 (No. 13 on tables).

This railway is, as a whole, similar to the Seethalbahn as far as the general conditions are concerned. It is specially interesting for various reasons. The contact-line voltage has been settled at 8000 volts, a value not very likely to become the standard. The periodicity, however, has been fixed at 15, the standard accepted in Switzerland for future electrification. The Martigny-Orsières Railway, branching off at Martigny from the Federal Railways' main line Lausanne-Simplon-Italy, was requested by the authorities to adopt a current of a periodicity compatible with that of electric traction on lines probably coming in operative connection with it in the near future—namely, the Simplon Tunnel and the Lötschberg services, both having adopted a periodicity of 15. While small differences in periodicity do not

Fig. 29. PROFILE OF LINE, MARTIGNY-ORSIÈRES

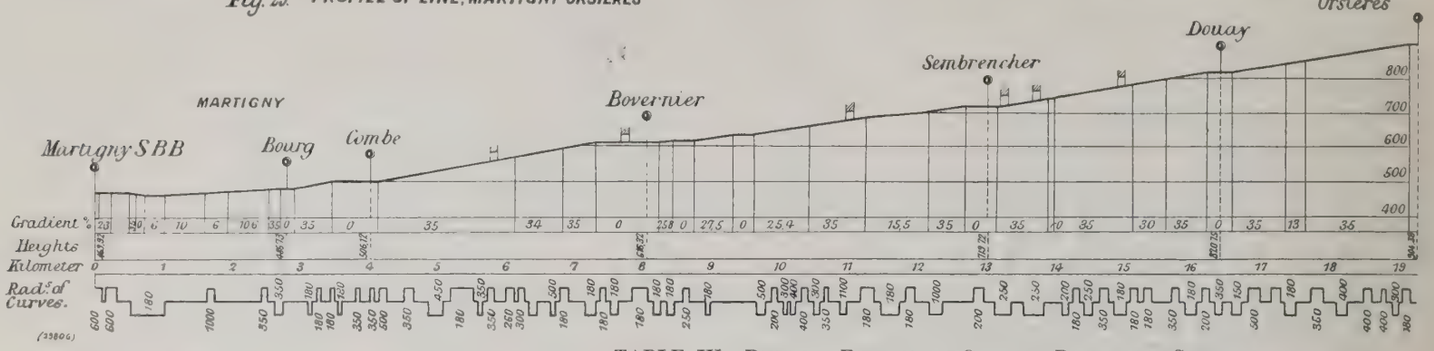


Fig. 30. 8000 VOLT SINGLE-PHASE ALTERNATING CURRENT. BOW CONTACT LINE IN TUNNEL MARTIGNY-ORSIÈRES.

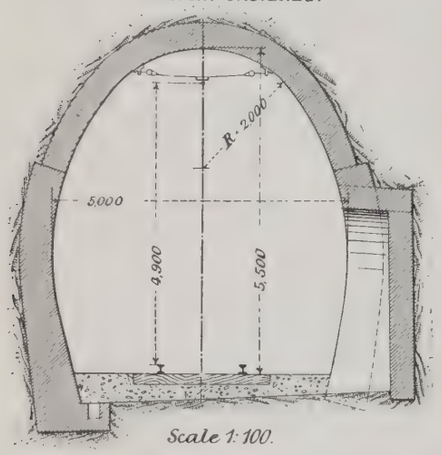


Fig. 31. 8000 VOLT SINGLE-PHASE. ALTERNATING CURRENT. BOW CONTACT LINE OVER OPEN TRACK. MARTIGNY-ORSIÈRES.

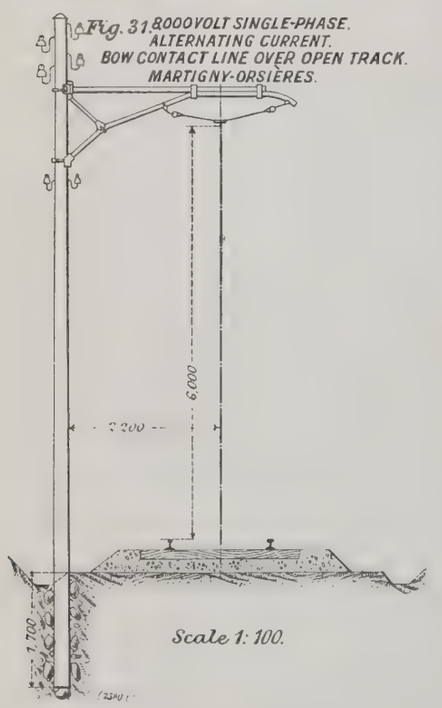


TABLE IV.—Principal Electrically-Operated Railways in Switzerland.

(*Continued from page 127 ante.*)

No. of Order	Railway, Name and Short Name (if any).	Year of Opening Railway.	Electric Operation since	Gauge of Track in Metres.	Length in Kilometres of Railway Operated Electrically.	Electric Current, Periodicity, Contact Voltage.	Type of Contact Line.	Motor Vehicles.	Observations.	Names of Original Contractors.
9	Seebach-Wettingen (Figs. 22 to 28)	1881	1907	1.435	19.4	Single-phase 15 cycles 15,000	Overhead, bow and rod	Locomotives	First high-voltage single-phase normal-gauge, regular railway electrification. Experimental.	M.F.O. Siemens-Schuckert
10	Locarno-Bignasco	1907	1907	1.000	27.1	Single-phase 20 cycles 5000	Overhead, rod	Motor-cars (trailing)	First narrow-gauge single-phase railway in Switzerland	M.F.O.
11	Bellinzona-Mesocco	1907	1907	1.000	31.3	Continuous 1500	Overhead, bow	Motor-cars (trailing)	First section of proposed railway over the Bernhardin Pass. First high-voltage continuous-current traction in Switzerland	Rieter and Co. Completed by M.F.O.
12	Seethalbahn.	1883 to 1906	1910	1.435	54.2 33.6 on public roads	Single-phase 25 cycles 5000	Overhead, bow	Motor-cars (trailing)	First permanent single-phase normal-gauge electrification in Switzerland	B.B.C.
13	Martigny-Orsières. (Figs. 29 to 32)	1910	1910	1.435	20	Single-phase 15 cycles 8000	Overhead, bow	Motor-cars (trailing)	New normal-gauge single-phase electric railway	B.B.C.
14	Berninabahn ..	1908 to 1911	1908 to 1911	1.000	67 9.8 on public roads	Continuous 1200	Overhead, bow	Motor-cars (trailing)	Prominent representative of a narrow-gauge through line across the high mountains	Alioth
15	Spiez-Frutigen. B.L.S. Lötschberg.*	1901	1910 to 1911	1.435	13.4	Single-phase 15 cycles 15,000	Overhead, bow	Locomotives motor-cars (trailing)	Section of the Lötschberg Tunnel route. Preparation of its electric traction; the most important one in Switzerland at present	M.F.O., S.S.W., A.E.G.
16	Rhätische Bahn. Upper Engadin section*	1903 to 1904	1912 presumed	1.000	12.6 49.1	Single-phase 15 cycles 10,000	10,000 Overhead, bow	Locomotives	First narrow-gauge single-phase electrification; powerful single-phase locomotives on narrow-gauge. In course of construction	M.F.O., S.S.W., B.B.C., A.E.G., Alioth
	Lower Engadin section. Rh. B.*	1912 presumed	1912 presumed							

* The illustrations and description of the Lötschberg, Engadine, and St. Gotthard form the concluding portion of the paper, and will be published in a future issue.

* See Huldschöner, Schweiz. Bauzeitung, vol. lvii., Nos. 16, 17

prevent transition of locomotive vehicles from lines of the one on to lines of the other periodicity, large discrepancies make it impracticable. Even a large difference in contact-line voltage, though, of course, very inconvenient, can always be dealt with in a suitable manner.

This railway is interesting from the fact that single-phase current has been adopted after careful investigation into the merits, in the particular case, of continuous current of 2400 volts, a voltage still in excess of that on the Bellinzona-Mesocco (No. 11 on the tables). Then it is extremely interesting on account of the system of motor-speed control as applied to traction.

It has, with reference to the Seebach-Wettingen experiment, been explained that, unlike multi-speed three-phase current motors, single-phase current motors permit of speed adjustment with perfect freedom. The means adopted for this control of speed possess the inherent feature of a step-like action, though by virtue of the number and pitch of the steps these are hardly felt as such within the range of speeds usual in driving.

In the case of the Martigny-Orsières Railway the speed-control is an absolutely gradual one, free from the feature of steps. It is performed according to the Deri system of alternate-current motors as perfected by B.B.C., the

90 H.P. SINGLE-PHASE ELECTRIC TRACTION MOTOR, DÉRI SYSTEM. MARTIGNY-ORSIÉRES. (BROWN, BOVERI.)

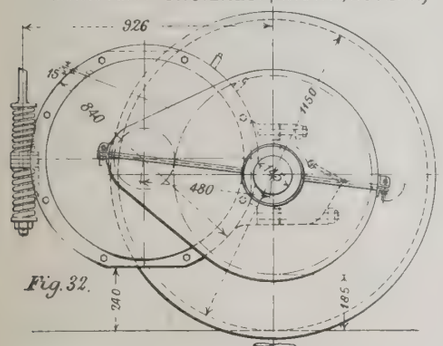


Fig. 32.

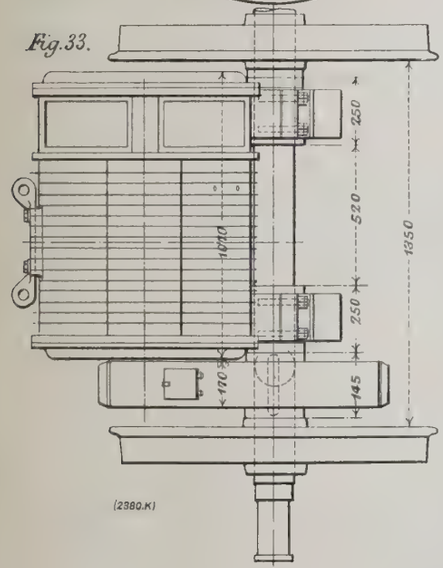


Fig. 33.

(2380.K)

makers of the entire electric equipment of this railway. The operation of speed-control is effected by shifting the brushes on the commutators of the motors, and is, therefore, as far as the means external to the motors are concerned, purely mechanical. Instead of controller switch-contacts and a certain number of connecting electric conductors, there is, with this novel type of locomotive-control, a system of spindles, shafts, bearings, bevel or other gears for transmitting motion by hand-power from either of the two drivers' cabins to the several motors on the car. In the case of four enclosed motors being lodged in two bogie-trucks below the car-body, this mechanical device of speed-control will require considerable skill on the part of the designer, and probably considerable attention in service. In the case of locomotives with high-level motors, open and accessible at any time, even when travelling, and rigidly mounted in the frame of the vehicle, the device cannot possibly give rise to mechanical troubles. Whether this system of speed-control, as a whole, will prove satisfactory, in general or under special conditions, experience has still to teach.

The contact line is overhead, of substantial character, of the catenary type on stations. The contact is made by pantagraph-bows. Electric current is obtained from the power-plant of the Société d'Electrochimie in Martigny-Croix. It is generated by a hydro-electric set specially for the purpose.

The data published on the motor-cars (non-electrical part by Schlieren), their equipment and the weight and speed of trains are as follows:—

	Passenger.	Freight.
Number of motor-cars ...	2	2
Capacity	40 seats, baggage compartment	10 tons load and 16 seats
Total weight of car complete, not loaded ...	40 tons (appr.)	34 tons (appr.)
Weight of electric equipment	17.8 tons	
Number of axles, all driving	4 (in two bogies)	
Distance between axles in bogie	2.500 m.	
Diameter of wheels	1.150 ,,	
Number of motors per car ...	4	
Power of one motor (one hour rating)	90 horse-power	
Normal speed of motor ...	450 revolutions per minute	
Periodicity of alternating current	15	
Voltage on contact line	8000	
Ratio of transformers on board car	8000 : 500	
Capacity of transformers on board car	2 × 130 kva.	
Motor voltage	500	
Mechanical arrangement ...	Single-reduction gear, spring suspension as usual	
Gear ratio	1 : 2.53	1 : 3.28
Contact	Pantagraph-bow	
Height of contact ...	5.500 m. to 6.000 m ; 7.000 m. on stations; 4.800 m. in tunnels	
Brakes	Westinghouse	

	Passenger.	Freight.
Weight of train	66 tons	126 tons
Speed of train, km. per hour	30 to 42	15 to 35
Number of trains (expected) in both directions	7	3

(*To be continued.*)

TABLE V.—CHARACTER AND COST OF CONSTRUCTION OF RAILWAY, ROLLING-STOCK, TRAFFIC, OPERATION.

(*Continued from page 127 ante.*)

Year, 1909.	9. Seebach-Wettingen.	10. Locarno-Bignasco.	11. Bellinzona-Mesocco.	12. Seethal.	13. Martigny-Orsières, 1910.	14. Bernina.	15. Lötschberg. Spiez-Frutigen.	15. Lötschberg. Frutigen-Brig (Building)	16. Engadin (Rhätische Bahn (Building).	17. For Comparison. St. Gotthard, 1908.	17. For Comparison. Federal* Railways 1909.
Gauge, in metres ..	1.435	1.000	1.000	1.435	1.435	1.000	1.435	1.435	1.000	1.435	1.435
Length, in kilometres	19.4	27.3	31.5	54.2	19.2	60.6	13.4	60.1	62.33	272.5 constructed 275.2 operated	2626 constructed 2672 operated
Length on public roads	..	..	..	33.6	—	—	—	—	—	—	—
Minimum radius of curves, metres ..	300	100	80	160	180	50	300	300	100	280	300‡
Level sections, per cent. of total	15 approximate	29.94	24.6	7.19	17.3 approximate	3.0 approximate	13.6	8.3	35.8	20.48	26.97
Grade maximum, ‰	12	33	60	37	35	70	15.5	27	25.0	25-27	26
Grade, average of sections not level, ‰	4 approximate	13.64	29.29	14.55	27.4	40 6	12.9	23.2 (excluding large tunnel)	14.35	11.76	8.49
Lowest point, metres a.s.l.	391	217	231	357	469	429	631	681	1290	205	277‡
Highest point, metres a.s.l. ..	459	441	769	651	904	2256	781	1244	1880	1153	1010‡
Aggregate up and down in metres of height	92	262	620	731	435 approximate	2391	150	1030 approximate	574	2563	16,565
Kilometres above 10 ‰	above 4 ‰ : 11.1	9.4	15.9	31.2	14.6 approximate	58.8	8.7	25 ‰ and more, 12.4 (north)	..	98.6	539.5
Kilometres above 30‰	Above 6 ‰ : 7.4	0.9	6.9	9.9	9.9 approximate	58 8 (27.0 with 70 ‰)	..	20 ‰ and more, 23.0 (south)	52 ‰ : 3.64	above 20‰ : 67.1	6.1
Weight of rail in kilogrammes per metre	36	20.7	25.0	..	36.0	..	36.0-42.0		23.5-27.0	36-51	25.0-51.0
Number of electric locomotives	3	..	..	14 (steam) 25.0-36.0 before electrification		..	(1911) 2		11	169	1178 steam 4 electric
Number of motor-cars	—	3	6	(1911) 10		15	(1911) 3		..	..	1 steam
Number of ordinary cars	—	18	26	108		59	33		..	2100	17,805
Average number of trains over whole line	16	13.74	12.86	18.88 (24 after electrification)		..	13 (1911 24 approximate)		20 (upper section 30)	43.63	33.47‡
Average number of axles per train	84 approximate in 1908†	5.28	7.35	10.51		(1910) —	11.07			32.01	30.72‡
Trains, kilometres run, 1 = 1000 ..		140	150	379		..	71			1,449	31,547‡
Passengers carried, 1 = 1000		188	229	786		274	211			1,051	76,285‡
Tons of all kinds of freight, 1 = 1000 ..		13	9	132		12	47			472	12,108‡
Thousand Francs per Kilometre:											
Cost of purchase of land		6	6	14			28			57	48‡
Cost of electric line equipment		10	11	—			..			..	(400 approximate Simplon Tunnel)
Cost of buildings and station machinery		9	15	16			19			78	45‡
Cost of construction complete		77	77	105			232			810	316‡
Cost of rolling-stock, locomotive and other		9	15	23			26			95	66‡
Cost of railway complete		94	99	136			273			1,083	426‡
Total amount .		2573	3125	7365			3664			296,823	1,023,089‡
Total operating expenses		96	103	644			150			5,124	99,757‡
Total receipts from traffic		136	143	732		8.48688	254			8,510	158,745‡

Experiments in 1906 and 1907. Regular operation from December 1, 1907, until May, 1909. — Statistical figures not on hand. — Figures not on hand. — Before electrification. — Before electrification. — In course of construction. — In course of construction.

* Excluding Brûnig, but including St. Gotthard. † 60 to 200 tons without locomotive. ‡ Excluding St. Gotthard and Brûnig.

LOCOMOTIVE MANUFACTURE IN GERMANY.—The large German locomotive manufacturers are complaining about the effect of the reduced orders from the Prussian railway department. In spite of a sufficiency of foreign orders prices have receded considerably, a fact which has affected the dividends for last year in more cases than one, although the shareholders still obtain very substantial dividends. The exceptional results of the record year of 1908 rather overshadow the present, but things are now distinctly better than during 1909 and 1910, at least as far as several works are concerned, but there seems to be a general complaint that the home demand fluctuates too much, which naturally causes a good deal of inconvenience. The home demand for locomotives steadily increased from the year 1905 to and through the year 1908, when a reaction set in, as will be seen from the appended table, which shows the aggregate sums expended by German railways on new locomotives during the years in question.

Year.	Marks.
1905	66,100,000
1906	76,900,000
1907	115,900,000
1908	124,200,000
1909	112,100,000

FOREIGN ENGINEERING PROJECTS.

We give below a series of foreign engineering projects. For several of these tenders are asked. Further data concerning same can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C.

Russia: The *Official Messenger* states that a Bill, designed to encourage Russian shipbuilding, has been drawn up by the Ministry of Trade and Commerce, and submitted to the Council of Ministers. The principal feature of the Bill consists in the granting of subsidies to Russian shipyards, the terms to be arranged in accordance with the ruling prices for ships in Russia and abroad.

Russia (Siberia): The *Official Messenger* also notifies that the municipal authorities of Verkhneudinsk have decided to arrange for surveying operations in connection with the building of a railway from Verkhneudinsk to Kiakhta (Siberia). The projected line will have a length of 133 miles, and will pass through the most populous and most fertile district of the Trans-Baikal province.

Spain: The *Gaceta de Madrid* contains a notice issued by the Ministry of Fomento, granting to the Sociedad Anónima Iberia Concesionaria de Bilbao a concession for the construction and working of an electric railway from Porriño to Vigo. The following information is from the report by the British Vice-Consul at San Sebastian on the trade of that district in 1910, which will shortly be issued:—There are several new railway projects in contemplation. One or two groups of British financiers have applied for concessions, but, so far as can be ascertained, nothing of a definite nature has been arrived at. From the point of view of the isolation of certain regions, the want of railway communication is very much felt; but, on the other hand, taking into consideration the generally sparse population, the question arises whether railways, unless subsidised by the State, would be paying concerns. There is reason for thinking that if many of the regions now without railway communication possessed these facilities, the country would be far more prosperous and the number of emigrants annually leaving the country would materially diminish.

Brazil: The British Vice-Consul at Rio Grande do Sul reports that tenders are invited by the municipal authorities of Pelotas for a forty years' concession for the supply of electric power and light and the establishment and working of electric tramways in the town. Tenders will be received by Senhor Luiz M. da S. Pennafiel, Secretario, Intendencia Municipal, Pelotas, up to 1 p.m. on November 14. A deposit of 5000 milreis (about 330*l.*) is required with each tender, to be increased by the successful tenderer to 25,000 milreis (about 1670*l.*). The *Diario Official* publishes decrees, as follows:—No. 8826, approving the plans and estimate of 12,026,000 milreis (about 801,000*l.*) for the construction of a section, 140 miles long, of the Goyaz Railway. No. 8827, approving the plans and estimate of 9,827,000 milreis (about 655,000*l.*) for the construction of another section, about 100 miles long, of the same railway. No. 8828, approving the plans for building a railway from Uberaba to S. Pedro de Alcantara, a distance of 140 miles, the cost of which is estimated at 12,077,000 milreis (about 805,000*l.*); this also forms part of the Goyaz Railway system.

Peru: El Peruano (Lima) notifies that the United States concessionaires for the completion of the railway from Huancayo to Ayacucho have arranged to proceed at once with surveying operations.

Chili: H.M. Consul-General at Valparaiso reports that, according to the press, tenders will shortly be invited by the Chilian Government for the construction of about 60 km. (37 miles) of railway between Valparaiso and Casa Blanca.

The Belgian Coal Market.—The *Moniteur Industriel* states that during the first six months of the current year Belgium exported 2,585,883 tons of coal, and imported 3,696,581, the excess of imports over exports being therefore 1,110,698 tons. Germany supplied to Belgium during the period under consideration 2,071,400 tons, as against 1,721,860 during the first six months of 1910. The figures for the same periods were, for England, 1,019,547, as against 734,823; for France, 419,257, as against 454,622; and for Holland, 187,241, as against 113,656. The total Belgian exports for the first six months of the current year were 2,585,883 tons of coal, 251,983 tons of coke, and 501,187 tons of briquettes. France purchased 2,201,194 tons of coal, 196,729 tons of coke, and 119,769 tons of briquettes.

Retirement of Mr. H. A. Ivatt.—It is officially announced that Mr. H. A. Ivatt, locomotive superintendent of the Great Northern Railway, is to retire at the end of next month. Mr. Ivatt has reached the age of sixty, and has, we regret to say, not been in the enjoyment of robust health for some time. He succeeded the late Mr. Patrick Stirling at Doncaster in 1895, and his tenure of office on the Great Northern system has resulted in many striking developments in the mechanical department. Mr. Ivatt is an old Crewe man, having served his time, after leaving Liverpool College, under Mr. Ramsbottom and Mr. F. W. Webb. After remaining on the London and North-Western for some years, in 1882 he went to Inchicore, on the Great Southern and Western Railway of Ireland, as assistant locomotive superintendent and works manager. In 1886 he was appointed locomotive superintendent to the company, remaining there until his transfer to Doncaster. He has been a Member of Council of the Institution of Mechanical Engineers for some years, and he is also a member of the Institution of Civil Engineers. He will be succeeded at Doncaster by Mr. H. M. Gresley, carriage and wagon superintendent, and formerly of the Lancashire and Yorkshire Railway Company.

ELECTRIC TRACTION IN SWITZERLAND.

(*See Page* 269.)

TABLE VI.—Electric System, Type of Contact, Locomotive Vehicles and Traction-Motor Equipment, Consumption of Power.

(Railways not described in paper.)

Notice.—All motor-cars are bogie-cars with four axles except No. 1 (two axles).

	1.	2.	5.	6.	7.	10.	11.	14.
	Orbe-Chavornay.	Stanstad-Engelberg. (Rack Locomotives Omitted).	Gruyère Chemins de Fer Electriques.	Montreux-Oberland Bernois.	Martigny-Châtelard.	Locarno-Bignasco.	Bellinzona-Mesocco.	Bernina.
Kind of current for propulsion	Continuous	Three-phase alternating	Continuous	Continuous	Continuous	Single-phase alternating	Continuous	Continuous
Voltage of contact line	500-550	750, periodicity 33	750	750 to 1000	750	5000	1500	1000
Number and kind of feeding (sub)-stations	1	Three (one power station and two static transformer sub-stations)	? (converting)	Five with converting machinery, one with accumulator battery	One (power-station)	One (power-station)	Two (one power, one converter station)	Four converter sub-stations
Kind of current generated in power-station	..	Three-phase alternating	Three-phase alternating	Three-phase alternating	Continuous	Single-phase alternating	Continuous 1500 volt 3-phase alternating	Three-phase alternating
Voltage on power line	..	5300, periodicity 33	8000, periodicity 50	8000, periodicity 50	Direct supply from power-station	5000, periodicity 20	10,000 volts 50 cycles	23,000 volts 50 cycles
Name and importance of power-station	..	Obermatt, about 9000 h.-p. for general power distribution for Luzern	Montbovon and Romont 6000-8000 h.p. for general power distribution	Montbovon and Romont, 6000-8000 h.-p. for general power distribution	Vernayaz, 5000 to 8000 h.-p. power distribution and electro-chemical	Pontebrolla, 3000 h.-p. power and light of Locarno and district	Cebbia (Mesocco), 1000 to 1500 h.-p. railway and other power	Brusio, 50,000 h.-p. for general power distribution (till Milan)
Type of contact, contact line, and supports	Sliding trolley, overhead wire, ordinary types	Two part bow, two overhead wires insulated from one another	Bow, overhead wire (in places 2) ordinary types	Bow, overhead wire (in places 2) ordinary types	Third rail, top contact, protected (bow, overhead on public road)	Rod, overhead wire lateral to railway (see No. 9)	Bow, overhead ordinary types	Bow, overhead ordinary types
Number of driving-axles of motor-cars	2	Two in the same bogie	..	Light cars 4 | Heavy cars 4	4	4	4	4
Total weight of car complete, without load, tons	11 approximate	14	..	22.5 | 27.5	34.5	29.7	31.3	28.1
Weight of electric equipment (tons)	2.5 approximate	..	Light cars 8.3	8.8	11 approximate	10.5 approximate	11.15	9.0 approximate
Car-length between buffers (metres)	..	..	13.700	13.700—14.000	17.810	16.000	16.100	13.910
Distance between front and rear axles (metres)	..	..	10.400	10.300	12.300	10.000	11.500	10.000
Distance between centres of bogies (metres)	No bogies	..	8.500	8.500	10.500	7.500	9.500	8.000
Distance between axles in bogie (metres)	No bogies	..	1.900	1.800—1.900	1.800	2.500	2.000	2.000
Diameter of wheels (metres)	..	..	0.850	0.850	0.958	0.860	0.850	0.850
System of traction motors (all single reduction)	Continuous-current series	Three-phase induction, rheostatic control	Continuous-current series, voltage of each motor 375	Continuous current series, voltage of each motor 750	Continuous current series, geared to adhesion and to rack driving-wheels	Single-phase series, voltage control motor voltage 200	Continuous series, voltage of one motor 750 (old), 1500 (new)	Continuous series, voltage of motors 1000
Gear ratio.. ..	?	?	1 to 4.87	1 to 4.3 to 1 to 4.6	1 to 10.05	1 to 5.15	1 to 4.3	1 to 4.5
One hour rating of one motor (h.-p.)	30-35	40	45	75	65	40	65	75
Total power on board (h.-p.)	60-70	80	180	300	270	160	260	300
Normal total pull on tread (kg.)	..	..	1400	2400	12,000 on rack rail	1400	2600	3400
Normal speed on average grade (km. per hour)	12-20	20 (rack section 6) not capable of increase by control	27-34	27-34	6.5 on 200‰ 16.0 on 70‰	25-30	25	18 on 70‰ grade
Maximum speed (km. per hour) ..	25	..	..	45	25	45	45	45 on level
System of brakes (automatic)	..	..	..	Vacuum and electric	Pressure air	Pressure air	Pressure air and electric	Hardy and electric
Number of seats..	..	..	..	Light cars 40 48 / Heavy cars 33-56	..	44	52	43
Weight of trains (tons)	.. ..	Usually 26	..	46-85	55	35-45	55	45 (toilet)
Observation .	..	On rack-rail section locomotives with two motors of 75 h.-p. each		Trains of double this weight, composed of two motor-cars and trailer (no multiple control) dining-car accommodation	Mixed adhesion and rack-gear, without clutch device operated in motion	Static transformer on board of car, ratio (variable) 500 : 200	Originally contracted by Rieter and Co.	Freight motor-cars 12.5 tons
Contractor for traction equipment	Geneva	B.B.C.	Alioth	Alioth, M.F.O.	Geneva, Alioth, M.F.O.	M.F.O.	M.F.O.	Alioth
Sub-contractor for cars	?	For rack locomotives, Winterthur	?	Neuhausen	For motor-trucks, Winterthur	Augsburg-Nürnberg	Ringhoffer of Prag	Neuhausen
Consumption of energy (watt-hrs. per ton-kilometre)	?	734, measured November 21, 1906; all year average probably lower		124, including losses of sub-stations	?	53, including all losses	51, measured at power sub-station, exclusive of losses in converting machinery	?

Our Coal Abroad.—The exports of coal from the United Kingdom in July were 4,874,558 tons, increased by the addition of coke and patent fuel to 5,091,436 tons. The exports for July, 1910, were 5,458,390 tons, increased by a corresponding addition to 5,647,223 tons; and for July, 1909, 5,658,499 tons, increased by a corresponding addition to 5,860,822 tons. A considerable decline occurred, accordingly, in last month's shipments. The quantity of coal shipped in July for the use of steamers engaged in foreign trade was 1,531,395 tons, as compared with 1,687,231 tons, and 1,749,948 tons. The aggregate exports of coal to July 31, this year, were 36,373,517 tons, as compared with 35,281,787 tons in the corresponding period of 1910, and 36,080,190 tons in the corresponding period of 1909. These totals were increased by the addition of coke and patent fuel to 37,899,821 tons, 36,671,699 tons, and 37,557,595 tons respectively, while in the same periods coal was shipped for the use of steamers engaged in foreign trade to the aggregate extent of 11,090,042 tons, 11,016,691 tons, and 11,288,941 tons respectively.

COMMUNICATIONS FROM THE GÖTTINGEN MODEL-TESTING INSTITUTE.*

(*Continued from page 207.*)

(5) EFFECT OF THE ASPECT RATIO ON THE WIND PRESSURE FOR CURVED PLATES. RESISTANCE OF WIRES.†

IN communication No. 2‡ the results obtained for the lift and drift of curved plates at different angles of inclination were given. The plates employed all had the ratio 1 : 4 of depth to breadth. The present communication deals with the influence of the aspect ratio on the wind pressures. The tests were made on eight plates of as nearly as possible the same curvature and of equal depth in the direction of the stream (Fig. 21). The breadth perpendicular to the direction of the wind varied between 20 cm. and 105 cm. The plates were made by bending sheet tin 2.6 mm. in thickness, the curvature being produced by hand to agree as nearly as possible with that of a template. The mean curvature of the individual plates varied finally from 1.48 cm. to 1.53 cm. From Figs. 4 and 5 in communication No. 2 it will be seen that a difference of 0.05 cm. in the curvature for a sagitta of 1.5 cm. makes very little difference. The two plates which come nearest in their curvature to those here considered are the plates with $f = 1.42$ cm. and $f = 1.65$ cm. For these the curvature difference is 0.23 cm., and the corresponding difference in lift is from 5 per cent. to 8 per cent. It may therefore be anticipated, for the plates now to be considered, with a maximum difference in the sagittæ of 0.05 cm.—that this, 0.05 cm. will not make a difference of more than 1 or 2 per cent. in the wind pressures. Neglecting these small differences, we may therefore say that all the eight plates had the same curvature. The exact measurements of the plates examined were :—

	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.
Depth a ..	20	20	20	20	20	20	20	20
Breadth b ..	20	30	40	55	70	80	90	105
Sagittæ ..	1.48	1.48	1.50	1.52	1.49	1.53	1.51	1.51

The curves were arcs of circles ; the edges fore and aft were rounded off to semi-circles. The plates were suspended in the manner previously indicated. The increase of pressure $\frac{\gamma v^2}{2g}$ due to the velocity was, in these experiments, as in all the preceding experiments on plates, 2.6 mm. of water, which, for $\lambda = 1.2$ kg. per cub. m., corresponds to a velocity of 6.5 m. per second. In Fig. 22 the coefficient ζ_L for the different plates is plotted against the angle of inclination α. As before, ζ_L is the coefficient in the formula :—

$$\text{Lift} = \zeta_L \text{ ; surface, } \frac{\gamma v^2}{g}.$$

Fig. 23 shows the variation in the corresponding resistance coefficient ζ_L with α.

The square plate, 20 cm. by 20 cm., shows the peculiarity that, in the region from 39 deg. to 43 deg., two completely different stable conditions of motion can obtain, one of which gives rise to forces 80 to 90 per cent. greater than the other. This peculiar behaviour has been already noted in the case of the flat, square plate (Communication No. 1). The line in the figure connecting the two branches of the curve, as before, does not correspond to any measured values. The corresponding resistance curve in Fig. 23 is only given up to 32 deg. At 43 deg. the resistance reaches its maximum value of 0.67. To the same angle belongs a second smaller value $\zeta_R = 0.39$.

To show more clearly the influence of the form of the plate, in Fig. 24 ζ_L is plotted, for a series of values of the inclination α, against the ratio of the sides of the plate $\frac{a}{b}$. In accordance with a suggestion made by Professor Prandtl, this furnishes a means of deducing the value of ζ_L for the plate of infinite breadth. If the breadth b of the plate is so great in comparison with the depth a that the two regions of reduced lift due to the end conditions no longer affect each other, the decrease in lift at the two ends can be allowed for by supposing the breadth b to be reduced by an amount proportional to the depth a. The lift coefficient ζ can then be expressed in terms of ζ_∞ in the following way :—

$$\zeta = \zeta_\infty \cdot \frac{b - \lambda a}{b}$$

$$= \zeta_\infty \cdot \left(1 - \lambda \frac{a}{b}\right).$$

In this formula λ is a factor whose magnitude can be determined from the results of the experiments. If ζ be plotted as a function of $\frac{a}{b}$, we get a straight line. The curves in Fig. 24 have accordingly been continued in straight lines up to $\frac{a}{b} = 0$, and the lift coefficients for the plates of infinite breadth thus determined. From the values so found the curve for the plate of infinite breadth has been indicated in Fig. 22.

In Fig. 25 the ratio of lift to drift is plotted against the angle α. To form an idea of the way in which the resultant is directed relative to the plate, the curve cot α has also been plotted. The values of $\frac{L}{R}$ would fall on this curve if the resultants were exactly perpendicular to the plate, as, for example, would be the case for the flat plate without friction.

Resistance of Wires.—Since the plates in the channel are suspended from wires, it is necessary to determine the resistance of the suspension separately, so that this may be deducted. For this purpose the resistance of ordinary bright metal wires or tubes (that is, of bodies of cylindrical form) was determined in a wind striking them at right angles. The experiments were made with 25 forms of 0.01 to 40 mm. in diameter. The result obtained was that the coefficient ψ for wires under 1 mm. in diameter was 0.53, and over 1 mm. in diameter about 0.48 for a velocity pressure, $\frac{\gamma v^2}{2g}$, of 5.5 mm. of water. More accurate measurements on this point will be made.

(*To be continued.*)

Fig. 21.

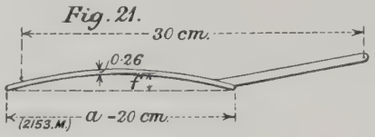


Fig. 22. "LIFT" IN TERMS OF ANGLE OF INCLINATION.

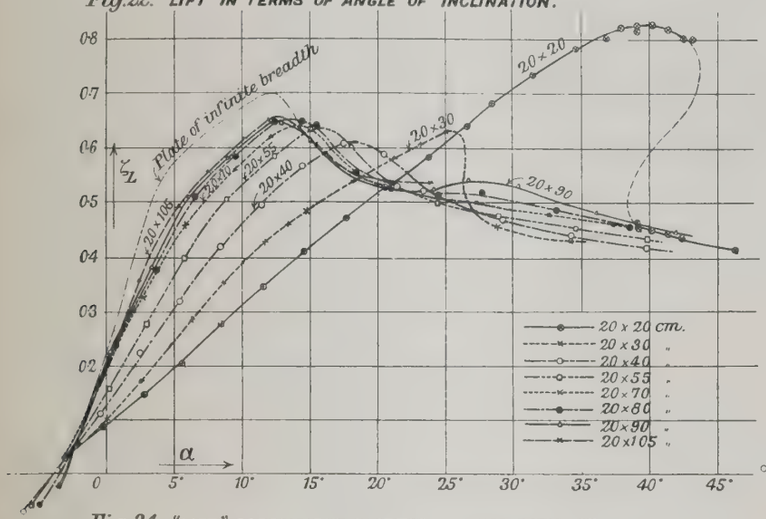


Fig. 23. RESISTANCE IN TERMS OF ANGLE OF INCLINATION.

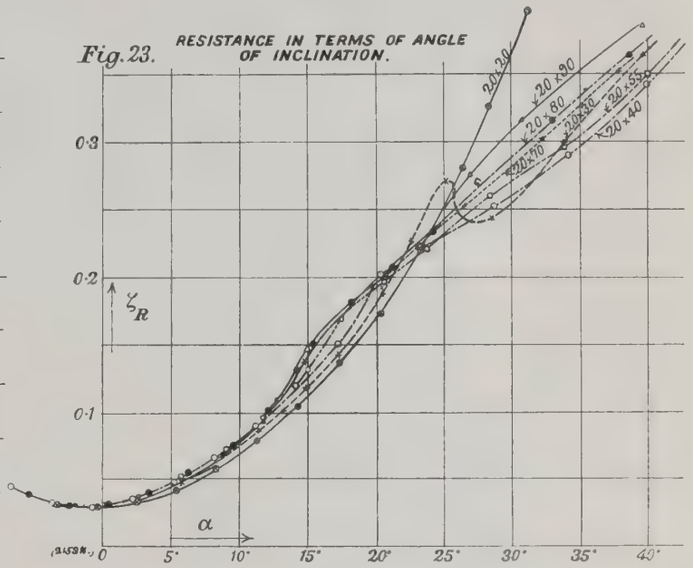


Fig. 24. "LIFT" COEFFICIENT PLOTTED AGAINST RATIO OF DEPTH TO BREADTH

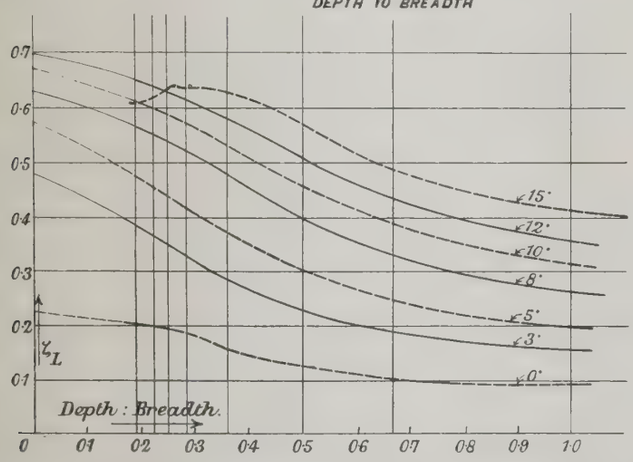
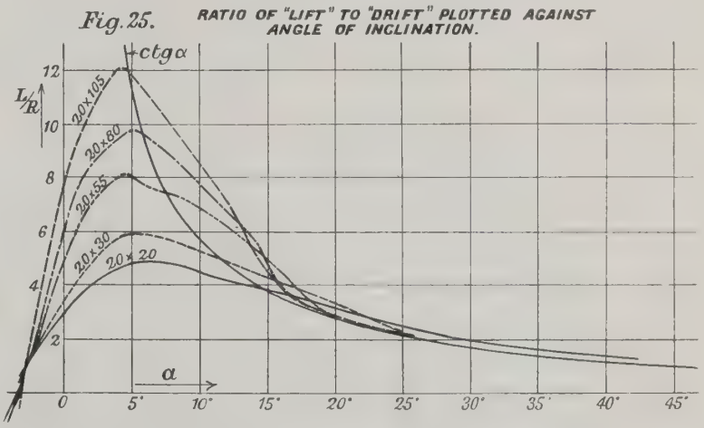


Fig. 25. RATIO OF "LIFT" TO "DRIFT" PLOTTED AGAINST ANGLE OF INCLINATION.



* Translated by permission from the *Zeitschrift für Flugtechnik* (Munich and Berlin : R. Oldenbourg).

† *Zeitschrift für Flugtechnik*, August 13, 1910.

‡ See ENGINEERING, vol. xci., page 804.

AMERICAN ENGINEERING SOCIETIES.—During the five years ending with June, 1911, inclusive, the American Institute of Electrical Engineers increased its membership by 3524 ; the American Society of Civil Engineers by 2407 ; the American Institute of Mining Engineers, by 314 ; and the American Society of Mechanical Engineers, by 970. The present membership is :—American Institute of Electrical Engineers, 7118 ; American Society of Civil Engineers, 5976 ; American Institute of Mining Engineers, 4200 ; and American Institute of Mechanical Engineers, 3899.

THE WESTINGHOUSE INTEREST.—Mr. E. M. Herr has been elected president of the Westinghouse Electric and Manufacturing Company. Mr. Herr, who is fifty-one years of age, has had considerable railway experience, and between 1895 and 1898 he became superintendent of motive power upon the Chicago and North-Western and the Northern Pacific Railroads successively. In 1899 he was appointed general manager of the Westinghouse Air-Brake Company, and he held that post until 1905, when he was elected first vice-president of the Westinghouse Electric and Manufacturing Company.

CATALOGUES.

Locomotives.—Circulars illustrating and giving particulars of goods and passenger locomotives they have recently built have reached us from the Hannover-che Maschinenbau A.-G., formerly Georg Egestorff, of Hannover-Linden, Germany. The particulars are printed in English, French, German, and Russian.

Switch-Gear for Mines.—We have to acknowledge receipt of a special publication issued by the British Westinghouse Electric and Manufacturing Company, Limited, of Trafford Park, Manchester, entitled "Electricity in Mines." This publication contains a reprint of the Report of the Departmental Committee on the Use of Electricity in Mines, and also illustrates and describes numerous examples of Westinghouse switch-gear and instruments specially designed for use in mines and collieries.

Electric Generating Sets.—Messrs. Fyfe, Wilson, and Co., 145, Bath-street, Glasgow, have issued a price-list of "Kelvin" electric generating sets, suitable for country-house lighting, &c. Prices and full particulars are given of standard sets capable of lighting 50 to 300 metallic filament lamps of 16 candle-power. These sets include a "Kelvin" vertical engine arranged to use petrol or paraffin as fuel, a shunt-wound dynamo, switchboard, storage battery, and various accessories. Particulars are also given of portable sets.

High-Speed Lathes.—Messrs. Thomas Ryder and Son, of Turner Bridge Iron Works, Bolton, have sent us a copy of their catalogue of Ryder high-speed lathes. The catalogue gives a general specification and full particulars of screw-cutting lathes in five sizes, ranging from 6½-in. to 16-in. centres. Each size is made with either an all-geared or cone-driven headstock. Particulars are also given of an all-geared hollow-spindle lathe with 11-in. centres, a 10-in. shafting lathe, and an 18-in. treble-geared break-lathe. Two lathes for machining the crank-shafts of motor-car engines are also fully dealt with.

Primary Cells and Batteries.—We have received from the India-Rubber, Gutta-Percha, and Telegraph Works Company, Limited, Silvertown, London, E., a copy of an illustrated price-list of galvanic batteries. The list deals with Leclanché, bichromate, Bunsen, Grove, Daniell, and other types of cells, in many different patterns and sizes. The Silvertown Bleeck-Love cell is also dealt with. This cell having the remarkably high electromotive force of 2.7 volts, with an internal resistance of only 0.15 ohm, is suitable for many purposes for which small accumulators are generally employed.

Pneumatic Tyres for Motor-Cars.—A catalogue of "Camel" tyres for motor-cars has reached us from Messrs. F. Reddaway and Co., Limited, of Pendleton, Lancashire. These tyres are made in four distinct patterns—steel-studded, three-ribbed, grooved and plain—and the catalogue states prices for various sizes in each pattern. Some useful notes on the care of tyres have also been included in order to assist motorists to obtain the maximum mileage from them. The notes are practical and concise, and cannot fail to increase the useful life of the tyres if the instructions given be followed out.

Petrol and Paraffin-Engines.—A price-list of small petrol and paraffin-engines has been issued by Messrs. Perkin and Co., Limited, Junction Engine Works, Whitehall-road, Leeds. The list gives particulars of slow-speed vertical engines, in six sizes, giving from 1½ to 10 horse-power on petrol; high-speed engines of the same type are listed for outputs ranging from 3 to 17 horse-power. Particulars are also included of small vertical and horizontal engines for gas and petrol, giving ½ to 2½ horse-power when using the latter fuel. Electric-lighting sets, pumps, and portable engines for farm-work and irrigation, are also dealt with in this list.

High-Speed Lathes.—From Messrs. Dean, Smith, and Grace (1908), Limited, of Keighley, we have received a nicely got-up catalogue of high-speed lathes, to the design and manufacture of which the firm devote their entire energies. The catalogue gives full particulars of screw-cutting lathes in seven sizes, ranging from 6½ in. to 28 in. centres, of which the three smallest sizes are made either with solid or hollow spindles. Particulars are also given of all-geared lathes with 6½ in., 8½ in., 10½ in., and 12 in. centres, the first two sizes having hollow spindles. The catalogue also deals with surfacing and boring lathes, railway-wheel turning lathes, capstan lathes, and various accessories, illustrating and giving brief general particulars of each.

Ball-Bearings for Machine-Tools.—A circular recently issued by the Hoffmann Manufacturing Company, Limited, of Chelmsford, Essex, deals with the application of their ball-bearings to machine-tools. The circular points out that the increased speeds of spindles, and other rotating parts, due to the introduction of high-speed steel, has rendered the lubrication of plain bearings more difficult, so that costly delays, due to the seizing of bearings, are becoming more common. The firm recommend the employment of their ball-bearings as a remedy for this, and also claim that a considerable saving in driving power is effected by their use. The accuracy and general efficiency of the machines are also stated to be increased by the use of ball-bearings. Several examples of tools, by different well-known makers, fitted with Hoffmann ball-bearings, are illustrated in the circular.

Stair-Treads.—We have received from the Safety-Tread Syndicate, Limited, 15, Barbican, E.C., a pamphlet relating to a new form of non-slipping stair-tread they have recently introduced. This tread is an improved form of Mason's well-known steel and lead treads, from which it differs only by having the groove between the lead strips filled in with carborundum cement. The carborundum is held in place by countersunk slotted holes cut through the steel base at the bottoms of the grooves. This form of tread has the advantage that the grains of carborundum worn away from their original position, become imbedded in the soft lead where they continue to be useful. It is also pointed out that the grooves existing in the earlier patterns of treads formed a receptacle for dust and dirt, so that the latest pattern, without the grooves, is more desirable from a hygienic point of view.

Damp Course.—A pamphlet recently issued by Mr. Alex. G. Lee, 14, John-street, Bedford-row, W.C., deals with his asphalted sheet-lead damp course, which consists of a single sheet of lead foil sandwiched between two layers of specially prepared fibrous asphalte sheeting. The material is stocked in rolls of a suitable width for all wall thicknesses up to 39 in. Some qualities are supplied with oiled paper bands inserted along the edges between the lead and asphalte sheets, so that the layers can easily be pulled apart to make watertight lap joints for covering large flat surfaces. The pamphlet points out that lead, owing to its imperishable nature, forms a suitable damp course, and illustrates, as an example of its durability, parts of the lead anchor of an ancient Greek ship. Although these were submerged for nearly two thousand years, the inscription is still legible.

Electrical Water-Level Signalling Apparatus.—Messrs. Siemens Brothers and Co., Limited, of Caxton House, Westminster, S.W., have sent us a catalogue giving particulars of apparatus specially designed for indicating the water-levels of reservoirs, wells, &c., at distant points. The apparatus consists of a transmitter operated by a float, and an indicator which can be situated at any distance from the transmitter. The indicator, which is, of course, in electrical connection with the transmitter, consists of a circular dial over which moves a pointer controlled by the transmitter. If desired a single transmitter can be used to operate two or more indicators. Several different patterns of indicators are listed (with and without warning bells) to indicate differences of level up to a total of 20 ft., in steps of 2 in. They can, however, be supplied to indicate by 1-in. or ½-in. steps. If required, recording apparatus can be combined with the indicator. The catalogue also gives full particulars of accessory apparatus such as iron pillar-boxes, telephones, bell-switches, cells, &c.

Steam Fittings, Heating and Ventilating Apparatus, &c.—We have received from the British Steam Specialities, Limited, of Leicester, a copy of their very useful catalogue of steam specialities, heating and ventilating apparatus, &c. The catalogue is bound in cloth, and contains some 300 pages, with very numerous illustrations and several useful tables. It is divided into four sections, the first of which deals with such articles as reducing-valves, steam and grease separators, steam-traps, feed-water heaters, pumps, and pump-governors. In the second section particulars are given of valves and cocks, pressure-gauges, water-gauges, safety-valves, thermometers, lubricators, fire-service fittings, radiator fittings, &c. Section three includes all classes of fittings and tools used in connection with piping installations; while the last section, which is devoted to heating and ventilating apparatus, gives full particulars of radiators, boilers, fans, ventilating gratings, &c. Prices are stated for all the articles listed.

Measuring-Gauges.—The Imperial Motor Industries, Limited, of 15, Castle-street East, Oxford-street, W., who are the sole agents for the Riebe-Kugellager und Werkzeug-Fabrik, G.m.b.H., Weissensee, Berlin, have sent us a copy of a leaflet relating to ball measuring-gauges. The leaflet states prices of male and ring gauges in sizes ranging from 5 mm. to 60 mm. The male gauges consist of specially manufactured and selected steel balls mounted on handles. Prices are also stated for special point gauges composed of a number of balls enclosed in steel tubes, the ends of which are partially closed over, so as to retain the balls in position, while allowing the end balls to project sufficiently to form the contact surfaces. They are listed in sizes varying in steps of 5 mm. from 55 mm. to 200 mm.; intermediate sizes can also be supplied. It is claimed that these gauges combine the qualities of cheapness and accuracy, and also that the spherical contact surfaces formed by the balls render the measurements independent of the position of the gauge. Wear is also stated to be very slight, since the balls are mounted so that they rotate slightly each time the gauge is used, and thus the wear is distributed over the whole surface of the balls.

Steam-Turbines.—We have received from the British Westinghouse Electric and Manufacturing Company, Limited, of Trafford Park, Manchester, a copy of their steam-turbine catalogue. The construction of these turbines, which are of the Rateau impulse type, is fully described and illustrated. The catalogue is divided into sections dealing with high-pressure, low-pressure, mixed-pressure, back-pressure, and reducing turbines. One of the high-pressure type was fully described in our issue of January 13 last, on page 40. The back-pressure and reducing turbines are intended to produce a supply of electrical energy or other power, and at the same time to provide a considerable quantity of steam at a few pounds above atmospheric pressure for heating purposes. The turbine is supplied with high-pressure steam, which, after doing work in the turbine, is exhausted into the heating mains at the required pressure. If all the steam utilised by the turbine for power production is not required for heating purposes, the surplus is used in the low-pressure part of the turbine and exhausted to a condenser. The catalogue includes the results of official tests of Westinghouse turbines, and also contains a list of installations, many of which are illustrated.

Wheels for Motor Vehicles.—We have received from Atlas Resilient Road-Wheels, Limited, 37, Cross-street, Manchester, a copy of the English edition of their illustrated catalogue of cast-steel wheels for commercial motor vehicles of all descriptions. Among those dealt with are light wheels for taximeter cabs, "Samsonian" resilient wheels for motor-omnibuses and "Herculean" wheels for heavy motor-wagons. The "Samsonian" wheels are of the detachable hub type. The rim and spokes are cast in one piece, with a central chamber of conical shape, into which a hardwood centre is fitted. The cast-steel hub is held in position by this hardwood centre, which gives the wheel a certain amount of resiliency. In the "Herculean" wheels the hub, spokes, and rim are in one casting. Wooden felloes are fitted into the rim, which is of channel section, and a steel tyre is shrunk on to the felloes. Besides rendering the wheel resilient, the wooden felloes serve to keep the tyre tight by compensating for the expansion which takes place in the tyre, due to the constant hammering on the road. The catalogue is also being printed in the French, German, Spanish, Italian, and Danish languages, for the convenience of foreign clients.

Steel Sections, Springs, Wire, &c.—From Messrs. Samuel Fox and Co., Limited, of Stocksbridge Works, near Sheffield, we have received a copy of a section-book they have issued recently. The book, which is a very creditable production, being well printed and bound in limp leather covers, gives particulars of the firm's works and productions, with numerous illustrations. Steel is made by the Bessemer, Siemens-Martin, and crucible processes, and is supplied in the form of ingots, slabs, blooms, billets, and rolled sections. The latter include rounds, flats, squares, hexagonal and octagonal bars, rails, chain sections, and many other special shapes. In addition to these tool-steel and spring-steel are supplied, the latter in a great variety of special sections of which particulars are given. The firm also manufacture railway-wheel tyres, axles, and springs of all kinds, as well as bright, cold-rolled steel strips for the manufacture of pens, saws, razor-blades, watch and clock springs, measuring tapes, &c. Wire-drawing forms another important branch of the company's business. They supply circular, flat, and special sections for all purposes, from winding guns to the manufacture of sewing-needles. They also manufacture umbrella frames and tubes, their "Paragon" frames having maintained a high reputation for many years.

Automatic Stokers.—From the British Niclausse Boiler Company, Limited, Caxton House, Westminster, S.W., we have received a small booklet illustrating and describing the Niclausse automatic stoker. In this stoker the grate is made up of a number of bearers, each composed of two flat steel plates, about 8 ft. long, bolted together at the ends, and provided with distance-pieces, so that a space, about 1 in. in width, is left between the plates. These bearers carry a number of cast-iron fire-bars with stepped faces about 6 in. wide, and having tangs which fit into the space between the steel plates. Each pair of bearer-plates, with its set of fire-bars, forms a complete element of the grate, which is made up of a suitable number of these elements placed side by side and slightly inclined. Each element rests at both ends on small rollers, and receives a longitudinal reciprocating motion from a rotating cam-shaft situated in front of the boiler. The cams on this shaft are arranged so that the motion of the elements proceeds from one side of the grate to the other, and at short intervals all of them are moved simultaneously. The fuel, which is fed from a hopper in front of the boiler, travels, by the movement of the bars, over three zones into which the grate is divided. The first of these is practically a dead-plate, where the fuel is coked by radiation before passing into the second zone, in which the greater part is consumed. The third zone is a dead-plate from which the ashes and clinkers fall into the pit after they have given up practically all their heat. Among the special advantages claimed for this stoker are:—That it can be used with any type of boiler; that it can be adjusted to suit various classes of fuels, giving perfect combustion without smoke or waste; and that the grate is entirely independent of the rest of the boiler, and, being provided with flanged wheels, can be removed in a few minutes to give easy access to the boiler or the grate.

The Copper Market.—In their mid-monthly report dated the 16th inst., Messrs. James Lewis and Son state that standard copper advanced from 56*l.* 2s. 6d. for cash on the 1st inst. to 56*l.* 16s. 3d. on the 14th, three months' prompt realising 57*l.* 11s. 3d. There was a reaction on the 15th to 56*l.* 7s. 6d. cash and on the 16th to 56*l.* on a renewal of labour troubles; the close was firmer at 56*l.* 5s. cash and 57*l.* three months. The exceptionally favourable American statistics advised on the 8th inst.—showing a decrease in the production of 5529 tons, and in the stocks of 8792 tons, there being, however, a decrease in the home consumption of 2086 tons, exports having increased 1527 tons—made but little impression on the market, being neutralised by the serious labour troubles and excessive heat interfering with consumption in this country and on the Continent, and also by the heavy fall in American securities. Refined copper had been in but moderate request, but the demand for sulphate for early delivery continued good and manufacturers were busy replenishing their depleted stocks. Over 1000 tons of Chili bars had been shipped from here to Italy for conversion into sulphate of copper. American shipments for the fortnight were advised as 11,356 tons. American and European stocks showed a decrease on August 1, of 5834 tons as compared with January 1, and of 36,625 tons as compared with August 1 last year. European consumption had increased this year so far by 28,333 tons and exports by 7190 tons—together 35,523 tons. American production had increased for the past seven months 979 tons, and consumption had decreased 22,013 tons, but exports had increased 38,763 tons.

FEED-WATER HEATING AND SUPERHEATING ON LOCOMOTIVES.—No. II.

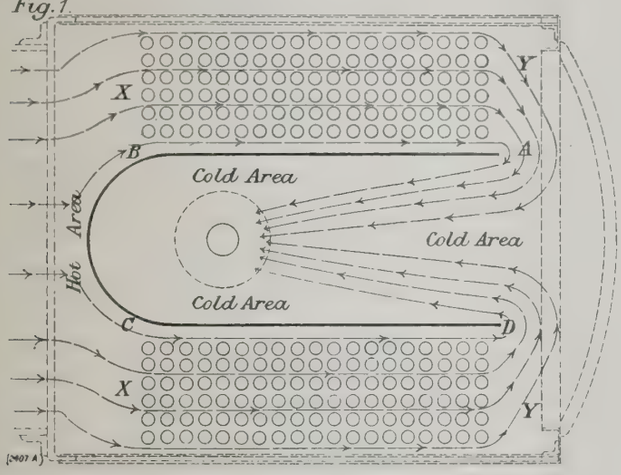
THE EFFICIENCY OF GENERATION OF SUPERHEATED STEAM.

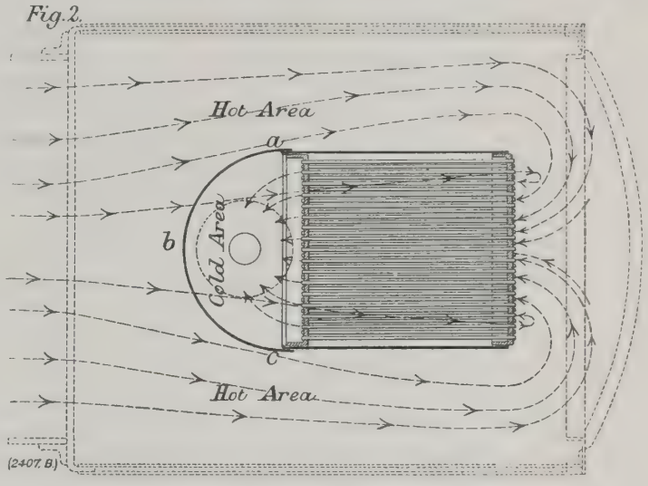
IN a previous article,* in which we dealt with several preliminary considerations relating to superheating, notice was drawn to the fact that the subject might fitly be divided into two parts, dealing respectively with steam generation and steam utilisation. Naturally, matters affecting steam generation claim first attention.

As previously stated, superheating may be conducted on two radically different principles. One of these systems involves making use of waste products only, and the apparatus employed constitutes an economiser in the proper sense of the word, putting to useful service heat which would otherwise go to waste. The introduction of a waste-gas superheater into the smoke-box need in no way affect the boiler itself. It neither diminishes the boiler water-heating surface, nor the evaporative capacity and efficiency of that heating surface. It is analogous to a heater placed in the flue of a stationary boiler, the boiler performance proper—*i.e.*, the steam production up to the point of saturation, or normal wetness—being thereby unaltered. The advantage of this type of heater lies in the fact that, without additional expenditure of fuel, the total heat in the steam generated is increased, and the over-all proportion of $\frac{\text{heat utilised}}{\text{heat in fuel}}$ is improved. This evidently leads to the expectation that any reasonable degree of superheat thus produced will show economy. So great has been the influence of this impression on design that, in many cases, it seems to have been thought sufficient merely to place in the smoke-box sets of curved pipes joining headers, passing steam through them, and deflecting the waste gases so as to pass over them.

Diagrammatically such a heater is shown in horizontal section in Fig. 1, herewith, which is typical only, representing no particular design. The superheater pipes are disposed on either side of the smoke-box, and steam passes in succession through groups of them. Sheet-iron diaphragms A B C D cause the gases to follow the paths shown by the arrows. A circle shows the position of the blast, above which is the chimney out of which all gases have to pass. The chimney is denoted by the dotted circle. This diagram is instructive in many ways. It shows, for instance, that it is, in the first place, possible, with such a heater, for the gases to retain to the last much of their heat (unless the pipes are of small size and very well arranged) and to escape to the atmosphere without imparting all that is possible to the heater. In some heaters of this type the gases are, in fact, allowed almost unobstructed passage through, instead of being induced to give up their heat by meeting with continual obstruction, as they would with staggered tubes, when the gas streams would be constantly in process of being broken up. In the second place, it is evident that if the waste gases have really done what is expected of them, and have given up a fair amount of their heat to the heater pipes, then the temperature at X will be much greater than at YY. Consequently, while the area outside A B C D is full of hot gases, the space inside is filled with gas at a much lower temperature. Disregarding the loss by radiation to the outside through the smoke-box plating, which may be, and sometimes is, hindered by lagging, it is clear that there is continually proceeding inside the smoke-box a wasteful flow of heat to the atmosphere across the diaphragms A B C D. This flow will be greatest between the part B C, where the temperature head is greatest; and though at the worst the loss may not be very large compared with others in a steam-engine, it is clear that here is a possibility for improvement in design. This leakage should be kept as small as possible, and the gases encouraged to give up their heat to useful surface only.

Again, there are practical difficulties with this type of heater in the way of taking advantage of the full length of the path of the waste gases. On the one hand, the spaces outside A B and C D must not be choked with tubes, and, on the other, the space inside the diaphragms cannot conveniently be put to use. The effectiveness of the heater is thus not satisfactory, because heat not taken out of the gases in order to satisfy the first condition, is by the second compulsorily wasted. Another reported disadvantage of this class of heater is that the smoke-box fills with cinders, which are prevented from getting far away from the smoke-box tube-plate.





Design may effect a reasonable compromise between these various factors, but a change in type presents a much more rational way out of these difficulties. By splitting up the gases and passing them through tubes of suitable proportion the transfer of heat to useful service may be encouraged to the greatest extent possible, assuming, of course, the selection of tubes of the best dimensions. Gases passing through an infinitely long tube of finite diameter would, after a definite distance, have been reduced to a temperature practically equal to that of the fluid surrounding the tube. Assuming conditions not to vary, they would, if passed through an infinitely short tube (a ring), suffer no diminution of temperature, while if the tube were only comparatively short, but of large diameter, it is quite conceivable that the molecules in the core of the gas stream might not have time to come in contact with the tube side before being swept out at the end. There are, therefore, certain proportions to be satisfied in order to arrive at good results. This has always been recognised in the case of boiler tubes, whose efficiency is fairly given, according to Professor Perry, by the equation $e = \frac{l}{h\,m + l}$, where e is the efficiency, l the length of the tube, m the hydraulic mean depth $\left(\frac{\text{area}}{\text{perimeter}}\right)$, and h a constant dependent on the circulation. If the circulation and flue length remain constant, this expression indicates that the flue efficiency will be greater when the value of $\frac{\text{area}}{\text{perimeter}}$ is small than when it is large, a condition satisfied with the smaller sizes of tubes. Where the circulation is less good and the heat transmission lower, the constant h is larger and the efficiency is lower. With a suitable constant the formula may evidently serve the case of a tubular superheater, and experience would lead to the conclusion that, except under the most favourable conditions, which do not obtain in smoke-box heaters, the value of the constant would then be somewhat greater than the figure used in connection with locomotive boiler-flues. For similar efficiency, therefore, m must be rather smaller for superheater work than for boiler work, for equal flue lengths. In other words, the proportion of length to diameter for superheater tubes should be somewhat greater than for boiler-tubes, while the expression also shows that the shorter the length l the greater will be the effect of any change in the value of m.

Instead of exercising extreme care, however, in this direction, there has actually been a tendency of designers to move in the reverse sense. Smoke-box superheaters have even been introduced in which the same sized tubes are used as in the boiler, though, of course, of much reduced length. The efficiency of such heaters cannot be otherwise than low, much lower, in fact, than if the same proportions of length to diameter, as in the boiler, had been retained, and still less than it would be if this ratio had been somewhat further exaggerated. The result is a cumbersome apparatus, giving a low degree of superheat, susceptible of great improvement. The Lancashire and Yorkshire Railway once erred in this direction, but the apparatus was not unnaturally ultimately abandoned. The Atchison, Topeka, and Santa Fe Railway still work on this incorrect principle.

If due care be taken in proportioning in design, as has been previously stated, a waste-gas heater may be produced which, though of comparatively small dimensions, will give 90 deg. Fahr. or so superheat at the steam-chest, calculated on boiler pressure. The style of heater with which this may be accomplished is shown in Fig. 2, which depicts diagrammatically a form of smoke-box heater introduced by Mr. F. H. Trevithick, M. Inst. C.E., on the Egyptian State Railways. The figure is self-explanatory, the heater consisting of a drum, filled with tubes, suspended in the upper part of the smoke-box. The path of the gases under and around the heater is indicated by arrows, and the chimney is again shown by a dotted circle. This heater is a contrast in many ways to the type shown in Fig. 1. In it the gases cannot escape to the atmosphere without parting with a great proportion of their heat, unless the size of tube has been badly chosen. Within certain limits, that size can be such as will give the best results for the length of the heater, and the volume of gas to be dealt with may thus be split up into a number of streams of the most effective size for the length chosen. Again, the surface across which heat may uselessly leak away to the atmosphere is reduced in this design to a minimum—viz., to the area of the diaphragm $a\,b\,c$ connecting the end of the superheater to the chimney. All other surface exposed to the hot gases is useful area. The ideal of reducing the temperature of the waste gases before leaving the heater to that of the surrounding steam is impracticable in any case, but it is eminently desirable to get as near to the ideal as possible, and the most favourable conditions should, therefore, be carefully selected.

It is now necessary for the moment to turn to the consideration of a few points connected with the high-degree superheater systems. It

* See page 213 *ante*.

has been stated that this type of superheater is virtually equivalent to an apparatus independently fired. A moment's reflection suffices for conviction on this point. These heaters are usually arranged within the barrel, in boiler tubes of specially large diameter provided for the purpose. It is not a matter of great difficulty to conceive of the conditions of gas flow in these larger tubes, as practically the equivalent of several independent streams flowing side by side, and each transmitting heat to a different surface, one to the containing surface of the larger tube, and one to each length of the superheater elements. The conception is facilitated, perhaps, by considering an infinitely short length, equivalent to a cross-section, and picturing in the gas space thus exposed areas in which the molecules would tend naturally to impart their heat most readily to one surface or the other. The areas thus marked out would form the momentary boundary limits of the several streams. With the idea carried but one step further, the interior tubes and their streams can, in imagination, be removed and accommodated in a separate insulated apparatus, leaving the stream flowing past the water-heating surface untouched. Thus it is clear that the gases passing through the smoke tube containing the heater elements may be apportioned, when dealing with averages, to the respective surfaces, according to their relative efficiencies, in spite of the actual mingling of the streams in practice. The actual disposition of the heater elements in smoke-tubes within the barrel is accordingly merely incidental. It simply affords a convenient method of utilising simultaneously, and without additional complication, heat produced at one grate, under induced draught, for two purposes—viz., both the boiler and heater.

In the case of new engines, the proportions of design may be chosen to give, within limits, whatever may be thought to be a desirable output according to the work to be performed. The real effect of the introduction of a high-degree superheater becomes, however, most clearly manifest if the conversion of an existing boiler be considered. With the grate area unaltered and the volume of gas unchanged, the total heat has then to be divided suitably between the water heating and the superheater surfaces. This can only be accomplished by reducing the normal water-heating surface and replacing it, sometimes only in part, by steam-heating surface. If this reduction is not properly brought about, an insufficient amount of gas will flow to the superheater elements, and the resultant degree of superheat will be low. Actual cases of failure due solely to insufficient supply of hot gas are on record. For instance, M. G. Noltein reports that he had found it necessary to place ferrules in the ordinary water-heating tubes, in order to get enough gas to give a reasonable degree of superheat, to pass to the large tubes containing the heater elements. At the same time he allowed scale to form on the outside of the large tubes, so that the transfer of the heat to the water through these should be impeded, and the gases kept hotter, to the benefit of the superheater elements. Such expedients are, of course, altogether undesirable, and may be avoided by the adoption of proportions which will give the distribution required. The effect of the changes due to the introduction of this form of superheater will now be considered.

Suppose an ordinary locomotive boiler to have an output of, say, x lb. of wet steam per unit of time. Then at a pressure, for instance, of 160 lb. per square inch, the steam produced, containing 4.5 per cent. of water (the figure arrived at in the previous article), would occupy $(0.955\ x \times 2.6)$ cubic feet, neglecting the volume of the water present. This is equal to a volume of $2.483\ x$ cub. ft. In passing through a waste-gas superheater the water in suspension is evaporated, and the temperature of the whole mass raised, say, to 80 deg. Fahr. superheat, which is well below the limit possible in practice with a good heater. The pressure being constant, the volume is thus increased to $2.96\ x$ cub. ft. by the introduction of the waste-gas heater in the smoke-box.

In connection with ordinary locomotive boilers investigations have shown that there is ground for the belief that, as an average figure, about 35 per cent. of the total evaporation may be taken as being accomplished in the immediate surroundings of the fire-box, about 65 per cent. coming from the tube-heating surface.* In the introduction of the high-degree superheater, the latter is reduced to some extent in making room for the large tubes which accommodate the superheater elements. The amount of the reduction necessary is placed by Herr Garbe at from 25 to 30 per cent. of the total tube surface. In actual practice the reduction of tube water-heating surface seldom approaches the higher of these figures, though cases of it doing so, and even exceeding it, are not unknown. The lower figure of 25 per cent. will therefore be taken, and it should also be remarked that instances are not lacking of the alteration brought about not always reaching this amount. This reduction curtails the evaporative capacity of the barrel portion of this boiler, compared with that of the same portion of an ordinary boiler. The output, in fact, for the barrel of the superheater boiler would be $[0.65 - (0.25 \times 0.65)]\ x$, or $0.4875\ x$ lb. compared with $0.65\ x$ lb. of the saturated boiler-barrel. Added to this is the $0.35\ x$ lb. unaltered from the box, making for the complete boiler of the superheater engine $0.8375\ x$ lb. evaporated. If the degree of superheat be taken as 220 deg. Fahr., this amount of steam would have a volume equivalent, at 160 lb. pressure, to $(0.8375 \times 3.516)\ x$ cub. ft., or approximately $2.945\ x$ cub. ft. There is not then much difference between the volumetric output possible with the high and the moderate-degree systems. If the reduction of heating surface in the high-degree system is not so considerable as is taken above, that system may have a very slight advantage, but it will only be to a very insignificant amount.

The example illustrates a fundamental difference between the waste-gas and the so-called smoke-tube superheaters. If existing boilers be taken and converted, in one case the heater increases the existing capacity directly, while in the other the capacity is first curtailed, after which this reduction is more than amended, though with reduced total heating surface. In the result, the volumetric output is practically the same, for what is lost in the high-degree type, in evaporative capacity, is made up for subsequently by heat added. This is one of the reasons why, if smoke-tube heaters be adopted, it is advisable to aim for a high degree of superheat, for the value of the compensating effect is dependent upon this. The same effect is not realised in all heaters. It is greatest for the double-loop type, of which the Schmidt pattern is the best example. In this type each superheater-element pipe runs, from a header in the smoke-box, back towards the fire-box, then forward again, and back once more, finally returning to the smoke-box end. This is in distinction from the single-loop type of superheater in which each tube element runs once from the smoke-box header towards the fire-box and back again, although each smoke-tube may contain two or more tubes. In the latter type the loops are, so to speak, in parallel, while in the former they are in series. In the earlier Cole Field-tube type of superheater, and the single-loop type in use on the Great Western Railway, superheat of about 100 deg. Fahr. to 120 deg. only is obtained, and the value of the compensation this provides is, of course, much less than in the double-loop types, giving, in cases, up to 270 deg. Fahr. superheat. The latter figure would result in a volumetric output for the high-superheat generator greater than for the example chosen with 220 deg., and rather greater than the output of the generator-set embodying a waste-gas superheater, giving 80 deg. Fahr. superheat; but, on the other hand, the waste-gas superheater-generator set, giving 80 deg. Fahr. superheat, is greatly superior to the smoke-tube heater-generator giving only 100 deg. or 120 deg. Fahr. superheat, for with this type of superheater, while the water-heating surface suffers curtailment to an extent practically equal to that needed by the double-loop system, there is only subsequent volumetric reparation on a much lower scale. The fallacy of considering the degree of superheat alone an index of the utility of superheating is thus apparent, for of two superheater boilers, giving values of superheat differing, perhaps, by more than 40 deg. Fahr., so far as generative output is concerned the advantage is incontestably with that giving the lower superheat.

The ultimate value of the several generating systems is affected by the relative efficiency of heat transmission of the water-heating, and steam-heating, surface. While a properly proportioned waste-gas superheater has no effect on the evaporative power of the water-heating surface of the boiler, by reason of the lowered temperature of the waste gases the over-all efficiency of steam production $\left(\frac{\text{heat utilised}}{\text{heat in coal fired}}\right)$ is considerably increased. The extent of this improvement may easily be found. By way of example, the same conditions may be used as above—viz., 160 lb. pressure (taken for simplicity as 175 lb. absolute), 4.5 per cent. moisture in the steam, and feed-water at 60 deg. Fahr. Taking 1195.9 units as the total heat in the steam from 32 deg. Fahr. at this pressure, and 28.08 units as the heat in the water at 60 deg. Fahr. above 32 deg. Fahr., the heat required to generate 1 lb. of such steam is $1195.9 - 28.08 = 1167.82$ B.Th.U. The heat required to raise 1 lb. of water from 32 deg. Fahr. to 370.8 deg. Fahr., the temperature equivalent to 175 lb. absolute, is 343.2 B.Th.U.; or with feed at 60 deg. Fahr. each pound of moisture contained in the steam receives $343.2 - 28\ 08 = 315.12$ units. The heat required, therefore, to produce 1 lb. of wet steam under the above conditions would be:

$$(0.955\ x \times 1167.82) + (0.045\ x \times 315.12) = 1129.45\ x \text{ B.Th.U.}$$

In superheating, the moisture has first to be evaporated. This would require $0.045\ x\ (1195.9 - 343.2) = 38.37\ x$ B.Th.U., which must be added to the heat required for superheating from dry saturated steam. If the total heat of steam superheated to 80 deg. Fahr., at 175 lb. absolute, be taken as 1243 B.Th.U. from 32 deg. Fahr., then the conversion of the wet steam into steam superheated 80 deg. requires, under the above conditions, $(1243 - 1195.9)\ x + 38.37\ x$ units $= 85.47\ x$ B.Th.U., which amount is added by the use of the waste-gas superheater.

Of the total heat supplied per pound of steam produced, 1214.9 B.Th.U. are therefore taken up in the waste-gas heater-generator, and 1129.45 in the case of the saturated-steam boiler. If the latter works, say, at an efficiency $\left(\frac{\text{heat utilised}}{\text{heat in coal fired}}\right)$ of 65 per cent., the former will consequently generate at an efficiency of 69.9176 per cent., or, say, 69.92. It has been already pointed out that the presence of a large amount of water in the saturated steam used as the basis of comparison, makes the improvement due to the introduction of superheating all the greater. If, in this case, the saturated steam were dry instead of containing 4.5 per cent. moisture, only $47.1\ x$ B.Th.U. would be added by the superheater, and the combined efficiency would then drop to 67.62 per cent.

It is to be noticed that with the waste-gas heater the amount of heating surface of the superheater and its efficiency are matters of which the generator efficiency is independent. The comparatively low efficiency of transmission of the heater surface is a matter of no moment, except from the influence it has on weight, resulting in the necessity of providing proportionately larger surfaces. The efficiency of transmission has, however, an influence on the combination of a smoke-tube superheater and boiler. A simple calculation will show, taking figures from actual practice, that the amount of heat transmitted on the average per unit of surface through steam-backed superheater surface is only half as great as that transmitted to the water in the boiler. The engines on the Lancashire and Yorkshire Railway apparently average this amount, while the tests at Purdue have shown various values, ranging from a figure of 0.34 to 0.53, under different conditions and with different heaters. Though the efficiency is commonly reported in this way, to do so is not quite fair to the superheater, owing to the large proportion of the boiler work performed just round the fire-box, and accuracy requires a rather more detailed examination of what actually occurs.

Still retaining the same conditions as used in the example above, if the evaporative capacity of a saturated-steam boiler be denoted by y lb. of wet steam per unit of time or surface, the heat transmission through the surface provided in the barrel will be equivalent to $(1129.45 \times 0.65\ y) = 734.14\ y$ B.Th.U. In the corresponding high-degree superheater boiler, the barrel water-heating surface is reduced, and the heat transmitted by it will only amount to $0.75 \times 734.14\ y$, or $550.6\ y$ B.Th.U. The total heat in steam at 175 lb. absolute superheated to 220 deg. Fahr. may be taken as 1313.95 units, from 32 deg. Fahr. In superheating to this degree 38.37 units have again to be added per 1 lb. to evaporate the moisture, after which $(1313.95 - 1195.9) = 118.05$ units must be added per pound to superheat the whole to 220 deg. Fahr., making a

* See, for instance, calculations, based on the St. Louis and Altoona Tests, by Mr. Lawford H. Fry. ENGINEERING, vol. lxxxvii., pages 237, 307, *et seq.*

total of 156.42 B.Th.U. The service performed, therefore, by a superheater giving 220 deg. Fahr. superheat in connection with the generator of reduced water surface in the barrel is

$$[(0.65 \times 0.75) + 0.35] \times 156.42\ y \text{ B.Th.U.} = 0.8375 \times 156.42\ y \text{ B.Th.U.}$$

This will be found to work out to practically $131\ y$ B.Th.U.

To obtain a value of the relative average efficiency of the water and steam tube heating surface it is necessary to know the relative size of the generating areas. Herr Garbe recommends that the proportion of superheater surface to total tube surface should be as much as 1 : 3, for by no means the highest degree of superheat often used. In practice, however, rather different proportions obtain. In one case giving a high degree of superheat the ratio of superheater surface to tube-water heating surface works out as 1 : 3.72; while in another, giving a much lower degree, it is found to be 1 : 4.65. In a third, giving superheat closely similar to the figure taken in the example, it is 1 : 4.2. This figure therefore represents a mean for several cases and is suited to the present purpose.

Compared then with the heat transmission through the boiler tubes of the high-degree generator, the superheater would transmit, for equal surface $(131 \times 4.2)\ y$, or $550.2\ y$ B.Th.U. The efficiency of transmission is therefore practically the same for the superheater elements and the water-tube surface under these conditions, and it is therefore also similar for the barrel portions of the saturated steam boiler and the high-degree superheater boiler. With all conditions unchanged, except the heating surface in the barrel, and this reduced, the volume of gas supplied per square foot would be greater in the smoke-tube superheater boiler than in the saturated-steam boiler, and, even with the efficiency undiminished, the smoke-box temperatures might therefore be higher, as it is sometimes considered they are. In the high-degree superheater boiler, since the barrel-heating surface is reduced, the very efficient fire-box surface plays thus a proportionately greater part in the total work performed, and the average transmission per unit of surface is improved. In the saturated-steam boiler there would be, in ordinary European practice, 10 sq. ft. of tube-heating surface in the barrel to 1 sq. ft. in the fire-box. If 0.35 of the total evaporation is performed in the neighbourhood of the fire-box, and 0.65 by the tubes, the fire-box evaporates 5.4 times the amount of water evaporated by the tube surface per unit of area. The average evaporation per unit of area for the whole boiler would therefore be denoted by the expression $\frac{5.4 + 10}{11}$, which gives the relative figure 1.40; that is, the average transmission for the whole boiler is equal to the average transmission through the tube water-heating surface multiplied by 1.40.

In the superheater boiler, giving 220 deg. Fahr. superheat, the tube water-heating surface is reduced 25 per cent., and the fire-box surface : tube water surface : : 1 : 7.5. The transmission through the tube water-heating surface and the fire-box remains as before, in the proportion of 1 : 5.4. Superheater surface replaces part of the removed water-heating tube surface, there being 1 unit of superheater surface to 4.2 units of water-heating tube surface. The fire-box surface therefore bears the relation to the total tube surface of $1 : \left[7.5 + \frac{7.5}{4.2}\right]$, that is, to 9.285, instead of 1 : 10, as in the saturated boiler. The average transmission per unit of area for this generator is therefore $\frac{5.4 + 9.285}{10.285} = \frac{14.685}{10.285} =$ 1.4278, compared with the 1.40 already found for the saturated-steam boiler. If the latter figure represents a boiler efficiency of 65 per cent., a superheater boiler giving 220 deg. Fahr. superheat, of equal total surface, well proportioned, would thus apparently have an efficiency of 66.29 per cent. It must naturally be understood that the proportionate surfaces involved in the above investigation are all supposed to be made use of in a manner conforming to good average practice. Otherwise, of course, calculations involving areas only would be of little or no value.

Practical corroboration of this conclusion is not easy. Several authorities contend that superheater boilers are superior in efficiency to the saturated-steam generators. The Purdue tests have led Dr. Goss to conclude that, in the case of the locomotives then used, the combined boiler and superheater of one was not less efficient than the saturated-steam boiler of the other, when worked at the same power, while "the face value of the data shows its efficiency to be higher by 4 per cent." Slight variations in the conditions of the various Purdue tests preclude any more definite conclusion being arrived at without study at greater length than is here possible

It would naturally be expected that in the case of the superheater elements and large tubes the gases on their arrival at the smoke-box would be of somewhat higher temperature than the normal, if only because of the fact that for much of the surface fed the temperature difference between the transmitting and the absorbing fluids is smaller than in the case of the ordinary boiler tube. The average temperature for the whole smoke-box would thus be slightly raised, compared with that in the smoke-box of the saturated engine. This impression is supported by records taken in connection with various trials, including, as far as can be gathered, those carried out at Purdue. There is, however, also testimony in a contrary sense. Among other authorities for this stands M. G. Noltein, who quotes a case coming under his notice in which the gases issuing from the large smoke-tubes were found to be even lower in temperature than those leaving the ordinary water-heating tubes, and that only on making arrangements to ensure the passage of a greater volume of gas to the large tubes was the temperature raised, the efficiency of generation coincidently showing improvement. It is possible that the explanation of this divergence of records lies in the fact that actually different bases of comparison have been taken. In the case of a superheater boiler of reduced surface, compared with the original saturated-steam boiler of larger surface, the smoke-box temperature for equal rates of firing would be, it may be supposed, increased, for reasons already indicated, while for boilers of equal surface, properly disposed, it would be reduced.

With good design the average efficiency of the superheater surface may equal the average of the tube water-heating surface, though this average does not at all compare with the average for the fire-box surface. To obtain this result the speed of the steam through the elements must be kept high, and the superheater surface must also be so arranged that a fair proportion of it is brought comparatively near the fire-box. Provision is made in both these directions in the Schmidt design, with which high temperatures are secured despite that, for a very large part of the superheater surface, the transmission is exceedingly low. The high efficiency of comparatively short lengths of the superheater surface will be realised, although it is not possible to reduce the rate of absorption to figures, when it is considered that in only two limbs of each element does the steam flow in a direction favourable to absorption — *i.e.*, in a direction contrary to that of the gas—while, again, in only two limbs is the temperature head considerable for any great part of the area exposed. The transmission at the end of the contra-flow limbs must be considerable, especially in the case of the first. It would also be high at the commencement of the second limb, but there the direction of flow is unfavourable, and the rate of transmission must fall rapidly. It is quite erroneous to imply, as is frequently done, that the added heat in superheated steam is easily obtained because the specific heat of steam is low. That the transmission is so good is principally due to the high velocity of the steam over the surface. Of course, the low specific heat improves the position, but it is well known that, with low velocities, the transmission of heat to steam is very inefficient, for reasons which it is not necessary to enter into here. It then falls far below the transmission through water-backed surface, and to point to the specific heat of steam as essentially a favourable factor in superheating is quite illogical.

This conclusion is supported by the results obtained with the single-loop superheaters, in which, the loops being in parallel, the steam velocity is a great deal lower than in the Schmidt and other double-loop types, in which the arrangement is virtually equivalent to loops in series. With the single-loop heaters the same arrangements have to be made in the barrel, and the ordinary tube-heating surface replaced in part by large tubes, as in the double-loop superheater boiler. The tube evaporative surface is thus curtailed to the extent of about 25 per cent., as before, the difference in the type now under consideration being in the superheater surface provided, and the superheat obtained. From a number of single-loop superheater engines it is concluded that for 120 deg. Fahr. superheat, as an approximate average, 1 sq. ft. of superheater surface is provided for every 5.4 sq. ft. of tube water-heating surface. As before, the heat transmitted through the latter surface is $550.6\ y$ B.Th.U., but now, since the total heat of steam superheated to 120 deg. Fahr. is 1263.9 units above 32 deg. Fahr., the service performed by the superheater is denoted by the expression

$$0.8375\ y\ [(1263.9 - 1195.9) + 0.045\ (1195.9 - 343.2)] \text{ B.Th.U.} = 89.1 \text{ B.Th.U.}$$

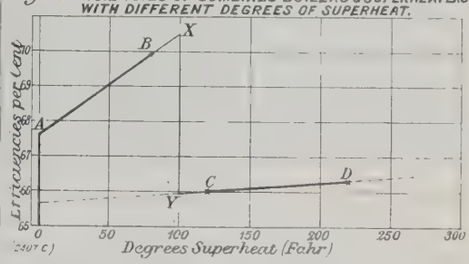
For equal surface, therefore, this superheater transmits $481\ y$ B.Th.U. compared with $550.6\ y$ B.Th.U. transferred through the water-backed tube surface. The superheater surface has thus an efficiency only 87.3 per cent. that of the latter, while the average efficiency of the whole barrel portion of the boiler is given by

$$\frac{(100 \times 5.4) + (87.3 \times 1)}{6.4 \times 100} = 98 \text{ per cent.}$$

that of a saturated steam-boiler barrel of equal total tube surface. The relative transmission of the fire-box surface and the tube water-heating surface is, as before, 5.4 : 1, but the fire-box surface now compares with the total tube surface as $1 : \left[(10 - 2.5) + \frac{7.5}{5.4}\right]$ or as 1 : 8.9. The average combined transmission for the boiler is thus denoted by $\frac{(1 \times 5.4) + (8.9 \times 0.98)}{9.9}$ which, reduced, gives the relative figure of 1.422 compared with the 1.428 of the generator producing steam superheated to 220 deg. Fahr. The figure for the average transmission for the 120 deg. Fahr. superheat boiler would thus correspond with an efficiency of 66 per cent. if the heating surface were well arranged. The total transmission for the original, and converted, boilers, is denoted by the following relative figures: — 154, for the saturated-steam boiler; 142, for the 120 deg. Fahr. smoke-tube superheater boiler; and 147, for the 220 deg. Fahr. smoke-tube superheater boiler. For the reductions in the two latter types compensation in other directions is forthcoming, as already explained.

The following approximate efficiencies have thus been arrived at as possible with suitable disposition of heating surface:—For the saturated steam boiler 65 per cent.; for the 80 deg. Fahr. superheat waste-gas heater boiler 69.92 per cent.; for the 120 deg. Fahr. superheat smoke-tube superheater boiler 66 per cent., and for the 220 deg. Fahr. superheat smoke-tube superheater boiler 66.3 per cent. These figures are plotted against superheat in the diagram, Fig. 3, which enforces

Fig. 3. EFFICIENCIES OF COMBINED BOILERS & SUPERHEATERS WITH DIFFERENT DEGREES OF SUPERHEAT.



the assertion that it is absurd to discuss economies in terms of superheat alone, without making distinction as to the systems used. If the wetness of the steam generated in the ordinary boiler be really less than 4.5 per cent., in all cases the efficiency of the superheaters would be less than that shown. On the other hand, if the wetness be taken as 4.5 per cent., an increase of efficiency is obtainable with the waste-gas heater-boiler if the steam be just dried and no more. The figure thus found is at A, at 67.6 per cent. From this point the improvement runs up to B at 69.92 per cent. for 80 deg. Fahr. superheat. At some point not far beyond this, probably in the neighbourhood of 100 deg. Fahr., no higher superheat is possible with the waste-gas heater on locomotives, though higher claims have sometimes been made, and no further improvement in economy is possible by these means. If, to secure advantages in other directions, still higher superheat is desirable, resort has to be made to the smoke-tube type. The possible generator efficiency therefore falls. The points C at 66 per cent., and D at

FOUNDRY PLANT AND MACHINERY.

(*For Description, see Page* 280.)

Fig. 488.

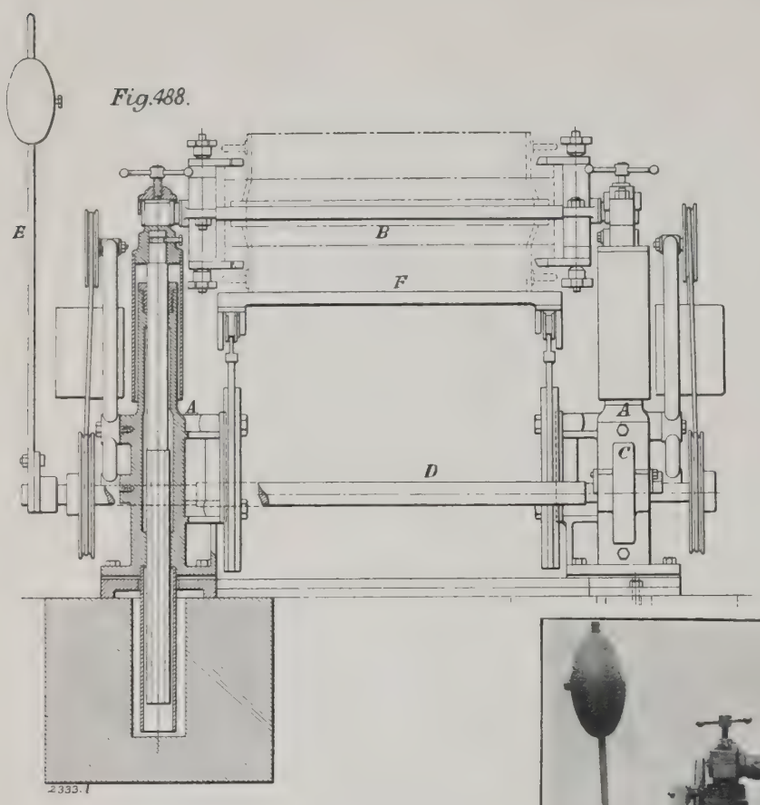


Fig. 489.

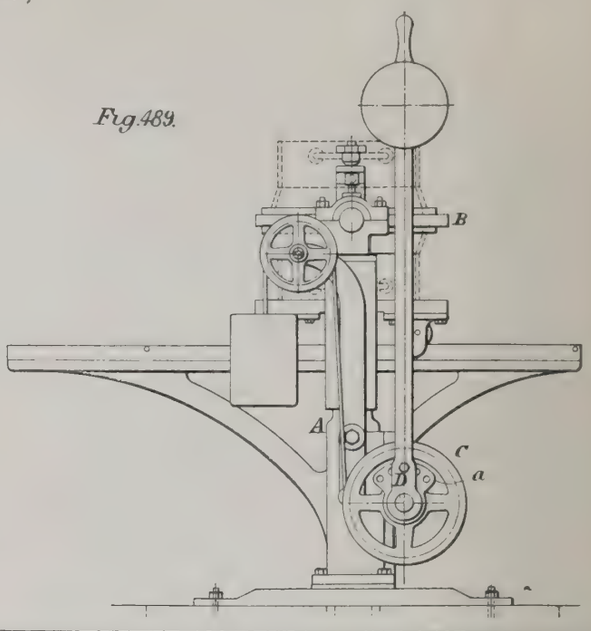


Fig. 492.

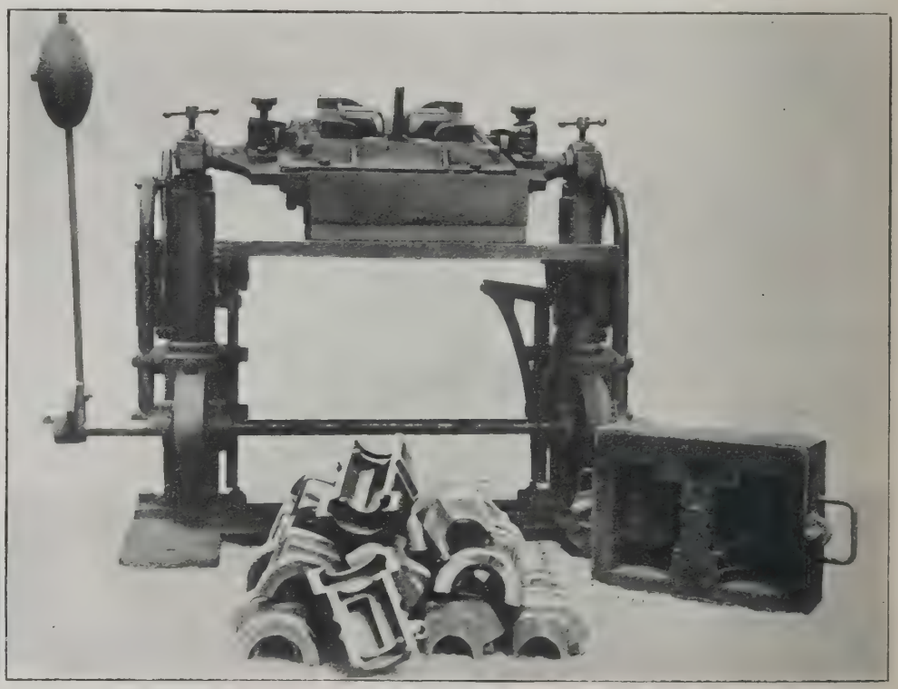


Fig. 490.

Figs. 488 and 489. Hand-Operated Moulding-Machine, with Turn-Over Table; The London Emery Works Company, Tottenham, London, N.

Fig. 490. Moulding Tramway Axle-Boxes.

Fig. 491. Pattern Plates for Moulding Ring Self-Oiling Bearings.

Fig. 492. Machine with Side Rams for Lifting Patterns.

66.3 per cent., represent efficiencies on this system based on proportions taken from practice. With corresponding velocities and areas, the line joining these two points prolonged, suggests that with a superheater just sufficient to give dry steam the efficiency would be 55.62 per cent., and that with one giving 100 deg. Fahr. superheat it would be about 65.92. Though placing no great weight on the position of points so found, attention may incidentally be drawn to the fact that with the superheat often used in European practice (270 deg. Fahr.) the efficiency of generation might be raised to 66.44 per cent., as indicated by the line C D prolonged. The line X Y shows the limit at which the change of system, and consequent loss of

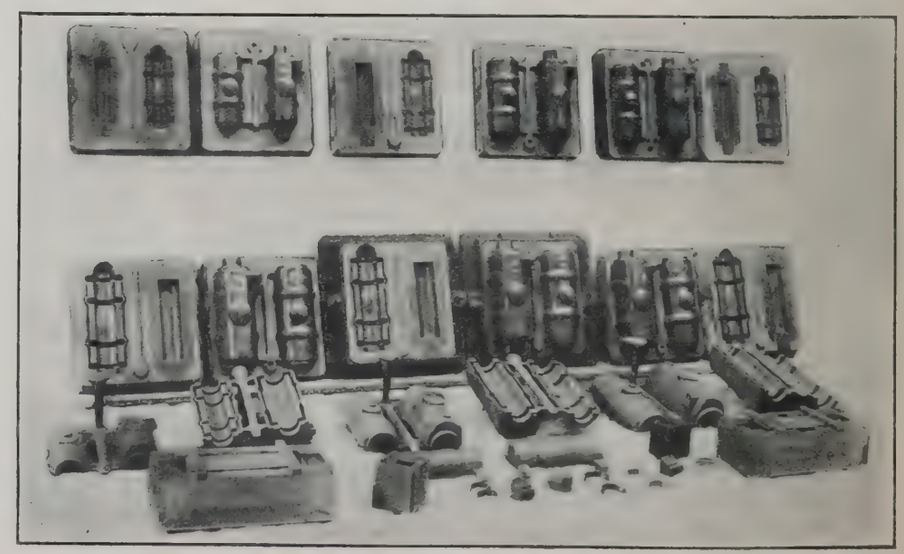
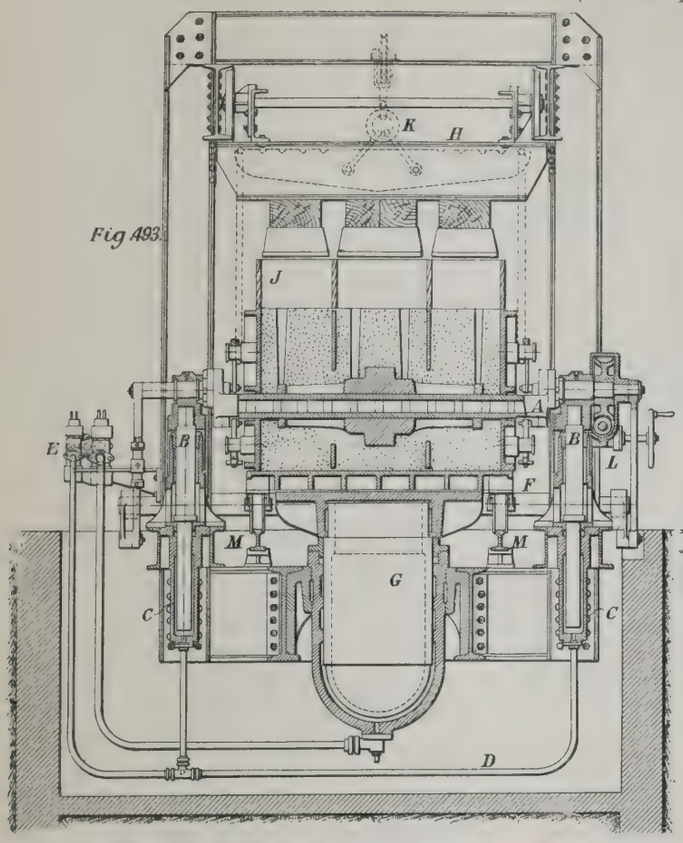


Fig. 491.

FOUNDRY PLANT AND MACHINERY.

(*For Description, see Page* 280.)



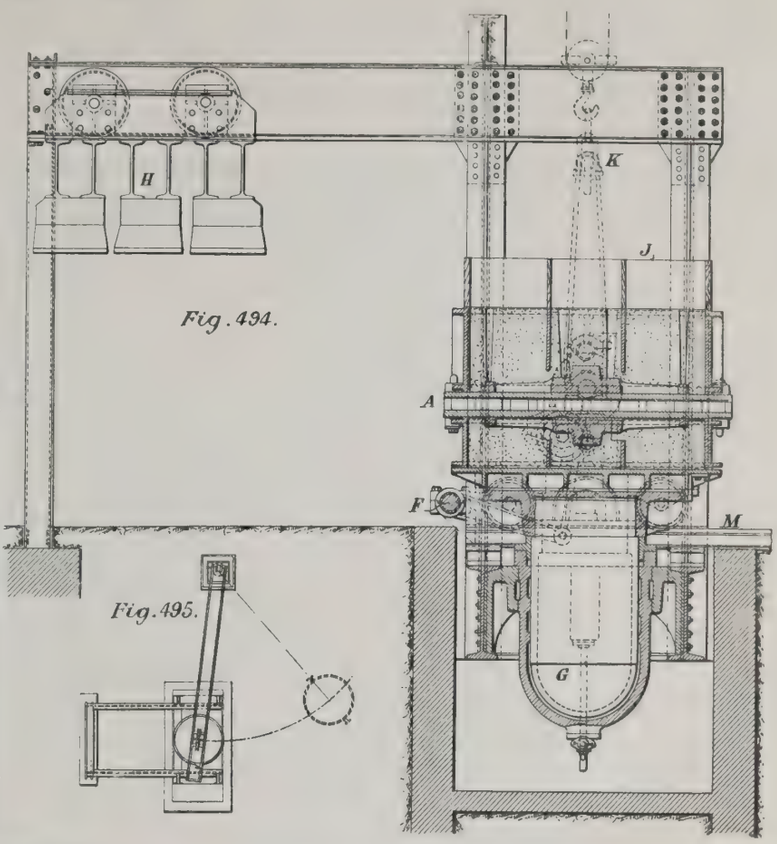


Fig. 494.

Fig. 495.

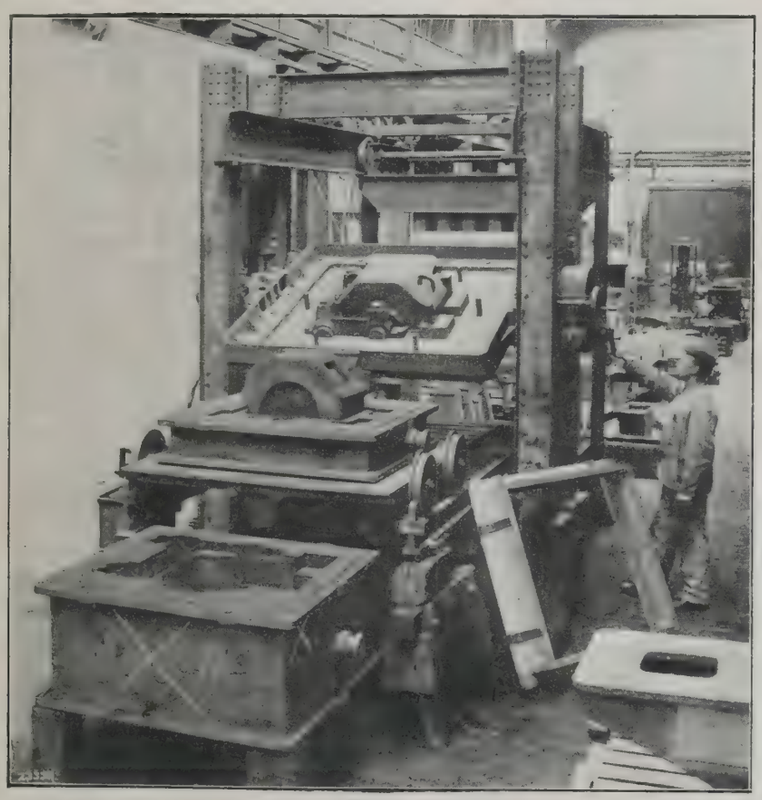


FIG. 496.

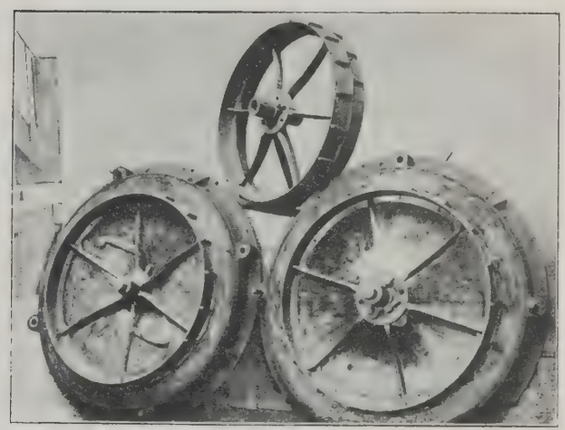


FIG. 497.

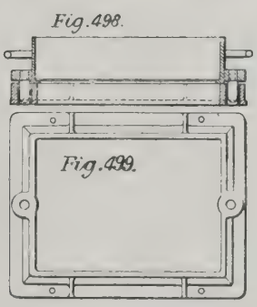


Fig. 498.

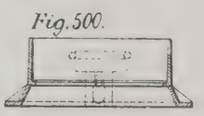


Fig. 500.

Fig. 499.

Fig. 501.

FIGS. 493 TO 496. HYDRAULIC POWER MOULDING-MACHINE; CONSTRUCTED BY THE LONDON EMERY WORKS COMPANY, TOTTENHAM, LONDON, N.
FIG. 497. PATTERN-PLATES FOR THRASHING-MACHINE WHEEL. FIGS. 498 TO 501. INTERCHANGEABLE PATTERN-FRAME AND MOULDING-BOX.

boiler efficiency, becomes inevitable. The points C and D unfortunately represent heaters in which both surface and steam velocity were different, so that, though the points themselves are based on actual practice, others on the line passing through them are of restricted value.

It is probably partly, at least, due to the foregoing facts that Professor Benjamin, experimenting at Purdue with a smoke-tube heater giving only 80 deg. superheat, has arrived at the conclusion* that "the first 80 or 100 deg. of superheat does not make the same proportional decrease in the coal consumption as does the second 80 or 100 deg. superheat." This statement has been frequently appealed to as conclusive argument in favour of high-degree superheating as opposed to a moderate degree. Actually it affords no proof whatever, for the above

* Proceedings of the American Railway Master Mechanics' Association, 1910, and repeated and enlarged upon in Professor Benjamin's latest (1911) report.

calculations show that it is manifestly improper to expect a boiler arranged for one degree of superheat to be equally efficient when a superheater giving much less than that amount is inserted in it, and for this reason:—The smoke-tubes are unaltered, though fed with the same amount of gas in both cases, but less heat is absorbed in one case than in the other, and there must be, therefore greater loss to the smoke-box. It may be imagined that the difference would be absorbed by the water surface, but in the Cole superheater experimented on at Purdue this can hardly have been so. In this case the superheater pipes were merely shortened, leaving the velocities unchanged, but, at the fire-box end, greater lengths of unoccupied smoke-tube. If, for the ordinary boiler-tube, the ratio of length to diameter, or, in other words, the ratio of gas supplied to the surface exposed, is about correct, evidently the area thus represented by the lengths so exposed is supplied with an excessive amount of gas, and, judged by this standard, the efficiency of this part of the water-heating surface is relatively lowered. The surface would not utilise the heat passing over it properly, so that, though the actual heat transferred might be somewhat greater, this would not afford compensation to an extent equal to the loss of ordinary tube surface. In view of these various factors, it appears reasonable to conclude that when widely different degrees of superheat are sought, the best results may be obtained by re-arranging the whole interior of the boiler, and not by simply adjusting the superheater tube lengths to give the desired degree.

It is thus manifest that the boiler efficiencies are, in all probability, different in the case of smoke-tube superheater locomotives generating and using steam of different degrees of superheat. It is, of course, known that the engine efficiencies under parallel conditions would be different. There are, therefore, two variables introduced, which would be quite sufficient to explain the point, in connection with this system of direct superheating, to which Professor Benjamin's remark, quoted above, refers.

The further fact, however, which Fig. 3 makes clear is ignored in the work at Purdue, and is always kept in the background by advocates of high-degree superheating. The superior efficiency of the waste-gas heater-boiler producing steam superheated to 80 deg. or 90 deg. Fahr. gives that system of superheating, when combined with the engine, a great advantage over any smoke-tube superheater system giving the same and even, within certain limits, higher degrees of superheat. Professor Benjamin's conclusion, of which so much is made by one school, is therefore not fair to moderate superheating as it may be applied to locomotives. It totally ignores the chief feature of the most efficient moderate-degree superheaters, and, on the whole, it appears that the purpose of the Purdue tests would have been better served if an altogether separately-fired independent superheater, quite apart from the boiler, had been used for them.

The waste-gas heater-generator plant therefore possesses a great advantage as regards coal consumption, and, other things being equal, loss in this direction has to be recouped in the engine before the high-degree system can lay claim to superiority. It has been shown that as between the high-degree and the best moderate-degree systems there is very little to choose as regards volumetric output. Between these two systems, therefore, arguments based on the specific volume of steam at different temperatures may, for all practical purposes, be eliminated.

Only if it becomes a question of considering the maximum capacity of different types of superheater generators does the question of volume become involved in a manner not taken into account in the method which will subsequently be adopted in the investigation of the engine performance. An examination as to the relative value, for equal service performed, of highly or moderately superheated steam, resolves itself into one concerned with the efficiency of generation already dealt with, and with the benefits secured in the engine as a result of the added heat in the steam, together, of course, with the usual financial aspect of the case.

It is, perhaps, unnecessary to remark that the difficulty present in all investigations of locomotive performance affects this problem as it does others. The wide variety of conditions which the locomotive is called upon to satisfy in service renders general analysis dependent upon the selection of fair averages. It is well known that the superheat produced under various conditions of work is very different, the tendency being for it to be higher in both systems as the consumption and draught increases. In this, as in other matters, average figures have had to be found; and with widely different results obtained with one engine under various conditions of work, and the difficulty of reconciling records from numerous sources, this has proved no easy matter. The figures taken are believed to be justified, as they have been arrived at from a consideration of the reported results obtained with engines actually in use, though, since they are averages, no particular class may have the exact proportions here employed. In our next article the subject of engine performance and that of the combined generator and engine will be dealt with.

FOUNDRY PLANT AND MACHINERY.

No. XXXI.

By Joseph Horner.

A design of machine constructed by the London Emery Works Company, of Tottenham, London, N., and illustrated on page 278, is a general type around which modifications are made to suit different kinds of castings. It is shown in Figs. 488 and 489 as a hand-machine simply, without mechanical pressure, but in some other forms it includes the latter, and also hydraulic pattern withdrawal arrangements. The general construction of the machine in its simplest form is as follows:—

Two tubular standards A, A, carried on a base, each enclose a flat-threaded spindle, the top of which is formed into bearings to receive the trunnions of the turn-over table B, on which the box parts are rammed. The racks are moved vertically through toothed gears enclosed in the casings seen at C, C, and connected by means of a horizontal shaft D, so that they work in unison by the movement of the long hand-lever E. This lever is adjustable to five different angular positions by bolt-holes in the plate a to suit different amounts of lift. The moving mass is counterweighted. The chains to which the counterweights are attached lead off from pulleys, one on each end of the gear-shaft D, and over pulleys above carried each in a light bracket.

The box part, secured by the screw-dogs seen, is rammed by hand on its own pattern-plate or frame on the side of the turn-over table which happens to be uppermost. It is then turned over and lowered by the lever E and racks on to the trolley F. The box part is then detached from the pattern-plate, and the pattern lifted out of the mould by the lever movement, and the box ran away on the trolley on which it is resting. In the small machines the pattern-plate is turned over by hand, but in the large ones by means of a hand-wheel operating worm gear. With this exception the smaller and larger machines of this design are practically identical. The largest of the small series of machines takes boxes up to 43 in. by 20 in., the smallest of the larger series, boxes measuring 34 in. by 16 in., and the largest boxes 72 in. by 32 in. The photograph reproduced in Fig. 490 shows one of these machines carrying the patterns for tramway axle-boxes. Fig. 491 illustrates a number of pattern-plates as used on these machines for making ring self-oiling bearings.

This design, the moulds still being hand-rammed, is built in much larger capacities to utilise hydraulic power for the delivery. Two of these main designs are constructed. For long boxes, and narrow and deep moulds ranging from 10 in. to 31½ in. depth of the half box, the pattern is lifted off its mould, the latter remaining on the trolley. For shorter boxes, but nearly or quite square and not of very great depth, say from 8 in. to 12 in., the box and the trolley which carries it is lowered from the pattern by one central ram.

Fig. 492 shows one of the first-mentioned type of machine, which lifts the pattern out of the mould by two side rams, with a pattern mounted for making bearing-end shields for motors, with the two parts of the mould and a casting. In use the machine is set into foundations, so that the turn-over table is conveniently placed for ramming purposes.

In the other design—that in which the trolley and box are lowered from the pattern—the turn-over table occupies an unvarying height, and has its trunnion-bearings in the tops of the end standards. Fixed in the foundations is an hydraulic cylinder, the ram of which carries the table on which the moulding-box is received after ramming and turning over. The lowering of the ram delivers the box from the pattern. The first-named machine, in which the pattern is lifted out of the mould, is generally to be preferred to the second. In the first the machine can be built lower, because the movement for delivery is upward, and the trolley-track is on the floor. In the second the trolley-track must be lower than the floor if the machine is not to be too high for comfortable working. With deepening of foundations cost of installation increases.

A machine in which the sand is rammed, and the pattern is lifted from the mould by hydraulic power, is shown in Figs 493 and 494, page 279. The turn-over table or plate A has its trunnions carried in the heads of two rams B, B, enclosed by the end standards. Their lower ends are enclosed in cylinders C, C, to which the same pressure pipe D is connected, so that both act in unison on the opening of the supply-valve E. But to ensure an even lift, each ram is connected by levers to a horizontal shaft F. The compression of the sand is effected by a large central ram G. The advantage of dividing the work of ramming and of withdrawal between distinct rams is that the machine need not be so high as when one plunger serves the double purpose of raising and compression, and water is saved, less being used for withdrawing the pattern than for ramming. The manufacturers call attention to the fact that the machine combines the advantages of a hand-moulding-machine with those of a machine worked by hydraulic pressure. It is a hand-moulding-machine type fitted with a press, and the first can be readily converted into the combined machine.

The presser-head H in this design does not swing, but is carried by trolley-wheels along tracks formed by the lower flanges of rolled joists. The framing of the head is constructed of channel sections, and timber blocking is attached to its lower face to compress the sand within the loose sand-frame J. The head can therefore be ran back out of the way to permit of placing boxes on the table or removing them with ease. The open-frame design of the press standards permits of passing a crane-hook, beam, and slings between them, seen at K, for placing boxes on the table. The diagram, Fig. 495, shows the jib-crane in plan relatively to the machine which it serves. The table A is turned over by the worm-gears L, Fig. 493. When it has been lifted as stated, by its rams, the bottom box is ran away on the tracks M, M. The photograph reproduced in Fig. 496 shows the machine in use, carrying the pattern for a motor base, with a mould part in the foreground and the trolley immediately behind with the other part of the mould. Fig. 497 illustrates pattern-plates for making a thrashing-machine wheel moulded on one of these machines.

The interchangeable pattern-frame and moulding-box used on this machine are shown in separate views in Figs. 498 to 501. They are used largely for the plaster pattern-plate system in making small castings.

THE DISTRIBUTION OF STRESS IN PLATES HAVING DISCONTINUITIES, AND SOME PROBLEMS CONNECTED WITH IT.

By Dr. K. Suyehiro, Assistant Professor to the Department of Naval Architecture, Tokio Imperial University, Japan.

Many investigations as to the distribution of stress in plates having discontinuities have been made by various naval architects, and their attention was again called to the matter by Professor Coker, who read a paper on a related subject before the spring meeting of the Institution of Naval Architects.

So far as I am aware, the subject in question has hitherto been treated experimentally only, and it seems that nobody has ever solved it mathematically. Therefore it naturally follows that, in spite of the many exhaustive experiments made, the comparative accuracy, and even the validity of the experimental methods themselves, is still *sub judice*.

The present paper is intended to show analytically how stress is distributed in plates pierced with a circular hole, and at the same time to consider briefly the validity of the experimental method, in so far as it may be judged from the results obtained analytically.

1. Mathematical Solution.

The present investigation is limited to the case of a tension strap with a rivet-hole—*i.e.*, of an

elastic plate pierced with a circular hole subjected to uniform parallel normal edge tractions in the plane of the plate.

In the equations in this paper the following notation is used :—

Two Dimensional Polar Co-Ordinates.

P = the radial normal stress—*i.e.*, the stress component, in the direction of the radius, across the circumferential area.

Q = the transversal normal stress—*i.e.*, the stress component across the radial area in the direction of the tangent to a circle

R = the shearing stress along the radial or transversal plane.

u and v = the radial and transversal displacements of a point respectively.

$e = \frac{d u}{d r}$ = the radial strain.

$f = \frac{1}{r}\frac{d v}{d \theta} + \frac{u}{r}$ = the transversal strain.

$c = \frac{d v}{d r} + \frac{1}{r}\frac{d u}{d \theta} - \frac{v}{r}$ = the shearing strain along the radius and transversely.

$\omega = \frac{1}{2 r}\left\{\frac{d}{d r}(r v) - \frac{d u}{d \theta}\right\}$ = the rotation.

$\Delta = \frac{1}{r}\left\{\frac{d}{d r}(u r) + \frac{d v}{d \theta}\right\}$ = the dilatation.

E = Young's modulus.

σ = Poisson's ratio.

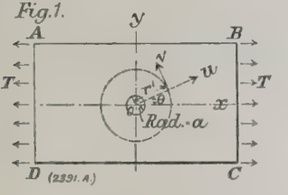
μ = The rigidity.

$\lambda = \frac{E \sigma}{1 - \sigma - 2\sigma^2}$.

Now let a rectangular thin elastic plate (thickness $2t$) pierced with a circular hole ($2a$ in diameter) in its centre be subjected to edge tractions (T per unit area) in its plane, normal to the sides A D and B C, and let the size of the plate be supposed to be taken as very large compared with the diameter of the hole (Fig. 1).

Then this is a problem of plane stress, and not of plane strain, so that the plate will not only be strained in its plane, but also in the direction of the normal to the plane.

Fig. 1.



By applying the method of "generalised plane stress,"* such a problem can be solved, as if it were one of plane strain, provided that the elastic constant λ is replaced by a new constant λ^1, and ordinary stress and strain are replaced by "mean stress and strain." Thus the equations in this case are :—

$$\left.\begin{aligned} \frac{1}{r}\frac{d}{d r}(P r) + \frac{1}{r}\frac{d R}{d \theta} - \frac{Q}{r} &= 0 \\ \frac{1}{r^2}\frac{d}{d r}(R r^2) + \frac{1}{r}\frac{d Q}{d \theta} &= 0 \end{aligned}\right\} \text{Stress equations of equilibrium.}$$

$$\left.\begin{aligned} P &= \lambda^1 \Delta + 2\mu \frac{d u}{d r} \\ Q &= (\lambda^1 + 2\mu)\Delta - 2\mu \frac{d u}{d r} \\ R &= -2\mu\omega + 2\mu \frac{d v}{d r} \end{aligned}\right\} \text{Stress-strain equations}$$

$$\left.\begin{aligned} (\lambda^1 + 2\mu) r \frac{d \Delta}{d r} - 2\mu \frac{d \omega}{d \theta} &= 0 \\ (\lambda^1 + 2\mu)\frac{1}{r}\frac{d \Delta}{d \theta} + 2\mu \frac{d \omega}{d r} &= 0 \end{aligned}\right\} \text{Displacement equation of equilibrium}$$

in which

$$\lambda^1 = \frac{2\lambda\mu}{\lambda + 2\mu}, \quad P = \frac{1}{2t}\int_{-t}^{t} P\, d z, \text{ \&c.},$$

and

$$\frac{d u}{d r} = \frac{1}{2t}\int_{-t}^{t} \frac{d u}{d r} d z, \text{ \&c.}$$

Now imagine a circle concentric with the hole (Fig. 1). If the diameter ($2 r^1$) of this circle is very large as compared with that ($2 a$) of the hole, the displacement of points in the circumference of the supposed circle will not be influenced by the presence of the hole. Therefore

$$\left.\begin{aligned} u &= \tfrac{1}{2}\frac{T}{E}(1+\sigma) r^1 \cos 2\theta + \tfrac{1}{2}\frac{T}{E}(1-\sigma) r^1 \\ v &= -\tfrac{1}{2}\frac{T}{E}(1+\sigma) r^1 \sin 2\theta \end{aligned}\right\} \quad (1)$$

provided r^1 is sufficiently large as compared with a.

From these equations we have

$$\left.\begin{aligned} \Delta &= \frac{T}{E}(1-\sigma) \\ 2\omega &= 0 \end{aligned}\right\} \quad (1A)$$

which hold at points remote from the pierced hole.

Moreover, as there is no surface force applied on the periphery of the hole,

$$\left.\begin{aligned} P_{r=a} &= \lambda^1 \Delta_{r=a} + 2\mu \frac{d u}{d r}_{r=a} = 0 \\ R_{r=a} &= -2\mu\omega_{r=a} + 2\mu \frac{d v}{d r}_{r=a} = 0 \end{aligned}\right\} \quad (2)$$

The equations (1), (1A), and (2) are boundary conditions, which must be satisfied by the equations of stresses and strains to be found.

It is well known that both Δ and ω are harmonic functions which are connected by the displacement equation of equilibrium.

By the nature of the problem, in that it treats of the space outside a hole, and from the form of the boundary conditions (1) and (1A), and also from the form of the displacement equation of equilibrium, we are led to assume that

$$\Delta = \frac{T}{E}(1-\sigma) + \frac{1}{\lambda^1 + 2\mu} A \frac{1}{r^2}\cos 2\theta.$$

Then

$$2\omega = -\frac{1}{\mu} A \frac{1}{r^2}\sin 2\theta.$$

Thus

$$\left.\begin{aligned} \Delta = \frac{1}{r}\left\{\frac{d}{d r}(u r) + \frac{d v}{d \theta}\right\} &= \frac{T}{E}(1-\sigma) + \frac{A}{\lambda^1 + 2\mu}\frac{1}{r^2}\cos 2\theta \\ 2\omega = \frac{1}{r}\left\{\frac{d}{d r}(v r) - \frac{d u}{d \theta}\right\} &= -\frac{1}{\mu}\frac{A}{r^2}\sin 2\theta \end{aligned}\right\} \quad (3)$$

These equations and the boundary conditions (1) and (2) suggest that

$$\left.\begin{aligned} u &= f(r)\cos 2\theta + k_1 r + k_2 \frac{1}{r} \\ v &= \phi(r)\sin 2\theta \end{aligned}\right\} \quad (4)$$

where f and ϕ are functions of r only, and k_1 and k_2 are constants.

Fig. 2. DISTRIBUTION OF STRESSES IN THE TRANSVERSE SECTION THROUGH THE CENTRE OF HOLE.

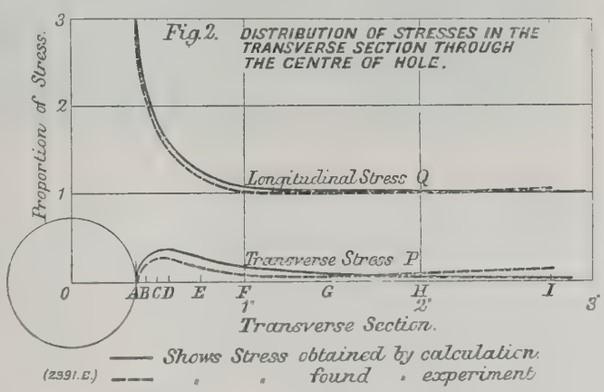


TABLE I.

λ^1 = 126 lb. per sq. in. 2μ = 174.5 lb. per sq. in.

Marked Points (see Fig.).	Distance from Centre.	Longitudinal Strain (e).	Transverse Strain (f).	Longitudinal Stress $=\lambda^1(e+f)+2\mu e$	Transverse Stress $=\lambda^1(e+f)+2\mu f$	Proportional Longitudinal Stresses.	Proportional Transverse Stresses.	Theoretical Longitudinal Stress	Theoretical Transverse Stress.
	in.			lb. per sq. in.	lb. per sq. in.				
A	0.375	0.307	− 0.127	76.2	0 52	2.93	0.020	3 00	0
B	0.437	0.206	− 0.075	52.4	3.42	2.02	0.132	2.20	0.284
C	0.500	0.169	− 0.051	44.2	5.97	1.70	0 230	1.75	0.375
D	0.563	0 150	− 0.041	39.9	6.58	1.54	0.253	1.52	0.369
E	0.750	0.108	− 0.033	28.3	3.69	1.09	0.142	1.22	0.282
F	1.000	0.102	− 0.036	26.1	2.03	1.00	0.078	1.10	0.181
G	1.500	0.102	− 0.037	26.0	1.79	1 00 (taken as unit)	0.069	1.04	0.089
H	2.000	0.102	− 0.033	26.5	2.83	1.02	0.109	1.02	0.051
I	2.750	0.102	− 0.031	26.7	3.53	1.03	0 136	1.01	0.029

Substituting these in equations (3), and remembering that the resulting equations hold for all values of θ, we obtain

$$k_1 = \tfrac{1}{2}\frac{T}{E}(1-\sigma), \text{ or } = \frac{T}{4}\frac{\lambda + 2\mu}{\mu(3\lambda + 2\mu)} \quad . \quad (5)$$

and a pair of simultaneous differential equations :—

$$f + r\frac{d f}{d r} + 2\phi = \frac{A}{\lambda^1 + 2\mu}\frac{1}{r}$$

$$\phi + r\frac{d \phi}{d r} + 2f = -\frac{A}{\mu}\frac{1}{r}.$$

Solving these simultaneous differential equations, and applying the resulting integrals and also the value of k_1 (5) to the assumed equations of displacement (4), we have

$$u = \left(-k_4 r - \tfrac{1}{2}\frac{A}{\mu}\frac{1}{r} + k_3\frac{1}{r^3}\right)\cos 2\theta + \tfrac{1}{2}\frac{T}{E}(1-\sigma) r + k_2\frac{1}{r}$$

$$v = \left(k_4 r + \tfrac{1}{2}\frac{A}{\lambda^1 + 2\mu}\frac{1}{r} + k_3\frac{1}{r^3}\right)\sin 2\theta,$$

in which k_3 and k_4 are integrating constants.

Comparing these with the boundary conditions given in (1), we have

$$k_4 = -\tfrac{1}{2}\frac{T}{E}(1+\sigma), \text{ or } = -\frac{T}{4\mu}.$$

Again, with boundary conditions (2), and on substituting ordinary elastic constants in place of λ^1, we obtain :—

$$k_2 = \frac{a^2}{4\mu} T.$$

$$A = -\frac{4 a^2 (\lambda + \mu)}{3\lambda + 2\mu} T.$$

$$k_3 = -\frac{a^4}{4\mu} T.$$

Thus we can find all the constants involved in the equations for u and v.

From the values of u and v thus found we can easily deduce the value of the required component strains :—

$$\left.\begin{aligned} e &= \left(\frac{1}{4\mu} - \frac{2(\lambda+\mu)}{(3\lambda+2\mu)\mu}\frac{a^2}{r^2} + \frac{3}{4\mu}\frac{a^4}{r^4}\right) T\cos 2\theta + \frac{T}{4}\frac{\lambda + 2\mu}{\mu(3\lambda+2\mu)} - \frac{T}{4\mu}\frac{a^2}{r^2} \\ f &= \left(-\frac{1}{4\mu} + \frac{\lambda}{(3\lambda+2\mu)\mu}\frac{a^2}{r^2} - \frac{3}{4\mu}\frac{a^4}{r^4}\right) T\cos 2\theta + \frac{T}{4}\frac{\lambda + 2\mu}{\mu(3\lambda+2\mu)} + \frac{T}{4\mu}\frac{a^2}{r^2} \\ c &= \left(-\frac{1}{2\mu} - \frac{1}{\mu}\frac{a^2}{r^2} + \frac{3}{2\mu}\frac{a^4}{r^4}\right) T\sin 2\theta \end{aligned}\right\} \quad (6)$$

Substituting these in the stress-strain equation, we obtain the required component stresses as follows :—

$$\left.\begin{aligned} P &= \frac{T}{2}\left(1 - \frac{a^2}{r^2}\right) + \frac{T}{2}\left(1 - 4\frac{a^2}{r^2} + 3\frac{a^4}{r^4}\right)\cos 2\theta \\ Q &= \frac{T}{2}\left(1 + \frac{a^2}{r^2}\right) - \frac{T}{2}\left(1 + 3\frac{a^4}{r^4}\right)\cos 2\theta \\ R &= -\frac{T}{2}\left(1 + 2\frac{a^2}{r^2} - 3\frac{a^4}{r^4}\right)\sin 2\theta \end{aligned}\right\} \quad (7)$$

As might be anticipated, the radial normal stress (P) and the shearing stress (R) have not much importance.

The important one is the transversal normal stress (Q); and its maximum value is

$$Q = 3\,T \text{ at the points } r = a, \ \theta = \frac{\pi}{2} \text{ or } \frac{3\pi}{2}.$$

Thus, on the periphery of the hole where it is cut by the central transverse section, there occurs a tensile stress, the intensity of which is three times that of the mean tensile stress.

The distribution of the stress on the transverse section through the centre of hole is given by the relation

$$\text{Longitudinal stress} \quad Q = \frac{T}{2}\left(2 + \frac{a^2}{r^2} + 3\frac{a^4}{r^4}\right)$$

$$\text{Transverse stress} \quad P = \frac{3}{2} T \left(\frac{a^2}{r^2} - \frac{a^4}{r^4}\right)$$

The distribution of stress worked out from these equations is shown in the diagram (Fig. 2), in which T is taken as unity, and the diameter of the hole as $\frac{3}{4}$ in.

The diagram shows that the longitudinal stress tends very rapidly to its mean value; even where $r = 1\frac{1}{2}$ in.—*i.e.*, at the point at a distance of twice the diameter—the stress is about 1.0372 the mean. Therefore, the assumption made above, that the plate is of an infinite extension, is not absolutely necessary, and consequently the equations found

* Love's "Mathematical Theory of Elasticity" (Second Edition), pages 135 and 205.

are applicable without significant error even in case of rivet-holes closely pitched.

2. Experimental Determination with an India-Rubber Model.

For the purpose of verification the author made an experimental determination by means of an india-rubber model.

In making such an experiment it must not be assumed that homogeneous materials would be strained in the same way when subjected to the same kind of forces (such an assumption is often made erroneously). As pointed out by Sir Gabriel Stokes,* and also by Mr. Michell,† that physical quantity, the similarity of which holds with two different materials, is stress, and not strain. This may be seen at once from the fact that in the equations (7) no elastic constants occur, while they are contained in the equations (6).

In view of this, the author made the following three operations :—

(*a*) Found the elastic constants of the india-rubber used as the model.

(*b*) Measured the longitudinal and transverse strains from the photographs of the model in the loaded and unloaded states.

(*c*) Calculated the stress by the stress-strain equation.

The dimensions of the india-rubber model used were as follow :—

Length	nearly 2 ft.
Breadth	5.985 in.
Thickness	0.154 in.
Diameter of hole	0.751 in. = $\frac{3}{4}$ in.
Load applied...	20.1 lb.

The measurements taken along the transverse section through the centre of the hole, and the results of the calculation, are shown in Table I., page 281. For the sake of comparison the theoretical values are also given. They are, moreover, shown graphically in Fig. 2.

The india-rubber used in the author's experiment, as might be anticipated with this kind of material, had not perfect elastic properties, the stress-strain relation being

$$218 \text{ lb. per sq. in.} = \frac{\text{stress} - 3.6 \text{ lb. per sq. in.}}{\text{strain}},$$

and Poisson's ratio ranged from 0.466 to 0.357, for the stresses from 6.77 lb. per square inch to 109.6 lb. per square inch. Therefore, neglecting the small deviation in Young's modulus and taking the mean of Poisson's ratios, the author assumed the values of λ^1 and 2μ as shown at the top of the table. It will be observed in the table that the transverse strains are negative, whereas the corresponding stress is tensile. This fact shows that if strains in one direction only were compared, the conclusions reached would be very erroneous.

3. Lines of Displacement, Lines of Principal Stress, and Stream-Lines.

The false assumption that the stress-lines in a strip subjected to end tractions would be similar to the stream-lines of a fluid obtained with a similarly shaped specimen fed at the ends, has been made by some experimenters.

In the course of a controversy in ENGINEERING last year, this assumption was disproved, and it was pointed out that, in order that the direction of stream-lines may coincide with that of stress-lines, another relation is necessary between the displacements—viz.,

$$u^2 = v\,f(y) - v^2$$

in addition to the conditions

$$\frac{d\,u}{d\,x} + \frac{d\,v}{d\,y} = 0$$
$$\frac{d\,v}{d\,x} - \frac{d\,u}{d\,y} = 0.$$

Now the latter conditions are those for irrotational and solenoidal strain—*i.e.*, pure shearing strain, which cannot be expected to arise in cases like this.

As will be seen from the result of the solution arrived at by the author,

$$\Delta = \frac{T}{2\,\mu\,(3\lambda + 2\mu)} \cdot \frac{\lambda + 2\mu}{} - \frac{\lambda + 2\mu}{\mu\,(3\lambda + 2\mu)} \cdot \frac{T\,a^2 \cos 2\theta}{r^2}$$

$$2\,\omega = \frac{\lambda + \mu}{\mu\,(3\lambda + 2\mu)} \cdot \frac{4\,T\,a^2 \sin 2\theta}{r^2}.$$

Thus, neither the dilatation nor the rotation vanishes. Hence even the fundamental conditions assumed in the stream-line analogue are not fulfilled.

Moreover, some engineers seem to believe that the relative closeness of stress-lines would be the direct and quantitative indication of the stress intensity. The values of the principal stresses, of course, can be found if the lines of principal stress are completely determined. But their closeness is not the quantitative indication of the stress. This can easily be shown as follows :—

The stress equations of equilibrium referred to the lines of principal stress as curvilinear co-ordinates are :—

$$h_1 h_2 \frac{d}{d\,\xi}\left(\frac{N_1}{h_2}\right) + N_2\,\omega_\xi = 0,$$

$$h_1 h_2 \frac{d}{d\,\eta}\left(\frac{N_2}{h_1}\right) + N_1\,\omega_\eta = 0,$$

where N_1 and N_2 are principal stresses in the directions of the tangents to the ξ and η curves respectively; ω_ξ and ω_η are the curvatures of ξ and η curves respectively,

$$h_1^2 = \left(\frac{d\,\xi}{d\,x}\right)^2 + \left(\frac{d\,\xi}{d\,y}\right)^2$$

and

$$h_2^2 = \left(\frac{d\,\eta}{d\,x}\right)^2 + \left(\frac{d\,\eta}{d\,y}\right)^2$$

If the closeness of one set of stress-lines (say ξ) indicates the stress, the ξ tube of stress must transmit constant tension or compression, in which case

$$\frac{d}{d\,\xi}\left(\frac{N_1}{h_2}\right) = 0,$$

and then we have

$$N_2 \omega_\xi = 0.$$

Hence, in order to fulfil the supposed condition, either N_2 or the curvature of the ξ curves must vanish. Thus, only in the case in which the other principal stress vanishes, or where the stress-line is straight, is the assumption valid.

Lastly, however theoretically absurd it may be, it will be interesting to make a comparison of the two results—namely, the result arrived at under the assumption that the stress-lines and stream-lines would be coincident and that their closeness indicates the stress, and that obtained by the mathematical solution.

For flow in a plane of an infinite extent, having a circular cylinder perpendicular to the plane, the stream function is

$$\psi = u\left(r - \frac{a^2}{r}\right)\sin\theta.$$

Therefore the closeness of ψ at the points in the periphery of the cylinder where it is cut by the transverse section through the centre of the cylinder is

$$\left(\frac{d\,\psi}{d\,r}\right)_{\substack{\theta = \frac{\pi}{2} \\ r = a}} = \left| u\left(1 + \frac{a^2}{r^2}\right)\sin\theta \right|_{\substack{\theta = \frac{\pi}{2} \\ r = a}} = 2u$$

and the same at an infinite distance is

$$\left(\frac{d\,\psi}{d\,r}\right)_{\substack{\theta = \frac{\pi}{2} \\ r = \alpha}} = u.$$

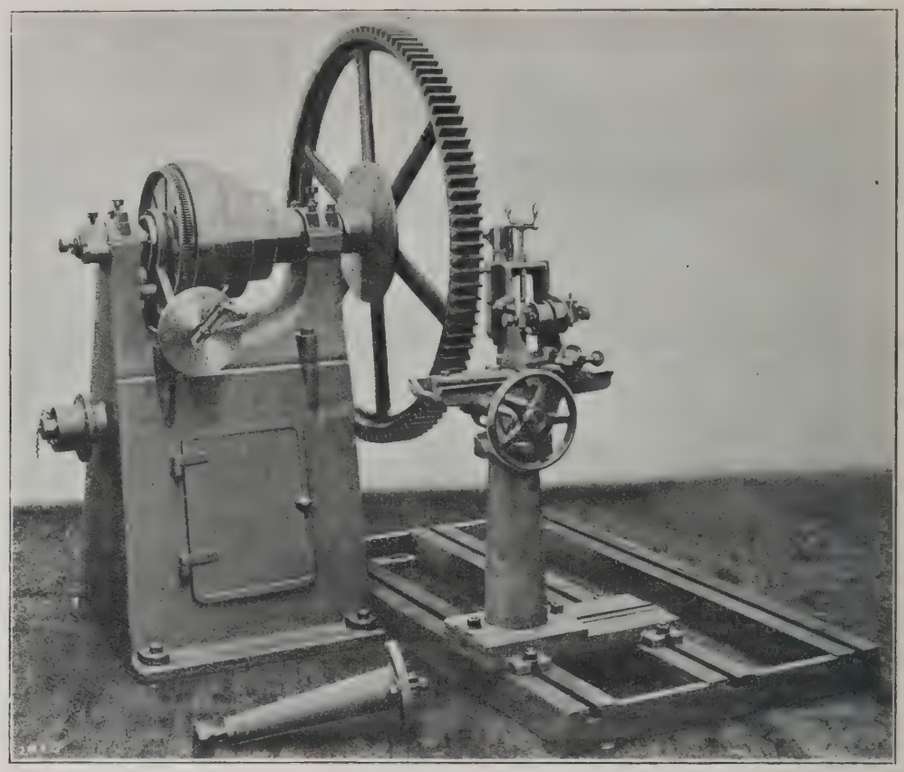
Thus the closeness at the above-mentioned point is twice the average closeness, whereas the maximum longitudinal stress at the same point as found by a mathematical solution is thrice the mean tensile stress.

* *Philosophical Magazine*, Series V., vol. xxxii.

† London Mathematical Society's Proceedings, vol. xxxi.

MACHINE FOR CUTTING GEAR PATTERNS.

CONSTRUCTED BY MESSRS. A. RANSOME AND CO., LIMITED, NEWARK.



We illustrate in the view above a machine which has been designed by Messrs. A. Ransome and Co., Limited, Stanley Works, Newark-on-Trent, and is built by them for cutting teeth on the patterns of spur or bevel-wheels of any diameter up to 6 ft., and of any pitch. The same machine can also be used for turning the wheel patterns before cutting the teeth. The mandrel runs in long adjustable gun-metal bearings, and is fitted, as shown in the view, with a four-speed cone, which comes into play when the machine is used as a lathe. Double-thrust ball-bearings take up the end play of the spindle.

A dividing apparatus fixed to the headstock is provided for accurately cutting the teeth; it can be adjusted for teeth of all numbers up to 50, and in some cases up to 312. There is no difficulty in fitting the machine with dividing-plates for other numbers of teeth. The dividing apparatus, which is thrown out of gear when the machine is used as a lathe, consists of a worm-wheel 17 in. in diameter, driven by a worm with dividing-plate for the required number of teeth. The plate is made with concentric circles, each circle having differently spaced holes, there being provided an adjustable stop for accurately measuring the exact number of holes required for the various numbers of teeth.

The teeth are cut by means of a spindle running in ball-bearings, fitted with a steel cutter-holder, and driven by a light belt from the overhead countershaft. The spindle is supported on a carriage having a vertical

PRECISION MIXING VALVE FOR LARGE GAS-ENGINES.

THE BRITISH HIGH-POWER GAS-ENGINE COMPANY, LONDON.

Fig. 1.

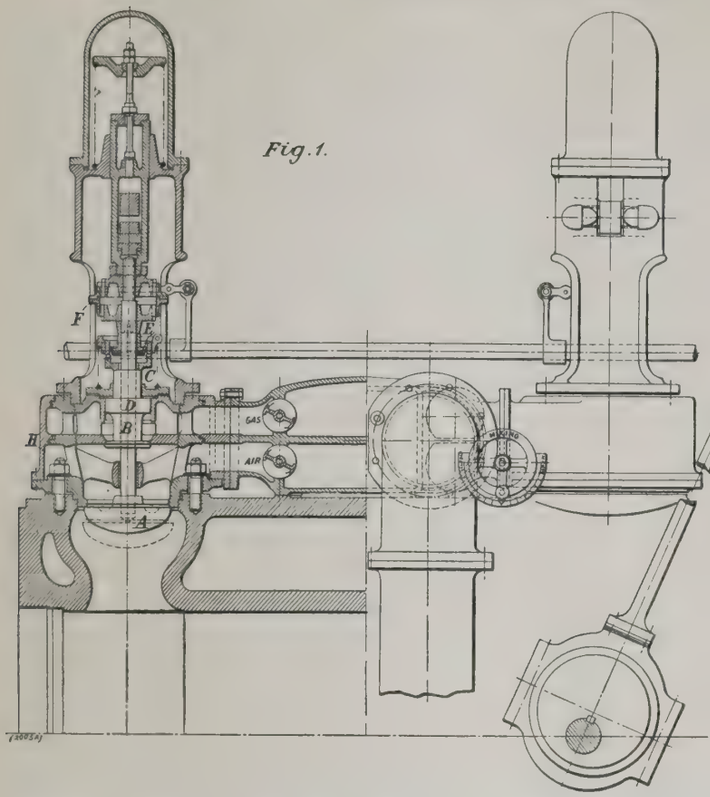
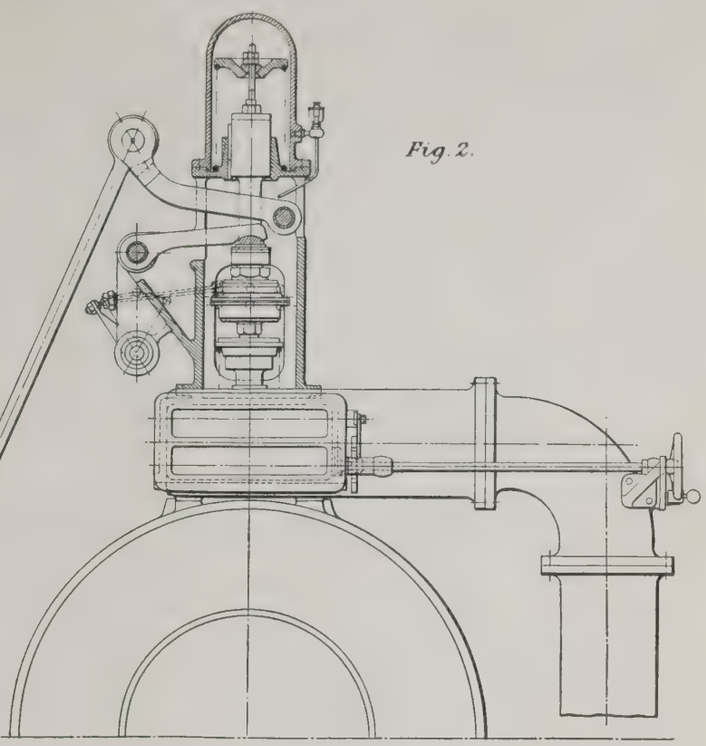


Fig. 2.



adjustment for setting the cutter exactly central with the wheel, and a fine screw adjustment for setting to the exact depth of tooth. The carriage is traversed by means of a rack and pinion operated by a hand-wheel. The apparatus is also made with a swivelling motion for cutting bevel or mitre-wheels ; it can be easily adjusted on the bed to suit wheels of various dimensions.

PRECISION MIXING VALVE FOR LARGE GAS-ENGINES.

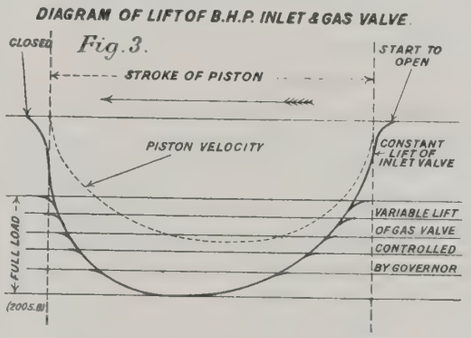
On this page we illustrate an arrangement of gas and air-valves for large gas-engines which has recently been introduced by the British High-Power Gas-Engine Company, of 3, London Wall Buildings, E.C. The engine is governed by cutting off the gas supply at a later or earlier period of the stroke in accordance with the load on the engine. With this plan of governing it is usual to have the gas and air-valves arranged side by side and operated by separate gears. In the new arrangement, illustrated in Figs. 1 and 2, the main valve is shown at A, with the gas-valve above it at B. This second valve is an easy sliding fit on the main valve spindle, and is pressed up against its seat by the spring indicated at C. Just above the valve B its hollow spindle is enlarged to form a plunger D fitting into a dashpot, which serves to deaden the return of the valve to its seat. A small non-return inlet valve, not shown in the figure, is provided in the cover of the dashpot. The valve B is opened by the descent of the main spindle, which carries with it a piston E, fitting into a second dashpot, which is also cast in one with B. The piston E, as already stated, is carried down with the main valve A when the latter opens. It is not, however, rigidly coupled to the spindle of the latter, but its position relatively to the same is alterable by the governor, which rotates a sleeve F which is screwed internally with right and left-handed threads. If the governor moves this sleeve in one way, the plunger E is lowered relatively to the main spindle A, and consequently the gas-valve B is opened earlier. A contrary rotation raises E relatively to the spindle A ; the gas-valve opens, therefore, later. The gear which operates the valves is shown in Fig. 2, and consists of an eccentric and a rocking lever. Such an eccentric gives a slow opening to any form of drop-valve, but in this case it is the main valve A which alone is operated direct by the eccentric. The gas-valve, on the contrary, is carried down with the latter after the latter has already made part of its travel and acquired a considerable velocity. In consequence the valve B always opens very rapidly.

The arrangement of the one valve above the other, instead of side by side, reduces greatly the clearance space in which gas may lodge.

It has further to be noted that the gas-valve with

DIAGRAM OF LIFT OF B.H.P. INLET & GAS VALVE.

Fig. 3.



the arrangement described has in all cases its maximum opening, about the same time as the engine piston has its maximum velocity. This is well shown by Fig. 3, which shows the travel of the gas and main valve for all points of the piston stroke. The main inlet-valve has a constant lift, and at full load the gas-valve begins to open when the piston has acquired about two-thirds of its maximum velocity. The valve closes again just before the piston reaches the end of its stroke. At half-load the gas-valve both opens later and closes earlier, and similarly at still lower loads. With the corresponding arrangement of gas-valves controlled by the governor in use on some other types of engine, the opening of the gas-valve always commences at the same point of the stroke, but closes earlier as the load falls. At light loads, therefore, the piston is moving but slowly the whole time the gas-valve is open, and thus the suction in the gas is so small that the charge drawn in is likely to be affected by trivial changes in the gas pressure or the like. Since the gas-valve is loose on the main valve stem, each can be kept tight independently of the other. Both valves are accessible for inspection and cleaning, by lifting the casing H, and this operation does not necessitate the disconnection of the adjustable parts. The sleeve having the right-and-left-handed thread has its weight compensated by a counter-balance keyed on the governor-shaft. The load on the latter is therefore always small, and very regular running is secured.

The makers of the engine, Messrs. Fraser and Chalmers, Limited, of Erith, have largely based their designs on the Nuremberg type, but, as explained above, have modified the gas and inlet-valve arrangements. Changes have also been introduced into the lines of the engine-framing, so that the heavy stresses are taken by straight instead of curved members. We may further add the piston faces are curved instead of flat. This plan has the advantage of giving the maximum of resistance against stresses, produced either by the pressure of the exploding gases, or by the expansion of the piston by heat, together with a complete freedom from casting strains. The piston is, of course, water-cooled internally, a flexible pipe system being used for the supply, thus avoiding the use of glands and stuffing-boxes.

THE JAPANESE NAVY.—A fifth large basin has been commenced at Yokosuka ; it is to be completed by 1914, and it will be capable of receiving vessels with a displacement of 30,000 tons. Electric cranes have been supplied to the Yokosuka, Kure, and Sasebo arsenals.

CONTRACTS.—We are informed that amongst other contracts which Messrs. Escher Wyss and Co., hydraulic engineers, of Zurich, Switzerland (London office : 109, Victoria-street, Westminster), have secured are an order from the Rio de Janeiro Light and Power Company for two 19,000-horse-power tangential wheels, the largest of their kind, to work under a head of 950 ft. This latter contract comprises also delivery of Messrs. Escher Wyss and Co.'s patent oil-pressure governors, as well as the two pipe-lines complete with valves, &c. Further orders have been received from the Tata Hydro-Electric Power Company, Bombay, for four 13,200-horse-power and two 1000-horse-power high-pressure turbines designed for a head of 1680 ft., and from the Fuji Cotton Mill, Japan, for four 3000-horse-power and one 100-horse-power turbines designed for a head of 280 ft. These orders also include delivery of the necessary number of Messrs. Escher Wyss and Co.'s governors. Orders have been coming in steadily from Japan, Canada, and other countries, and the total output of water-turbines ordered from Messrs. Escher Wyss and Co.'s in the course of this month exceeds 130,000 horse-power.

THE LATE MR. HARTLEY MOTHERSOLE.—The death is announced of Mr. Hartley Mothersole, formerly joint secretary of the Shipbuilding Employers' Federation, Newcastle, at the age of 42. Mr. Hartley Brinkley Newton Mothersole was educated at Trinity College, Cambridge, where he obtained a third class in Part I. of the Law Tripos in 1890, and a second class in Part II. in the following year. He afterwards took the LL.M. degree, and was called to the Bar at the Inner Temple in 1893. He practised for some years on the South-Eastern Circuit, and served as secretary of the Home Office Departmental Committee on the Procedure of Royal Commissions and of the Royal Commission on Trade Disputes and Trade Combinations. In 1909 he was appointed joint secretary of the Shipbuilding Employers' Federation, Newcastle, and of the North-East Coast Shipbuilding and Engineering Association. This position he resigned in the following year. As joint secretary with Mr. T. Biggart of the former body, Mr. Mothersole took a prominent part in the negotiations which passed between the employers and the men during the boiler-makers' dispute last year.

INDUSTRIAL NOTES.

By the end of last week the country had apparently settled down to its normal condition, at any rate with the exception of South Wales, which was still in a state more or less of disorder. The lawlessness there seemed to have degenerated into brutal treatment of Jewish traders, in spite of the presence of large bodies of infantry, cavalry, and police. The numerous strikes of transport workers which have been in unpleasant evidence since the middle of June can, however, really be said to have ended when the Liverpool tramway difficulty was overcome. This took place on Thursday in last week, the uniformed men who had struck being reinstated by the general manager of the tramways in accordance with the decision arrived at on that day, and all the transport workers resumed their labours with the exception of 30,000 dockers who had been locked out. The case of these men was, however, put right during the afternoon, when the shipowners decided to allow the men to resume work at seven o'clock on the following morning, on the condition that all the men went in. One thing, among others, brought prominently forward during the late strikes was that so-called peaceful picketing should in future be prohibited by law, and it is particularly desirable that this part of the Trades Disputes Act should be repealed. Under the present condition of things there evidently can be no such thing as peaceful picketing, and any attempt to recognise it must lead to trouble in the future. Very strong feeling has been expressed on the subject in various parts of the country, and the Associated Chambers of Commerce have started a movement to have picketing prohibited and the Trades Disputes Act generally amended.

Renewed trouble appears likely on the Great Eastern Railway, owing to complaints that certain grades of men are not being reinstated in the positions which they held before the strike. It is claimed by the railway company, however, that they are loyally carrying out the terms of the settlement of the men's leaders. The joint executive committee of the railway trade unions have the matter in hand, and the representatives of the Board of Trade have offered their services to aid in getting the matter settled.

On Friday last a special meeting of the Highways Committee of the London County Council was held to consider the demands of the men employed in the County Council's tramway service. The result was an interview with the representatives of the Amalgamated Association of Tramway and Vehicle Workers, which ended in a better understanding between the contending parties. Thus all danger of a strike is removed, at any rate for the present. It was also agreed that a conciliation board should be called, on or before October 9, if the men desire it. The Conference was of a private nature, but it is understood that the concessions demanded by the men were well received. They were as follow :—The minimum wage for adult labourers to be 30s. per week. Rates of pay to be 5s. per day on entering the service and for the first four months, 5s. 6d. per day for the second four months, 6s. per day after eight months, and 6s. 6d. per day after twelve months. Hours of labour to be eight per day, or forty-eight hours per week. Rates of pay for all public holidays to be time and a half, with the exception of Christmas day, which shall be paid at the rate of double time, or in lieu thereof three days' holiday per man per annum. All men called upon to work upon their recognised weekly rest-day to be paid at the rate of time and a quarter. All overtime—that is to say, all time worked over schedule time (as per time-board)—to be paid for at the rate of time and a quarter. All men promoted to positions as inspectors, &c., whilst on probation, to be paid at the rate of 7s. per day, the period of probation not to exceed one month. A court of appeal to be established to deal with cases of dismissal from the service of the Council.

Although peace was practically arranged by the middle of last week, a conference was held on Saturday between the leading officers of the London tramway system and a deputation from the men, at which the following matters were discussed :—Stoppages for lost tickets, spread-over time, deferred pay, payment for dental examination and treatment, and suspensions from work. A future conference will be devoted to the discussion of the ticket system. On this point it is contended that the continued increase in the number of tickets and the system of transfer tickets is so complicated that the men are not able to do their work properly. It appears that matters of detail are being arranged in a satisfactory manner.

At the Royal Commission to inquire into the working of the Railway Conciliation Act, which met on Monday last, the first evidence to be heard was that of the men, and it was left to trade unions to prove their case against the Conciliation Boards. It is thought that this evidence will occupy some weeks, after which the case for the companies will be taken. It is expected that the Commission will be able to present their report at the end of October, or soon after Parliament has reassembled.

The actual terms of the agreement of the London dock dispute, the settlement of which was announced last week, are the following :—(*a*) The day's work shall be any consecutive twelve hours. (*b*) The week's work shall be six days. (*c*) For lightermen the week's pay shall be 48s., with 1s. an hour overtime after a day of twelve hours. Any lighterman called for work between 4 a.m. on Sunday and 4 a.m. on the following day shall be paid 9s. for the shift or part of a shift. (*d*) For tug captains and tug foremen an increase at the rate of 10 per cent. upon the existing wages shall be paid. Overtime shall be paid for at the rate of 1s. 1d. per hour. Any tug captain or tug foreman called for work between 4 a.m. on Sunday and 4 a.m. on the following Monday shall be paid 9s. 6d. for the shift or part of a shift. (*e*) The rate of pay to those roadsmen now receiving 5s. a day shall be increased to 6s. for a day of twelve hours. (*f*) The usual public holidays to be paid for. (*g*) Travelling expenses actually incurred to be paid. (*h*) Where absolutely necessary, two consecutive shifts may be worked, but these must be followed by two consecutive shifts off. (*i*) Any question arising as to the interpretation of this agreement shall be referred to the Board of Trade for decision.

On Saturday last the Liverpool Docks began to present their usual appearance, as there was a general resumption of work. At seven o'clock in the morning large crowds waited at each dock for the gates to be opened, but although as many men were engaged as were required, many had to be turned away owing to the congested state of the sheds and quays, which made it impossible to proceed with the discharging of some of the vessels. At some of the docks only four gangs were required where usually eight would have been employed. It was not expected that the full number of men would be needed for three or four days. There was a similar state of congestion at the railway stations. At some of the stations the congestion was so great that at 10 o'clock on Saturday morning it was decided to close down, although hundreds of wagons and other vehicles were waiting. In coal-trimming much excellent work appears to have been done by clerks, so much so, in fact, as to win the admiration not only of the soldiers who guarded the ships on which the work was done, but also of the strikers themselves.

Trafalgar-square was the scene last Saturday afternoon of a demonstration against what the labour leaders are pleased to call "the unwarrantable extension of military authority and the unconstitutional imposition of martial law by the arbitrary ukase of the Home Secretary." The ineptitude of such high-flown language is, of course, perfectly clear to the average normally-minded man ; but, unfortunately, the strike agitators have not normal minds, and either will not or cannot see the absurdity of their position. The military have only been used to protect life and property, and had they not been so used it is not pleasant to think what would have been the result, for there is little doubt that an orgie of outrage and disorder would have swept over the whole country. To say that the appearance of the soldiers made matters worse is to display a foolishness of mind which would be amusing if the result had not been sometimes grave mischief. No peaceable, law-abiding person objects to soldiers and police protecting property in times of disorder and riot. It is those who do not want their lawless practices interfered with who hate the military. The soldiers were, during the recent strikes, the means of saving the situation, and the Home Secretary is to be commended on his promptness in grasping the true situation, and deserves the thanks of all law-abiding citizens.

It is intended, at the annual conference of the Miners' Federation of Great Britain, to be held at Southport in the first week of October next, that the Lancashire and Cheshire Federation will propose a resolution in favour of demanding a uniform wage for miners, to be secured by means of a general strike if necessary. What the outcome of this may be remains to be seen. The Lancashire and Cheshire miners are strong, their numbers amounting to about 100,000. A resolution in favour of a minimum wage was, of course, passed two years ago, but it was then rather looked upon as mere talk. It is now thought, however, that at any rate the Lancashire and Cheshire miners are in earnest, and it is regarded as probable that, if they do what is threatened, the Welsh miners and those of Northumberland, Durham, and Scotland would support them. As to the wages, as much as 7s. a day has been hinted at, whereas the Scottish miners are, it is said, inclined to demand 8s. a day. The wage at present earned by thousands of miners is not more than 5s. a day. The coalowners state that they have been so hard hit by the Eight-Hours Act that they cannot give any increase, particularly in view of what the National Insurance Bill threatens them with in the near future. In South Wales at the present time a certain section of the miners are doing their best to bring about a general strike, and a conference is to be held at Cardiff to-morrow in order to discuss the subject. In the Midland coalfields trouble is expected soon to arise over the employment of non-unionists ; at one pit in the Derbyshire and Nottinghamshire coalfields the men are reported to have received the permission of their union to give a fourteen days' strike notice unless the employment of non-union men ceases. The movement appears also to be spreading through this and other coalfields. It is said that several of the large companies are already declining to employ non-union men. If this is really the case, it shows an amount of trade-union tyranny which cannot be too strongly condemned—a tyranny to which the masters will surely regret giving way.

The Grangemouth dockers are still on strike, having rejected an offer of 7½d. per hour from the shipowners. The men say they are determined to remain on strike until they obtain 8d. and 10d. per hour for day and night work respectively.

Some very interesting particulars were given in a letter to the *Times* of the 29th ult., from Mr. A. Kaye, Butterworth relating to the North-Eastern Railway Company and the trade unions. We gather from this that for some years past the North-Eastern Railway Company have, in accordance with the usual practice of the employers in the North, recognised trade unions, which in their case has mainly applied to the Amalgamated Society of Railway Servants, as they have a much larger membership amongst railwaymen on the line than any other union. By their rules, if any question arises between a railway company and its men which negotiation fails to settle, the society has first to make an offer of arbitration. Upon refusal of this, a ballot of members is taken to decide whether a strike shall be entered upon. Should the ballot favour a strike, the notices of intention to cease work are handed in to the company, the length of notice being determined by the terms of the employment. Dispute, negotiation, arbitration, ballot, strike notices, and cessation of work are therefore provided for in the rules of the society. In face of this the Amalgamated Society men struck during the late trouble, their actions being thus compared with their rules :—

Rules of the Amalgamated Society of Railway Servants.	How far Observed towards the North-Eastern Railway Company.
1. Dispute.	Entirely disregarded.
2. Negotiation.	Ditto
3. Offer of arbitration.	Ditto
4. Ballot.	Ditto
5. Strike notice.	Ditto
6. Cessation of work.	Yes, after 24 hours' ultimatum, which did not apply to the North-Eastern Railway.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, August 23.

AFTER several months of comparative dulness the demand for machinery business has began to pick up, and large orders for shop equipment have been placed for prompt execution. Several systems are now making up their estimates as to what kind of equipment would best answer their purpose. In this regard Western railway systems are in the lead in the equipment of shops. Some shops have been recently constructed, and are located at points in the Far West which have not heretofore been thought of as shop locations. Within a few days large orders for structural material have been placed ; among them may be noted 6000 tons taken by the Carnegie Company for the new naval colliers. The placing of contracts for 4000 steel cars by the Erie Railroad has resulted in sending very large orders to the steel mills for plates. The Panama Canal Commission have placed supplementary orders for steel plates and castings amounting to 14,000 tons. Besides this the Bethlehem Steel Company has secured an order for 6500 tons of rails for the Panama Canal. After a long delay the material for the two Pittsburg bridges has been ordered to be made by the mills represented by the American Bridge Company. A sky-scraper building is to be erected in Pittsburg, twenty-four stories high, which will call for 7000 tons. The Westinghouse Electric Company and the General Electric Company will use 4000 tons of material for new shops at Pittsburg and Erie, Pa. New hotels are to be built at Cleveland, Ohio, which will take 6500 tons. Japan has ordered rails amounting to 4100 tons, and Mexican contracts amount to 7500 tons. Good-sized orders have also come from Cuba. The Southern Railway Company has ordered 5000 tons of open-hearth rails, which will be made at Johnstown, Pa. The 'Frisco system on the Pacific Coast has ordered 4500 tons.

ELECTRIC TRACTION IN SWITZERLAND.*

By E. HUBER-STOCKAR, of Zurich.

(*Concluded from page* 271.)

Lötschberg.†—(Figs. 34 and 35, page 286.) (No. 15 on tables.)‡—Some explanation must be given to prevent confusion of the different names of the railway used with reference to the particular line to be described.

The Berner-Alpenbahn, officially called Bern-Lötschberg-Simplon, or B.L.S., is a limited company with a share capital of about 44, and a consolidated debt of about 30 millions of francs (in 1909). This company is constructing a normal-gauge double-track railway, which will be the most direct access to the Simplon, and, consequently, to Italy from the north-western part of Switzerland and those more central districts that gravitate towards Bern and the Bernese lake district. It will be of prime importance to international passenger and freight traffic, as it considerably shortens the distance of travel between important places. For all traffic passing Biel, the reduction in distance from Milan is 54 km., and for all traffic passing through Bern it is 74 km., or about 12.5 and 18 per cent. respectively, of the distance at present.

The new railway is noted for its tunnel across the northern main range of the high Alps. This tunnel, noteworthy of the short time taken for its piercing, is 14,536 m. (9 miles) long; that is to say, only 463 metres shorter than the St. Gothard Tunnel. The new railway, still in course of construction, and opened probably within about two years from now, has a length of 60.4 km. between Frutigen and Brigue, and will resemble the St. Gothard Railway a good deal in general character. The smoke from steam-locomotives would, as it does on the St. Gothard, interfere with the comfort of travellers and inconvenience the operation. Electric traction has therefore been, from the very beginning, a *sine quâ non* with the B.L.S. Company.

The access to the northern end of the new railway from the system of main lines is a railway from Spiez, on the Lake of Thun, to Frutigen, 13.4 km. long, and operated by steam since 1901. This railway will be, or has already been, absorbed, and has been equipped electrically by the B.L.S. After careful consideration, single-phase traction with high voltage (15,000) and low frequency (15) was adopted, and towards the end of 1908 orders were placed with A.E.G. for one locomotive of 1600 horse-power (Fig. 37, page 286, and Fig. 53, page 287), with M.F.O. and S.S.W. jointly for three passenger motor-cars of 450 to 900 horse-power each, one locomotive, of 2000 horse-power, and the equipment of the line. The three motor-car equipments have been made by S.S.W., the cars by Schlieren (Figs. 38 to 43, Plate XXXVIII.), the large locomotive by M.F.O., its mechanical part by Winterthur (Fig. 36, page 286, Figs. 44 and 45, page 290, and Figs. 46 to 52, Plate XXXVIII.). The mechanical part of the A.E.G.'s locomotive is by Krauss and Co., of Munich.

The electrification of this short line of access, Spiez-Frutigen, was undertaken as an experiment, and, in case of success, as a preparation of the means for the electric traction on the whole line from Spiez to Brigue, 73.7 km. in all. The electrification of the Spiez-Frutigen line was completed near the end of 1910, and exclusive electric operation has since been commenced. The success of this electrification has been such that it will be extended to the whole line and on the same system. For this reason the Spiez-Frutigen electrification deserves special consideration as the first section of a main railway, furnishing in certain respects exactly the problem of the St. Gothard electrification—namely, long and heavy grades of 2.7 per cent., and heavy trains requiring 2000 horse-power and more.

The load put on the power-stations will be of a similar character to that of the St. Gothard Railway, with reference to which some remarks will be made later. In regard to the Lötschberg, more definite figures have not yet been published, and will not be so until the traffic has acquired a definite and steady nature and volume. Nevertheless, the power-supply question, with reference to the Lötschberg, is in a sound way of solution, by virtue of the controlling interest of the State of Bern, both in the B.L.S. and in the Bernische Kraftwerke A.G., who carry on hydraulic-power development and electric-power supply in the Canton of Bern on a very large scale and in a progressive spirit.

The electric current for the present service on the Spiez-Frutigen line is supplied from the above-mentioned power company's works near Spiez,* called Kanderwerk, which supplies current to the B.T.B. (No. 3).† In the Kanderwerk (also called Electricitätswerk Spiez) there are, for the special purpose of the Spiez-Frutigen electric traction, two hydro-electric sets of 3200 horse-power each, generating single-phase alternating current at a voltage of 15,000 and a periodicity of 15; that is to say, a current which requires no further transformation nor conversion to suit directly the motor-cars and locomotive equipments. The power-supply from the Kanderwerk is temporary. The Bernische Kraftwerke have started the operation of a new power-station at Kandergrund, a place situate near the B.L.S. Railway, not far from its centre of maximum power demand for traction on the northern slope. There are already working two sets of 4000 horse-power each for general power distribution in connection with the other power-stations of the Bernische Kraftwerke A.G., at Spiez (aggregating about 20,000 horse-power), and at Hagneck (aggregating about 8000 horse-power). In the future, however, the supply of power to the northern slope of the B.L.S. will be from the power-station at Kandergrund, while the southern slope will be supplied from another (private) company's works on the Rivers Rhone or Lonza.

A more detailed description of the works in Spiez, which have utilised the power of two different rivers (the Kander and the Simme, the water of the latter being conducted in an aqueduct across the valley of the former), and have installed water-power storage in an artificial lake above Spiez, must be left to the discussion.

The overhead contact-line of the Spiez-Frutigen line is of most substantial design, all supports being of steel. The devices for shunting the supply of current to the individual sections of line or railway stations, the devices for protection from lightning (playing, after all, according to experience, a rather harmless rôle), and the electrical instruments for measuring or supervision purposes, are very complete and nicely housed in a style that may appear luxurious in comparison with most other electric railways in general, but is in reality only up to the general standard of installation on main railways. The equipment of the line is the outcome of a thoroughly up-to-date judgment of things on the part of the B.L.S. Railway Company and their consulting engineer. The motor-cars and locomotives are well represented by illustrations and plates.*

The general data of the motor-cars and locomotives are found in Table VII. The brakes of all vehicles are of the Westinghouse type.

The contacts are of the pantograph pattern, and are capable of self-adjustment from 4.800 m. to 7.050 m. height. (See Fig. 44, page 290.)

The large gears of the 2000-horse-power locomotive are novel as to power transmitted. They are of the N spiral type, made by Messrs. Citröen and Co., of Paris. The pitch circle diameters are 1453 mm. and 447 mm. (see Fig. 46, Plate XXXVIII.). They are automatically machine-cut, and run without noise and vibration. They engage with each other with surfaces much in excess of those of any other type of gear-wheels, and run at a circumferential speed of 22 m. per second. The maximum surface pressure on the teeth is 260 kg. per sq. cm.

The B.L.S. locomotive of the M.F.O. is near the limit, where the use of gearing affords a decided advantage over connecting-rods direct from the motor. Thus the gearing does away with all reciprocating parts within the cabin of the locomotive, and makes balancing easy. For low-speed locomotives, especially freight engines, with a large pull on the draw-bar, and comparatively little horse-power, the gearing is of decided advantage in many respects, and is likely to become commonly adopted. The locomotive built by the A.E.G. for the B.L.S. is of a design novel in electric traction on Swiss railways. It has the motors placed high in the cabin, and cranks on the motor-shafts, from which motion is transmitted to the horizontal connecting-rods of the driving-wheel axles by means of a system of intermediate connecting-rods reciprocating up and down. The geared and the gearless type of locomotives will probably have each a more or less distinctly defined field of application of its own. There will be a field accessible to both types, where the one as well as the other represent more or less a compromise. Practical experience alone can determine which type will be the more advantageous to adopt in each individual case of duty to be performed. The question of gears is more or less a question of electric-traction motors proper, and cannot be discussed except by going into the very details of their design, and not without considering certain particular features of the different systems of motors regarding their adaptability to high or low speeds. It may only be said here that, in general, with low speed, and more particularly with powerful low-speed locomotives, the adoption of gears permits of a more satisfactory design, construction, and operation, while, with all high-speed locomotives, the elimination of gears is either more advantageous or otherwise desirable. The locomotives of the B.L.S. are neither of high nor low speed. Their maximum power is, however, developed on the up-grades at speeds decidedly low, while the higher speeds occur on the down slopes with no load, and on the gentle slopes or levels only with less than full load on the motors. It will be highly interesting and important to compare the two radically different types of locomotives on the B.L.S., where there are reasons for existence of each. The B.L.S. Railway Company and their consulting engineer are to be congratulated on their not having failed to cause this comparison to be made. The transformers on the vehicles were so arranged as to permit of working at half contact-line voltage, if, for one reason or another, 15,000 would have proved impracticable. In fact, at the time when all trains were steam-driven and the electric vehicles were being run for experimental purposes, some flashing over from smoky insulators in the Hondrich Tunnel (1604 metres long) just behind Spiez was observed, and a periodical cleaning of the insulators was made. Since steam traction has disappeared, no such trouble has been experienced, and it is expected, as the smoke nuisance will not exist on the new line, that the contact-line voltage will not require any reduction. At any rate, the B.L.S. electrification may be looked upon as a railway which will, within a short time, conclusively prove whether single-phase, high-voltage, low-periodicity electric traction is the right method for the operation of a railway.

Engadin, Rhätische Bahn (No. 16 on tables).—This railway is quite of the character of a principal railway, and is likely to be one of the most efficient and up-to-date narrow-gauge railways on the Continent. The first section of the Rhätische Bahn was opened in 1889. The company operates to-day about 217 km. of line, all in the Kanton Granbündten, and is constructing at the present time a new line from Bevers in the Upper Engadin to Schuls in the Lower Engadin, about 49 km. long.

This new line, together with the sections already existing in the Upper Engadin, will be operated by electricity. Single-phase alternating-current of a periodicity of 15 and a voltage of 10,000 has been chosen. The voltage of only 10,000 is justified by the smaller power effects occurring on a narrow-gauge railway and by the difficulty which might have been engountered in placing the contact wires in the restricted freé space of the numerous and lengthy narrow-gauge tunnels.

The contact line will be overhead, and the contacts of

TABLE VII.—GENERAL DATA OF THE MOTOR-CARS AND LOCOMOTIVES FOR THE BERN-LÖTSCHBERG-SIMPLON RAILWAY.

No. 15. Bern-Lötschberg-Simplon.	Motor-Cars (3) by S.S.W. and Schlieren.	2000-H.-P. Locomotive (1) by M.F.O. and Winterthur.	1600-H.-P. Locomotive (1) by A.E.G. and Krauss and Co.
Number of axles, driving	Two in one bogie (later on four)	6	4
Number of axles, other	Two in one bogie (later on none)	..	2
Arrangement of axles	Two bogies with two axles each	Two bogies with three axles each	Two half-locomotives each with two driving and one adjustable pony axle.
Total weight	52 tons approximate 64 seats, toilet, electric light and heat	90 tons	96 tons
Total weight on drivers	30 tons (later on 52 tons)	90 tons, equally distributed	68 tons, 25 tons on pony axles
Weight of electric equipment	21 tons approximate	44 tons	49 tons
Weight of one motor, one transformer	3.3 tons, 4 tons	9.8 tons, 5.5 tons	14 tons
Length between buffers	20.300	15.020	15.750
Distance between outer wheels	14.800	10.700	12.450
Distance between outer axles of bogie	2.500	4.050	5.300
Diameter of wheels, driving	1.1000	1.350	1.270
Diameter of wheels, other	1.100 (later on none)	None	0.850
System of motors and speed-control	Series, auxiliary poles, speed-control by contactors	Series, auxiliary poles, voltage-control by contactors	repulsion voltage speed-control by contactors
Transformers on car	Two of 450 k.v.a.	Two of 1000 k.v.a.; ratio, 15,000 : 420	—
Voltage of motors	..	420-0	—
Power of one motor (one hour rating)	230 horse-power	1000 horse-power	800 horse-power
Number of motors on vehicle	Two (later on four)	2	2
Mechanical arrangement	Enclosed motor, spring suspended, geared (1 : 3.45), to driving axle	Motor rigid in spring-supported bogie-truck, high, open, geared (1 : 3.25) to counter-crankshaft below, connecting-rods	Motor rigid in spring-supported main frame, high, open, connected by almost perpendicular rods to counter-crankshaft, connecting rods horizontal
	With Four Motors.		
Normal total pull on tread	5000 kilogs.	13,000 kilogs. coefficient of adhesion 1 : 6.8	—
Normal total pull on hook	3900 ,,	10,000 kilogs.	8,000 kilogs.
Maximum total pull on tread	7400 ,,	16,000 kilogs. coefficient of adhesion 1 : 5.3	13,500 ,,
Maximum total pull on hook	6300 ,,	13,000 kilogs.	—
Normal speed of vehicle	45 km. per hour	42 km. per hour	40 km. per hour
Normal weight of train for normal speed with motor-car or locomotive	240 tons on 15.5 %; 160 tons on 27 ‰ with four motors	—	
Ditto, without motor-car or locomotive	..	500 tons on 15.5 %; 310 tons on 27 ‰	400 tons on 15‰; 250 tons on 27 ‰
Speed, maximum	70 km. per hour	70 km. per hour	75 km. per hour
Acceleration	..	0.05 m. per second per second	—

* Paper read before the Institution of Mechanical Engineers, at the Zurich Meeting, July 25.

† See Zollinger, *Schweiz. Bauzeitung*, lv., Nos. 25, 26.

‡ See Tables IV. and V., pages 270 and 271 *ante*.

* See Thut, *Schweiz. Bauzeitung*, lii., Nos. 11, 12, 13, 16, 17, 18, 20.

† See Tables IV. and V., page 127 *ante*.

* See Stix, *Schweiz. Bauzeitung*, lvii., 6 and 7.

the pantograph bow type. After the description which has already been given, it is superfluous to go into generalties of plant. It is intended to work exclusively on the locomotive-train plan, which is the plan of operation of the remainder of the Rhätische Bahn. The orders for three locomotives of 600 horse-power each, for eight of 300 horse-power each, and for the line equipment, have been placed by the Rhätische Bahn with the following firms:—A.E.G., Alioth, B.B.C., M.F.O., and S.S.W.

There will be, at least as far as the electric equipment is concerned, to begin with, three different patterns of each of the two different types of locomotives. As far as the author is informed, all these locomotives will have motors placed in the cabin above the axles geared to counter crank-shafts, the cranks of which are connected with the cranks of the driving-axles by connecting-rods, the details being arranged in any of the numerous ways possible. As these locomotives have not yet been delivered, the author has not thought it desirable to represent them by drawings in the paper.

The Schweizerische Studiencommission für Electrischen Bahnbetrieb.—This paper would be incomplete if it did not consider, in addition to the electric railways working or building, the work, more scientific than practical, done for years in Switzerland, with a view to elucidating the general railway electrification question under Swiss conditions, to determine by investigation the merits of the several systems, the cost of plant and of operation, and to make a fair comparison between steam and electricity for definite lines or groups of lines. Work of this kind has been and is still being done by a society with the title "Schweizerische Studiencommission für Electrischen Bahnbetrieb." It was founded on the initiative of Dr. E. Tissot, and under the auspices of the Society of the Electricians of Switzerland. It was constituted and commenced work in 1904. Railways, electricity works, manufacturing firms, and science are represented on this Commission. The presidency has been held from the beginning by Mr. I. Flury, member of the Board of General Managers of the Federal Railways, and the office of general secretary by Professor Dr. W. Wyssling, under whose superintendence the lengthy investigations and systematic work of a number of sub-commissions and collaborators went on in regular order.

To-day it is easy to state the principal conclusions of the Studiencommission as to systems of electric traction, and more particularly as to unified periodicity of the alternating current for electric traction on the railways mentioned in this paper, which is more or less identical with the scope of the work of that Commission. These conclusions are exhibited in their essence and in practice in the series of railways described, beginning with the Seebach-Wettingen experimental line of the past, and ending with the Engadin line of the Rhätische Bahn, now in course of construction.

It is, of course, difficult to estimate the value of, and the influence on the events that are to be attributed to the work of the Studiencommission. It is, however, certain that the collaboration in the Commission of representatives of interests in competition with each other in business has acted beneficially, so as to make the question of system less one of competition and more one of general scientific and common practical interest.

St. Gothard Railway.—(See Table V., No. 17, page 271 *ante*.)

After having arrived at the conclusions herein set forth by practice in Switzerland, the Studiencommission made different comparative projects with special reference to the St. Gothard Railway as a railway, which, before all others in Switzerland, appears to be ready for electrification. For more than 100 km. it goes through country with tens of thousands of hydraulic horse-power doing nothing but embellish the landscape, while the locomotives with their smoke detract from its beauty. The traffic on the St. Gothard line has developed so as to have reached the limits of steam operation. There is a continuous and permanent demand for more powerful engines for dealing, on the long and heavy grades, with a tonnage comparable with that of the busiest flat-country main railways. The railway, with a length of 274 km. (170¾ miles), presents the problem of electrification in a still more general way than does the Lötschberg; firstly, because there the creation of the power-stations forms part of the problem; and, secondly, because the more or less level sections north and south of the steep slopes require high speeds. Moreover, the St. Gothard electrification is of an unusual size and responsibility.

The Studiencommission has, in addition to certain alternative suggestions, prepared two complete projects with great care and attention, as if they were tendering for a contract. The first project, called "1904," has been prepared for the sole purpose of a fair and complete comparison of actual steam traction with a hypothetical electric traction under known precise conditions of traffic. The second project, called "Future," presupposes a traffic considerably in excess of the traffic of 1907, which holds the record up to now, at the same time adopting speeds and accelerations more or less in excess

Fig. 34. PROFILE OF LINE SPIEZ (ON THE LAKE OF THUN) BRIG (NORTH ENTRANCE OF SIMPLON TUNNEL) (BERN-LÖTSCHBERG-SIMPLON.)

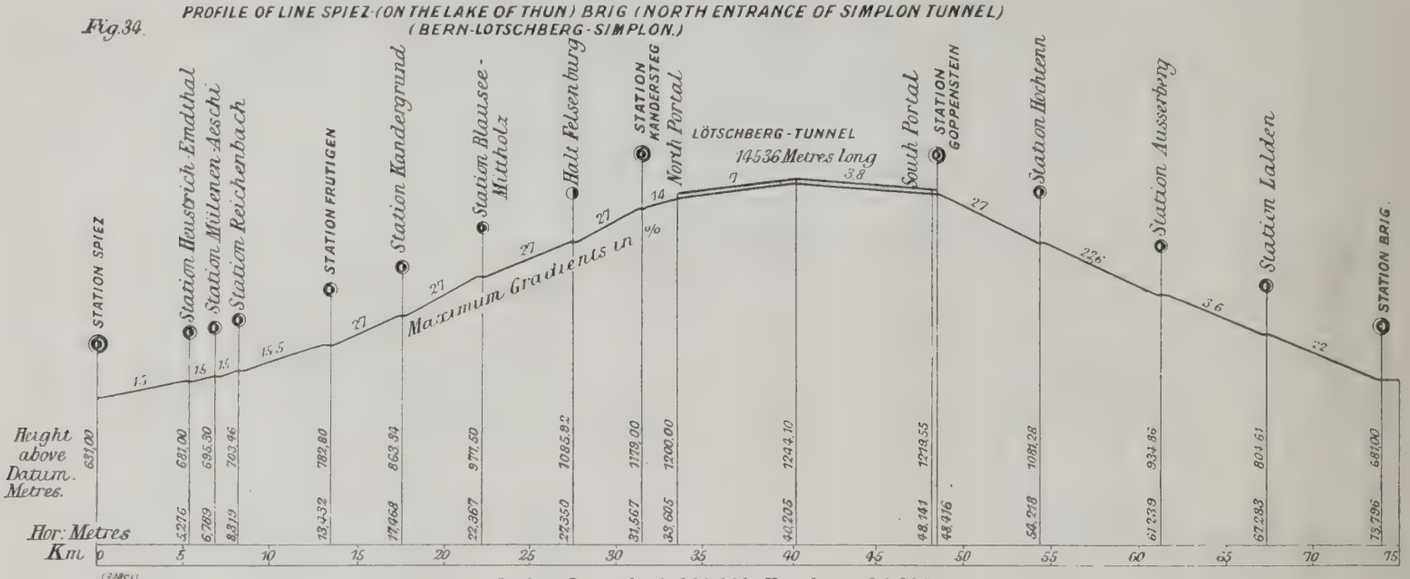


Fig. 35. GEOGRAPHICAL SITUATION. BERN-LÖTSCHBERG-SIMPLON

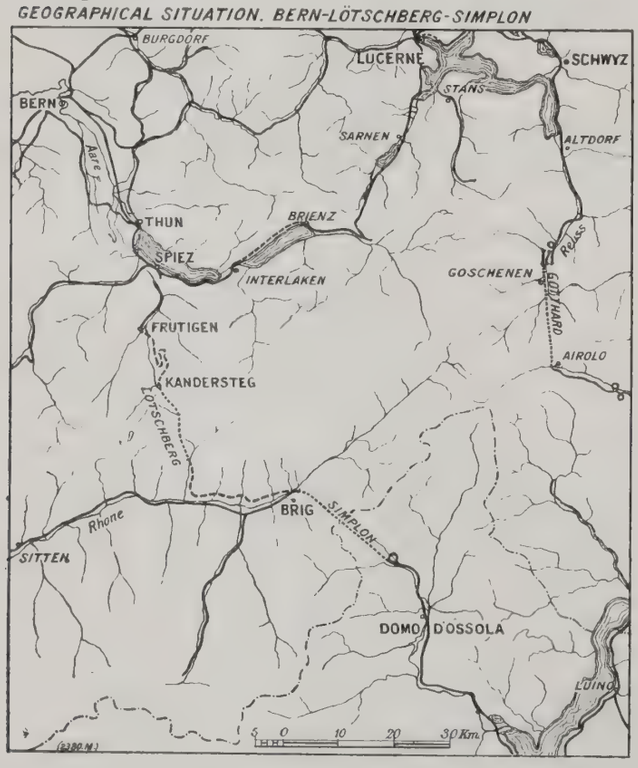


Fig. 36. B.L.S. 2000 H.P. 15000-VOLT SINGLE-PHASE ELECTRIC LOCOMOTIVE. (MASCHINENFABRIK OERLIKON)

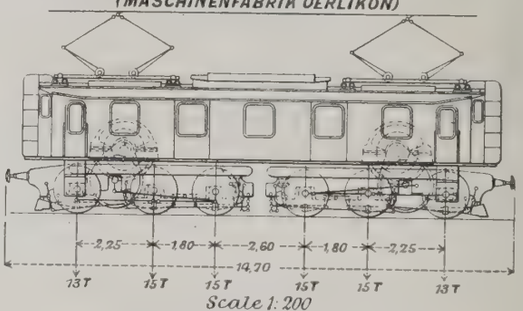
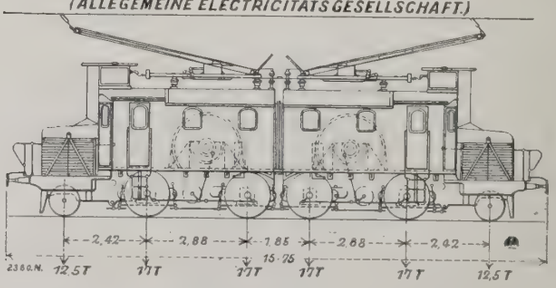


Fig. 37. B.L.S. 1600 H.P. 15000-VOLT SINGLE-PHASE ELECTRIC LOCOMOTIVE (ALLEGEMEINE ELECTRICITÄTS GESELLSCHAFT.)



ELECTRIC TRACTION IN SWITZERLAND.

(*For Description, see Page* 285.)

Fig.38

B.L.S. 460 (920) H.P., 15,000-VOLT SINGLE-PHASE ELECTRIC MOTOR-CAR.
(SIEMENS-SCHUCKERT WERKE UND WAGGONFABRIK SCHLIEREN.)

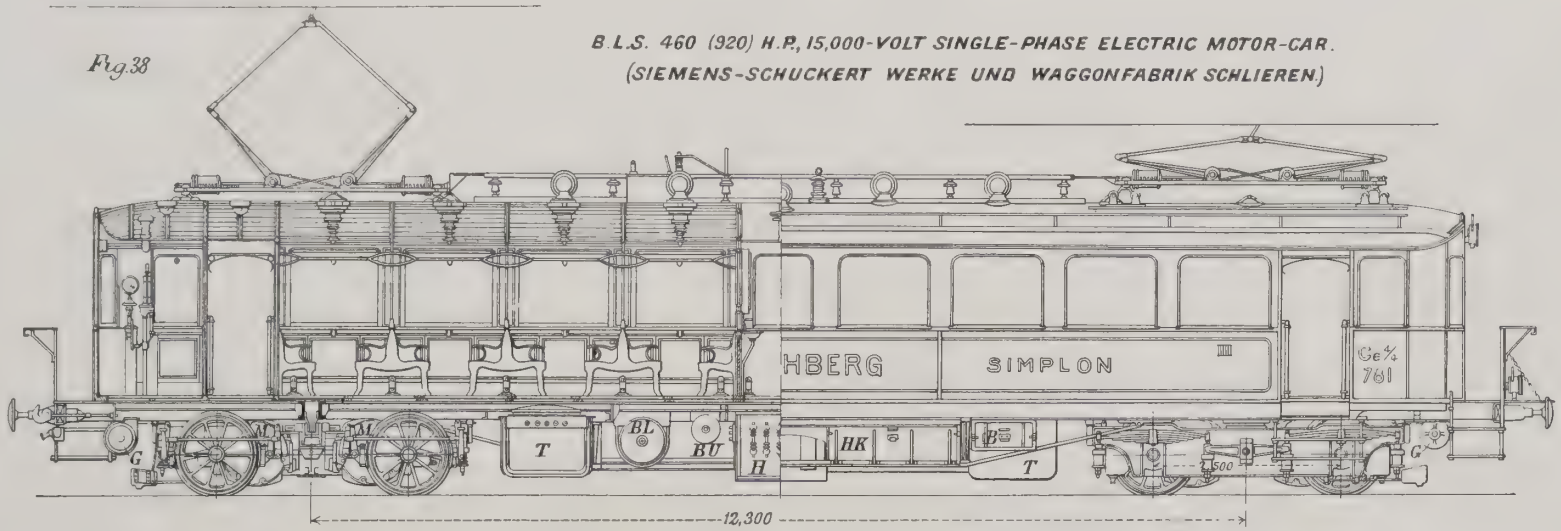


Fig.39.

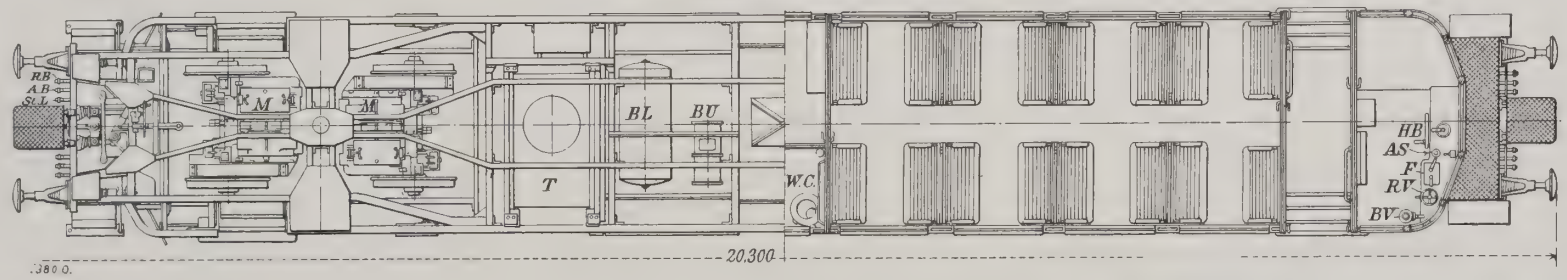


Fig.40.

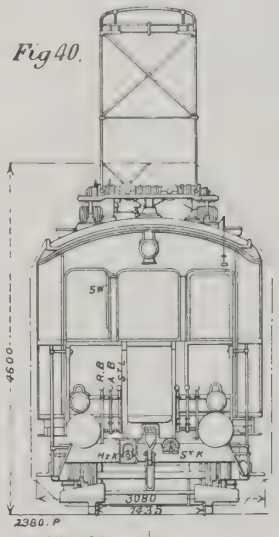


Fig.41

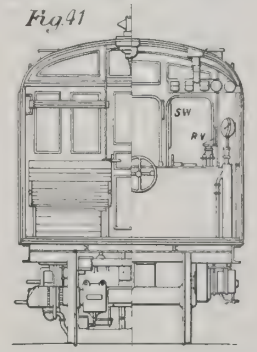


Fig.42. **B.L.S. 230 H.P. SINGLE-PHASE ELECTRIC TRACTION MOTOR.**
(SIEMENS-SCHUCKERT WERKE)
Scale 1:10.

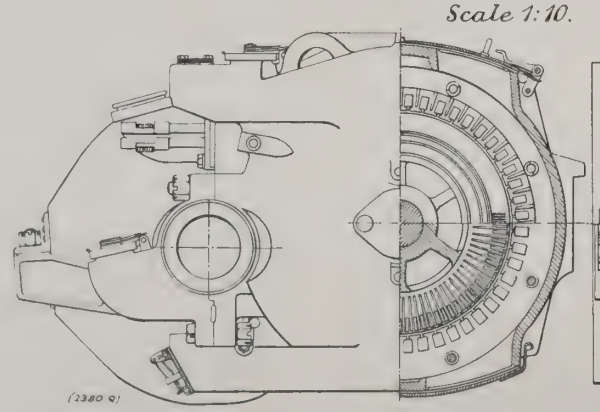
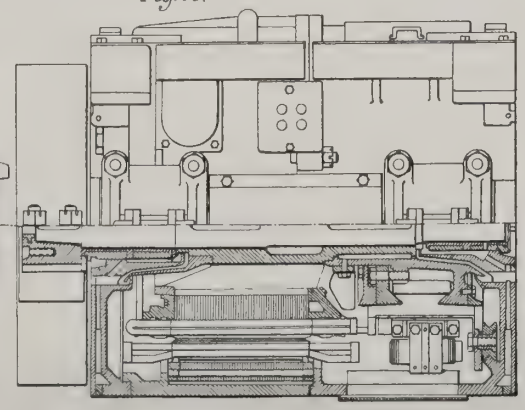


Fig.43.



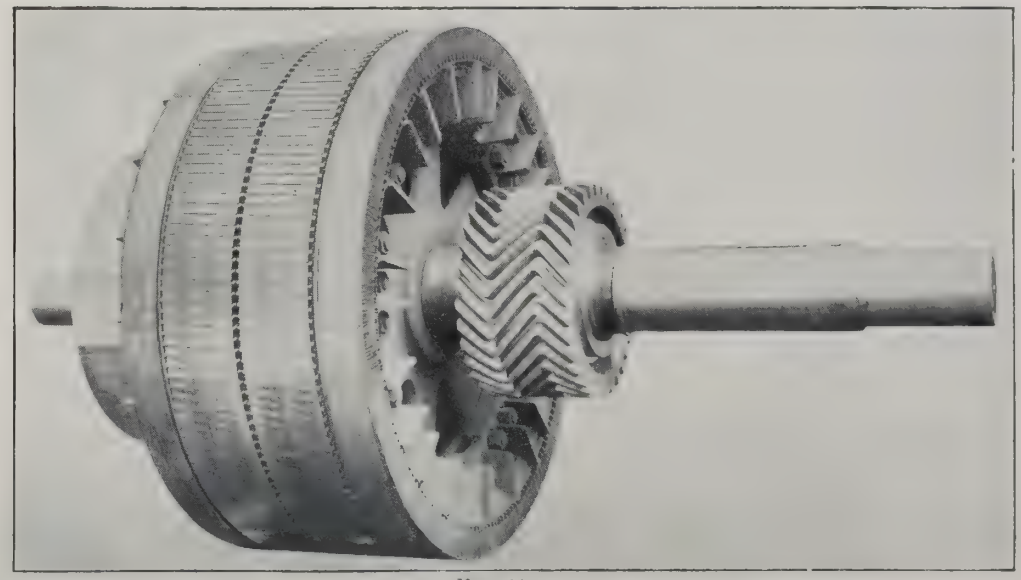


FIG. 46.

Fig.47.

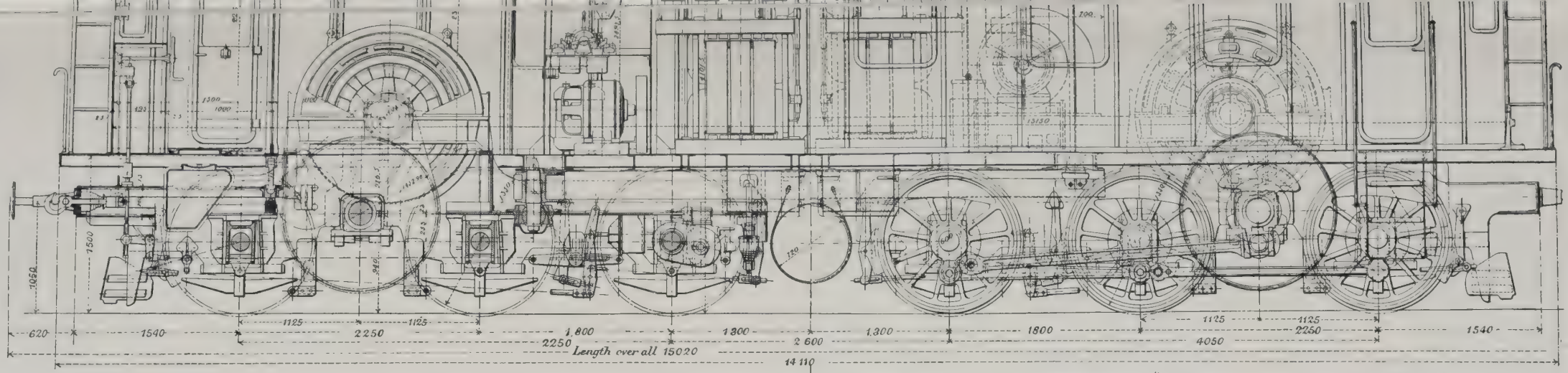


Fig. 48.

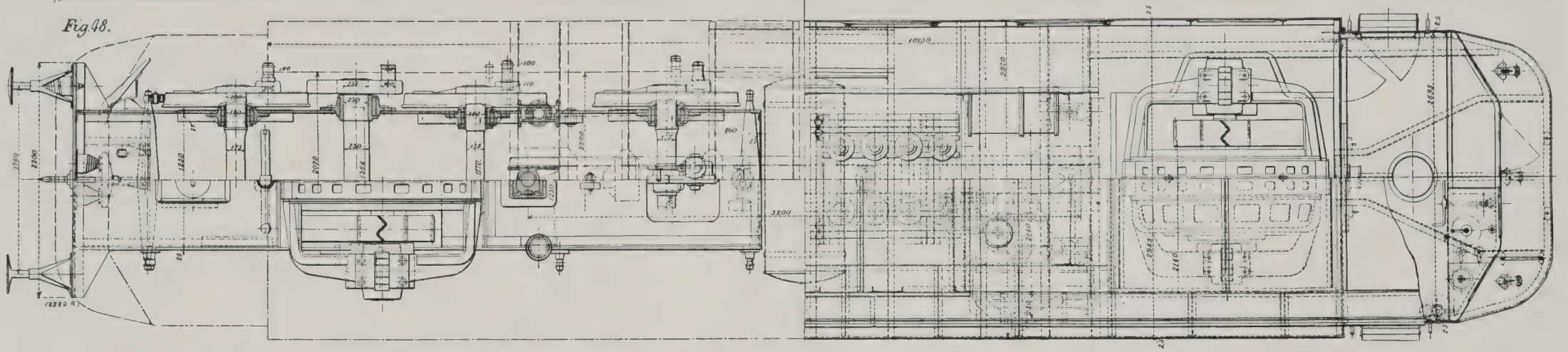


Fig. 49.

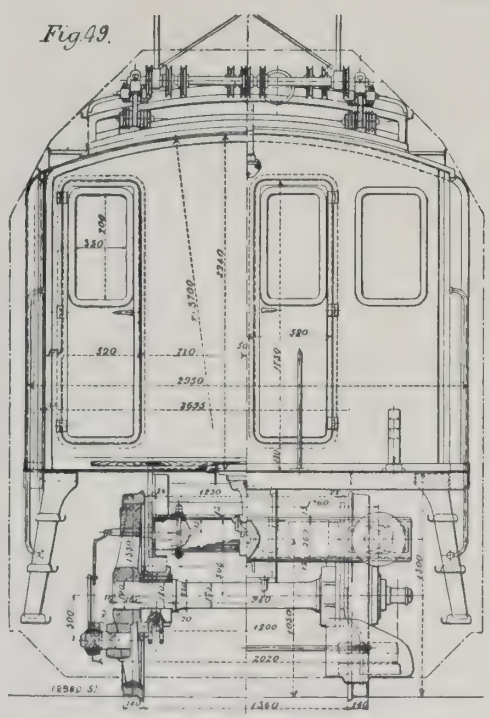


Fig. 50

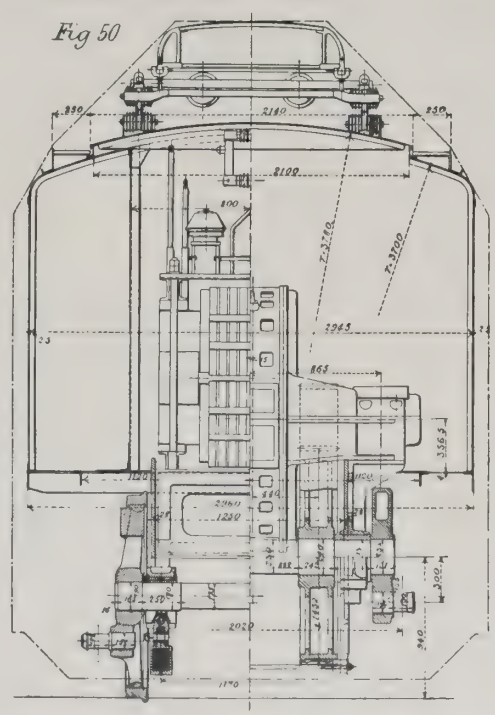


Fig. 51.

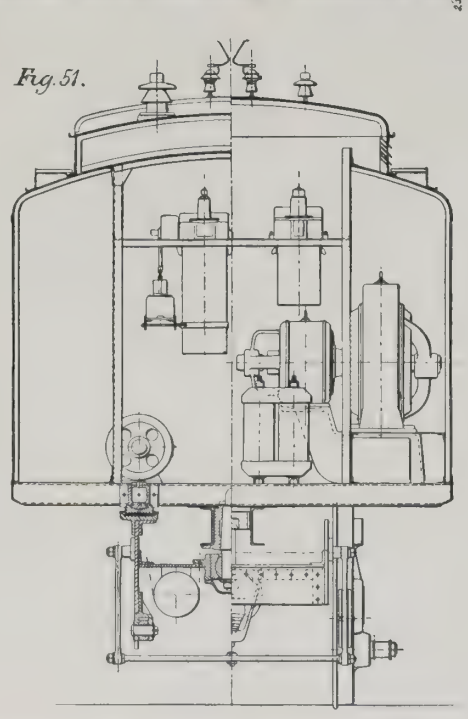
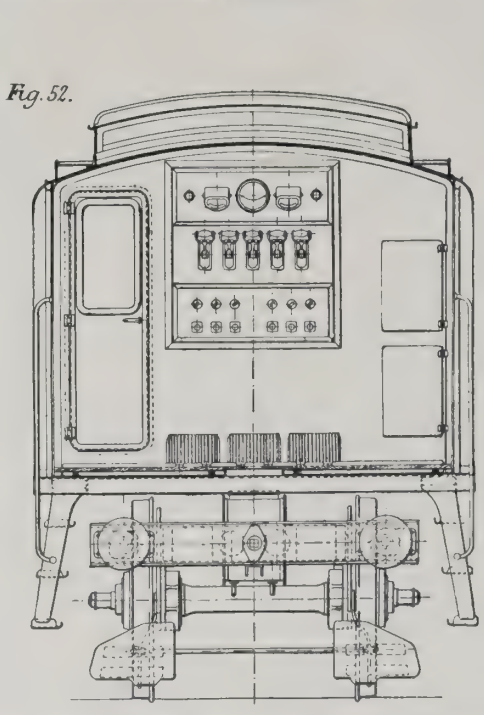


Fig. 52.



FIGS. 46 TO 52. 2000-HORSE-POWER ELECTRIC LOCOMOTIVE FOR THE BERN-LÖTSCHBERG-SIMPLON RAILWAY, CONSTRUCTED BY THE OERLIKON ENGINEERING WORKS AND BY THE SWISS LOCOMOTIVE WORKS, WINTERTHUR.

of those accepted for the hypothetical electric traction of "1904."

The author does not think that it should have been necessary to ask permission for giving details of those projects. He thinks it sufficient to make a few indications, some of which have been published by the Schweizerische Studien Commission,* which will be sufficient to give an idea of what would have been required in 1904 and what is expected in the "future" of electric traction on the St. Gothard Railway. Of the figures that follow, those in parentheses refer to the "future." The speeds of express trains are from 85 (90) km. per hour on the level to 40 (50) km. on 1 in 40 grades. The speeds of passenger trains are 55 (75) km. to 26 (50) km., and those of freight trains 38 (45) km. to 18 (35) km.

The starting horse-power is limited to 1.25 times the normal horse-power on 1 in 40 grade; acceleration as such is, however, limited to 0.15 (0.20) m/s/s with express, to 0.15 (0.30) m/s/s with passenger, and to 0.10 (0.10) m/s/s with freight trains. The weights of the trains will not increase much in the future because of the car couplings (all increase in traffic to be met with faster and more machinery, plant, maintenance, and operation. Water-storage was resorted to exclusively for providing for peak loads, because it was indispensable in providing for the seasonal variations of fresh-water supply in relation to the seasonal variations of traffic. While the storage for the latter purposes requires large reservoirs, storage for the former purposes requires reservoirs comparatively small. In the case of the St. Gothard, the power-station at Ambri-Piotta, with the Lake Ritom as a storage basin with 36,000,000 cub. m. on a level more than 800 m. above, will provide for the seasonal variations and other large variations not of a simple peak character, while small basins in the other power-station (power-stations) will deal with the peak loads local in their particular district of supply.

The total cost of new plant, new rolling-stock and accessories, alterations on telegraphs, telephones, and signals, supervision, interest during construction, all complete, will amount to about 44 (67) millions of francs.* These figures give an idea of the magnitude of this electrification, which is expected before long. The Federal Railways have, a few years ago, acquired ample water-

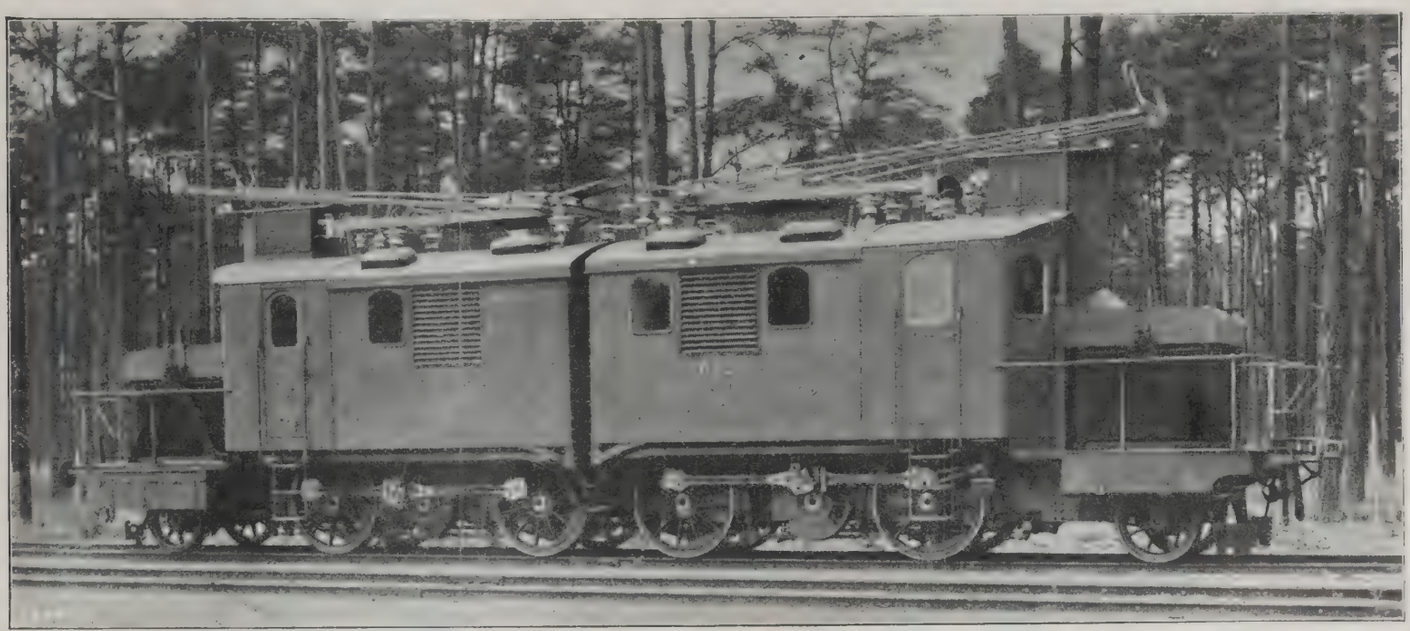


FIG. 53. 1600-HORSE-POWER 15,000-VOLT SINGLE-PHASE ELECTRIC LOCOMOTIVE; CONSTRUCTED BY THE ALLGEMEINE ELECTRICITÄTS-GESELLSCHAFT, BERLIN, AND MESSRS. KRAUSS, MUNICH.

frequent trains); they were in 1904 (maximum in parentheses) actually (first figures): with express trains on most sections 200 to 220 (280 to 350) tons, with passenger trains 120 to 180 (240 to 350), with freight trains on the main line 350 to 380 (500), and on other sections 270 to 350 (330 to 370) tons, all exclusive of locomotives. In fact, freight-trains being moved by two eight-wheelers at the head and one at the rear are a usual appearance on the slopes. There will be required about 19 (21) motor-cars of 200 to 500 (400 to 1100) horse-power, about 9 (15) fast locomotives of 1800 (2200) horse-power, and about 37 (38) locomotives of 800 (1500) horse-power.

Electric single-phase alternating current, of a periodicity of 15 and of a voltage of 15,000 for the supply to sections immediately adjacent, and of perhaps three times as much for transmission to transformer sub-stations supplying the sections remote from the power-station, is adopted. There will be 2 (3) power-stations required, the most important one situated a little below Airolo, near Ambri-Piotta station, having the Lake Ritom, into which other lakes drain, as an enormous water-power storage basin. The power required for traction is considerable, and the load-line has enormous peaks. The total power developed on the tread of the locomotive vehicles on the whole line ("future" figures in parentheses) will amount to about 14,000 (22,000) horse-power maximum and about 5000 (10,000) on the average. On individual sections the proportion of maximum and average is, however, less favourable. There will be required from the hydraulic turbines 27,000 (46,000) horse-power maximum. There will be installed in 2 (3) power-stations hydro-electric machinery of about 50,000 (95,000) horse-power, including stand-by. It is expected under "future" conditions to tap eventually about 26,000,000 cub. m of water from the Lake Ritom, temporarily, of course, leaving but 6,000,000 cub. m. in it, and thus lowering its surface more than 30 m.—a procedure which is of no material inconvenience in the case of a mountain lake with precipitous shores. In the case of the St. Gothard, the Studien Commission has investigated into the application of accumulator batteries for storing power locally, independently of the site of the water-power stations, and for providing for the local peak loads. It has, however, been found uneconomical, on account of a highly increased expenditure for sub-station powers in five places along the line, which amount to considerably more than what will be required by any electric traction to come on the St. Gothard not too dangerously crowded. The author prefers not to give in detail the comparative figures of the cost of operation per unit.

In the hypothetical case of "1904," where electricity does not show to advantage on account of the small traffic to keep the plant busy, the cost per ton-kilometre of train-weight, exclusive of locomotive weight—that is to say, the decisive comparative figure—is exactly equal for steam and electric traction, if scrapping of useless steam locomotives is not considered; if it is, the cost of electric traction is not quite 3.5 per cent. in excess. On account of the greater weight of steam-locomotives, steam traction appears to be notably cheaper, if measured by ton-kilometres inclusive of locomotives.

In the "future" case the comparison of electricity and steam is somewhat difficult, because steam traction on the St. Gothard has not yet been dealing with it, and the cost of steam traction must be calculated from the basis of that during 1907 and 1908. Then it is found that, under the "future" conditions of traffic—certainly to be expected in less than a decade, in consideration of its actual steady growth for more than twenty-five years—electric traction is much cheaper than steam traction was in 1907 and 1908, depreciation of steam locomotives, now still running but useless elsewhere, even being fully considered. The difference is so great that the conclusion appears to be justified that the St. Gothard can be operated electrically at a financial advantage over steam in the near future.

Interest on new capital investment and depreciation of new plant have been fully considered in determining the cost of operation. The investigations into the plant and rolling-stock required, and into all details influencing the resultant cost of operation, have actually been made with the aid and under the control of men thoroughly conversant with the operation and management of the St. Gothard Railway, now forming part of the Federal Railways.

Though cheaper operation as expressed in figures is the only efficient stimulus in the case of a railway so successful as the St. Gothard has hitherto been, still, the greater comfort to travellers, to train crews and to trackmen in the tunnels, of which there are more than 46 km. in all, the reduced corrosion of rails in tunnels, the less rapid deterioration of the carriage outfits, the elimination of the feed-water nuisance in winter, the cost of coal more probably increasing than decreasing, and many other things not expressed in figures, are of considerable practical importance, and will, if those estimates appear satisfactory, cause electrification to come earlier.

Conclusion.—Railway electrification has made, and is making, noteworthy rather than rapid progress in Switzerland. As regards system, single-phase current of low periodicity (15) and high-contact line voltage, varying from 5000 to 15,000 according to circumstances, is being sanctioned by experience and by authority.

An important electrification of a new principal line, the Lötschberg, is about to be carried out in the immediate future; and a still more important one, that of the St. Gothard Railway, is well prepared by the investigations of the Schweizerische Studien Commission für Electrischen Bahnbetrieb and by the Federal Railways' purchase of water-powers along the line.

Railway electrification and electric traction on a large scale is in a great measure a problem of power-station economics. The heavy variations of load, and those due to rapid seasonal variations in the fresh-water supply, make, under Swiss conditions, water storage desirable and even imperative. All electrification in Switzerland is directly connected with the utilisation of water-power.

APPENDIX.

English Equivalents of Metric Measures.

Linear	1 metre (m.) = 3.2809 feet. 1 millimetre (mm.) = 0.001 m. = 0.03937 inch. 1 kilometre (km.) = 1000 m. = 0.6214 statute mile. 1 foot = 0.3047945 m. 1 inch = 25.39954 mm. 1 statute mile = 1.609315 km.
Surface	1 square metre (m^2.) = 10.764 square feet. 1 square kilometre (km^2.) = 247.11 acres. 1 square foot = 0.0929 m^2.
Volume	1 cubic metre (m^3.) = 35.317 cubic feet. 1 cubic foot = 0.0283 cubic metre.
Weight	1 kilogram (kgm.) = 2.20462 lb. 1 ton = 1000 kgm. = 0.9842 (long) tons. 1 lb. = 0.45359 kgm 1 (long) ton = 2240 lb. = 1.01605 tons (metric). 1 short ton = 0.907 ton (metric).
Weight Moved ..	1 ton-kilometre = 0.61157 ton-mile.
Power Effect ..	1 PS. (Pferdestärke) = 75 kilogrammetre per second = 0.9863 h.-p (horse-power). 1 h.-p. = 1.0139 PS.
Money (Swiss) (approximate) ..	1 franc (fr.) = 9.6 pence. 1 centime = 0.01 fr. = 0.096 penny. 1 shilling = fr. 1.25. 1 pound sterling = fr. 25.

1 % = one in hundred.
1 ‰ = one in thousand.
1 m/s/s = 1 metre per second per second (acceleration).
= 3.2809 feet per second per second.

ELECTRIC STEEL PROCESS.—The electric steel process which Albert E. Greene recommends as a competitor to the Bessemer and the open-hearth processes (American Electro-Chemical Society's Transactions, vol. xix., page 233) consists in blowing a mixture of carbon monoxide and carbon dioxide into the molten pig. This gas mixture is obtained from blast-furnaces or cupolas. The Greene furnace is an induction furnace of the simple Kjellin type, whose annular trough is enlarged to a pot in the portion opposite the tap-hole; the gas tuyeres dip into this pot.

* *Mitteilungen der Schw. Stud. Com. für Electr. Bahnbetrieb*, edited by Professor Dr. W. Wyssling; Rascher, and Co., Zurich, 1906-1908.

* For total cost of the St. Gothard Railway, see Table V. (page 271 *ante*).

THE SPANISH GUNBOAT "RECALDE."

WITH the permission of the Spanish Naval authorities, we are enabled to reproduce on Plate XXXIX. an elevation and deck plans, and the general arrangement of the machinery, of the new gunboat Recalde, just completed for the Spanish Navy, and the first vessel tried of an extensive and powerful fleet now being constructed in the Spanish arsenals. It will be remembered that, having a desire to recover the high place formerly held among the world's maritime Powers, Spain decided, fully two years ago, to invite tenders from Spanish firms, associated with foreign naval construction companies in a consultative capacity, for the reorganisation and reconstruction of the Royal dockyards at Ferrol and Cartagena, the construction of graving docks and wharves, and the dredging of Ferrol harbour, and for the building at these arsenals of three battleships, four gunboats, three torpedo-boat destroyers, and twenty-four torpedo-boats. Tenders were submitted which included designs from the leading naval construction firms in the world, and these were reviewed in ENGINEERING of July 16, 1909 (vol. lxxxviii., page 87). After the examination of the designs and consideration of the report of the technical advisers, the Minister of Marine accepted the tender and designs of the Sociedad Espanola de Construccion Naval, which had the benefit of the co-operation, in the capacity of advisers and technical guarantors, of a British combination of firms which included those of the highest skill and greatest experience in the design and construction of modern munitions of naval warfare. Since then the work under the respective heads of the contract has been progressing most satisfactorily. We described at some length the main characteristics of the important ships of the programme, and reviewed progress in their building in ENGINEERING of July 15, 1910 (vol. xc., page 77), and now we illustrate the first of the vessels to be completed—the gunboat Recalde.

The Recalde has just passed with great success through her official trials, and is being prepared for commission at Cartagena, where the other ships of the class—the Laya, Bonipaz, and the Lauria—are being built. The principal dimensions of these gunboats are:—Length between perpendiculars, 200 ft.; beam, 30 ft.; depth, 15 ft.; the displacement tonnage on a mean draught of 9 ft. being 800 tons.

As will be seen from the sectional elevation (Fig. 1), the Recalde has been constructed with a ram bow, poop, forecastle, main and lower decks, with deck-house on the main deck amidships. The vessel is provided with two pole-masts, which will carry fore and aft sails in emergency, with the usual appliances for signalling. The hull, generally, is of Siemens-Martin steel, and special care has been taken to ensure ample strength. The hull is divided up into compartments by six water-tight bulkheads, and some of the compartments are subdivided, thus rendering the possibility of foundering very remote. The main deck is plated all fore and aft, whilst the lower deck is made thoroughly water-tight for a considerable distance over the magazines. The general arrangement of the decks is clearly shown on the plans, Figs. 2, 3, and 4. The accommodation throughout is roomy and well ventilated, and in the living spaces a supplementary air-supply is provided by means of electrically-driven propeller-fans. The commander, seven officers, and eight engineers are berthed in cabins on the main and lower decks aft, and are also provided with well-furnished dining-room, ward-room, and mess-room; there is also a ship's office. The crew's quarters are situated forward, twenty-seven being accommodated on the main deck and sixty-three on the lower deck. In addition, cabins have been provided for twelve petty officers on the lower deck forward. The ship is lighted throughout by electricity, and a powerful searchlight of 20 in. diameter has also been fitted on top of the wheel-house.

The armament of the vessel consists of four 76-mm. guns, and two Maxim field guns. As shown on Fig. 2, two of the former are placed on the forecastle deck and two on the poop deck. The magazines for the supply of ammunition are placed in convenient positions at the forward and after ends.

The propelling machinery is illustrated in Figs. 5 to 8, on the two-page plate. The engines are of the reciprocating type, consisting of two sets of three-cylinder surface-condensing engines, with cylinders 11 in., 17½ in., and 27½ in. in diameter respectively, by 18 in. stroke. Steam is supplied by two large Yarrow water-tube boilers of 200 lb. working pressure, capable of working under either forced or natural draught. The auxiliary machinery comprises two independent circulating pumps, an evaporator capable of supplying 10 tons of fresh water per 24 hours, a fresh-water distilling condenser, a 15.75-kilowatt dynamo, a fan and engine for forced draught, two Weir steam-pumps for main and auxiliary feed, and a steam-pump for fire and bilge purposes. The vessel is steered by a two-cylinder steam-engine placed in the engine-room. This is controlled by a steering-wheel placed in the wheel-house, and is connected to the engine by shafting and spur-gearing. A hand steering gear is provided in the steering-gear compartment for use should the steam-gear break down.

The vessel has been well equipped with boats. On skid beams amidships, there are placed, as shown in Fig. 2, three 9.14-metre cutters, one 5.48-metre commander's gig, two 3.67-metre dinghys, and, in addition to these, an 8.228-metre motor launch is also carried.

The Recalde was designed to steam 13 knots on trial with 1000 indicated horse-power, and on the official full-power trials recently conducted this speed was exceeded by fully one mile per hour. The following table shows the performance of the vessel at these trials:—

	Natural Draught.	Forced Draught.
Mean speed of eight runs on measured course	10.22 knots	14.004 knots
Mean indicated horse-power	333	965
Mean revolutions per minute	180	255
Mean coal consumption per indicated horse-power per hour	2.4 lb.	2.16 lb.

These results have given great satisfaction to the Spanish Naval Commission and to the firms interested in the construction of the new vessel, and promises the success of the other and larger vessels of the new Spanish fleet, which are being rapidly pushed forward. The Recalde, it may be added, has been completed two months ahead of the contract date.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data concerning colonial and foreign engineering projects. Further information concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.:—

Canada: According to the *Monetary Times* (Toronto), over 1000 miles of new railway line will be laid in Saskatchewan in the present fiscal year. Last year 476 miles of line were laid in this province. According to the plans so far announced by the three principal railways of Canada, the Canadian Northern Railway will construct 330 miles in the province, the Grand Trunk Pacific 342 miles, and the Canadian Pacific about 350 miles. In addition to this new construction work, about 1350 miles of regrading will be done. The extensions of the Grand Trunk Pacific in Saskatchewan projected this year are as follow:—Melville to Regina, 70 miles; Battleford to Biggar, 50 miles; Regina to the boundary line, 90 miles; Regina to Moose Jaw, 40 miles; Young to Prince Albert, 90 miles.

Netherlands East Indies: According to the *Dépêche Coloniale*, the Netherlands Colonial Minister has introduced into the Chamber of Deputies a supplementary estimate to the East Indies budget to provide for the construction of a railway in South Sumatra from Telok Betong to Batoeradja, at an estimated total cost of 37,581,000 florins (about 3,132,000*l.*), the expenditure to be spread over six years.

Denmark: The British Acting Consul at Copenhagen states that tenders are invited by the Danish State Railways Administration for the supply of 936 accumulators for electric light in trains. Tenders, marked "Tilbud paa 936 Stk. Akkumulatorer til elektrisk Togbelysning," will be received at Direktören for Maskinafdelingen, Gl. Kongevej 1 D, 3 Sal, Copenhagen B, up to 1 p.m. on September 4.

HYDRO-ELECTRIC POWER FROM THE DANUBE.—The water power of the Danube is to be utilised between Vienna and Budapest, near Theben and Pressburg, which are situated near the Hungarian frontier. An open canal is to be led from the river with this object. A steam reserve plant is contemplated. The project has been worked out by L. Fischer-Reinau, A. von Steller, and Von Hoor-Tempis. Power amounting to 70,000 horse-power will be obtained.

THE UNION STEAMSHIP COMPANY OF NEW ZEALAND.—This company, which was formed over thirty years ago, and began operations with two small steamers, has now seventy vessels, of about 200,000 tons; the seventieth, the Maunganui, was launched on August 24, from the works of the Fairfield Shipbuilding and Engineering Company, Limited, Govan. The vessel is 430 ft. in length, 55 ft. 6 in. in breadth, 42 ft. 6 in. in depth to promenade deck, and of about 7000 tons gross. She is divided into nine water-tight compartments, and there are five decks—boat, promenade, upper, main, and lower. Accommodation is provided for 244 first-class, 175 second class, and 80 third-class passengers, and for a crew of 136 men. The main passenger entrance may be either on the main or upper decks, according to the state of the tides at the landing-stage. The dining-saloon is over 50 ft. in length and extends the full width of the vessel; small tables are arranged for 144 persons. The second-class dining-saloon has sitting accommodation for 110 persons. The third-class saloon has seating accommodation for 58 persons, and state-rooms adjacent. The propelling machinery will consist of two sets of quadruple-expansion balanced engines. Steam at a pressure of 220 lb. will be supplied by two double-ended and two single-ended cylindrical boilers adapted for Howden's system of forced draught.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was weak, and business amounting to 2000 tons of Cleveland warrants was done at 47s. 3½d. cash, 47s. 5d. twenty-one days, and 47s. 6d. one month. At the close there were sellers at 47s. 4d. cash, 47s. 7d. one month, and 48s. 1½d. three months. Hematite was quoted at 62s. 10d. cash sellers. Weakness increased in the afternoon, and dealings were limited to 1500 tons of Cleveland warrants at 47s. 3½d. eight days, with closing sellers at 47s. 3d. cash, 47s. 6d. one month, and 48s. three months. Friday morning saw no change in the tone of the market, and Cleveland warrants (1000 tons) changed hands at 47s. 3d. cash and 47s. 6d. one month, with sellers over in each case, and also at 48s. for the three months position. Hematite was easier, with sellers at 62s. 9d. cash and 63s. 9d. three months. In the afternoon there was still little change and only 1000 tons of Cleveland warrants were dealt in at 47s. 2½d. cash, and closing quotations were 47s. 3d. cash, 47s. 6d. one month, and 48s. three months sellers. On Monday morning weakness prevailed, and Cleveland warrants were down to 47s. 1½d. cash. The only dealing was one lot of 500 tons, and at the close sellers quoted 47s. 2d. cash, 47s. 5d. one month, and 47s. 11d. three months. At the afternoon session the turnover was again small, and was limited to 1000 tons of Cleveland warrants at 47s. 4½d. one month, with sellers over at that figure, and at 47s. 2d. cash and 47s. 11d. three months. On Tuesday morning the market was easier in tone, and 4000 tons of Cleveland warrants were done at 47s. 4d. one month and 47s. 8d. November 16. Closing sellers quoted 47s. 1½d. cash, 47s. 4½d. one month, and 47s. 10d. three months. Weakness prevailed in the afternoon, when 1500 tons of Cleveland warrants changed hands at 47s. 3d. one month and 47s. 8d. three months. At the close there were sellers at 47s. 0½d. cash, 47s. 3½d. one month, and 47s. 8½d. three months. When the market opened to-day (Wednesday) Cleveland warrants were lifeless, and no dealings of any kind were recorded. The closing quotations were called 47s. cash, 47s. 3d. one month, and 47s. 9d. three months sellers. In the afternoon Cleveland warrants were again easier, and 3000 tons were done at 46s. 10d. cash, 46s. 11d. nine days, 47s. 2d. fourteen days, 47s. 1d. and 47s. 2d. one month. At the close sellers quoted 46s. 11d. cash, 47s. 2d. one month, and 47s. 8½d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 61s.; Gartsherrie, 61s.; Summerlee and Langloan, 63s.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 64s.; Shotts (at Leith), 63s.; and Carron (at Grangemouth), 63s. 6d.

Sulphate of Ammonia.—A strong demand continues to be felt for sulphate of ammonia, and inquiries in the market point to a healthy business in autumn shipments. America is a good buyer just now, and also a good inquirer for forward lots, while sellers have large inquiries on hand from Japan. The current quotation for prompt delivery is now up to 14*l.* 5s. per ton, Glasgow or Leith, which price is only 5s. per ton under the highest point of the year. The amount shipped from Leith Harbour last week was 61 tons.

Scotch Steel Trade.—Conditions in the Scotch steel trade are good, and heavy material is still in excellent demand. Rolling-mills are all running at full pressure, and specifications on hand for plates are sufficient to ensure this state of affairs for several weeks to come. The booking of new business is improving, but merchants are securing the bulk of the orders, as they are well placed and can offer under makers' quotations. The demand for angles and boiler-plates is much better. The general export trade is satisfactory, and a lot of material is going through. Japan has bought a fair tonnage of plates and structural sections, while firm inquiries are in the market for light material for India and Australia. The demand for black and galvanised sheets continues brisk, and prompt orders cannot be undertaken. A good all-round inquiry prevails, and prices have hardened up.

Malleable-Iron Trade.—The improvement in the malleable-iron trade of the West of Scotland continues, and the full number of shifts is being secured. Specifications are more plentiful, and new business is being secured rather more freely, but some difficulty is being experienced in getting better prices. The current price for crown bars is a shade above 6*l.*

Scotch Pig-Iron Trade.—A good trade is now being put through in Scotch pig iron, with local consumers taking large supplies, and buyers in the South sending in urgent orders for immediate despatch. The recent trouble with the railwaymen and dockers has delayed deliveries to England, and stocks have all but run out; hence the urgency of the demand. The local steelmakers are desirous of booking forward in order to cover their requirements, but sellers are very stiff in regard to prices. Foundry iron is in good demand, and some satisfactory business has been put through. Hematite is dull, and business is limited, with the price nominally 65s. per ton.

GERMAN COAL.—The deliveries of coal from the German groups of collieries in the first seven months of this year were 72,029,760 tons, as compared with 66,299,620 tons in the corresponding period of 1910, showing an increase of 5,730,140 tons, or 8.68 per cent. The total of 72,029,760 tons, representing the deliveries to July 31, this year, was made up as follows:—Ruhr, 45,638,390 tons; Upper Silesia, 15,381,890 tons; Lower Silesia, 2,305,070 tons; Sarre, 5,018,250 tons; Aix-la-Chapelle, 1,349,260 tons; and Rhine (lignites), 2,336,900 tons.

THE SPANISH GUNBOAT "RECALDE."

CONSTRUCTED BY THE SOCIEDAD ESPANOLA DE CONSTRUCCION NAVAL, FERROL AND CARTAGENA.

(*For Description, see Page* 288.)

Fig. 1.

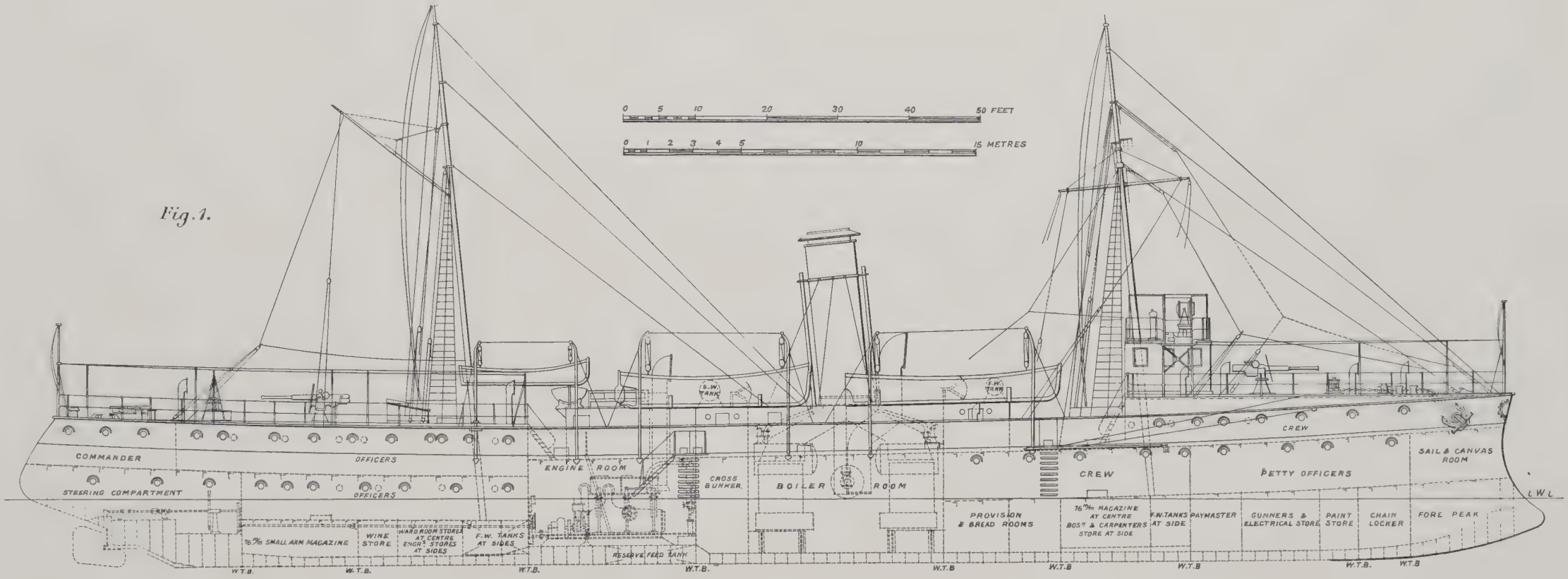


Fig. 2. POOP AND FORECASTLE DECK

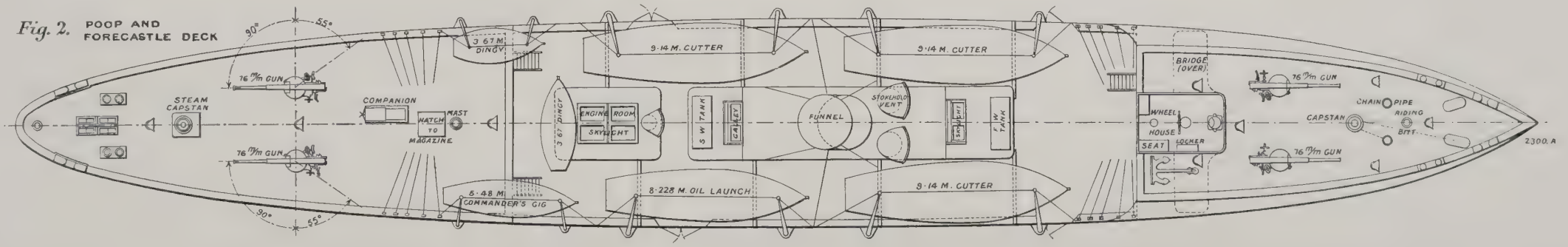


Fig. 3. MAIN DECK

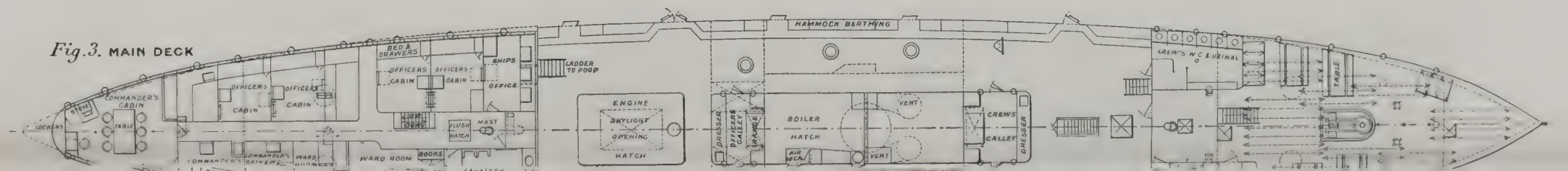


Fig. 4. LOWER DECK

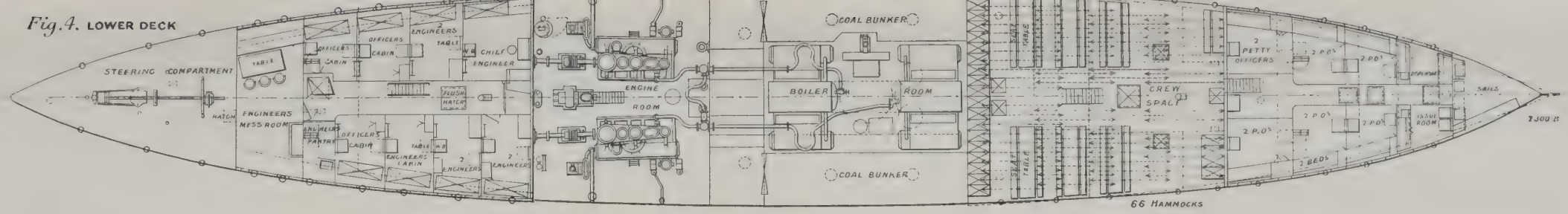


Fig. 5.

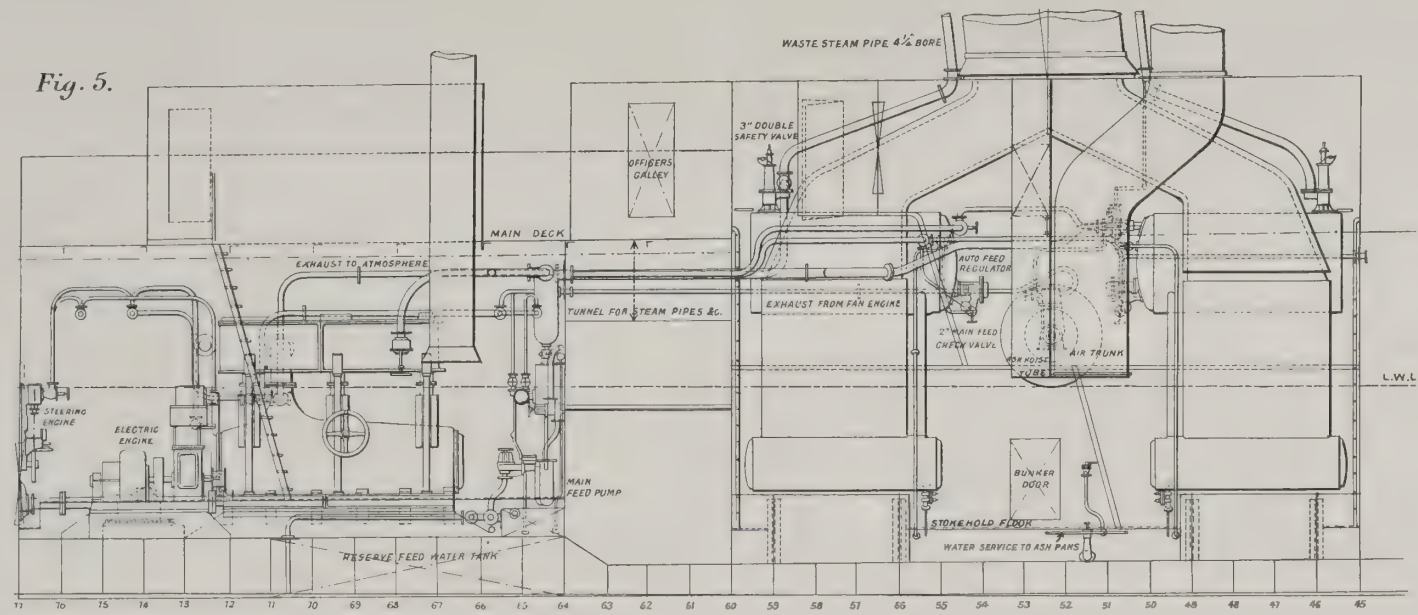


Fig. 6.

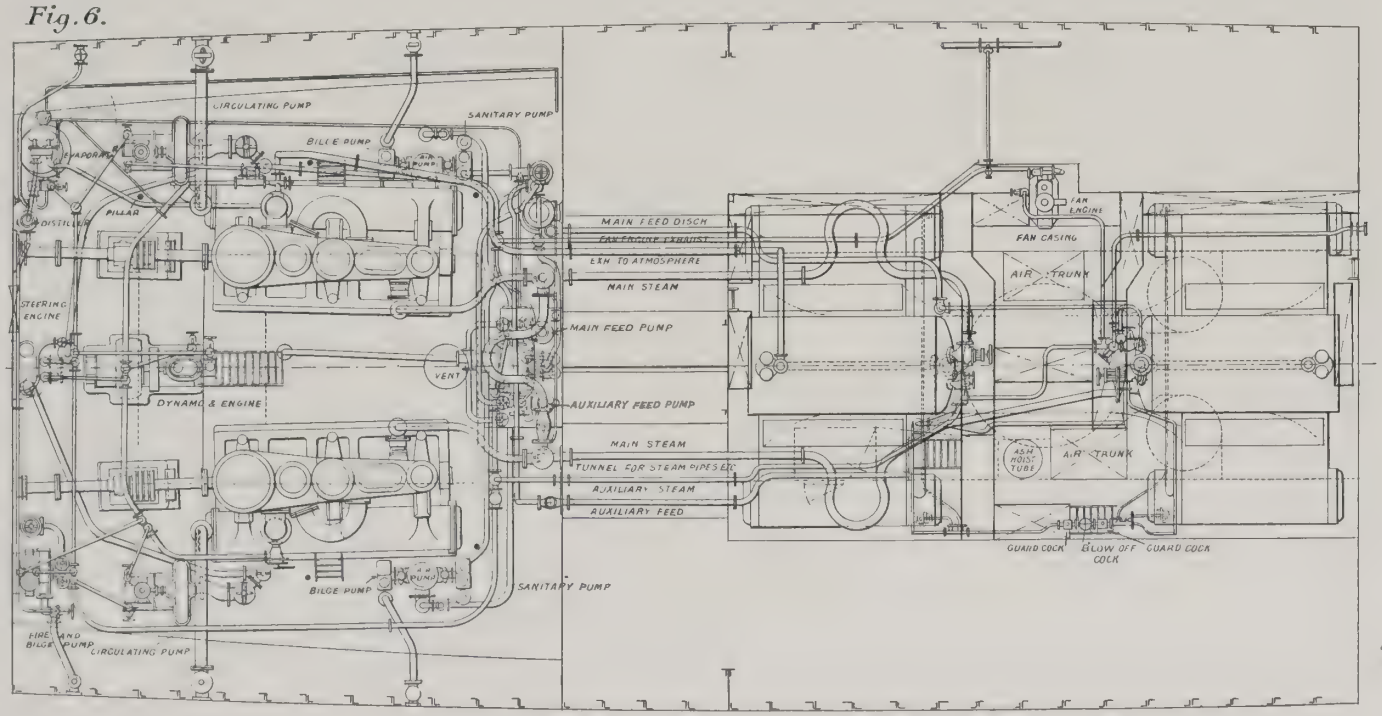


Fig. 7.
SECTION THROUGH BOILER ROOM
Looking Aft.

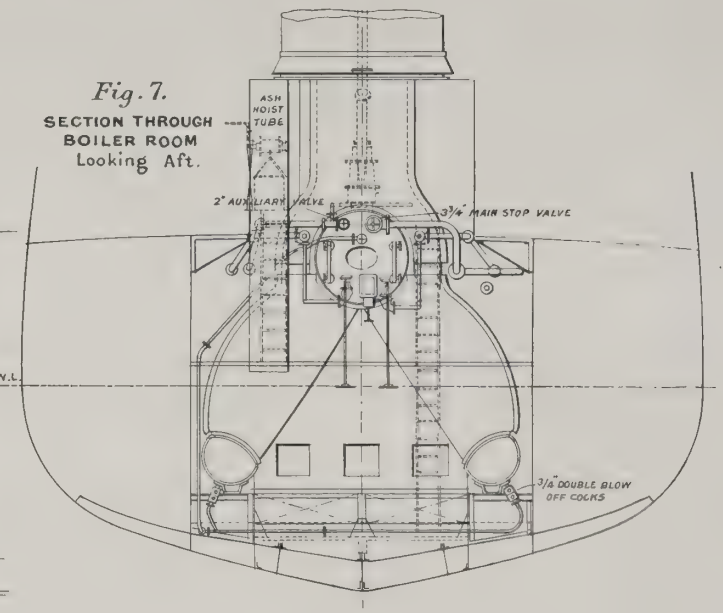
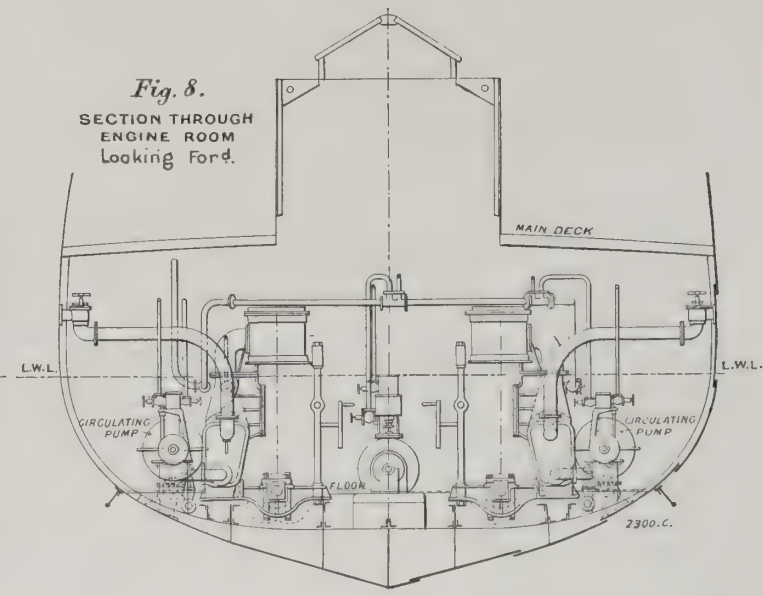


Fig. 8.
SECTION THROUGH ENGINE ROOM
Looking Ford.



Scale for Figs. 5 to 8.

10 9 8 7 6 5 4 3 2 1 0 5 10 15 20 Feet

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Good Signs.—At the meetings of two large Sheffield companies last week the note of optimism was distinctly struck. The chairman of the Sheffield Forge and Rolling Mills Company, Limited, had to report that increased trade had compelled them to put down two new bar-mills, which he believed would be quite satisfactory, and would shortly be working. The step had been necessitated, he explained, because they were at a period in their history when they must go forward if they did not wish to go back. The turnover of the company for the past year constituted a record. An action that was taken by this firm gives an interesting glimpse of a less familiar side of the recent labour troubles. The manager explained that consequent upon the combined strike of the railway men and the transport workers their works had had to shut down temporarily owing to lack of fuel. He had conferred with the men thus thrown out of work, and informed them they would receive half wages during the time they were unemployed, an action which had brought a warm letter of appreciation from the employees. In spite of keen foreign competition, increased wages, and higher cost of fuel, the chairman, at the annual meeting of the Brightside Foundry and Engineering Company, was able to report that the works were well employed, that extensions, necessitated by increased trade, were being made, and that the prospects for the coming year were favourable. Two or three large contracts had just been received, amounting to 15,000*l.*

South Yorkshire Coal Trade.—The steam-coal market remains in a very strong position, both in regard to shipments and industrial requirements. Deliveries for the next month or so will be heavy. The pressure at most of the large works is responsible for the big call for manufacturing hards, and merchants and owners are obtaining good prices. There is an increase in the inquiry for gas-coal, several consumers having depleted stocks. Slacks maintain a good position, though there is not the same scarcity experienced. However, they are not so plentiful as to have depressed values. A slight improvement is noticeable in house coal, orders for stocking are being more freely received both at pits and dépôts, and a good deal of stock has been cleared. The accumulations in sidings caused by the strike have resulted in a shortage of empty wagons. London inquiries are becoming of larger dimensions. The following were the quotations on the Sheffield Exchange at the week-end:—Best branch hand-picked, 13s. to 14s.; Barnsley best Silkstone, 11s. to 12s.; Silkstone, 9s. to 10s.; Derbyshire house, 9s.; large nuts, 7s. 3d. to 9s.; small nuts, 5s. 6d. to 6s. 6d.; Derbyshire brights, 9s. 6d. to 11s.; washed nuts, 7s. 6d. to 8s. 6d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. 3d. to 5s. 3d.; and smalls, 2s. to 3s.

Iron and Steel.—The condition of the city's industries is almost normal again after the dislocation caused by the strike. The exact effects cannot, of course, be yet determined, but it is certain that considerable financial loss has been suffered. It now appears that it was not the very large East End firms which were most affected by the partial stoppage of the coal and raw material supply, but the smaller manufacturers, who have to rely for their supplies exclusively on the carters, who were then on strike with the railway men. As the larger firms have the railways running through their works, they were able largely to defeat the efforts of the transport workers to hold up supplies. In the iron market buying has been on the small side, but the steadiness in the tone may be accounted for by the fact that only small stocks are held and small outputs are the rule. A number of furnaces are shortly to be re-started, and these may weaken prices, but, on the other hand, there is every indication of a big consumption of raw materials by steel-makers in the autumn and winter, and consequently producers' expectations are of big demands. Present prices are:—Hematites—West Coast, 76s. to 78s.; East Coast, 68s. to 70s.; Lincolnshire No. 3, 50s. 6d.; Lincolnshire forge, 49s. 6d.; Derbyshire No. 3, 51s.; Derbyshire forge, 49s. It is stated that Lincolnshire makers are asking small premiums, and the position of Derbyshire brands is stronger. Finished-iron makers have good work and better prospects. Most of the large steel works will be very busy for some time to come, making up for the time lost during the strike and during the various holiday periods which have been so numerous this summer. Contrary to custom, they have been engaged on large orders during what are usually slack months. The heavy branches represented by the forges, foundries, and railway steel works, are all active, and the activity promises to continue. Right through the general trades a similar condition of things is to be found. The rolling-mills are busy, always a good sign, and in the lighter trades the manufacture of all kinds of tools, mining and agricultural machinery, &c., continues to be brisk. It is expected the returns will show one of the best seasons on record. There is no decrease in the demand for special kinds of steels.

TELEPHONES IN GAS WORKS.—The Association of German Gas and Water Works has sent an inquiry sheet to its members and to the postal authorities in order to ascertain whether any accidents had been caused by the installation of telephones and electric bells in their apparatus rooms. No case of gas being lighted by sparks from those instruments was reported; in special experiments ignition sometimes—but only rarely—resulted when gas was blown on the instruments in action. The association hence resolved to permit the installation of telephones in apparatus rooms of gas works; the telephones should, however, be fixed outside, and the bells, if inside, be provided with guards of gauze.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The pig-iron market is in an unsatisfactory state, and values, contrary to anticipation, are declining. The reason is the general unrest in the labour market, particularly on the railways, consumers of pig being unwilling to operate, with possibility of delayed delivery hanging over them. Less favourable reports from the United States, and the condition of the stock market, also assist to depress the iron market. It might reasonably have been believed that the settlement of the dockers' strike at Grangemouth would have benefited the position here, for under normal conditions about 1000 tons of pig iron per day go from here to that port; but the settlement has apparently had no influence on this market. No. 3 g.m.b. Cleveland pig is offered freely by merchants at 47s. 3d. for early f.o.b. delivery, and some producers might also sell at that figure. No. 1 is 50s. 9d.; No. 4 foundry and No. 4 forge, each 46s. 9d.; and mottled and white iron, each 46s. 3d.—all for early delivery. East Coast hematite pig continues flat, notwithstanding the fact that the consuming industries are very busy. Mixed numbers are on offer at 61s. for early delivery, and forge hematite is quoted 60s. Business in foreign ore is at a standstill, and consumers declare that there will be no buying of any consequence until prices are lowered. Market rates are based on 19s. ex-ship Tees for best Rubio.

Stocks and Shipments of Pig Iron.—Stocks of pig are still heavy, but it is gratifying to be able to report some reduction. To-night Messrs. Connal and Co., the warrant store keepers, hold 596,046 tons of Cleveland pig iron, which is a decrease since the beginning of August of 4463 tons—a larger reduction than has been recorded since June, 1908; in fact, there has never been a decrease at all in any month since that time. Shipments of pig this month (August), up to to-night, amount to 82,698 tons, as compared with 76,577 tons to the same date last month, and 94,813 tons for the corresponding part of August last year.

Manufactured Iron and Steel.—Producers of nearly all descriptions of finished iron and steel are very busily employed, and not only have they large contracts made, but good inquiries are still in the market. Substantial orders for steel rails are understood to have been secured recently. Quotations all round are well maintained. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 11*l.* 5s.—sheets less 4 per cent. f.o.b., railway material net at works, and all other descriptions less 2½ per cent. discount.

German Coke for Middlesbrough.—The cargo of 1500 tons of German coke bought during the railway men's strike is this week being discharged at Middlesbrough. The buyers are Messrs. Gjers, Mills, and Co., of the Ayresome Iron Works. The cargo was brought from Westphalia, *via* Rotterdam.

MINING MACHINERY.—A falling-off is observable this year in our exports of mining machinery. The value of the shipments in July was 78,668*l.*, as compared with 113,983*l.* in July, 1910, and 80,276*l.* in July, 1909. The aggregate value of the exports for the seven months ending July 31, this year, was 580,743*l.*, as compared with 762,785*l.* and 492,422*l.* respectively. South America took British mining machinery to July 31, this year, to the value of 37,156*l.*, as compared with 31,350*l.* and 40,613*l.* respectively.

LARGE DAM ON THE WEST COAST OF SLESWICK.—The Prussian Government has been preparing plans for the building of a large dam between the Island of Syet, and the west coast of the Duchy of Sleswick, and this comprehensive scheme is now understood to be approaching its completion. The distance is some 10 km., and the dam in question is to accommodate a road and a railway. There can be no donbt that this dam will bring about a considerable amount of land reclamation, and be a protection for portions of low-lying land; but this costly undertaking is also of strategic importance, and a link in the defensive measures on the Fries coast, the more so as the fortification of Heligoland is now approaching its completion.

ELECTRIC POWER IN PENNSYLVANIA.—Over 200 charters for electric companies have been granted by the State of Pennsylvania since May 1, this year, and considerable significance is attached to the fact that the groups into which they were divided embrace coal and water-power centres. The companies were chartered with nominal capital, and each one was given a district in which to supply electricity for light, heat, or power, the ultimate plan being to consolidate. The large coal companies of the anthracite region are behind some of the charters, New York capital being interested in a group chartered for the Lehigh Valley. In the soft-coal region groups have been secured for townships in the vicinity of Johnstown, Pittsburg, Washington, and Uniontown. Fourteen were taken by interests which will use Susquehana river power, and charters for nineteen are pending for a group to operate in the Clarion Valley.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has, upon the whole, been quiet; tonnage arrivals have scarcely equalled expectations, and with threats of further strikes buyers and sellers do not show much eagerness to enter into large transactions. Sellers of Admiralty steam coal appear to be well booked; other large coal has shown little change; cargo smalls have been freely offered. The best large steam coal has made 19s. to 19s. 6d. per ton; secondary qualities have ranged between 16s. 6d. and 18s. per ton; best bunker smalls between 10s. and 10s. 6d. per ton; and cargo smalls between 8s. and 8s. 6d. per ton. The best ordinary household coal has realised 14s. 6d. to 16s. 6d. per ton; No. 3 Rhondda large has brought 17s. to 17s. 6d. per ton; and smalls, 10s. 6d. to 10s. 9d. per ton. No. 2 Rhondda large has made 12s. 3d. to 12s. 6d. per ton; smalls, 8s. to 8s. 6d. per ton. Foundry coke has been quoted at 18s. to 20s. 6d. per ton, and furnace ditto at 16s. to 17s. per ton. As regards iron ore, Rubio has realised 18s. 6d. to 19s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

The Eddystone.—Trinity House notifies that it is intended to establish next month a bell buoy, which will be fitted with an automatic submarine bell, in a position three cables S. 17 deg. W. from the Eddystone lighthouse. The buoy will be painted in black and white vertical stripes, will be fitted with a can-shaped superstructure, and will have the name "Eddystone" in white letters on its side. The submarine bell will be worked by the movement of the buoy, so that the number of strokes per minute will not be uniform.

Dowlais.—The blast-furnaces in the Bessemer department have been well employed. The Goat Mill has been engaged upon tin bar, steel sleepers, and steel rails; and the Big Mill has been busily employed with light sections of steel rails, angles, fish-plates, &c. The collieries have been well employed, and their production has been heavy.

Torpedo-Boats as Targets.—The want of a better target for night firing in the Navy is about to be met by the conversion of a number of the old 60-ft. second-class torpedo-boats into practice targets. The work is proceeding on several of the boats at Devonport, and when completed they will closely resemble the principal section of a modern torpedo vessel, canvas and wooden structures to represent the funnels, &c., being reared above the upper deck. The interior of the boats having been cleared out, cork, &c., is to be filled in to render them unsinkable.

NORWEGIAN STATE RAILWAYS.—The Norwegian Storthing has sanctioned the proposal of the railway committee that the important Dovre railway, now in course of construction, shall be built heavier than originally proposed, in accordance with a new normal type, which makes it possible to increase the speed from 65 to 90 kilometres per hour.

GERMAN INTEREST IN SWEDISH IRON MINES.—German purchases of shares in Swedish iron mines is contradicted. It is a well-known fact that Germany is concerned about her future supply of iron-ore, and is doing her best to secure suitable iron-ore deposits. A number of shares in the important Swedish concern, the Norberg mines, coming on the market, a large German firm in Lübeck was understood to be anxious to acquire them. In order to prevent this five Swedish iron works have taken over the said shares.

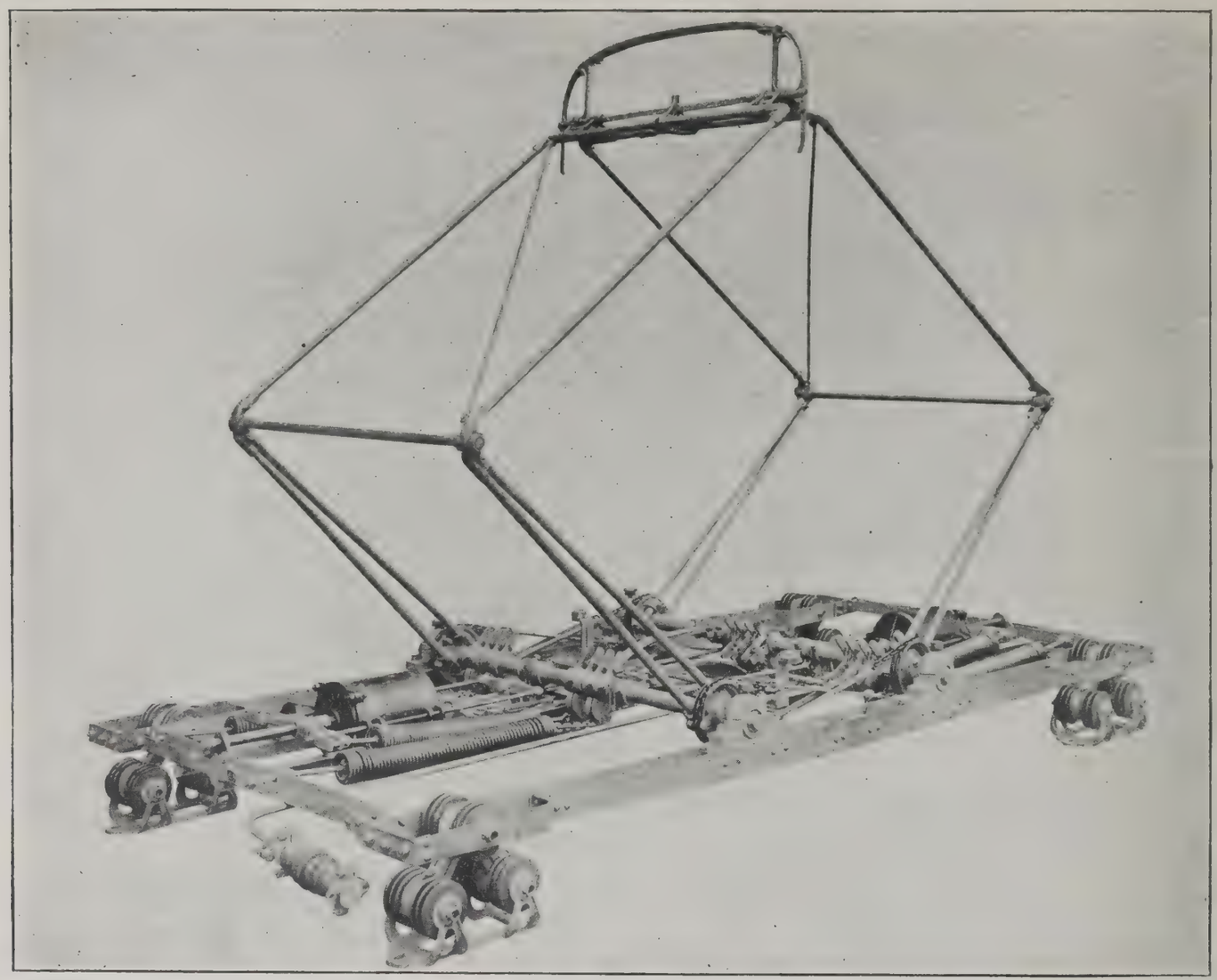
GRINNELL AUTOMATIC SPRINKLERS IN PRINTING WORKS.—A case of the efficiency of these sprinklers has recently been brought to our notice which shows how useful they may be in saving property. A fire occurred on August 13, about 3 p.m., at the printing works of Messrs. Hazell, Watson, and Viney, Limited, Long Acre, W.C. It originated in the heart of the building, where high racks were filled with stationery. Two sprinklers came into operation at once and promptly extinguished the fire. It is highly probable that but for the timely action of the sprinklers a very serious fire would have occurred.

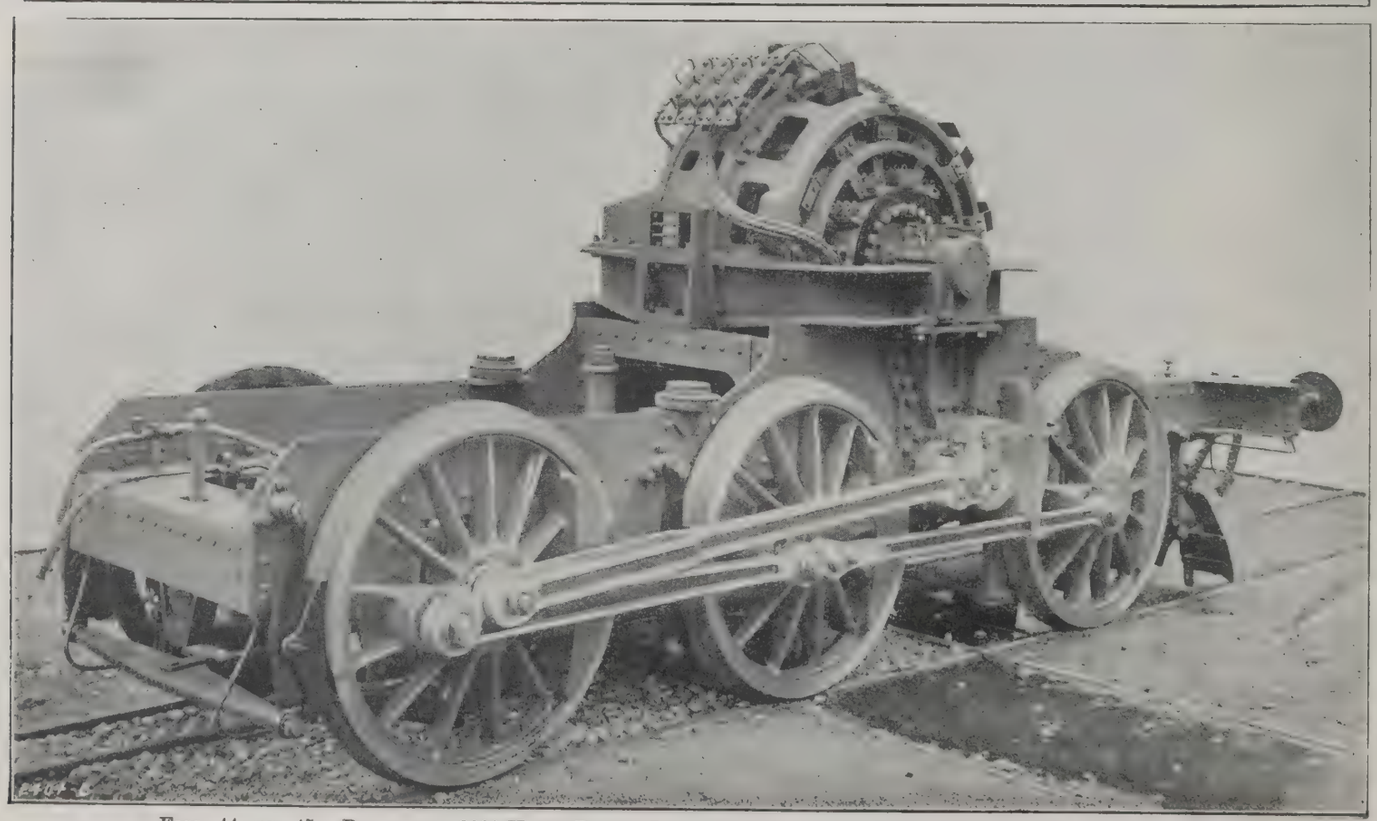
MEXICAN TRAMWAYS.—The revenue of the Mexico Tramways Company last year was 609,430*l.*, as compared with 560,784*l.* in 1909; 549,269*l.* in 1908; 510,134*l.* in 1907; and 436,235*l.* in 1906. The working expenses, including taxes, were 298,981*l.* last year, as compared with 280,527*l.* in 1909; 288,118*l.* in 1908; 285,996*l.* in 1907; and 239,637*l.* in 1906. The ratio of the working expenses to the traffic receipts accordingly declined from 54.93 per cent. in 1906 to 49.06 per cent. in 1910. The length of line worked last year was 181¼ miles, of which 172 miles were worked by electricity; the remainder of the system was worked by mules, which are being gradually displaced by electric power.

COAL IN EAST AFRICA.—British financiers are about to exploit the coal and mineral fields of Portuguese East Africa. A concession granted covers mineral rights for five years over an area of the Mozambique province estimated at 3500 square miles, embracing all the territory lying to the south of the Lourenço Marques and Transvaal Railway. This area is served by two railway lines and four navigable rivers. Active prospecting and development are expected to be shortly commenced. Of the mineral resources of the area conceded but little is known; it, however, contains extensive coal deposits similar in character to those found in Swaziland, which are said to be only 7 per cent. inferior to the best Welsh coal.

ELECTRIC TRACTION IN SWITZERLAND.

(*For Description, see Page* 285.)





Figs. 44 and 45. Details of 2000-Horse-Power Locomotive for the Bern-Lötschberg-Simplon Railway.

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With a Two-Page Plate of ELECTRIC TRACTION IN SWITZERLAND, and a Two-Page Plate of the SPANISH GUNBOAT "RECALDE."

ENGINEERING.

FRIDAY, SEPTEMBER 1, 1911.

THE DISTRIBUTION OF STRESS ROUND DECK-OPENINGS.

FOR many years past engineers have been in doubt as to the effect, on the distribution of stress, of punching a hole in the centre of a tie-bar or other simple tension member. Common-sense made it evident that the resulting distribution of stress in the immediate neighbourhood of the hole must be far from uniform, but it was not an easy matter to estimate the relative importance of the local increases in stress intensity. That this increase of stress might well be very considerable was evident from the fact that mathematicians had shown that the piercing of a small hole in the centre of a rotating disc had the effect of doubling the maximum stress as compared with the stress in an unpierced disc subject to the same centrifugal forces. There is, however, no very direct analogy between the stresses in such a disc and those developed in the neighbourhood of deck-openings in ships. To obtain the high speeds now demanded in certain classes of war vessels, scantlings must be reduced to the minimum consistent with safety, and consequently naval architects have been driven to various expedients to estimate the value of the local concentrations of stress round such openings. The favourite resource has been experiments on models; but in certain cases these have been based on fallacious analogies between the equations of hydrodynamics and of the mathematical theory of elasticity. The conclusions reached were accordingly certainly erroneous, but the magnitude of the error involved was unknown. That it was large is now proved in the able and original paper which we publish elsewhere in this issue, in which Dr. K. Suyehiro, of the Department of Naval Architecture, Tokio Imperial University, shows that the problem in question is not impervious to direct attack by the mathematical theory of elasticity. Strictly speaking, his solution appertains only to the ideal case of a plate pierced at the centre and extending to infinity in all directions. This is assumed to be subjected, in one direction only, to tension, the distribution of which is uniform at an infinite distance from the origin. Dr. Suyehiro then works out what the distribution of stress is in the immediate neighbourhood of the hole, and finds that the maximum value of the stress is no less than three times that of the average value. If there were any real analogy between stream-lines and stress-lines, the maximum stress, he points out, would be double the mean.

The great difficulty in all these mathematical solutions of stress problems lies in the fact that the method of solution is necessarily tentative. A form of solution is assumed, and this is then tested to ascertain whether it satisfies the necessary mathematical relationships. If it does, then the solution is necessarily right; whilst if it fails, another guess must be made and tested in its turn. In far the majority of cases no satisfactory guess is found, and Dr. Suyehiro is therefore to be congratulated on a distinct addition to the number of known solutions in the mathematical theory of elasticity. The difficulty of effecting such a step in advance is well illustrated by the fact that the late Sir George Airey, applying the tentative method outlined above, arrived, in 1862, at a solution for the distribution of stresses in a loaded beam which, a quarter of a century later, was discovered to be fundamentally erroneous.

In respect to the practical aspects of Dr. Suyehiro's discovery, a number of interesting considerations intervene. He shows that though his solution only applies with mathematical exactness to the problem of the infinite plate, the results are practically accurate even in the case of quite narrow plates, since the local concentrations of stress have practically vanished at points distant from the centre of the hole by $1\frac{1}{2}$ radii. He has further compared the results of his calculations with direct experiment on a strip of india-rubber, and finds a remarkably close agreement between the two. This observation furnishes fresh evidence of the value of india-rubber as an instrument of stress analysis by the direct experimental method.

As already stated, Dr. Suyehiro finds the maximum stress, which occurs at the ends of the transverse diameter of the hole, is three times the mean, so that, with quite a moderate average stress in the body of the plate, the elastic limit may be exceeded at these two points. With a plate subject to tension or compression in one direction only this is, of course, of no importance whatever; the overstrained area then simply stretches a little, and passes on its overload to adjacent fibres. In the case of a ship's deck, however, the stresses may alternately be tensile or compressive, according as the ship swims on the crest or lies in the trough of a wave. Here the fact that the stresses exceed the elastic limit may be of serious import, since no material will long withstand being strained beyond its elastic limit first in one direction and then in the opposite. It would seem that there is here an excellent opening for experimental research, and it might well be taken up in the laboratory of one or other of our technical colleges. It would not be at all difficult to make arrangements by which a wide bar pierced with a hole should be subjected to alternate tension and compression. The determination of the process of elastic breakdown and final rupture could hardly fail, in comparison with Dr. Suyehiro's results, to afford interesting and valuable information.

The theory now arrived at relates, as stated, to the stress round an opening in plates, and is therefore not directly applicable to the case in which the hole is filled by a rivet, which transfers to the plate the load by which it is strained. In view of the success attained in the case of the simpler problem, there is, perhaps, fair ground for hoping that this too may not prove intractable to analysis. Apparently the conditions in this case are more closely allied to the problem of the distribution of stress in a bar subjected to a concentrated load at one point of its edge than to Dr. Suyehiro's problem. The weak points of an eye-bar, for instance, are not at the sides of the hole, but at the end.

THE BRITISH ASSOCIATION AT PORTSMOUTH.

THE eighty-first annual meeting of the British Association for the Advancement of Science was formally opened in the Portsmouth Town Hall on Wednesday evening last. What modern Portsmouth means everybody knows. Historically the city is far more interesting than one might think, and the excellent guide-book prepared for the members of the Association duly dwells on matters historical. Yet we are afraid that the prediction we made last week of but a moderate attendance at the present meeting will not be wrong. By Wednesday afternoon 1123 members of all classes had entered their names—about 150 fewer than last year at the commencement of the Sheffield meeting. All the same, people experienced some trouble in finding accommodation. The Connaught Drill Hall makes a spacious, excellent reception-room. The offices are in the front portion, and the very comfortable sitting and writing-room is separated from this portion by a simple but appropriate screen. The presidential address was delivered in the Town Hall, an imposing classical building, erected in 1886, at a cost of 140,000*l.*; the lecture theatre accommodates 2000 people, and it was not filled on Wednesday evening.

Professor Bonney was the retiring President, and Sir William Ramsay, K.C.B., F.R.S., of University College, London, the President-Elect. Professor John Perry, F.R.S., is the Hon. Treasurer, Major P. A. MacMahon, F.R.S., and Professor W. A. Herdman, F.R.S., are the General Secretaries, Mr. O. J. Howarth, M.A., is the Assistant Secretary, and Mr. H. C. Stewardson the Assistant Treasurer. The Local Officers are Alderman T. Scott Foster, Mayor of Portsmouth, one of the Vice-Presidents, and Messrs. C. Hammond Etherton, Town Clerk, and A. Mearns Fraser, M.D., Local Secretaries.

In introducing his presidential address Sir William Ramsay quoted the object of the Association as explicitly stated at its first meeting at York: "To give a stronger impulse and a more systematic direction to scientific inquiry, to promote the intercourse of those who cultivate science in different parts of the British Empire with one another and with foreign philosophers, to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress." These objects, we should like to add, are printed at the head of the official circular

of the Association; they justify the policy which the Association has pursued, and they undoubtedly help to explain its success. In 1831, Sir William continued, the workers in the domain of science were few. The Royal Society, founded in 1645 as the "Invisible or Philosophic College," and incorporated in 1660, stood alone until 1788, when the Linnean Society was founded, and most of our learned societies arose after 1831, during the age of railways, telegraphs, and telephones, when the engineering problem was hardly: "Can it be done?" but, rather, "Will it pay to do it?"

Passing to education, Sir William spoke out in refreshingly plain words, many of which we can endorse. "In England," he said, "we have made technical education a local, not an imperial, question. Instead of half-a-dozen first-rate institutions of University rank, we have a hundred, which are necessarily understaffed, in which the staffs are mostly overworked, and the training given is not that for captains of industry, but for workmen and foremen. 'Efficient captains cannot be replaced by a large number of fairly good corporals.' Moreover, to induce scholars to enter these institutions they are bribed by scholarships—a form of pauperisation practically unknown in every country but our own; and to crown the edifice we test results by examinations of a kind not adapted to gauge originality and character (if, indeed, these can ever be tested by examination), instead of, as on the Continent and in America, trusting the teachers to form an honest estimate of capacity and ability of each student, and awarding honours accordingly. The remedy lies in our own hands. Let me suggest that we exact from all gainers of university scholarships an undertaking that, if and when circumstances permit, they will repay the sum which they have received. It would then be possible for an insurance company to advance a sum representing the capital value—viz., 7,464,931*l.*—of the scholarships, reserving, say, 20 per cent. for non-payment, the result of mishap or death. In this way a sum of over six million pounds, of which the interest is now expended on scholarships, would be available for university purposes. A large part of the income of this sum should be spent in increasing the emoluments of the chairs. Having made the profession of a teacher so lucrative as to tempt the best intellects in the country, it is clear that such men are alone capable of testing their pupils. The modern system of external examination, known only in this country and answerable for much of its lethargy, would disappear. . . ."

Sir William did not pursue this matter. He did not allude to the absurdity of the competitive mark system, which lies at the root of the trouble. His colleagues on the platform and in the theatre were able to agree with him, about the increase of emoluments at any rate. The abolition of scholarships and of external examinations may seem an ideal to some professors; but scholarships and successes in competitive examinations bring students and emoluments, and a modification of the present system seems to promise the best practical solution of the problem. The common German University practice, we might add, is that scholarships and facilities for deferred payment of fees—apart from research grants—are given only on the strength of a *testimonium paupertatis;* the recipient of facilities signs a form promising to pay as soon as he will be in a position to do so.

Sir William Ramsay returned to the aims of the Association, accentuated the importance of friendly and unrestrained intercourse between scientists, and asked his older colleagues not to let opportunities slip of stimulating the young worker by sympathy. He then referred to the losses which the Association and science had had to mourn since the last meeting: John Beddoe, Rubert Boyce, Francis Galton, Thomas Rupert Jones, Story Maskelyne, and Johnstone Stoney, in this country, and Bohr, Brühl, Caro, Fittig, Van't Hoff, and Cannizzaro abroad.

Sir William then passed to his first main subject, the elements of the chemists. The Greeks had by their elements—fire, air, water, earth—rather denoted properties of matter than constituents of a compound. Robert Boyle, in his "Skeptical Chymist," had given to the word "element" its present meaning. But he could not suggest any particular substance as elementary, and it was only after Lavoisier's overthrow of the phlogiston theory of Stahl that individual elements were recognised. Lavoisier put the case with remarkable lucidity in the preface to his "Traité de Chimie" of 1789, the year of the Revolution:—"If we mean by elements the simple and indivisible molecules of which bodies consist, it is probable that we do not know them; if, on the other hand, we mean the last term in analysis, then every substance we have not been able to decompose is for us an element; not that we can be certain that bodies which we regard as simple are not themselves composed of two, or even a larger number of elements, but because these elements can never be separated; or, rather, because we have no means of separating them, they act, so far as we can judge, as elements." In 1807 Humphry Davy split oxides and hydrates into oxygen, hydrogen, and metals; Scheele "dephogisticated" marine acid and isolated chlorine; Courtois discovered iodine in 1812, Balard bromine in 1826; but the fourth halogen, fluorine, frustrated all attempts of isolation until Moissan finally demonstrated that it really resembled the other halogens in its properties as predicted.

The modern conception of the elements, Sir William continued, was much strengthened by Dalton's revival, in 1803, of the Greek hypothesis of the atomic constitution of matter and the assigning of a definite weight to each atom. In those days the ancient idea of the unitary nature of matter was held to be very probable. At first oxygen was regarded as the common basis; Prout then brought forward the claims of hydrogen, which, about 1842, were revived by Liebig, Redtenbacher, and Dumas. Of recent years great advance had been made in the accuracy of the re-determinations of atomic weights. The annual table of the International Committee on Atomic Weights for 1911 counted 81 elements, and no fewer than 43 of these had atomic weights within one-tenth of a unit above or below an integral number. The probability against such a condition being fortuitous was 20,000 millions to 1, according to Karl Pearson. Döbbereiner, Dumas, and others, and then, in 1862, John Newlands, had meanwhile arranged the elements in the numerical order of their atomic weights, and the latter had, in his "law of octaves," pointed out that every eighth element was, like the octave of a musical note, in some measure a repetition of its forerunner. Thus potassium, at that time the eighth known element above sodium, repeated the character of sodium in its physical properties and in the properties of its compounds. The same fundamental notion was independently reproduced by Lothar Meyer and by Dmitri Mendeleieff, and the elements were arranged according to the "periodic system." Some vacant spaces on this table had been filled by the discovery of new elements as predicted, and it might be thought that it only remained to fill up the remaining gaps. But the metals of the rare earths with atomic weights ranging from 139 to 180 would not fit into the columns of the periodic table. On the other hand, the discovery of the inert gases, which Johnstone Stoney foresaw in his spiral curve of 1888, joined the strongly electro-negative alkali metals to the highly positive halogens by a series of chemically and electrically inert substances, neon, argon, krypton, xenon, which formed links between fluorine and sodium, chlorine and potassium, bromine and rubidium, and iodine and calcium.

Including these gases, and adding some elements of the rare earths and radium, 84 elements found places in the periodic table if merely numerical values were considered. Between lanthanum, atomic weight 139, and tantalum, 181, seventeen spaces remained empty; they could not well be filled with the metals of the rare earths (as just stated) and be distributed in successive columns, for they all resembled lanthanum. Disregarding this objection, however, there would still remain eleven gaps, assuming uranium, with the highest known atomic weight of 238 5, to form the upper limit. But we were confronted by an *embarras de richesse.* For the discovery of radioactivity (by Henri Becquerel), of radium (by the Curies), and of the disintegration of the radioactive elements (by Rutherford and Soddy) indicated the existence of no fewer than twenty-six hitherto unknown elements. But were these bodies elementary substances?

Radium formed salts like barium, the metal (isolated by Mme. Curie) resembled barium, and its atomic weight was, according to Curie and to Thorpe, 226.5; it was undoubtedly an element, yet a very unstable one, and stability was considered the essential characteristic of an element. Radium, however, changed into other bodies, and disintegrated at a constant rate. Of 1 gramme of radium only ½ gramme would remain after 1760 years; the other half would have passed into different products. The first of these were radium emanation, a condensable gas, and helium, undoubtedly an element belonging to a well-defined series. Again, the emanation, which was incapable of chemical union, had been liquefied and solidified at University College, its density determined, and its atomic weight been calculated, and the emanation had thus been proved to be a congener of argon, belonging to the series: helium, atomic weight 4; neon, 20; argon, 40; krypton, 83; xenon, 130; unknown substance, 178; niton (proposed name for the emanation, which was phosphorescent), 222.4. The formation of niton from radium would therefore be represented by the equation: radium (226.4) = helium (4) + niton (222.4).

Niton, in its turn, disintegrated much more rapidly than radium. In four days half of it had changed into helium and radium A—a substance of metal character, of atomic weight 218.4. But RaA could not be investigated chemically, because in 3 minutes half of it had changed into RaB (214.4) and helium. Of RaB half passed into RaC_1 and electrons (atoms of negative electricity) in 27 minutes; RaC_1 had a half-life period of 19 minutes, yielding helium and RaC_2 (210.4); RaC_2 (period 2.5 minutes) gave off electrons and RaD. RaD allowed the chemist a chance, its half-life period being 16½ years; without parting with any thing detectable it passed into RaE, period three minutes, which changed spontaneously into RaF, the polonium of Mme. Curie. Polonium finally changed in 140 days into helium and a metal, possibly lead. If that were so, the equation should be: Polonium (210.4) = helium (4) + lead (206.4). The atomic weight of lead was 207.1. To account for this discrepancy—which looks small enough to the non-chemist in view of the amazingly quick changes indicated—Sir William suggested that the atomic weight of radium might be 227.1 (instead of 226.4), and that of uranium, the parent of radium, might be 239.4 (instead of 238.5, or Clark, 239.0), as Richards and Merigold indeed believed. The most careful determination of the atomic weight of helium, by Watson (at University College), yielded 3.994; one atom of uranium changed into three atoms of helium and one atom of radium.

There were, moreover, in addition to the α rays (or atoms of helium) β rays, or electrons, which had weight too. How many electrons were lost was unknown, but the probable weight of the electrons escaping during the change uranium-radium was 0.6.

The conclusion which Sir William drew was that we had, for the first time, accurate knowledge as to the descent of some of the elements; our readers may reserve their doubts, though this genesis has been worked out, and is credited by specialists both here and abroad. The correct solution of the problem would in great measure clear up the mystery of the irregularities in the periodic tables, and would account for the deviations from Prout's law—that the atomic weights are multiples of some common factor. It would also throw light on allotropy, which in some cases might be due to the loss or gain of electrons. Of the twenty-six elements derived from uranium, thorium, and actinium, ten were formed by the emission of electrons alone, and they might be regarded as allotropes or pseudo-elements; their existence should certainly not be regarded as irreconcilable with the periodic table.

Turning to the enormous quantity of energy stored in radium and its descendants, Sir William said that if the heat of disintegration of niton (or emanation) were available, it would be equal to 3½ million times the energy available by the explosion of an equal volume of detonating gas (oxygen and hydrogen). The major part of this energy seemed to come from the expulsion of α particles with enormous velocity. If the energy of a ton of radium could be utilised in thirty years (instead of being evolved at the slow rate of 1760 years for half-disintegration) it would suffice to propel a ship of 15,000 tons, with engines of 15,000 horse-power, at the rate of 15 knots, for 30 years, which would otherwise require a million and a half tons of coal. "I have attempted to apply the energy contained in niton to various purposes; it decomposes water, ammonia, hydrogen chloride, and carbon dioxide, each into its constituents; further experiments on its action on salts of copper appeared to show that the metal copper was converted partially into lithium; and similar experiments, of which there is not time

to speak, indicate that thorium, zirconium, titanium, and silicon are degraded into carbon; for solutions of compounds of these mixed with niton invariably generated carbon dioxide, while cerium, silver, mercury, and some other metals gave none. One can imagine the very atoms themselves, exposed to bombardment by enormously quickly-moving helium atoms, failing to withstand the impacts. Indeed, the argument *a priori* is a strong one; if we know for certain that radium and its descendants decompose spontaneously, evolving energy, why should not other more stable elements decompose when subjected to enormous strains."

This is all Sir William had to say about his alleged transmutations of elements, and we cannot but regard it as disappointing. One may assent to the suggestion that enormous strains might decompose elements; but Sir William's critics require proofs. Those which Sir W. Ramsay offered some years ago were severely criticised at the time, and naturally some reply to the objections raised was expected in his presidential address.

Turning to his last theme, the sources of energy at the disposal of man, Sir William pointed out that even if we could accelerate and control the rate at which radium was evolving its stored-up energy, it would be of little importance, for the production of radium would probably never surpass half an ounce a year. If, however, the elements now considered as permanent were capable of changing with an evolution of energy which catalysers could accelerate, the whole future of the human race would be altered.

Progress was chiefly a question of means of concentrating and transforming energy. The use of the stick, spear, arrow, &c., had made man the master of animals. A steam-engine converted one-eighth of the potential fuel energy into useful work; the gas-engine more than one-third. Vast progress had been made in this respect in the nineteenth century, especially since its middle, the beginning of the golden age of science. The people of Athens had attained a high, unsurpassed watermark in literature and thought, because they had ample leisure; each freeman had had at least five helots who did his bidding. We were much better off in Britain. The population was 45 millions, and at least 50,000,000 tons of coal were consumed annually in our factories, at an average expenditure of 5 lb. of coal per indicated horse-power per hour (Royal Commission on Coal Supplies). That gave 7 million horse-power per year, which, assuming that a Bhutanese could carry 230 lb. plus his own weight, 400 lb. in all, up a hill 4000 ft. in height in eight hours, would mean twenty-five times as many man-power, so that a British family of five persons would on average have twenty helots at its command, instead of the five helots of the Athenian. We did not gain more leisure by that, but it was that which made it possible for the British Isles to support their population.

Referring further to the General Report of the Royal Commission on Coal Supplies (1906), Sir William stated that the stored-up energy of the British Isles was very limited. In 1870, 110 million tons of coal were mined; the amount had been increasing at the rate of 3⅛ million tons per year, and estimating the whole available store in the proved coal-fields at 100,000 million tons, it would at that rate be exhausted in 175 years. As coal became dearer the rate might finally slow down. So far it showed no signs of slackening, however. Between 1905 and 1907 the amount of coal raised in the United Kingdom had increased from 236 to 268 million tons, equal to 6 tons per head of population, against 3½ tons in Belgium, 2½ tons in Germany, and 1 ton in France.

Our commercial supremacy and our power of competing with other European nations was evidently governed by the relative price of coal, and when the prices rose, we might look forward to the approach of famine and misery. Struck with the optimism of non-scientific friends, he (Sir William) had some years ago suggested that a committee of the British Science Guild should investigate the available sources of energy. Sir Charles Parsons, Mr. Dugald Clerk, Sir Boverton Redwood, Dr. Beilby, Dr. Hele Shaw, Professor Vivian Lewis, and others had reported, and had reviewed the possibilities of utilising the tides, the internal heat of the earth, winds, solar heat, water-power, the extension of forests, and the use of wood and peat as fuel, and finally the possibility of controlling and utilising the undoubted, but almost infinitely slow, disintegration of the elements. It would be folly to consider seriously a possible supply of energy in a conceivable acceleration of the liberation of energy by atomic change; it would, according to the Hon. R. J. Strutt, be impracticable to attempt to utilise the terrestrial heat from boreholes; it looked utterly improbable, too, that man should ever be able to utilise the rotational energy of the earth or that of its proper motion; and the other sources mentioned promised little. Attention should undoubtedly be paid to forestry and peat. Germany and France spent annually 2,200,000*l.* on the conservation of their forests, and the net return was 6,000,000*l.* The peat industry was moderately profitable in Germany; but our climate lent itself little to the natural evaporation of the water contained in peat.

We had therefore chiefly to rely on our coal reserve. We could economise in the use of coal in many ways, by the substitution of turbines for reciprocating engines, which would lower the coal consumption to 1½ lb. or 2 lb. per horse-power; by the further replacement of turbines by gas-engines, lowering the coal consumption to 1 lb. or 1¼ lb.; by creating the power at the pit-mouth; by replacing beehive coke-ovens by recovery-ovens. According to Dr. Beilby, 6 million out of a total of 16 or 18 million tons of coal were coked in recovery-ovens in 1909, at a saving of two or three million tons of fuel. The substitution of gas for coal in works also economised fuel; but it had to be remembered that for economic use gaseous fuel must not be charged with the heavy costs of piping and distribution. The domestic fire also claimed immediate attention. The actual loss of thermal energy in the form of smoke was small, at most half a per cent. of the fuel consumed; still, the presence of smoke was a sign of waste. There was probably no single remedy applicable; but central heating, gas fires, and improved grates would help, and a fine of 6d. might be imposed for every smoke offence, which instantaneous photography would prove.

In conclusion, Sir William regretted that the disclosure of the gravity of the situation by the Coal Commission had not been heeded. A little was being done. But when trade was good, manufacturers made the best of opportunities, and had neither time nor inclination to adopt economies; and when trade was bad, there was no money to spend on improvement. But we should do as other nations had done, and take stock annually. The United States had a permanent Commission, consisting of three representatives from each State, solely to keep abreast with the diminution of the stores of natural energy, and to lessen its rate. We might leave the combating of waste to self-interested competition, or we might initiate legislation. That legislation should be of two kinds: penal, by imposing penalties on wasteful expenditure of energy supplies; and helpful, by imparting information, by advancing loans for carrying out reforms, and by insisting on the greater prosperity which would result from the use of more efficient appliances. There was no time that evening for entering into detail. The coal energy could be converted into high-potential electric energy at the pit mouth; the nearest practical approach to a direct conversion, the Mond gas-battery, had not succeeded owing to the imperfection of the machine. In his final words Sir William pleaded for the study of pure science, without regard to applications, referring to the widening of the bounds of thought by the discovery of radium.

The vote of thanks to the President was proposed by the Mayor of Portsmouth—who, in welcoming the Association, referred with pride to Portsmouth as a naval station—and was seconded by Professor H. B. Dixon, F.R.S., of Manchester.

CONTRACTORS' CLAIMS.

It seldom happens on public works carried out by contractors that the final accounts are agreed and settled up without any claims for extra payment under some head or other.

Claims may be made on account of alleged deviations from the contract during the progress of the work, or in respect of extra cost incurred by the contractors above that anticipated, due to alterations on the part of the engineer, or to difficulties and delays encountered which may, or may not, have been beyond the control of the contractors. The form of contract and specification, if properly drawn, may, if strictly enforced, cover the employer's alleged liability, and place the whole onus on the contractors. Sometimes claims put forward by contractors are largely frivolous and vexatious, and are raised merely in the attempt to get as much out of the employers as possible. The contract may not have been remunerative, and an endeavour is made to finally come out on the right side, to a greater or less extent, by what can be got out of claims, often irrespective of the real merits of the case. There are contractors who, from the start of work, make it a special business to raise or manufacture claims on every conceivable opportunity, whether these can or cannot be substantiated wholly or in part. As a rule contractors' claims may be classed generally as follow:—

1. Claims arising out of alleged alterations or non-fulfilment of the contract through no fault of the contractors.
2. Claims on account of delays or difficulties beyond the contractors' control.
3. Claims arising from alterations made as the work proceeds.
4. Claims made in the attempt to cover losses due to the contractors' mismanagement, oversights, or bad luck.
5. Indirect claims, or claims for consequential damages.
6. Frivolous and vexatious claims.
7. Petty claims.

Nearly all contracts give rise to some or all of the claims falling under the above heads. They may be further roughly sub-divided into:—

1. Claims which the resident engineer cannot settle, and which should obviously be left to the arbitrator.
2. Claims the resident engineer should settle, if a reasonable settlement can be made.
3. Claims which only the resident engineer can and should settle, and which ought never to be carried to a higher authority.
4. Claims which ought never to have been made.

It is probable that under each division there may be items which ought to be withdrawn, which the contractors, if fair and reasonable, will readily withdraw. At the same time matters not infrequently arise in which the contractors are fairly entitled to some consideration which the resident engineer or immediately responsible official will not or cannot see. Some people are unable to see two sides of a question; some will haggle over pence and miss pounds.

A mistake often made on public works is the deferring of the settlement of many trivial matters, involving small sums of money, for months or even until the completion of the contract. Those on both sides of the fence are frequently equally to blame—neither side will budge. Of course, an important principle may be involved in a matter of small moment monetarily, and in this case it may be necessary and wise to delay settlement. A certain amount of the spirit of compromise over matters in dispute or differences of opinion arising during the progress of works is often equitable and needful. A delay in final settlement until the heat of argument has passed away may be judicious and wise.

Nevertheless, the number of small and trivial matters held over until the end on many contracts becomes almost an absurdity. Contractors with an undue appetite for claims are inclined to prefer delay in order thereby to confuse the issue and so hope for an advantage. Moreover, time is a great softener, and by long delay many small matters which assumed comparatively great importance cease to do so, and thereby this class of contractor may obtain eventually what he is not really entitled to. These matters should, as far as possible, be settled up as the work proceeds, full particulars being kept of all items not agreed or withdrawn, so that the lapse of time shall not militate unfairly against either party.

On questions of fact no doubt can arise if the engineer's and contractors' representatives know and attend to their business. It is a good plan when a claim arises, or is likely to be made, for both sides to agree upon the facts and on the work done in those cases which are deferred or left to higher authority, so that when the principle involved is decided, there can be no doubt as to the basis of settlement or the amount fairly at stake.

To carry out work well, confidence in each other on the part of the resident engineer and contractors' representatives is essential. Neither should be seeking an advantage over the other. The contractors are, of course, there to make money, but to do so squarely and honestly under the contract. The

engineer is there to watch the interests of the employers, to see fair play, to get fair work for fair payment under the contract and specification, and to render all reasonable assistance to achieve the speedy and satisfactory completion of the work.

A specification properly written endows the engineer with great powers. It is intended to give him the whip hand if required, and it sometimes is required. On the other hand, specifications are usually meant to be applied with reason and judgment, not losing sight of the principles of equity between decent and honourable men.

Day work is a fruitful source of dispute between engineers and contractors. In the hands of some contractors, it is not putting it too strongly to say that day work amounts to daylight robbery. This method of working should not be adopted unless circumstances render it unavoidable. It not infrequently happens that work has to be done for which no item appears in the schedule, or to which no schedule item can be fairly applied. Whenever possible, prices should be agreed upon between the engineer and the contractors. If the resident is a confident and strong man, this course can usually be adopted. As a rule, a resident is not empowered to alter a schedule rate, but he can, if in the position and exercising the authority which ought to be his, make a new price, within limits, to meet particular circumstances not previously provided for. The contractors may decline to accept a price which the resident knows is a fair one, and hold out for too high a rate, or press the alternative of day work. The latter course is often pressed, but if the resident engineer is satisfied the work can be fairly done without recourse to day work, he may decline to allow it, and pay a price on account, leaving the final settlement until later. In this case he would naturally take care that the payment on account was not too high.

Some resident engineers are very loath to settle prices, readily taking refuge in day work. It is perhaps less trouble, and by doing the work on the basis of time and material, he imagines he is getting rid of responsibility. The clerks of works or others can be instructed to return the time, and as long as there is a return, showing so many men so many hours, it matters little what the work is costing. The resident certifies for it, and takes refuge in the returns. It is common knowledge that when work is done and supervised, as a good deal is, in this manner the cost is often higher than it should be, and a longer time taken to complete it. A resident engineer who acts in this way is either partially ignorant or inefficient.

There are many causes which militate towards unnecessary cost in the execution of public works. It is sufficient to say here that one reason which tends towards the line of least resistance is that it sometimes happens the final accounts are subject in full detail to the review and scrutiny, as to prices and everything else, of an accountant's staff. These persons are very competent accountants, *qua* accountants, but are not engineers, and know nothing of the value of work. It is as easy as A, B, C for a man who knows his way about to drive a coach-and-four through these people. Consequently, if a price is arranged, not being in the schedule, long, tedious, and irritating explanations are asked for. Whereas, so long as hours, men, and material appear in the accounts, the money checks out at schedule rates, and nobody asks why a job has cost 300*l.* which might, and probably ought to, have been done for 200*l.* Moreover, it sometimes happens that a certain sum has been sanctioned by a committee, and if the money be not spent, it is almost as awkward, in a sense, as having to ask the committee for an extra sum. If this happens, the resident may get little more credit with his head office for saving than he loses if increased expenditure is incurred. Either the system or the committee are to blame for this. In any case, the tendency is opposed to economy.

A source of trouble with contractors' claims lies in the fact that even where a *bonâ fide* claim exists the amounts at first asked by so many contractors are nearly always considerably in excess of anything that can be reasonably substantiated. In fact, the total is a good deal higher than is expected or hoped will be allowed. It is made up in order to bear substantial reduction. Unfortunately, human nature is largely responsible for this mode of doing business, which is to be deprecated. Swollen claims become a part of the stock-in-trade of claim-seeking contractors. They wish to obtain all that is possible, not much minding how they get it. On the other hand, engineers are in some measure responsible for this custom, so frequently resorted to, of making up outrageous claims.

The idea fixed in the minds of many engineers (we do not refer to those acting in the capacity of arbitrators) is that contractors' claims, whatever the amounts and whatever the argument upon which they are based, must be substantially reduced. The merits of the case are lost sight of so long as a settlement can be reached at a figure well below the original claim. The engineer is anxious for a good reduction, and the smaller the proportion of the amount claimed for which he can settle the better he is pleased. Contractors know this. They soon learn to know the man they have to deal with, and make up their claims accordingly. At the same time, everybody knows many engineers who possess the faculty of distinguishing reasonable claims and settling matters fairly on their merits, having, of course, due regard to contracts and specifications. With such men it generally is to the contractors' advantage to confine claims to reasonable proportions, which can be substantiated both in principle and amount, rather than to ask for 200*l.* and be quite ready when pressed to accept, say, 75*l.*, or nothing at all.

WAGES IN THE METAL, ENGINEERING, AND SHIPBUILDING TRADES.

THE sixth report of a series being issued by the Board of Trade relating to the earnings and hours of workpeople of the United Kingdom was published last week. It deals with the metal, engineering, and shipbuilding trades. The earlier volumes were for the textile, clothing, building, and woodworking trades, certain public utility services, and agriculture. The average earnings of men returned as working on full week in each of the principal trades dealt with in the present report were as follow :—

	s.	d.
Pig-iron manufacture	34	4
Iron and steel manufacture	39	1
Tin-plate manufacture	42	0
Engineering and boilermaking... ...	32	5
Ship and boat-building and repairing...	35	11
Railway carriage and wagon building	30	9
Manufacture of light iron castings, stoves, grates, &c.	31	4

In the other metal trades included in the inquiry the earnings of men were highest in the manufacture of jewellery (38s.), and lowest in farriery and general smiths' work (27s. 9d.). In addition to the general summary of the results given, each of the industries is dealt with in considerable detail, and a review of the statistics relating to the engineering industry may be of more immediate interest to our readers. In passing it may be remarked that the Engineering Federation is specially referred to, in an introductory letter signed by Mr. G. R. Askwith, as having readily co-operated with the department in the inquiry. The figures for the engineering industry are therefore probably much more accurate than would otherwise have been the case. From an examination of the form of schedule appended to the report it is evident that the work involved in the preparation of their returns by the individual firms must have been very considerable. It is surprising, therefore, to find that in a voluntary inquiry such as this 60 per cent. of the workpeople employed were included in the returns received.

It should be stated that the inquiry relates to the year 1906, so that the figures are very much out of date. Since that date wages have risen considerably, and are probably from 1s. to 2s. per week higher on the average. The value of the figures, however, is more dependent on the fact that they form an official record of the conditions prevailing in the engineering industry at the date of the inquiry, and should be of great value for comparison in the future. For this reason alone it is unfortunate that the statistics have not been given in greater detail. For example, the areas for which details are given are, in some cases at least, too wide in extent and embrace branches of the industry of widely different character, and of sufficient importance in themselves to have been treated separately. Thus, in the North and West Midland counties, an area comprising counties as far apart as Gloucester and Lincolnshire, we find grouped together Leicester and Nottingham, with their hosiery and lace machinery, and Lincoln, with its agricultural machinery. Such a grouping cannot be defended either on the basis of a geographical grouping or the linking up of districts in which the industries carried on are the same. That this criticism is well founded is evidenced by the report itself, in which, explaining the difference between the average earnings of workpeople who worked full time and the average earnings of all the workpeople, including those who worked less or more than full time, it states, amongst other reasons, that the difference between these two amounts is in part due to the varying proportion of full-time workers in different districts, &c. Now, if this difficulty occurs in dealing with the country as a whole, it is probably much greater in its effect in the case of an area such as that referred to above. No doubt, however, as the Board of Trade appear to have considered the difficulty, its effect on the statistics may not be very great. It is a point, however, to which we think some special attention should be given in the event of any similar inquiry being undertaken in future.

Turning again to the report we find that rather less than three out of four of the male operatives were employed on time wages. Of the men, 72.6 per cent. were returned as time workers, 22.8 per cent. as piece-workers, and 4.6 per cent. as being paid on the bonus system. These percentages would, of course, vary in different occupations. Pattern-makers, for example, are all time-workers, while, on the other hand, in machine shops and boiler-shops piece-work or bonus systems are almost as common as time-work.

The following comparison of the wages paid in certain of the principal districts to moulders, fitters, turners, machinemen in general engineering works, and platers, riveters, and caulkers in boiler-shops, may be of some interest. The wages given are those of time-workers.

District.	Iron & Steel Moulders.		Fitters, &c.		Turners.		Machinemen.		Platers.		Riveters and Caulkers.	
	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
The Tyne, Wear, and Tees	37	6	35	7	35	4	27	0	40	1	38	9
The Mersey and Barrow	39	8	37	11	36	5	29	9	44	0	44	4
The Clyde..	39	4	35	3	36	4	29	10	39	5	36	5
London	39	8	40	7	41	6	32	5	—		—	
Sheffield	38	5	37	4	37	6	28	10	—		—	
Leeds	35	1	33	0	32	9	26	7	—		—	
Manchester	34	3	34	10	34	8	27	1	—		—	
Certain large Lancashire towns	38	10	35	5	34	10	26	0	..		35	2
North and West Midland counties	32	8	33	5	32	10	26	0	37	4	33	7
Southern and south-western counties ..	34	4	36	3	35	9	23	9	37	11	39	1
United Kingdom .	36	11	34	8	34	2	27	0	38	11	36	7

Where the workpeople are employed on piece-work their earnings are, on the average, from 4s. to 6s. per week higher. In this connection it may be of interest to refer specially to the earnings of workpeople employed on the bonus system, against which for some time past the unions have been conducting a vigorous campaign, denouncing it and the employers concerned in no measured terms. The results of this inquiry by the Government do not seem to justify in any degree the accusations made, and show that the earnings of men working on the bonus system are well above their time ratings. The figures for the principal classes concerned are :

—	Average Full-Time Rates.	Average Full-Time Bonus Earnings.
Fitters, &c. ...	34s. 8d.	39s. 10d.
Turners ...	34s. 2d.	41s.
Machinemen ...	27s.	32s. 10d.

These figures speak for themselves.

Of the total number of men returned as working full time in the engineering industry, 9.1 per cent. earned less than 20s. per week ; 32 9 per cent. earned between 20s. and 30s. ; 38 4 per cent. earned between 30s. and 40s. ; 13.8 per cent. earned between 40s. and 50s. ; 3.7 per cent. earned between 50s. and 60s., and 2.1 per cent. earned 60s. per week and over. Thus, in all, nearly 20 per cent. of the men employed earned 2*l.* per week or over. As regards those earning under 20s. per week the report gives no indication of the classes of workpeople concerned, but no doubt the workers represented include labourers of the casual type.

Another important section of the report is that relating to the changes which have taken place in average wages since 1886, in which year an inquiry of a similar character to that under consideration

was made by the Board of Trade. A comparison of the details given respecting the earnings of adult workmen in the principal occupations is given below. The figures relate to both time and piece-workers.

Occupation.	Average Earnings for Full Time.		Percentage Increase.
	1886.	1906.	
	per week s. d.	per week s. d.	
Patternmakers	30 8	37 3	21.5
Moulders (iron and steel)	31 5	37 10	20.4
Smiths	30 1	37 2	23.5
Smiths' strikers	19 11	24 1	20.9
Turners	29 9	36 2	21.6
Fitters, erectors, and millwrights	29 6	36 1	22.3
Platers	34 1	42 3	24.0
Riveters and caulkers	29 9	39 4	32.2
Holders-up	22 8	28 10	27.2
General labourers	17 11	21 0	17.2

The average increase for all adult workmen was 25.9 per cent. It will be understood that these general percentage increases result not only from the change which has taken place in the level of wages in the various occupations, but also from the proportionate weight which is given to each occupation by the number of workpeople for whom full-time rates have been obtained, and from the increase which has taken place since 1886 in the proportions of workpeople paid on piecework and bonus systems, as compared with those paid time wages. As we have already noted, wages have risen considerably since 1906, so that probably present rates are well over 30 per cent. higher than in 1886. Other sections of the report deal with hours of labour and holidays, but these present no features of special interest.

INVESTIGATION OF BEARING-METALS.

THE research on bearing-metals which Professor E. Heyn and O. Bauer have been conducting in the Materialprüfungsamt,* was undertaken mainly with the object of ascertaining how far repeated meltings of the metals, with or without additions, and various rates of cooling would influence their strength and reliability. The bearing metals investigated were white metal and bronzes, all of the purity which the Prussian Railway Department enacts; the alloys did not contain more than 0.2 per cent. of impurities, in accordance with these regulations. The alloys were prepared in the laboratory from analysed metals, or taken as supplied after analysis.

As regards white metal (alloys of copper, antimony, and tin), it resulted that refusion repeated five times did not alter the grain noticeably, nor did it affect the hardness, and the strength as determined by impact and by tensile tests. Refusion altered the composition somewhat, there being a comparative enriching in copper owing to the partial oxidation of the tin and antimony. Addition of magnesium or aluminium or of other reducing agents for the purpose of preventing this oxidation increased the hardness, but had little influence otherwise, and such additions would hence appear unnecessary. The rate of cooling was, however, of influence; quick cooling yielded finer grain and higher hardness and strength, and the investigators recommend that such metals should not be heated to high temperatures and that they should be cooled rapidly.

The bronzes of copper, tin, and zinc were similarly investigated, and cooling curves were taken with the aid of thermo-couples of platinum and platinum-rhodium. These observations revealed strong recalescences at 938 deg., 781 deg., and 525 deg. Cent., due to the separation of solid crystals or to modifications taking place in the already congealed mass. The castings were made in steel moulds or in sand.

It would result that, by regulating the rate of cooling, bronzes poor in tin, and therefore comparatively inexpensive, may be obtained mechanically equal to rich and more expensive bronzes. The bronzes were heated, for the refusion tests, up to temperatures ranging from 400 deg. to 950 deg. Cent. When they were rapidly cooled from temperatures above 782 deg. Cent. the hardness and the strength were found to be increased, and this effect was more marked in the chilled castings than in the sand castings.

* *Mitteilungen des Kgl. Materialprüfungsamts*, 1911, pages 29 and 63.

The rate of cooling would depend upon the cross-section of the specimen, and this was more noticeable in the sand castings than in the iron-mould castings, as was to be expected. In the specimens containing little zinc, re-melting had little effect on the mechanical properties of the alloy, although there was some oxidation of the tin to stannic acid. Most of the stannic acid formed remained mixed with the metal, and did not force its way up to the surface. The slight mechanical effect mentioned consisted in a reduction of the tensile strength of the resistance to blows, and of the elastic stretching; the hardness and the crushing strength hardly suffered. The account does not, so far, give definite information about the best temperatures to be applied, and the most favourable rates of cooling. It is pointed out that slowly-cooled alloys tend to pass into a metastable modification, which is only stable at low temperatures, and that rapid cooling suppresses this tendency. The beautiful micro-photographs illustrating the account explain some features better than words could do. As the stability of the alloys cooled at different rates varies with the temperature, however, we should think that actual running tests of bearings will be required.

With respect to the addition of other substances to the bronzes, arsenic alone appears, so far, to have been tried in amounts up to 2 per cent. The addition of arsenic affected the temperatures at which crystallisation set in, and it lowered these temperatures. This influence was only observed, however, when the arsenic contents amounted to at least 1.52 per cent., and the structure and some mechanical properties were also not altered by a low percentage of arsenic. The crushing strength was increased by arsenic; the ultimate strength was slightly lowered, but the elastic limit decidedly raised. An improvement in the resistance to hammering showed when 0.65 per cent. of arsenic was present, and the elastic extensibility was still more sensitive, as it was lowered as soon as the arsenic percentage exceeded 0.3.

NOTES.

THE SCANDINAVIAN LABOUR CONFLICTS.

THE Swedish masters do not appear to have shown, during the present comprehensive lock-out—comprehensive at least on paper—the same amount of discipline as that by which the great strike of 1909 was distinguished. In several branches independent arrangements with the men have been considered, or actually entered upon, as, for instance, in the case of the pipe-laying contractors. The Central Employers' Union, in this case, decided that the contractors had committed an offence against the regulations, and the board came to the conclusion to confiscate the guarantees of the said contractors in connection therewith to the amount of some 110,000 kr. (6110*l*.). The Central Union of Employers strongly deprecate the fact that certain members have offered to make, or already have made, separate arrangements with the men's unions, and, at a meeting recently held, the delegates of the masters' union stated that in no case could they sanction the right of members to make separate arrangements, inasmuch as this could only tend to trouble in the labour market, and not benefit any member of the masters' union. Both the central and the district boards have, therefore, been authorised forthwith to take steps, according to the regulations of the union, against such members as have broken or who may break their undertakings. The union of masters have decided to refuse acknowledgment of all separate arrangements and to confiscate the guarantees of the respective members. In Norway the terms of agreement accepted by the respective delegates (thanks to the admirable work done by the mediators, who have had conferred upon them the Gold Medal of Merit, which is only held by two other Norwegians) were duly passed by both masters and men. The question of a possible addition to the minimum wages for miners was left to the two mediators—the President of the Storthing, M. Halvorsen, and Dr. Alfred Eriksen—on the basis of the information which has been put forward during the mediations. The Norwegian Government has to appoint an umpire, and the arbitrators are to meet within two months from August 17. In Denmark one of the companies has consented to take back some 12 per cent. of their old employees, on worse terms than those on which they went out. Their former colleagues have excluded them from their union, and several trade unions have prohibited their members, with wives, children, and relatives, from travelling by the lines of the tramway companies in question; the men who have gone back have also been molested and annoyed in various ways.

H.M.S. "ORION" AND HER 13.5-IN. GUNS.

The illustrations published on page 298 will be studied with interest, as they show the first of our Dreadnought ships fitted with 13.5-in. guns. Each of the three views, which are from photographs by Mr. Stephen Cribb, of Southsea, establishes the increase in size, particularly of the gun-hoods. The guns themselves are not much longer, and their weight is but 11 tons more, than the latest "mark" of the 12-in. gun, being 76 tons; but the gun-mountings are necessarily much heavier, although ingenuity in design and considerable research as to the strength of metals have enabled a surprising degree of compactness and lightness to be achieved. In view of these developments the gun trials will be watched with great interest. The 13.5-in. gun has a considerably increased muzzle energy, nearly 70,000 ft.-tons, as compared with about 48,000 ft.-tons in the latest 12-in. service weapon, and as a consequence the power of recoil will be greater and the stress on the gun-mounting considerably more. But the invariable success of the ordnance machinery by British manufacturers allows no room for doubt regarding the success of the Orion's gun trials next month. The armour-piercing shell fired has a weight of 1250 lb., as compared with 850 lb. in the case of the 12-in. gun, and it will be understood that a much larger bursting charge can be accommodated within the shell, so that the destruction, when the enemy's armour has been penetrated, will be considerably more. This, rather than greater penetration, is the principal reason for the adoption of the gun of increased bore. The Orion mounts ten of these 13.5-in. guns, all of which may be fired on either broadside, in addition to fourteen 4-in. guns for repelling torpedo-boat attack. Fig. 3 shows well the arrangement of the four 13.5-in. guns at each end of the ship; the two guns in the amidship barbette are in the centre line, and can be trained through a complete circle; the deck erections, boiler uptakes, &c., have been cut away to compass the widest possible bearings before and abaft the beam. The Orion has been built at the Portsmouth Dockyard. The keel was laid on November 29, 1909, and she will be in commission by the end of the year, so that the vessel will be completed in two years from the laying of the keel. This is an important achievement in view of the great dimensions of the ship. She has a length between perpendiculars of 545 ft., a breadth moulded of 85 ft. 6 in., and a depth moulded of 43 ft. 6 in. On a draught of 27 ft. 6 in. the displacement will be 22,500 tons, and when at this draught it is anticipated that a speed of 21 knots will be realised, with the Parsons' turbine machinery developing 27,000 shaft horse-power. This turbine machinery has been constructed by the Wallsend Slipway and Engineering Company, Limited, Wallsend-on-Tyne. There are four shafts, each with an ahead and astern turbine, but arranged as independent units on each side of the centre line. For steaming ahead there are two high-pressure and two low-pressure turbines, and for steaming astern, two high-pressure and two low-pressure turbines. The low-pressure turbines for ahead and astern steaming, on port and starboard sides respectively, are within one casing, whereas the high-pressure ahead and astern turbines are each independent units.

THE HUMPHREY PUMP PATENTS.

In view of the interest which is now being taken in the construction of internal-combustion pumps, special interest attaches to the judgment of the Comptroller in a recent case, in which the Pump and Power Company opposed the sealing of a patent which they claimed to be an infringement of Mr. Humphrey's. Many inventors are apparently at work on the design of internal-combustion pumps, and it is, perhaps, for this reason that the unusual course has been adopted of printing the Comptroller's decision as a public document. In this, the view of the Patent Office as to the ground covered by the fundamental Humphrey patents is explicitly stated, and would-be constructors of internal-combustion pumps would be well advised to consult the document before filing an application for patent protection. In his decision the Comptroller states that the

Humphrey pumps show an important advance in the art, and to show the reasons for this conclusion he gives a survey of the prior state of the art. Attempts to make internal-combustion pumps date back, he states, to 1858, and from that date up to 1906 thirty or forty specifications had been filed. None of these, however, he states, embodies the principles of working disclosed in the Humphrey-Cerasoli patent No. 20,736, of 1906. In this specification, the Comptroller proceeds, it was stated, in the first place, that the momentum of the water column is used to draw in fresh liquid and combustible charge, and until then no one, he states, had recognised the importance of the principle as applied to internal-combustion pumps. Secondly, Humphrey lays down the principle that the movement of water in the discharge-pipe shall be free and unobstructed by valves, so that there is a back flow into the combustion-chamber when the momentum is expended. This return flow of liquid effects the compression of the fresh combustible, and is, the Comptroller states, "entirely charactoristic" of the Humphrey pump, "no such action being described in any prior invention relating to pumps of this class." Thirdly, Humphrey expels the spent gases from the explosion-chamber by causing fresh water from the supply tank to flow into this chamber before the column of water in the main discharge-pipe has come to rest. The result is that the fresh water which has entered the combustion-chamber is partly withdrawn again and follows the water in the discharge main, thus drawing in a fresh supply. "This operation also seems to be entirely novel." Three other of Humphrey's most important patents—*i.e.*, Nos. 18,594, 18,595, and 19,341, of 1907—are referred to in the decision, and in a subsequent part of his judgment the Comptroller states that Humphrey "is throughout claiming methods of working rather than the particular apparatus, and, indeed, many forms of apparatus may be devised without invention which would be in fact Humphrey pumps."

THE TURIN INTERNATIONAL EXHIBITION.

(*Concluded from page* 251.)

THE very brief descriptions given in our two previous issues cover but a small fraction of the exhibits to be seen in the Italian Naval Pavilion, the electricity and the machinery buildings situated in Valentino Park, on the left bank of the river. The exhibits shown include a large variety of other engines and pieces of machinery, among which may be mentioned a Brown-Boveri turbine having a velocity-compounded impulse-wheel at the high-pressure end, the remainder being constructed on the reaction principle. This turbine is coupled to a three-phase 8000-volt 42-period alternator, built to run at a speed of 2530 revolutions. Water turbines are well represented by the exhibits made by the well-known firm A. Riva and Co., Milan, successors to A. Riva, Monneret, and Co.; these include a 6000-horse-power Pelton wheel, for a speed of 500 revolutions, and a head of 470 m. (1540 ft.); a 4800-horse-power Francis turbine; various other small turbines and examples of accessory gear and fittings. The Société Théodore Bell and Co., Kriens-Lucerne, show a turbine with a vertical shaft for a head of 5 m. (16 ft. 5 in.), a body of water of 31,200 litres (6900 gallons) per second, and to develop 1600 horse-power; also an oil-pressure governor.

A number of small oil and petrol-motors are to be seen exhibited by different manufacturers, and running empty or for lighting the stands on which they are erected. Automatic and semi-automatic steel and wood-working machine-tools are numerous. The Maschinenfabrik Lorenz, Ettlingen, Baden, have an interesting machine, located close to the Sulzer 1000-horse-power Diesel engine, and built for cutting double-helical teeth on gear-wheels. Exhibits of gears having double-helical teeth are made by several makers, including Messrs. André Citroën and Co., Paris, and the Societá Italiana Ingranaggi di Precisione, Milan. In this connection we may mention the Firm Luigi Pomini, Castellanza, who have a most interesting exhibit of transmission gear complete, including built-up fly-wheels, pulleys, toothed-wheel gearing, of cast iron and steel; also elastic couplings, hangers, and so forth. Adjoining their stand they have an electrically-driven shaft fitted with their various types of clutches to illustrate their working.

Electrically-driven machinery in the electricity building is of the general types usually met with at exhibitions, including ventilating fans of various patterns. In addition to these there are a number of applications of current for heating purposes, exhibited by Messrs. Otto Baur and Co., Zurich, including heated carpets of different sizes, electric bed-warmers, electrically-heated footstools, and so forth. Among the other interesting machinery electrically driven, we may mention book-sewing machines and examples of spinning machinery and power-looms. The noise made by these latter is a disadvantage from which their attendants are the first to suffer, but which also causes much annoyance to the attendants at neighbouring stands and to visitors generally. The grouping together in one separate building of the textile machinery exhibited by the makers of all nations would greatly improve matters in this respect. We see no insuperable difficulty in carrying out such a grouping.

The British Pavilion, being situated on the left bank of the river, is in a most favourable situation, and bids fair to be much more visited than the pavilions of other countries located on the other, or right, bank. The present summer is an exceptional one; the heat in Turin has been almost unbearable for many weeks past, and we fear that it will have led many visitors to consider twice before they crossed the river by any of the several means available—by boat, by aerial ropeway, by the bridges, or by the "tapis roulant" underneath the platform of the monumental bridge—with a view to inspect the admirable displays made by different other nations on the right bank.

We have already stated that the British Pavilion is self-contained, and have given a brief description of the Hornsby and Campbell gas-engines which supply it with current for power and lighting. These engines are in the engineering section, which contains a very complete display made by other British works. This includes a 36-horse-power gas-engine, with suction-gas producer, by the National Gas-Engine Company, Limited, Ashton, Manchester, who also show 22, 12½, 7, and 3-horse-power "National" oil-engines. Messrs. Blackstone and Co., Limited, Stamford, exhibit a 25-horse-power crude-oil engine, a 6½-horse-power stationary engine working on refined petroleum, an 8-horse-power portable engine also running on refined petroleum, and a 2-horse-power engine using this same fuel and coupled to a treble-throw pump. The above exhibits, and others of a similar class, are arranged round the sides of the engineering section. The centre contains a very fine display made by several British firms, including Messrs. Ruston, Proctor, and Co., Limited, Lincoln, who show two portable steam-engines of 25 and 12 horse-power, the former with superheater; a 12½-ton steam road-roller with superheater; a 75-horse-power suction-gas engine and producer; and two crude-oil engines of 40 and 20 horse-power. Close to this is the stand of Messrs. Richard Garrett and Sons, Limited, Leiston, who exhibit a compound superheated-steam semi-stationary engine, condensing; a single-cylinder superheated-steam portable non-condensing engine; a 10-ton compound superheated-steam roller; a steam motor-wagon and other agricultural machinery; and that of Messrs. Clayton and Shuttleworth, Limited, Lincoln, who have a very fine display of machinery, which includes a single-cylinder portable engine capable of developing 30 effective horse-power; an 8-in. centrifugal pump; an 8-horse-power (nominal) single-cylinder traction-engine, with two speeds, compensating gear, winding-drum, injector, and improved gear-driven feed-pump; a 3-horse-power (nominal) single-cylinder portable engine, and several thrashing and other agricultural machines.

The largest stand in this section is occupied by Messrs. Marshall, Sons, and Co., Limited, Gainsborough, who show four portable engines, a light traction engine, a 10-ton steam road-roller, and several thrashing-machines of different dimensions. Parallel with this is the stand of Messrs. John Fowler and Co. (Leeds), Limited, which contains excellent specimens of complete steam ploughing plant. Messrs. J. and H. McLaren's adjoining stand is equipped with plant of a similar nature. The remainder of the central portion of the engineering section is occupied by textile machinery and machine-tools, most of which are shown in action. The textile machinery exhibitors are Messrs. Hacking and Co., Limited, Bury; the British Northrop Loom Company, Limited, Blackburn; Messrs. Brooks and Doxey, Limited, Manchester; Wilson Brothers Bobbin Company, Limited, Garston; and Messrs. John Hetherington and Sons, Limited, Manchester. The machine-tools are exhibited by Messrs. Alfred Herbert, Limited, Coventry, and include steel and wood-working machines.

Such is a brief description of the British machinery exhibits. Close by are displayed excellent specimens of British-built motor-cars, motor-bicycles, and accessories of all the various kinds used in the motor-car industry.

The British exhibits of scientific instruments, furniture, tailoring, library fittings, ceramics, among others, are certainly unsurpassed by those of any other nation. This applies with equal force to our photographic exhibits. We have compared these with similar exhibits proceeding from other countries exhibited at Turin, and also the British with the foreign photographic displays shown at other former Continental exhibitions, and have always found ours to be much superior. Our atmosphere, against which we complain sometimes, and which frequently causes the foreigner to leave our shores in despair, is no doubt conducive to excellent photographic results, if these be not attributable to our greater skill in conducting the various phases of the process.

Where, however, we fall short at the Turin Exhibition is in the number of ship's models, of warships more especially; models of British-built ships are very few in number. The conflagration at the late Brussels Exhibition is, no doubt, partly responsible for this state of things. In this connection we should like to call special attention to the warship models displayed in the Pavilion of the Royal Italian Navy. These models are in goodly number; they are all in sombre hues, and thus they represent much more truthfully than our own highly-finished gilded and silvered productions what a real warship actually is like, being, besides, far less costly.

From the British Pavilion access is had *via* the Corso Dante subway to the Public Works Building and to that containing the railway material. Interesting particulars are given in the former, by means of maps, drawings, and books, of the extensive reclamation work which has been carried out in different parts of Italy, but more especially in the marshy district of Ferrara, to the south of Venice. The land in that district which extends between Ferrara and the Adriatic Sea was found to be very suitable for raising various agricultural products; unfortunately, it became easily swamped in rainy weather, and the problem was to put down at different points draining stations to pump into the River Po, and into the sea, the rain water with which the land became so easily covered. An idea of the quantity of rain water dealt with by the pumping plant is afforded by the fact that in October, 1907, the amount of rainfall was 201 mm. (8 in.), representing several hundred thousand tons per square mile. Several large pumping plants for draining the district had been carried out at different periods, under the direction of the Ministry of Public Works and Agriculture. These, however, were soon found inadequate, in that they did not deal with a sufficiently large tract, and the Ministry therefore ordered a more powerful installation from Messrs. Sulzer Brothers, Winterthur, which was put down in 1910, at a place called Codigoro. This plant contains five 1200-horse-power steam-engines direct coupled to an equal number of low-lift pumps, capable together of dealing with 80 cub. m. (17,600 gallons) per second.

The Public Works Pavilion contains other interesting exhibits in the shape of maps, drawings, and general data on many important installations carried out in various parts of the country. But more striking than these are the displays made in the same pavilion by the principal Italian works to illustrate their power of production in heavy metallurgy and large engine construction. These displays include a rolled steel plate shown by the Terni Steel Works, measuring 15 m. by 4 m. by 50 mm. (49 ft. 2½ in. by 13 ft. 1½ in. by 1.97 in.), and weighing 23,500 kg. (23 tons 2½ cwt.); a rough forged gun tube for a 12-in. 46-calibre gun, the tube being 17.5 m. (57 ft. 5 in.) in length, and weighing approximately 34 tons; several armour-plates tested in proving-ground experiments; and a rudder-frame for the new battleship Giulio Cesare, one of the Italian Dreadnoughts now in course of

construction, weighing about 16 tons. They also show several guns, including one in a land turret. The Ansaldo Company have also a fine display of artillery and ships' models; they also exhibit a complete steering-gear for a battleship of the Giulio Cesare type, several propeller and thrust-shafts, and a propeller for a Dreadnought. The Ansaldo Company have recently entered into an agreement with Messrs. Schneider and Co., Creusot and Havre, for the manufacture for Italy of the Schneider pattern of field, mountain, and other guns; and the Ansaldo stand includes several specimens of these guns, a Schneider torpedo, and a coast defence cupola with a 28-cm. (11-in.) 36-calibre gun, being one of the cupolas ordered from the Creusot Works and now in course of delivery. Beautiful ships' models are exhibited in this same pavilion by Messrs. Fratelli Orlando, who also show marine-engine models and a model of a Zoelly turbine. Messrs. N. Odero have similar exhibits. The activity of the Italian works is very fully illustrated by other classes of industrial products displayed in the same pavilion. These include welded receivers and tanks, riveted boilers, and similar work, shown by the Officine Metalliche Togni, Brescia; armour-plate mill and other rolls, one measuring 3.200 m. (10 ft. 6 in.) in length, 900 mm. (35.43 in.) in diameter, and weighing about 17 tons, by the Franchi Griffin Company, Brescia; rolling-mill housings, one weighing about 19 tons, and several ingot moulds, one of which weighs approximately 2.5 tons, manufactured by the Piombino Blast-Furnace and Steel Works Company; the Società Metallurgica Italiana, Leghorn, exhibit a Muntz metal disc 2.48 m. (8 ft. 1½ in.) in diameter, 20 mm. (0.79 in.) in thickness, and weighing 1 ton, besides a very fine display of locomotive boiler tube-plates, tubes, cartridge-cases, and so forth.

Rolled material—plates, bars, rails, and sections of mild and hard steel—is exhibited by several works, among which we may mention the Società Siderurgica di Savona. The Società Anonima "Ilva" display particulars of their organisation. The latter company are of relatively recent formation, their object being to develop the manufacture of iron and steel in the southern part of Italy. The "Ilva" were established by virtue of a law passed by the Italian Government, and they have absorbed the Società Siderurgica di Savona, and other Italian metallurgical works, in that they centralise the sales of metallurgical products and divide the orders among the establishments forming the group. They are also putting down an extensive plant at the Bagnoli, close to Naples, which is to comprise coke-ovens with complete by-product recovery, blast-furnaces, also with gas utilisation, steel works, and rolling-mills. The coal is to come from Great Britain or Germany. The iron ore will be taken from Elba, where the company have obtained a special concession. So far only part of the coke-ovens and blast-furnaces have been built and completed. The coke-ovens deal with 600 tons of coal per day, and yield 480 tons of coke, 10 tons of tar, and 6 tons of sulphate of ammonia. The blast-furnaces, of which two are completed and in working order, produce each between 200 and 250 tons of pig iron per day. The steel works are to contain ten basic Siemens-Martin furnaces of 55 tons capacity each, and two 300-ton mixers. The rolling-mill department is to be fully equipped for the manufacture of plates and bars, the object being to render the country entirely independent of foreign supplies of iron and steel, which at the present time are purchased at the rate of 4,000,000*l.* sterling per year.

Close to the Italian heavy metallurgical exhibits are the French exhibits of a similar nature. The French works have taken special pains to call attention to their artillery. Thus, besides the Schneider guns shown in the Ansaldo stand referred to above, the St. Chamond Company show a 24-cm. (9.45-in.) coast-defence gun, weighing, with its mounting, 91 tons, having a muzzle velocity of 850 m. (2788 ft), and a range of 15,000 m. (16,400 yards); a 70-mm. (2.75-in.) mountain gun; projectiles of different calibres; tested armour-plates; together with a few locomotive wheels and automobile chassis. Messrs. Marrel Frères have also gun-tubes, gun-hoops, projectiles, a tested armour-plate, crank-shafts, chassis, and an anchor. The Chatillon Commentry Company have a 75-mm. (2.95-in.) Deport field-gun of 30 calibres and one of 28 calibres, with ammunition-wagons, also projectiles and two tested cupola-plates. Messrs. Holtzer have a fine display of projectiles and a cylinder cover of crucible steel; while the Pont á Mousson Company have built a pyramidal stand formed of water-pipes, very similar to the one they showed at the Brussels Exhibition.

The last building on the left bank of the river is that containing the exhibits made by the Italian State Railways and locomotives of Italian and foreign manufacture. It gives directly into that covering the heavy metallurgical displays made by Italy and France. The Italian State Railways exhibit views, drawings, maps, models, and printed matter concerning their permanent way and rolling-stock. The progress made in regard to traction on these railways is fully illustrated by two locomotives, one built in 1853, and the other in 1857, and coupled to two trains of the period. Close to these are modern engines of various types built by Ansaldo; by the Construzzioni Meccaniche, Saronno; the Officine Meccaniche, Milan; the Ernesto Breda Works, besides a splendid display of French, Swiss, Belgian, and German engines. We gave data on one of the Breda engines on page 258 *ante*, and hope to describe some of the other units later on.

The display at the Pilonetto opposite the railway building, on the other side of the river, contains bicycles, motor-cars, aerial navigation exhibits, agricultural machines, chemicals, historical exhibits on the army and navy, silk and other industries, exhibits of Italian statuettes, and other objects of art. This part of the Exhibition, as stated in a former article, is lighted by current supplied by a Fiat 100 to 140-horse-power electric set.

Various congresses of engineers have been held already in Turin. Others are announced, including the autumn meeting, on October 2 and 3, of the Iron and Steel Institute; this will give members a welcome opportunity of witnessing the power of production of the Italian metallurgical and mechanical works.

THE ROAD BOARD.

As already announced, the Road Board has arranged to lay a number of experimental lengths of roadway of different materials, or composition of materials, for experimental purposes, in order to acquire information useful to the Board and to road engineers in general.

The Board has now published, through Messrs. Waterlow and Sons, Limited, Great Winchester-street, E.C., a pamphlet bearing the title "Trials of Road Materials by the Kent County Council, under arrangement with the Road Board, on the New Eltham-Sidcup Road," price 1s. 6d., giving particulars of the various materials selected for the trials. A preliminary statement by Colonel R. E. Crompton, C.B., consulting engineer to the Board, is included, in which it is stated that "the object the Road Board has in view is to secure a service test, under uniform conditions, of a number of trial lengths of roadway laid down under the general direction and supervision of the advisory Engineering Committee of the Board, so that a record of comparative results can be obtained in a better and more reliable manner than is generally obtainable in the case of road surfaces laid down in the ordinary course of road maintenance in different parts of the country."

Complete records are to be kept as to conditions, weather, and details of construction, and the results will be published. The accurate information so collated is bound to be of great utility to all responsible for the maintenance of roads. The cost of the experiments is to be defrayed by the Road Board. The tests will be severe, owing to the heavy traffic habitually passing over the route selected. Particular care was taken in the selection of the route, which is not shaded by trees except in a few places. The traffic, ascertained by observation, amounts to a density of nearly 500 tons per yard width per 24 hours, and includes a frequent service of motor-omnibuses.

The pamphlet includes a copy of the specification under which the work is to be carried out. It is provided that the various contractors shall be responsible for the maintenance of their work from the date of the commencement of the laying of the materials until the County Surveyor of Kent gives notice that the same requires reconstruction. The obligation on the part of any of the contractors to maintain their work may cease on notice being given to the County Surveyor by the contractor concerned, that in his opinion his section requires reconstruction, when the life of the section is to be considered at an end.

It is pointed out that the cheapest road is that for which the cost is lowest when, at the end of its life, the total sum expended on prime cost and annual maintenance, spread over the life, works out at the lowest figure.

The area subjected to test amounts to 18,420 square yards, and 23 different materials or methods are to be tested. The construction of the various trial lengths is now in progress, and it is anticipated the whole will be completed by the end of September. Road engineers are invited to visit the works during progress, or at any time afterwards, and Mr. F. W. Greig, 20, Alma-road, Sidcup, Kent, the resident engineer, will give any information on the ground. Persons interested are also invited to apply at any time for information to the County Surveyor, Maidstone, Kent, or to Colonel Crompton, C.B., Queen Anne's Chambers, Broadway, Westminster, London, S.W.

A detailed summary of the traffic census is appended, together with a table stating the names of the twenty-three contractors, descriptions, and finished thicknesses of materials, with the contract price per square yard of each, and contract price for maintenance, and also the cost (including maintenance at contract rates) per square yard per annum. Added to the pamphlet, which is well worth perusal by those interested, is an appendix showing how to get to the site from London, with a railway time-table. We congratulate the board on the compilation of this pamphlet, and on the facilities offered for the dissemination of information deduced from these experiments of national interest and importance undertaken at the public cost.

INSURANCE AGAINST STRIKES.

AT the recent general meeting of the Danish Employers' Union, the chairman went at some length into the matter of insurance against strikes, winding up with a statement to the effect that the central board of Danish employers recommended a thorough investigation of the whole question, seeing in such investigation not only a possibility of solving the problem as to how compensation should be paid to members who suffer loss by cessation of work, but also a means of consolidating the financial position of the union, which the future will no doubt necessitate. The board, he said, knew that this would be costly, but this consideration ought not to weigh heavily in the balance. They were prepared for the investigation leading to the result that the joint fund of the Employers' Union would have to become the guarantee fund for the strike insurance. Further, that a sum would have to be levied as an entrance fee, which contribution, however, in most cases, it was thought, could be covered by the aid funds, which would discontinue after the establishment of strike insurance. Finally, the ¼ per cent. paid to the administration of the Employers' Union would have to be continued, in such a way that the sums which were not absorbed for this purpose should be transferred to the guarantee fund of the Employers' Union.

What premium otherwise would have to be levied on the wages paid in addition to the above ¼ per cent. it was quite impossible to state at present, but preliminary examination seemed to point to the fact that an annual payment to the strike fund of ½ per cent. on the wages paid would go a very long way towards the attainment of the desired end. If this were really the case, it meant that whilst the members at present paid ¼ per cent. to the aid fund, the future payment would be ¼ per cent. to the administration, and ½ per cent. to the strike insurance, varying considerably in the different cases, according to the nature of the concern. This, of course, would not provide cover for such possibilities as a large general lock-out, but in ordinary conditions it would enable the union, or the strike insurance fund, to meet all the obligations which could be reasonably laid upon the union as regards its members, and, above all, they would have done with that discontent which the past has shown very easily springs up.

THE GAUSS TOWER ON THE HOHENHAGEN.—A tower in honour of the great physicist Gauss has been erected on the Hohenhagen, a hill 508 metres in height, near Dransfeld. This particular locality has been selected because Gauss stayed on that hill for a long time in 1831, when engaged in the Brocken-Hohenhagen-Inselsberg triangulation, comprising two of the most prominent heights of the Harz Mountains. The tower is a square four-story structure, 35 metres in height, built in basalt, with a pyramidal roof. The interior has been fitted up as a Gauss Museum, and contains a bust of the savant, an exact copy of the first Gauss-Weber telegraphic apparatus (kept at Göttingen, where the experiments were conducted), copies of other instruments of Gauss, and also pictures of the south polar exploration ship named after him, &c.

OUTLOOK OF THE CHLORINE INDUSTRY.—The development of the electrolytic alkali and chlorine production is putting more chlorine on the market than is wanted, and the chief problem is now to find applications for this substance. Most chlorine is still converted into chloride of lime or bleach. But liquefied chlorine, and to a greater extent even, electrolytic sodium hypochlorite, compete with the old bleach. It is claimed that the electrolytic hypochlorite is more active than the old bleaching powder; at any rate, it yields a more bluish tint, and is often preferred for that reason. New bleach works are still in course of erection on the Continent, although the price of the lime chloride has fallen very much, and although most bleach consumers supply their own requirements. In electrolytic alkali works potassium chloride is, in Germany, decomposed by preference to sodium chloride, because the potash commands a higher price than the soda; there is less demand for potash, however. Dye works and other chemical works require a certain amount of chlorine; as a rule, however, they can make their own chlorine, and the outlook is becoming serious.

HIS MAJESTY'S BATTLESHIP "ORION."

BUILT AT THE ROYAL DOCKYARD, PORTSMOUTH; ENGINED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY.

(*For Description, see Page* 295.)

Fig. 1. Bow View.

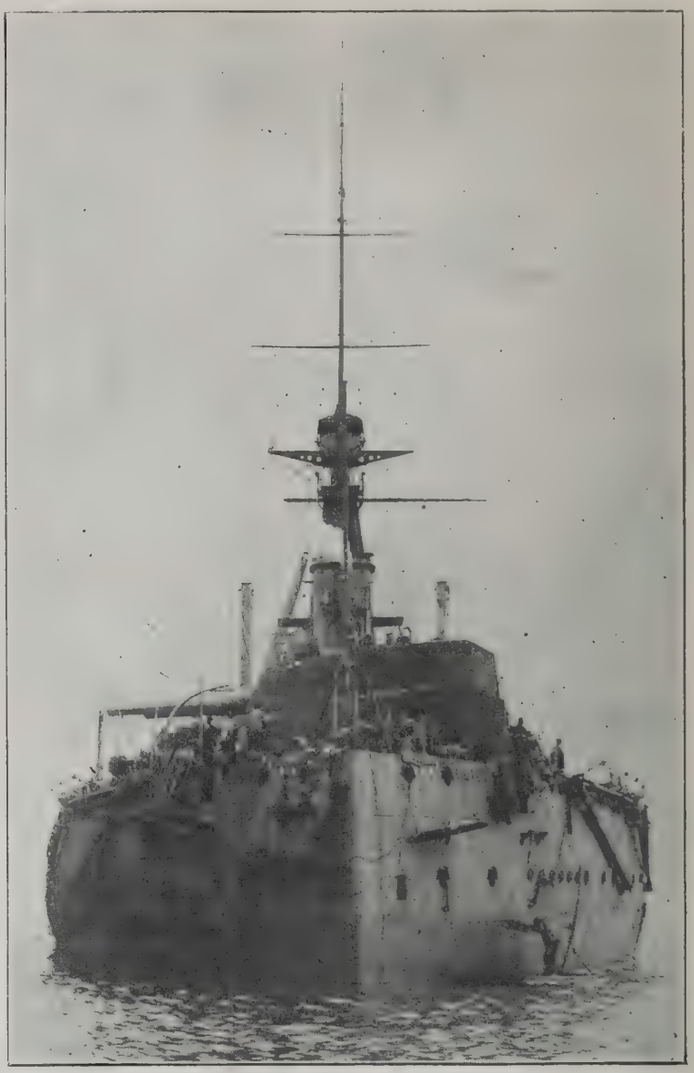


Fig. 2. Stern View.

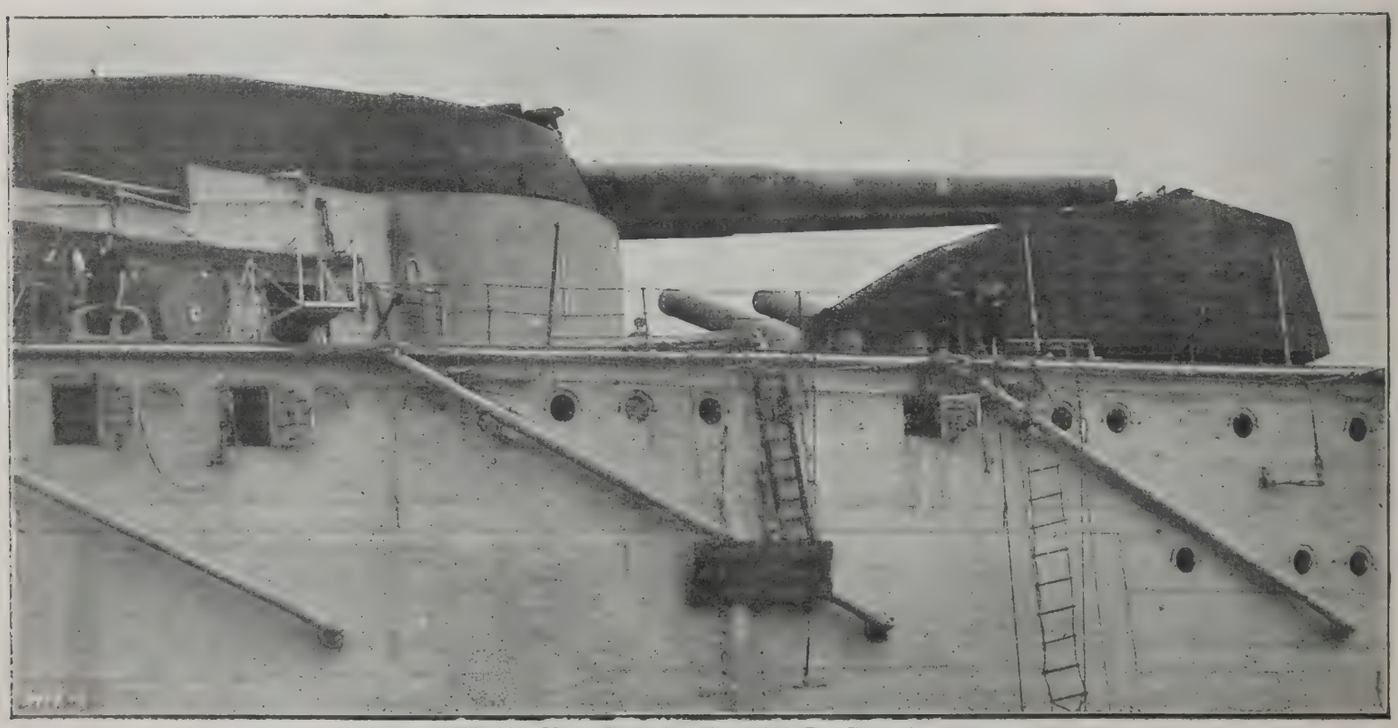


Fig. 3. View Showing Four 13.5-In. Guns Aft.

CARBON GLANDS FOR STEAM-TURBINES.

CONSTRUCTED BY THE MORGAN CRUCIBLE COMPANY, LIMITED, BATTERSEA, S.W.

Fig. 1.

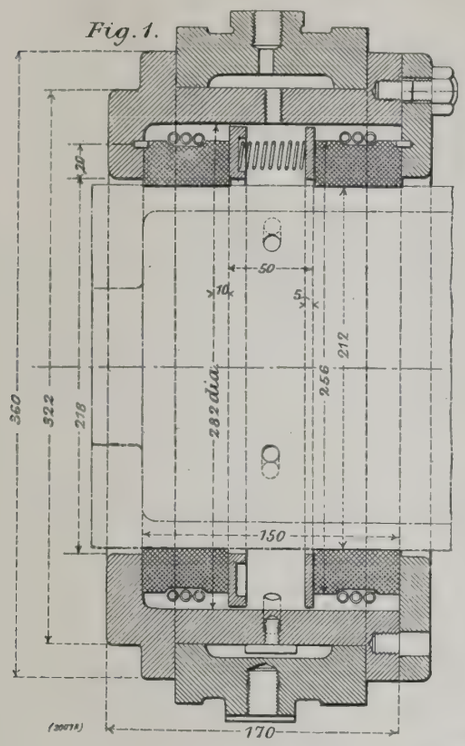


Fig. 2.

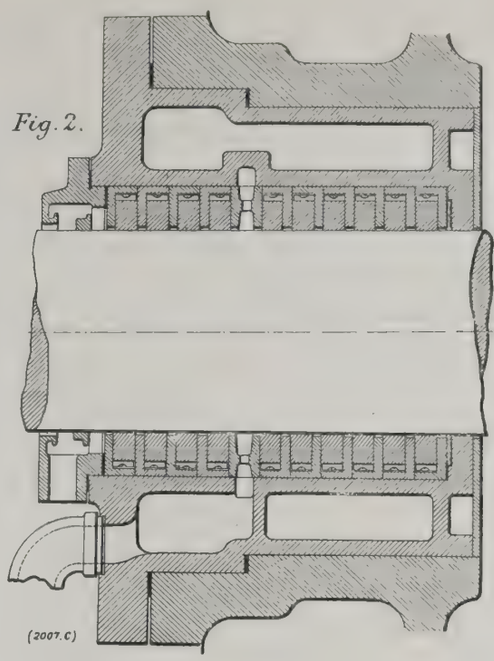


Fig. 3.

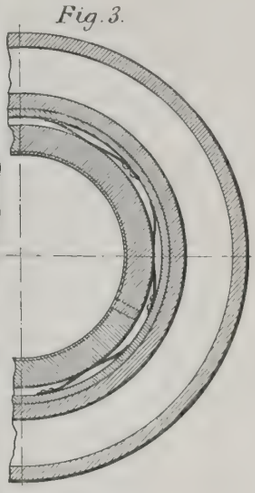


Fig. 4.

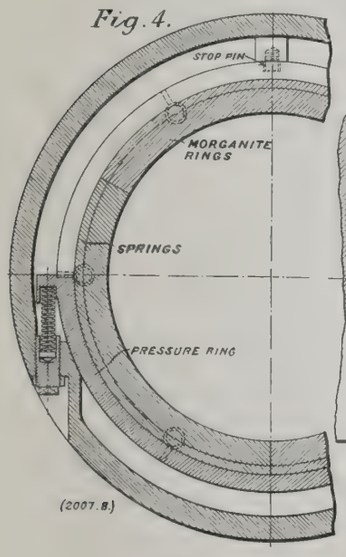
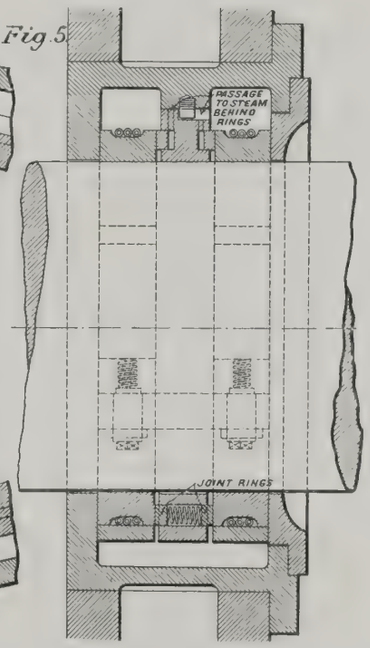


Fig. 5.



As is well known, ordinary piston-rod packings are unsuitable for use on turbine spindles, the high speed of rotation giving rise to lubrication difficulties and other troubles. The problem of devising a form of gland not requiring lubrication was solved by the Hon. Sir C. A. Parsons, who introduced the labyrinth packing, one of the most ingenious of his many novel contributions to practical mechanics. Many attempts have been made to discover other solutions of the problem, and in view of its self-lubricating properties, and its resistance to high temperatures, attention was naturally directed to graphitic carbon as a material for packing-rings. At the outset great difficulties were experienced, as the rings first used were very fragile, and gave trouble from breakage in place. The problem was then attacked by the Morgan Crucible Company, of Battersea, S.W., who had previously successfully solved the equally difficult matter of producing a reliable carbon brush for continuous-current dynamos. As the result of much experiment, this firm succeeded in producing carbon gland-rings of exceptional mechanical strength, and glands packed with these are now being tried by many builders of steam-turbines. Practice in this matter cannot, however, be said as yet to have been fixed, and we illustrate above three different arrangements which the Morgan Crucible Company have supplied to different firms.

In the packing illustrated in Fig. 1 there are two carbon packing-rings, each of which is built up of three segments, which are preferably made with simple butt joints. These segments are held together by spiral springs encircling the lot, as indicated in our engraving. Two brass rings, pressed apart by springs, as shown, keep the carbon rings up against their seats, and provision, it will be seen, is also made for introducing steam into the 'tween space. Pegs projecting from the seats on which the rings are bedded prevent these being carried round by the shaft as it rotates.

An alternative form of gland is illustrated in Figs. 2 and 3; the spiral springs holding the segments together are here replaced by flat plate springs mounted on brass spacing rings as shown. Here, again, provision is made for admitting steam to the interior of the packing, thus preventing any possibility of air leakage into the turbine and thence to the condenser.

The gland represented in Figs. 4 and 5 is in principle the same as that illustrated in Fig. 1, with the addition of an arrangement for supporting the weight of the packing-rings on springs. This provision is intended to obviate any possibility of the rings wearing oval. As will be seen, a half strap of brass passes under each carbon packing-ring, and is itself supported at each end by a spiral spring as shown to the left in Fig. 4.

THE ROLLING OF SHIPS.*

Address to the Engineering Section of the British Association for the Advancement of Science, by Professor J. H. BILES, LL.D., D.Sc., M. Inst. C.E., President of the Section.

IT has occurred during recent years that accidents have happened to ships, and they have mysteriously disappeared. The complete disappearance, without leaving any trace, has led to the assumption that the vessel has capsized. The circumstances of such cases obviously preclude the existence of any direct evidence. The only subjects of investigation can be (1) the condition of the ship prior to the accident, and (2) the probability that such a condition could be one which in any known possible circumstances could lead to disaster. The first is determinable by evidence in any particular case. The second involves a consideration of the whole question of the behaviour of ships at sea. What is the effect upon any given ship of a known series of waves? What waves is a ship likely to meet?

This subject has occupied the attention of scientific engineers, and it may be said to have been considered a solved problem. We have thought that if a ship has a certain metacentric height and a certain range of positive stability, she is quite safe from the action of a series of waves of any kind which we know to exist. If, however, a known ship (and perhaps more than one) has these safety-ensuring qualities and mysteriously disappears, it may be desirable to review the grounds of our belief, to see whether any known possible combination of circumstances may cause disaster.

Let us then briefly review the grounds of our belief. Fifty years ago Mr. William Froude showed that the large angles occasionally reached in rolling are not due to a single wave impulse, but are the cumulative effect of the operation of successive waves. The period T of a small oscillation of a ship in water free from wave disturbance and resistance is $\pi \sqrt{\frac{k^2}{g\,h}}$, where k is the radius of gyration, and h is the metacentric height—*i.e.*, the height of the metacentre above the centre of gravity. The period T of a wave is $\sqrt{\frac{2\,\pi\,l}{g}}$, where l is the length of the wave, and g is the acceleration due to gravity. The line of action of the resultant of the supporting pressures acting on a ship in undisturbed water is the vertical through the centre of gravity of the volume of the water displaced by the ship. In wave-water it is in the normal to the effective wave-slope (which is approxi-

* Address delivered before Section G of the British Association for the Advancement of Science, at Portsmouth, August 31.

mately the wave surface). The oscillation of this normal as the waves pass causes a varying couple tending to incline the vessel. If the vessel is very quickly inclined by this couple she will place herself in or near the normal, and the inclining couple will be of zero value. If, however, her movements are very slow, the normal may make one or more oscillations before any appreciable effect is produced on the vessel. The tendency to incline in one direction, caused by the normal acting on one side of the vertical, is checked by the rapid oscillation of the normal to the other side of the vertical. It is therefore evident that the relation between the period of the ship and that of the wave normal is a dominating feature in the resulting movement of the ship. Mr. W. Froude's mathematical solution of this relation is the basis of our belief that we understand the behaviour of a ship in the uniform system of waves when the vessel is placed broadside on to the waves. To obtain this solution he assumed that within the limits considered the moment of stability varied as the angle of inclination. In the curve of righting levers of a ship, usually known as a curve of stability, this condition holds generally for angles up to about 10 deg. The curve usually reaches a maximum value at about 30 deg. to 40 deg., and vanishes at 60 deg. to 80 deg., so that for large angles of roll the assumption does not hold. On this assumption, however, he showed that the motion of a ship amongst such a system of waves is the same as for still water plus a motion composed of two sine terms. The amplitude of this latter motion depends upon the maximum slope of the waves and the ratio $\frac{T}{T_1}$ (the period of the ship in undisturbed water to the period of the wave). If the ship starts from rest in the upright, θ is the maximum angle of inclination of the ship, and θ_1 the maximum wave-slope; then

$$\theta = \theta_1 \frac{1}{1 - \frac{T^2}{T_1^2}}$$

He considered several solutions of the equation of motion:—

1. $T = T_1$; this is synchronism, and the angle of inclination gradually increases. Each wave-impulse adds something to the ship's inclination, and without any resistance to rolling the vessel would capsize.

2. $\frac{T}{T_1} = 0$; this is the case of the ship's period being very small compared with that of the wave. θ will then be positive and equal to θ_1. In other words, the ship will place herself normally to the wave-slope. The maximum amplitude will only be the maximum wave-slope.

3. $\frac{T}{T_1} < 1$. In this case the wave-period is greater than that of the ship, and θ is always positive and greater than θ_1. The vessel always inclines away from the wave-slope. If

$$\frac{T}{T_1} = \tfrac{1}{4},\ \theta = \frac{16}{15}\theta_1. \quad \text{If } \frac{T}{T_1} = \tfrac{1}{2},\ \theta = \frac{4}{3}\theta_1.$$

$$\text{If } \frac{T}{T_1} = \tfrac{3}{4},\ \theta = \frac{16}{7}\theta_1.$$

The nearer $\frac{T}{T_1}$ is to unity the larger is the maximum amplitude.

4. $\frac{T}{T_1} > 1$. In this case the wave-period is less than that of the ship, and θ is always negative. The vessel inclines towards the wave-slope.

If

$$\frac{T}{T_1} = 1.1, \text{ then } \theta = -4.76\,\theta_1;$$

$$\frac{T}{T_1} = 1.26, \text{ then } \theta = -\theta_1;$$

$$\frac{T}{T_1} = 2.0, \text{ then } \theta = \tfrac{1}{3}\theta_1;$$

$$\frac{T}{T_1} = 2.235, \text{ then } \theta = \tfrac{1}{4}\theta_1.$$

This shows the advantage of having T greater than T_1.

He showed that the ship goes through a cycle of changes and considered the effect of variations of $\frac{T}{T_1}$ upon these cycles. He showed that $\frac{T}{T_1} = \frac{5}{4}$ is better than $\frac{T}{T_1} = \frac{4}{5}$, so that it is better to lengthen T rather than to shorten it. Similar results for $\frac{T}{T_1} = 2$ and $\frac{1}{2}$ respectively gave better results by lengthening than shortening T. In each of the cases $\frac{T}{T_1} = \frac{5}{9}$ and $\frac{T}{T_1} = \frac{9}{5}$ the results show balked oscillations in which, while the vessel swings towards the vertical, she does not reach it, but swings back again. The lengthened value of T here also gave better results than for shortening it. The results given above are greater than would be obtained in practice, because resistance has been neglected. Later he determined the effect of resistance upon rolling in still water free from waves. He determined the law of resistance and found it to vary partly as the angular velocity and partly as the square of it. He rolled a ship, and after she was allowed to roll free from disturbance he measured the angle of inclination at the end of each roll. These showed the rate of extinction of the rolling due to the resistance. The loss of extreme angle of roll between one roll and the next represented the work done by the ship in rolling. It is possible to calculate the work done in inclining the vessel to any angle, and the difference between the amount of work thus done in two different angles represents the difference in work necessary, and therefore work done in resistance to bring the ship to these angles of inclination. Hence the work done by resistance between two consecutive rolls can be actually measured by measuring the extreme angle of inclination in successive rolls.

Having determined the resistance in terms of angles of roll and time, it was easy to determine the law which represented the resistance in terms of the angular velocity.

In applying this to waves, all that is necessary is to take account of the fact that the position of equilibrium about which the ship oscillates is the normal to the effective wave-slope. This normal has a definite oscillation about a fixed vertical. It is therefore possible to determine the angle of inclination in terms of time.

As these angles of roll may be considerable, the assumption upon which the general solutions for unresisted rolling, already given, were based will not hold. The actual moments of stability depend upon the form of the ship and the position of its centre of gravity, and as these vary in different ships, it is only possible to obtain the relation between inclination and time by a special investigation in each case. A solution by a method of graphic integration was devised by Mr. W. Froude, and has been applied to a very small number of cases. The information necessary to obtain a solution in any one case is as follows:—

1. A curve of righting levers in terms of angle of inclination. This is called a curve of statical stability.

2. The form and period of the wave on which the ship is supposed to be placed broadside on.

3. The constants which determine the actual value of the resistance moment in terms of the angular velocity. These can be obtained by rolling the ship in still water and observing the rate of extinction of rolling when that extinction is due to resistance only. The form of the curve of extinction can be obtained by rolling a model of the ship, but the actual ordinates of the curve for an actual ship can only be obtained by experiment on the ship herself, or by inference from a similar ship of approximately the same size, form, and arrangements.

A consideration of these three necessities for the solution of one particular case shows that a considerable amount of work is necessary for determining the angle of inclination in terms of time. Even this solution can only be made for one assumed maximum angle of inclination as a starting condition. For instance, in any case where a ship is assumed to start with a maximum inclination of 20 deg. it is only possible to obtain one solution of angles of inclination in terms of time. If we take another maximum angle of inclination, another complete solution is necessary. The work of each solution is considerable.

For ships which vary much in draught and condition of loading it is evident that for each ship the work of complete investigation for all the conditions of loading of different waves and different angles of maximum inclination is very great. For this reason the investigation of rolling by the Froude graphic method has only been made for a very small number of cases and our knowledge of the actual angles of inclination of ships obtained by this method is very small.

The curve of statical stability is worked out for many ships in a few conditions of draught and position of centre of gravity. These curves are of little practical value, because they only serve as comparisons between ships. It is assumed that if a ship has a fair range of statical stability—*i.e.*, that the angle of vanishing statical stability is not less than, say, 60 deg., and the maximum righting lever is not unlike some previous ship which "has been to sea and come home again" safely, this ship will be safe. This assumption is based on the belief that only what has happened to previous ships will happen to the one in question—that is, that the contingencies of waves will be the same in all cases. But when we find that occasionally ships are missing we are compelled to ask ourselves the question, Is it possible that some occasional contingencies of sea or ship, or both, may exist which will produce a dangerous and perhaps fatal roll?

Mr. W. Froude's investigations were made for a uniform system of waves. He showed that in unresisted rolling a ship initially at rest and in the upright position is acted upon by a uniform series of waves such that $\frac{T}{T_1} = \frac{p}{q}$; where p and q are the smallest whole numbers which express this ratio then the rolling of the ship will be in q cycles, the maximum inclination in each roll gradually increasing, and again gradually diminishing, and so on. The period of occurrence of the maximum of maxima will be $2qT$. The number of times the ship passes through the upright in each complete cycle is $2p$ or $2q$, whichever is the smaller. The ship is upright at the middle of the cycle, and on either side of this middle there is an equal maximum, which is approximately $\theta_1 \frac{q}{q-p}$, and never exceeds this value (where θ_1 is maximum wave-slope). If T is much larger than T_1, and therefore p is much larger than q, then the value of $\theta_1 \frac{q}{q-p}$ approaches $\theta_1 \frac{q}{p}$, and is less than the wave-slope. If T is much smaller than T_1, then the value of $\theta_1 \frac{q}{q-p}$ approaches θ_1. If T is nearly equal to T_1, then $\theta_1 \frac{q}{q-p}$ approaches a high value.

From this it is seen that our investigations in unresisted rolling may be over a very wide field, but would produce no definite result in the matter of finding cases of large angles of roll in practice. We can only obtain valuable results when resistance is included.

Mr. R. E. Froude, in 1896, was led to deal with the subject of non-uniform rolling of ships in an assumed uniform system of waves which did not synchronise with the ship such as is dealt with above for unresisted rolling, and he dealt with the effect of resistance in such a case. He pointed out that there is a particular phase-relation between the ship and the wave which will produce uniform rolling, just as there is in the case of a synchronous system of waves. If at any stage for any reason the rolling is of the cyclic character considered in non-resisted rolling, then the resistance must gradually introduce uniformity, because the rolling is made up of two sets of oscillations—

1. That due to the rolling relatively to the water surface, such as would occur in undisturbed water.

2. That due to the oscillation of the water surface itself, caused by the passage of the wave.

We have already seen that the resisted oscillation in undisturbed water gradually decreases when the vessel is left free to oscillate, but takes place in practically uniform time T. The oscillation of the water surface is forced on the ship and causes a simple harmonic oscillation of the ship in time T_1 in algebraic addition to that due to the free resisted oscillation. When the maximum angle of a roll due to the free oscillation coincides with the maximum angle due to the forced oscillation of the wave, we shall have a maximum extreme inclination which is the sum of that due to the free and the forced. When they are in opposition we shall have a minimum extreme oscillation which is the difference of these two. At stages between coincidence and opposition we shall have extreme angles varying between maximum and minimum. As time goes on the extreme angle due to the free oscillation gradually decreases under resistance, and the sum and the difference referred to above approximate to each other, and the rolling becomes that due to the wave alone. We have seen that in the case of unresisted rolling where the wave and the ship synchronise there is an addition to the angle of inclination for each passage of the wave, and were it not for resistance these accumulated increases would cause the vessel to upset. But in the case of resisted rolling each increase of extreme angle of roll causes an increase in the work done upon the resistance of the ship, and when the increase in the work done in increasing the angle of heel by each passage of the wave equals the work done in increasing the resistance incurred in swinging through this greater angle, then we shall have a balance of condition and a uniform angle of roll. The angle at which this balance takes place depends on the period and maximum slope of the wave and the coefficients of resistance between the ship and the water. For instance, with a maximum wave-slope of 3 deg., and with a ratio of ship to wave-period of 1.1, the value of the angle of ultimate uniform rolling in the case of H.M.S. Revenge was found to be 13.9 deg. without bilge-keels, and 10.8 deg. with them. In the case of synchronism of the ship and the wave, the rolling is uniform always and reaches a maximum of 41.1 deg. without and 14.85 deg. with bilge-keels. The nearer the wave and ship are to synchronism, the larger is maximum inclination reached before uniform rolling sets in and during uniform rolling. Resistance is of much more importance in the case of synchronism. If the ratio of ship to wave period be 1.3, the maximum angle before uniform rolling is reached is 8.25 deg. without and 6.6 deg. with bilge-keels, while that due to uniform rolling is 4.35 deg. without and 4.24 deg. with. We see, therefore, the important part that the near approach to synchronism plays in creating large angles of roll, and the value of bilge-keels in reducing the rolling in conditions approaching synchronism. When on waves of smaller period, when small angles of roll may be expected, the bilge-keels give but small advantage. The assumption in these cases is that the vessel starts from rest in the upright in the mid-height of the wave, and that the rolling is caused by the assumed uniform swell. The vessel will go through the cyclic change already described, and will reach a maximum inclination of not more than double that which she reaches when uniform rolling has set in.

A later investigator—Colonel Russo, of the Italian Navy—found by experiment that by varying the assumption as to starting condition of the ship, by letting the wave action begin to operate first when the vessel is upright and at rest on the crest of the wave, the maximum angle before uniform rolling sets in can be more than four times that due to uniform rolling if the time of the ship is greater than that of the swell. There is an infinite number of solutions of rolling amongst waves, because there is an infinite number of initial circumstances; but, whatever these may be, the rolling in a uniform swell will always soon degenerate into a series of uniform forced oscillations in the wave period.

From this discovery of Colonel Russo we see that the region of investigation of possible causes of upsetting is removed from that of uniform rolling even in a non-synchronous sea. The following table shows for the Revenge, with bilge-keels, the variation in maximum angle of inclination before and during uniform rolling in terms of the period and length of the swell:—

Period of swell in seconds	8	10	12	13.3	15	17	19
Length of swell in feet ..	328	512	738	910	1153	1481	1850
Maximum angle in degrees before uniform rolling	6.3	8.0	14.7	21.4	17.1	13.0	11.0
Maximum angle in degrees during uniform rolling	2.5	4.2	12.6	21.4	15.4	11.0	8.7

The period of free rolling of the Revenge through small angles for a double roll was about 16 seconds. The foregoing shows that the maximum rolling (which occurs at synchronism) took place at a period of swell of 13.3 seconds. The period of roll was less at large than small oscillations. The above figures are for waves varying from one thirty-seventh to one fifty-fourth of their length in height. The length of wave which corresponds to

maximum inclination is 910 ft., and height is about one-fiftieth. The maximum wave-slope for such waves is 3.6 deg. We are in the habit of dealing with waves of one-twentieth of their length in height for strength calculations. Observers have recorded waves in the open ocean of 600 ft. to 800 ft. in length, and of 30 ft. to 45 ft. in height, so that we know that the slope of the waves assumed by Colonel Russo is much less than may be encountered at sea. A wave whose length is twenty times its height has a maximum slope of 9 deg. Records of waves having a ratio of height to length of as great as one-thirteenth have been published. The maximum slope of wave corresponding to these proportions is 14 deg. If it is admissible to take much larger angles of wave-slope we may expect to get much larger angles of maximum inclination both before uniform rolling sets in and when it does. In a case given by Mr. Froude, in which the maximum inclination in the Revenge was 12.0 deg. before uniform rolling, he showed by calculation that the corresponding maximum wave-slope must have been 5.09 deg, For 20 deg. maximum inclination the wave-slope was 10.3 deg. Both these cases were for periods of ship and wave of 16 and 13 seconds respectively. For similar periods of 16 and 14.6 seconds the wave-slope to produce 20 deg. maximum before uniform rolling is only 7 deg. These figures give some idea of the effect of the wave-slope on the maximum inclination. It is to be remembered that these are the maximum angles obtained by Mr. Froude; but if we take Colonel Russo's maximum angles, which in some case are double those obtained by Mr. Froude, it is easy to see that large wave-slopes may produce very large angles of roll.

Summarising, we see that:—

1. With wave-slopes of 3.6 deg. the angles of maximum roll obtained by them in the Revenge with bilge-keels may be taken at 22 deg.

2. This roll takes place when synchronism exists between the wave and the ship, when the wave is 910 ft. long and 18½ ft. high, and has a wave slope of 3.6 deg.

3. Waves exist which are of this length, but which may have a height of 50 ft. and possibly more, and a wave slope of 10 deg.

4. In such steeper waves we should expect to get much larger angles of roll.

5. Each ship has peculiarities of rolling due to its form as well as to its lading and bilge-keels, &c.

6. These peculiarities, and the effect they have upon rolling, and the effect different waves will have upon the rolling of the ship, can best be studied experimentally.

It was my intention, when you appointed me as your president, to have placed before you the results of an experimental study made on lines somewhat similar to those carried out by Colonel Russo, but extended to a wide range of types of ship, waves, and resistance.

The machine for carrying out these experiments is practically complete; but, having met with an accident at the end of April last, which incapacitated me for some time, I was prevented from being able to do anything further to this subject. I am therefore obliged to ask you to be content with the general *résumé* of the subject which has been given.

I think enough has been said to show what a field of investigation is open to the experimenter. The little that has been done and published by Colonel Russo is only for three battleships of about the same size. For the great bulk of the ocean wayfarers nothing has been done. If it is possible to determine the kind of rolling which is likely to take place under stated conditions, it seems to be desirable to do so.

In all that has been said it will be seen that it is possible to determine experimentally the kind of rolling which will take place in a ship which is snug and seaworthy. But it is also possible to study the effect of loose water in a ship under the same set of conditions as to waves, lading, and form of ship. This part of the subject has not received any experimental treatment, except in a very limited number of full-sized ships. It is quite conceivable that some conditions of loose water associated with some conditions of sea may produce large angles of inclination.

The subject has been treated as one in which it is probable that the kind of waves met with at sea will be uniform in size and period. That this is not so is a fact with which we are all more or less familiar. The effect of a uniform system of waves is to rapidly induce a condition of uniform rolling. But any deviation from uniformity of sea immediately introduces non-uniformity of rolling, and generally greater extreme angles of roll. Any experimental study of the action of waves upon a ship must include a variation in the character of the waves. The field of investigation is thereby widened, and the search for large angles of inclination made more laborious. But the work is of a kind which can be done by many people, and can be done fairly rapidly, so that there seems to be no insuperable objection to doing it. The details of the apparatus need not be described, but the study of the objects attained may be of interest.

1. Wave-motion is simulated by the revolution about parallel axes of two parallel cranks of different lengths. The line joining the ends of the arms of the cranks is always in the line of the normal to the wave-surface, and a line perpendicular to it is therefore parallel to the wave-surface.

2. From the form of the ship are determined curves which are the shape of rollers which roll on a straight line parallel to the wave surface. The form of these rollers is such that the model of the ship in rolling maintains the position in relation to the wave surface (*a*) which cuts off constant volume of displacement at any angle of inclination; (*b*) in which the perpendicular to the straight line parallel to the wave surface through the point of contact is the line of the resultant of the water pressures acting on the vessel.

3. The resistance to rolling is obtained by (*a*) electromagnets, the current to which is generated by the motion of the model, (*b*) secondary electromagnet, the current for which is in the first magnet. (*a*) represents the resistance due to the angular velocity, (*b*) represents the square of that velocity.

The variations in the lengths of the cranks and the speed of revolution give the variation in the wave-form assumed. The variation in the electric current by resistances in the circuit gives the variation in the resistances to the rolling of the ship. For instance, the current necessary to represent the resistance of a ship with bilge-keels is very different from that for one without.

It is hoped that sufficient has been said to call attention to the possibility of extended study of the rolling of ships at sea, so that some valuable work may be done in this important subject.

OUR PRESENT KNOWLEDGE OF THE VIBRATION PHENOMENA OF STEAMERS.*

By Konsul Dr. O. SCHLICK, Member.

IN view of the apparent impossibility of dealing scientifically with the vibrations which made their appearance with more or less intensity in every steamer, these were, up to about the beginning of the eighties of last century, regarded as an unavoidable evil.

With the gradual increase in the engine-power and speeds of steamers, however, the cases in which the vibrations assumed an exceptionally violent form became more and more frequent, and greater attention began, therefore, to be given to this phenomenon.

Twenty-seven years ago, at the spring meeting of the Institution of Naval Architects (1884), I had the honour of reading a paper "On the Vibration of Steam Vessels," and I believe this was the very first publication of an attempt to give a scientific explanation of vibration phenomena.

The contents of this paper mainly consisted in the proof, then given for the first time, that vibrations were in no way caused by weakness of the hull of the vessel, but that they were chiefly produced by the inertia forces of the reciprocating parts of the machinery when these occurred at periods corresponding with those of the bending oscillations of the hull in the vertical plane. In this paper, therefore, the principles underlying the action of the inertia forces and the phenomenon of resonance were investigated.

In 1891 Mr. Yarrow conceived the happy idea of letting the engine of a torpedo-boat run with the propeller-shaft uncoupled, so that only the inertia forces exerted by the reciprocating parts of the machinery came into play. It became clearly evident that the vibrations which appeared had their origin in the synchronism of the inertia forces with the bending oscillations of the longitudinal axis of the vessel in her vertical middle-line plane.

Further investigations led me to study the dissimilar behaviour of the various types of engine met with in practice, and of the influence exercised by the position of an engine in a vessel, according as only vertically acting inertia forces, or tilting couples, or both of these together, came into play. Amongst other things the remarkable fact was established that the ordinary triple-expansion engine, in spite of the considerable exertion of vertical inertia forces and tilting couples which characterise it, was, under certain circumstances, and when it was placed in a particular position in the vessel, harmless as regards the setting up of vibrations.

I succeeded further in constructing a simple formula, which made it possible to determine the number of the vibration-oscillations beforehand, and thus to avoid the critical number of revolutions in the first design of the engine.

As soon as it was recognised that means for the avoidance of the vibrations must be provided, not by the shipbuilder, but by the marine engineer, the efforts of the latter became directed to the destruction, as far as possible, of the action of the inertia forces, and the result of these was the invention of the balanced four-crank engines, which were proposed by me in 1894 and very speedily attained general adoption under the title of the "Yarrow, Schlick, and Tweedy System."

With the creation of the balanced reciprocating engine, the first act in the solution of the vibration problem was in a manner brought to a conclusion. The extremely violent vibrations, which are to be attributed to the action of the inertia forces of the reciprocating parts of the machinery, can, with the exception of a small residue, always be avoided by correct balancing.

After this short historical review, I should like to proceed to show with what phenomena we have to reckon in vertical reciprocating engines. To this point I shall give very brief expression, as I am no doubt right in assuming that the more important of the matters entering into the discussion are well known.

If a single-screw steamer be equipped with an unbalanced vertical engine, there will in most cases arise (with a particular number of revolutions) vibrations, which consist in a bending of the longitudinal axis of the vessel in a vertical plane, in the course of which two nodes are formed. These two-node vibrations are termed "Vertical vibrations of the first order," and are said to be of single frequency. The latter expression is intended to convey the fact that the hull of the vessel makes a number of oscillations per minute exactly corresponding with the number of revolutions of the engine. If the revolutions per minute advance beyond the critical number, the vibrations disappear, only to appear again in a violent form at a number which is generally less than twice as great. Three nodes now appear; this is called the "Vertical vibration of the second order." The frequency, however, remains single, since the numbers of vibrations and revolutions coincide with each other here also.

In very rapidly running engines, indeed, vibrations of the third order with four nodes may also, in exceptional cases, be observed. So far as I am aware, the presence of vibrations of a still higher order has not been established with certainty.

Engines which develop only vertical mass-forces, such as vertical engines with single cranks, provided they be placed exactly at node points and the critical number of revolutions be not considerably exceeded, so that no vibrations of a still higher order with more nodes situated at other points are set up, can never produce vertical vibrations.

On the other hand, when engines of a description that produce tilting couples, but no vertical forces, are placed at a node point, they cause violent vibrations, provided they reach the critical number of revolutions belonging to the order of vibration in question. This is, for instance, the case with engines having three cranks set at 120 deg. with each other and having all moving parts of the same weight.

Ordinary triple-expansion engines with three cranks set at angles of 120 deg. with each other, and four-crank engines with cranks set at 90 deg. with each other, which produce vertical inertia forces as well as tilting couples, and generally make the vessel vibrate very violently, can, strange to say, under certain circumstances remain quite passive.

The conditions under which this takes place are as follows:—At the two extreme positions of the oscillating longitudinal axis of the vessel, tangents may be assumed to be drawn from the positions of the engines, which then intersect at a point a short distance behind the node belonging to the order of vibration in question. When the product of the weight of the vertical mass, multiplied by the distance of the corresponding piston axis from the point of intersection of the tangents mentioned, is the same for each cylinder, no vibrations will occur.

In the case of twin-screw vessels with pairs of exactly similar independent engines, interference phenomena will, as may readily be understood, be set up as a consequence of the vertical forces produced by them. If the reciprocating pistons of analagous cylinders be moved simultaneously in the same sense, the inertia forces thereby produced supplement each other, and very violent vertical vibrations ensue. Since, however, the two engines do not move with exactly equal speeds of revolution, the crank of the one will, after a little while, have forged ahead of that of the other by 180 deg., and the two sets of inertia forces produced will then work simultaneously in opposite directions and thus counteract each other, so that the vertical vibrations will, for a short time, disappear.

Since, however, the two engines are placed at a certain distance apart in the athwartship direction, the vertical inertia forces now acting in opposite directions form a couple which give the section of the hull in way of the engines a lateral oscillation similar to that of the rolling motion of the vessel. These oscillations are communicated to the whole vessel in the form of torsional vibrations, and are of the single order of frequency of the number of revolutions per minute of the engine.

When unbalanced engines are fitted in twin-screw vessels, periodically alternating vertical and torsional vibrations appear, and the period corresponds with the time in which one engine outstrips the other by a complete revolution.

When correctly-balanced engines are fitted, there is, of course, no further cause for the vertical and torsional vibrations of single frequency here illustrated. True, we shall see further on that both kinds of vibrations of higher frequency may notwithstanding be observed in a mild degree, and that weak vertical vibrations of single frequency also occur here and there.

As already mentioned, the vibration problem was in 1894 regarded as solved by the balanced reciprocating engine, and, indeed, as a matter of fact, vibrations of single frequency never occur in vessels equipped with these engines in anything like the degree formerly experienced.

After the main evil was removed, however, it was found that weak tremors, which had formerly been masked by violent vibrations and thus escaped notice, were still present. The demands in regard to the quiet behaviour of a steamer had become considerably greater, and I was now confronted with the question as to what might be the cause of these residuary vibrations, and how they could be removed.

In regard to the nature of these residuary vibrations, the following observations may be made. In most cases vertical vibrations (bendings of the longitudinal axis in the vertical plane) of frequency still showed themselves, though to a considerably less violent degree, and in twin-screw steamers they also occurred in periods. The appearance thus presented was that of the engine being still incompletely balanced. In addition, vibrations showed themselves, which, though of small amplitude, were still unpleasantly felt, because their frequency was very great—generally threefold and fourfold.

It cost me much time and trouble before I could determine the cause of these phenomena with certainty, and I owe large debts of gratitude to the Stettiner Maschinenbau Actien-Gesellschaft Vulcan, the Hamburg-Amerika Line, and the Norddeutscher Lloyd for the ready willingness with which they allowed me to pursue these investigations, and for the obliging manner in which they lent assistance.

In the first instance, the experiment was repeatedly made of allowing the engines of the large Atlantic liners of the companies named to run at their critical numbers

* Paper read at the Jubilee Meeting of the Institution of Naval Architects.

of revolutions with their propellers uncoupled, and under these conditions not even the least suspicion of the vibrations otherwise experienced was felt. This proved conclusively that the residuary vibrations were not caused by defective balancing. The causes, then, had to be sought elsewhere.

It would be going too far were I to describe here the exact manner in which I set about my experiments. I first sought, by the help of the pallograph, designed by myself, to determine in which positions of the cranks the maximum amplitude occurred which again should enable a conclusion to be come to as to the position in which the impulse reached its maximum, since the latter must always be a quarter of an oscillation in front of the maximum oscillation amplitude.*

It very soon appeared that the vertical vibrations could not by any means be brought into fixed relation with a particular adjustment of the cranks. In the individual vessels the maximum amplitude occurred in connection with different positions of the cranks, and even in one and the same steamer the conditions changed as time went on. On the other hand, it became clearly apparent that the instant at which the ends of the vessel passed through the middle point of their upward swing, and therefore also the instant of maximum impulse, always coincided with that at which a particular blade of each propeller (the experiments were conducted almost exclusively with twin-screw vessels) assumed an almost exactly horizontal position—*i.e.*, when both were moving simultaneously downwards from the uppermost position.

The assumption is here made, that the propellers turn outwards, as it is generally expressed. When, on the other hand, the blades in question, stood at different angles—*i.e.*, when one of them pointed horizontally inwards, while the other pointed horizontally outwards—a case which occurs when one engine has forged ahead of the other by 180 deg.—the vertical vibrations of single frequency disappeared, or at any rate reached their minimum. While, then, one engine was advancing to a point a full revolution in front of the other, the vibrations diminished from a maximum to a minimum and then rose again to a maximum.

The explanation of this phenomenon is that one blade of each of the two propellers meets with a greater tangential resistance than the others, and the cause of it is to be found in the very slight excess of pitch of the blade in question. The difference in the pitch is so small that it can rarely be detected by the help of the ordinary appliances ("pitchometer").

To understand this clearly, we must picture to ourselves that the acceleration of the water by the propeller is already in some degree imparted to it before the particles reach the leading edge of the blade. The angle at which the propeller-blade cuts the threads of water flowing towards it (slip-angle) must therefore be a very small one—probably about 3 deg. When the pitch-angles of the different blades are not exactly the same, the one that has a very slightly greater pitch than the others has a considerably greater tangential resistance, while another one with smaller pitch may turn in the water almost without resistance, or, so to say, without load. While the blade with the greatest resistance moves, in the course of a revolution, from the upper position downwards, it imparts to the propeller-shaft an upward pressure, and endeavours to draw the after part of the vessel upwards, thus producing vertical vibrations of a period equal to that of the time of revolution of the engine—that is to say, vibrations of single frequency which are generally of the first order, and thus have two nodes.

The occurrence of vertical vibrations of single frequency may thus, in vessels with balanced engines, be quite naturally explained. Now, just as a difference in the pitch of the propeller-blade may suffice to produce vibrations of single frequency in steamers with balanced engines, so also can a like difference destroy the vibrations of single frequency set up by the action of the inertia forces of an unbalanced engine when these two causes of vibration always act in senses contrary to each other and are approximately equal in their action. As I have already explained in detail in my paper of 1884, "On the Vibration of Steam Vessels," this may sometimes be easily attained by turning the propeller in coupling up the shafting in such a way as to make a different angle with the cranks.

The striking vibration phenomena which were observed on the occasion of the experimental trials with different angular positions of the cranks in H.M.S. Terrible find their simple explanation in slight differences in the pitch of the propeller-blades.

That differences in the pitches of the individual blades may to a high degree be detrimental has long been known; but trifling ones of this kind, the very existence of which could scarcely be demonstrated, were not thought to have so much influence. But the result of these investigations also has the further effect that it clearly shows what great differences there are in the tangential pressures exerted by individual propeller-blades, and at the same time in the stressing of the latter. The blade fractures which so frequently occur may thus find an explanation of the simplest kind. It is evident also from these considerations how necessary it is, in all cases in which it is desired to avoid even the smallest vibrations of single frequency, and to obtain a specially good efficiency from the propeller, that the blades be machined, so that exact equality of these as regards both form and pitch is attained. When propeller-blades are exactly adjusted, the vibrations of single frequency disappear, provided always that the engines are correctly balanced; and since, by the help of the pallograph, every blade can be picked out which produces a tangential pressure differing from that of the rest, vibrations of single frequency can also be avoided in every case.

An attempt has also been made to connect the cause of vibrations of single frequency with inequalities in the turning moments. Theoretical investigations, however, have shown that the vibration-producing impulses of this kind do not suffice to produce the effects observed, and exact observations have shown this to be correct.

In all twin-screw steamers, again, an analysis of the diagrams drawn by the pallograph gives periodically occurring vertical vibrations of fourfold or threefold frequency, according as the propeller has four blades or three. In steamers which were originally fitted with three-bladed propellers, and showed vertical vibrations of threefold frequency, these latter gave place to vibrations of fourfold frequency as soon as three-bladed propellers were replaced by four-bladed ones.

The explanation of this phenomenon is as follows: The relative motion of the water flowing along the after body of the vessels does not take place exactly in the horizontal direction, but, on account of the large stern-wave, it follows a sternwards rising curve, as shown in Fig. 1, above. In consequence of this, each propeller-blade meets with greater resistance when it has moved down from above till it is about horizontal, that is to say, when it has reached the position denoted by A and A', in Fig. 2, than when it is in the position opposed to this. Now, when the two four-bladed propellers simultaneously assume a position in which one of each of their blades points horizontally outwards, as shown in Fig. 2, an upward pressure is given to each propeller-shaft. These two forces combine in endeavouring to raise the after body. Their magnitude diminishes considerably, however, when the two propellers have turned 45 deg. further round, and thus reached a position such as that shown in Fig. 3. This process is repeated four times for every revolution of the engine (or three times in the case of three-bladed propellers) and accordingly produces vertical vibrations of fourfold (or threefold frequency).

When in the case of four-bladed propellers, one of the two engines has outstripped the other by an angle of 45 deg., it follows, that while one blade of the one propeller is pointing horizontally outwards, and thus assumes the position of greatest resistance, two outer blades of the other propeller form angles of 45 deg. with it, as shown in Fig. 4. The two inclined blades will then together exert a somewhat smaller upward pressure on the shaft than that of the horizontal blade of the other propeller. When both propellers have turned through a further angle of 45 deg., the analogous forces again come into action, with the difference, however, that the two propellers have exchanged positions. In this manner there are produced during a single revolution eight upward impulses, which act on the after body of the vessel, and accordingly produce vibrations of eightfold frequency, these being, it is true, generally of very small amplitude and scarcely discernible.

The upward impulse acts on the starboard and port sides alternately, as illustrated in Figs. 4 and 5, and, as may easily be seen, sets up at the same time torsional vibrations of fourfold frequency (threefold in case of three-bladed propellers).

When, after a while, the one engine outstrips the other by 45 deg. more, the vertical vibrations of eightfold frequency disappear, and give place to others of fourfold frequency; at the same time, however, the torsional vibrations also disappear, and so on till, with another advance, made by the one engine of 45 deg. more, the game begins afresh. In this way the periodical increases and diminutions of the vibration phenomena may be explained.

The results obtained during my long years of investigation have so often been confirmed by experience that not the slightest doubt can now be entertained as to their reliability.

In order to facilitate a general review of the subject, I shall once more briefly recapitulate the phenomena which occur in a modern twin-screw steamer equipped with correctly-balanced engines.

A steamer of this class generally shows periodically recurring vertical vibrations of single frequency arising from the defective pitch of one blade of each propeller. When the propellers are machined, these vibrations disappear. Further phenomena take the form of vertical vibrations of frequencies the number of which is in each case equal to that of the blades of one of the propellers, periodically alternating with other vibrations, the frequencies of which are twice as great. Simultaneously with these last-mentioned vertical vibrations, torsional vibrations occur of frequencies equal in number to the

Fig. 1.

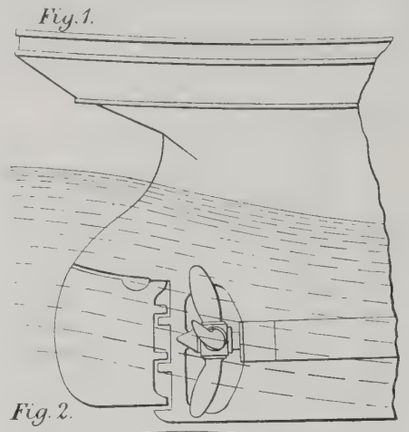


Fig. 2.

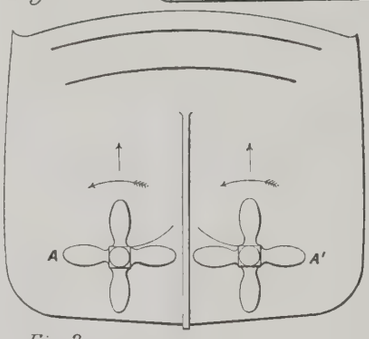


Fig. 3.

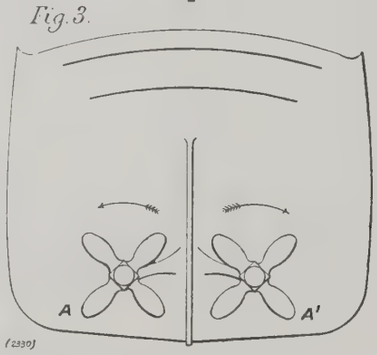


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Fig. 4.

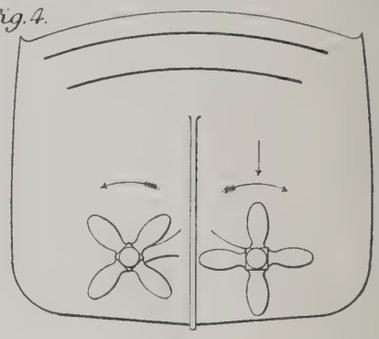


Fig. 5.

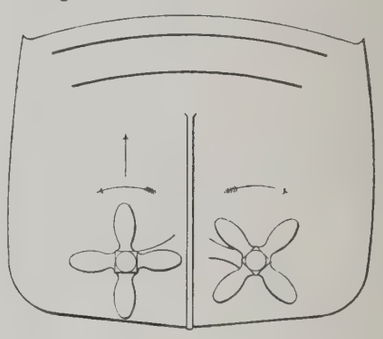


Fig. 6.

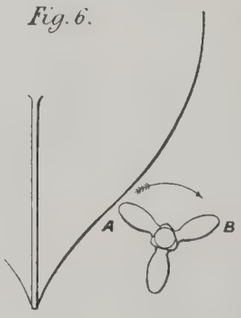
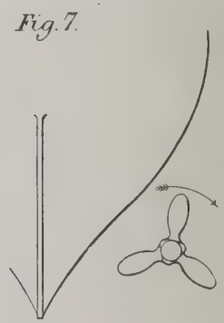


Fig. 7.



* The first experiments made in connection with these investigations were conducted by myself at the trial trip of the Atlantic liner Deutschland. I laid these before the Institution of Naval Architects in June, 1901, in my paper, "On Some Experiments Made on Board the Atlantic Liner Deutschland," during her trial trip. In subsequent experiments the method was materially improved.

blades of the propellers. Every twin-screw steamer shows torsional vibrations per minute exactly equal in number to the product of the revolutions multiplied by the number of the blades of one of the propellers.

If a single-screw steamer equipped with a correctly-balanced engine be considered, vertical vibrations of single frequency will first make their appearance, when, by reason of defective pitch, one of the propeller-blades shows greater tangential pressure than the others. A further characteristic is that of vertical vibrations of a frequency which corresponds with the number of the blades of the propeller, and in addition torsional vibrations, usually of considerable severity, occur, the frequency of which is likewise equal to the number of the blades. All these different vibrations, however, show no periodic increase and diminution such as are found to exist in the twin-screw steamers; their intensity remains constant.

The torsional vibrations of the single-screw steamers, however, are due to a different cause from that which operates in twin-screw steamers. In the case of the former, each propeller blade experiences the greatest resistance when it is in its upper vertical position or somewhat beyond this in the direction of rotation. The difference in the tangential pressure which the blade has to exert during a revolution is, in this case, considerably greater than in the case of the propeller of a twin-screw steamer. Since, however, the masses of the moving parts of the machinery, as in the case of a fly-wheel, seek to preserve a uniform speed of rotation, an increase of torsional stress will, each time that a blade passes the screw-frame at the upper vertical position, be imparted to the shafting, and thence to the engine-seating, and will endeavour to incline the section of the vessel at the position occupied by the machinery in a sense opposed to that of the revolution of the propeller. In this manner an impulse is given, which tends to produce torsional vibration.

In accordance with the foregoing, the torsional vibrations of single-screw vessels take their rise at the part of the vessel occupied by the engine, and not at the after bearing of the propeller-shaft, as in the case of the twin-screw steamers. This also explains the circumstance that torsional vibrations generally occur with considerable intensity in the fore body, while in twin-screw steamers they diminish gradually towards the fore body.

With the balancing of reciprocating engines, which came into fashion about the year 1894, everything that was possible was done for the removal of vibration, and the severe vertical vibrations formerly observed in unbalanced engines were, in fact, eliminated.

The periodical torsional vibrations of threefold or fourfold frequency occurring in the manner described above were still very unpleasantly felt, especially in swift passenger steamers. Although in the twin-screw steamers, which are principally dealt with here, they had their origin entirely in the propeller, and made their way into the fore body of the vessel, so that they made themselves felt very unpleasantly, especially in the saloon. Endeavours have, of course, been made to get rid of this evil, but these have been attended with only a comparatively small degree of success; for the only means at our disposal for the removal of these torsional vibrations consists in the prevention of resonance, or, in other words, in the avoidance of the critical number of impulses. The simplest means of attaining this end is the alteration of the number of the propeller blades, provided that, in view of other considerations, this appears permissible.

When a twin-screw steamer fitted with three-bladed propellers shows very severe torsional vibrations, the evil may, in nearly every case, be almost entirely removed when the propellers are replaced by others with four blades. On the other hand, I have, observed that in the case of a very large steamer the vibrations almost entirely disappeared when, in deference to a proposal of mine, the four-bladed propellers were replaced by three-bladed ones. A measure of this kind, however, is sometimes attended by unpleasant secondary phenomena. For the altered frequency of impulse attained with an altered number of blades not infrequently coincides with the critical number of impulses for vertical vibrations of higher order. It then becomes possible almost to avoid the torsional vibrations, but their place is taken by vertical vibrations which are of threefold and fourfold frequency according to the number of blades borne by the propeller. These latter vibrations are, it is true, generally less unpleasant than the torsional ones.

In such a case, and when it is desired to avoid the expense of replacing the existing propellers by new ones with other numbers of blades, there is still another way which, it is true, only brings partial success, as a rule. It consists in the alteration of one of the propellers, assumed to be fitted with ajustable blades, by a modification of its pitch as compared with that of the other, so that at the normal speed of the vessel the one engine has the greater number of revolutions per minute by about 5 to 7 per cent. The period within which the torsional vibrations advance to a maximum and return to a minimum again is by this means considerably shortened, and the vibrations never then attain the intensity experienced in the case in which the two engines work with almost exactly equal numbers of revolutions. This is explained by the circumstance that, under such conditions, the intensity of the impulse increases with great rapidity and reaches its maximum before the oscillating masses can be accelerated to such a degree that even an approximate approach can be made to the amplitude of oscillation which would be attained if the impulses had been continued with equal intensity for a considerable period of time. The same principle underlies the endeavour to reduce the torsional vibrations of twin-screw vessels by giving four blades to the one propeller and three to the other. In some instances this method has been attended with appreciable success.

It will probably be unnecessary to add that, in connection with the methods last described for diminishing the vibration, the speed of the vessel is always, to some extent, unfavourably affected.

With the introduction of the steam-turbine the vibration phenomena entered into a new phase. Since, in the case of the turbine, every periodic action of the inertia forces in a direction at right angles to the longitudinal axis of the vessel becomes impossible, and since, further, the turning moment is completely uniform, all the disturbances which set up vibrations in the unbalanced reciprocating engine are entirely avoided. It was accordingly at first asserted, even by professional men, as an immense advantage of steam-turbines that they could not impart any vibration to vessels so engined. This view, to which frequent expression was at one time given, proved how little the vibration phenomena were understood at that time.

The vibrations due to the propeller must, in turbine-steamers, occur in a manner analogous to that in which they show themselves in steamers equipped with balanced reciprocating engines; but, by reason of the relatively very high speed of revolution of the propellers in these vessels, the frequency of their vibration per unit of time must be considerably higher. For instance, if a three-bladed turbine propeller makes 200 revolutions per minute, and there are only two propeller-shafts, 600 (or 1200) vertical vibrations per minute will be set up, and these figures will increase to 800 (or 1600) when the propellers are of the four-bladed description. The number of revolutions of 200, however, must be regarded as almost the lower limit, and it is met with only in large steamers. In most cases from 400 to 500 revolutions per minute have to be reckoned with, and in such case frequencies of vibration up to about 1500 to 3000 per minute, or 25 to 50 oscillations per second, occur.

The amplitude of these vibrations, which are caused by the propeller alone, is, under like conditions, generally smaller in turbine-steamers than in steamers with reciprocating engines, since in the former the work imparted during one revolution, and consequently also the vibration-producing impulse, is less in inverse proportion to the relative numbers of the revolutions. The extremely high frequency of the vibrations of turbine-steamers, however, involves great inconvenience to the passengers and crew, and is a drawback for these vessels.

It is, on the other hand, a favourable factor that the unpleasant torsional vibrations do not extend over the whole length of the vessel, as they often do in steamers equipped with reciprocating engines. This phenomenon may be explained as follows:—In theory the speed of transmission of the torsional oscillations of the longitudinal axis of a vessel is, for steamers of like types, the same. Now, when the frequency of the oscillations per unit of time is comparatively low, as, for instance, in vessels equipped with reciprocating engines, a few large waves will make their appearance in the longitudinal axis, that is to say, only a few nodes for the torsional vibrations will show themselves. If, on the other hand, the frequency be very high, as in the turbine-steamers, a large number of small waves and a good many nodes will be formed. Now, since the assumption may fairly be made that, on account of damping action, the vibrations will cease after a certain number of oscillations, or, in other words, that, after reaching to a distance from their origin corresponding with a certain multiple of their wave-length, they will cease to be perceptible, the point at which the vibrations will no longer be unpleasantly felt will, in turbine-vessels, be considerably nearer the after end of the hull than in steamers with reciprocating engines.

The use of torsion indicators to determine the horse-power developed by steam-turbines has supplied a means for obtaining interesting information in regard to the fluctuations in the resistance to which the propeller blades are subject during a revolution. It may, for instance, be assumed that one of the outer propellers of a turbine-steamer with three or four shafts is arranged, as shown in Figs. 6 and 7, and that it has three blades. If the torsion angle of the shafting be measured at the instant at which the propeller is in the position illustrated in Fig. 6—*i.e.*, in which the tip of a blade is nearest the skin of the vessel, a higher value is obtained than in the case in which the torsion angle is measured in the position shown in Fig. 7. This is explained by the circumstance that the tip of the blade lying nearest to the skin takes hold of the layer of water drawn along by the wetted surface in consequence of the forward motion of the vessel, and that the particles of water at this point move forward at a considerable speed. At this instant the blade in question meets with considerably greater resistance, and a greater twisting of the shaft must accordingly take place at the instant when the propeller assumes the position illustrated in Fig. 7—*i.e.*, when the tips of two blades are further removed from the skin of the vessel.

This increased resistance of a single blade acting unsymmetrically produces, somewhat in the manner already described, a one-sided pressure on the after-bearing, which, together with the pressure exerted by the propeller on the shaft at the other side of the steamer, produces torsional vibrations. These vibrations occur with special vehemence, because the distance apart of the two shafts, and therefore, also, the arm of the couple thus produced, is considerably greater than, for instance, in the case of twin-screw steamers.

Further, when it is realised that, in consequence of the large stern wave, the water flows to the propeller, not exactly in horizontal lines, but in a curve which rises somewhat in the sternward direction, it will be further evident that the direction of rotation is not a negligible matter in contributing to vibration. If a rotary motion in the outward direction be assumed, as indicated by the arrow in Fig. 6, the blade A will, for the reason alluded to above, experience in the first place an especially high degree of resistance in the position shown, and will in consequence exert a downward pressure. But in this position the blade B also meets with a greater tangential resistance, because it bears against the particles of water of the stern wave which are here curving upwards, and accordingly produces an upward axial pressure. The pressures produced radially to the shafts by the blades A and B respectively thus in part neutralise each other. If, on the other hand, the direction of rotation of the propeller be reversed—*i.e.*, the latter turn inwards, it will readily be seen that neutralising of the radial pressures of the kind referred to does not take place, and the arrangement will in consequence be attended by vibrations of somewhat greater severity.

In turbine-steamers there is an additional circumstance which tends to increase vibration. This is the inclination which usually has to be given to the propeller shaft, because, by reason of the large diameter of the turbine casings, their inboard ends usually lie considerably higher than in a vessel with reciprocating engines. As a result of this, the direction of motion of the water flowing towards the propellers makes a still greater angle with the axis of the latter than that with which it already approaches them in the rising course of the stern-wave, and strong vibrations are set up in the manner already explained.

From what has been said, it will no doubt be clear that, for the removal or diminution of the vibrations in turbine steamers, in reality only one method remains—viz., that of the prevention of resonance, or, in other words, of the avoidance of the critical number of revolutions for the vertical as well as for the torsional vibrations. A reliable prediction of these critical numbers of revolutions, such as that which my formula enabled me to make in steamers with reciprocating engines, has up to the present, unfortunately, not become possible. In particular the determination in advance of the critical number for the torsional vibrations still presents great difficulties. I have, indeed, busied myself for some time with this problem, but I am not yet sure whether I shall succeed in finding a practical solution of it.

In view of the high frequencies which occur in turbine-steamers, one great difficulty lies in the circumstance that the critical frequency numbers for the successive orders of vibration lie comparatively near each other. It may accordingly very easily happen in the case, for instance, in which the torsional vibrations are avoided by an alteration of the numbers of revolutions, that vertical vibrations make their appearance, and *vice versâ*.

In the foregoing I have avoided all theoretical mathematical investigations, since they are of little or no value in actual practice, and do not provide us with any serviceable means for the removal of the vibrations. What I have said here can only be regarded as a short abstract of the most important questions which have to be dealt with in connection with the vibration phenomena. Were a treatment of the whole question to be attempted, it would probably occupy ten times as much space as the present paper.

CORROSION OF RAILS IN TUNNELS.—The corrosion of steel rails in different localities on a railway is an interesting and important subject, bearing directly as it does on road expenses. Some particulars given in the *Engineering Record* of the wasting of steel rails in the tunnel at Land Patch, Pa., on the Baltimore and Ohio Railroad, U.S.A., which is 4775 yards long, and which is operated with double-track traffic on a single-track line, show that the dampness and tunnel gases greatly reduce the life of the rails. Plain Bessemer rails have a life of about eighteen months, and the deterioration proceeds in the flaking of the scale from the rail until the edges of the base become quite sharp, and the rail has to be removed. At the last renewal chrome-alloy rails were substituted for Bessemer rails, and have now been in service for nearly three years. Not only have these chrome-alloy rails been found to resist corrosion much better than the Bessemer rails, but they also show fewer breakages, the number being less than one-fourth of those in the plain rails.

THE STABILITY OF AEROPLANES.—In a treatise recently published, M. G. de Bothezat shows mathematically that the lateral stability of an aeroplane is essentially unstable. When disturbed there is no force or couple brought into action which will automatically restore the original *régime*, and this conclusion holds whatever the form, dimensions, and disposition of the apparatus. To ensure lateral stability, it is necessary, he states, to employ positive corrections, which in practice are effected by the use of *ailerons* of different types, or by warping the wing surfaces. To the latter arrangement he objects, as involving the use of flexible wing surfaces, which may be "fatigued," and have their reserve of strength destroyed by repeated warpings. On the other hand, automatic longitudinal stability is possible without altering the form of the sustaining or guiding surfaces. The original Wright method of securing longitudinal stability is, he states, so to arrange matters that the thrust of the screw passes above the centre of gravity of the machine. With this arrangement a restoring couple comes into play at every longitudinal perturbation, but the method is, he thinks, less advantageous than the use of a rear tail, which, he holds, should be independent of the surface used for guiding the machine up or down. Neither method, however, suffices to secure automatic stability in gusty weather, and the mathematical investigation of the problem leads to the conclusion that this defect is unavoidable. Two classes of perturbation are always, and of necessity, damped out slowly, so there is always a chance with flights made in any but still air that a new perturbation may arise before the effects of a previous one are extinguished, and safety must then depend on an alteration in the trim of the machine.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

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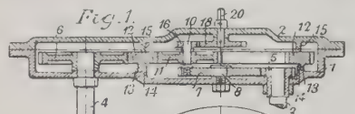
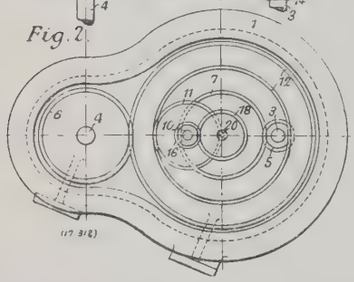
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

SHIPS AND NAUTICAL APPLIANCES.

17,312/10. Chadburn's (Ship) Telegraph Company, Limited, and A. J. Grant, Bootle. Speed Indicators. [2 *Figs.*] July 21, 1910.—This invention has reference to speed indicators of the type wherein the mean speed of two revolving shafts is indicated, say, the two driven propeller shafts of navigable vessels, where it is desired to keep the mean speed of the two shafts the same, or where it is desirable that the same total number of revolutions of the shafts should be made in any given period of time. According to this invention, the train of wheels between the shafts which transmit motion to the apparatus and the indicating spindle or axis, are of the spur type and arranged in parallel frames; and the two motions are transmitted from the two shafts to a large wheel, which is toothed externally to be geared up directly with the one shaft, and toothed internally to mesh with a "floating" wheel, which is carried on an axis adapted to be rotated relatively to or about the centre of the said large wheel; and the rotation of this wheel about its revolving axis or spindle is transmitted through gearing to the indicator spindle or axis. The spur-wheels are disposed in a casing consisting of a body 1 and a removable cover 2 into which the two-motion transmission shafts 3 and 4 lead. The toothed wheel 5 on the shaft 3 is smaller than the toothed wheel 6 on the other shaft 4, and the wheel 5 drives a larger toothed wheel 7 mounted on the fixed spindle 8, and carrying a spindle 10, which has loosely mounted upon it the "floating" toothed wheel 11. This wheel gears with the teeth on the inner edge of a relatively large annular wheel 12, while the wheel 6 on the shaft 4 gears with the external teeth on the periphery of this annular wheel.

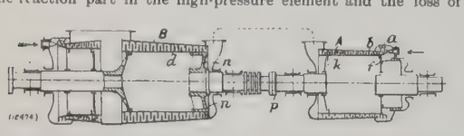




If the mean speed is to be recorded, the wheels 5 and 7 will be in ratio as one to four—that is, if there is no other gearing existing between the shafts of which the speed is to be recorded and the shafts 3 and 4. In the drawings, the wheels 5 and 7 are shown in a different ratio to that of one to four, and therefore if the mean speed is to be recorded there will be employed in connection with one or both of the shafts 3 and 4 gearing for suitably adjusting the speed transmitted thereto. The annular toothed wheel 12 has a flange 13 on its under side, which rests on a seat on the casing 1 outside a guide-flange or ring 14, which constitutes its bearing, it being held on the upper side by a depending ring 15 on the inside of the cover 2. On the spindle 10, carried by, and revolving with, the toothed wheel 7, is a small pinion 16, which is fixed to the wheel 11, and revolves with it on the spindle 10, and this pinion 16 gears with a larger toothed wheel 18 fixed on a spindle 20, mounted and revolving on the casing-cover 2. It may be assumed that the two shafts 3 and 4 will be geared up from the engine-shafts so as to revolve at convenient and required rates. In such a case, as in that shown in the drawings, it will be convenient if the spur-wheel 6, driven by the shaft 4, be half the diameter of the pitch line of the teeth of the periphery of the annular wheel 12, and the wheels connected with the pointer or indicator-spindle 20 may also be, as in the case shown, in the ratio of one to two, the wheel 18 on the indicator-spindle 20 being twice the size of the wheel 16. By the above apparatus and its gearing the speed indicated by the indicating pointer and moved by the spindle 20 will be the mean speed of the two shafts which it is desired to indicate. (*Sealed August* 2, 1911.)

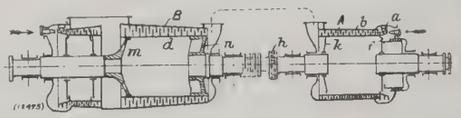
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

12,474/10. C. A. Parsons, Newcastle-on-Tyne. Turbines. [2 *Figs.*] May 23, 1910.—In an elastic-fluid-operated turbine of the axial-flow type divided up into two elements which are balanced according to the arrangement disclosed by Patent No. 22,196 of 1903, an impulse stage is provided in front of the reaction part in the high-pressure element and the loss of



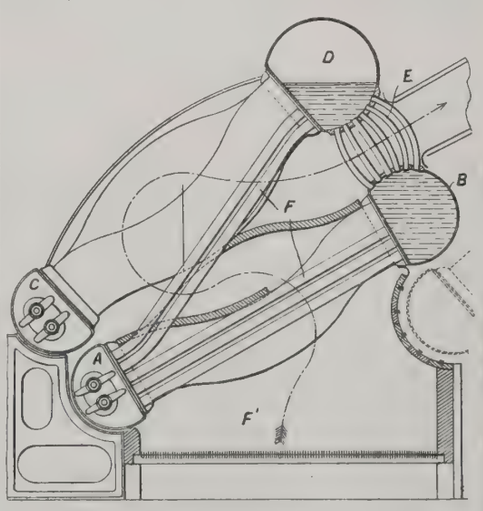
axial thrust due to the use of the impulse stage is compensated for by an additional balancing surface placed at the inlet to the high-pressure reaction part and subjected to the fluid pressure in the impulse stage. The high-pressure turbine element A is connected by a shaft coupling p to the low-pressure element B, the elements A, B being connected in series. The ends of the rotors of the two reaction-turbine parts b and d are provided at their adjacent ends with balancing surfaces k and n which are equal in area. These balancing surfaces are placed in, or connected to, the passage through which the working fluid passes from one element to the other, and are, therefore, subjected to the same pressure which causes equal thrusts in opposite directions, these thrusts therefore neutralising one another. In order to allow of a greater range of fluid pressure being possible with economy and exact balancing, the reaction part b of the high-pressure element A is preceded by an impulse or action stage a having a variable number of expansion nozzles. Since there is practically no axial thrust in the impulse stage a capable of being utilised to balance the propeller thrust, and the thrust in the reaction part b has also been considerably diminished, it is necessary to provide an additional balancing surface. This additional balancing surface f is preferably placed at the end of the rotor of the reaction part b adjacent to the impulse stage a, and is subjected to the pressure of the working fluid in the impulse stage a. The balancing surface f thus arranged may be of a relatively small area, and advantageously dispenses with the use of a dummy piston and its rotary packing, since the force of the fluid pressure acting on the surface f together with the thrust in the reaction parts b and d now completely balances the propeller thrust. The provision of a balancing surface in the high-pressure element as well as in the low pressure element allows of balancing the propeller thrust under widely varying loads, while the utilisation of the front end of the high-pressure reaction turbine rotor dispenses with the use of a dummy piston. (*Sealed August* 2, 1911.)

12,475/10. C. A. Parsons, Newcastle-on-Tyne. Turbines. [2 *Figs.*] May 23, 1910.—In an elastic-fluid turbine according to the specification of Patent No. 22,196 of 1903, in which the two turbine elements are connected by a flexible coupling adapted to allow the turbine shafts to move longitudinally relatively to one another, independent balancing of the high-pressure element is obtained by providing an impulse stage in front of the reaction part thereof, and a balancing surface subjected to the fluid pressure in the impulse stage, and formed on the inlet end of the rotor of the succeeding reaction part. One turbine A has a reaction part b, preceded by an impulse stage a, while the other turbine B is purely of the reaction type. The two reaction parts b and d of the turbines A and B are placed in separate casings, while the shafts are connected together by a flexible coupling h, adapted to allow the shafts to move longitudinally relatively to one another. As before, the adjacent ends k and n of the two rotors of the parts b and d are of the same area, and the turbines being in series with one another, these end surfaces are subjected to the same fluid pressure. Owing, however, to the flexible connection h between the two turbines, each turbine is now independent of the other as regards balancing; and further, on account of the impulse stage in



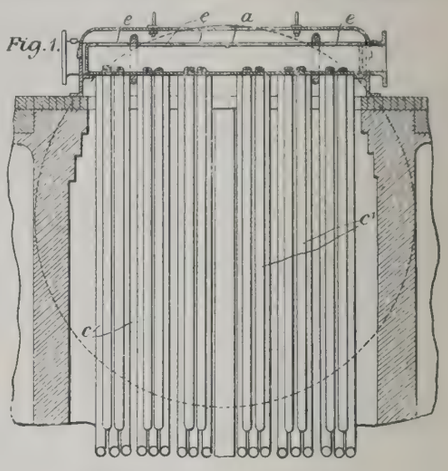
the turbine A, an additional balancing surface is now required, since the impulse stage a produces practically no steam thrust which could be utilised to balance a part of the propeller thrust. This additional balancing surface is placed conveniently at the exhaust end of the impulse stage a, and forms the end of the rotor for the succeeding reaction stages b, so that the surface f will be subjected to the higher pressure steam. The area of this surface f is arranged so that the thrust on the surface f, together with the steam thrust on the reaction stage b, will exactly balance the thrust in the opposite direction on the surface k at the end of the reaction stage rotor. The turbine B is then independently balanced by arranging the area of the surface n at the steam inlet end of the rotor to balance the propeller-thrust, and if the surface n is insufficient, the inner surface therefore is subjected to the exhaust pressure of the turbine by admitting the exhaust into the interior of the rotor d by openings m at the exhaust end thereof. It will be seen that the provision of a balancing surface in the high-pressure part, as well as in the low-pressure part, allows of balancing the propeller thrust under widely varying loads, while the utilisation of the front end of the rotor in the low-pressure part for balancing purposes enables a complete dummy piston and its necessary packings to be dispensed with. (*Sealed August* 2, 1911.)

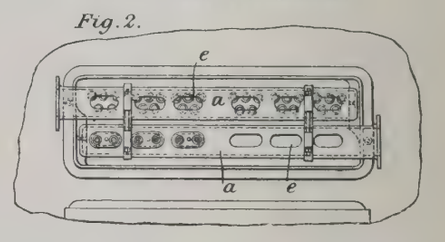
10,412/10. C. M. Shaw, Yoker. Steam-Generators. [3 *Figs.*] April 28, 1910.—In this generator all the water-tubes are of the same length and bent to the same shape. The steam-generator is made up of sections or elements, each consisting of a group of water-tubes expanded at one end into a water-chamber, and at the other end into a steam and water-drum.



The drawing shows a steam-generator made up of two sections. The lower section A, B is inclined at about 30 deg. to the horizontal, and it lies right over the furnace F1. The upper section C, D is inclined at about 45 deg., and it lies over the lower section. The water-chambers A and C are close together and parallel to one another, but the steam and water-chambers B and D are some distance apart, leaving a space through which the products of combustion pass to the uptake. The steam and water-drums are connected by numerous tubes E. These tubes form additional heating surface. The steam and water-drums are connected to the water-chambers by large pipes F situated outside the casing of the steam-generator. (*Accepted May* 10, 1911.)

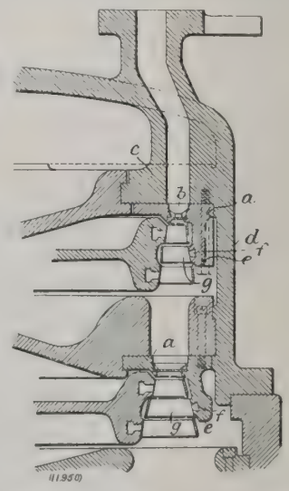
19,348/10. Galloways, Limited, and H. Pilling, Manchester. Superheaters. [3 *Figs.*] August 17, 1910.—A superheater for steam boilers, according to this invention, comprises two steel tubular headers connected by a bank, or banks of U-shaped steel tubes, to which access is obtained by means of a series of elongated holes opposite the ends of the steam-tubes, the holes being normally closed by means of internal lids adapted to pass through the holes. The two steel tubular headers a, a are ranged in rear of, and at right angles to, the boiler, parallel with each other, and are connected with each other by two banks c, c^1 of steel tubes of elongated U-shape. The ends of the steam-tubes





may be bent so that they enter the headers radially, or substantially so, and in order to facilitate this disposition the limbs of the tubes of the inner bank c^1 may be arranged to converge slightly towards their ends. The upper side of each header a has an elongated hole e opposite the ends of the steam tubes. The holes have parallel sides and semicircular ends, and they are normally closed by means of internal lids of corresponding shape, the edges of which are suitably bevelled or coned to make a tight joint with the internal surfaces around the edges of the holes e. These lids are drawn firmly into their seatings, and there secured by means of bolts and caps, or bridge-pieces, which straddle the holes e on the outside of the headers. (*Sealed July* 27, 1911.)

11,950/10. The Warwick Machinery Company (1908), Limited, London, and F. Samuelson, Rugby. Steam-Turbines. [1 *Fig.*] May 13, 1910.—This invention has particular reference to the method of securing the stationary or intermediate guide vanes or buckets within the casing of a turbine of the now well-known Curtis type. The invention consists in securing the intermediate guide vanes to an annular projection formed integral with, or secured to, the diaphragm between the stages, or on the plate in which the inlet nozzles are formed. A ring plate a, preferably made in sections, is provided in which the



inlet-supply nozzles b for the elastic fluid are formed. This plate is let into the face of the diaphragm c on the end of the casing d. Projecting from the face of this plate, near its periphery, is a cylindrical ring e, the depth of which, measuring from the outer face to the face of the plate, slightly exceeds the distance from the face of the plate to the outer edge of the roots of the last row of intermediate vanes. The inner side of this cylindrical ring is grooved at f to receive the roots of the stationary vanes g, which may be secured in place in any well-known manner. (*Sealed July* 27, 1911.)

THE STRENGTH OF STEELS IN COMPOUND STRESS, AND ENDURANCE UNDER REPETITION OF STRESS.

By L. B. TURNER, B.A.

(*Concluded from page* 250.)

ENDURANCE AND THE ELASTIC LIMIT. HYSTERESIS.

WÖHLER'S researches (confirmed by later experiments) established that :—

1. Steel and iron will fracture under varying stresses which never exceed, nor even nearly attain to, the ultimate strength of the material.

2. If the extremes of stress are kept sufficiently small, the material will have an indefinitely long life.

3. Within fairly wide limits beyond the simply alternating stress (equal positive and negative values), the endurance depends almost entirely on the range of the varying stress, and not on its extreme value.

These results were of immense practical importance, but they cast no light on the manner of failure under repeated stress ; no relation was found between the endurance and other better-known properties of the material ; nothing in the nature of an explanation was forthcoming.

Bauschinger's experiments on repeated tensions (zero to a maximum) included tests of the primitive elastic limit and ultimate strength of the material, and thus marked a large advance. He found nothing very interesting in connection with the ultimate strength, but he did find that the elastic limit changed during the repetitions of the stress, rising to a higher value than the limiting endurance stress. In all cases where the load was small enough to allow the specimen to withstand a large number of repetitions, the elastic limit rose above the primitive value. If it rose above the stress applied in the machine, the specimen had a long, maybe indefinitely long, life ; whereas if the elastic limit remained below the applied stress, the specimen soon broke. It was this discovery which doubtless led Bauschinger to make his later researches on the variation of the elastic limit, and thereby to enunciate his theory of the "natural" elastic range, which affords the best insight yet gained into the nature of failure by fatigue.

Bauschinger subjected bars of iron and steel to static applications of pull and push, with varying intervals between loadings. He found that an attempt to raise the tension elastic limit by overstraining lowered it in compression, and *vice versâ*. After a succession of loads just exceeding the elastic limits in each direction, he found the elastic limits to have settled down to approximately steady values, and the distance between these he terms the "natural" elastic range of the material. The significance of this range so found was that it approximately equalled the limiting endurance range for the same or similar material, as found by Wöhler's and Bauschinger's experiments.

This conception of a natural elastic range, constant in magnitude and equal to the limiting endurance range, but, like the latter, variable about the point of zero stress, is a very great help towards the understanding of the fatigue problem. The discrepancy between the primitive and the natural elastic limits is explained on Bauschinger's hypothesis as due to the process of overstraining undergone in the manufacture, by which the elastic limit has been raised in one direction at the cost of a lowering in the opposite direction.

Now the theory of endurance just set forth is doubly important as being some sort of theoretical explanation of the phenomena, and as suggesting a practical means of discovering, without a laborious set of tests under varying stress, what is the limiting safe varying stress to which a material may be subjected. Yet although "Professor Bauschinger's conclusions rest on extremely delicate measurements of the behaviour of bars in ordinary testing, and are not likely to be generally recognised without further and independent investigation,"* it is regrettable that the experiments of Stanton and Bairstow, and of the present writer, are alone in paying any attention to the elastic limit of the materials tested.

Many laborious static reverse-bending and reverse-torsion tests were made by the present writer on the §-in. tube (torsion) and the mild and nickel steels (torsion and bending), in the attempt to arrive at the natural elastic ranges. Frequent resort was made to boiling the specimens between successive loadings, in the hope that thereby the destructive effect on the elasticity of the former overstrain would be abolished without long periods of rest. But the results have been disappointing ; the limits lacked uniformity and were very uncertain ; so that it has been considered unwise to attempt to draw any conclusions from them. Bauschinger's remain the only experiments of this nature on record.

Now if Bauschinger's explanation of the "unnaturally" high primitive elastic limit in a tension test be correct—if, *i.e.*, it is due to overstrain in the process of manufacture—annealing the specimen would reduce the elastic limit to the natural value. Further, in the case of torsion of a rod or tube, the elastic aeolotropy induced in the rolling or drawing can produce no inequality in its resistance to torque in the two directions, so that the primitive elastic limit in torsion could not be an artificially raised one. Both these implications of Bauschinger's theory are to some extent contradicted by the present experiments. The maximum endurance limit of the annealed specimens is below the primitive elastic limit both for bending and for torsion, although not so markedly for the latter as for the former (see Table IX., page 247 *ante*). In the discussion of Messrs. Stanton and Bairstow's paper, also, the authors gave a few figures relating to the effect of annealing, whence Table X. has been prepared :—

TABLE X.—*Stanton and Bairstow.*
Units : inch, ton.

Material.	Percentage of C.	Primitive Elastic Limit.	Endurance Limit.	Ratio.
Swedish Bessemer steel No. 2	0.45	25.0	15.2	0.60
Same annealed at 1000 deg. Cent.	..	19.6	14.0	0.72
Swedish Bessemer steel No. 1	0.17	21.4	13.4	0.62
Same annealed	..	11.6	9.2	0.80

This table shows that annealing increased the ratio of the limiting endurance limit to the primitive elastic limit, but that it did not rise nearly to unity.

Referring again to the author's results (Table IX.), if we could overlook the discrepancies between the shears for endurance and elastic limit in the case of the nickel-steel,* Bauschinger's case would be strengthened ; for in the other three materials the shears for endurance and elastic limit are nearly equal, and the tension discrepancies may conceivably be due to insufficient annealing. Except the mild steel, which was annealed by the makers, and, to judge from the scale, had been kept at the high temperature for a considerable time, the specimens were not annealed for a long time ; and in the mild steel, be it noted, the tensions for endurance and elastic limit are nearly equal.

Thus, as far as these experiments go, we may perhaps hold to the Bauschinger account of the high primitive elastic limit under pull as approximately true ; but, if so, it will be necessary to suppose that remarkably lengthy annealing is required to wipe out the effects of overstrain in the manufacture.

Turning now to the other experimental method employed by Bauschinger to determine the natural elastic limit—viz., by a static test after the specimen had long been subjected to varying stress in the machine, again his results are to some extent, but by no means entirely, confirmed by the later experiments. In Table XI. are the figures taken from Bauschinger's endurance tests on bars subjected to tension (zero to upper limit),† all those, and only those, being tabulated where the bar stood five million or more repetitions of the stress.

With two exceptions, in each case the elastic limit acquired during the test exceeds the load applied. Further, the acquired elastic limit for a life of more than 5 million repetitions is a little higher than the greatest load which may be applied. Hence, according to Bauschinger's figures, when fracture is never going to occur (or only after 5 million), the work done on the specimen is elastic only.

* This discrepancy ought, perhaps, to be somewhat smaller. For the three tests of the elastic limit in simple shear, of which the figure in the table is the mean, gave one value considerably higher than the other two. The three were 44,500, 39,700, and 38,100 lb. per sq. in.

† Unwin, page 353, Table XI.

TABLE XI.—(*Bauschinger*).
Units : inch, ton.

Material.	Elastic Limit. Primitive.	Elastic Limit. Acquired.	Load Applied.
Wrought-iron plate	6.84	12.3	7.1
		13.2	9.85
		14.4	13.1
Mild-steel plate	15.6	19.4	16.0
		20.0	16.0
		16.4	16.0
Bar iron	11.8	21.4	13.2
		10.7	16.4
	14.8	16.3	13.8
		18.6	17.2
Thomas steel axle	17.6	20.4	16.3
		20.8	19.7
Thomas steel rail	19.0	24.0	16.4
		17.6	19.7
Mild-steel boiler-plate ..	17.6	18.0	16.4

The later tests on the same point are given in Table XII.

TABLE XII.
Units : inch, pound.

	Specimen.	Elastic Limit. Primitive.	Elastic Limit. Acquired.	Stresses Applied. Maximum.	Stresses Applied. Minimum.	Endurance Stresses.† Upper	Endurance Stresses.† Lower.
Stanton and Bairstow. Stresses are tensions	A. Sw. Bess. Steel, No. 3.	61,800	36,600*	40,700	..	41,000	
	B. Sw. Bess. Steel, No. 2.	55,900	32,500*	37,800	..	39,600	
	C. Do.	55,900	28,400*	..	−27,100	..	−28,300
Author. Stresses are shears	3. Nickel steel.	44,500	32,700	±33,000		±35,000	
	8. Do.	39,700	0	±37,000		±35,000	

* These elastic limits are independently obtained by the writer by plotting the table of extensometer readings. They differ somewhat from the figures given in the text of the original paper, and are believed to be more accurate.

† *i.e.*, with the ratio of positive to negative stress adopted in the applied stresses.

The last test in this table merely shows that stress above the limiting endurance stress reduces the elastic limit to zero. The graph was curved from the beginning. Neglecting this test, in each case the load applied was slightly lower than the endurance limit—*i.e.*, the greatest load which might be applied without ever producing fracture. The specimens, therefore, would never have broken. And yet, in three of the four cases, the elastic limit has dropped from the primitive value to one which is less than the applied stress. For specimen C (Stanton and Bairstow) the acquired elastic limit is just beyond the stress applied ; but taking B and C together—for they supply the positive and negative parts of one complete test—we have :—

Acquired elastic range = 32,500 + 28,400 = 60,900
Applied stress range = 37,800 + 27,100 = 64,900
Endurance range = 39,600 + 28,300 = 67,900

Thus both Stanton and Bairstow, and the author, have found, for different steels, that a specimen will endure indefinite repetition of a stress-strain cycle which is not entirely elastic.*

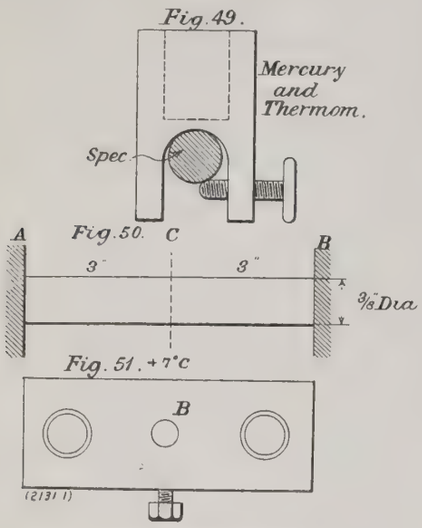
This result is surprising. The acceptable rationality of Bauschinger's hypothesis lies chiefly in its making the endurance range just that limiting range in which none of the work of deformation remains on removal of the stress. The reason for the acquired elastic limit being found by Bau-

* "The Testing of Materials," by W. C. Unwin, page 360.

* This fact is not explicitly mentioned by Messrs. Stanton and Bairstow ; indeed, it only becomes apparent in the complete test (B and C together) when their elastic limit figures are revised. The figures in the text make the elastic limit range and the applied stress range exactly equal ; and seeing that the elastic limits are only called, and only could be, approximate, it seems that the localisation of these points from the rather sparse stress-strain observations must have been influenced by the preconception that the acquired elastic range was to equal, or, at any rate, not to exceed, the applied stress range. In publishing the extensometer readings, the authors of the paper very properly furnish opportunity for revising their elastic limit figures, should occasion arise for so doing.

schinger to be just above the applied stress, and by Stanton and Bairstow and the author to be just below, cannot be stated with any certainty. The explanation may be that his experiments were with stress varying from zero to an upper limit, while in the others the stress underwent reversal of sign; or perhaps the difference lies in the nature of the materials; or, again, in the comparatively low speed of Bauschinger's tests. One or both of the two last suggestions must also account for the much greater number of repetitions in the earlier larger in the torsion than in the bending specimens, which was to be expected, seeing that the torque was uniform along a specimen, whereas the bending moment was a maximum at only one section. The hysteresis is shown to occur sensibly not only where the stress is greatest—viz., at the skin of the ground section—by the fact that the torsion specimens, when they were only moderately hot, were hottest in the middle, and not at the ground section near one end. On the other hand, when the load was very great, so that the life was short, the ground section tended to be hottest, thus showing that with large strains, much exceeding the elastic-limit strain, the hysteresis work is disproportionately large. The work done in such a case is mostly while the material is undergoing plastic strain, a condition with which we are made familiar by ordinary static tests carried well beyond the elastic limit. Table XIII. gives an idea of the amount of heating which took place.

Of these specimens, No. 12 deserves special attention. In this—a torsion specimen—the rise



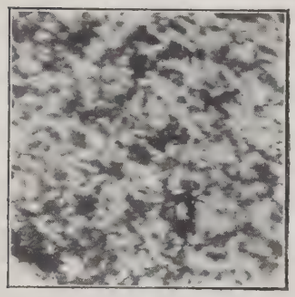


Fig. 53. Thin Drawn Tube.

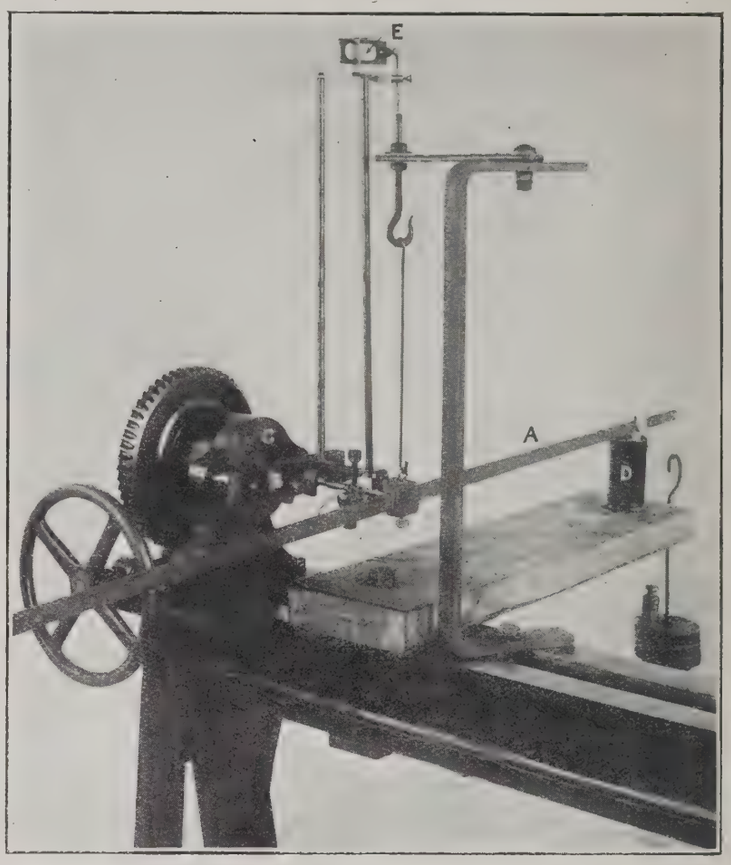


Fig. 52.

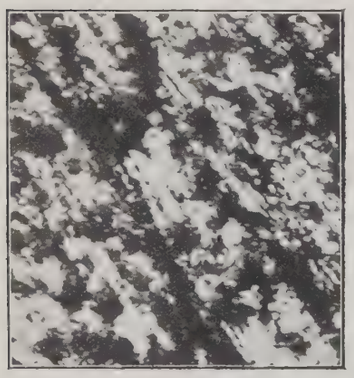


Fig. 54. Thick Drawn Tube.

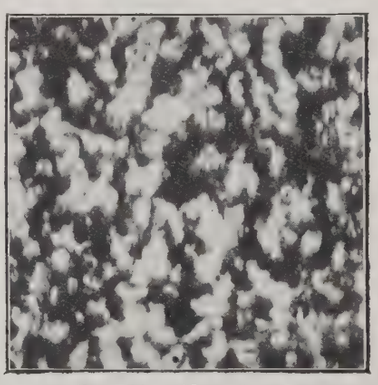


Fig. 55. Mild Steel.

Fig. 56. Tool Steel.

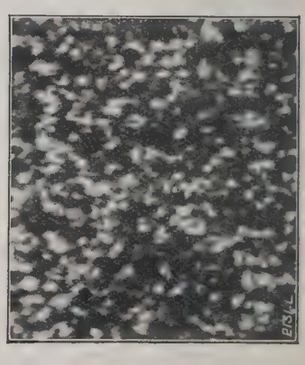


Fig. 57. Nickel Steel.

The Steels are Annealed, as Used. Magnification, 250 Diameters.

experiments before the asymptote to the endurance curve is sensibly reached.

However this may be, we have seen from actual stress-strain measurements that imperfect resilience and indefinitely prolonged endurance are compatible. It will be interesting to inquire how much of the work of deformation is not returned on removal of the deforming load. The work which remains in the specimen exhibits itself in a rise of temperature, and this rise has been observed in the present experiments. Rough measurements were made by means of a sensitive thermometer, which was immersed in the mercury contained in a hole drilled in a small brass block clamped to the specimen. Fig. 49 will make this plain.

The tool-steel specimens suffered much the most pronounced rise in temperature, and on these only were measurements made. The rise was, in general,

Table XIII.—*Temperature Rise of Tool-Steel Specimens Undergoing Alternating Strain.*

(Unless otherwise stated, the temperature was measured at the ground section of the specimen.)

Specimen. Bending.	Specimen. Torsion.	Rise of Temperature (Cent.)	Revolutions to Fracture in 1000's.
2	7	Sensibly warm to the fingers. (Probably in the neighbourhood of 5 deg.)	297
2	8	Sensibly warm to the fingers. (Probably in the neighbourhood of 5 deg.)	7
16	..	2½ deg.	568*
27	..	4½ deg.	166
28	..	6½ deg	29
..	10	7 deg at middle	240
..	12	7 deg at middle	834*
..	14	11½ deg.; 11 deg. at middle	186
..	23	3 deg. at middle	113
..	24	26 deg. (ground section hottest)	22

* Signifies unbroken.

of temperature in the middle amounted to some 7 deg. Cent., and the specimen was removed from the machine unbroken after more than 1½ million reversals of stress approximately equal to the limiting endurance stress. It will be interesting to obtain some notion of the amount of the hysteresis this involves.

Let us take, as an approximation to the actual case, that of a rod 6 in. long and ⅜ in. in diameter, whose middle is 7 deg. Cent. hotter than the ends, and which is subjected to the same alternating torque as was specimen 12. Taking the thermal conductivity of the material as 0.2 C.G.S. Cent.,* the amount of heat passing per second by conduction from C to A and B is found to be

0.037 gm. deg. Cent. = 0.12 ft.-lb.

* This value is given for iron in Lupton's tables.

If we take the temperature gradient as uniform along the bar—viz., about 0.92 deg. Cent. per centimetre—and the emissivity of the surface as, say, half that of a black body,* the radiation loss per second works out to be

0.052 ft.-lb.

Adding these two amounts together, and assuming that convection and conduction through the atmosphere are negligible, we have, as the total hysteresis work on the specimen,

0.17 ft.-lb. per second.

If we suppose that all the hysteresis occurs in the outer layer of the specimen of depth, say, $\frac{\text{radius}}{10}$; *i.e.*, in the material where the maximum stress lies between the greatest value in the specimen (26,000) and 10 per cent. less (23,400), we find the amount of twisting work put in to this portion of the material is

0.29 ft.-lb. per twist (*i.e.*, per ½ cycle) or 2.4 ft.-lb. per sec. (∵ 250 revolutions per min.)

Thus the hysteresis amounts to some

$$\frac{0.17}{2.4}, \text{ or 7 per cent.}$$

The writer also made some static reverse-torque tests on the tool-steel, expecting that, although the ordinary determinations of the elastic limit had shown a straight-line graph (without which there would have been no elastic range at all, in our sense of the term), yet on reversal of load some hysteresis effect would appear. For there was the indisputable fact that the specimen became hot in the alternating machine. The apparatus used was devised to fulfil the three conditions:—(1) convenient reversal of torque; (2) absence of all bending moment from the specimen; (3) absence of all friction which would render the torque on the specimen indeterminate. It was entirely satisfactory in these respects, and is described in Appendix I.

The specimen, freshly annealed, was turned down to 0.350 in. in diameter, and the twist was measured over a 3-in. length. There was no trace of hysteresis for a cycle between the limits ± 214,000 lb. per square inch, but about 2 per cent. between the limits ± 32,600 lb. per square inch. The graph enclosed an area owing to the up and down curves, which were sensibly straight, having slightly different slopes.

It is thus made clear that the large hysteresis effect noticed under alternating stress only develops, or at least augments, with the continued action of the alternating stress. It is not to be found in the fresh specimen. Table XII. has shown how the elastic limit falls under the action of the varying stress, and so it, too, points to the development of the hysteresis during the subjection to the varying stress. The fact of this development is sufficient, without resorting to any calculations, to show that the effect is not that by which Kelvin accounted for the damping of his torsional vibrators—viz., by the change of temperature produced by change of stress, and depending on the rate of the change, leading to irreversible interchanges of heat.†

A small amount of static hysteresis was observed by Professor Ewing‡ in various metals under cycles of tension between positive limits, and within the elastic range as ordinarily conceived. Unfortunately, he employed wires of his materials (iron, mild steel, high-carbon steel, brass and copper), and this is a form of specimen in which the effects of overstraining in the manufacture are particularly noticeable. (In the case of the mild steel the wire was annealed, but was overstretched before testing.) But the effect of the overstraining could hardly lessen the hysteresis, and in these experiments it was always small. In the iron, the extreme tensions being 9860 lb. and 44,500 lb. per square inch, for a tension midway between the extremes the difference of the stretch reading on the up and down curves was about 0.33 per cent. of the total change of stretch. The corresponding figures for the mild steel are 0.34 per cent. for cycles between 13,000 lb. and 37,500 lb. per square inch; and for the high-carbon steel, 1.16 per cent. for cycles between 22,100 lb. and 63,800 lb. per square inch. These experiments confirm the conclusion that the hysteresis appears or grows during the repetitions of stress.

It is noteworthy that, in the author's experiments, the tool-steel exhibited the phenomenon much more noticeably than did the other materials. The nickel-steel became less, though sensibly, warm to the touch with stress just below the limiting endurance stress; while the mild steel was not observed to rise in temperature at all; but no thermometric readings were taken with these steels. It is interesting to find that this marked hysteretic character of the high-carbon steel was also observed by Ewing in his static experiments just referred to. It may or may not be fortuitous that the ratio

$$\frac{\text{limiting endurance}}{\text{elastic limit}}$$

tension in the present experiments is exceptionally low for the tool-steel and the nickel-steel (see Table IX.).

That there may be hysteresis with unlimited endurance, and so large a quantity as we have been observing, even with stress considerably below the limiting endurance stress, is surprising. We are, of course, familiar with a somewhat analogous phenomenon in magnetic hysteresis, in which the maintenance of the magnetic character of the iron seems independent of the range and the number of repetitions of the cycle.* But the two cases are probably not quite parallel. For with small ranges there is very little or no mechanical hysteresis in the fresh material; whereas in the very first magnetic cycle the B—H curve encloses an area comparable with the steady value to which it rapidly tends. With the exception of the present, more or less incidental, observations, experiments on this development of mechanical hysteresis seem to be entirely lacking. A research devoted specially to the subject might well render important contribution to the further understanding of the fatigue phenomenon.

APPENDIX I.

FRICTIONLESS, PURE TORQUE APPARATUS.

For the torsion tests on the small solid rods (about 0.350 in. in diameter) it was necessary to employ some special device to avoid bending moment in the specimen. The arrangement of a torque lever, with lathe-centre supports, as used for the 1-in. tubes, while satisfactory for them, would have produced longitudinal tension of disturbing amount in the small solid specimens.

For the hysteresis test it was necessary to avoid all friction, and to apply the torque conveniently in both directions.

The simple and efficient arrangement shown in Fig. 52 was therefore adopted. The ends of the specimen are fitted into the double-ended torque lever A, and into the centre of a bar of iron B (Fig. 51). Holes in the ends of this bar, countersunk on both sides, slip loosely over the pair of pins projecting from the face of the torsion headstock C. The torque lever is itself suspended by a link vertically over the axis of the specimen, so that the reaction between the specimen and the lever is a pure couple.

The friction between the link and the eyelet on the torque lever is quite negligible; so small was it that an oil dashpot D was absolutely necessary to damp out the vibrations set up on touching the lever.

For tests on short specimens, the sensitiveness of the twist readings was increased by replacing the original paper scale and scratched glass-plate on the vertical twist arms by a transparent glass scale E (graduated in $\frac{1}{100}$ of an inch); and parallactic error was avoided by substituting a narrow strip of thin spring steel (about ⅛ in. wide) for the former scratch on the glass plate.* The strip, set edgewise, was adjusted to be very close to the scale. A piece of white paper behind the latter, and a convex lens supported in front, enabled deflections to be read to within 0.005 in.

When ⅝ in. tubes were tested with this apparatus, they were attached to the lever A and the bar B by means of their gun-metal ends.

APPENDIX II.

ANALYSES, MICROSTRUCTURES, AND TENSILE TESTS OF MATERIALS USED.

TABLE XIV.—*Analyses of Materials as Supplied by the Makers.*

Per Cent.

Name of steel	C.	N.	Mn.	Si.	S.	P.
Drawn tube (thick and thin) (Figs. 53 and 54)	0.15 – 0.30	0	0.40	trace	0.03*	
Mild (Firth's) (Fig. 55)	0.32	0	.5 – 0.7	0.115	0.04*	
Tool (Fig. 56)	1.25	0	0.35	0.12	0.02*	0.02*
Nickel (Hadfield's) Fig. 57	0.31	3.01	0.60			

* Outside figure.

TABLE XV.—*Tests to Destruction in the Testing-Machine.*

Pounds per square inch.

Steel.	Elastic Limit.	Ultimate Strength.	Elongation on 8 In.	Contraction of Area.
			per cent.	per cent.
Tube (thick)	34,300	55,200	24	63
Mild	42,300	61,400	29	69
Tool	67,700	107,000	9	39
Nickel	81,200	108,000	14	36

The steels were annealed, as used in the experiments. Except for the elastic limit, the figures refer to a single test. The yield-point was almost coincident with the elastic limit in every case.

THE STEAM-TURBINE.

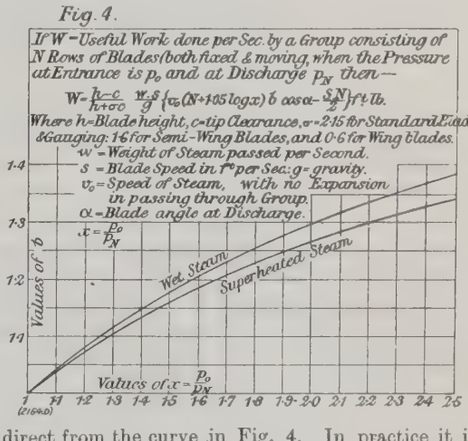
(*Continued from page 246.*)

THE velocity of flow, v_0, into a group being obtained from equation (1) *ante*, or from Table I. (page 246 *ante*), then W, the useful mechanical work done in the group per pound of steam passed per second, assuming no tip leakage, is given by the relation

$$W = \frac{s}{32.2} \cdot \left\{ r_0 (N + \tfrac{1}{2} \log_\epsilon \rho) b \cos a - \frac{N s}{2} \right\} \quad (2)$$

where s denotes the blade speed, N the number of rows of blades in the group, and ρ is the ratio $\frac{V_N}{V_0}$ of the specific volume of the steam at discharge from, to the specific volume of the steam at entrance into, the group, whilst a denotes the angle of discharge, and b a coefficient, which can be read

Fig. 4.


If W = Useful Work done per Sec. by a Group consisting of N Rows of Blades (both fixed & moving, when the Pressure at Entrance is p_0 and at Discharge p_N then—
$W = \frac{h-c}{h+c\sigma} \frac{w.s}{g} \{v_0(N+1.05 \log x) b \cos\alpha - \frac{s.N}{2}\}$ ft. lb.
Where h = Blade height, c = tip Clearance, σ = 2.15 for Standard Blades & Gauging: 1.6 for Semi-Wing Blades, and 0.6 for Wing Blades.
w = Weight of Steam passed per Second.
s = Blade Speed in ft. per Sec.: g = gravity.
v_0 = Speed of Steam, with no Expansion in passing through Group.
α = Blade angle at Discharge.
$x = \frac{p_0}{p_N}$
Wet Steam
Superheated Steam
Values of b
Values of $x = \frac{p_0}{p_N}$
1.4
1.3
1.2
1.1
1 (Orifice)
1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4 2.5

direct from the curve in Fig. 4. In practice it is sufficiently correct in the above equation to write 1.05 log x instead of $\frac{1}{2} \log_\epsilon \rho$, and, indeed, when N is a large number the whole logarithmic term may be omitted.

Taking standard blades set to one-third pitch, the formula given above simplifies to

$$W = \frac{s}{32.2} \cdot \left\{ 1.093\, r_0 (N + 0.16) - \frac{N s}{2} \right\}$$

for $x = 1.41$ and

$$W = \frac{s}{32.2} \left[1.056\, r_0 (N + 0.13) - \frac{N s}{2} \right]$$

for $x = 1.29$.

Suppose, for example, that s is fixed at 100 ft. per second, and $x = \frac{p_0}{p_N}$ is taken as 1.41, then from

* The loss of heat by radiation from a body at T_1 (Cent. absolute), enclosed by surroundings at T_2, is

$\sigma (T_1^4 - T_2^4)$ ergs per sq. cm. per sec.

For lampblack	... ...	$\sigma = 5.32 \times 10^{-5}$
Tarnished lead	... ...	2.39
Clean lead	... ...	1.01
Polished iron	... ...	0.80

(See Poynting and Thomson, "Heat," pages 226 and 250.)

In our present case of unpolished rolled steel rod, σ has been taken as 2.7×10^{-5}; and atmospheric temperature as 288 deg. Cent. absolute. The energy radiated per second is then found by evaluating the integral

$$2 \int_0^{7.6} \sigma [(295 - 0.92x)^4 - 288^4] \times 0.95 \pi d x,$$

giving the result stated above.

† See J. A. Ewing, "Strength of Materials," page 58.

‡ "On Hysteresis in the Relation of Strain to Stress" (British Association Report, 1889).

* This has been demonstrated by Professor Ewing. See his "Magnetic Induction in Iron and other Metals." Third edition, page 193.

the above table it will be seen that the velocity of flow into the group is about 222 ft. per second if N is taken as 24. Hence the work done per pound of steam passed through the group per second will be

$$\frac{100}{32.2} \cdot \left[1.093 \times 222\,(24 + 0.16) - \frac{24}{2} \times 100\right]$$

= 14.490 ft.-lb. per second, or 26.354 horse-power per pound of steam passed per second.

Very commonly in marine practice the complete turbine consists of twelve groups, so that if each were equally effective, the total output would be $12 \times 26.354 = 316.25$ horse-power per pound of steam passed. The final pressure would, on the assumption of equality of conditions, be

$$p_0 \div (1.41)^{12} = \frac{p_0}{64},$$

so that if p_0, the pressure before the first row of guide-blades, was 150 lb. absolute, the final pressure would be 2.34 lb. absolute, equivalent to a vacuum of about 25.2 in. In actual practice the vacuum is, of course, always higher than this.

On the other hand, successive groups do not work under the same conditions. The product $p_0 V_0$ tends to diminish from group to group, though, as already stated, this tendency is, in certain cases, more or less corrected by the fact that a greater weight of steam passes the low-pressure blading, owing to the circumstance that the high-pressure dummy leakage may be much greater than that at the low-pressure dummy. Further, the ratio of blade-speed to steam-speed increases from group to group, and this fact improves the efficiency of the later groups. These different factors, speaking roughly, more or less compensate for each other.

It was, of course, presumed in the foregoing that there was no tip leakage, and this factor tends to increase the consumption. This, however, is in its turn compensated for by the fact that the vacuum is always higher than the 25.2 in., which would have been its value if all the groups operated under equal conditions. For this reason there is always some one degree of vacuum at which the total output of the turbine is equal to the work done by the first group multiplied by the total number of groups. If the tip clearance in the first group is 3.5 per cent. of the blade height, then it appears that this condition will be fulfilled if the condenser pressure is equal to the absolute pressure before the first row of blades divided by 106. This may conveniently be called the "proportionate" back pressure. Thus with an initial pressure of 150 lb. absolute the required condition is that the "proportionate" back pressure shall be 1.413 lb. absolute, or 2.88 in. of mercury. It is, of course, assumed that tip-clearances throughout the turbine bear the usual proportion to that over the tips of the first group. Proceeding on this basis, the lay-out of a marine turbine becomes a very simple matter, the output and the consumption being easily estimated.

As already shown above, a group of 24 rows (with a blade speed of 100 ft. per second and a steam speed of 222 ft. per second) would, in the absence of tip clearance, develop 26.35 horse-power per lb. of steam passed through it. The effect of tip clearance is to increase the weight of steam passed per horse-power developed in the ratio $\frac{h - c}{h + \sigma c}$, h being the blade height, and c the clearance, whilst for standard blades at standard setting σ is found by direct experiment to be equal to 2.15. With c equal to 3.5 per cent. of h the work done in such a group will thus be $26.354 \times \frac{0.965}{1.075} = 26.354 \times 0.8977 = 23.66$ horse-power per lb. of steam passed.

To develop a total of, say, 8000 horse-power, the output of the first group should be $\frac{8000}{12} = 666.7$, and hence the weight which it is necessary to pass per second is $\frac{666.7}{23.66} = 28.2$ lb. If, then, the initial pressure be 175 lb. absolute, the "proportionate" back-pressure will be $\frac{175}{106} = 1.652$ lb. per square inch, which is equivalent to a vacuum of 26.64 in. If the actual vacuum is $27\frac{1}{2}$ in., then, since in this region the steam consumption diminishes 5 per cent. for each inch of vacuum, the steam actually needed through the blades will be $28.2\,(1 - 0.05 \times (27.5 - 26\,64)) = 26.9$ lb. per second.

Since steam at 175 lb. absolute has a specific volume of 2.602 cubic feet per pound, the volume passed per second will be 70 cub. ft., and hence the area necessary will be $\frac{70}{222} \times 144 = 45.4$ sq. in.

Experiment with standard blades gauged to one-third pitch shows that the angle of discharge may be taken as 18 deg. 20 min., so that, if there were no tip clearance, the steamway through the blades would be 0.3145 of the whole annulus between the drum and the rotor, hence the annular area needed in that case would be

$$45.4 \div 0.3145 = 144.2 \text{ sq. in.}$$

Now the effective annular area is equal to the $\pi\,(D + h)\,(h + \sigma c)$, where D denotes the drum diameter in inches, h the blade height, c the clearance, and σ the experimental coefficient, which, as already stated, is equal to 2.15. Since c was assumed to be 3.5 per cent. of h, this reduces to $\pi\,(D + h)\,h \times 1.075$, which is to be equal to 144.2 sq. in.

Thus, if either D or h is assumed, the value of the other is directly obtainable.

If the revolutions per minute (R.P.M.) of the screw are given, we have the blade speed

$$s = \frac{(D + h) \times \text{R.P.M.}}{229},$$

taking s as 100 and R.P.M. provisionally as 500 we get

$$100 = \frac{(D + h) \times 500}{229},$$

or

$$D + h = 46 \text{ in. nearly.}$$

But

$$\pi\,(D + h)\,h\,(1.075) = 144.2$$

$$\therefore h = \frac{144.2}{46 \times 1.075\,\pi} = 0.927 \text{ in.}$$

As it is best to use even figures for the blade heights, the revolutions may be adjusted and the blade speed lowered. For small changes in the blade speed the horse-power falls nearly proportionately. Hence, if we lower the revolutions in the ratio of 0.927 to 1, and increase the blade height correspondingly, the horse-power will be practically unaffected. The revolutions thus become 465 per minute, and the weight passed through the blades $26.9 \div 0.927 = 29$ lb. per second.

It is usual in such an installation for the turbine equipment to consist of one high-pressure turbine on a centre shaft, discharging into two low-pressure turbines on wing-shafts, the former having four groups of blades with heights increasing from group to group in the ratio of $\sqrt{2}$ to 1; whilst the low-pressure turbines each consist of eight groups with the same height ratio (apart from the wing-blades), and in this case the blade height at the entrance to each of the two low-pressure turbines is the same as it is for the first group of the high-pressure turbine, since the drum diameters are also increased in the ratio of $\sqrt{2}$ to 1.

The blading of the high-pressure turbine would thus consist of four groups of twenty-four rows each (half fixed and half moving), with blade heights as follow :—

Group No.	1	2	3	4
Blade height	in. 1	in. $1\frac{3}{8}$	in. 2	in. $2\frac{3}{4}$

The low-pressure turbines would have a drum diameter equal to 45 in. $\times 1.41 = 63.6$ in., say 64 in., and would consist of eight groups of twelve rows each, since the number of rows in equivalent groups should be inversely proportional to the square of the blade speeds.

The make-up of each of the two low-pressure turbines would thus be as follows :—

Group No. ..	1	2	3	4	5	6	7	8
Blade height ...	in. 1	in. $1\frac{3}{8}$	in. 2	in. $2\frac{3}{4}$	in. 4	in. $5\frac{1}{2}$	in. $5\frac{1}{2}$	in. $5\frac{1}{2}$

The last two groups would, of course, consist of semi-wing and wing blades.

The weight of steam through the blading as now adjusted is 29 lb. per second, which is equivalent to $\frac{29 \times 3600}{8000}$ lb. = 13.05 lb. per horse-power per hour. This, however, requires correction for the loss by dummy and gland leakage, and also for the actual tip clearances as distinguished from those provisionally assumed.

To take the latter first; in marine practice the tip clearances usually allowed are well represented by the formula given below, though since the introduction of the process of thinning the tips of the blades some builders have ventured to use smaller clearances :—This formula is, tip clearance = 8 mils per foot of drum diameter plus 5 mils per inch of blade height.

Hence for the high-pressure turbine the clearances will be as follow :—

Group No.	1	2	3	4
Tip clearance in mils ...	35	40	40	45

Whilst in the low-pressure turbine the clearances will be :—

Group No.	1	2	3	4	5	6	7	8
Tip clearance in mils ...	50	50	55	55	65	70	70	70

These, as it chances, agree with those provisionally adopted above. If, however, the clearances were increased by 50 per cent. above these figures, making that of the first row—50 mils—and the others in proportion, the consumption per shaft horse-power would be increased. Such a change would increase the clearance at the first row by another 1.7 per cent. of the blade height, and experiment shows that the corresponding increase in consumption would be twice this, or 3.4 per cent., making the steam through the blades equal to 13.46 lb. per shaft horse-power instead of 13.05 lb.

As, however, the clearances tabulated above are in accord with practice, the latter figure will be maintained, and it corresponds, it will be remembered, to a flow of 29 lb. of steam per second through the blading.

The dummy losses can be calculated by the formula established in our issue of January 10, 1908, —viz. :—

Weight of steam through dummy per second

$$= 68\,\Omega \sqrt{\frac{p_0\left(1 - \frac{1}{x^2}\right)}{V_0(N + \log_\epsilon x)}}$$

where Ω denotes the area (measured in square feet) available for flow of the steam, p_0 the absolute pressure in pounds per square inch of the steam on the high-pressure side of the dummy, and V_0 the corresponding specific volume of the steam; N denotes the number of points at which the steam is wire-drawn, or, in other words, the number of rings in the dummy, whilst x denotes the ratio of the pressure at entrance to the dummy to the pressure on discharge. When the three-shaft arrangement of turbines is adopted, x for the high-pressure dummy may be taken as very approximately 4, so that the formula for flow becomes—

$$\text{Weight discharged} = 68\,\Omega \sqrt{\frac{p_0\left(\frac{15}{16}\right)}{V_0\,(N + 1.38)}}.$$

For high-pressure dummies N is commonly 30, whilst in low-pressure dummies the number of rings is less, being usually 16. Hence, weight discharged from high-pressure dummy is equal to

$$= 11.76\,\Omega \sqrt{\frac{p_0}{V_0}}.$$

To find Ω it is necessary to know the dummy diameter which depends upon the relative thrusts of the screw and of the steam. The axial thrust of the steam on the rotor blades is given by the formula*—

$$\text{Thrust of steam} = \frac{p_0\,A\,G}{2} \cdot \left(1 - \frac{1}{\lambda}\right)$$ where p_0 is the pressure in front of the first row of blades of turbine, A the area in square inches of the annulus between the drum and the casing at the first row of blades, and G the number of groups in the turbine, whilst λ is the ratio of successive blade heights. In the present case we have $p_0 = 175$, $A = 144.5$ sq. in., $G = 4$, and $\lambda = \sqrt{2}$. Whence we get—

Thrust of steam = 14,819 lb.

This is more than balanced by the thrust of the propeller. Assuming the propulsive efficiency to be 0.50, and the designed speed 21 knots, or 35.5 ft. per second, we have for the propeller-thrust T the equation—

$$T \times 35.5 = 0.50 \times \text{S.H.-P.} \times 550 = 1334 \times 550$$

or

$$T = 20{,}667.$$

The difference between this and the steam thrust is 20,667 − 14,819 = 5848, which must be compensated for by making the dummy diameter less than that of the turbine main drum. The pressure being 175 lb. per sq. in. at the entrance to the dummy

* Minutes of Proceedings of the Institution of Civil Engineers, vol. clxvii., page 34.

and about 44 lb. absolute on the discharge side, the effective pressure is 131 lb. and the area required is $\frac{5848}{131} = 44.6$ sq. in.

The drum diameter being 45 in., it has an area of 1590.4 sq. in., and the dummy area must be 44.6 in. less, or 1545.8 sq. in. Hence the dummy diameter should be $44\frac{3}{8}$ in., the corresponding circumference being 139.4 in.

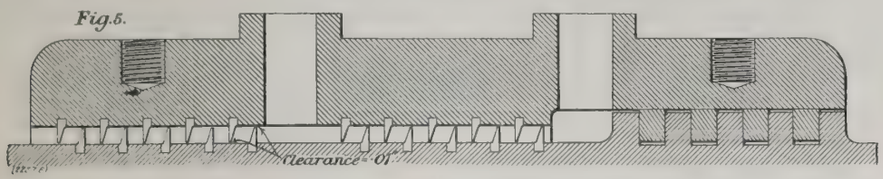
In marine practice, dummy clearances are about 5 mils per foot of diameter—say, 20 mils in this case. Hence the area available for flow through the dummy is $\frac{139.4}{144} \times 0.02$ sq. ft. $= 0.0194$ sq. ft.

All the data necessary for calculating the dummy leakage are now known, and we get the weight discharged per second

$$= 68 \times 0.0194 \sqrt{\frac{175}{2.602} \cdot \frac{15}{16 \times 31.38}} = 1.87 \text{ lb. per second.}$$

This is the loss through the high-pressure dummy, but as this leakage passes into the low-pressure turbines, only one-third of it, or 0.62 lb., is net loss. This brings up the steam consumption per second to 29.62 lb , and to this must now be added the loss from the low-pressure dummies.

Fig. 5.



The propeller thrust will be the same as before, and the same formula may be used for the steam thrust, though, owing to the presence of the wing blades and the rapid fall of pressure through them, it is less accurate here than as applied to the high-pressure turbine.

The pressure at entrance to the low-pressure turbine, allowing for losses in the connecting pipe, may be assumed as equal to 42 lb. absolute, whilst the area A of the annulus will be 204.2 sq. in., the drum diameter being 64 in., and the blade height 1 in. Hence the formula

$$\text{Steam thrust} = \frac{p_0 \text{ A.G.}}{2}\left(1 - \frac{1}{\lambda}\right)$$

becomes

$$\text{Steam thrust} = \frac{42 \times 204.2 \times 8}{2} \times 0.293 = 10{,}052 \text{ lb.}$$

Hence the thrust to be taken by the dummy is $20{,}667 - 10{,}052 = 10{,}615$ lb. Taking the effective pressure as 41 lb. per square inch, the area needed is 259 sq. in. nearly. The drum cross-section has an area of 3217 sq. in., hence the cross-section of the dummy must have an area equal to $3217.0 - 259 = 2958$ sq. in., equivalent to a dummy diameter of $61\frac{3}{8}$ in., the corresponding circumference being 192.8. Taking, as before, the clearance as equal to 5 mils per foot of diameter, or 25 mils in all, the area available for flow through the dummy is $\frac{192.8 \times 0.025}{144} = 0.0334$ sq. ft.

Taking p_0 as 42, V_0 as 9.6 cub. ft. per pound, and x as 34, approximately, we get for the flow through one dummy—

Weight discharged per second

$$= 68 \times 0.0334 \sqrt{\frac{42}{9.6\ (19.05)}}$$

$= 1.086$ lb. per second through one dummy, or 2.172 lb. through two. As the low-pressure turbines do two-thirds of the work, the net loss is $2.172 \times \frac{2}{3} = 1.45$ lb. per second, which brings the steam consumption up to $29.6 + 1.45 = 30.05$ lb. per second.

The gland leakage may be calculated in the same way. A standard shaft-gland is shown in Fig. 5. There are, it will be seen, twenty constrictions in each gland, and the clearance is about 8 mils per foot of shaft diameter. Taking the shaft as 12 in. in diameter at the glands, and applying the formula already given, the total leakage at the two high-pressure glands works out at 0.188 lb. per second, about half of which can be saved if the leak off is led into the low-pressure turbine half-way down the casing. In the case of the low-pressure turbines the loss from each gland amounts to 0.0147 lb. per second, or 0.06 lb. for the four. Thus the aggregate loss from the glands may be taken as 0.15 lb. per second, making the total steam consumption 30.2 lb. per second. Of this, it will be seen, about 5 per cent. is attributable to dummy and gland leakage. The steam consumption per shaft horse-power hour will be $\frac{30.2 \times 3600}{8000} = 13.58$ lb. This figure will, of course, be increased if the steam is not supplied in a dry condition.

The method of proportioning set forth above is really a rational one, though it embodies certain short cuts based upon actual experience and experiment with turbines. It is, in fact, quite possible, with the formulæ already given for the velocity of inflow into a group, and for the work done by the latter, to design each group separately, just as if it formed one pressure stage of an impulse turbine. The work done by each group, and its efficiency, can be readily calculated, as will be shown in the sequel; but the data and reasoning from and by which the formulæ already given have been derived will now be discussed in detail.

So long as standard practice is not departed from, the method of proportioning described above leads to very close estimates both as to the power developed and as to the steam consumption. Thus applied to the Mauretania, the horse-power in the full power trial conditions as regards steam pressures and clearances comes out as 79,122, calculated as against 78,245 actual, and the consumption as 12.16 lb. per shaft horse-power hour, as against the actual figure of 12.03; but, as will be shown later, the different losses are capable of being individually estimated, thanks to the results of recent experiments and investigations.

(To be continued.)

THE BRITISH ASSOCIATION.

As already announced in our last issue, the annual meeting of the British Association for the Advancement of Science was opened at Portsmouth on Wednesday, the 30th ult., when Sir William Ramsay delivered his presidential address to a large gathering in the Town Hall. This address has already been dealt with in ENGINEERING, and we now proceed to our report of the sectional meetings, commencing, as usual, with the proceedings in Section G.

SECTION G.—ENGINEERING.

In taking the chair in Section G, which met in the Municipal College, Professor J. H. Biles remarked that he felt it a great honour to follow so long a line of distinguished predecessors, and expressed the hope that the papers which were to be read and discussed would be found of great interest. In order to meet the convenience of members, not all of whom were interested in the same branches of engineering, an attempt had been made to classify the papers to a certain extent, so that those dealing with allied subjects should be taken on the same day.

The Rolling of Ships.

The President then proceeded to read his address, which we reprinted last week (page 299 *ante*). In too many cases, we may say, a president is tempted to range over the whole field covered by his section, and there are, no doubt, times when a general review of the advance of mechanical science may be profitable; but however necessary it may be in matters of commerce, an annual stocktaking is neither illuminating nor interesting in the applied sciences. Professor Biles accordingly chose the better part, and devoted his address to the discussion of a subject on which he has special competency. Unfortunately, owing to a personal accident last April, he was unable, as he had originally intended, to bring before his auditors the results of an elaborate experimental investigation, for which the apparatus had been prepared; but he was able later on to assure his hearers that in the end his injury would result merely in the research being delayed, and not in its abandonment. This circumstance led, however, to the address being in the main a statement of the problem presented to naval architects by the mysterious disappearance of certain ships, instead of substantially solving it.

The theory of rolling as developed by the Froudes was, President Biles stated, laborious to apply, and had consequently not been worked out for any very great variety of conditions. Ship oscillation in general was, he said, compounded of two elements—viz., the "free" oscillation which arose in still water, and which tended to be damped out owing to the resistances developed by the very fact of the movement; and, secondly, a forced oscillation impressed on the boat by the motion of the waves. This latter oscillation was superimposed on the other, and the extent of the maximum roll was dependent on the periodicities and relative phases of these two components. Ultimately a state of uniform rolling was attained; but before this condition was reached, extreme rolls, greater than those appertaining to the permanent *régime*, might be experienced. Owing to the complication of the problem the history of ship oscillations, prior to the attainment of the state of uniform rolling, had, he said, been worked out in but a few cases. Froude had assumed certain initial conditions, but Colonel Russo had shown that, starting from other initial conditions, much greater rolls might arise during the period of transition. As matters stood, ships were considered safe if they had a fair range of statical stability, and a maximum righting lever not very unlike that of other ships which had had a good sea record. This conclusion, Professor Biles stated, involved the assumption that previous ships had exhausted the possible relations between their natural periodicities and those of the waves they encountered. The mathematical investigation being tedious, Professor Biles had, he stated, devised a machine in which the motion of a ship amongst waves was simulated by the oscillatory rolling of a curve along a connecting-rod common to two cranks of unequal length. The oscillatory motion was resisted by magnetic induction, one portion of this resistance being made directly proportional to the velocity of the rolling, whilst the other varied with the second power of this velocity.

A vote of thanks to Professor Biles was moved by Sir William Ramsay, this year's President of the Association, who expressed the hope that the proposed experiments would be proceeded with. This was seconded by Mr. Alexander Siemens, who said that, as one concerned in cable-laying, the results of the proposed investigation would have a special interest to him. In cable-laying, he continued, the question of rolling had to be considered, not only from the human standpoint, but from that of the cable

In expressing his acknowledgments Professor Biles said that the machine was practically complete, and he thought he might say that without doubt the experiments would be proceeded with and the results published. The object of them was to find what was the maximum possible angle of roll under all possible combinations of initial conditions, phases, and periodicities.

Rail Corrugation.

Mr. W. Worby Beaumont next read his paper on "The Origin and Production of Corrugations on Tramway Rails." This paper we print in full on page 330, and so may at once proceed to the discussion.

This was opened by Mr. Alexander Siemens, who said he would venture to ask the author if he really believed that any of the remedies he suggested were practicable. Of these, there were four—viz., a reduction of speed, a reduction of weight, the use of larger wheels, and the use of harder rails. Personally he believed the three remedies first named quite impossible. As to the use of larger wheels, this would involve the adoption of slower running, and thus heavier, motors. The use of harder rails was, perhaps, practicable, but he would suggest that the hard metal should be confined to the sides of the rails, a softer metal being sandwiched between. This, he believed, would reduce the flowing and crumbling action, and it should not be impossible to produce rails having the constitution in question, with different qualities in different parts.

Sir W. H. White, who followed, said that in the earlier days of turret ships they had been met with a series of difficulties very similar to those described by Mr. Beaumont. The rollers and the roller-path had to take not merely the dead-weight of the turret, but also the shock due to the firing of the gun at perhaps a considerable elevation, and,

moreover, it was not possible to arrange matters so that this shock should come on special rollers. As a consequence, they had in the early days cases of the roller-paths being corrugated, and of the rollers being crushed. By varying the quality of the material, however, the difficulties first experienced had been eliminated. Referring to Mr. Siemens's remarks, he thought that the present situation, as regarded tramway rails, was parallel to that which had arisen when steel came to be substituted for iron on railways. The question was largely a commercial one, but he noted a life of thirteen years in the case of some of the rails discussed by Mr. Beaumont; and to his mind, therefore, the question was not of very serious import, though the obstruction of traffic, which arose from the necessities of relaying, was no doubt objectionable. Mr. Beaumont's paper showed that the matter was being carefully studied by railway engineers, and the author had himself attacked the problem in a scientific way, by obtaining quantitative measurements as to the actual intensity of the pressures experienced. These figures must prove of great value to those who had to deal practically with the problem. Corrugations, he might add, were not confined to tram-lines, but, as every motorist knew, were frequently met with on macadam roads. Here, again, they were not accidental occurrences, but arose from the flowing of the material produced by the traffic. He did not agree with Mr. Siemens's suggestion for a composite rail.

Professor G. W. O. Howe asked what was the objection to the corrugations, and who were the people who complained of them.

Professor Petavel, who followed, suggested that the local intensity of the pressure which produced the detrusion of the rail, and thus led to the formation of corrugations, might be reduced by the use of spring tyres, which would deform so as to give a larger area of contact. The actual areas were, as the paper showed, extremely small, and he was not, therefore without hope that it might be possible to increase them in the way he suggested.

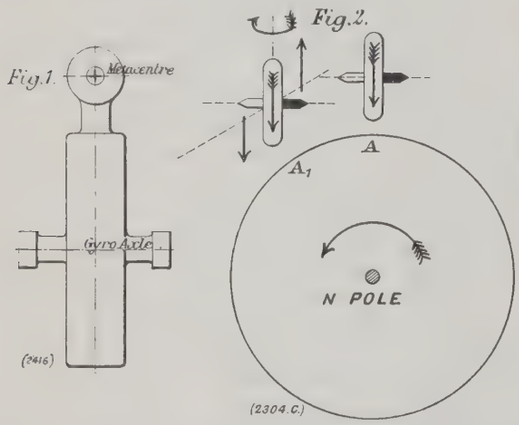
Mr. Charles Hawksley remarked that the question of road corrugations had arisen at Dublin, and one of the county surveyors had given a half promise of a paper on the subject, but the speaker had heard nothing further on this head.

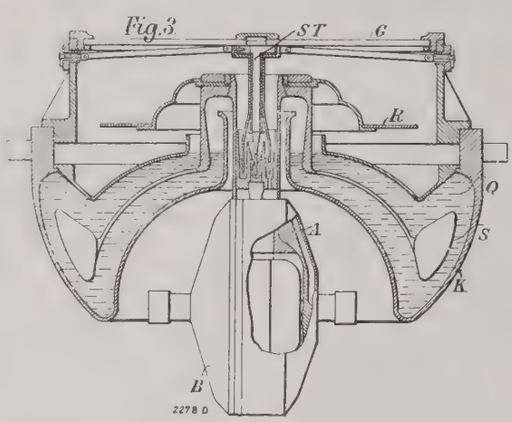
Mr. Hudson said that he had noticed, in many towns, road corrugations where a cross-road made a junction with one paved with granite setts. These corrugations were deepest close up to the setts, and then gradually got less pronounced. He thought they arose from spring-borne vehicles passing off the setts on to the macadam.

A speaker, whose name did not transpire, said that on railways corrugation was distinctly worse in cuttings than on embankments, and this he attributed to the greater rigidity of the road-bed in the former case. If this view were correct, it might possibly prove the cheapest plan in the end to alter the bedding of tram-rails, particularly as further growth in speeds and weights must be anticipated.

In reply, Mr. Beaumont said that he thought Mr. Siemens must have studied but little the properties of rail metals, if he thought it possible to get a material so well tempered that it would recover perfectly its form after every indentation. In the sense he intended it, moreover, a reduction of speed was certainly possible, though a great many would declare the contrary. The great trouble was that trams, moving as they did on fixed lines, had to make very high speeds when they got a clear way, if they were to maintain an average speed which would retain them their customers. Mr. Siemens suggested use of a soft metal would be a reversion to the soft wrought-iron rails and soft tyres of years ago. These spread under the traffic so that long ribbons could be removed from the sides of the rails and almost complete rings from the sides of the tyres. In 1876 the speaker had read a paper before the Institution of Civil Engineers, in which this matter had been investigated and the reason given why the tyres failed, and why, which was the puzzle, breakages were more frequent where the tyres were solid metal than at points where holes passed through them. Mr. Siemens had said that there would be a difficulty in using large wheels on tramcars, and this was true if the present design were retained; but the speaker questioned whether this could not be modified. The experiences with roller-paths, described by Sir William White, had been duplicated with tram-plates. Those at one time laid over Westminster Bridge, to accommodate heavy traffic, soon lost their original flatness, and arched upwards, owing to the stretching of their upper surfaces by the cold-rolling they received.

The whole question of tramway corrugation was largely a commercial matter. The life of thirteen years, quoted by Sir William White, referred to a case in which the traffic density was not high. The matter had, however, now attained such an importance, owing to the cost of repairs and renewals, that it was becoming improbable that tramway systems could be permanently maintained without aid from the rates. Professor Howe had asked who it was that objected to the corrugations. To this he might reply, "Everyone along the line of route," owing to the resultant noise and vibration. The former difficulty alone had given the greatest anxiety to the tramway people. Professor Petavel's suggestion to use spring wheels he regarded as impracticable, since the cars ran many million miles in a relatively short time, and any moving parts, introduced as proposed, would soon be worn out.





The Gyro-Compass.

Mr. G. K. B. Elphinstone next read a paper on "The Anschutz Gyro-Compass." This device has already been fully described in our issue of June 23 last, page 816. This compass, Mr. Elphinstone said, was now in use on a considerable number of warships, and was under consideration for adoption on some large liners. It had some great advantages over the magnetic compass, though, of course, it had, on the other hand, some troubles of its own. Its chief merit lay in the fact that it was quite unaffected by magnetism. On modern warships the mass of steel was enormous, and made the adjustment of the magnetic compass so difficult as to appear at first sight almost impossible, and the conditions were daily becoming more onerous. The enormous funnels now necessary were, for example, sometimes hot and sometimes cold, so that their magnetic condition varied. The experiments which had resulted in the instrument he had on view were commenced some twelve years ago, with the primary object of finding a substitute for the magnetic compass to be used on a projected expedition to the North Pole. After eight years' work the instrument, with which his paper was concerned, was devised, and, curiously enough, there were only two places on the globe where it would not work, and these were the North Pole and the South Pole. To illustrate the difficulties of applying the ordinary magnetic compass to modern warships, Mr. Elphinstone said that, on the Neptune, both the standard compass and that on the bridge were in very exposed situations. The former, moreover, was very close to an enormous gun-shield, the position of which was not fixed. In fact, there were hundreds of tons of movable steel on board a modern warship, the magnetic condition of which could not accordingly be constant.

The principle of the Anchutz compass was, he said, illustrated in Figs. 1 and 2. The former represented what was essentially a pendulum, of which the gycoscope formed the bob. Gravity constantly tended to keep this axis horizontal. Suppose, however, the effects of gravity were cancelled, then, if by the rotation of the earth the pendulum gyroscope was carried from A to A_1 (Fig. 2), it would maintain invariable its original plane of rotation, its axis remaining parallel to itself, as indicated. If now gravity came into play, it would tend to make the axis of the gyroscope tangential to the earth's surface. The couple acting as indicated by the arrows would cause the gyroscope to precess in the direction indicated by the curved arrow near the top of the instrument. In fact, a precession would always arise in this way unless the original axis of rotation of the gyroscope lay in the meridional plane, which alone constituted a position of equilibrium.

The actual machine was illustrated, he said, in the cross-section, Fig. 3. The gyroscope ran on ball-bearings at 20,000 revolutions per minute, being driven by an induction motor, of which the armature (of the squirrel-cage type) formed part of the gyroscope disc. The whole weight of the machine was carried by a steel ring floating in mercury. After starting up the machine, the meridional plane was attained in 2½ to 3 hours, and would then be maintained indefinitely.

In another room Mr. Elphinstone had an actual instrument on view. This was fitted with electrical repeating gear, by which the gyroscope readings could be transferred to any part of a ship. Provision was also made for magnifying, in this transmission, the actual motion, and, as a result, the steersman was able to maintain his course much more accurately, as was proved by charts, also exhibited, which showed the comparative errors made in steering with the gyro-compass and with the magnetic compass.

There was no discussion on the paper.

Electrical Ship Propulsion.

When the section met on Friday the chair was again occupied by Professor Biles, and the paper taken first had as its author Mr. H. A. Mavor, and was entitled "Electrical Drives for Screw-Propellers." This paper we print in full on page 332. It described an application of Mr. Mavor's system to a petrol launch and to a Canadian canal and lake barge. It was also stated that the system was to be adopted in a collier to be built for the United States Navy, a sister-vessel being fitted with geared turbines. One advantage of the arrangement, as installed on a number of these boats, is that the condenser can be placed below the turbines. Though the fact was not mentioned by Mr. Mavor, we may add that this arrangement makes it possible to start up the turbines with practically no preliminary heating up. In land stations the accepted practice, at least with the reaction type, is to get the turbine turning round as soon as possible, and the full load is commonly put on within a quarter-of-an-hour from the commencement, and on emergencies this has been done almost instantly. At sea, on the other hand, where the outlet to the condenser is generally at the top, and not at the bottom, of the casing, a preliminary heating up of 2½ to 3 hours' duration is usual.

The discussion was opened by Professor Dalby, who said that the paper marked a very interesting departure in the transmission of power where there was a demand for a great velocity ratio between the prime mover and its follower. The only question that arose was whether the great flexibility of the system would be bound up with a considerable sacrifice of efficiency. He asked,

therefore, if the author could state definitely the ratio of the shaft horse-power delivered to the screw to the horse-power supplied to the motor. He would be glad to have these figures for the case of full-load, half-load, and quarter-load. Another point on which he desired information had reference to the size of the motors on the propeller-shaft. What was the diameter of that used on the slow-speed boat described, and also on the collier to be supplied to the United States Navy? Though no scale appeared on the drawings, these gave the impression that the fly-wheel action would be very considerable, and questions then arose as to what would be the consequent strains on the shaft and bearings.

A speaker, whose name could not be obtained, owing to the Chairman not adopting the excellent plan of announcing the name of each speaker to the meeting, observed that Mr. Mavor's system involved the placing on board of three sets of machinery, each in itself sufficiently powerful to drive the ship. On the score of weight, he thought this must be a distinct disadvantage.

Professor Petavel, who followed, said the possibility of being able to couple up a high-speed motor to a low-speed follower would frequently compensate for considerable losses in transmission. Mr. Mavor's system had the advantage of flexibility and of the possibility of connecting up separate sources of power to one drive. The reverse side of the picture was the danger of complication and of breakdowns. There were three separate units, each liable to its individual defects, and at sea a breakdown would be a serious matter.

Sir W. H. White congratulated the author on having attained the point at which he could refer to actual results, and not merely to proposals. He could now declare that his system had been seen at work by independent parties, who had been so impressed that they were prepared to go further. The decision of the United States Government to try the method was very important, and the more so in that a direct comparison would be made with a sister-boat fitted with Westinghouse geared turbines. Such a large-scale comparison was of very great interest, and as the United States Navy was in the habit of publishing the results of such experiments, every one would benefit by them. He had already expressed his personal views on the system in the discussion at the Institution of Civil Engineers. As he then stated, he did not believe that a lessened efficiency with screw-propellers running at high velocities was inevitable. The present condition of matters in this regard was not, he thought, a permanent one. Already great advances had been made and there was a prospect of further improvement. He might say that the Parsons Marine Turbine Company had set up apparatus to test the matter exhaustively. Mr. Taylor, of the United States Navy, was already working in the same direction, and had satisfied himself that it was possible to proceed to much higher revolutions than usual, and yet maintain the efficiency. Further, Sir Henry Oram had stated that the propulsive coefficient of the Invincible was quite satisfactory as compared with screws running at lower rates of revolution. There was thus, he thought, more than a possibility of obtaining efficiency with high-speed propellers. If this were so, it would greatly influence the type of machinery to be adopted on modern ships. Professor Petavel had stated the objections to the conversion and reconversion of power. On the other hand, Mr. Mavor had been quite fair in his statement of the advantages, and if these proved satisfactory on the whole, and there was an economy of propulsion, and extra carrying power, the system would go on. It would, however, have to justify itself on shipboard. He had now nothing to do with the Royal Navy. The author had said that the Admiralty had missed the opportunity of making the first practical trial of the proposed system, but the speaker thought that all would agree that the authorities might be trusted to avail themselves of all means of advance in ship propulsion, wherever they came from.

Professor Howe asked the author to give particulars as to the winding of the motor. In the paper it was explained that there were three separate stator windings, and it was claimed that the whole were independent, so that if one of the three generating units broke down, no trouble would arise. The speaker would have thought that in such a case the motor would have pumped back currents and motored round the idle generator. As to the three links in the power-transmission system, he was not in agreement with a previous speaker. Squirrel-cage motors and alternate-current generators were so strong and reliable that that they did not weaken the chain; not so much, indeed, as the provision of an extra row of blades on the turbine.

Dr. Morrow, who spoke next, said that the question arose as to what type of vessel the system proposed was best adapted. In the case of low-speed cargo-boats it would have to compete with the reciprocating engine and with the geared turbine, since if a turbine was installed in such craft at all, it must be geared. In the case of high-speed liners there could be a direct drive between the turbine and the screw, and here the competition would be between the Mavor system and direct or geared turbine-driven screws. In the case of warships, again, there was a demand for economy at low powers. To which of these classes, he asked, was the proposed system specially suited? With the cargo-boat it had, as stated, to compete with the geared turbine; and as to the liners, a case had yet to be made out for the electric drive, it being a doubtful question whether the possible increase in efficiency would compensate for the extra complication. Where low-speed economy was very important, it was interesting to note that the United States Navy had discarded the turbine, and were fitting reciprocating engines. Here perhaps might be a chance for Mr. Mavor.

Mr. Dyne asked what was the efficiency of the squirrel-cage armature at one-third full power; and Mr. C. E. Hankey inquired what was the reason for adopting three engines instead of one for the boat to run on the Canadian lakes. A cargo-boat, he stated, was not generally required to run at one-third speed.

Sir W. H. White, again rising, said he thought he should state that it was not exactly the case that the United States Navy had discarded the turbine. The fact was that, in the case of one ship being built at Newport News, it had been decided to adopt reciprocating engines, on account of the remarkable economy attained with previous engines by the same builders.

Mr. B. P. Haigh, referring to the possibility of the motors being drowned in sea-water, said that he had known a motor flooded in this way which yet continued to work. The voltage in this case was not high, but he nevertheless thought that Mr. Mavor's motors could be kept running in the condition stated, provided the duration of the flooding was not too long.

Mr. H. A. Mavor, in replying, said that the voltages he adopted ranged from 600 to 2000, the latter being adopted with the larger sizes so as to keep down the weight, but lower voltages could be used. As to Professor Dalby's questions, he might say that the efficiency from the generator terminals to the screw-shaft was of the order of 90 per cent. It was quite possible to get a figure of 96 per cent., but the motor was then less suitable for use at sea. The amount of clearance allowed settled the efficiency, and it was thought advisable to sacrifice some of this, so as to make possible a rougher construction. The loss could well be afforded, as in the case of the bulk-freighter Freda, described in this paper, which required 1900 horse-power, the consumption with the electric drive would be 30 tons a day, in place of 40 tons with ordinary reciprocating engines. The motors, he might state, had a diameter of 12 ft. to 15 ft., the latter size being adopted for the United States collier. He had found, indeed, that a diameter of 15 ft. was enough in most cases, and it should be remembered that with a large diameter the axial length was short. As to the suggestion that special strains might arise in the bearings, his experimental boat had answered this question. The motor ran more sweetly in a seaway than the engines did. The suggestion made by one speaker that there were three links in his transmission chain was, he thought, misleading. He claimed that his system was even less complicated than a direct drive by a reciprocating engine, there being fewer individual moving parts. The turbine and generator rotors constituted one moving part, and the motor armature and the screw-shaft another. The construction of a squirrel-cage armature was, in fact, simpler than that of a cart-wheel, and to an electrical engineer the suggestion of complication was mere nonsense. Changes in the connections to the copper coils on the stators were made with the plant stationary and no current passing. Of course, in cases where a direct drive from the turbine to the propeller was possible, there would be no sense in adopting electrical means of transmission, and hence he must make a reservation as to high-speed vessels in advocating the applicability of his system. Slow-speed ships could not, however, be driven by high-speed screws, since at 10 or 12 knots the revolutions must be between 70 and 150 as practicable speeds. He, however, proposed to run his generator at 3000 revolutions, and here he thought the electrical system offered advantages. Through the courtesy of the Parsons Company he had had the opportunity of making a direct comparison between the geared turbine and the electric drive for a ship of this class. This showed the geared turbine to be a very serious competitor, but the weight and the efficiency proved to be practically the same as with his system. In the Freda, to which he had already referred, the propeller was to be the same as with reciprocating engines, but the steam consumption 25 per cent. less. As to the suggested increased danger of breakdowns resulting from the use of three independent units, all he could say was that we were now dependent on electric transmission for driving tramcars and the like, and it did not break down.

A pretty full description of the motor construction had already been published in ENGINEERING on June 9 of this year, page 768. The windings were arranged so as to be mutually non-inductive, and then there was no pumping back of current into the idle circuit. The efficiency of the squirrel-cage motor was comparatively low at low powers, but in this regard compared favourably with that of a steam-engine. The boat in which the three independent engines were used was not an ordinary cargo-boat, but was intended for the Canadian lake services. Here in the canals the speed had to be kept down to 3 or 4 knots, whilst in the lakes a speed of 8 or 9 knots was required. This accounted for the subdivision of the engine into three units, but this possessed advantages also in other cases, since two smaller engines could be built with a less total weight than a single equivalent large one. As to the danger of short-circuits, commonly this was associated in the popular mind with the destruction of apparatus; but with an alternate-current generator feeding a single motor on a single circuit no damage could arise, as the maximum current was not more than $2\frac{1}{2}$ to 3 times the normal. On a street main matters were different. It was designed to take, say, 100 horse-power, but there was, perhaps, 10,000 horse-power behind it in the station. In that case a short circuit might blow up the street, but if the maximum power which could enter the circuit was only equal to that for which it was intended, no damage could arise. On shipboard a sudden reversal of the motor was equivalent to a short-circuit, only worse, and this operation had been carried out on his yacht before the Admiralty inspectors, who were surprised to find that nothing happened save that the screw began to revolve backwards. Nature in this instance was on the side of the engineer, and made it impossible to blow up the dynamo. Indeed, if the generator were connected by a naked wire to the skin of the ship, only $2\frac{1}{2}$ to 3 times the normal current would flow, and at a reduced voltage. There would be no burning up. He had tried the experiment of running a motor under water. The machine was twenty years old at the time of the test, and it ran for a whole day. Of course, as Mr. Haigh had said, the experiment could not be repeated indefinitely. Apart from other effects, however, the water tended to keep the machine cool, and there was no explosion. The machine used was a continuous-current one with commutator and brushes. He had not thought it would run, but it did.

In proposing a vote of thanks to the author, Professor Biles said that some remarks in the paper rather tended to the conclusion that coal economy was less important on short cross-Channel passages than on long voyages. In the latter, of course, the matter was complicated by the difficulty of finding bunker room for excessive quantities of fuel, but those who had to pay for the coal used on short sea trips were quite as keen as anyone else on the matter of fuel economy.

ELECTRIC STEERING.

Mr. B. P. Haigh then read his paper on "Electric Steering," which we reproduce on page 333. In the system described a constantly-running electric motor is used, which is coupled up at will by magnetic clutches to gearing, which

turns the rudder one way or the other as required. The plant had, the author stated, been under test for some months, with very satisfactory results. Owing to the flywheel action which resulted from the use of a continuously-running motor, there was never any excessive demand for current, and consequently the steering gear could be run without trouble from the lighting circuits of the ship.

The discussion was opened by Sir W. H. White, who stated that Mr. Beaumont had requested him to say that his own experience with control gears led him to believe that there might be trouble with the red fibre blocks used in the friction clutches. Mr. Beaumont also thought that the wires which conveyed the current to the magnetic clutches, and which were buried in the shaft, might also prove objectionable. Speaking for himself, Sir William White continued that he regarded the method of electrically-operated steering gear with favour, its advantages being very great. In a yacht with which he was acquainted, the whole of the power equipment outside of the engine-room was originally made electrical. In connection with the steering-gear, however, a difficulty had arisen, owing to its extreme sensitiveness, which, in combination with a nervous quartermaster, had nearly resulted in a collision. A hunting (overtaking) gear was fitted, but the quartermaster would not give it time to act. This hunting-gear was accordingly removed, and a helm-indicator provided, the steersman being then instructed simply to give so many degrees of helm, and the whole difficulty thus disappeared. Professor Hele-Shaw's gear had now been fitted to the yacht, and was beautifully sensitive. Experience would show which type would survive. He might say that the question of economy of power could not be neglected. An ordinary quartermaster never let the helm alone, although such continual movements had no real value in keeping the vessel on her course. In the yacht already mentioned electrical gear was first fitted, but on the score of economy of power was afterwards replaced by steam; and now this had been in its turn superseded by another form of electrical gear.

Professor Dalby asked if the author could state the coefficient of friction of the red fibre, and also what was the limiting pressure used on it.

Mr C. Hawksley said that he supposed it was usual to fit hand steering-gear in addition to the electrical. As to the necessity of this, he had recent experience. In a boat *en route* to Gibraltar, the power steering-gear broke down, and when an attempt was made to use the hand-gear this also was found to be out of order, and it took three hours to put it right. Had the accident occurred half an hour earlier the vessel would probably have drifted on to some rocks.

In reply, Mr. Haigh said that they had tried different substances in their clutches, but found red fibre to give the least trouble. The only objection to it was that it was hygroscopic, readily absorbing moisture. This made them afraid that the blocks would swell up in their holders and make it impossible to take up wear. They had accordingly adopted the plan of boiling the fibre in linseed oil, thus closing up its pores and making the absorption of water impossible. They had found no unequal wear during the several months over which their experiments with the system extended. They had, moreover, found no change in the friction with rise of temperature. They had repeatedly tested this by locking the rudder and running the gear for five minutes, the friction clutches slipping the whole time. This he considered a severe test, and he could state that the torque was as great at the end of the five minutes as at the outset. The current taken by the motor could never exceed that necessary to slip the clutches, and consequently the gear could be run from the lighting circuits, and the working of fans, hoisting-gears, and the like would be quite unaffected. The burying in the shaft of the cables carrying the current to the magnets could not give rise to any trouble. In the three-phase enclosed motors used in collieries, the whole of the three cables passed through a hollow shaft, and no trouble arose, though the currents might be heavy. In the case of his own gear, the cables in question only carried the current to the clutches, and its strength was only half an ampere. As to the sensitiveness of the gear causing trouble, when a hunting-gear was used, this was provided for by supplying the gear with different degrees of sensitiveness to suit different cases.

In the first instance, however, they had worked out the problem for the most difficult case—that of a very fast boat. In the case of a cargo-boat a much less sensitive gear would be fitted. The worst condition that could arise was when the wheel was first placed hard over and then moved back amidships before the rudder had caught up with the first movement. The only result in this case would be that the clutches would slip. The coefficient of friction for red fibre was not very different from that of wood. They found they could rely on a coefficient of one-sixth, but allowed for a smaller value. They were, indeed, quite prepared to face the possibility of oil between the friction surfaces. They had, in fact, poured oil in, with the result that slipping occurred, and lasted for 12 revolutions, at the end of which the oil was squeezed out and the surfaces gripped again. The time lag was therefore only a few seconds. In the experimental gear the pressure between the friction surfaces was about 100 lb. per sq. in.

Repulsion Motors.

Mr. T. F. Wall was the author of the next paper taken, entitled "The Single-Phase Repulsion Motor." This paper was purely mathematical, and essentially one to be studied *in extenso*. We hope to reprint it in a future issue.

The discussion was opened by Mr. B. P Haigh, who said it was impossible to criticise the paper until one had had an opportunity of studying it. He thought the author's method might be amplified so as to take into account the voltage in the coils under the brushes, which determined the sparking limit.

In reply, Mr. Wall said that in the Déri type sparking had been greatly diminished.

Sensitiveness to Vibration.

The President then called upon Captain H. Riall Sankey to read the paper of which he and Mr. W. Pollard Digby were joint authors, entitled "Some Preliminary Notes on Human Susceptibility to Vibration." This paper we reprint on page 333. In his introductory remarks, Captain Sankey added a few further details as to the instrument used in recording the amplitudes of the vibration. This consisted of a small mirror floating on mercury, and centred by a fine spindle passing through a hole in the middle of it. Setting the mercury in vibration caused the mirror to oscillate, the amplitude being magnified optically. In use the instrument was placed on a table, which was set in vibration by resting on it a revolving weight more or less out of balance. The instrument was calibrated for vibrations of different periodicities and amplitudes by direct measurement of the latter.

In the discussion which ensued a speaker questioned whether the method could give exact data. Different people differed so much, and their estimates were largely dependent on preconceived ideas. In one case in which a business man complained of the vibration caused by machinery in an adjacent building, the speaker was able to prove to the complainant that this was much less than was caused by the heavy traffic along the street.

Sir W. H. White suggested that the conditions were so varied that the research was essentially one for people of leisure. He had himself seen some curious instances of the erratic way in which different individuals estimated vibrations, and believed accordingly that mere impressions were useless, and actual measurements were alone to be relied on. On one occasion, in a trial trip in Stokes Bay, the captain declared to him that the ends of the ship, which was 300 ft. long, were moving up and down a full 18 in. On being made to change his position, the complainant was astonished to find that his impression was totally unfounded. Complaints had at one time been made of vibration on the Lusitania and Mauretania, and the speaker was in possession of the actual measurements made on these and on other liners. The actual amplitude was trivial in the case of the two turbine boats as compared with the other vessels, but the high frequency led to complaints of vibration in certain limited portions of the ships. He had, however, on one occasion found one of the loudest of the complainants asleep in the very region where the disturbance was greatest.

Professor Petavel suggested that the association of sound with vibration greatly added to the discomfort. If there were some object in a room in imperfect resonance with a vibration, he thought the conditions would be hardly consistent with the peace of mind and comfort of the occupants.

Some New Aluminium Alloys.

Under the above title Professor E. Wilson had prepared a note on the conductivity of light aluminium alloys. This was taken as read. The author stated that alloys formed by alloying commercial aluminium with 2.6 per cent. of copper had proved unsatisfactory, and that in the course of ten years those containing copper and manganese had not seriously deteriorated. Some experiments had been made on "Duralumin," which proved to have a specific resistance of 5.35×10^{-6} ohms as against 2.76×10^{-6} ohms for pure aluminium.

Aerial Flight.

The proceedings last Monday opened with a joint discussion of Sections A and G on the subject of aeronautics, which was remarkable for the fact that no mathematician ventured to speak. We trust that this circumstance is not to be taken as an indication that the mathematical side of the subject is being neglected in this country. Some important contributions to the theory of stability have been recently made in France, one of the conclusions reached being that automatic lateral stability is inherently impossible. The French writers also claim to have established the fact that two of the possible periods of oscillation in the fore and aft direction are necessarily long, and hence in non-uniform air-currents a second disturbance may arise before the first has been damped out, the conclusion being that stability in a fore and aft direction must also depend partially on the skill of the pilot unless the air currents chance to be reasonably uniform. It would have been of interest to have had these conclusions criticised by other mathematicians, but the discussion was left wholly in the hands of engineers, meteorologists, and physicists.

The discussion was opened by Mr. A. E. Berriman, who had had printed in advance a summary of his remarks, which we reproduce on page 337. To make clearer the points to which he wished discussion to be directed, the speaker had prepared a number of diagrams. Thus the sweep of the aeroplane was, he said, the depth of the layer of air set in motion by it, as represented in Fig. 4, subjoined. One point on which he said

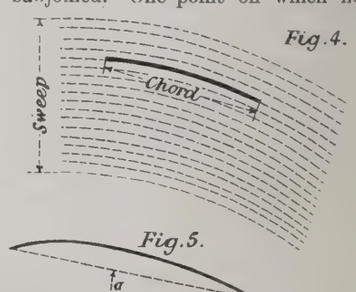


Fig. 4.

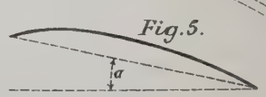


Fig. 5.

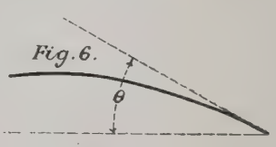


Fig. 6.

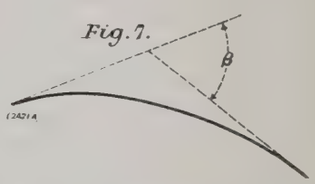
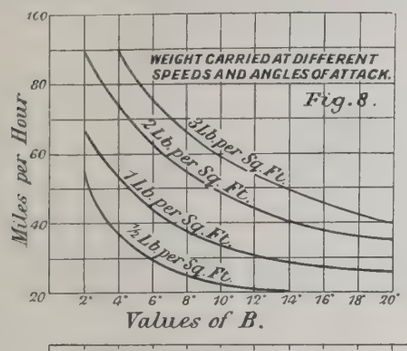


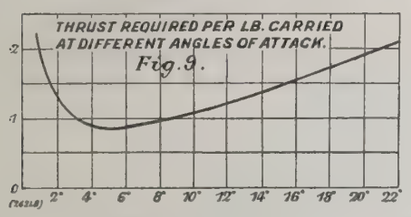
Fig. 7.

there was much divergence of opinion was the proper measure of the angle of attack. Some took it to be the angle α between the chord to the aerofoil and the horizontal, as represented in Fig. 5. Others claimed that the trail angle (see Fig. 6) was alone of importance, whereas he himself contended that the angle of attack was properly taken as the angle included between the tangent to the leading edge of the aerofoil and the tangent to the trailing edge, as represented in Fig. 7. He also showed Fig. 8, which represented, he said, the speed necessary to support weights of $\frac{1}{2}$, 1, 2, and 3 lb. per sq. ft. respectively, when β the angle of attack had various values between 0 deg. and 20 deg.

This curve was obtained by plotting the equation $P_\beta = \frac{V^2 \tan \beta}{200}$ where P_β = weight supported per square foot, V the speed in miles per hour, and β the angle of attack.

Taking into account skin friction as deduced from Zahm's experiments, the thrust required per pound of load carried was plotted for various values of β in Fig. 9, and there was, it would be seen, he said, a minimum value with $\beta = 5$ deg. With respect to skin friction, he observed further that the object of adopting a stream-line form was to convert head resistance into skin friction. Surface





for surface, the latter was only $\frac{1}{300}$th part of the former ; so that, with no increase in total resistance, 1 sq. ft. of surface offering head resistance could be replaced by 300 sq. ft. of surface disposed in fair form. The speaker also showed experimentally that, owing to gyroscopic action of the engine, a turn to the right might make an aeroplane soar, and *vice versâ*.

Professor H. H. Turner, the President of Section A, who occupied the chair, complimented Mr. Berriman on the able manner in which he had opened the discussion. In order, however, to give the mathematicians time to catch their breath, after listening to remarks on cambered planes (he supposed they would next hear of curved straight lines), he asked Dr. W. N. Shaw to discuss the matter from the meteorological standpoint.

Dr. Shaw said that the opener had treated the mathematical aspect of the subject almost wholly from the standpoint of a machine traversing a medium at rest or in uniform motion. The airman's business was to make his way through the atmosphere, whilst it was the part of the meteorologist to tell him what he had to expect on his passage. He would not in general find the atmosphere to be a fluid in uniform motion. Wind had the characteristic that it did not blow uniformly, but in gusts. If its average speed were 20 miles an hour, the minimum might be 10 miles, and the maximum 30 miles per hour, as determined by the Dines pressure-tube anemometer. The irregularity was, moreover, dependent on the locality. On a sea-coast station, with the wind sweeping over the sea, the oscillations in velocity might be quite small, but in the case of land stations the variations were much larger, and if the range were from 10 miles to 30 miles, the difference in the force acting on the aeroplane would be as 1 to 9, that corresponding to the mean velocity of 20 miles an hour being measured by 4. These very considerable variations in wind velocities constituted a point in favour of high-speed flight, since the same absolute variation would then be proportionately less. One discovery the meteorologist owed to the airman—viz., that known as the "hole in the air." On certain occasions the aeronaut found that he suddenly began an involuntary descent. Meteorologists had been trying to find out whether this "hole in the air" was due to something new, or was merely associated with familiar phenomena, of which the effect had not been numerically developed. They had had therefore to examine the structure of the atmosphere and see what evidence there was of sudden vertical motions. Such, it was found, did exist, but not in places where the aeroplanist was likely to trust himself. Thus at the top of a sea cliff eddies were formed which would be a serious obstacle to aerial navigation there. No experienced airman would, however, expose himself to these, and hence the conclusion reached was that the whole phenomenon was due to variations in the speed of the wind. The effect of sudden gusts on an aeroplane should be studied more closely. It was more or less analogous to that of a bumpy road on the stability of a bicycle. Records showed further that in a 20-mile wind the speed might pass seventeen times a minute from 10 to 30 miles an hour. If an airman came into a lull, his machine would suddenly appear too heavy and down he would come. He had thus always to face what were in appearance up-and-down currents. The variations in the wind were, moreover, not confined to velocity only, but there were also sudden changes of direction, and these made the airman worse off than a cyclist moving over a bumpy road, since he experienced sudden side-thrusts from which the latter was free. As to the extent of these variations Mr. J. S. Dines could give details better than himself, but he might say that there was no apparent relation between the changes in direction and the changes in speed. When a sudden gust came it might, or might not, be in the same direction as the prevailing current.

Before calling on the next speaker Professor Turner said that Dr. Shaw had shown that the meteorologist had much to say on the question. He had himself been struck by Mr. Berriman's experiment with the gyroscope, which indicated that if an airman turned in one direction, the gyroscopic action of his engine would tend to make him soar, and if in the reverse direction to dive. He had himself seen one aeroplane accident, in which the airman fell in turning, and he thought the gyroscopic effect might well have been responsible for the disaster.

Professor Petavel, who followed, said he desired to say a few words on the question of safety, reliability, and efficiency. Of these, safety was the most important, and was dependent essentially on the stability of the machine. It would, he thought, be well to admit at the start that perfect automatic stability was never likely to be realised. In uniform air it was in certain directions easily attained, but in the actual disturbed condition of the atmosphere success was far distant. Perfect auto-stability was, however, not a necessity. Comparing a bicycle with a tricycle, the latter was stable, but most people felt safer on the bicycle ; and he thought, therefore, that a good deal might well be left to the experienced control of the pilot. The only successful method of obtaining automatic stability was attained by attention to the shape and position of the wings or aerofoils, to use Lanchester's term. In this direction Mr. Dunn had been reasonably successful. One possible way of improving the stability was to increase the speed of flight, so that atmospheric variations were proportionately smaller percentages of the velocity of the machine, and the gusts would thus produce correspondingly less disturbance. Unfortunately, however, a high increase in speed led to increased danger in alighting unless some plan was adopted to reduce the speed at that time. This might be effected by increasing the area of the wing-surfaces just before landing, but there were very great mechanical difficulties in effecting this. Another plan would be to make the angle of attack adjustable, and this might be done to a certain extent. It would, however, be necessary to use machines which had a reasonable efficiency, with angles of attack varying over a large range, which was not the case with some of the machines in use. Automatic control had not so far proved successful, and he himself would feel safer without it, as he had an idea that any attempt to effect the control by the gust itself would set up oscillations more dangerous than those due to the original gust. In certain weather the atmospheric conditions were very variable. The machine met gusts the effect of which might be likened to those experienced on a motor-car traversing the drains across French roads. The machine suffered a sharp impact which could hardly be met by an automatic control. At other times the machine seemed to move in all directions at once, and an automatic control would probably prove excessive. With the "Gnome" engine, the gyroscopic effect was such that on turning to the right the machine tended to tip over backwards, and every learner was warned to run down before making a turn to the right in order to correct this tendency. Another danger in existing machines could, he said, be eliminated by a change in the design. Where the tail carried part of the weight, the amount supported by it was partially dependent on the draught from the propeller. If the engine stopped, this draught disappeared, and the centre of pressure moving forward, the machine tended to soar, and a danger thus arose. Another factor involved was the skill of the pilot. Accidents arose partly through the natural rashness of courageous men, who were tempted to go out in circumstances of extra danger, and also through the insistence of the public, who were not content to stand by the judgment of experienced men, but insisted on starts being made in unsuitable weather. Unnecessary risks were thus taken which contributed nothing to the advance of aeronautics. Feats like the very steep dive known as the *vol piqué* were unnecessary, and liable to break up the machine owing to its inertia. In other cases such steep dives had terminated in disaster, because the elevator had lost, through the steepness of the descent, so much of its leverage that it could not redress the machine. Again, very steep banking and sharp turning added enormously to the strains on the machine, and, should a gust occur during the banking, the machine might turn over. It was, he said, a very pretty evolution, but had led to many accidents.

Mr. Worby Beaumont, who followed, expressed the opinion that there was little hope for much improvement on the screw-propeller. If anything substantial was to be effected in increasing propulsive efficiency, it must be by invention, and not by mere improvement of existing screws. The engine itself had about reached the limit of weight consistent with reliability, and about 1 horse-power could now be obtained continuously from 4 lb. of weight. He wished to add that it was entirely erroneous to suppose that builders were at present without scientific assistance. They had the aid of men of great acuteness and knowledge, and possessing also the ability to apply it practically. He thought it likely that the engine with rotating cylinders would ultimately be superseded.

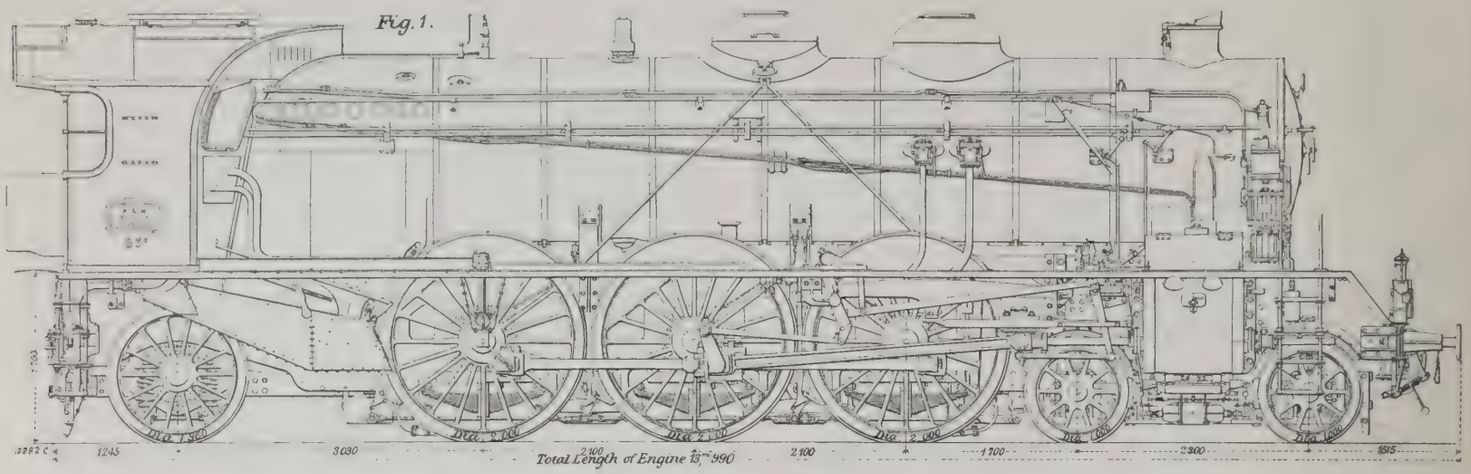
Sir W. H. White said he had hoped that Section A would have been more in evidence in the discussion ; but he was grateful to Dr. Shaw for his contribution. The feeling of engineers on the subject of aviation might be summed up in the view that the problem must be attacked experimentally ; but, of course, experiment should be guided by science, and the results should be scientifically analysed, and it was here, he thought, that the mathematician would prove of most service. As he had said at Sheffield, all the progress made so far had been due to practical men, perhaps reckless, though the best of them were not, as, for example, the Wright Brothers. These men knew the risk, but faced it in order to ascertain facts. It might not be known to all that the Wright Brothers had been careful students of the works of Octave, Chanute, and Professor Langley, and had they had at the outset a more perfect knowledge of mechanical engineering they would have gone still further. M. Blériot had shown what could be accomplished when the aviator was also a skilled engineer. Many aviators, otherwise skilful, had little knowledge of the internal-combustion engine, and this engine, moreover, was often so placed as to be inaccessible save when the machine was on the ground. Even in hydraulics, there were many problems connected with propulsion and resistance which were intractable to direct mathematical attack, and which had to be dealt with experimentally. He was quite confident, therefore, that when the scale of comparison had been established model experiments would give the airman all the information he wanted as to frictional resistance and propulsive efficiency. Dr. Stanton had already shown that the air-pressure on complicated structures, such as bridge girders, could be accurately estimated from model experiments. In such cases there were eddies developed with which the mathematician could not deal. As to automatic contrivances, those who, like himself, had had much experience with them, would prefer to trust to human control, intelligence being essential to successfully meeting the unexpected. It would be necessary, therefore, properly to train the men who flew the machines. As to the question of design, the aeroplane had to float in a tenuous medium filled with

FOUR-CYLINDER LOCOMOTIVE; PARIS-LYONS-MEDITERRANEAN RAILWAY.

CONSTRUCTED AT THE PARIS WORKS OF THE PARIS-LYONS-MEDITERRANEAN RAILWAY COMPANY.

(*For Description, see Page* 317.)

Fig. 1.



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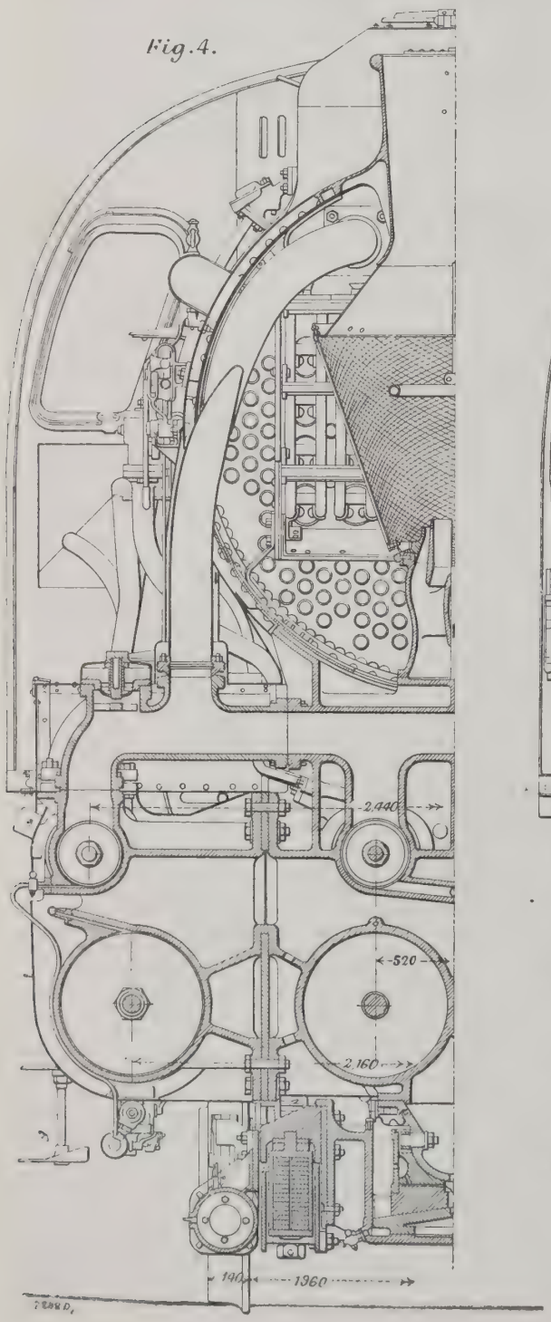

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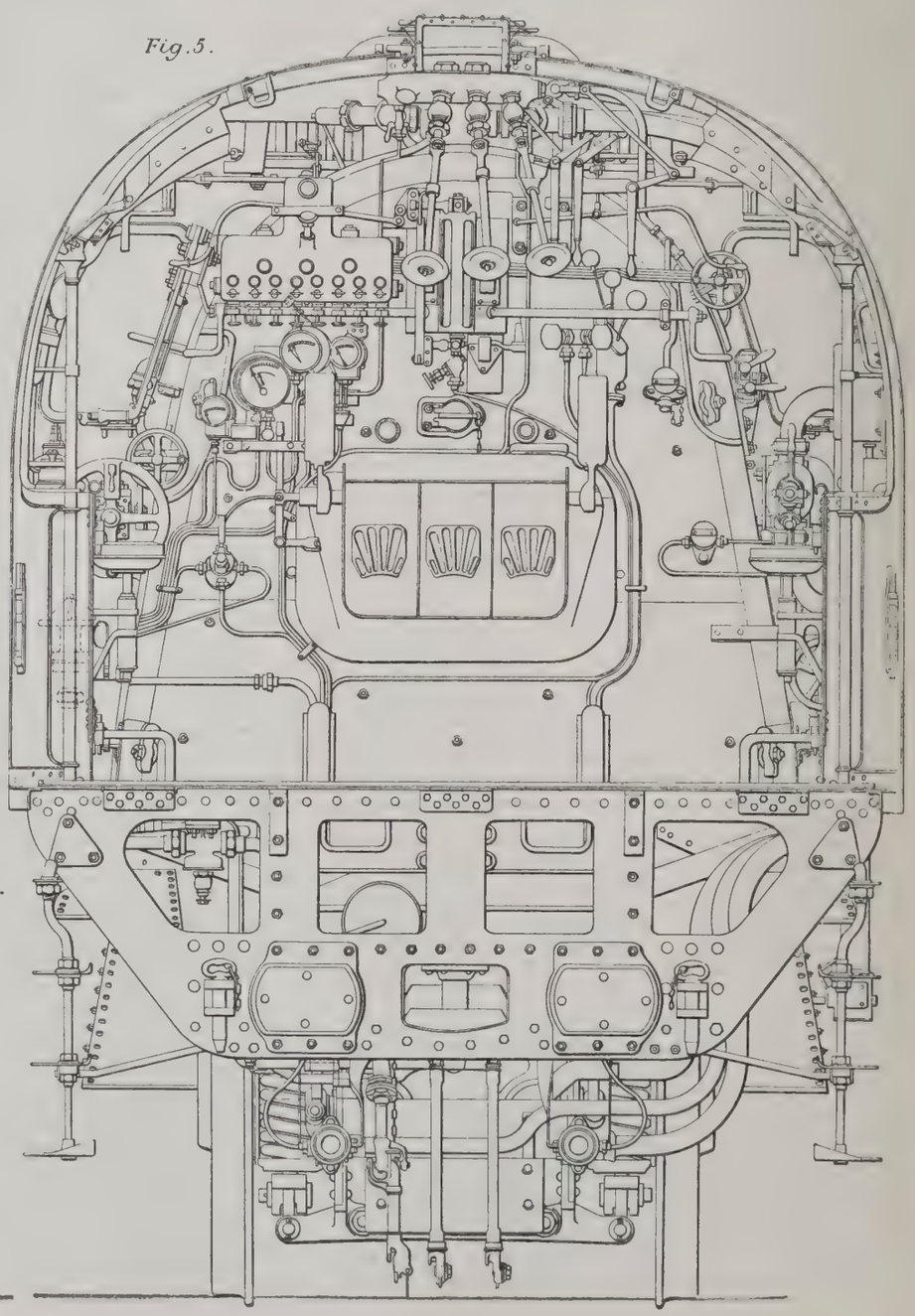

FOUR-CYLINDER PASSENGER LOCOMOTIVE (4-6-2 TYPE) FOR THE

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Fig.2.

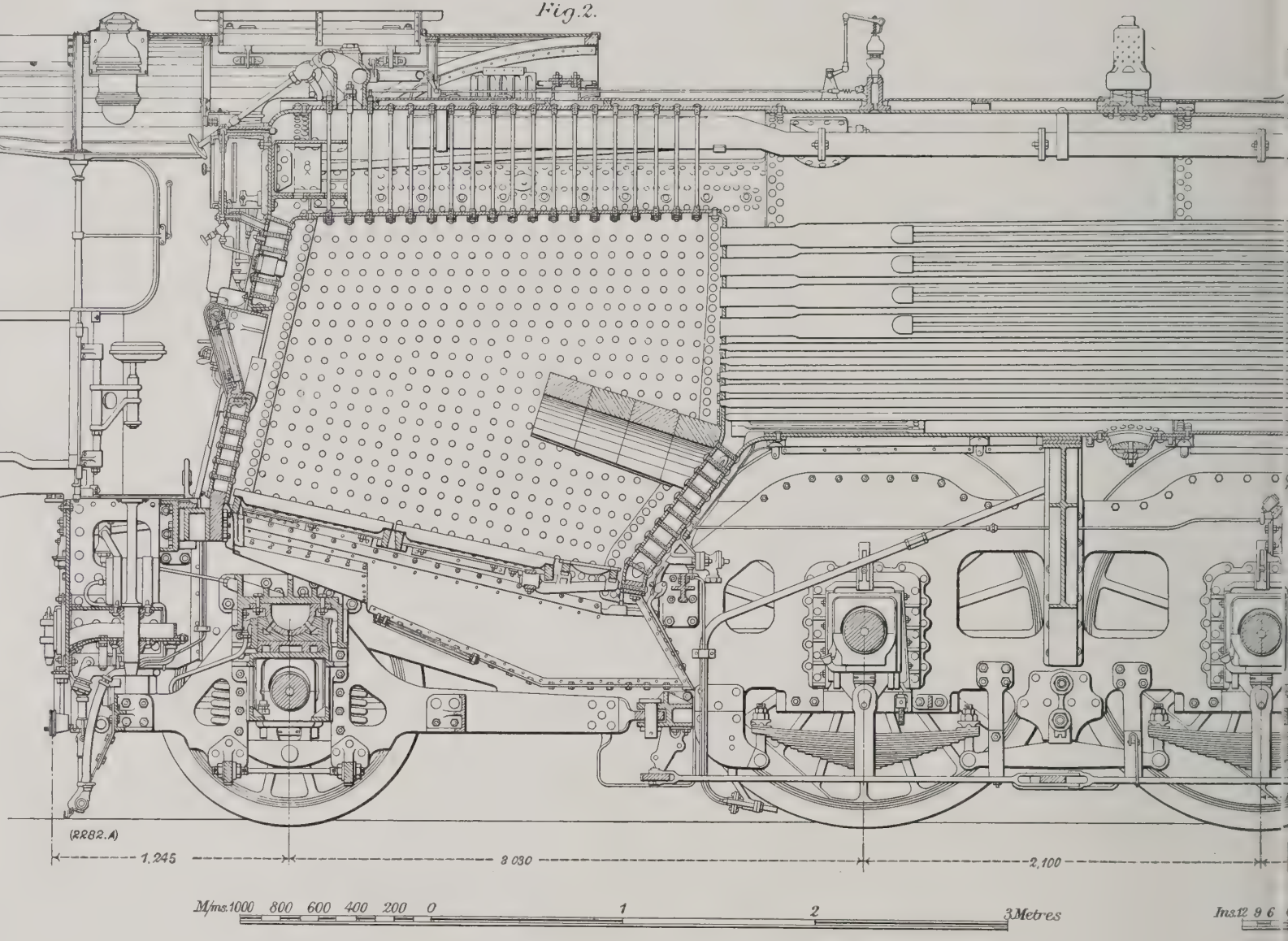
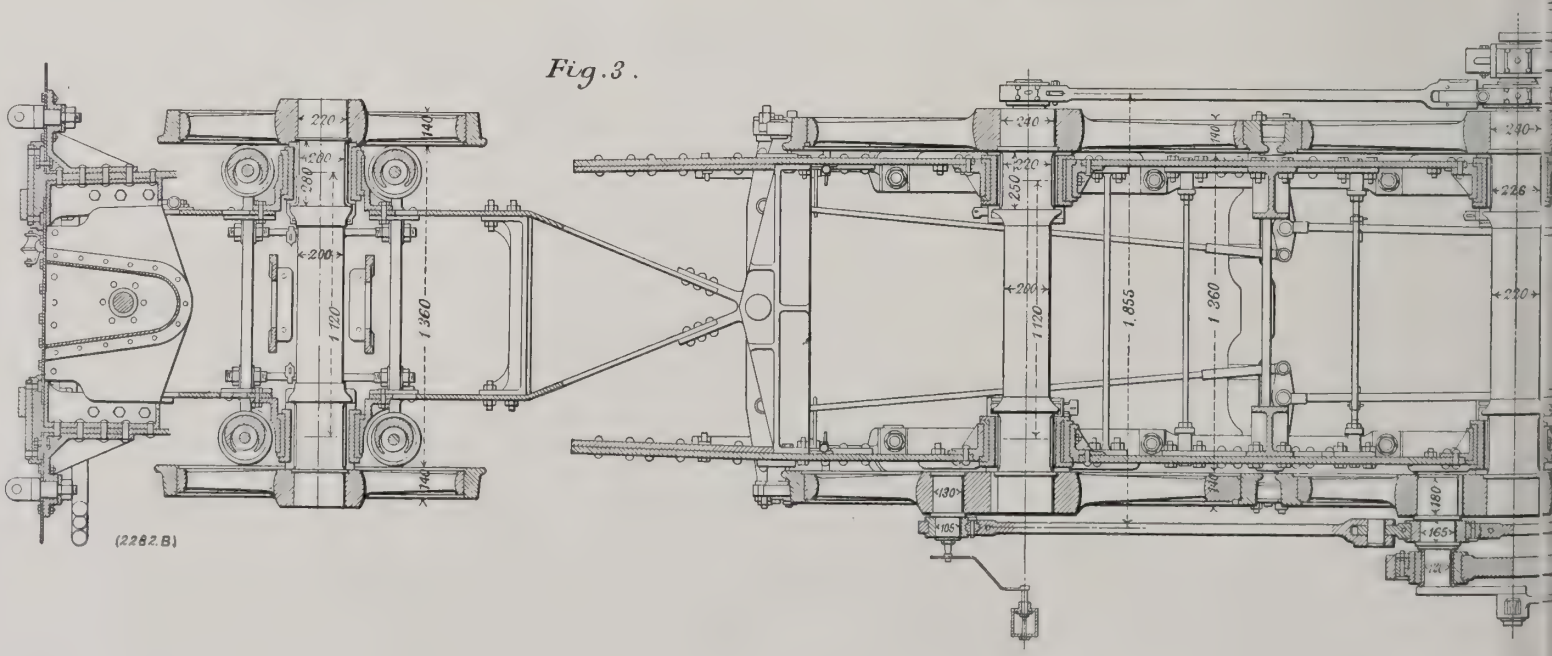


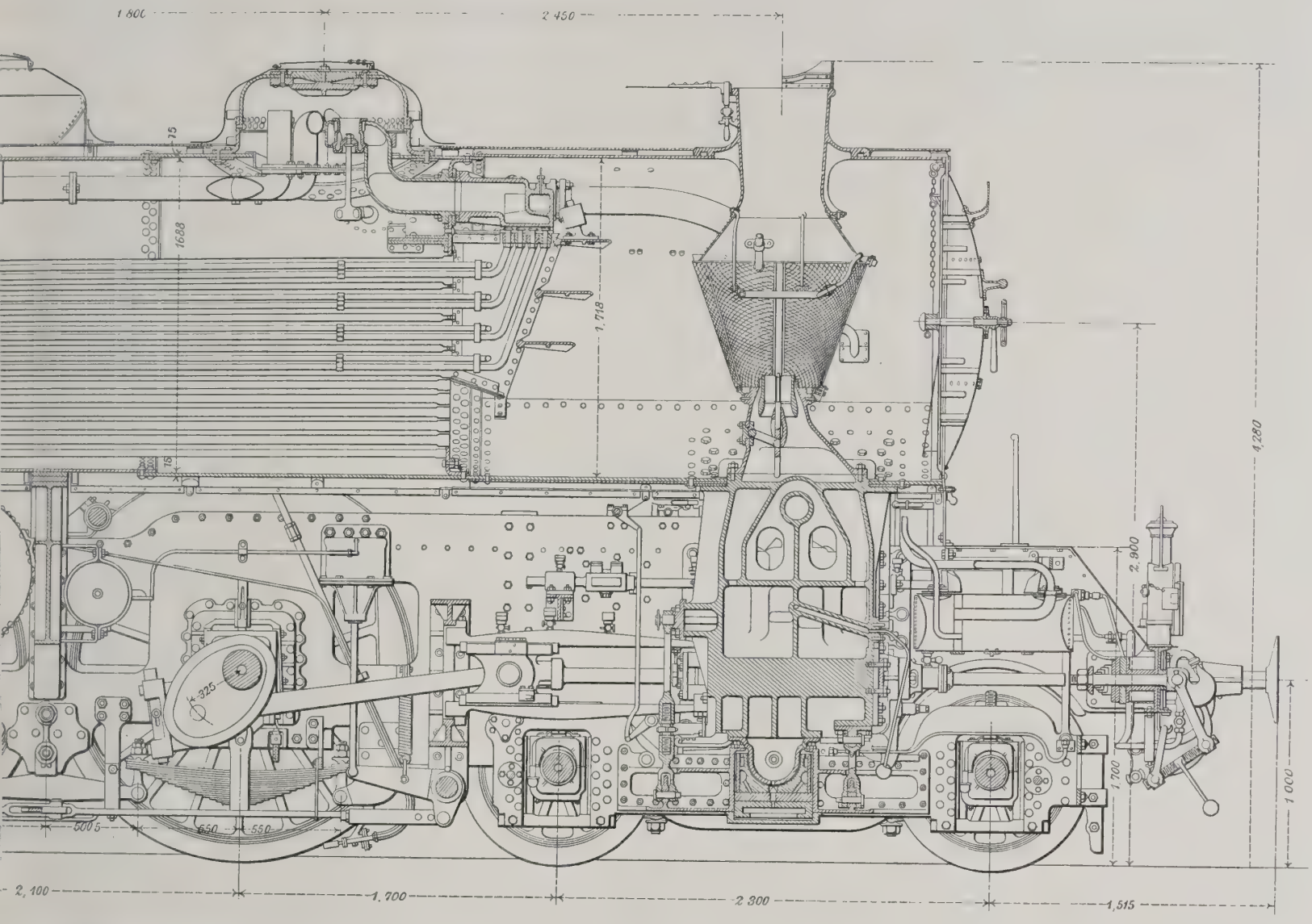
Fig.3.

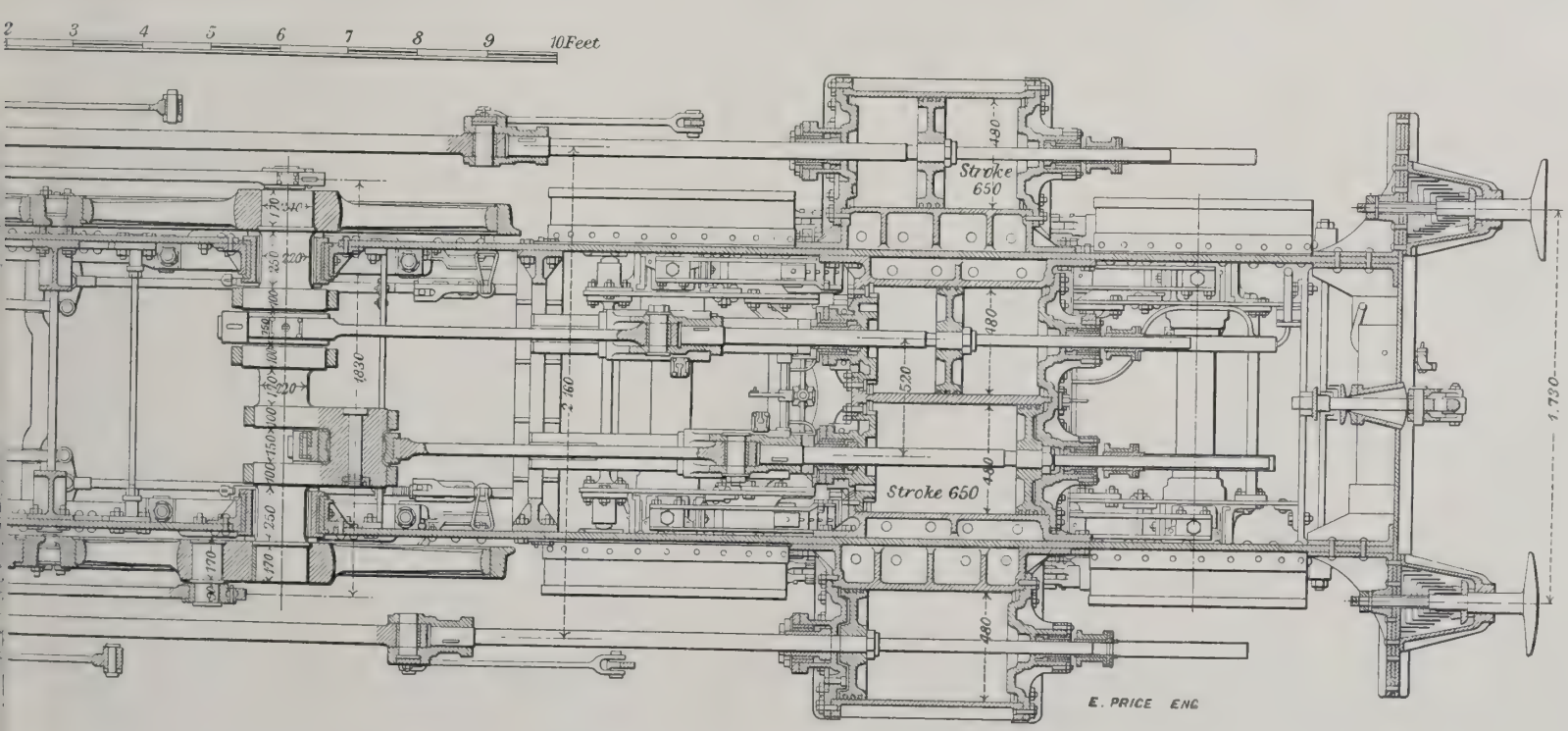


S-LYONS-MEDITERRANEAN RAILWAY, AT THE TURIN EXHIBITION.

S-LYONS-MEDITERRANEAN RAILWAY COMPANY.

(See Page 317.)





FOUR-CYLINDER LOCOMOTIVE; PARIS-LYONS-MEDITERRANEAN RAILWAY.

CONSTRUCTED AT THE PARIS WORKS OF THE PARIS-LYONS-MEDITERRANEAN RAILWAY COMPANY.

(*For Description, see Page 317.*)

Fig. 6.

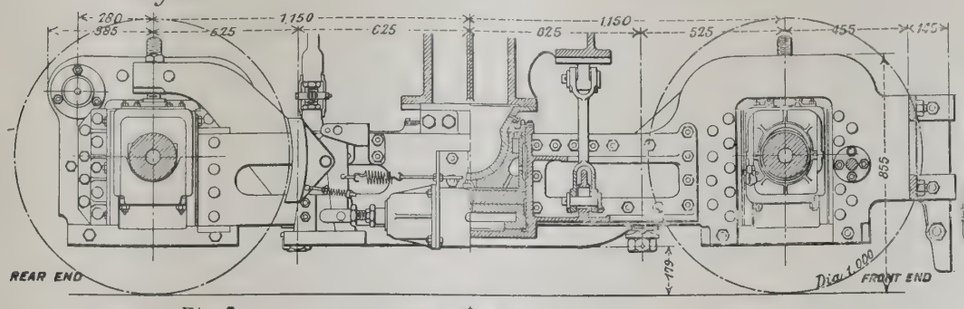


Fig. 8.

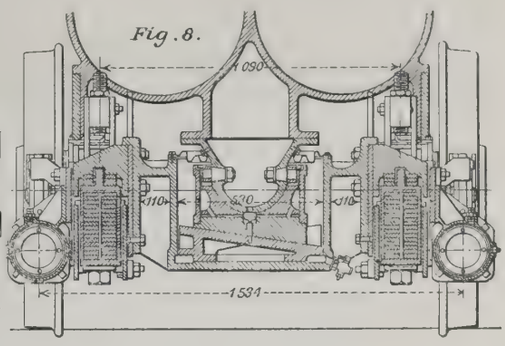


Fig. 7.

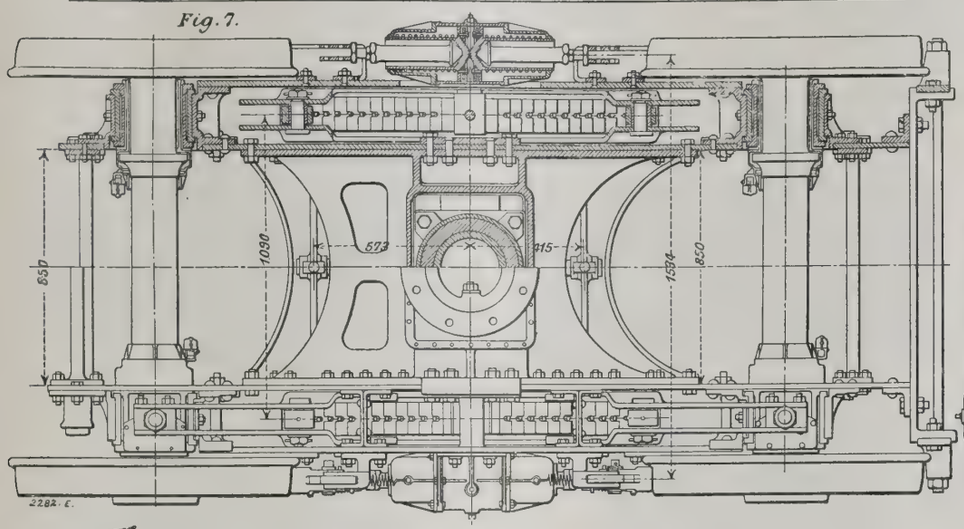


Fig. 9

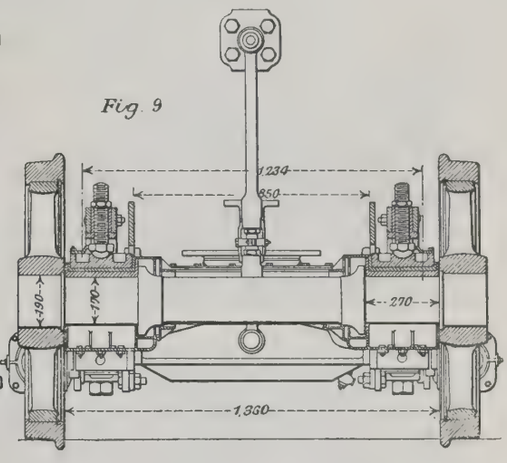


Fig. 10.

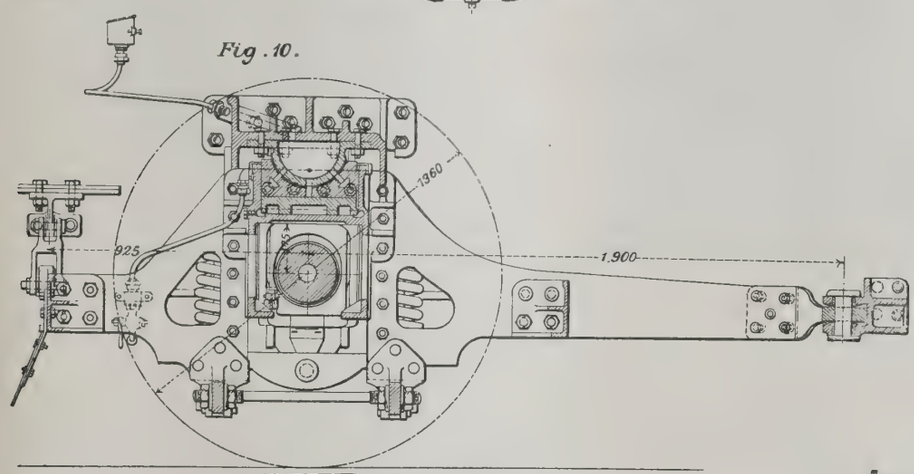


Fig. 12.

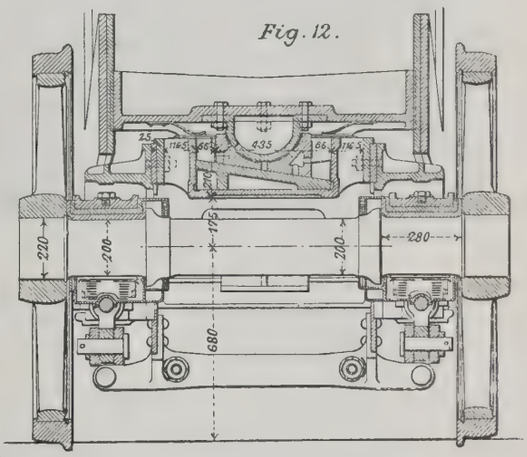


Fig. 11.

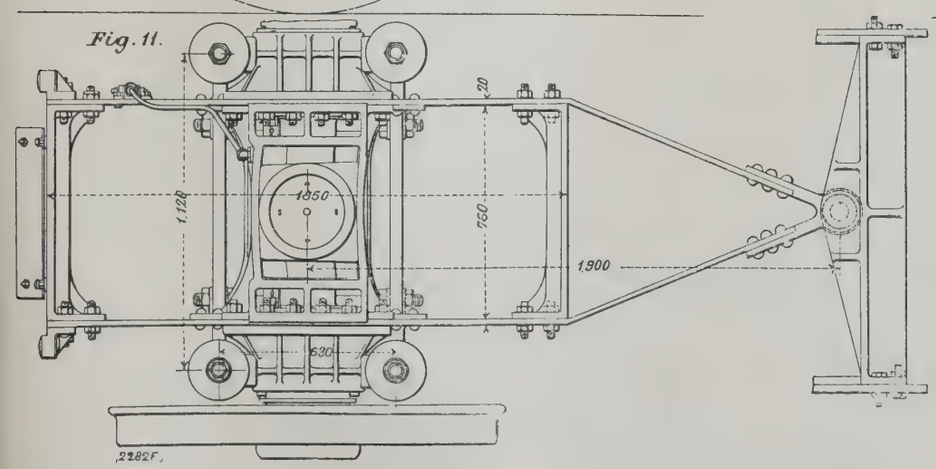
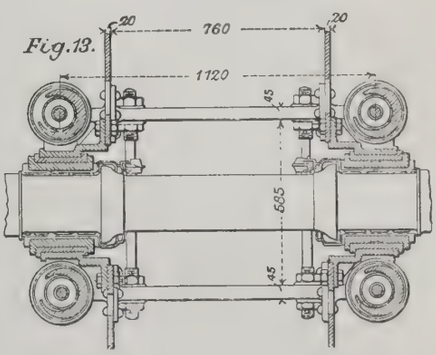


Fig. 13.



currents varying both in velocity and direction, and this made, he thought, automatic control impossible. He thought the question of body resistance raised by Mr. Berriman would prove very important. The addition of a body to a simple aeroplane altered the stream-lines round the latter, and consequently its supporting power, quite apart from all question of added resistances. In the last resort flying-machines must remain fragile structures. Let them consider all that had been spent on the Zeppelin machines and how little had come of it. Like a submarine, the flying-machine had only one position of rest, and that was at the bottom, and this would always be a difficulty. The fragility of the machines might, however, be mini-

mised by skilful design, and the lines might also be chosen so as to minimise the resistance, and here he thought there was a great field for improvement. The ultimate solution would, he thought, be the outcome of joint effort.

Professor Trouton, who followed, asked whether edge resistance had been allowed for in deducing the formula expressing the results of Zahm's experiments in air friction. Vernon Boys' photographs of bullets showed, he said, that an enormous quantity of air was affected by the bullet, and this effect should be eliminated in determinations of skin friction. He desired also further information as to the size of the "holes in the air." If these pockets were small, then by a system of Darwinian development we would reach machines of enormous size, which would be free from danger from small pockets.

Mr. J. S. Dines, who spoke next, said that his experiments on wind velocities had been made mainly at a height of 100 ft. above ground-level. A few had been made at greater heights, and these showed a much lessened range of variation. It followed, therefore, that speeds should be high tion of his experiments. The Wright Brothers appreciated from the outset the possible importance of gyroscopic action, and used, accordingly, two propellers revolving in opposite directions. An English machine, he might add, was now being built in which there were two independent engines and propellers.

Professor Turner expressed the thanks of the meeting to the various speakers, and added that Professor Petavel had just returned from a course in practical flying at Salisbury Plain.

In closing the discussion, Professor J. H. Biles said he thought much of the mathematics needed in the discussion of aeroplanes had already been worked out by Froude in his investigation of the screw-propeller. Actually a propeller revolved, but mathematically Froude had neglected this circular motion. His experiments had taken full account of skin friction and had confirmed his mathematical theory. The efficiency curves found corresponded with Fig. 9, given by Mr. Berriman. He wished to add that one of the earliest practical investigators of the problem of flight was Mr. Pilcher, who had been one of his own assistants, stated, carried the aerial and various odds and ends arranged in two boxes, which simply hooked on to the special saddle used. No. 2 horse carried the high-tension equipment on one side, and the low-frequency plant on the other (Figs. 10 and 11). The high-tension portion was sealed into an hermetically-closed box, and was therefore weather-proof. The low-frequency instrument-box opened out, leaving all necessary parts accessible to the operator. Both valve and crystal receivers were used. The third horse carried the petrol-engine and the dynamo used for generating the primary current (Fig. 13), and also the requisite supplies of petrol. The saddle itself could be lifted off by four men and rested on the ground, and then formed the framework supporting the engine and the dynamo. These were connected by a flexible shaft, which was removed when the saddle was replaced on horseback. The generator with its engine is shown to a larger scale in Fig. 14. The fourth horse carried the two masts (Fig. 12), each of which consisted of ten lengths, each 6 ft. long. These were hollow hexagons in section, so as to be light, strong, and capable of being closely packed.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

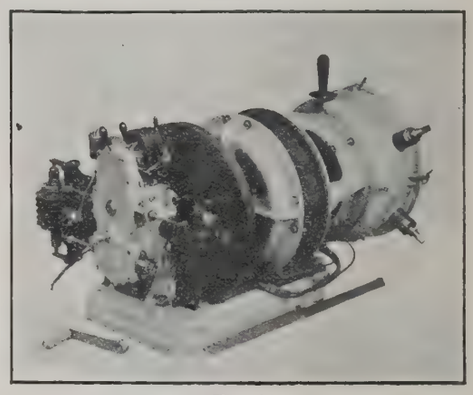


Fig. 14.

Figs. 10 to 14. The Marconi Company's Portable Wireless Telegraphic Plant for Military Service.

near earth, and that high speeds were not required at great elevations. This would make it difficult to adopt Professor Petavel's suggestion to fly fast and reduce the speed on landing. It was just at landing that the greatest variation in the air-currents might be expected.

Captain Maryatt, who spoke under pressure of time, expressed the view that without the loss of life which had been referred to we should still be lacking the knowledge already gained. It was impossible to teach a man to fly by formula.

Mr. E. Kilburn Scott said that he thought certain accidents could only be attributed to the gyroscopic action of the propelling machinery. Moreover, the aeroplane was necessarily fragile, and the machinery could accordingly easily get out of line, in which case the gyroscopic action might become very serious. He might add that Mr. Brennan was now investigating the question of gyroscopic control. For the reasons he had stated, a small gyroscope must be used (in order not to strain the framework), which would operate relays.

In reply, Mr. Berriman said that Dr. Shaw, Professor Petavel, and Mr. Dines had expressed different views as to the value of speed. Mr. Beaumont had stated that the limit of weight in engines had now apparently been attained. The speaker thought that the credit for the reduction effected belonged to the pilots, who insisted on the makers halving the weights of the engines. The Wrights were the first to build engines which would fly, and had introduced hollow connecting-rods with screwed-on ends, so as to save weight. With respect to the "edge effect," he would refer Professor Trouton to Zahm's own descrip-

and a naval officer. We had owed much to the Navy in the past, and he hoped for much in the future, particularly with respect to aerial navigation.

Wireless Telegraphy.

On the conclusion of the joint meeting with Section A, a paper by Professor G. W. O. Howe was taken, entitled "Recent Developments in Radiotelegraphy." Before reading his paper Professor Howe explained that he had an instrument coupled up to an aerial secured to the roof of the adjacent Town Hall, and that a Brown telephonic relay was coupled to this, which would enable the whole room to hear the signals sent from Norddeich and from Wilhelmshaven, in Germany. A modification of the Brown relay had, he stated, been fitted to certain ships supplied with the Telefunken apparatus, and the long distances covered were widely advertised, though nothing was said as to the Brown relay with which the results were secured. When the signals came through from Norddeich, Professor Howe drew attention to the clear musical note which was received, which was due, he said, to the use of the Wien spark-gap. He then read his paper, which we reproduce on page 335.

Captain H. Riall Sankey then exhibited a number of slides illustrating the portable wireless plant introduced by the Marconi Company. A few of these are reproduced on the present page. Of these equipments, one was arranged for cavalry use, the limit of weight per horse being fixed at 185 lb., and the actual weight a little less. The whole outfit was carried by four horses, and there were four more carrying riders in attendance. No. 1 horse, he

The earth used was a mat of copper gauze. The aerial was stretched between the two masts as a horizontal conductor, 350 ft. long. The sending apparatus was connected at one end of this, and a directed wave was obtained, the strength of wave being much greater in one direction than elsewhere. This plan had, he said, great advantages for military equipments. The saddle framings were all constructed out of bicycle tubing, padded to fit the horse, and each saddle would stand when rested on the ground. With skilled men the time needed to erect the plant ready for working was 9 minutes, and to dismantle and pack it again 6 minutes. With unskilled hands in Turkey the equipment, at the first time of asking, had been erected in 21 minutes. One infantry set was identically the same equipment, but carried in two carts. The power needed was 400 watts, and the range, even in mountainous regions, was 20 miles. Over moderately hilly country it was 75 km., and over sea 100 miles. A more powerful equipment with a generator yielding 1½ kw. was also supplied, and this had a range of 200 miles. In this case the height of the masts was 80 ft. instead of 60 ft. The generator supplied 300 sparks per second. This equipment was all carried on a single motor-car.

Professor Dalby, who occupied the chair in the absence of Professor Biles, moved a vote of thanks to the authors, and the discussion was opened by Mr. E. Kilburn Scott, who asked whether any trouble was experienced with nitro-peroxide gas generated by the spark. This, Captain Sankey replied, was not the case. A speaker, whose name did not transpire, asked whether it was necessary for the attendant at the receiving end to be always

listening, or whether there were means of attracting his attention.

Captain Sankey then said that the operator at the receiving end had to wear the telephonist's apparatus, but this was no great drawback, as he could be reading a novel until called. Discussing Professor Howe's paper, he said that there would soon be a long-distance transmission at work from Coltano, Italy, and in South America. He also remarked that it was interesting to observe that if a spark lasted one-twentieth of a second, the wave would in that time have traversed 9500 miles.

Professor Dalby asked for information as to the longest and the shortest wave-lengths practically employed, and whether it was possible, if desirous of receiving a note of 2000-ft. wave-length, to tune out one of 2100 ft.

In reply, Professor Howe said that on the trans-Atlantic service a wave-length of 20,000 ft. was employed, and in the other direction about 300 metres was the minimum length used. Most ships were equipped with apparatus designed for wave-lengths of from 300 to 600 metres. As to how far waves could be tuned out at the receiver depended upon the plant at the transmitting station. If the latter gave a well-sustained wave, it was easy to tune it out; but it was impossible to tune out an explosion, which was what was transmitted by some stations. The stations on the French coast in particular were fitted with very bad apparatus, so that, in fact, it was impossible to say what their frequency was supposed to be, The Clifden transmission, on the other hand, was easily turned out.

(To be continued.)

FOUR-CYLINDER LOCOMOTIVE; PARIS-LYONS-MEDITERRANEAN RAILWAY.

THE Paris-Lyons-Mediterranean Railway Company show at the Turin Exhibition a four-cylinder (4-6-2 type) passenger locomotive which they have built in their Paris works for heavy express train service. This particular engine was put on the line on August 25, 1909, and previous to being sent to Turin it had run, both in the course of trials and in active service, a distance of 75,000 km. (46,500 miles).

The engine exhibited, which we illustrate this week by Plate XL., and by detail views on pages 314 and 315, is numbered "6101," and the company built at the same time at their Paris works another engine, No. 6001, of equal power, but compound, without superheat; pressure, 16 kg. per sq. cm. (228 lb. per sq. in.). This engine, No. 6001, was tried in the same time as that—No. 6101—we illustrate. The latter engine has four equal cylinders, and is fitted with a superheater, and during the trials just mentioned it was found to be the better of the two. The economical advantages, in fact, were about the same as those of the compound type with superheat over the compound type without superheat. These trials led the company to order at once thirty engines of the 6101 type, which are now being delivered. The following is an abstract of the tests carried out with this engine, and with the one, No. 6001, referred to above :—

COMPARISON OF TEST RESULTS OBTAINED FROM LOCOMOTIVES No. 6001 AND No. 6101.

	Average Water Consumption per Unit of Coal Consumption.	Average Consumption per Horse-Power Hour, indicated on the Pistons		Average Consumption per Horse-Power Hour Absorbed by Tender Draw-Hook	
		of Coal.	of Water.	of Coal.	of Water.
Engine No. 6001	7.31 litres per kg. (0.73 gal. per lb.)	1.553 kg. (3.4 lb.)	11.27 litres (2.48 gals)	2.661 kg. (5.9 lb.)	19.39 litres (4.27 gals.)
Engine No. 6101	7.12 litres per kg. (0.71 gal. per lb.)	1.350 kg. (2.98 lb.)	9.57 litres (2.11 gals.)	2.221 kg. (4.9 lb.)	15.74 litres (3.46 gals.)
Difference	0.19 litre per kg. (0.019 gal. per lb.)	0.203 kg. (0.42 lb.)	1.70 litres (0.37 gal.)	0.440 kg. (1 lb.)	3.65 litres (0.81 gal.)
Equal, per cent.	2.60	13.07	15.08	16.53	18.82

The following are the principal dimensions of the engine exhibited at Turin :—

Total length of grate	2.135 m. (7 ft.)
Width of grate, front	2.086 m. (6 ft. 10 in.)
,, ,, ,, rear	1.922 ,, (6 ,, 4 ,,)
Grate area	4.25 sq. m. (45.25 sq. ft.)
Inclination of grate	12 deg.
Height of fire-box inside, front	2.016 m. (6 ft. 7⅜ in.)
Height of fire-box inside, rear	1.530 ,, (5 ,, 0¼ ,,)
Length of fire-box inside, at top	2.258 ,, (7 ,, 5 ,,)
Length of fire-box inside, at bottom	2.078 ,, (6 ,, 9 13/16 ,,)
Width of fire-box inside, level with centre of boiler	1.516 ,, (4 ,, 11 1/16 ,,)
Width of fire-box inside at bottom, front	2.086 ,, (6 ,, 10 ,,)
Width of fire-box inside at bottom, rear	1.922 ,, (6 ,, 3 1/16 ,,)
Thickness of copper, sides and back plate	14 mm. (0.551 in.)
Thickness of copper, tube-plate	25 mm. and 14 mm. (0.984 in. and 0.551 in.)

The boiler-tubes are of steel, and they are smooth. There are 143 having 55 mm. (2.165 in.) outside diameter, and 28 of which the outside diameter is 133 mm. (5.236 in.); the former are 2.2 mm. (0.085 in.) thick, and the latter 4 mm. (0.157 in.). The length of the tubes between tube-plates is 6 m. (19 ft. 8 3/8 in.). The superheater tubes are also of steel; they form 28 sets, their outside diameter is 35 mm. (1.378 in.), and their thickness 3.5 mm. (0.137 in.).

Heating surface, fire-box	15.87 sq. m. (171.12 sq. ft.)
,, ,, tubes	202.24 ,, (2176.58 ,,)
,, ,, total	218.11 ,, (2347.70 ,,)
Superheating surface	70.63 ,, (760.10 ,,)
Outside length of fire-box shell at top	2.540 m. (8 ft. 4 in.)
Outside length of fire-box shell at bottom	2.311 ,, (7 ,, 7 ,,)
Outside width of fire-box shell at bottom, front	2.341 ,, (7 ,, 8 ,,)
Outside width of fire-box shell at bottom, rear	2.181 ,, (7 ,, 2 ,,)
Diameter of boiler-barrel, inside large ring	1.688 ,, (5 ,, 6½ ,,)
Length of barrel	5.890 ,, (19 ,, 4 ,,)
Thickness of barrel-plates	15 mm. (0.590 in.)
Inside length of smoke-box	2.630 m. (8 ft. 7 9/16 in.)
Inside diameter of smoke-box	1.718 ,, (5 ,, 7⅝ ,,)
Height of centre line of boiler above rail-level	2.900 ,, (9 ,, 6 ,,)
Water capacity up to 100 mm. (4 in.) above fire-box crown	8.150 cub. m. (1793 gal.)
Steam space	3.670 cub. m. (130 cub. ft.)
Working pressure	12 kg. per sq. cm. (170 lb. per sq. in.)

The chimney has an inside diameter of 485 mm. and 411 mm. (19.1 in. and 16.2 in.). Its top rim is at a height of 4.135 m. (13 ft. 7 in.) above the rail-level. The top of the blast-nozzle is 0.318 m. (12½ in.) below the centre line of the boiler.

Distance between frame-plates	1.234 m. (4 ft. 0⅝ in.)
Thickness of frame-plates	28 mm. (1.102 in.)
Outside width of foot-plate, front	2.600 m. (8 ft. 6⅜ in.)
Outside width of foot-plate, rear	2.880 ,, (9 ,, 5⅜ ,,)
Length of engine outside buffers	13.990 ,, (45 ,, 10¾ ,,)
Diameter of wheels — tyres 70 mm. (2.756 in.) thick)— bogie	1.0 m. (39.37 in.)
Diameter of coupled wheels	2.0 ,, (78.74 ,,)
Diameter of trailing wheels	1.360 ,, (53.54 ,,)

There are four cylinders, two outside and two inside, they all are 480 mm. (18.898 in.) in diameter, with a 650 mm. (25.59 in.) stroke.

Distance from centre to centre of outside cylinders	2.160 m. (7 ft. 1 in.)
Distance from centre to centre of inside cylinders	0.520 ,, (1 ,, 8½ ,,)
Length of outside connecting-rods	3 m. (9 ft. 10 1/16 in.)
Length of inside connecting-rods	1.675 m. (5 ft. 6 in.)
Lead of inside cylinder cranks over outside ones	180 deg.

The valve motion of both the outside and inside cylinders is on the Walschaert principle; the slide-valves are cylindrical, 220 mm. (8.661 in.) in diameter, with a 121-mm. (4.764 in.) maximum stroke. The outside lap is 30 mm. (1.181 in.), and the inside lap 4 mm. (0.157 in.).

Average maximum steam admission	70 per cent.
Angle of oscillation of link	43 deg. 32 min.
Length of steam-ports of all cylinders	512 mm. (20.158 in.)
Area of inlet and exhaust-ports	0.02048 sq. m. (31.75 sq. in.)
Area of steam inlet-pipe	0.0154 sq. m. (23.87 sq. in.)
Area of exhaust-pipe	0.0240 ,, (37.20 ,,)
Maximum opening of adjustable exhaust-pipe	0.0223 ,, (34.56 ,,)
Minimum opening of adjustable exhaust-pipe	0.0150 ,, (23.25 ,,)
Weight of engine, empty	83,200 kg. (81 tons 18 cwt.)
Weight, in working order, on each bogie axle	11,200 kg. (11 tons)
Weight, in working order, on each coupled axle	18,500 kg. (18 tons 4 cwt.)
Weight, in working order, on the trailing axle	14,900 ,, (14 ,, 13 ,,)
Total engine weight in working order	92,800 kg. (91 tons 6 cwt. 3 qr.)
Weight on the springs	70,800 kg. (69 tons 13 cwt. 3 qr.)
Weight unsprung	22,000 kg. (21 tons 13 cwt.)
Weight available for adhesion	55,500 kg. (54 tons 12 cwt. 2 qr.)

The boiler, with the exception of the inside fire-box, which is of copper, is built throughout of mild steel. The top part of the fire-box shell joins direct on to the barrel, without an intermediate dished plate. The fire-box shell is in three parts, the crown and two side plates double-riveted together. Hollow steel stays connect together the crowns of the inside and outside fire-box; a row of transverse stays, drilled only for a length of 194 mm. (7.638 in.) at both ends, connect together the fire-box side-plates at their top part, where they are flat, and not stayed by the crown stays. The front and rear fire-box sheets are not vertical, but slant, as shown. The back plate is strengthened above the fire-box by plate-stays and by two longitudinal stays fitted to the barrel.

The front and back plates and the side plates of the inside copper fire-box are stayed to the outside shell by manganese-bronze stay-bolts, except at the part of the side walls underneath the fire-brick arch, where the stays are of copper. The fire-box tube-plate is also connected to the barrel by ten steel stays. The inside fire-box crown is curved transversely, and slants from the front to the rear. This assists in maintaining a good supply of water over the fire-box when the engine is descending an incline.

The barrel is built of three rings. The longitudinal seams are butt-jointed with double straps; the inside strap is double riveted to each ring-plate, while the outside strap is single riveted only. The transverse seams are lap-jointed and double riveted. The boiler lagging consists of yellow brass sheets fitted to a series of supports and held in place by rings on the barrel and by screws on the fire-box shell. The space between is filled with asbestos boards. The fire-box door is on a horizontal hinge; it opens from bottom to top on the inside of the fire-box. It consists of three flaps; the end ones open by means of levers, the central one butting on either one of the former. The levers are fitted with counter-weights sufficiently heavy to maintain the door open, but not too heavy to prevent it from closing automatically under the action of an escape of steam should a boiler-tube burst.

The superheater is of the Schmidt type. The smoke-tubes containing the superheater tubes end in a casing closed in front by three doors which open out automatically as soon as the regulator is opened; the circulation of hot gases in the smoke-tubes is thus only made possible when steam from the boiler circulates in the superheater tubes.

The frame-plates are of steel, 28 mm. (1.102 in.) in thickness. They are inside the wheels and are connected together in front by an I steel buffer beam, in the rear by a draw-plate built up of plates and angles, by six intermediate cross-beams cast in steel, and by the inside cylinders. The front bogie, which is illustrated fully in Figs. 6 to 9, on page 315, offers no special feature. The single-axle Bissel bogie at the rear end is illustrated on the same page by Figs. 10 to 13, which show the details clearly. It has a 66 mm. (2.598 in.) play on each side.

The driving-axles are bored through their whole length, the diameter of the hole being 40 mm. (1.575 in.). The inside cylinders drive the first axle, which is a crank-axle; the outside cylinders drive the second axle. There is one valve-gear for both cylinders on each side of the engine; it is outside the frame-plate, and is, as we have already stated, of the Walschaert type. It operates the valves of the outside cylinders directly, and those of the inside cylinders through a rocking lever jointed at the middle of its length on a support fixed to the frame-plate. By this means the steam distribution to the inside cylinders is the reverse of that to the outside cylinders. The valves are cylindrical, and with inside admission. Air-inlet valves are fitted to the steam-pipes for running with closed regulator. The reversing gear is with screw mechanism. The relative positions of the cylinders and valves is shown by Fig. 4, on page 314.

The steam supply is effected through a regulator with balanced valve, placed inside the steam-dome, and operated by a lever from the footplate. The steam flows first to a compartment of the steam-collector, which distributes it to the twenty-eight sets forming the Schmidt superheater, whence it proceeds to the other compartment of the collector, and thence to the cylinders by two pipes fitted at the two ends of this second compartment. The slide-valves are lubricated by a sight-feed lubricator having eight tubes, two for each valve-chest, and fitted to the back plate of the fire-box. Each cylinder is provided with a ball lubricator.

The engine is fitted with a combined automatic

THE BARBOUR HOMOPOLAR DYNAMO.

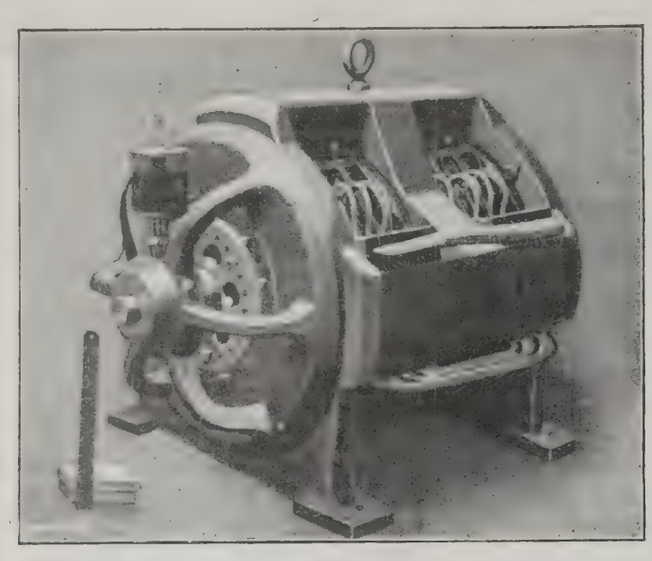


Fig. 1.

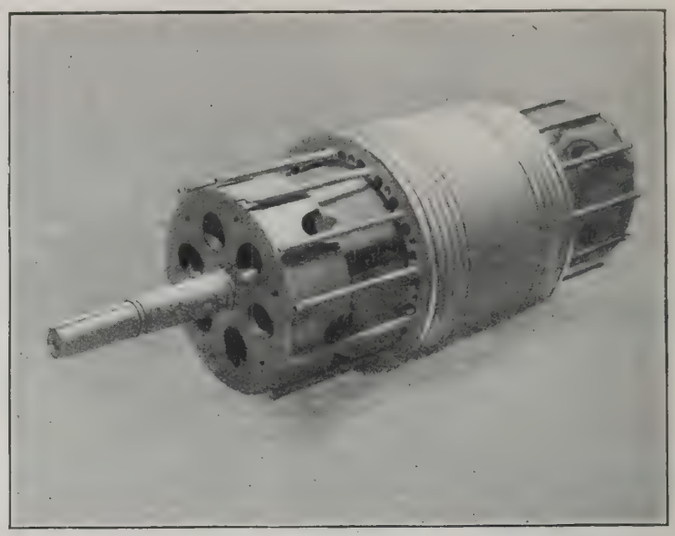
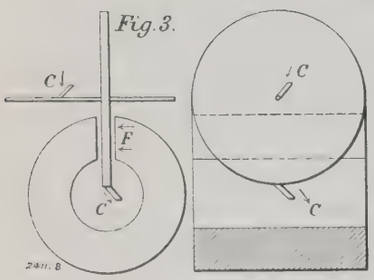
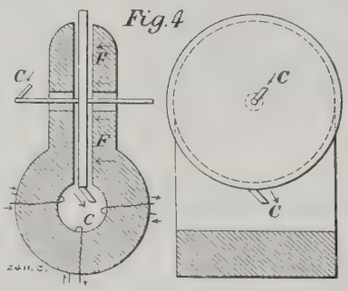
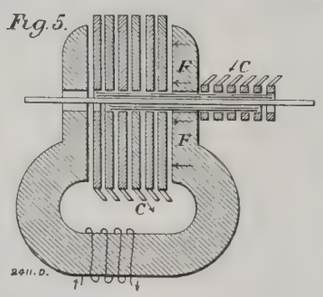
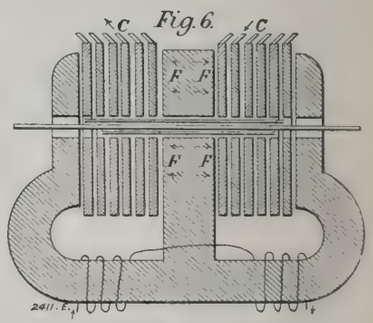


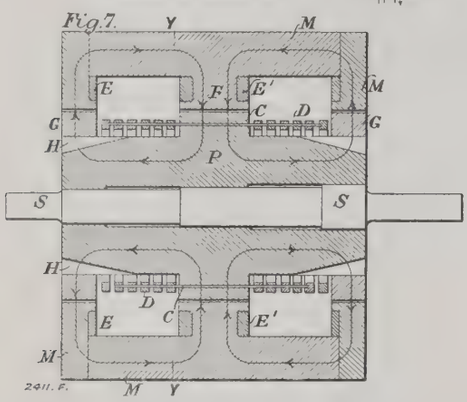
Fig. 2.

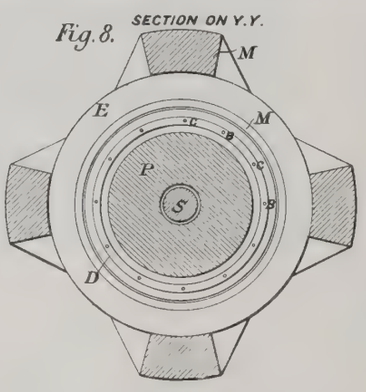


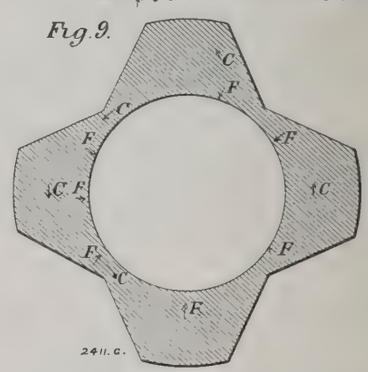












Westinghouse-Henry compressed-air brake. All the axles, with the exception of that of the Bissel bogie, are braked up to 50 per cent. of their weight on the rail. There are two sets of independent brake mechanisms, one for the bogie truck and one for the coupled wheels. The engine is also provided with a Flaman speed-indicator.

The tender has a total length of 9.380 m. (30 ft. 9 in.), it is carried on two bogies, and has a water capacity of 28 cub. m. (6160 gallons), and a coal capacity of 5 tons. It weighs, empty, 28,290 kg. (27 tons 17 cwt.), and in running order 61,940 kg. (61 tons).

The Paris-Lyons-Mediterranean Company also exhibit at Turin a saloon carriage, a first-class carriage with compartments *de luxe* and sleeping compartment, another first-class carriage with sleeping berths, and a third-class carriage, all most substantially built and carefully finished.

THE BARBOUR HOMOPOLAR DYNAMO.

It is well known that the development of direct-current turbo-generator units has been much retarded by difficulties encountered with their electrical ends. These difficulties arise mainly in connection with commutation, and become more serious as units increase in size. They are of such gravity that only with the most skilful design do satisfactory machines become possible, while for large sizes it has become the practice to mount and run two smaller machines in tandem, which naturally decreases efficiency and increases first cost. Really large direct-current turbo sets, comparable in size to large turbo-alternators, are unknown, and it is probable that in many cases alternating-current generators, with converting machines, have been installed to deal with situations which might have been better met by direct-current turbo-generators had these been available in sufficiently large units. These considerations have led to a revival of interest in the homopolar type of dynamo, and a fortnight ago we dealt with a design which had been produced by M. Ugrimoff, of Moscow, and which was fitted with mercury brushes. We now illustrate a design which has been developed by Mr. R. H. Barbour, and of which an example is to be exhibited at the forthcoming Electrical Exhibition at Olympia. Homopolar dynamos are peculiarly suited for high speeds, and Mr. Barbour, in his design, would appear to have achieved a machine of singular mechanical excellence, and one that should be capable of meeting the large potential demand which exists for a satisfactory direct-current dynamo of large output and high speed. Up to the present the design of the brush-gear has been one of the difficulties limiting the employment of homopolar machines, and the radical alteration in type which Mr. Barbour has adopted is one of the features of interest of his machine. Whatever may be thought of his system by those having no experience of it, it is at least likely to appeal more strongly to engineers than any arrangement depending on a mercury contact.

The dynamo which will be seen at the Exhibition to be opened at Olympia on the 23rd of this month is of 50 kw. capacity, and generates 100 volts at 3500 revolutions per minute. It is illustrated in Figs. 1 and 2 above. Before dealing in detail with the machine, however, it will be of interest to trace its development from the simplest possible type of homopolar machine as represented by Faraday's disc, and illustrated in Fig. 3, above. This machine consists merely of a plain copper disc rotating in the field of a magnet F, and having brushes C C, one at the circumference and one on the shaft. This type of machine has received a commercial application in a certain type of ampere-hour meter. The Faraday machine in its simplicity is, of course, characterised by a very low voltage, and in adapting it for practical use it is necessary to bring the whole surface of the disc under the influence of the field, and at the same time to arrange for a uniform magnetic field in order to avoid eddy-current losses. A machine modified in this way, and fitted with field coils, in the place of a permanent magnet, would appear somewhat as in Fig. 4.

The next stage in the development of the homopolar disc machine is illustrated in Fig. 5, which shows a number of discs which are connected in series in order to increase the possible voltage, and are arranged to rotate in a single magnetic field in order to economise iron. This figure represents diagrammatically the lines on which the disc type of machine has tended to develop. Electrically the arrangement is fairly satisfactory, but the connection of the external slip-rings to the centres of the discs introduces mechanical difficulties. Improvement is effected by using a twin field, as shown in Fig. 6, since this doubles the voltage without increasing the number of slip-rings, but the mechanical difficulties remain, and it must be noted that if the clearances at the ends of the rotor are not equal, there may be a serious magnetic end-thrust. The reluctance of machines of this class need not be high, since the current density in the discs is low, and they may be

THE BARBOUR HOMOPOLAR DYNAMO.

Fig. 10.

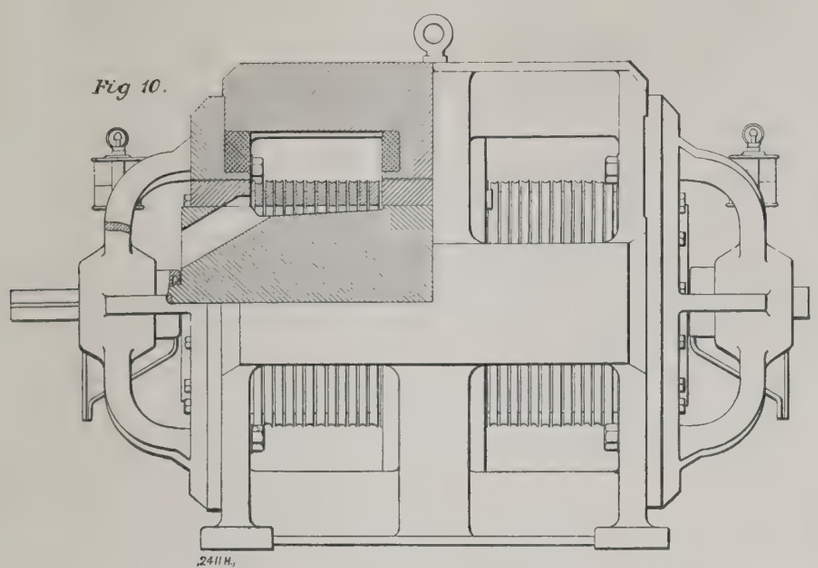


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Fig. 11.

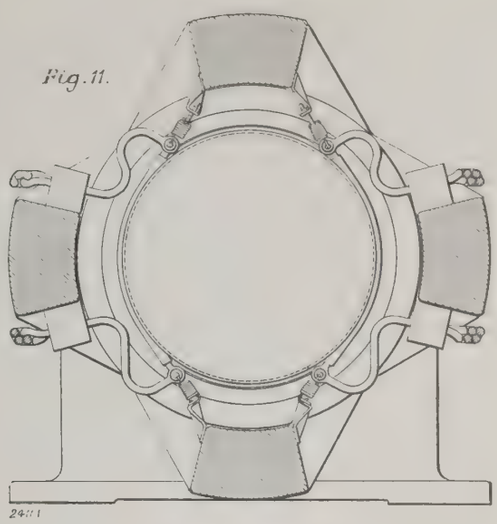

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Fig. 12.

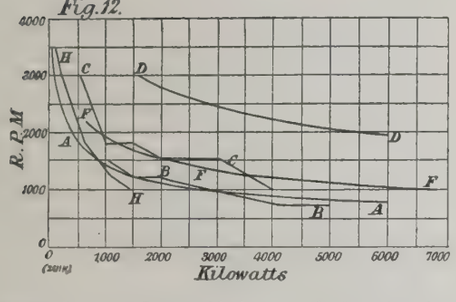
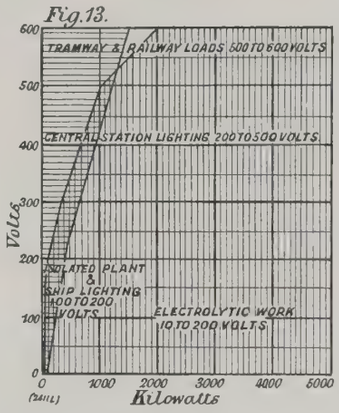


Fig. 13.



made of iron. It should be noted that in these machines the actual path of the current in the rotor is a matter of no importance, and a consideration of, and experiment with, a machine somewhat on the lines of Fig. 6, led Mr. Barbour to the final design of his machine, which is shown in the essentials in Figs. 7 and 8, on page 318.

This machine, which may be looked upon as a direct development from that shown in Fig. 6, is really of the cylinder type, and illustrates the fact that the disc and cylinder machines are in essence identical. It consists of a solid rotor P and a fixed frame M. E E^1 are the field cores, C C the conductors carried in mica tubes in tunnels in the rotor, and D D are the collector-rings. The end poles of the rotor, which are necessarily made removable, in order to permit of the assembling of the machine, are, in the example exhibited, made with laminated rings, as also is the centre pole, which, however, may be one with the main part of the rotor. The collector-rings are carried by bolts running from end to end of the rotor, parallel to the conductors, and insulated with mica tubes. Their positions are indicated at B B in Fig. 8. The conductors C C are also carried in mica tubes through the collector-rings, except, of course, through those to which they are connected. There is also mica insulation between the collector-rings. Various grooves, as shown at H in Fig. 7, are made at the end of the rotor core, and air drawn in through them is, owing to the high speed of rotation, ejected between the collector-rings, effectively cooling them, and also serving to blow out any incipient arc forming between an adjacent pair. The difference in voltage between neighbouring rings is, of course, small. An important detail of the machine is shown in Fig. 9, on page 318. This illustrates a section taken through the casting forming the centre pole of the fixed part of the machine, and shows the method of constricted paths by which the magnetism induced by the armature current is throttled and prevented from interfering with the shunt flux. The path of the armature flux is shown at C C, and of the shunt flux at F F.

The brushes of the machine, which are said to operate very satisfactorily, are one of its points of special interest. The collector-rings are grooved, and the brushes, which are stretched around the greater part of their circumference, consist of very flexible copper cores wound with German-silver armouring. The armouring, although it slightly decreases the flexibility, protects the core from wear, and is found to make remarkably good contact. The brushes are held in place by springs arranged with tension-nuts, and carried by brackets secured to the framework. The internal cores of the brushes are led away from one end to the terminal board of the machine. It is found that for good contact the tension of the brush springs can be kept low, so that there is no undue friction loss or wear. It should be said that German silver for the armouring was chosen not as the material which under some specified condition gave the lowest contact resistance, but as the material which proved the most practically satisfactory and gave the most consistent results. Provision is made to allow a certain amount of lubricant to feed on to the brushes.

Some particulars of the machine to be exhibited at Olympia are as follow :—

Capacity	50 kw.
Voltage	100
Revolutions per minute	3500
Length between bearings ...	29⅜ in.
Height of frame	28¾ ,,
Width of frame	28 ,,
Diameter of rotor	14¼ ,,
Peripheral velocity	... 12,800 ft. per min.
Field amperes	5
Number of conductors	12
Width of each collector-ring ...	½ in.
Axial length of centre pole ...	6 ,,
Length of each end pole	3½ ,,

Two views taken from working drawings of the machine are given in Figs. 10 and 11, above, but it must be pointed out that the arrangement there shown of making the shaft and rotor as a single piece has been abandoned, and that the Olympia machine is not constructed in this way. These two views, together with Figs. 7 to 9, will enable the construction of the machine to be followed in considerable detail.

Two diagrams of some interest, which have been prepared by Mr. Barbour, are given in Figs. 12 and 13, above. Fig. 12 is intended to show the peculiar suitability of the homopolar type of generator for coupling to the steam-turbine. Curve A shows the speeds of homopolar machines of the same peripheral velocity and general design as that described above, while curve H shows the speeds of a well-known make of commutator turbo sets. Curve B gives the lowest speeds of standard turbines by a leading maker. From these curves it appears that above a certain capacity the commutator machines are too slow for the turbines, but that the homopolars are just right. Curve F shows the speeds of homopolar machines of 25 per cent. higher peripheral velocity than that to be shown at Olympia. This is in every way a feasible type. Curve C is intended to show the speeds at which turbine-builders would prefer to run, and, again, the coincidence of these curves is very striking. We think, however, that for modern practice Mr. Barbour has got curve C somewhat low. This, however, does not affect his argument, since curve D D shows the limit of possible speed of his type of machine, so that a slight increase in the speed shown in curve F would be a simple matter. In connection with these curves, it should be pointed out that the external characteristics of homopolar machines are similar to those of other types. They may be shunt-wound, series-wound, or compounded in any way, while, owing to the absence of commutation, very large overloads may be carried for brief periods. The second diagram given in Fig. 13 is intended to illustrate the applicability of the homopolar machine, and the large potential field which is open to it. The diagram, of course, refers to turbo-driven sets. The part covered by horizontal lines represents the field open to commutator machines, and the part covered by vertical ones the field which could be covered by homopolar machines. The two fields overlap to some extent, as may be expected, but the diagram is very striking, as suggesting the possibilities inherent in the homopolar dynamo.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, August 31.

CHIEF interest is now centering in the prices of pig iron for 1912 delivery. There is a disposition among consumers to take advantage of present low prices in the placing of contracts for remote delivery. Curtailment has continued so long that stocks are barely sufficient for more than current demand. The policy of the greater railway systems is to retrench in expense and discharge thousands of men. The stock markets are flat, and a general hesitancy prevails. Fortunately, all railway systems are not withholding orders. The Baldwin Locomotive Works' strike was called off on Monday, and the big plant will now be run to full capacity. All of this week's orders for structural steel are for small quantities for bridges in various sections. The present output of pig iron is at the rate of 23,000,000 tons per year. The merchant furnaces continue to curtail, and only six of the eighteen furnaces in the Shenango and Mahoning Valleys are in operation. The steel furnaces are turning out the greater bulk. Ten of the eleven steel furnaces of the Edgar Thomson plant are running, and all the other Carnegie plants at Duquesne. Homestead, Clairton-Bellane, and Newcastle are running full, the first time in eighteen months. Cotton growers are endeavouring to finance a loan of 60,000,000 dols., in order to finance cotton at 13 cents. A general slacking up in freight traffic is complained of, but in the agricultural States this will soon be compensated for. Crop reports are generally favourable. The tin-plate mills are doing well because of the activity in the canning industry.

Coke output is now 70 per cent. of maximum capacity, with an increasing demand in sight. The Pennsylvania rail requirements for the year foot up 150,000 tons.

THE THYSSEN-PFLEIDERER ROTARY AIR-PUMP.

THE fact that the steam-turbine can utilise effectively steam at a very low pressure, has led to much attention being paid to the subject of improving vacua. The most obvious step to be taken is naturally to reduce to a minimum the air-leakage into the condenser, but at the same time much has been done in improving methods of abstracting what air there is, from the condenser. Vacua of 29 in. with the barometer at 30 in. are now by no means unusual during the winter months. With an absolute pressure equivalent to but 1 in. of mercury even a small weight of air occupies a large volume. This, and the fact that large volumes of any fluid are commonly more conveniently handled by rotary than reciprocating mechanism, has led to a revival of the use of rotary air-pumps, first tried with reciprocating engines many years ago, but abandoned, since an ordinary reciprocating air-pump easily gave as good a vacuum as was then considered desirable. In the conditions which now rule in power-station practice, the re-introduction of the rotary air-pump has proved in every way satisfactory. It can be very conveniently run by means of an electro-motor, whilst with an air-pump of the ordinary type this is only possible by the use of reduction gearing. The vacuum obtained is as high as the condenser conditions will permit, and wear and tear appear to be practically negligible quantities, so that the increasing popularity of this type of air-pump is readily intelligible.

Fig. 1.

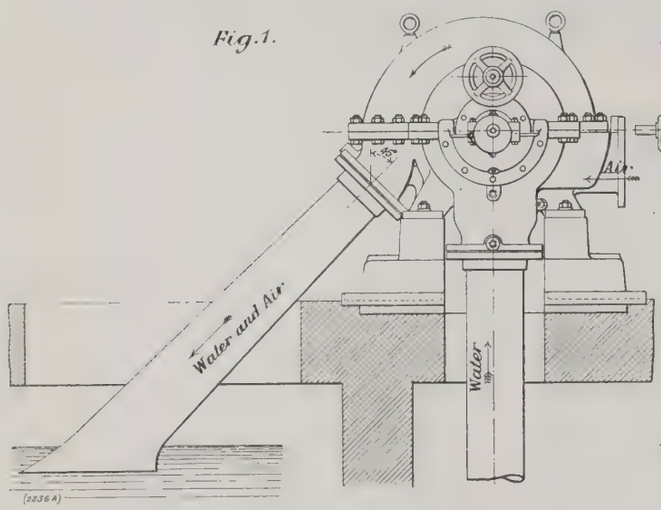
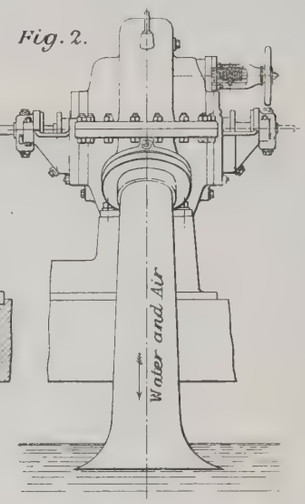


Fig. 2.



On this page and on page 322 we illustrate a form of this type of pump manufactured by the Maschinenfabrik Thyssen A.-G., of Mülheim-Ruhr, Germany, which possesses certain special characteristics. All such pumps are essentially modifications of the well-known ejector or jet-pump. In the Thyssen pump each of the two jets is an annulus, which receives the water supplied by the impeller of a centrifugal pump of the ordinary type, and discharges this water through the "combining cones" shown at *a a*, in the cross-section, Fig. 5. In passing through these combining cones the water draws in by induction the vapour and air in the space *b*, which is in direct communication with the condenser by the branch shown to the right in Fig. 1, and discharges through the inclined pipe shown in Figs. 1 and 2, above. A section through the air-inlet branch is shown separately in Fig. 6. The water supply to the pump is admitted at the branch *c*, and flows both ways to the impeller, as shown in the drawing, so that the impeller-thrust is completely balanced. The special feature of the pump lies in the fact that the discharge area through one of the annular jets is adjustable from the exterior, by means of the hand-wheel shown at the right top corner of Fig. 5. By turning this hand-wheel the top of the ring *d* moves in or out. This ring is virtually a lever working on a fulcrum at *e* below, and connected by pins at its centre to a plate carrying the guide-vanes. This is best seen in Fig. 3, where the ring is shown removed from the casing. As this ring is tilted one way or the other, by turning the hand-wheel, it carries the guide-plate in or out, thus diminishing or enlarging the width of the annular jet discharged into the combining cone *a*, *a*. In this way the supply of water can be adjusted to be in exact proportion to the quantity of air to be extracted, which naturally varies with the degree of tightness of the condenser and turbine joints. It should be added that the two inner portions, *k k*, Fig. 5, of the combining cone are mounted on a sleeve, which slides loosely on the shaft; and by this means automatic adjustment is provided, and the waterway through both jets is kept the same. If, for instance, the hand-wheel is turned so as to reduce the orifice available for discharge at the right-hand cone, the pressure rises on this side, and the portion *k k*, being free, is consequently automatically moved to the left, increasing the discharge area through the right-hand cone and diminishing that through the left-hand one. The reverse action takes place if the discharge is a maximum on the right-hand side; the movable portion *k k* in that case slides to the left, again equalising the waterways. The portion *k k*, though loose on its shaft, is nevertheless carried round by the latter owing to friction, and hence one wall of the combining cone is stationary whilst the other rotates. The makers claim that owing to this fact an eddying motion is set up in the escaping water which causes the issuing jet to break up into a state in which it can abstract a maximum of air. It is further claimed that this relative motion of the opposing walls breaks up any foreign solid body, such as lumps of mud or wood, which might by accident lodge in the narrow passageway. As will be seen, the impeller spindle runs on ball-bearings, which are supplied with oil by ring lubricators.

One of these pumps was recently opened up after running day and night for nine months, and there was found to be an entire absence of wear, either in the cones or on the surfaces of the impeller or guide-blade chambers, the bronze of which, in fact, was found to be covered with a fine patina, under which the original tool marks were plainly visible. The amount of steam entering the condenser at full load was 66,000 lb. per hour, and the makers inform us that the vacuum was readily maintained at over 99 per cent. of that corresponding to the temperature of the cooling water.

CONTRACTS.—The Horsfall Destructor Company, Limited, Atlas Works, Pershore, and 17, Victoria-street, London, S.W., have received an order from the Hull Corporation for twenty-four four-wheeled refuse-collecting vans of their improved design, with low loading rail.—Messrs. Royce, Limited, Manchester, have been awarded an order by the Great Eastern Railway for eleven electrical capstans of the Royce patent free bollard type for use at Blackwall. The order also comprises ten electrical jib-cranes and two electrical hoists.

ROYAL ENGINEER CADETS.—2ND LONDON DIVISION.—Recruits are wanted for this Corps, and great efforts are to be put forth to bring it up to its establishment. The company at present in existence is a Fortress Company; but if the right kind of recruit is forthcoming in sufficient numbers, it is proposed to form a Communication Company. Youths between the ages of 13 and 18 years having a knowledge of electricity or telegraphy should send in their names. The cadets are instructed in all branches of military engineering, and the training and instruction are of a very interesting character for any lad desirous of serving his country. Cadets transferring to the Territorial force from their Cadet Corps are excused their recruit drills, and service in a Cadet unit after the age of fifteen counts towards the Territorial Efficiency Medal. Recruits are enrolled between the ages of 13 and 18, and should apply at the Duke of York's headquarters, Chelsea, S.W., on Monday and Friday evenings, between 7.30 and 9 p.m. Full particulars can be obtained from Sergeant-Major G. D. Elms, R.E. (T), 37, Langthorne-street, Bishop's Park, S.W. Colonel Sir Howland Roberts, Bt., V.D., D.L., &c., is the honorary commanding officer, and the officer in command of the Corps is Captain Beeman, R.E. The Corps attended the annual training and camp this year with the Royal Engineers, 2nd London Division, at Shorncliffe, from August 7 to 19, and worked with the Sappers in building a redoubt and in constructing a trestle and double-lock bridge. The cost of uniform and equipment amounts to about 15s., and there is an entrance fee of 1s. Rifles, bayonets, and brown Slade-Wallace equipment are supplied, and remain the property of the Corps.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—The pig-iron market was dull and quiet last Thursday morning, and the dealings were limited to 1500 tons of Cleveland warrants at 46s. 10d. cash and 47s. 1½d. one month. At the close of the session sellers quoted 46s. 11d. cash, 47s. 2d. one month, and 47s. 7½d. three months. There was little change in the afternoon, when 2500 tons of Cleveland warrants were done at 47s. 6d. November 22, and 47s. 7d. three months. Closing sellers quoted 46s. 11½d. cash, 47s. 1½d. one month, and 47s. 7½d. three months. On Friday morning a better tone prevailed, but the only business was one lot of Cleveland warrants at 47s. seven days. The market closed with sellers' prices firmer at 47s. cash, 47s. 3d. one month, and 47s. 9d. three months. Cash hematite was quoted at 62s. 6d. sellers and 62s. 1½d. buyers. The afternoon session was quite idle, and Cleveland warrants were quoted without change at 47s. cash, 47s. 3d. one month, and 47s. 9d. three months sellers. On Monday morning Cleveland warrants were weak, and a fair business of about 9000 tons changed hands at 46s. 10½d. and 46s. 10d. cash, and 47s. 8d. and 47s. 7½d. three months. Closing sellers quoted 46s. 10½d. cash, 47s. 1½d. one month, and 47s. 7½d. three months. In the afternoon a steady tone prevailed, but dealings were confined to one lot of Cleveland warrants at 47s. 1d. one month, and at the close there were sellers at 46s. 10½d. cash, 47s. 1d. one month, and 47s. 7½d. three months. On Tuesday morning the market was quiet, and Cleveland warrants were easier in price. The total business only amounted to 1500 tons at 46s. 10½d. seventeen days and 47s. one month, and closing sellers quoted 46s. 9d. cash, 47s. one month, and 47s. 6d. three months. The afternoon session was also quiet, and one lot of Cleveland warrants was done at 47s. October 10. The prices at the close were 46s. 9d. cash, 47s. one month, and 47s. 5½d. three months sellers. When the market opened to-day (Wednesday) a steadier tone prevailed, and a fair business of 5000 tons of Cleveland warrants changed hands at 46s. 10d. and 46s. 9½d. cash, and 47s. 6d. three months. The closing quotations were 46s. 10d. cash, 47s. 0½d. one month, and 47s. 6½d. three months sellers. In the afternoon the market was quiet, and the dealings consisted of 2500 tons of Cleveland warrants at 46s. 10d. and 46s. 9½d. cash, and 47s. 0½d. one month. At the close the tendency was harder, and sellers quoted 46s. 10d. cash, 47s. 1d. one month, and 47s. 7d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 61s.; Gartsherrie, 61s. 6d.; Summerlee, 64s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 64s.; Shotts (at Leith), 63s.; and Carron (at Grangemouth), 63s. 6d.

Sulphate of Ammonia.—The demand for sulphate of ammonia is not quite so active this week, and the price is a turn easier. For prompt lots the current quotation is 14*l.* 2s. 6d. per ton, Glasgow or Leith.

Scotch Steel Trade.—The recent improvement in the Scotch steel trade continues, and makers are well supplied with specifications for heavy material. The amount of plates going into consumption at the shipyards on the Clyde at the present time is very large, and the demand from that source is likely to continue on a large scale for some time to come. The export trade is also good, and shipments of a considerable tonnage have recently been put through. The position of angle-makers is again somewhat better, and with an increased demand prices are firmer both for home and export lots. In light steel and structural sections there is a fairly large business passing, not only for local markets but also for export, and fresh inquiries are in circuit for a considerable tonnage. Black and galvanised sheet makers continue very busy and prices have been rising steadily, but much of this advance is due to the increased price of spelter. Local firms have this week booked some orders of importance for plates and structural sections for shipment to India, Australia, and Japan, while a lot of 2000 tons of bars has also been sold for export to Australia. The general condition of the steel trade is very healthy at the moment, and the outlook for the remainder of this year is fairly good.

Malleable-Iron Trade.—The malleable-iron trade of the West of Scotland, although better than it was, is still capable of considerable improvement. Business has certainly increased, but specifications are not yet as plentiful as makers would like, and prices are still very poor. The basis price for crown bars is no better than 6*l.* per ton, less 5 per cent.; but, it may be mentioned, only odd lots can be purchased at that figure, as makers are naming their price as 2s. 6d. to 5s. above that value, although that increase is difficult to secure.

Scotch Shipbuilding.—The shipbuilding returns for the month of August, although not excessively heavy, are without doubt very satisfactory. The total Scotch output was 29 vessels, of 44,172 tons, made up as follows:—

	Vessels.	Tons.
The Clyde	21	38,372
The Forth	2	3,000
The Tay	1	2,000
The Dee	5	800
	29	44,172

These figures make the total output for the year to date, from all the yards in Scotland, 251 vessels, of 411,330 tons; but of that total the Clyde builders account for 174 vessels, of 382,590 tons. The latter figure is above the total for the corresponding eight months of last year by nearly 87,000 tons, and although it is under the record years of 1906 and 1907, it ranks next to them in output. The work on hand is sufficient to ensure steady employment

for some months to come, and if the sectional disputes which periodically crop up can be settled amicably, then there is little fear but that the shipbuilding output for 1911 will touch high-water mark.

Scotch Pig-Iron Trade.—Rather a quieter tone prevails in the Scotch pig-iron trade at the moment with regard to demand, but the recent output has been on a large scale, and inquiries point to an increased business in the near future. Prices are very firm. There is little change to report in the position of hematite, although a fair amount is being put through. The price is nominally 65s. per ton, but a fairly prompt lot could be secured at about 1s. per ton under that figure.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The steam-coal trade is just now in a very good position. Both for shipment and industrial purposes the pits are experiencing pressure for deliveries, and have very little stock on hand. Prices are firm, and on the up grade. It is reported that many manufacturers in Sheffield are laying in extra stocks of reserves to make provision against the possibility of further labour troubles. Gas coals are moving freely, and users are sending in increasingly large requirements. Shipments also are good. Coke is improving, both as to demands and prices. There is a good market for slack. House coal is very much busier in consequence of active ordering from householders laying in winter stocks. Owing to the recent dislocation of affairs on the railways there has been some difficulty in getting supplies through. Orders have been coming in much more freely both to dépôts and collieries, and few stocks are held. Prices are about the same, but have a stronger tendency, and it has been practically decided to advance prices all round within the next fortnight. Quotations on 'Change at the week-end were :—Best branch hand-picked, 13s. 6d. to 14s. 6d. ; Barnsley best Silkstone, 11s. to 12s. ; Silkstone, 9s. 6d. to 10s. 6d. ; Derbyshire house, 9s. ; large nuts, 7s. 9d. to 9s. ; small nuts, 5s. 6d. to 6s. 6d. ; Derbyshire brights, 9s. 6d. to 11s. ; washed nuts, 7s. 6d. to 8s. 6d. ; rough slacks, 5s. 3d. to 7s. ; seconds, 4s. 3d. to 5s. 3d. ; and smalls, 2s. to 3s.

Iron and Steel.—The general condition of the city's industries may be said to be very good. A large number of manufacturers are still exceptionally busy, making up for time lost during the recent strike, and most of the firms have pretty good order-books. Some of the export houses are expecting losses consequent upon delays in shipment. The iron market is hardly as steady, but there has not been any change in official quotations, which at present are :—Hematites, West Coast, 76s. to 78s. ; East Coast, 68s. to 70s. ; Lincolnshire, No. 3, 50s. 6d. ; forge, 49s. 6d. ; Derbyshire, No. 3, 51s. ; and forge, 49s. It will be seen that the Derbyshire forge is slightly the cheaper, but buyers are unable to get any very material concessions. Some merchants have obtained a little business by offering easier terms for hematites, but they are firm in regard to forward inquiries. The billet trade is good, and it is stated that during the past two months billets were delivered in exceptionally large quantities at the Sheffield works. The furnaces and foundries are well engaged, although it is reported that new orders are not arriving in satisfactory quantities. The general trades are full of work, excellent reports being received from manufacturers of special steels, tools, machinery, mining and agricultural implements, &c. The growth in the export trade has also been very noticeable both on foreign and colonial orders, and there is nothing to suggest any diminution in the immediate future. In regard to tools, advices state that home orders have been better, and business is good in hand tools. The railway steel-makers are looking forward to more orders in consequence of additions by the companies to their rolling-stocks. All the lighter trades are well employed.

THE COPPER MARKET.—In their monthly report dated the 1st inst., Messrs. James Lewis and Son state that Standard copper had fluctuated within a range of 16s. 3d. per ton during the past month, opening at 56*l.* 2s. 6d. for cash, advancing to 56*l.* 16s. 3d. on the 14th ult., declining to 56*l.* on the 16th, and closing at 56*l.* 3s. 9d., with three months' prompt 56*l.* 15s. Deliveries had been delayed by the lock-outs and strikes, and the severe fall in the value of American securities had a depressing effect on speculators. Consumption in Europe continued large, but American producers were willing sellers at 58*l.* per ton c.i.f. for electrolytic. American shipments for August had been advised as 27,893 tons.

NORTHAMPTON POLYTECHNIC INSTITUTE.—Particulars of the Institute's day and evening courses of instruction in technical optics, for the ensuing session, have reached us in the form of excerpts from the complete prospectus. The classes are intended to provide a thorough theoretical and practical training in optical work, suitable for all those engaged in, or intending to engage in, any branch of the industry. Special attention is given to practical work, the Institute possessing well-equipped laboratories and workshops for this purpose. The subjects dealt with include applied optics, optical instruments, and visual and physiological optics. At present the full-day courses extend over two years, but a third-year course will be established for specialising students as the work develops. Candidates for admission to the day courses are required to pass an entrance examination, which will be held on the 27th and 28th inst. ; the actual work of the course will commence on the 2nd prox. The evening classes commence on the 25th inst., but enrolments commence on Monday next.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Quietness still characterises the iron trade. Though the time of year has quite arrived when considerable sales to meet autumn requirements are usual, buyers are not coming forward, and business is on only a very limited scale. A general opinion, however, prevails that, but for the unrest in the labour market, a brisk business would be passing, and many traders still look for considerable activity over the fall of the year. The blast-furnaces are now working normally after the damping down which was necessary owing to the railwaymen's strike, but the furnaces, as was to be expected, have produced a lot of inferior iron. It is estimated that the damping down lowered the output of pig by 45,000 tons. No. 3 g.m.b. Cleveland pig is 47s. f.o.b. ; whilst No. 1 is 50s. 3d. ; No. 4 foundry and No. 4 forge, each 46s. 6d. ; and mottled and white iron, each 46s—all for early delivery. East Coast hematite pig is in a very unsatisfactory state. Merchants are pressing mixed numbers on the market at 61s. for early delivery, and it is difficult to sell even at a trifle below that figure, the reason being that consumers are using as far as possible steel scrap, which is very plentiful just now. Good steel scrap is quoted 47s. 6d. to 50s. Business in foreign ore is at a standstill, and market rates remain nominally on a basis of 19s. ex-ship Tees for best Rubio. Coke is steady and in good demand. Medium blast-furnace qualities are 14s. 6d. delivered here.

Manufactured Iron and Steel.—Very gratifying accounts are to hand concerning the manufactured iron and steel industries. Producers generally are very busily employed, and several firms have contracts made which will keep them in full swing for many months. Rail-makers in particular have excellent order-books. In addition to this satisfactory state, inquiries are still coming in, so that it is not surprising to hear that values of several descriptions tend upward. So far, however, there are no quotable changes to report, and principal market rates stand :—Common iron bars 7*l.* ; best bars, 7*l.* 7s. 6d. ; best best bars, 7*l.* 15s. ; packing iron, 5*l.* 15s. ; iron ship-plates, 6*l.* 10s. ; iron ship-angles, 7*l.* ; iron ship-rivets, 7*l.* 5s. ; iron boiler-plates, 7*l.* 7s. 6d. ; steel bars, 6*l.* 5s. ; steel ship-plates, 6*l.* 15s. ; steel ship-angles, 6*l.* 7s. 6d. ; steel boiler-plates, 7*l.* 10s. ; steel strip, 6*l.* 10s. ; steel hoops, 6*l.* 12s. 6d. ; steel joists, 6*l.* 10s. ; cast-iron railway chairs, 3*l.* 12s. 6d. ; light iron rails, 6*l.* 10s. ; heavy steel rails, 5*l.* 12s. 6d. ; steel railway sleepers, 6*l.* 10s. ; and galvanised corrugated sheets, 11*l.* 5s.—sheets less 4 per cent. f.o.b., railway material net, and all other descriptions less 2½ per cent.

Iron and Steel Shipments.—Shipments of iron and steel last month came quite up to expectations ; and, in fact, those of pig iron turned out better than was generally anticipated. The total pig despatched reached 101,336 tons, 94,655 tons of which went from Middlesbrough, and 6681 tons from Skinningrove. The total loadings of pig for the previous month were returned at 88,055 tons, and those for the month of August, last year, at 100,066 tons. Of the shipments from Skinningrove last month, 5601 tons went to Scotland, and 1080 tons to the Continent. Of the pig iron sent from Middlesbrough last month, 72,521 tons went abroad, and 22,134 tons coastwise. Italy was the largest importer, receiving 13,971 tons ; Japan being second, with an import of 13,961 tons ; whilst Scotland received 10,706 tons ; France, 8719 tons ; Germany, 5064 tons ; Belgium, 4479 tons ; the United States, 4105 tons ; and Sweden, 4000 tons. Manufactured iron shipped last month amounted to 9710 tons, 5920 tons of which went to foreign ports, and 3790 tons to coastwise customers. The total steel loaded reached 25,735 tons, 22,305 tons of which went abroad, and 3430 tons coastwise. India was again the largest importer of both manufactured iron and steel, receiving 9538 tons of the former and 4300 tons of the latter. The other principal customers for steel were Japan, 2881 tons, and Canada, 2021 tons.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has remained quiet and stationary, upon the whole. The tonnage position has continued unfavourable. The best large steam coal has made 18s. 3d. to 18s. 9d. per ton ; secondary qualities have ranged between 16s. 3d. and 17s. 9d. per ton ; best bunker smalls between 10s. and 10s. 3d. ; and cargo smalls between 7s. 6d. and 8s. 6d. per ton. The best ordinary household coal has been quoted 14s. 6d. to 16s. 6d. per ton. No. 3 Rhondda large has made 17s. to 17s. 6d. ; and smalls, 10s. 6d. to 10s. 9d. per ton.. No. 2 Rhondda large has realised 12s. 3d. to 12s. 6d. ; and smalls, 8s. to 8s. 6d. per ton. Foundry coke has brought 18s. to 20s. 6d. ; and furnace ditto, 16s. to 17s. per ton. As regards iron ore, Rubio has made 18s. 3d. to 18s. 9d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Bristol Docks.—The accounts of the Docks Committee of the Bristol City Council for the year ending April, 1911, have just been issued. The revenue for the year was 308,718*l.*, of which 54,000*l.* was absorbed by the sinking fund. A feature of the accounts is the remarkable growth of the tonnage in the last ten years. The advance from 1891 to 1901 was from 1,323,731 to 1,538,254 tons, but in the past decade the total has gone from 1,538,254 tons to 2,370,001 tons. The dock and city dues last year amounted to 169,852*l.* ; ten years ago the corresponding total was 116,629*l.*

The Ebbw Vale.—A portion at least of the Ebbw Vale works will re-start on Monday, when the Bessemer department will resume operations. There are also signs that the furnaces, coke-ovens, and washeries will soon be again employed.

Electricity at Cardiff.—During the past year Cardiff Corporation electrical plant was brought more closely up to date. The installation of the motor-generator plant for the transference of the whole of the day load of the old station at Canton and part of the evening load to the Roath power station resulted in a gain to the electric lighting department of 2787*l.* The depreciation fund was increased last year from 36,627*l.* to 44,515*l.* In 1910-11 the total number of car-miles run was reduced from 2,514,648 to 2,475,542, and the proportion of tramway working expenses worked out at 56.10 per cent., as against 57.10 per cent. in 1909-10. Notwithstanding the fact that the car-mileage was reduced by 39,106 miles, there was an increase of 214,596 in the number of passengers carried, the total amounting in 1910-11 to 25,662,830. The population of the city was thus carried 128 times over during the year.

New Swansea Works.—The Swansea Harbour Trust has agreed to lease land to M. Alrig, of Paris. His business has been in existence for forty-three years. From 1870 M. Alrig imported large quantities of Scotch coal to compete with Belgian coal, and opened an office at Boulogne. Later, requirements having changed in consequence of the introduction of stoves burning with slow combustion, M. Alrig looked for a coal to suit these stoves, and he found in Welsh anthracite the quality necessary. He applied himself to giving this combustible the maximum of calorific power by breaking and sizing it. He now proposes to carry on similar operations at Swansea.

Channel Steamers.—It is stated at Plymouth that the steamship service which has been maintained between Plymouth and Brest by the Great Western Railway Company is to be shortly abandoned, as is also traffic between Nantes and Plymouth. The latter is chiefly cargo trade, but a service for passengers has been carried on to Brest.

Coaling at Devonport.—The new coaling dépôt, which is approaching completion at the north-western end of the North Yard at Devonport, will be extremely well equipped. A feature of the equipment is that the overhead transporters will allow coal to be deposited on or lifted up from any part of the area. The electric light is being introduced and will enable work to be carried on at night.

Bristol Dock Charges.—The docks committee of the Bristol City Council has approved a notice to local merchants to the effect that, in consequence of the increased rates of wages recently granted to men engaged in general goods work, dock charges will be increased proportionately.

MOTOR-OMNIBUSES. — As a result of the successful running of the new Tilling-Stevens petrol-electric omnibuses in London service, Messrs. Tilling have decided to adopt that type for all their future omnibuses, and are constructing a fleet to replace their present horse-drawn vehicles. Messrs. Tilling have designed the chassis and body, which are being built at their works at Peckham. The electrical transmission is supplied by Messrs. W. A. Stevens, Limited, of Maidstone.

FEED-WATER HEATING AND SUPERHEATING ON LOCOMOTIVES : ERRATUM.—In our issue of the 1st inst., on page 278, an error found its way into the figure given, as suggested by the diagram, page 277 *ante*, for the possible efficiency of generation of steam dried by the use of a smoke-box heater. The figure given by mistake was 55.62 per cent., that indicated by the diagram being in reality 65.62 per cent. As pointed out at the time, there is actually little value attaching to this particular figure. It is merely a suggestion arrived at from other known values, and is not capable of proof, one way or the other, by means of any available data.

COASTING VESSEL WITH CRUDE-OIL ENGINES.—The Ardrossan Dry Dock and Shipbuilding Company, Limited, Ardrossan, are building, for a Glasgow firm, a coasting vessel of 142 ft. by 25 ft. by 10 ft. 6 in. draught, and the engine contract has been secured by Douglas Primrose and Co., Engineers, Glasgow, for a four-cylinder "Bolinders" direct reversible crude-oil engine, of approximately 500 indicated horse-power—that is, of sufficient power to give the vessel a sea speed of 8½ knots. The vessel, if fitted with steam machinery, would carry 420 tons, but the saving in weight and space occupied by the oil-engines increases this to approximately 480 tons. Steam steering gear, steam capstans, and steam winches are being fitted, and these will get their power from a donkey boiler, fed with the same oil fuel as used in the main engines.

STEAM NAVVIES IN SWEDEN.—Owing to various important new railway works at present under construction in Sweden, a number of excavators or steam-navvies are required. The Swedish State railways have had several of these machines from abroad, but an American machine having proved most efficient, the State Railways invited tenders for such machines from a number of makers both at home and abroad, with the result that a Stockholm firm of manufacturing engineers secured the order, and this firm has already delivered four such machines to the State Railways. The type of machine adopted weighs about 73 tons ; its capacity is 250 cubic metres of gravel per hour. The scoop can work 9 metres to each side, and the angle is 180 deg. The above capacity was stipulated in the contract, but the machine has an actual capacity of 350 cubic metres per hour.

THE THYSSEN-PFLEIDERER ROTARY AIR-PUMP.

CONSTRUCTED BY THE MASCHINENFABRIK THYSSEN A.-G., ENGINEERS, MÜLHEIM-RUHR, GERMANY.

(*For Description, see Page* 320.)

Fig. 3.
Ring d.

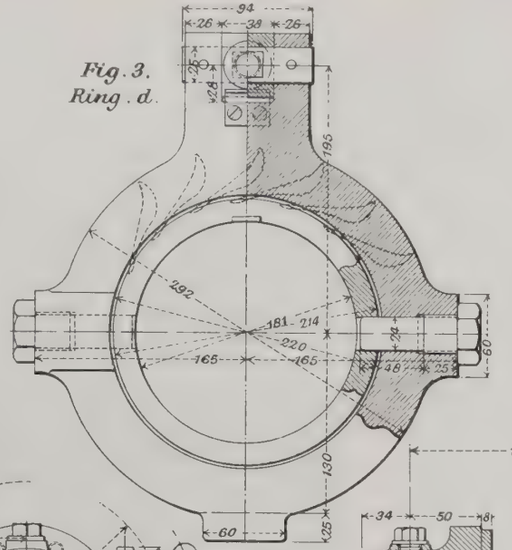


Fig. 4.

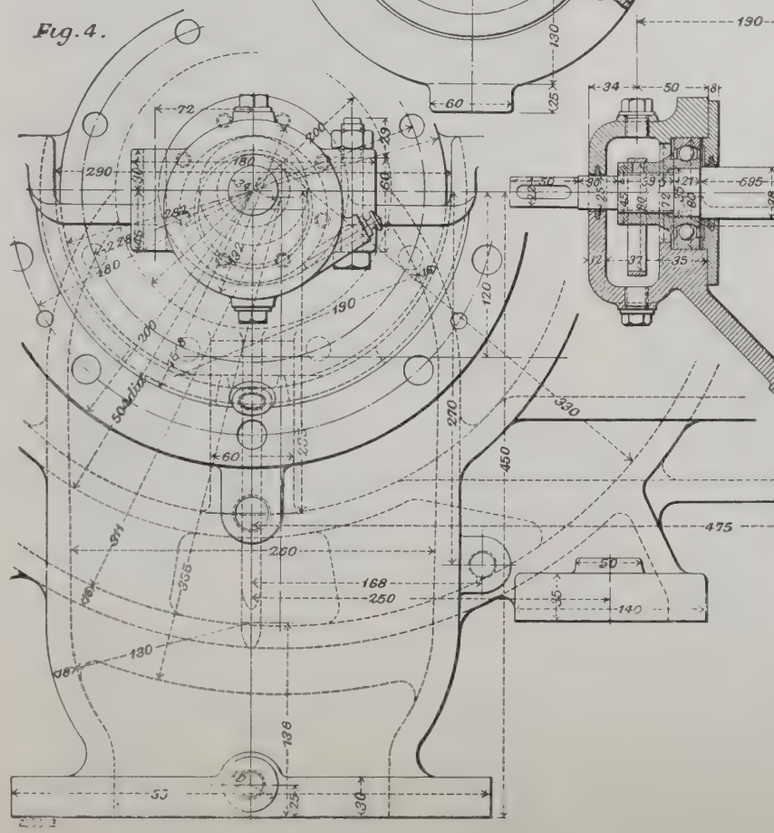


Fig. 5.

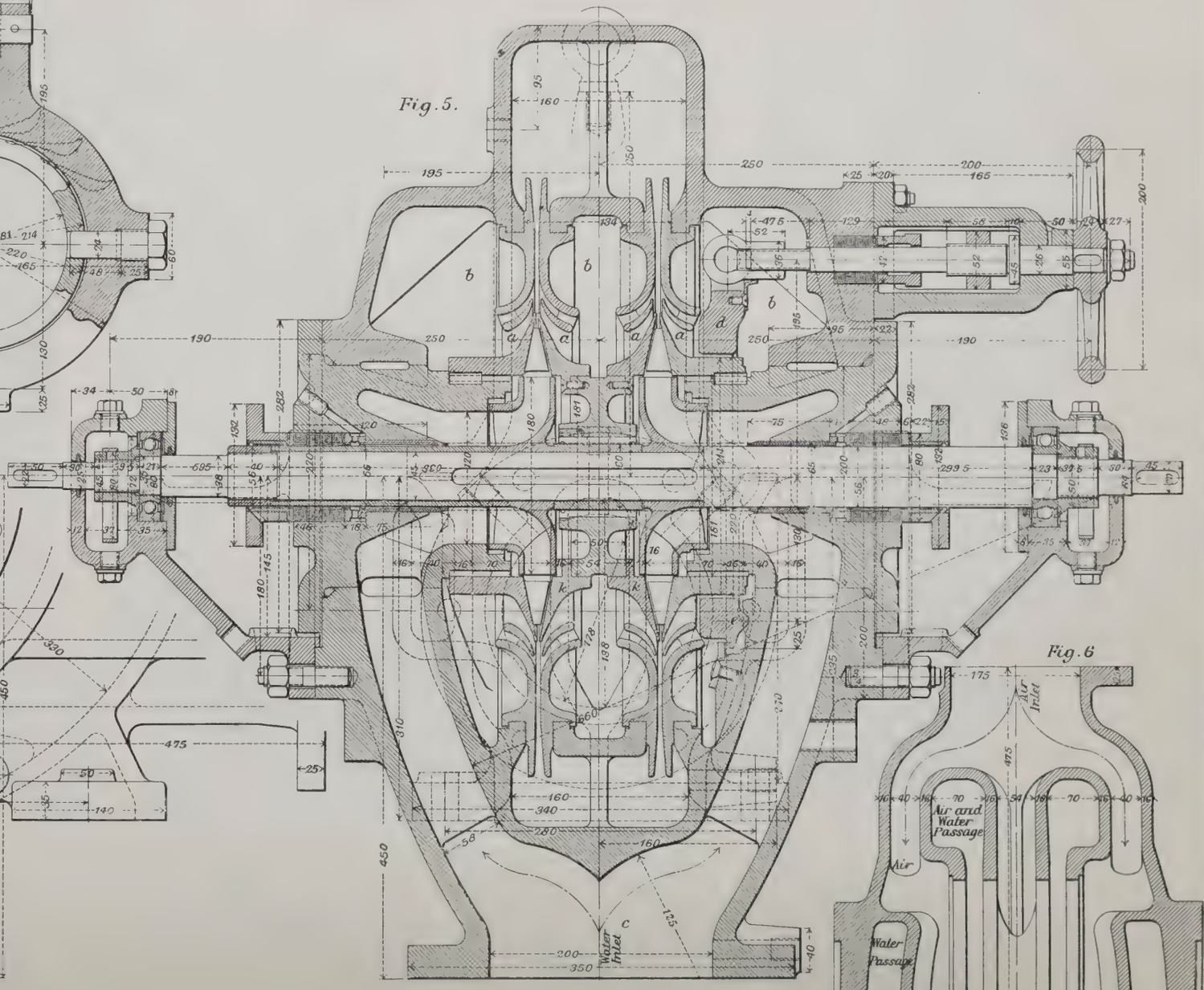
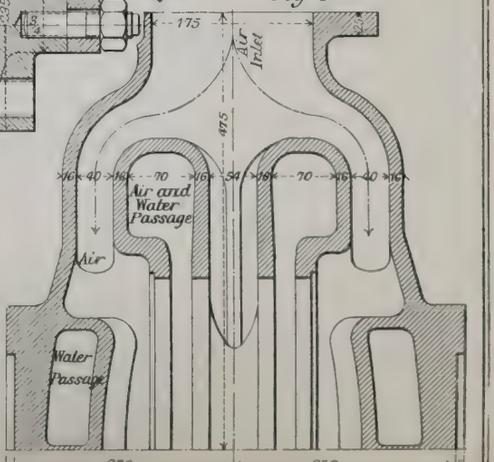


Fig. 6



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ENGINEERING.

FRIDAY, SEPTEMBER 8, 1911.

THE TRADES UNION CONGRESS.

NEVER before have such unique circumstances waited upon a Trades Union Congress in this country as has been the case with that in session at Newcastle this week. Following hard upon the heels of a period of turmoil, for which the avowed leaders of certain classes of organised labour are justly held responsible at the bar of public opinion, it is not unnatural that rather more heed than usual should be paid to the doings of this assemblage. The reason for this has arisen partly out of an expectancy that recent events could scarcely fail to have an influence on the temper of the meetings, and partly out of a desire to secure evidence as to whether trades unionism collectively considers those tactics to be justified, of which the country has lately had so unhappy an experience.

The very place of meeting favoured such ideas. The North-East Coast is fertile soil for trades unionism. It is one of the strongholds of the movement; and Newcastle itself, where the session is now being held, has witnessed its growth and development When the Congress was but nine years old, thirty-five years ago, it visited that centre; and again, some fifteen years since, it was in session there, under the presidency of Mr. Thomas Burt, who is, unfortunately, now regarded as belonging to an older school of trades unionism, whose methods of procedure are not sufficiently drastic for the younger generation.

Of experiences of modern trades unionism the North-Eastern district has furnished many examples. In such a place, therefore, and at such a time, it was not unnatural to expect something of the heroic at the meetings, if anything of this nature be at all compatible with the movement. Some high note might have been struck, or some aspirations sounded, broad enough even, perhaps, for others not of their own peculiar economic creed to subscribe to. Instead, however, of anything on this level, the Congress has so far been deadly dull, for we take little account of the brawls which annually mar its proceedings, and the President's address this year scarcely rose above the commonplace. It was little more than an extensive report, in which platitudes supply the place of lofty sentiment. We are not certain, as a matter of fact, that this course was not the best which could have been adopted. If there were any risk that the Congress would go to greater lengths in the matter of expression than the leaders might desire, it was evidently the best policy to avoid such topics as might give rise to trouble of this nature. Whether this is what was done we cannot say, but the President's persistent attempts to deal only with matters brought forward by the General Purposes Committee suggests something of the kind. Naturally, the President, Mr. W. Mullin, J.P., of the Card and Blowing-Room Operatives, could not escape without some reference in his address to recent events. His treatment of the subject was suited, we suppose, to the views of those he was addressing. His statements are forcible examples of difference of interpretation as a result of difference in point of view.

"The suffering," he said, "placed on the public generally by the high-handed action of the railway managers will not easily be forgotten." Apart from some few hundred thousands blindly led into the recent broil, we have no hesitation in saying that the people of this country in general consider that the high-handed action taken, was not perpetrated by the railway managers at all, but by those responsible for the despatch of the telegrams calling upon the men to strike at twenty-four hours' notice, refusing to delay while negotiations were proceeding, and over-riding their own regulations requiring them first to take a ballot, before further and more serious action. Whose also, we may ask, was the high-handed action in connection with the position on the North-Eastern Railway? Here the unions stabbed their own friend, in, apparently, a fit of petulance, ordering the men to cease work without deigning to reply to the company's inquiry as to the reasons for taking this course. The cap on this occasion fits better, we feel sure, on the head of the union officials than on that of the railway managers.

Proceeding, Mr. Mullin said: "To all the men who so loyally stood by the action of the railway unions, I tender my deepest sense of admiration." Here again the point of view may give quite another interpretation to this particular incident. While we are not wanting in our respect for the man whose *esprit de corps* compels him in stirring times to act with the comrades with whom in quieter days he has chosen to throw in his lot, we cannot maintain the same admiration for men who, apparently, silently surrender their right to give expression to their views by means of the ballot, and become the tools of leaders who pay so little heed to the economic factors on which their prosperity is dependent. Neither, we think, does the attitude adopted by the community coincide with the view taken by Mr. Mullin. The spontaneity of the response to the suggestion that the public should show in some tangible form its admiration for all the men who so loyally stood by the action of the railway companies, to adapt Mr. Mullin's own words, is proof that public sympathy was with the loyal workers rather than the more disorderly servants. The President urges the railway workers to place implicit trust in their leaders. "Implicit," indeed, is well chosen, for it means, of course, "trusting without questioning!" If any man is wise enough to start questioning the advisability of countenancing the methods into which trades unionism has lately been rushed, he will undoubtedly, if he have the courage, ultimately repudiate the leadership of these very men.

In another part of his address Mr. Mullin dwelt in rather intolerant terms on the "conscience of the minority" as illustrated by facts arising out of the Osborne judgment. For conscience Mr. Mullin says he prefers to employ the expression "the selfish spirit of the minority." If this term must be applied to some of their own members whose action is displeasing to them, what expression, we may ask, can be fitly applied by the whole nation to that one section of the community which encourage, not for conscience sake, but avowedly for selfish ends, misery and confusion to lay waste their fatherland? Mr. Mullin's unfortunate expression is, we fear, all too true an indication of the growing intolerance of the unions. A few days ago the text was published of a trades union manifesto, circulated on the North-Eastern Railway during the recent strike. This manifesto concluded with the words addressed to non-unionists, "we must cease to regard you as fit fellow-workers, and must act accordingly." The modern trades-union spirit restricts the brotherhood of man to members only. The application of the adjective "fraternal" to men of known and proved sympathy with the better characteristics of the labour movement has been assailed even at this very Congress. Too often do these sessions produce examples of an illogical lack of either gratitude or foresight on the part of delegates. In the past some of the best men in the movement have suffered at the hands of their comrades. On Tuesday last Mr. D. J. Shackleton was dragged into an unpleasantly prominent position. Because he and two other Government officials had been listed by the committee as "Fraternal delegates," the occasion was taken by several members to insist that to no representative of the Government now in office could the designation "fraternal" be applied. This must have been rather trying to Mr. Shackleton, who in past years has taken prominent parts in this very Congress.

The cause of all the trouble was the Government's action with regard to the use of the military forces in the recent strikes. Our views on this subject have already been expressed in these columns, and we do not intend to enlarge upon them again. While the trades unionists seem convinced that the soldiers were employed to bludgeon peaceful workers into submission, we, with many others, hold that their presence was necessary for the safeguarding of the public, whose interests were treated with such scant consideration by the strikers. It is something to have obtained even a belated admission from the labour leaders that the public has suffered at all. Mr. Mullin, in the quotation of his speech we gave above, has gone thus far. How well it would be if some economist could convince trades unionists of the folly of expecting prosperity to follow upon violence and conflict, and could show them that to involve others in distress in such a way really means inextricably involving themselves also. The end of all sections of the community is the national well-being and welfare. The roads taken are vastly different. We do not wish to travel to what Mr. Mullin calls "the

promised land" through a wilderness called desolation, laid bare by discord, rapine, and strife. The road leading to the haven where we would be is called political economy, and it passes through fair lands, each fairer than the last, and the names of some of the countries, by the way, are toleration, reason, conciliation, &c., in each of which a stay may profitably be made.

The presidential reference to the journey to the "promised land," from which Mr. Mullin says we are still a long way off, reminds us that it was for their sins that the ancient Hebrew people were detained so long in the wilderness. Let us take warning, then, lest unwise action now delay for us the day when we may attain to the improvement desired by all, and not alone by those whose interests are confined to one class only. If we may make another reference, it would be to an old Hebrew prophecy, which speaks of a time when "instead of the thorn shall come up the fir-tree, and instead of the brier shall come up the myrtle tree." The reverse just now seems to have happened. Instead of trade unionism developing into strong and useful material, of service in building up a great monument to national industry and endeavour, it seems to have turned into a thorny bramble, spreading everywhere and wounding chiefly the innocent passer-by.

As regards the business before the meetings, there have up till the time of writing been few incidents of note. After considerable difficulty had been put in its way by the President, a resolution objecting to the word "fraternal" in connection with the Government representatives was brought forward and subsequently lost. A carefully-worded official resolution on the use of the military in the recent strikes was passed with scarcely any discussion, the delegates showing their interest in it by leaving the hall in large bodies while it was before the meeting. Realising subsequently that the opportunity had been missed, the attempt was made to raise the subject on the following day, but was promptly quashed by the President. On Tuesday the ever-recurring resolution in favour of the nationalisation of the railways was adopted with little discussion, in face of the fact that, in countries where it is in vogue, much more drastic methods of dealing with strikes are adopted than were resorted to here recently. A proposal for a citizen army brought forth a rather humorous speech from Mr. J. Ward, who pictured the officers as presenting themselves to the rank and file each morning, to be dismissed from the service if they did not give satisfaction to them. The talk in support of this resolution had very little of reason or weight in it.

WORKMEN'S DAILY AND WEEKLY TICKETS ON FRENCH RAILWAYS.

At a time when, in England, it is urged that greater facilities should be afforded by the railway companies to the general worker, it is of interest to know what is happening in this matter in foreign countries. In France, particularly, precise information is available on the subject. The French State, it is true, has no authority over railway rates, at least in principle. On the other hand, some of the companies have the power, within the limits of certain maxima imposed upon them by the concessions granted on the formation of their systems, to reduce their fares, submitting to the superior administration (the State) the proposed tariffs, which become operative when the State has approved of them. The State itself, however, cannot suggest to the companies a reduction of rates, and, *a fortiori*, cannot impose such a reduction. Nevertheless, it has means of influencing the companies and of opposing them, as is evidenced at the present time in the matter of the relations between the companies and their *personnel*. At different times the State has made it clear that it regards with favour the concession of exceptional travelling facilities to workmen and other classes of employees; that is, of extremely low tariffs, which might result in actual loss to the companies if they did not recoup themselves on the tickets issued to the ordinary travelling public.

For more than twenty-five years certain of the French railway companies have had in operation, quite as a matter of favour, advantageous tariffs for workmen, including sometimes other employees, between either a large town and its outskirts, or between neighbouring towns. The companies know that this course is agreeable to the Government, and hope by such means to render more favourable their relations with the latter. Greatly reduced fares, whether issued in Great Britain, France, or Belgium, cannot adequately reimburse the companies, and this particular class of passenger is often carried at a loss. Notwithstanding this, for the reasons just pointed out, the Chemin de Fer de l'Ouest, in 1883, signed a convention with the State (similar to that signed by all the companies at that period), which imposed on it many burdens, while it assured certain advantages, and the company undertook to concede special conditions to workmen in regard to return tickets between Paris and the stations in the vicinity. The rates for these special tickets amounted to a reduction of 50 per cent. upon the ordinary maximum tariff imposed on the companies for third-class passengers. The tickets thus granted were only available by specified trains in the morning and evening, and workmen travelling with these tickets had no right to take with them any luggage other than their tools.

At the present time these workmen's tickets are to be met with on all the systems; they entail a very large traffic, without bringing anything considerable in the way of receipts to the companies. At a later date the various companies published new rates and conditions of transport, even more appreciated by workmen and employees with very moderate resources. These are known as "workmen's season-ticket rates" (*abonnements ouvriers*), and they are, for the most part, weekly tickets, so as not to tax the *clientèle*, with too large a prepayment. For the last twenty-five years the Chemin de Fer du Nord have issued weekly third-class tickets or cards to working men and women in certain very important centres. These season tickets were, at the outset, issued at a reduction of 74 to 75 per cent. upon the prices of single tickets, conferring, however, the right to go and return. Obviously this reduction was enormous.

In the same way, on the systems of the Chemin de Fer de l'Est and the Orleans line, weekly season tickets were granted at a price which about corresponded with the cost of a single journey over the route for which the ticket was issued. The Paris-Lyons-Méditerranée Company granted similar tickets, weekly, monthly, quarterly, and half-yearly, and also tickets which allowed working men and women to return to their families on Saturday evening or Sunday morning, setting out again on Sunday evening or Monday morning. Naturally, they laid down special conditions for the issue of these workmen's tickets. It was provided, for instance, that only certain trains, specially indicated on the bills, should be taken. To secure a ticket, a workman had to prove his right to be classed as a workman by a guarantee or voucher from his master, or a certificate from the mayor of the place in which he resided, and, almost without exception, the men to whom these low-priced tickets were issued could travel only by the trains specially indicated.

At the present time this matter of workmen's tickets, more especially the season tickets, has developed in an extraordinary manner, seriously adding to working costs, but not by any means yielding to the companies a proportionate monetary return. Not only have the privileges granted to workmen been extended to other classes of employees, but there has been a further tendency to make concessions in rates, while the companies, ever under the influence of the State, and anxious to acquire popularity, have also been persuaded to give these favoured persons, who travel at prices inconsistent with economic requirements, the choice of many more trains. In short, the establishment of particular rates and exceptional privileges sets up a striking inequality among the customers of the railways and among the population of the country. In order to obtain these special rates it is mostly necessary for the applicant to prove that his income does not exceed a certain sum; but others may have an income which, apparently much larger, is balanced by heavy burdens, and such people are as worthy of interest as the privileged workmen to whom these concessions are made.

Let us consider first the case of the system of the Chemin de fer du Nord. Workmen's tickets are in this case very numerous, because this system serves a considerable number of industrial and manufacturing centres in the neighbourhood of Paris, and on its lines there travel daily an enormous number of workmen and employees going to their work in the morning, and returning in the evening. Workmen's daily tickets are not issued on this line, the third-class weekly ticket, or card, prevailing. This, of course, in no way affects the existence of the ordinary season ticket—for three months, six months, or a year, which is supplied to the general public, the latter not deriving any benefit from the exceptional conditions so freely granted to the working classes and the small employee. The tickets available for a week are furnished to the working men and women at the stations serving the neighbourhoods in which they reside, so that they may reach their work. On the system du Nord these weekly workmen's tickets have been adopted for a number of journeys which seems altogether to exceed the requirements of the public. Wherever there is traffic of working men and women towards a certain industrial centre, more or less remote, the principle of these tickets has been applied. It must be allowed that there is evidence of a desire to include with the workmen other employees of both sexes, and to confer the same benefits upon all when they reside in the suburbs of Paris and go to work in Paris. Such employees must, however, prove that they have an income of less than 2000 francs; this proof is furnished by certificates from their masters. They must prove, moreover, by an official document, that their main tax or impost on personal effects (*côte personelle mobilière*) does not exceed 20 francs. If an employee has more than two children, the allowable maximum of 20 francs for the tax on personal effects is increased by 5 francs for every child over and above two. These tickets are available only for the trains specially indicated in the company's bills, and confer a right to one outward and one return journey per day. The workmen or employee, contracting in this way, who takes a place in a train not intended for him, or in any other than a third-class carriage, may be made to pay the price of a full-fare ticket. If, however, he cannot find a place in the train set apart for either the morning or the evening, he is allowed to travel by the next train. The cheapness of the fares demanded of these special subscribers on the Chemin de fer du Nord is shown by the following figures:—The price for a weekly ticket of this kind is 10d. for distances not exceeding a total of 3 miles between stations, 14d. when the distance is between $3\frac{3}{4}$ and $6\frac{3}{4}$ miles, 20d. when between $6\frac{3}{4}$ and 11 miles, and 44d. for 20 to 25 miles. To show how greatly these tickets are appreciated by the *clientèle* of the system du Nord, it may be stated that more than 176,000 of them were distributed in 1906, available to Paris and back; in 1910 the figure reached 271,000. Over the rest of the system, regard being had to intercourse between the various stations and industrial centres in the North of France, there were 843,000 workmen's weekly contract tickets distributed in 1906, while the corresponding figure for 1910 was approximately 1,200,000. That represents for the whole of the system nearly 1,500,000 weekly tickets. Yet during the year 1910 these brought to the coffers of the company only 86,800*l*., after deduction of the impost paid to the State. The figures are indicative, however, of very heavy traffic.

By way of comparison, and to show the greatly reduced price at which workmen and employees having only a minimum income are permitted to travel, it may be stated that for the ordinary third-class subscription or season tickets, issued for the benefit of those who do not belong to these privileged classes, the price is 7s. 2d. for a distance of $3\frac{1}{10}$ miles for one month. According to the rates on which the weekly ticket are based the cost would amount to 4 francs. The workmen and employees therefore pay less than half what the ordinary passengers pay for their third-class season tickets.

If we consider the Chemin de fer de Paris à Orléans, we find that workmen's return tickets and weekly season tickets are available. The return tickets, available exclusively for third-class and for specified trains, agree precisely with the workmen's tickets for the double journey already referred to. For example, the cost within distances of $3\frac{3}{4}$ miles is sometimes 3d. and often 2d. For 12 miles the price will be about 10d. This tariff is not absolutely fixed for each direction and distance, and varies somewhat; the prices just quoted represent the mean. The return portion of the tickets can only be utilised on the day of issue. So far as the season tickets for workmen are concerned, the conditions imposed are almost identical with those in force on the Paris-Lyons-

Mediterranean Railway, and other systems. The period starts with the Sunday, ending the following Saturday. Apart from the tools of their trade, the holders are not allowed any luggage that cannot be carried by hand, also as previously mentioned. In regard to employees other than workmen, the conditions do not differ from those obtaining on the system du Nord. With respect, however, to those weekly tickets which apply to employees in districts beyond the precincts of Paris—the Orleans Company having introduced weekly tickets for certain industrial centres on their lines—the maximum annual remuneration of the employee desirous of benefiting by such tickets must not exceed 1800 francs (72*l.*), and the tax on personal effects must not exceed 15 francs (12s.).

It is chiefly in the outskirts and vicinity of Paris that the weekly season tickets for working men and women and employees are utilised, but the system is adopted in the neighbourhood of Bordeaux, Orleans, and some other more or less important and industrial centres on the Paris-Orleans line. In a general way the price of such a weekly ticket, representing fourteen double journeys, is 10d. for 4½ miles between stations; 12½d. for 5 to 6 miles; while 21d. is charged when the distance is from 11 to 12 miles; and 3s. for 24 to 30 miles. Here also, and justly, workmen only, or workmen and employees, derive the chief profit from the cards and tickets which are issued on such advantageous terms. In 1906 the number of return tickets for workmen which were supplied in the Paris district reached 39,000; in 1910 nearly 42,000 were issued. The advance is not very marked, because workmen in regular employment prefer the weekly season card. Moreover, it should be mentioned that in those outskirts of Paris which are on the Orleans line there is no great traffic in passengers of the working class. It is in the outskirts of the Paris-Lyons-Mediterranean line, the system du Nord, and, above all, the system formerly belonging to the Cie. de l'Ouest, that such traffic is most dense. Over the whole Orleans system the workmen's tickets represented in 1910 some 29,000 units. The case of the weekly contracts is, however, different; 203,000 of these were distributed in the outskirts of Paris in 1906, and in 1910 the figure was 287,000. The corresponding figures for the provinces, or districts other than the precincts of Paris, were about 6500 and 19,000 respectively. The receipts, however, for the 306,000 weekly tickets distributed in the course of the year did not exceed 500,000 francs.

While not attempting to review what is being done on all the railroad systems of France, some reference must be made to what was formerly the Cie. de l'Ouest, which system is now controlled by the State. This line, in fact, has by far the largest traffic in passengers in the suburbs of Paris; indeed, the traffic of this character is quite extraordinary. In consequence of this and the enormous working population residing in the various localities served by the lines of the Cie. de l'Ouest, and going every day to Paris to work, the workmen's tickets, and particularly the contract cards, constitute a heavy burden on the resources of this line. The workmen's tickets, allowing the bearer to utilise specified trains in the morning and evening, call for no special comment; they closely resemble the workmen's tickets to be found on other systems, and the prices are quite analogous to those already mentioned. With regard to the weekly tickets granted to workmen or employees, the conditions do not differ materially from those set forth above. Yet, by a caprice which may be noted, but cannot be explained, the weekly season tickets are obtainable not only by employees whose annual remuneration does not exceed 2000 francs (80*l*), but also by those whose remuneration does not exceed 2400 francs (96*l.*). Moreover, it is unnecessary that the tax on personal effects should not exceed 20 francs; it may be as much as 25 francs (1*l.*), with a permissible addition of 5 francs per annum for every child over and above two which the applicant for such tickets may possess. As for the proof of his various qualifications which the applicant must present, this is similar on the system de l'Ouest to that on the other lines. Weekly season tickets are issued to workmen for the districts immediately around Paris, and also in the neighbourhood of certain industrial towns, such as Le Hâvre, Rouen, &c. For the outskirts of Paris the price of one of these third-class weekly tickets is 1 franc for 6 km. (10d. for 4 miles, station to station), 1 franc 50 cents. for 14 km., 2 francs for 17 km. to 19 km., and 2 francs 50 cents. for 21 km. to 24 km. (2s. for 13 to 15 miles). There is, too, the same difference, as noted above, between the price of the weekly cards issued to workmen and employees with very limited incomes and the price of the weekly cards obtainable by the general public.

Before concluding, we may give some idea of the great extent to which these workmen's tickets, and especially the weekly subscription tickets, are employed. In 1909 upon the system l'Ouest, controlled by the State, and also upon the old State line (of little relative importance), not less than 1,060,000 workmen's tickets were issued. Upon the whole system the number of weekly season tickets for workmen and employees supplied during 1909 was 1,200,000. In this total the great lines beyond the vicinity of Paris are represented by only about 150,000 to 160,000 cards. There are certain stations in the vicinity of Paris which alone distribute during the year some 80,000 to 90,000 workmen's season-tickets.

The comparative figures which we have given relative to the price of workmen's tickets and that of the ordinary third-class tickets must make it clear that these subscriptions offer little profit to the companies transporting workmen and employees at such reduced rates. Nevertheless, the State Railway is at present endeavouring to extend these facilities. It contemplates permitting the workmen and employees, who are the beneficiaries of these reduced-fare tickets, to take almost any train, and not be under compulsion to take only the trains specified, and they are about to increase still further the advantages offered to these privileged travellers. It is true that in doing this the endeavour is being made to direct favourable attention to the State railways, which, in recent years, have been subjected to considerable criticism as being unequal to their work.

PINCH-EFFECT ELECTRIC FURNACES.

SOME years ago Carl Hering and E. F. Northrup drew attention to the "pinch effect" as a disturbing factor in the working of induction furnaces of the Kjellin type. In these furnaces the metal contained in an annular trough forms the secondary of an alternating circuit, and is heated and fused by the currents induced in the metal. It was observed that the liquid steel would sometimes squirt and seethe violently, and it was found that there was a stricture in the trough at such a point, caused possibly by a piece of slag or some other reason. The iron would become overheated in this portion of reduced cross-section, a transverse valley would form in the liquid column, the metal would rise on both sides of this valley, and the continuity of the liquid column would momentarily be broken; the current would thus be interrupted. In the next moment the gap would be bridged over again by the liquid metal, but the surgings thus set up might become almost dangerous. This rough explanation is not the one given by Hering; the phenomenon is really considered to be more complicated, and Hering speaks of an electro-magnetic force acting from the circumference to the centre of the conductor in radial lines perpendicular to the axis. The indirect heating by induced currents, we should point out, is not essential to the phenomenon.

Last year A. L. Queneau suggested a way to utilise the pinch effect. He constructed a steel furnace, consisting of a basin, from which two legs projected downward, slightly inclined outward; there were electrodes at the bottom of the two legs, and another electrode of opposite polarity dipping into the surface of the metal. The fused metal in the legs would be under the hydrostatic pressure of the metal in the bath, and the current was to be so proportioned that a series of pulsations would be produced leading to disruption and re-establishment of the continuity of the molten metal; mixing of the steel was thus to be secured. The experiments were made with charges of 500 lb. We are not aware that they have been carried much further; the surgings might evidently become explosive, and the linings of the legs (magnesia and pitch and alundum were tried) would hardly hold out for a long time.

At the New York meeting of the American Electro-Chemical Society C. Hering himself suggested another type of pinch-effect steel furnace. If the cylindrical furnace had the section of a T, that is to say, if it consisted of a vertical column widening out to a circular basin at the top, he pointed out the pinch effect would tend to set up a circulation of the metal up the core of the T, and down again by the furnace walls, such that the metal would rise fountain-like in the middle of the bath, the "squirting" force increasing with the square of the current, and diminishing as the cross-section was increased. The phenomenon was best adapted to large furnaces. The furnace which Mr. Hering described at the end of the discussion was apparently small, however; dimensions were not given. The furnace was also provided with two legs and two electrodes, and that seems to be important, not only because this arrangement permits of reducing the depth of the leg or "hole" to one-half the depth required for one electrode, as Mr. Hering put it, but also because one does not know how the electrodes would be arranged with one leg only. The furnace as described was a crucible of rectangular section, from the bottom of which two inclined passages went out through the bottom of the crucible to its front wall. There they ended in horizontal cylindrical electrodes, directly joined to the secondary poles of a transformer. The dimensions of these passages, which are called heaters, would depend upon the charges to be dealt with and the currents to be applied. The electrodes consist of the metal to be fused—*i.e.*, iron; this is another essential feature which came out during the discussion. Mr. Hering had a great deal to say on the disadvantages of other furnaces and on the superiority of his new furnace, and he might have described it more clearly.

What he accentuated was that the furnace was simple and cheap, as it consisted of a plain crucible, with two suitable holes at the bottom plugged with the electrodes. The heat was generated in the metal itself, not in the slag, and at the bottom of the hearth, where it was wanted, so as to produce a brisk circulation upward, in the direction in which the hotter metal would naturally rise. The hot column of metal was formed against the slag and brought repeatedly in contact with it, so that a thorough refining was secured. Mr. Hering made light of the objection that the lining of his resister would be exposed to rapid destruction by the heat and the mechanical scouring.

The metal was hottest, he said, in the central portion, and colder where it came in contact with the walls, and if the electrodes were made of the same diameter and material as the resisters (the metal in the heaters), the furnace would become self-regulating as to temperature. The squirting force was very powerful, and produced a real suction; the metal would sometimes be upheaved at an angle of 45 deg. But Mr. Hering gave little definite information, and in his reply he seemed particularly anxious to refute the suggestions made during the discussion, that both Gin and Girod had unknowingly anticipated the squirting effect in some of their constructions.

THE LATE MR T. HURRY RICHES.

WIDESPREAD regret will, we feel sure, be occasioned by the announcement, made on Tuesday last, of the death at Cardiff, on the day previous, of Mr. T. Hurry Riches. Although Mr. Riches remained, practically all his life, most closely associated with South Wales, the esteem in which he was held was confined to no such limited area. Among engineers, indeed, and especially among mechanical engineers, with which branch of the profession he was particularly connected, he was recognised as a man of great worth and exceptional character.

Tom Hurry Riches was born in Cardiff in 1846, and was the son of the late Mr. Charles Hurry Riches, of that town. His successful career commenced when he was still quite young, and it is noteworthy that in later life he was inclined to recommend the type of training which had stood him in such good stead. He entered the works of the Locomotive Department of the Taff Vale Railway in 1863 as an apprentice under Mr. Joseph Tomlinson. He spent five years in the shops and drawing-office of the company, pursuing his studies at the same time with such success at Science and Art classes that he won a local medal, and was awarded, in 1868, a scholarship at the Royal School of Mines. The announcement of this was made while he was at sea, serving as second engineer on the s.s. Camilla, a position he had taken, for the sake of experience, on the termination of his apprenticeship. As a result of the scholarship, he very soon returned to continue his theoretical education, obtaining while at the Royal School of Mines the Science and Art and also the Whitworth scholarships.

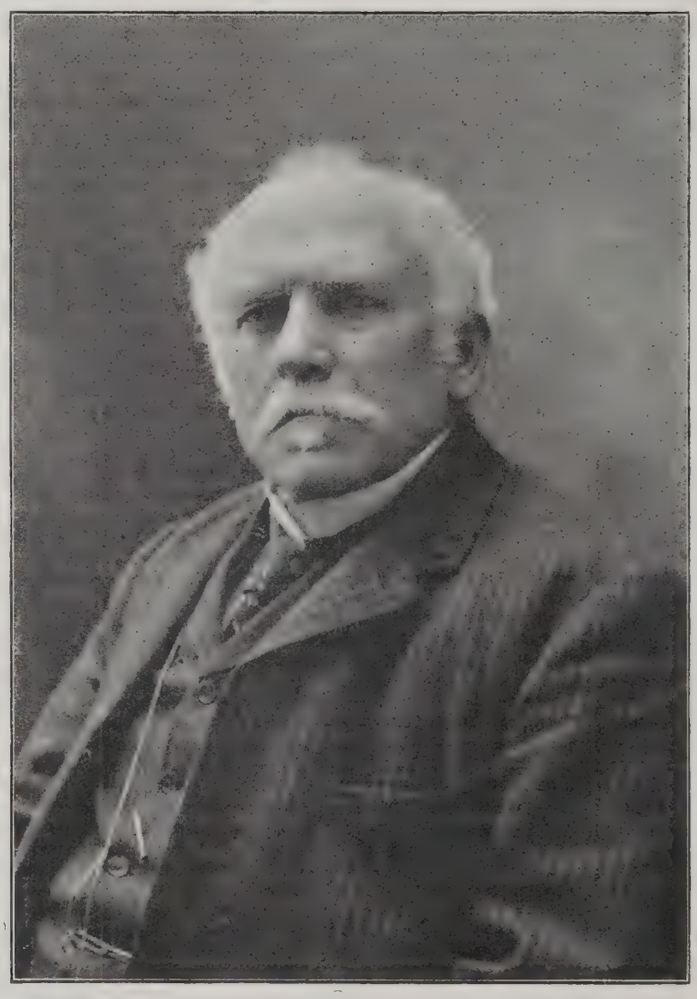
Mr. Riches subsequently became manager of the Bute Iron Works and of the Bute Old Works, under

Mr. John McConnochie. These works were engaged in general engineering, building bridges and roofs, &c., as well as in the construction of boilers, engines, and other machinery. In 1872 he returned, as chief locomotive foreman, to the Taff Vale Railway; and in 1873 was made locomotive superintendent, in succession to Mr. Fisher, who followed Mr. Tomlinson. At that time Mr. Riches was the youngest locomotive superintendent in the kingdom. That appointment he retained from that day till the time of his death, though ill-health had unfortunately rendered it necessary for him latterly to relinquish part of the active duties connected with the position. During his superintendence the locomotive stock of the company was augmented more than 100 per cent., and the importance of his office was increased in an even greater proportion, for, in addition to the locomotive department, his responsibility was extended to embrace the carriage and wagon work, the hydraulic and dredging machinery, dock machinery, gates, &c., as well as coaling appliances, &c., belonging to the company.

As a locomotive engineer Mr. Riches was held in high esteem by his brother superintendents; but it will not be merely in connection with a railway of some 124 miles in length that he will be remembered. He was recognised not only as an all-round man, but also as being almost unique in his particular combination of certain qualities. No greater testimony to his worth could be given than the fact that, though continuing in his connection with one of the smaller railway systems, professionally he ranked with the leading members of the engineering world. He was at one time president of the Association of Locomotive, Carriage and Wagon Superintendents of the United Kingdom, and was also a member of the Institution of Civil Engineers, the Iron and Steel Institute, the British Association, and other bodies. His most valuable services to technical societies were rendered, however, in connection with the Institution of Mechanical Engineers and the South Wales Institute of Engineers. He was admitted a member of the former in 1874, being elected to a seat on the Council in 1885, when again, we believe, he had the distinction of being the youngest that had ever been so honoured. In 1899 he was elected Vice-President, and he was called to the highest office the Institution could offer him in 1907. He was re-elected for a second term in the following year, and in each term of office he discharged his duties in a manner which made him not only respected, but the friend of all with whom he came in contact. Although not President in 1906, when the summer meeting of the Institution of Mechanical Engineers was held at Cardiff, he was largely instrumental in securing the success of that event, taking a very active part in it as joint secretary of the local reception committee. During the two years of his presidency the Bristol and Aberdeen meetings were held. His contributions to the discussions were numerous, and he was always a welcome speaker at the Institution meetings. In addition to his presidential address, which was largely devoted to the development of rolling-stock, he was the author, or joint author, of six papers read before the Institution. His first was in 1877, when he read one on the "Tynewydd Colliery Inundation." In 1880 he contributed one entitled "Automatic Action in Continuous Railway Brakes." A paper by him entitled "Notes on Testing Locomotives" was brought before the Institution in 1904. At the Cardiff meeting, as joint author, he was responsible for two papers, one being on the "Coal-Shipping Appliances at Penarth Dock," and the other on "Railway Motor-Car Traffic." At the Bristol summer meeting in 1908 he was joint author of a paper on "Forced Lubrication for Axle-Boxes."

Mr. Riches took a considerable interest in the South Wales Institute of Engineers, and was President of that body in the two years 1901-2 and 1902-3, taking for his inaugural address the theme of education of engineers, which he had so much at heart. His professional reputation, moreover, was not confined to this country. In 1900 he was appointed reporter to the International Railway Congress, for Great Britain and the Colonies, on the subject of express passenger engines. This report was handed in at the Paris meeting. In 1910 he held a similar office, the subject then committed to him being "Railway Motor-Carriages." The value placed upon his views is emphasised by the fact that he was chosen as a member of the provisional committee on the formation of the Institute of Metals.

As an engineer, perhaps, three incidents in his career claim some special notice. The first relates to the changing of the gates at Penarth Docks, accomplished without the loss of a tide and the least delay to shipping. This was at the time declared to be an impossible feat by engineers of much greater experience than Mr. Riches could summon to his aid. In spite, however, of the prophecy of failure, Mr. Riches carried the undertaking through to success. The second incident has reference to the flooding of the Tynewydd Colliery in 1877, when Hurry Riches worked night and day underground installing the plant for unwatering the mine. The rescue work on this occasion proved successful, the entombed colliers being rescued after some 240 hours. For his valuable share in this excellent work Mr. Riches was subsequently presented at the Mansion House, London, by the Lord Mayor, with a piece of silver plate "in recognition of his bravery." The third matter has connection with the enlargement of the resources of the company with which he was connected practically all his life. Owing to their failure to obtain Parliamentary powers to enlarge their dock accommodation, the Taff Vale Railway Company, on the advice of Mr. Riches, installed hydraulic plant, constructed to his design, which enabled the shipment of coal to proceed with greater expedition at Penarth than, we believe, anywhere else. He was a great advocate of high-speed hydraulic machinery, and in his capacity as mechanical engineer to the Taff Vale Railway had considerable experience of it.



From a Photograph by A. and G. Taylor, Cardiff.

The late Mr. T. Hurry Riches.

Mr. Riches was of an exceedingly amiable nature, and took a very kindly interest in all the younger members of the profession with whom, in any way, he was brought into touch. He had a great ideal of fitting himself to be of service in the world, and, so far as in him lay, encouraged younger men to turn their thoughts and efforts in a like direction. With this ideal it was not unnatural that he should pay considerable attention to the apprentices under his care. He had personally profited by the Science and Art classes, which were the beginning of technical education in Cardiff, and he insisted that the lads going through the shops of which he was in control should also take steps to improve their theoretical knowledge by similar means. He was a staunch adherent to the policy of embodying a very thorough and extensive practical training in the course of education for a young engineer, but he was no less keen in his advocacy of sound theoretical knowledge also. His views on engineering training were frequently ventilated, and always commanded a respectful hearing. In fact, much more than this was accorded to them, for so high was the esteem in which his opinion on this subject was held, that he occupied at one time and another many positions of responsibility in this connection. He was, for instance, a member of the Board of Governors of the Imperial College

of Science and Technology, being nominated to this position by the Institution of Mechanical Engineers, and a member of the Court of Governors of the University of Bristol. He was also a member of the Advisory Board of the Studies in Engineering of the University of London.

His services to Cardiff and South Wales were very many, and he was looked upon in that district as one of whom there was just cause to be proud. His genuine and unassuming character was thoroughly appreciated by all who were fortunate enough to have any intimate knowledge of it. As often happens with men of such a nature, Mr. Riches was not altogether happy in the turmoil attending certain phases of public life, and one of the greatest compliments ever paid to him was due to this very trait. He was returned as a Town Councillor for three years, but election work was distasteful to him, and he was finally defeated at the poll. In view of the valuable services he had rendered, he was, however, immediately co-opted, being appointed Chairman of the Technical Committee for the County Borough of Cardiff. This position he occupied for 12 years, during which time technical education in that western centre developed from mere Science and Arts classes into an organisation ranking with the best in the kingdom, and possessed of equipment in keeping with its reputation for thoroughness. Mr. Riches was also a member of the Education Committee of the county borough; but it was in technical education that he took especial interest. He was a Member of Council of the University College of South Wales and Monmouthshire. Among other duties which he discharged with scrupulous care were those of Justice of the Peace and Governor of the National Museum of Wales, of the Court of which he was a member. He was also connected with the engineering sections of several important exhibitions at one time and another.

As may be gathered from the above sketch of his career, Mr. Riches' life was fully occupied. During the last four years, however, his health had prevented him from leading so active a life as formerly, and for some weeks past his condition had given serious cause for anxiety, and he had been confined to the house. His death was due to heart failure. His loss, we are sure, will be deeply felt, not only in his own particular district of the country, but among a very large circle of friends, professional and otherwise.

THE DEVELOPMENT COMMISSION.

THE first report of the proceedings of the Development Commissioners has now been issued. The Commissioners were appointed by Royal Warrant in May, 1910, under the Development and Roads Improvement Fund Act, 1909, as amended by the Act of 1910. The first-mentioned Act is entitled "An Act to Promote the Economic Development of the United Kingdom and the Improvement of Roads therein," and the Commission was authorised to deal with that part of the Act relating to economic development.

The report refers to the period of nine months from July 1, 1910, when the Commissioners got to work, to March 31 last. Nine official meetings were held, and many informal meetings of Commissioners and of Committees. During the period under review twenty-four applications officially reached the Commissioners, proposing a capital expenditure of about 208,000*l.*, and an annual expenditure of about 211,000*l.*, though about 170 were made to the Treasury for advances from the Development Fund. In the first instance applications must be made to the Treasury. Applications from Government departments are sent direct to the Commissioners to be examined. Other applications are sent to the Government Departments concerned, which pass them on to the Commissioners, accompanied by the reports of the departments. The Commissioners report in turn to the Treasury, the latter deciding whether their recommendations, if favourable, shall be adopted or not.

The Commissioners have no executive power, and are only able to recommend, and no expenditure can be incurred without Treasury sanction. The Commissioners, in the exercise of their powers of making recommendations to the Treasury, decided to adopt certain main principles, at the same time recognising that general rules could not always be rigidly adhered to.

The necessity of a comprehensive policy taking account, in connection with any particular subject, of the needs of the whole kingdom, as far as possible, or at least of one of the main divisions —England and Wales, Scotland, and Ireland— of the kingdom, was appreciated. Such a policy is especially desirable in relation to the allocation of subsidies from public funds for purposes of research work, in order to avoid unnecessary duplication, and to ensure, as far as possible, that the various institutions which might be interested should undertake the work for which they were best fitted, and that the whole field of research open to the subject should be explored. Under a comprehensive policy it is impossible to deal with individual applications for particular objects as promptly as if each one were considered by itself; but the latter course would undoubtedly lead to waste both of money and energy.

There are many difficulties in attempting to follow a comprehensive policy, and to make "block grants" in preference to a number of separate grants, owing in a large measure to the inevitable complications of administration of Government and the extent to which the interests and jurisdiction of many Government and other authorities, or persons, of necessity overlap. The Commissioners resolved, as a general rule, to decline to make recommendations in respect of schemes requiring Parliamentary powers until such powers were obtained. They are not prepared to recommend advances in aid of any scheme until estimates of cost and sufficient details have been approved. They take the view, broadly speaking, that the fund at their disposal is intended to promote new work, and therefore, as a general rule, recommendations will not be made for grants in relief of existing expenditure. It is the idea that, under certain circumstances, grants may be made with a view of encouraging expenditure on work of public utility, provided contributions from local authorities or other sources are forthcoming.

Loans from the development fund will in general only be recommended for schemes which may be reasonably expected to become remunerative. Under certain circumstances loans may be made without interest, repayment not being required for years, and the terms may vary from these to loans granted on a commercial basis.

A provision in the Act of 1909, in reference to works involving employment, directs that the Commissioners in recommending advances for such works shall have regard to the general state and prospects of employment. They hope in periods of depression to be able to do something towards regulating the labour market by encouraging the kind of development work referred to.

It is not proposed to make any recommendations, so far as is avoidable, the effect of which will be to put public money drawn from the fund into private pockets. The Commissioners note the distinction between assisting individuals to help themselves, and simply putting public money into the pockets of certain persons.

Amongst the most important of the purposes for which the Development Fund was authorised are— the development of agricultural and rural industries and forestry and afforestation. In regard to the development of agriculture, &c., the first care of the Commissioners is the increase in quality and quantity of the products of agriculture by the extension of scientific investigation, together with a system of education, in order that the results of investigation and research may be widely known and put in practice. They also hope, by the knowledge made available, to increase the variety of production where this can profitably be done. A further important object the Commissioners have in view is the extension and organisation of co-operation.

Results of value on a large scale are not attainable merely by expenditure, and the Commissioners, at the start, have found themselves seriously handicapped by the difficulty of collecting a competent and trained staff. They point out that very few men are qualified to conduct agricultural research, and the number cannot be increased at short notice. Also, at present, in this country, very few are to be found capable of directing operations of forestry on a large scale.

As regards forestry, the Commissioners have come to the conclusion that the first requirement is education, regulated by organised research, and, secondly, that State afforestation on a big scale is out of the question until investigation has shown where State forests might be remuneratively established, and a body of trained foresters is available. Further, they consider that, for the present, applications for grants in aid of forestry should include provision for the creation and maintenance of a suitable staff. The situation on March 31 is summarised as follows:—England and Wales: A comprehensive scheme has just been received from the Board of Agriculture and Fisheries. Scotland: The Commissioners have agreed to the provision of a central demonstration area, and preliminary steps are being taken to acquire it, and of a forestry school in connection therewith, and also to the provision of small forest gardens for local use of agricultural colleges. Ireland: Advances of 25,000*l.* or 30,000*l.* have been recommended for the purchase of land, and the Commissioners have agreed to further advances, for additions to staff and for the management of small woodlands in the hands of county councils, when formal applications under the Act are made.

Applications were received in connection with the development and improvement of fisheries in Ireland for grants towards the improvement of harbours. An interim grant of 4000*l.* towards the purchase of a dredger was recommended, and the other applications postponed or referred for further information.

Under the heading "Construction and Improvement of Harbours," a grant of 6500*l.*, and a loan of 7000*l.*, without interest, repayable by annual instalments in 30 years, were recommended, on certain conditions, to be made to the Stonehaven Harbour Trustees. In response to the application by the River Dee Conservancy Board the Commissioners declined to recommend a grant.

Under the Act of 1909 application may be made to the Commissioners for orders for the compulsory acquisition of lands, and they have therefore prescribed rules and a form of draft order in connection with such applications. One application was received, during the period under review, to enable the rounding-off of two street corners to be effected.

The Commissioners have recommended, or agreed to recommend when satisfactory schemes are drafted, approximately 165,000*l.* per annum, and about 100,000*l.* non-recurring grants. These sums include for agricultural research and education in England and Wales 105,000*l.*, a lump sum of 60,000*l.* to Scotland, and 5000*l.* per annum and 9000*l.* per annum to Ireland. So far the allocation of one-third of the annual income guaranteed to the Development Fund for five years has been recommended. The Commissioners anticipate considerable increased expenditure in the near future, and express the fear that the fund will not be in a strong position a few years hence without Parliamentary aid.

Copies of the Development Acts of 1909 and 1910, Treasury regulations as to methods of application for advances and as to payments, with a list of applications officially received up to March 31, provisions prescribed as to compulsory purchase of land, and a list of witnesses examined, are published as appendices to the report.

PERSONAL.—The Nottingham Corporation Water Engineer's Department has been removed from St. Peter's Church Side to the Castle Water Works, Castle Boulevard.

THE TRAMCAR ACCIDENT AT DITCHCROFT HILL, MILLBROOK.—The report of Lieut.-Colonel P. G. von Donop on the accident which occurred at Millbrook on the Stalybridge, Hyde, Mossley, and Dukinfield Electric Tramways, on June 5, shows the fault to have been, on this occasion, with the manipulation of the brakes. It will be remembered that the accident, attended, unfortunately, by fatal results, happened to a car descending Ditchcroft Hill between Stalybridge and Mossley. The hill is 229 yards in length, of which 146 yards are on a grade of 1 in 11.4. There is a curve, said to be of 1½ chains, but of apparently 56 ft., radius at the bottom, and at this point the car, which had got out of control on the hill, overturned. The Board of Trade Inspector's conclusion is that the driver, who seems to have been a capable man, on this occasion applied his hand-brake at the compulsory stop at the top of the hill, but did not stop there, having locked the wheels. As the car began to descend the hill and gain speed, the driver appears to have tried to apply his Westinghouse magnetic brake, which, however, had been rendered inoperative by the skidding of the wheels. It is understood that the Westinghouse Company are now fitting an additional appliance to this brake, which enables it to be brought into service mechanically as well as magnetically, and the Inspector suggests that the advisability of adding this gear to the cars on this route should be considered. The accident is the third of its kind on the hill, and the report recommends that until the curve at the bottom is eased, only single-deck cars should be allowed to travel on this hill.

NOTES.

German Labour.

A report issued by the Employers' Union for Hamburg and Altona, gives some striking particulars about the heavy weekly contributions which the social democratic unions inflict upon their members, and which exceed the taxes which the members have to pay to the State. The members of the social-democratic unions in Germany during the year 1909 paid in weekly contributions to their unions on the following scales, the number of members and the percentage of the total paying each class of contribution being given :—

	Members.	Per Cent.
Up to 2.4d.	59,947	3.28
2.4d. to 3.6d.	126,821	6.92
3.6d. to 4.8d.	534,895	29.18
4.8d. to 6d.	504,436	27.52
6d. to 7.2d.	480,981	26.24
Above 7.2d....	125,587	6.86
Total	1,832,667	100.00

Compared with the previous years, the percentage of the three higher contributions shows an increase, the reverse being the case with the three lower classes. These regular contributions are further swelled, and not immaterially so, by extra local and other contributions, making the weekly payment for the majority of the members more than 1 mark. Added to this come contributions for political purposes, and thirdly those for a large joint war fund, upon which the organisations can fall back in cases where it is a question of specially important conflicts with the masters, when the funds of the separate unions do not suffice. This fund naturally challenges the masters to a display of greater zeal in self-defence. One point which is now considered of great importance, in Germany and elsewhere, is the adequate protection of those hands who are willing to continue or commence work when others go on strike. Pending legislative measures, the masters are urged to exert themselves earnestly in this direction, and thus make up for all the negligence they have hitherto shown in this connection. A report issued by the Dortmund Chamber of Commerce gives vent to somewhat pessimistic views of the labour question and problem. The "red" trade unions, says the report in question, comprise at the present time 1,832,667 members, constitute the *élite* of the social democracy, disturb and damage the industrial life, coerce, in an unheard-of manner—in secret and openly—those who are willing to work, or who hold divergent views, and do now not even refrain from egging on their followers to violence and revolt as long as they are able to mock the State and her representatives. The insurance of workmen has utterly failed in bringing about that conciliation which was hoped for thirty years ago. In representations where masters and men stand in equal numbers, the latter often frustrate all rational and beneficial work.

The 15-Ton Héroult Steel Furnace at Chicago.

Some particulars of the 15-ton Héroult furnace of the Illinois Steel Company at South Chicago, the largest electric steel furnace in existence, were given by Mr. C. G. Osborne at the meeting of the American Electrochemical Society, held at New York last April. The furnace had then been working more or less continuously for eighteen months, and had produced material for steel rails, billets, plates, structural shapes, and forgings, of all sizes and grades, as well as alloys with nickel, chrome, manganese, and silicon. The furnace is built up of 1-in. steel plates, and has five doors. The bottom is lined with a mixture of dead-burned magnesite and basic open-hearth slag, in the proportion of 4 : 1, tamped down with tar; after tamping the furnace is filled with wood, dried for 48 hours, and then filled with coke; the electrodes are lowered, and the current is turned on to flux the bottom into place. The three electrodes are grouped in an equilateral triangle of 5 ft. side, and penetrate through the nearly flat roof of the furnace, which is made up on a movable ring and consists of silica bricks 12 in. in thickness. Each electrode has a holder of cast copper, bolted directly to the bus-bar and split in front; the holder is opened and closed by a left and right screw. Round and square electrodes up to 24 in. in diameter have been used. Each electrode has its own regulator and motor, the regulation being by hand, or by controllers or automatic. The automatic device comprises a stationary electromagnet, fed by adjustable current, and a movable magnet mounted on a spring and fed from a transformer on the bus-bar. Normally the two magnets balance one another. When the one or the other current prevails, the motion of the floating magnet is communicated to a lever and a rocking-wheel, so that contact is made for turning the motor to the right or the left, and for raising or lowering the electrode $\frac{1}{8}$ in. at a time. The primary current, three-phase at 2200 volts and 25 periods, is reduced in three 750-kw. transformers to about 90 volts (from 80 to 110). The furnace is generally charged with full-blown Bessemer pig, blown hotter than usual, because the converter is about a quarter of a mile from the furnace, and the transport takes 5 minutes. While the charging-ladle is tilted, the slag is cleaned off, and iron oxide and lime are shovelled into the furnace, whereupon the electrodes are lowered. This basic slag is removed after 30 minutes, lime and fluor-spar are poured on the bare surface, and finely-divided coke-dust is thrown in after the new slag has melted; calcium carbide is then formed, and reduction commences. A heat lasts from $1\frac{1}{2}$ to 2 hours. Steel produced electrically is, according to Mr. Osborne, considered mechanically superior to other makes, chiefly because it is comparatively free from segregation and from oxidation; the actual contents of free oxygen and of nitrogen are not known, however, in spite of thousands of experiments. The roof of this Héroult furnace was fairly gas-tight, but during the first stage of the heat a good deal of ebullition took place, and the electrodes were constantly moving. At starting some 1950 kw., 650 on each leg, would be absorbed by the furnace; that figure went down considerably—to 750 kw.—as the process continued. No statements as to the cost were made.

The Rüping Process of Creosoting.

On Tuesday last, the 5th inst., an interesting demonstration of the Rüping process of creosoting took place at the extensive Staddlethorpe yard of Messrs. Richard Wade, Sons, and Co., Limited, near Hull. Owing to the large exports of creosote from England, and the increased demand for timber preserving, the cost of creosote has risen rapidly. The object of the new process is, therefore, to protect effectively the substance of the timber without wasting any of the preserving liquid. In explanation, it was stated at the demonstration that the red fir tree, the species mainly used in this country in a creosoted state, contains about 40 per cent. of heart-wood, which cannot be impregnated to any appreciable extent by any preserving liquid, owing to the cells of the wood having become closed. The remaining 60 per cent. is sapwood—*i.e.*, open cellular tissue—about half of which is the substance or fibre of the tree, the remainder being open spaces. The object of the Rüping process is thoroughly to saturate the fibre or cell walls with the preserving liquid, and to allow none to remain in the interior of the cells. By this means there is no ultimate oozing or sweating of the wood, which keeps perfectly dry and clean. It is claimed that the direct result is a great saving in first cost, without any reduction in the life of the timber. The process is effected by compressed air, the creosoting cylinders being similar to those used in the vacuum process, but with the creosote tank located above the cylinder level instead of being beneath. When the cylinder has been charged with the wood to be treated, and its openings carefully closed, an air pressure of about 50 lb. per sq. in. is gradually raised in it, and also above the creosote contained in the overhead tank. In less than half an hour after the air-pump has been started the creosote from the overhead tank is admitted to the creosoting cylinder, the same air-pressure of about 50 lb. per sq. in. being maintained. About 15 minutes after the cylinder has been filled with oil the connection between it and the overhead tank is closed; a pressure-pump is then started, and increases the pressure inside the cylinder by about 80 lb. per sq. in. These conditions last for about 35 minutes. The connection between the cylinder and the overhead tank is next re-established, and the excess oil in the former is returned to the tank; the compressed air in the pores of the wood also drives out of the timber under treatment, the greater portion of the oil which it contained in excess. The pressure is then removed, the cylinder is opened and allowed to drain into a receiver placed beneath the opening. In the demonstration referred to above, a number of pieces of timber were placed inside a cylinder; they were carefully weighed before and after treatment, the following being the figures for each class. Twelve redwood telegraph poles were first taken and weighed separately; their total weight before treatment was 1 ton 2 cwt. 3 qr. 21 lb., their volume being 70.76 cub. ft. After treatment, their weight was 1 ton 6 cwt. 1 qr. 5 lb., showing that they had absorbed 3 cwt. 1 qr. 12 lb. of oil, equal to 5.31 lb. per cub. ft. On these had been placed twenty-four redwood fence-posts, weighing 4 cwt. 1 qr. 21 lb., and measuring 18.25 cub. ft. After treatment, the weight was 5 cwt. 1 qr. 23 lb., equal to a total weight absorbed of oil of 3 qr. 10 lb., or 5.04 lb. per cub. ft. Twenty-four redwood fence-rails had absorbed 5.79 lb. per cub. ft. Twenty-five redwood paving-blocks had taken 6.89 lb. per cub. ft. The figure for twelve redwood sleepers was 5.05 lb. per cub. ft., and that for twelve white-wood pieces, 5 ft. in length, 1 ft. to $2\frac{1}{2}$ ft. in width, and 4 in. to 7 in. thick, weighing before treatment 1 cwt. 12 lb., measuring 4.37 cub. ft., and weighing 1 cwt. 19 lb. after treatment, was 1.6 lb. per cub. ft. All the wood thus treated dried most rapidly in the air, and presented a very clean appearance. Several pieces were cut across, and showed a remarkable penetration of the oil, almost to the centre.

INDUSTRIAL NOTES.

The report of the Labour Department of the Board of Trade on Changes in Rates of Wages and Hours of Labour in the United Kingdom in 1910, with comparative statistics for 1901 to 1909, has just been published as a Parliamentary paper, and shows that the year 1910 was one of improving trade and employment, the net increase of wages shown being 14,500*l.* per week, as compared with net decreases of 69,900*l.* and 59,200*l.* in 1909 and 1908 respectively. There have, according to Mr. Askwith, been, since 1896, three periods of rising wages (1896-1900, 1906-7, and 1910), and two periods of falling wages (1901-5 and 1908-9), the net effect being an increase of 353,985*l.* in an ordinary week's pay of the workpeople directly affected. The net effect of the changes in each of the years 1896-1910 was as follows :—

	Periods of Rising Wages.	Periods of Falling Wages.
	£	£
1896	26,519	—
1897	31,507	—
1898	80,713	—
1899	90,314	—
1900	208,590	—
1901	..	76,587
1902	..	72,595
1903	..	38,327
1904	..	39,230
1905	..	2,169
1906	57,897	—
1907	200,912	—
1908	..	59,171
1909	..	68,922
1910	14,534	—
	710,986	357,001

Mr. Askwith goes on to say that as regards the methods by which changes in rates of wages were arranged in 1910, changes affecting 7 per cent. of the workpeople involved were arranged under sliding-scales, changes affecting nearly 70 per cent. by conciliation boards, mediation, arbitration, &c., and changes affecting 23 per cent. by other methods. Since 1902 the operation of sliding-scales has been almost entirely confined to the pig iron and iron and steel industries, while the great majority of the workpeople whose changes are arranged by conciliation boards, arbitration, mediation, &c., are employed in coal-mining. The net effect of the changes in hours of labour reported in 1910 was a reduction of 47,575

Period to which the Figures refer. First Week in December.	Number Employed in Selected Week.	Amount Paid in Wages in the Selected Week.	Average Weekly Earnings per Head.
		£	s. d.
1901	440,557	551,114	25 0½
1902	448,429	559,179	24 11½
1903	448,321	557,819	24 10½
1904	445,577	557,820	25 0½
1905	449,251	563,338	25 3½
1906	457,942	582,207	25 5½
1907	478,690	618,304	25 10
1908	459,120	574,059	25 0
1909	459,444	582,782	25 4½
1910	463,019	596,342	25 9

in the weekly working time of the workpeople affected. Early in 1910, the downward movement, which began in 1908, changed to a slight upward tendency, and at the end of the former year the general level of wages was higher (with the exceptions of 1907 and 1908) than at the end of any year since 1893. Apropos of the late railway strike, the table annexed is interesting. It refers to twenty-seven railway companies employing more than 90 per cent. of the total number of rail-

way servants of the United Kingdom, and these companies supplied the information on which the table is based.

The above is a statement of earnings, not of rates of wages.

Arrangements have recently been completed for the union into one of the Amalgamated Society of Carpenters and Joiners, having head-quarters in Brunswick-street, Manchester, and about 60,000 members, and the Associated Society of Carpenters and Joiners, having head-quarters at Glasgow, and 4000 members. The object is simply to strengthen the trade organisation. The amalgamation of the two societies had been proposed for some time, but hitherto the two-thirds majority of votes in favour had not been secured. This is now the case, and the amalgamation will come into effect within the next few days. It is proposed to call the society the Amalgamated Society of Carpenters and Joiners.

The autumn conference of the Association of Chambers of Commerce of the United Kingdom met in Trinity College, Dublin, on August 30, under the chairmanship of Earl Brassey, and unanimously decided to request Government to appoint a special Commission to inquire into the working of the Trades Disputes Act, 1906, which Act, by authorising peaceful picketing, had rendered intimidation, violence, and interference with food supplies and trade possible, as was instanced in the recent railway and other strikes. The resolution, which was voted upon as a matter of urgency, was moved by the Hon. Rupert Beckett, who said he conceded the right to strike to any man, but where he quarrelled with him was where methods were adopted, when a strike was in progress, which led to violence, intimidation, and the direct breaking of the law. Mr. A. J. Hobson, Sheffield, seconded, stating that the resolution was a statesmanlike one, and one calculated to build a bridge for those responsible for the passing of the 1906 Act to reconsider their position. The resolution was carried unanimously.

The men of the Cambrian Combine, who had been on strike for ten months, have resumed work upon the terms agreed upon by the coalowners of South Wales and by the Miners' Federation of Great Britain in May last, terms which the Welsh miners had until now refused to accept. The strike commenced in November of last year with the Ton-y-pandy riots; the cost is stated to have reached several million pounds sterling. The following are a few statistic figures which throw light upon the dispute and upon its consequences:—The South Wales Miners' Federation paid 150,000*l.* in strike pay, and levied 4s. a month upon the miners at work. The Miners' Federation of Great Britain contributed a further sum of 72,000*l.* The Coalowners' Association gave the Cambrian Combine 280,000*l.* It is estimated that the output of the Combine for the ten months in question would have have exceeded 2,500,000 tons, which, at an average of 15s. per ton, would have yielded 1,875,000*l.* The men's wages would have amounted to 960,000*l.* from this latter sum. As additional losses there must be counted 300,000*l.* loss of revenue to the railway companies and 80,000*l.* loss in freight to steamers; also 80,000*l.* loss to middlemen at the docks, and 50,000*l.* loss to the rates of the county. Besides these, there are many other losses, both direct and indirect, which are borne by practically every member of the community. Moreover, most of the collieries will require putting into working order again, and this will lead to expenditure which means a further loss.

According to the *Journal of the Royal Society of Arts*, there are indigenous to Brazil, and growing wild in certain regions, two well-known species of trees which are of interest to the commercial world because of their possibilities as producers of cotton fibre. Not the least remarkable feature about these trees is their occurrence in precisely those regions where it had seemed to be impossible, or, at least, difficult, to grow ordinary cotton. No other country possesses so large an area of land which may be utilised for the growing of cotton as does Brazil; the fact that in other areas it is possible to cultivate trees for the production of cotton fibres must appeal to the textile industries as indicating that Brazil must be reckoned with as a future source of the world's cotton supply.

As a result of the intervention of the Board of Trade, an arrangement was arrived at on August 31 with the Great Eastern Railway Company, according to which the company gave an assurance satisfactory to the officials of the men's unions with regard to the reinstatement of the men who left work at the time of the national strike two weeks ago. The decision was "that the company should fall into line with the other companies, and reinstate the men as soon as possible."

The coalworkers' strike at Grimsby Docks was settled on September 1, in the course of the evening, after somewhat lengthy conferences between the masters' and the men's representatives. The former agreed to several of the men's demands; they also agreed to a joint conference which is to settle within ten days the rate of wage to be paid the tippers, and, further, to establish some basis with reference to payment for waiting time. The men resumed work immediately, and the shops which had been held up for want of coal were to be freed. Councillor Farrar, J.P., who had acted for the men, stated that the employers had shown a very fair spirit, and on one or two points had agreed to terms which were even better than the men had demanded.

A mass meeting of all grades of railwaymen was held in Sheffield on Sunday, the 3rd inst., when a resolution was passed, complaining of an alleged breach of settlement by the Midland Railway Company in declining to reinstate two guards in their former positions, re-employing them as under-guards at 8s. per week less wages; they called on the joint executive committees to bring all the men out on strike if this were not remedied.

About 4000 men of the North-Eastern Railway held a meeting at Darlington on Sunday, the 3rd inst., and passed unanimously a resolution declaring that, in order to protect their interests, it was necessary that all railwaymen should join the union. They further expressed the opinion that the time had arrived when a date should be fixed to cease working with non-unionists. The committee is to consider what steps should be taken to put the resolution in operation. Mr. Williams, secretary of the Amalgamated Society of Railway Servants, supported the resolution, and stated that when the men approached the railway directors for better conditions they were always taunted with the "supposed" contentment of the non-unionists. Yet the non-unionists never lost time in asking for the benefits obtained by organised effort. He (Mr. Williams) wanted the men to conduct the movement on constitutional lines, when it would have the whole-hearted support of the society. Mr. Hudson, M.P., who followed, added that they had reached the position when they would have to say to the employers that non-unionists should not participate in concessions, or to the men that they had to enter the union and pay their share.

THE LATE MR. E. B. THORNHILL.

THE death occurred, at Colwyn Bay, on the 31st ult., of Mr. Edward Baylies Thornhill, formerly chief engineer to the London and North-Western Railway Company. Mr. Thornhill's regretted death occurred rather suddenly, after, however, a protracted illness.

Mr. Thornhill was born in 1841. He was a pupil under Dr. W. Pole, and a scholar at King's College, London. In 1862 he entered the London and North-Western Railway's service in the engineer's office at Euston, and in 1864 he was first put in responsible charge of works. He spent fifteen years as resident engineer in charge of various important works, including undertakings in Manchester, the reconstruction of Lime-street Station, Liverpool, its approaches, &c., of various new railway lines, and of docks at Garston. In 1879 he was appointed chief assistant engineer, and in 1902 succeeded Mr. F. Stevenson as chief engineer. This appointment he held till his retirement in 1909, during which period he was responsible for the improvements in the approach to Euston, the new Garston dock, &c. He was admitted to the Institution of Civil Engineers as a member in 1870.

THE LATE MR. T. D. SMYTHE.

WE regret to have to record the death, on the 26th ult., of Mr. Thomas Dixon Smythe, who was connected with much railway construction work in South America. Mr. Smythe's engineering education was commenced at the Gymnasium, Aberdeen, where he followed the civil engineering course. He subsequently went to Edinburgh University, after which he served a four years' apprenticeship under Messrs. H. Wylie and J. Peddie, civil engineers, engaged on railway and other work. In 1868 he was made assistant to Mr. J. Peddie. He subsequently held the positions of chief assistant engineer on the location and construction of the Chilian and Talcahuano Railway, 115 miles in length, and acted as resident engineer on location, construction, and traffic of the San Rosendo, Los Angeles and Angol Railway, 60 miles in length. In 1882 he was holding the position of chief engineer on the location of the Coihue and Mulchen Railway, and in 1883, in a similar position, made reconnaissances for the Southern Railways. From 1883 to 1888 he was chief engineer of the Angol and Traiguen Railway section of the Arauco Railways, and subsequently engineer-in-chief on the final location of the Pelequen and Penmo Railway. He was born in 1845, being therefore in his sixty-sixth year at the time of his death, which followed upon a short illness. He was admitted to the Institution of Civil Engineers as a member in 1889.

THE LATE MR. EDWIN FODEN.

WE regret to have to record the death, which occurred at his residence, Elworth House, on Thursday, August 31, of Mr. Edwin Foden, the senior partner of Fodens, Limited, Sandbach. Mr. Foden was born seventy years ago at the village of Smallwood, three miles from Sandbach. His parents were in a humble situation and had secured for him, when he was quite a youth, the position of village postman, with a view to increase the income of the family. The lad, however, wanted to be an engineer; his father at last yielded to his entreaties, and at the age of fifteen he was apprenticed at Messrs. Platt and Hancock's Engineering Works, Elworth. Four years later, at the age of nineteen, he was made foreman, a position which he held for several years. He then went to Crewe Works, where he stayed twelve months, going next to an engineering works at Kidsgrove, where he remained eighteen months. On an invitation from his old employer he returned to Elworth, and at the age of twenty-five he was made a partner in the firm, which was known for some time as Hancock and Foden. Six years later Mr. Hancock retired, and Mr. Foden took over full control. The works gradually increased and gained importance in the manufacture of agricultural machinery and traction-engines. With the advent of the steam motor-wagon, the construction of which the firm adopted as a speciality, the extension of the works was extremely rapid; the success which the Foden type has repeatedly met with has led the name of Fodens, Limited, Sandbach, to become known over a very wide circle. Mr. Foden found time to engage in local business; he has filled, in fact, almost every position in local public life. He had a passion for music, and formed the Elworth band, now called Foden's band, which has achieved great reputation at many musical competitions. Mr. Foden was of a most kindly disposition; he entertained a real affection for the old people, especially for those who had grown old in his service, to whom he allowed a substantial pension. He will be greatly missed by his workpeople and by his numerous friends. The works, which he practically created, remain as a monument to his memory.

THE EFFICIENCY OF STEAM-TURBINES.

To the Editor of Engineering.

SIR,—In view of the remarks made in Mr. Chorlton's letter published on page 255 of your issue of the 25th ult., I have written to Mr. Eric Brown at Baden to ask him to substantiate my statement regarding the information he gave at his recent lecture, and I think it would be best to quote the following from the answer I have received from him:—

"The efficiency mentioned in my lecture concerned that of a 15,000-kw. turbo-generator set now building at our works, and on referring to my notes I find the words '*Thermal efficiency from steam to current delivered* 70 *per cent.*,' which words, I am told, were clearly uttered. As my firm are builders of complete sets, including turbines and generators, I considered that mentioning the total efficiency of the set would be of general interest."

Yours faithfully,
M. G. S. SWALLOW.

Hartlepool Engine Works, Hartlepool,
September 4, 1911.

SUPERHEATER LOCOMOTIVES.

To the Editor of Engineering.

SIR,—In the article on "The Railway Situation" in ENGINEERING, of August 18 last, it is said that "several of the Great Northern locomotives . . . are to be fitted with superheaters, and the results will certainly be awaited with interest." The former part of this statement appears to do less than justice to a line which has taken a leading position in the introduction of superheated steam on British railways, and which has for the past three years been obtaining and utilising experience thus gained.

In 1908 one of the eight-coupled mineral engines, No. 417, and one of the smaller "Atlantics," No. 988, were fitted with Schmidt superheaters, and in 1909 a 4-4-0, No. 1383, was fitted with the Baldwin smoke-box superheater. Following these, five 8-coupled mineral engines, Nos. 451-5, ten large "Atlantics," Nos. 1452-61, and fifteen 4-4-0's, Nos. 51-65, have been built, all provided with Schmidt superheaters.

The results obtained are understood to be very satisfactory in the matter of coal consumption, and as advantage has been taken of superheating to reduce the working pressure, it is to be expected that the boiler repairs will certainly not exceed the exceptionally low figure for which the Great Northern Railway is well known. The fact that Great Northern locomotives are still in the van of progress, and are surpassed in forward development, whether of main features of design or detail fittings, by those of no other railway, materially enhances the feeling of deep regret generally felt at the loss to the engineering profession sustained by the retirement of Mr. Ivatt.

Yours faithfully,
September 4, 1911. L. A. F.

THE ORIGIN AND PRODUCTION OF "CORRUGATION" OF TRAMWAY RAILS.*

By W. Worby Beaumont, M. Inst. C.E.

Few of the phenomena of the behaviour of materials employed in tramway construction have given rise to so much inquiry, speculation, and diversity of opinion in the last few years as the phenomenon known as "corrugation" of tramway rails. The rapid spread of its occurrence, in nearly all towns with heavy tramway service, has directed anxious attention to the discovery of its cause, and much has been written concerning it, and some experimental investigations have been made. Unfortunately, the indoor experiments have seldom been conducted with apparatus or under conditions which simulate those of the tramway itself.

On the other hand, the observations which have been made by many on the rails themselves have led to every possible variety of interpretation of the cause of corrugation, largely because of the apparent contrariety of its occurrence and non-occurrence. The author had commenced the preparation of an index to the papers and articles which have appeared in this and other countries during the past five years, but it was soon found that this would be of intolerable length, and, after all, of but little service. The Proceedings of the Institution of Civil Engineers provide abstracts of papers too numerous to mention; the Institution of Electrical Engineers has dealt with the subject; the Municipal Tramway Association and the Tramway Congress hardly ever met without dealing with the subject; the Tramways and Light Railways Association Official Circular and Journal for some years has been crowded with corrugation inequalities and vagaries, and lately a joint committee of the two Associations—the Municipal Tramways Association and the Tramways and Light Railways Association—has been working on the subject. To the proceedings of this Committee the author has contributed, and had previously dealt with the subject elsewhere. Foreign authors have contributed largely, and a report by a Committee consisting of the managers of nine continental tramway systems, one British professor of engineering, and the secretary, was discussed at the International Tramway Congress held in Brussels in 1910. One of the recent and most useful reports on the subject (although some judicious analysis of the facts presented is required) has been prepared as a provisional report by a Committee of the Technical Department for Railway Construction and Exploitation of Amsterdam, including Messrs. J. Schrooder van der Kolk, M. P. Mass Geesteranne, and T. E van Putten, and, more recently, a paper by Herr von Borries, of much merit, has been published.

Having given some attention to all this literature of this particular engineering ailment, and being aware of the indecision that still exists in the minds of many upon it, the author now ventures at more length, and with the object of greater precision, the explanation he has on previous occasions attempted to convey. The subject has hitherto been treated mainly from the general point of view suggested by the practical experience of the tramway manager and engineer, and has seldom attracted or received the considered reasoning conjointly of the mechanic and the physicist. It is, however, one which in a marked degree demands the patient application of the attributes of both, and in this paper I may repeat the words of Mr. H. R. A. Mallock,* and say: "It is often useful to have a simple, even if incomplete, theoretical treatment of a subject, provided that the theory is correct so far as it goes, and is kept within bounds by comparison with actual observations."

In a surface of a homogeneous solid under compressive stress in orthogonal directions in the plane of the surface, every particle tends to cause every particle surrounding it to recede in every direction. If one surface of a free flat bar of steel or iron, as Fig. 1, be rolled or hammered, the material of that surface is subjected to a compressive stress. Of this stress it is relieved in the direction of length of the bar so far as the stress is no greater than that which is necessary to bend the bar, and cause it to keep the bent form of Fig. 2. If of wrought iron, the molecular surface stress will in part be relieved by flow of the material or detrusion along the edges of the hammered surface, and the longitudinal bending be less than if the bar be of rail steel, in which the detrusion will be less.

If of cast iron, the surface compressive stress will accumulate, and the bar will be bent by it, but the accumulation of stress reaches an earlier limit, as it sooner exceeds the limit of cohesion between the surface and subjacent films. The result is that with cast iron surface crumbling occurs and limits stress accumulation. It does, however, become sufficient to permit its use as a means of straightening cast-iron coping-plates and the like if slightly curved when taken out of the sand.

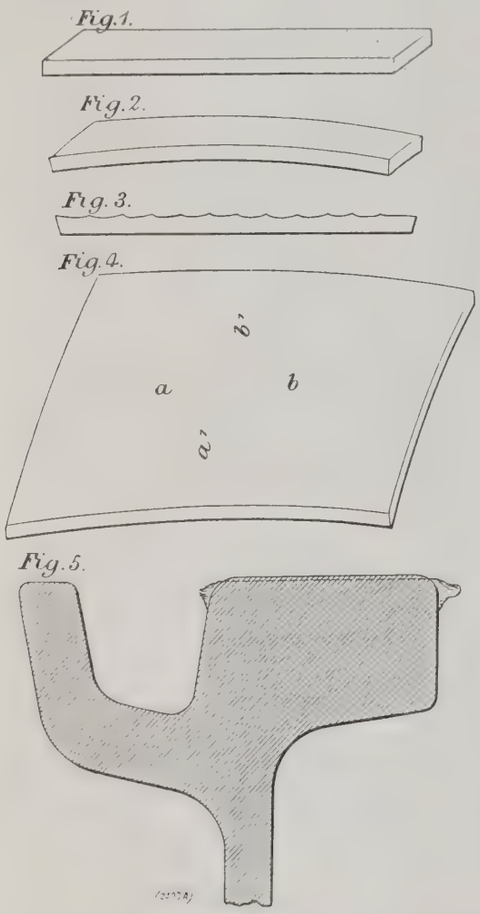
If, when a bar has been bent by surface compression of one side, it be forcibly straightened, the compressive stress will be increased, and a tensile stress impressed on the opposite side sufficient to eliminate the difference of dimensions of the two sides caused by the compression. To remove the difference permanently the stress on the uncompressed side must reach the character of strain equally distributed throughout the whole length of the bar. At the same time an increase is made in the compressive stress on the rolled or hammered surface. This cannot be removed by a single pucker or extrusion of the surface about the centre of length of the bar, as the stress is uniformly distributed. Hence at distances apart (or pitch) depending on the elastic and cohesive properties of the material there will result incipient surface crumblings or corrugation, as shown exaggerated in Fig. 3.

The bearing of this fact on the tramway or railway rail will appear hereafter, but here it may be observed that the stresses in a bar which is bent by compression of one side, and caused to retain the bent form by that resident molecular stress, is not in the same condition as to stress throughout its structure as a similar bar bent and maintained in a bent form by mechanically imposed distributed load.

In the bar bent by compression of the material on one side, there is molecular tensile stress immediately below the hammered surface. The compression differentiates in intensity from the surface, to a zone or couche under tensile stress resulting from the molecular cohesion which has prevented the compressed and extended surface from separating itself by shear. Below this, tensile stress differentiates into a neutral zone, and therefrom into the compressive stress, which remains resident in the bar so long as it is bent by these internal forces.

In a surface, such as that of an iron plate which has been rolled or hammered on that surface only, the particles of the hammered surface are, as previously mentioned, restrained by cohesion of and with the subjacent particles, which are less and less under compression as they are remote from the compressed surface film.

If any two points a b or a^1 b^1, Fig. 4, be taken in such a surface film, it will be seen that all the particles round each point press towards it with forces proportional to some function of their respective distances from such points. In a line drawn from a to b, or a^1 b^1, there are therefore equal and opposite forces tending to separate those points, and when their amount exceeds the elastic



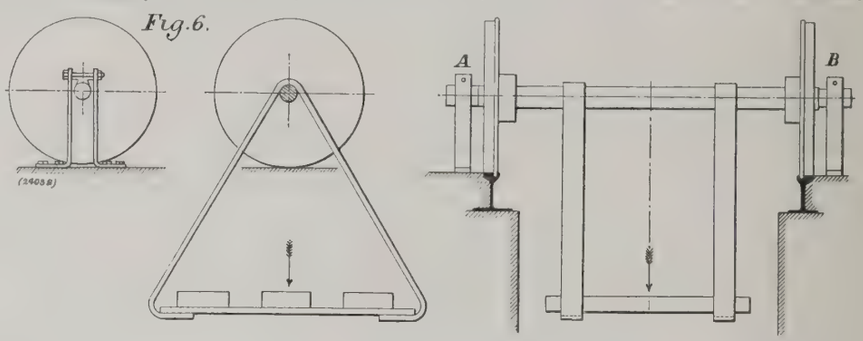
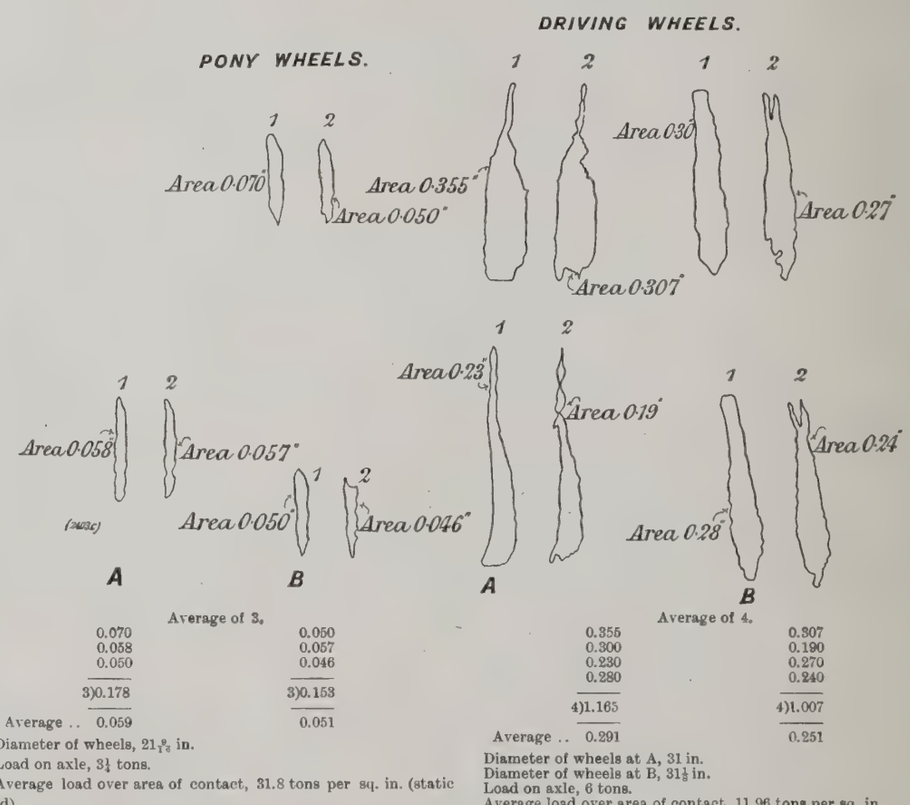


Fig. 7. DIAGRAMS OF CONTACT AREAS. (REDUCED)



	A	B
	Average of 3.	
	0.070	0.050
	0.058	0.057
	0.050	0.046
	3)0.178	3)0.153
Average ..	0.059	0.051

Diameter of wheels, 21 5/8 in.
Load on axle, 3¼ tons.
Average load over area of contact, 31.8 tons per sq. in. (static load).

	A	B
	Average of 4.	
	0.355	0.307
	0.300	0.190
	0.230	0.270
	0.280	0.240
	4)1.165	4)1.007
Average ..	0.291	0.251

Diameter of wheels at A, 31 in.
Diameter of wheels at B, 31⅛ in.
Load on axle, 6 tons.
Average load over area of contact, 11.96 tons per sq. in.

* Paper read before Section G of the British Association at Portsmouth, August 31.

* Proceedings of the Institution of Civil Engineers, vol. clxxviii., 1909.

resistance of the material, deformation or crushing or crumbling must occur, if change of form of that of which the surface is a part be restrained. If the surface be that of a deformable plate then the forces are in part relieved by bending the plate in orthogonal directions. It is not necessary here to determine the distance between a and b at which any given material will reach the yielding point or at which the accumulated forces will be sufficient to cause either the bending of a plate, or give rise to destructive stresses in any other form of which the compressed surface is part.

To this a return may be hereafter made, but here it is sufficient to repeat that it will be dependent upon the relation between the elastic resistance of the material to compression and its elastic tensile strength, and its hardness.

In dealing with these stresses as occurring in practice, and in such forms as those of a railway or tramway rail, it will be seen from the foregoing that the values of the stresses in orthogonal directions soon reach inequality, because, while they become cumulative in the direction of length of the rail, the distance transversely separating the points a and b earlier reaches the limits of dimensions at which the forces can arise, because relief of the stresses is found in lateral deformation or detrusion at the rail edges (Fig. 5).

There is a further view of the physical conditions to be considered which, under the mechanical conditions of the rolling of a wheel on the plane surface of a rail under pressure greater than or approaching its elastic resistance, gives rise to that which results in what is known as corrugation. A loaded circular surface, as of a roller or wheel resting upon a deformable straight plane surface, has but a line contact with that surface until either or both the circular and flat surfaces of contact are so deformed by loading the roller as to increase the area of contact. The deformation will continue until the resistance to deformation equals the force producing it. If the materials of the two surfaces be equally resistant, the circular surface will be flattened and the flat surface will be depressed or indented. If the roller be of the more resistant material, the deformation may be chiefly in the material of the flat surface. If the roller be made to roll along the surface which it can so deform, it presses before it a wave of deformation. The depression giving rise to this wave may (as in the case of the tramcar wheels and rails) approach or exceed the limit of elastic deformation of the material of the rail. When this is the case, continuation of the movement of the roller upon the surface demands the translation of the crest of the wave, and this would involve the destruction of the cohesion between the rolled compressed surface wave crest and the material supporting it, and of which it is a part. The result, therefore, is that tensile stress arises, *pari passu*, with the wave formation between the wave particle and the subjacent particle of the material supporting it, and the point is reached at which the tensile resistance to the increase of the wave height prevents further increase. The roller then must rise upon the minute crest, and in doing this with its heavy load upon the extremely small area, compresses it to extreme hardness. The roller (wheel) in its continued progress repeats the process and continuously adds to the rearward dimensions of the hardened spot.

The foregoing then shows that the rolling and hammering of the upper surfaces of a rail originate a condition of intense compressive stress, the elimination of which produces or tends to produce modification of form. It also shows that areas of maximum compression are originated at points separated by distances which are determined mainly by the relation between compression resistance and elastic strength of the material rolled, but in part by the relative hardness of the roller and rail, and by the mechanical conditions which affect the area of the roller and rail contact.

The area of contact of hard-tyre tramway wheels on steel rails is very small—is less than on ordinary railway wheels. On the latter it has been found to vary, with wheels of 4 ft. 6 in. to 5 ft. in diameter and carrying a steadily-applied static load of from 12,000 lb. to 14,000 lb. per wheel, from 66,000 lb. to 48,000 lb. per square inch of contact area. The minimum and maximum areas of a larger number of observations gave loads of per square inch of contact area of from 26,607 lb. to 85,961 lb. This, however, was the minimum pressure, as it was taken with engines standing on a level rail, and the wheel gently lowered on to it. With an engine moving at speed, and heeling over as on curves, this pressure would be much greater. It must further be noted that the central part of the area of contact would be much more severely pressed than the borders of the area.

By the courtesy of Mr. A. L. C. Fell, M.I.E.E., the author has been enabled to give measurements, made at his request, of the pressure of the wheels of a standing car on rails of standard type. These measurements were made by loading the axles of the larger and the smaller wheels of the bogie of one of the large standard London County Council double-bogie trucks. For the purpose of the experiments a sling was made as shown on the sketch (Fig. 6). This consisted of flat bars, to which were bolted three pieces of timber, on which the load was placed. The rails were carefully cleaned, and the wheels turned to the correct standard taper, but with a finer cut than that usually adopted in practice. The load used was as follows in each case:—Driving-wheels, 31 in. in diameter, 6 tons; pony-wheels, 21.56 in. in diameter, 3.25 tons. These weights approximate closely to the actual weights on a standard bogie car when loaded.

The wheel on the side marked "A" (Fig. 6) was on the rail, where it was continuously supported. On the side marked "B" the wheel rested immediately above the centre of a pier 14 in. wide, where the rail was not quite so rigidly carried. The diagrams obtained, marked 1, were slightly larger on this side. The rails showed very little sign of wear, and the experiments were made at the end of a shop which has not been very much used. At each end of the axle a guide-bracket was fixed to the ground, as shown on the sketch (Fig. 6); between these brackets and the axle journal taper-pieces of wood were fixed to prevent lateral movement. The axle was lifted at the extreme end by means of a jack and lowered carefully on a piece of tissue-paper on thin carbon paper placed on the rail under the wheel. The impressions made are shown by the diagrams (Fig. 7). The rails are of British Standard hardness, and the tyres were manufactured to the specification, for the following extract from which the author is indebted to Mr. Fell.

Tensile strength not less than 55 tons and not more than 70 tons per sq. in., minimum elongation of 11 per cent. to 8 per cent. in 2 in., and of the following composition:—

	Per Cent.
Carbon	0.65 to 0.75
Silicon	0.32
Manganese	0.6 to 0.8
Sulphur	0.035
Phosphorus	0.035

The tyres are thus of harder material than the rails, which have 0.49 to 0.55 per cent. carbon.

The areas of contact, carefully measured from these diagrams, are given on the drawings accompanying this paper, the areas and pressures given being those obtained from the smaller diagrams marked 2, measured on the inner edge of the black lines made by the carbon paper. The loads given per square inch are the average loads over the whole area of the diagram when the tyre had pressed into the rail, and the tyre itself also microscopically deformed until the area of support given was obtained. The pressure per unit of area in the centre of the area of support would, of course, enormously exceed this average, and I estimate the maximum static pressure to be not less than 35 tons per sq. in. under the driving-wheels. When the car is running at ordinary speeds this pressure would rise to not less than double this as impulse pressure, and when the car runs at speed round curves, and the greater part of the load with the heeling over of the car is visited on the wheels on one side, the pressure might easily reach at least 100 tons per square inch.

On the pony-wheels the average pressure of the whole area of contact under static loads reached 31.8 tons per sq. in. The maximum pressure in the centre of area of contact was probably not less than 50 tons. This, with the car running at ordinary speeds, would probably reach 90 tons per sq. in., and when running at speed round curves, and the car heeling over so that the greater part of the load rested on the wheels on one side, the maximum pressure would probably reach 120 tons per square inch.

It is clear, then, that the pressure per unit of area exceeds the limit of elastic compression of the material of the average rail, and that flow or deformation would occur were it not that the area pressed is supported by the surrounding material and held *encastré*, so that flow cannot occur. One result of this is the detrusion of one or of both the rail edges, as shown by Fig. 5, by which cumulative disruptive forces are in part dissipated and the extruded material on the groove edge of the tread is removed by the car-wheel flanges. Another result is

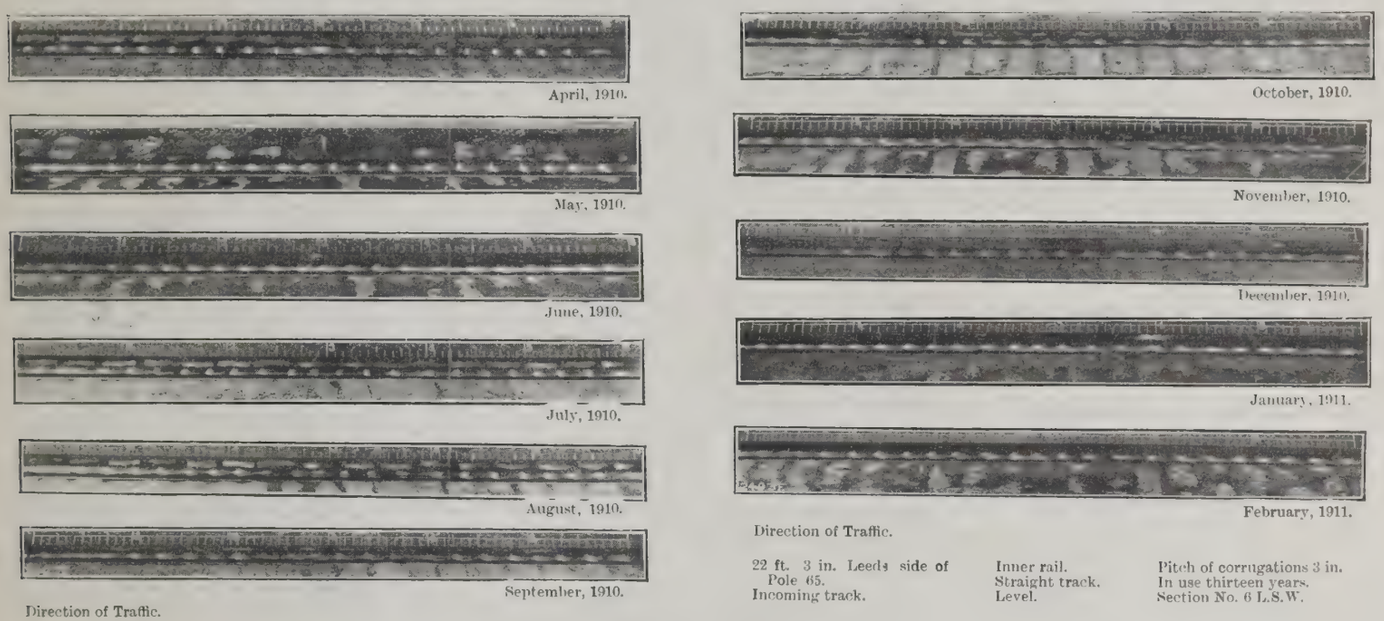


FIG. 8. PHOTOGRAPHS SHOWING CORRUGATIONS IN VARIOUS STAGES OF GROWTH FROM MEANWOOD LINE OF THE LEEDS CITY TRAMWAYS.

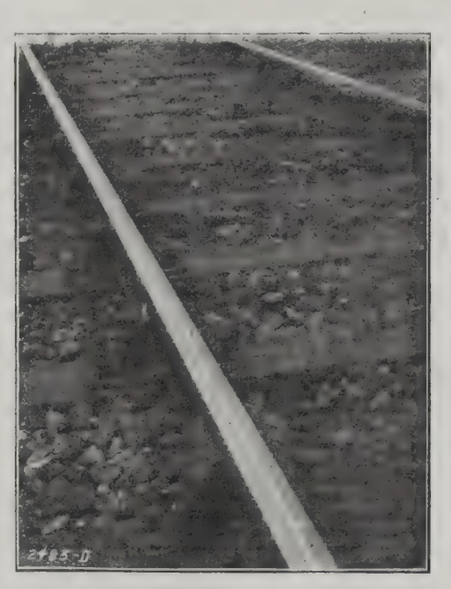


FIG. 9. VIEW OF RAIL FROM STRAIGHT TRACK ON THE MIDLAND RAILWAY, SHEFFIELD (FALLING GRADIENT 1:100).

corrugation, and a third is the minute crumbling and pitting of the rolled surface.

Under some circumstances and conditions corrugation may decrease as the raised hardened surfaces approach by lengthening; and as corrugation and the surface become more uniform by the removal of surface material by crumbling or minute flakings, especially of the harder rails with up to 0.66 of carbon which best resist the causes of corrugation. The removal of corrugations, however, by grinding, only prepares the rail surface for quick recommencement or corrugation or for lengthening the hardened part of the corrugations.

If the preceding be accepted as the origin and production of corrugation, then the question remains, what are the remedies. The mechanical originating conditions being the weight on the wheels and the increase of that weight more especially on outside curves by car-heeling at the higher speeds, then:—The first and most effective remedy is the reduction of the great destructive weight on the wheels of the modern car. The second is the use of larger wheels than can be used with the present design of car. The third is the maintenance of moderate speeds; of much lower speeds than are common on curves even those of large radius, and moderate speeds on lines that may be classed as straight, but which have such departure from straightness, horizontal and vertical, as will encourage boxing or wandering of the cars from side to side. Fourthly, the use of harder rails than the hardest at present employed.

The reduction of weight is possible, the reduction of speed is possible, the use of larger wheels is possible with future cars, and the use of harder or more resistant rail materials may be possible, but they would have to be produced by methods more costly than those now adopted.

The remedies will involve modifications in the views at present prevalent as to the place, purpose, and working of tramway services, but even the most ardent advocates of tramway ubiquity will ultimately be constrained to admit that tramways, like all other things that have and offer desirable ends and conveniences, have also their economic and expediency limits.

Addendum.—The occurrence of corrugation of electric tramway rails as recorded by many tramway engineers and managers, and, as found by my own observations extending over some years at home and abroad, is everywhere associated with the following broad generalisations of facts.

1. That it occurs on straight lines and on curves.
2. That it is most prevalent and generally commences on curves of large radius—flat curves.
3. That it never or rarely occurs on curves of small radius—*e.g.*, from 40 ft. to 80 ft.
4. That on hills, and especially on slight gradients, it is most prevalent on the down line.
5. That its occurrence as to date or length of time after laying the rails varies broadly with (*a*) the position of the rail on straight or flat curve or down gradient; (*b*) the frequency of the service; (*c*) the mechanical properties and composition of the rails as shown by more or less outer-edge detrusion.
6. That it occurs with all types of truck.
7. That it is most prevalent where the speeds are highest.

The general appearance of corrugated rails is known to all who are interested in the subject, and photographs showing corrugations in various stages of growth in many towns might be shown. The author is enabled, by the courtesy of Mr. J. B. Hamilton, the general manager of the Leeds Tramway, to show thirty-three photographs of three rails in that city. [One set of eleven photographs is reproduced in Fig. 8.] These photographs show rails which have been in use from four to thirteen years on straight track. Those which have been in use thirteen years are on the level, those of ten years are on a gradient of 1 in 70, and those which have been in use four years are on a gradient of 1 in 50.

A small photograph is also reproduced (Fig. 9) of a rail in a straight piece of track on the Midland Railway, Sheffield, on a falling gradient of 1 in 100. This shows a much worn rail, with the bright hard spots about the centre of the tread, and shows that what is called "corrugation" is not confined as to nature of origin or production to street-tramway rails, although it is necessarily much more general and severe on tramways and other rails where heavy vehicles with small wheels and high speeds are used, as, for example, on some of our tube lines and the Metropolitan, of Paris.

ELECTRIC DRIVES FOR SCREW-PROPELLERS.*

By H. A. Mavor.

The problems of marine engineering have until recent years been solved exclusively by the application of various forms of the reciprocating steam-engine, and the power, speed, form, and general arrangement of power-driven vessels have been developed in connection with this means of propulsion. The advent of other appliances has opened up new lines of development, and in certain departments there is evidence of need for intermediate devices between the power-producing and the power-absorbing elements.

The necessity for these devices arises when the properties of the propeller in respect of rate of revolution are incompatible with those of the power-generator. This incompatibility is most conspicuous in vessels which have to operate at relatively slow speeds. An examination of the conditions which have emerged in the development of marine propulsion soon shows that the incompatibility is not accidental, or due to imperfections in the design, construction, or use of the propelling equipment, but that it is associated with the essential properties of the substances and appliances with which we have to deal.

It may be said in general terms that high efficiency is associated with low rate of revolution of the propeller, while in the steam-turbine high rates of revolution are essential to the most economical use of the steam. Internal-combustion engines have speeds more nearly approximating those of reciprocating steam-engines, but here also there is a tendency to speeds higher than are convenient or economical from the propeller standpoint.

In addition to those fundamental incompatibilities arising from causes out of the reach of direct accommodation, there are other conditions which limit the direct application of engine to propeller. The draught, beam, and form of the vessel limit the area of the propeller. The traffic for which the vessel is designed influences the determination whether one, two, or more propellers are to be used, and the speed, size, and form of the vessel determine limits to the designer's choice. All these considerations taken together frequently fix the diameter, pitch, and thrust of the propeller, and, within very narrow limits, also the rate of revolution. Now this rate of revolution is not always the most favourable for the power-generator, and the designer is in such cases compelled to resort to new expedients if he is to attain the standard of efficiency in power generation which has been set by the results attained on land. At the present moment the economy of power production in the best practice on land is considerably in advance of what has been done at sea. The principal reason for the better economy of the land work is the higher rate of revolution of the power-generator when untrammelled by propeller conditions. There are cases where the special limitations in respect of dimensions and weights permissible for the machinery are such as to preclude the use of any intermediate mechanism between the prime mover and the propeller.

In a ship whose voyage is short, whose speed is high, displacement small, and the propeller efficiency as good as is attainable, and the quantity of fuel carried small relative to the weight of machinery, the possible economy in fuel may be insufficient to warrant any increase in the weight of machinery; or, to put the case otherwise, it is advisable to sacrifice economy in fuel to keep down the weight of the equipment—*e.g.*, a vessel running one-day voyages, and burning 50 tons of coal, could not possibly submit to an increase in weight of machinery in excess of the coal-saving, because such increase would increase the displacement and the power necessary to drive the vessel. If, on the other hand, the vessel makes a 10-day voyage, and the saving in fuel carried amount to 10 tons per day, a considerable increase in weight of machinery might be associated with decreased displacement and a substantial all-round economy.

Various methods of making the required adaptation of generator to propeller are at present under trial. For this mechanical gearing by toothed wheels or hydraulic transmission may be considered serious competitors with electric transmission, but for large powers it seems reasonable to expect that electric transmission, which is already developed for this very purpose on land, is likely to find an equally useful field where the conditions are such as to require an intermediate device at sea.

The cost, weight, and efficiency of electric transmission compare favourably in the examples which have been examined with either of the two competing methods. There are other important qualifications of electric transmission in which it stands altogether unrivalled. The most important of these qualifications are:—It provides a ready means of reversing the direction of rotation of the propeller without changing the direction of rotation of the power-generator.

The electric transmission also provides means for changing the speed ratio between generator and propeller, so as to permit of the power of the generator being developed under the most favourable conditions at all speeds of the ship.

Lastly, it provides means for applying the power of one or more engines to one or more propellers, so that the power-generating units may be so disposed as to give the highest efficiency, and when they are not required they can be stopped. These properties of the electric transmission supply exactly what is required to render steam-turbines, and also internal-combustion engines, completely adaptable to the purpose required. Both types of power-generators give their best efficiency when full speed of rotation is maintained, even when running below full power. It is, therefore, advantageous to keep the engine revolutions within the range of governor control, while the required speed change is accomplished by electric combinations.

The properties of the electric motor lend themselves well to the requirements of manœuvring. The rate of reversal is under perfect control. The possibilities of rapid and certain action are more than are attainable in a reciprocating steam-engine connected direct to the propeller, and the electric-motor is applicable to powers for which there is no possibility of using anything in the nature of reversing gears or clutches.

The property of combining the power of more than one engine for application to one or more propellers is the special feature of the author's inventions as distinguished from the ordinary methods of electrical engineering. Engines of different types, sizes, and rates of revolution can have their powers combined without interconnection of their electric circuits, and without risk of mistake or error. An oil-engine at 100 revolutions may be running the vessel at slow speed, and a steam-turbine running at twenty times the speed may be jointly applied to the propellers without any complication of the electric equipment. Each unit does its own work independently.

The advantage of such an equipment in vessels which are required to operate under varying load conditions is evident. Without subdivision of the power units the whole of the main machinery must be in motion while the ship is in motion. At speeds reduced below its normal rate of revolution the steam-turbine is even less economical than the steam-engine. Subdivision into high-pressure, low-pressure, and intermediate elements has been carried out in certain steam equipments, but this results in a somewhat complicated and inconvenient system of piping, because the steam has to be led from one part of the system to the other across the vessel. In the electric system each unit can be self-contained, and disposed in the manner best suited to a convenient arrangement of the engine-room. The size of the individual units can be adjusted to suit the powers required at the different working speeds, or they may be duplicate.

A few examples of application of the system are here presented, together with a description of a small vessel built to demonstrate and illustrate the principles of operation and to provide experience in the use of the plant. In all cases alternating 3-phase currents are used, and interlocking devices connect mechanically the main reversing switches with the existing switches, so that no change can take place in the connections while they are passing currents.

*Description of the Turbo-Electric Steamship "Frieda," for American Owners.**—This vessel has been specially designed for the transport of bulk freights between the Gulf of Mexico and New York City. The vessel is to be 300 ft. long, and will carry a dead-weight of approximately 5000 tons, at a mean loaded speed of 12 knots at sea. The propelling machinery is aft, and consists of a turbo-electric outfit for 1500 kw. three-phase 50 cycles when running at 3000 revolutions per minute. The turbine is supplied with steam at a pressure of 200 lb. per sq. in. at the turbine stop-valve. This electric generating plant is arranged on foundations on a platform deck in the engine-room, and the condensing plant in the engine-room hold. The condenser is fitted with a vacuum augmenter, and is suitable for dealing with the full-load quantity of steam from the turbine. The vacuum obtained will be 28½ in., with cooling water about 85 deg. Fahr. This condensing plant consists of a vacuum condenser, three-throw air-pumps, and centrifugal circulating pump with electric-motor drives. The current is led to a three-phase motor, which is keyed direct to the main propeller shaft, and is capable of developing 1900 brake horse-power at a speed of about 84 revolutions per minute. The steam is generated in two Scotch boilers, with Howden's forced draught, and liquid-fuel burners. This installation costs and weighs less than the normal equipment. The coal saving is over 10 tons per day. The design of the ship itself presents many other novel features. This design was prepared by Messrs John Reid and Co., 17, Battery-place, New York City.

Oil-Electric Tank-Barge for Canadian Service.—In this the system is applied to the propulsion of a 245-ft. Canadian canal-type tank-barge for the Standard Oil Company of New York. The equipment consists of three separate units of Diesel non-reversible oil-engines, each capable of developing 200 shaft horse-power, each directly connected to an alternating-current generator. The currents from one or all of the units are led to the separate windings of a three-phase motor, keyed to the main propelling shaft, and operating a single slow-turning screw. The great advantage and economy of this system consists in being able to run at full power or at one-third power using one or three engines at full-load economy at will, thus providing for an economical operation impossible with any other propulsive system. The fact that non-reversible oil-engines are used running under governor control greatly simplifies the maintenance and operation. The control is operated by a low-tension interlocking switch, operated by an ordinary engine-room telegraph stand located in the pilot-house, so that manœuvring of the vessel is at all times in the hands of the navigating officer. This equipment increases the cost of the ship about 10 per cent. above the normal, but the carrying capacity is very largely increased.

Marine Turbo-Electric Installation Proposed for United States Navy Colliers.—A marine turbo-electric installation has been submitted to the United States Navy Department for adoption in one of the four large colliers recently given out to contract. The installation consists of a steam turbo-alternator of 5000 kw., with condensing plant; the current is led to two motors, one being keyed to each propeller shaft. The machinery is right aft in the vessel. The steam is generated by Scotch boilers. The vessels in which it is proposed to instal this machinery are 525 ft. long, and will carry a dead-weight of 12,500 tons of coal at a speed of 16 knots at sea. Here, again, the cost, weight, and economy are better than can be shown with the normal reciprocating-engine equipment.

Trials of Potato-Diggers and Potato-Sorters.—The Royal Agricultural Society of England have arranged for the trials of potato-diggers and potato-sorters to take place at the farm of Mr. William Dennis, at Littleworth, Lincolnshire, commencing on Tuesday, September 26. The trial-fields are almost adjoining the railway-station at Littleworth, on the Great Northern Railway, and are about 6 miles from Spalding. The following prizes have been offered:—Class I., potato-diggers: first prize, 20*l.*; second prize, 10*l.* (For these prizes fourteen entries have been received from seven different firms.) Class II., potato-sorters: first prize, 10*l.*; second prize, 5*l.* (For these prizes six entries have been received from five different firms.)

* Paper read before Section G of the British Association at Portsmouth, September 1.

* [As a vessel on this system was illustrated in our issue of June 9, we have not reproduced the illustrations. —Ed. E.]

HUMAN SUSCEPTIBILITY TO VIBRATION.

*Some Preliminary Notes on a Study as to Human Susceptibility to Vibration.**

By W. POLLARD DIGBY and Captain H. RIALL SANKEY, R.E.

IN regard to all the senses of taste, sight, sound, or smell, the range of the individual sensitiveness of human beings is recognised as a matter of considerable variation. Even those with no pretence to scientific training class their fellows as short or long sighted. In regard to sound, the degree of discrimination of different people, both at any one age or at different ages, is a matter of much anthropometric interest. The physiological effects of mechanical vibration are probably worthy of investigation, but before the medical aspects can be discussed, fairly exhaustive preliminary investigations are necessary. It has long been known that different persons are affected in different manners by the same conditions of vibration. So far as the authors are aware, this subject has not yet been the subject of any very definite study and investigation.

In the course of his professional work, one of the authors had occasion to design a portable instrument for taking permanent records of the amplitudes of vibration of steam-turbines and reciprocating engines, and of measuring the effect of such vibrations on neighbouring buildings. On showing this to his co-author, the latter referred to a statement by Admiral Melville that the effect of vibration depends upon the frequency and on the actual amount of linear motion, and that the frequency multiplied by the amount of motion was a constant.†

Further, in the same paper, which deals with steamship vibrations, Admiral Melville quotes Mallock's statement, in regard to the Central London Railway cases, that vibrations rarely exceeding $\frac{1}{1000}$ in. when the frequency is over 10 per second, are a genuine source of annoyance.

After discussing Admiral Melville's dictum (which one presumes applies to normal persons), the authors decided to pursue the present study. The phrase "human susceptibility to vibration" was coined to cover the range of sensitiveness of various people to vibrations of short duration of different amplitude and frequency, together with their opinions as to when those vibrations approached or exceeded the point of being a nuisance.

At the time of writing this paper only a certain number of cases have been studied. The information collected is not yet sufficient for the enunciation of a comprehensive law, but it does suffice for the propounding of certain general statements.

At the outset, the authors found it necessary to adopt both verbal standards of degree of vibration and precise units of measurements, in order that the comparative value of the conceptions of the verbal standards by different persons might receive some co-ordination.

The verbal standards of degree of vibration selected were as follows:—

1. Imperceptible.
2. Very faintly perceptible.
3. Faintly perceptible.
4. Perceptible—not a nuisance.
5. Perceptible—just a nuisance.
6. Perceptible—distinct nuisance.
7. Perceptible—serious nuisance.
8. Perceptible—excessive nuisance.

The precise unit of measurement adopted by the authors as a mechanical unit of intensity of vibration is a vibration having a maximum linear amplitude of one-tenth of a millimetre at a frequency of 10 cycles per second. (Alternatively, and, of course, identical in value, would be the definition of 1 millimetre at 1 cycle per second).

Referring to the verbal standards of degree of vibration, it should, perhaps, be explained that the series starts at unity and not at zero, because the apparatus used in these measurements indicates vibration not felt by any persons resting the palm of the hand on a table vibrating under the effect of a variable-speed electric motor placed on it.

As the writers have stated, only a certain number of individuals have, so far, been investigated. While this number does not permit the enunciation of definite laws, certain distinctive general tendencies seem to be clearly indicated. Among these may be noted the following:—

1. That for various individuals the range of vibration rated as degree 1 (*i.e.*, as imperceptible) is a wide one. Thus upwards of twenty-one cases are recorded in which a vibration of from 0.10 to 0.20 units is classed as imperceptible, while six cases classify vibrations in this range as degree 2, and five cases as degree 3.

2. That there is also wide variation in regard to vibration rated as degree 2—*i.e.*, as very faintly perceptible. Three cases class this as under 0.10 units, six as between 0.10 and 0.20, six as between 0.40 and 0.50, while seven cases could only distinguish vibrations in excess of 0.50 units.

3. That each individual shows a "fatigue" effect, and gives expressions of opinion as to the degree of vibration after 30 or 40 minutes of observation, which are not consistent with his previous expressions of opinion. In general these point to a diminished sensitiveness.

4. That individuals can be classed into the broad classes of (*a*) delicate, and (*b*) coarse perceptiveness. The former class, although capable of discrimination in regard to vibrations of small intensity, give uncertain and contradictory readings when the vibrations exceed a certain amplitude. The latter class, while distinguishing clearly between vibrations of differing large intensities, cannot feel vibrations of small intensity, and are not always consistent in their classification of vibrations of medium intensity.

5. That, so far, the general concensus of opinion points to the degree of vibrations classed as 5 (perceptible, just a nuisance) being reached for a mean intensity of 1 unit. The lower range, for persons of delicate perceptiveness, is in the neighbourhood of 0.70 units; and the higher range, for persons of coarse perceptiveness, is about 2 units.

The comparison of the mean value of an intensity of 1 unit as the point at which vibration just becomes a nuisance compares very strikingly with the value quoted by Admiral Melville. Converting Mr. Mallock's value of 1 mil multiplied by cycles per second into the authors' alternative of millimetres multiplied by cycles per second, we have 2.54 units of intensity of mechanical vibration as a genuine source of annoyance.

It is quite obvious that the present study is purely of a preliminary nature. For the purposes of this research, perceptiveness to vibration has been estimated by the sense of touch of a person's hand resting on a table, the table being disturbed by a variable-speed electric motor. Flywheels attached to each end of the motor-shaft have concentric rings of holes drilled and tapped in them, so that the amount of the unbalanced force can be varied at will. In one or two cases observations have been made of the opinion expressed when the elbows of the subject rested on the table, the palm of the hand supporting the face. Another interesting alternative (and there are many such) would be for the subject to sit on the table.

In the further pursuit of this investigation it will probably be of interest to ascertain—

1. To what extent the susceptibility of any single individual is influenced by conditions of physical health, the effect of over-work, or railway travelling.

2. To what extent age and sex are modifying factors.

3. Whether occupation has any broad general effect—*i.e.*, whether, say, surgeons, barristers, or engineers (regarded as classes) differ to any marked degree from the mean value obtained.

All the present vibrations have been due to practically pure sine waves at a stated frequency, which latter was kept of constant value at the time of observation. Nothing has yet been done to simulate in the laboratory the superimposition of waves giving a third or fourth harmonic. Neither has anything yet been done to simulate in the laboratory a recurring intermittent vibration such as that produced when propellers, or the exhausts from non-condensing engines approach, reach, and get out of synchronism with one another.

The authors hope to pursue this research along the lines indicated. They will be glad if members of this Association and their friends care to visit Mr. Digby's laboratory on either Monday or Thursday afternoons after October 1, and form the subjects of experiment. It is desirable from many points of view, and not least the legal one, that there should be some definition of what exact intensity constitutes a nuisance. It is not possible to deal with more than, say, three cases in any afternoon, and to prevent waste of time the authors would therefore be glad of notice of intending calls. For the enunciation of a general law they would like to deal with a total of 100 to 150 cases. The nature of the experiments will be demonstrated in an adjoining room.

* Paper read before Section G of the British Association at Portsmouth, September 1.

† See ENGINEERING, vol. lxxv., 1903, page 33.

ELECTRICAL STEERING.*

By B. PARKER HAIGH, B.Sc., Assoc. M. Inst. C.E.

To many who are familiar with the development and the present reliability of steam steering-engines it must appear doubtful that electrical power can offer any considerable advantage for this purpose. The steering-gear being one of several important auxiliaries carried by the ship, the question it involves is the power supply of all of these, and it is generally admitted that the present system of supplying auxiliaries with steam is not only inconvenient, but wasteful in the extreme, partly on account of the low economy of small engines worked non-expansively, and partly on account of leakage and condensation in the steam mains. A number of vessels have been equipped with partial installation of electrical power, in some cases for the cranes and boat-hoists, in other cases for fans; and as the difficulties connected with these have now been largely overcome, a considerably extended use may be expected.

It is beyond the scope of the paper to deal with the use of electrical power for auxiliaries in general, but it is desired to emphasise the disadvantages of a mixed power system involving the upkeep charges on both steam mains and electrical installation. Vessels fitted with internal-combustion engines offer a field for electrical steering, for on such vessels the steam supply, if available at all, would not generally be maintained at sea.

Electrical power may be applied in steering in connection with two separate problems. In the first place electrical apparatus may be used in place of the customary control-shafting or hydraulic telemotor to transmit the motion of the hand-wheel aft to the steering-engine. Several such electrical "telemotors" are now available, and these have the advantages of being very easily worked even in the longest ships, and of convenience in installation. The second and more important problem is that of supplying and controlling electrical power for moving the rudder itself, and it is here that electrical steering offers the greater advantages over gears now in general use requiring a supply of steam. The main difficulties experienced in electrical steering have been those of limiting the amount of power required to the capacity of the ship's dynamos, and in controlling the heavy power in a reliable manner. The electric motor must not only be arranged to move the rudder promptly and accurately within the small angles of 5 deg. or less that are required for keeping a course, but must also be capable, without any adjustment of the control gear, of rapidly putting the helm hard over to 35 deg. to either side, against heavy water resistance. As this is the crux of the whole question, it may be well to state working conditions in some detail.

* Paper read before Section G of the British Association at Portsmouth, September 1.

The action of a rudder in steering is similar to that of the blades of an "impulse" turbine. Water flowing under the counter of the vessel strikes the rudder surface and is deflected so that its subsequent motion is more or less parallel to the direction of helm. In changing its direction of motion the water exerts a certain force on the rudder, tending to swing the vessel about an axis somewhere well forward in its length, and also acting as a drag reducing the speed of the vessel. The steering moment reaches a maximum when the angle of helm is about 40 deg., and as the drag increases quickly, it is not customary to arrange the steering gear for angles of over 35 deg. The time generally taken to bring the rudder from hard-over port to hard-over starboard, or *vice versâ*, varies from 15 seconds, or even less, in small vessels to about 40 seconds in the largest, these times being those required while under way ahead.

The power required in the steering-engine depends upon the torque produced in the rudder-post by water pressure, which is usually of considerable magnitude, as the centre of water pressure is generally some distance abaft the axis of the rudder-post, even when a "balanced" rudder is used. Little effort is required to move the rudder within small angles, even when an "unbalanced" rudder is used, partly because the angle of deflection of the water is small, and partly because the centre of pressure on the rudder surface is near the leading edge. Unless a heavy sea strikes the rudder, the steering-motor has therefore little to do beyond overcoming friction within the gear itself, and as the great majority of steering motions consist in moving the rudder through small angles near the midships position, it will be recognised that electrical power promises economy as compared with either steam or hydraulic power. When the angle of helm is increased, the torque in the rudder-post increases rather more rapidly than the sine of the angle, for an increasing body of water is deflected, and the centre of pressure shifts further from the leading edge of the rudder surface. After the rudder has been held hard over for a few seconds, the torque in the rudder-post falls off somewhat, partly because the vessel commences to swing, and partly because the vessel's speed is reduced; but it is clear that the steering-gear must be designed to meet the heavier initial stresses, and it is fortunate that these can be readily estimated.

In order to economise power, the gearing between the electric motor and rudder-post should be designed for a high efficiency, and consequently will not be "self-sustaining." Means must therefore be provided to hold the rudder in its hard-over position. A magnetic brake similar to those used on cranes is suitable for this purpose, and will serve to stop the gearing promptly when the required position has been reached. In returning the rudder to the midships while the vessel is moving ahead, the force of the water assists the motion of the rudder, and this complicates the matter of the control.

Further, when the flow of water past the rudder is reversed, by reversing the propellers, the centre of pressure shifts to the after edge of the rudder surface, and considerable power is then required to bring the rudder back amidships even when the speed of the vessel is low. It is this fact which prevents a rudder being balanced under all conditions; but, nevertheless, balancing is a great advantage for electrical steering, allowing a smaller motor to be used, minimising the demand for current, and reducing the wear and tear on the control gear.

Experience has led to the design of steam-engines of special proportions for steering, and in the same way electrical motors used need not be designed to carry their full load continuously. Motors of smaller dimensions, for "half-hour rating," and fitted with commutating-poles, are preferable; and as the heating limit is not here in question, the motor may be totally enclosed even in large sizes, without any considerable increase in its dimensions.

Besides possessing adequate power, a steering-gear must be satisfactory as regards sensitiveness—that is, it must be capable of moving the rudder to an angle that accurately corresponds to the position of the steering-wheel. This is especially necessary within the range of small angles that are used for keeping the vessel on its course. In any steering-gear there is naturally some "idle travel" of the steering-wheel, within which the gear will not respond. In long ships this is minimised by using a telemotor in place of control-shafting with gearing, in which latter the total effect of spring and backlash may be objectionable. But, apart from such loss of motion, there is a further idle travel due to the practical necessities of the control-valve or control switch-gear, and this loss is kept as low as possible. Requirements as regards sensitiveness vary greatly, and high-speed vessels naturally require closer control than slower vessels, for, as the size of the rudder cannot be reduced without loss of manœuvring power at low speeds, very small angles of helm are sufficient for ordinary steering. In the highest class work the steering-gear should respond to a motion of the hand-wheel corresponding to 1 deg. of helm (less than one-eighth turn of the wheel). Little advantage is gained by working closer than this, and many high-speed vessels with fine lines are worked with gears requiring double this allowance. A certain small amount of idle travel is desirable to prevent the gear being used unnecessarily. Sensitiveness does not only depend on the idle travel of the hand-wheel, but also on the "time-lag"—*i.e.*, the interval between the movement of the wheel and the

corresponding movement of the rudder, and in this respect it appears that electrical steering may possess considerable advantage over ordinary steam-gears, for, as it can be arranged that the rudder responds more quickly, a closer course may be kept with watchful steering. As regards idle travel, there is little to choose between steam and electric gears. In steam gears the idle travel is kept down by reducing the already small steam-lap on the control-valve, which, in order to obtain a fast-running gear with little time-lag, is generally a piston-valve of ample size. Such a valve is liable to leakage when slightly worn. In electrical gears, on the other hand, sensitiveness does not reduce the economy, but complicates the control arrangements.

In the following table a number of different types of electrical steering-gear are classified, according to the method of control:—

A. Steering-gears in which the motor is started and stopped for every motion of the rudder.

1. The motor being supplied with current at variable voltage from a special generator.
2. The motor being controlled by reversing switch and resistances.

B. Steering-gears in which the motor is kept running continuously, mechanical control being introduced in one of the following forms:—

1. Friction-clutches with gearing.
2. Hydraulic transmission with rotary or reciprocating pumps.
3. Magnetic friction-clutches on motor-shaft.

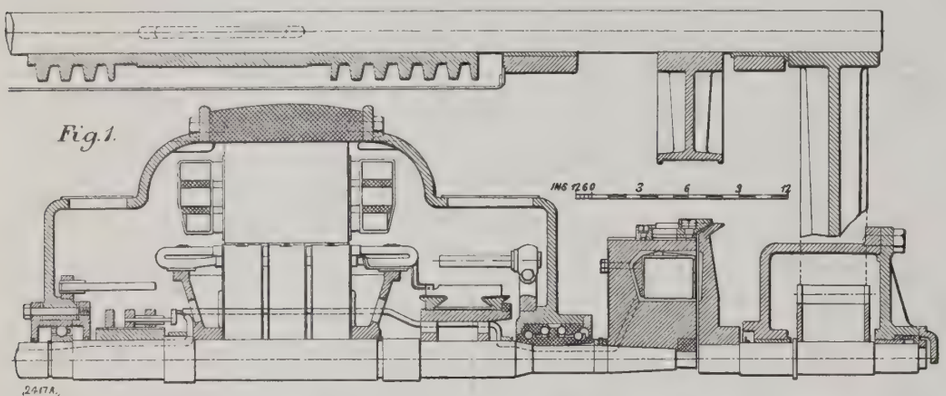
The second line of development, including the gears grouped together under heading B, appears to offer more promising results than method A, to which one great objection is the wear and tear unavoidable where so much switch-gear for heavy currents is used. A further advantage of the different types classed together under B is that the shock of the sea on the rudder is greatly reduced before it reaches the ship's electrical installation. The armature of the motor acts as a fly-wheel, or extra fly-wheel weight may be added, and by using a compound motor a large part of the energy kinetically stored in the revolving masses is given up to the steering-gear before any excessive current is demanded from the ship's mains. The steering-gear can therefore be supplied from the ship's lighting generator without any noticeable flicker in the lamps coupled to the same mains. It is difficult to over-estimate the importance of this feature, both as regards simplicity and, consequently, reliability, and as regards economy of power.

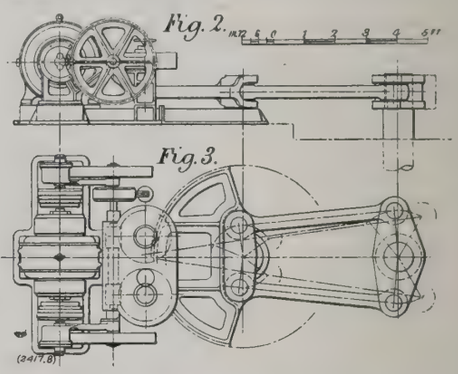
To indicate the amount of power required under these conditions we may take the case of the proposed gear described later, and shown in Figs. 1 and 2. This is designed for an 11½-in. rudder-post, suitable for a vessel of, say, 450 ft. in length, of 16 knots speed. In this case a motor of 30 brake horse-power is provided, capable of developing a torque of 175 foot-tons in the rudder-post, and of moving the rudder through 70 deg. in 20 seconds. These figures are based on special features in the design of the gear, and on an efficiency of 64 per cent. in the gearing, which, though high in comparison with that of gears having right and left-hand screws, is not higher than that obtainable with double-worm drive. The 30 horse-power motor would be a continuous-current motor with compound winding, and would run at a speed at 500 revolutions per minute under full load, and at varying speeds up to 1000 revolutions per minute on lighter loads. The current required at full load would be 270 amperes at 100 volts. In some respects, and especially as regards reliability, a three-phase motor is preferable to the continuous-current motor, but its constant-speed characteristic causes a heavier maximum demand for power. The choice of the type motor to be used on any particular vessel naturally depends on many matters outside the steering-gear. A vessel of this size engaged in passenger service would probably be provided with generating plant for lighting and forced-draught purposes of about 200 kw., and if this is divided among four dynamos, each of 500 amperes capacity at 100 volts, it should be possible for any one of these running alone to put the helm hard over in emergency.

Probably the first electrical steering-gear in which the motor was kept running continuously was that designed and built in 1895 by the late Mr. A. B. Brown, who may be justly regarded as the pioneer in the scientific development of power steering-gear. Being constructed on the same principle as his well-known steam-tiller, the motor of this gear was mounted on a forged-steel tiller which carried a pinion engaging with a toothed rack attached to the deck. The control was by means of two metal-to-metal friction clutches, with coil springs, driven at a lower speed than the motor by means of gearing. The clutches were arranged to move the tiller in one of the two opposite directions, and the chief difficulty experienced was that of obtaining accurate and sensitive control.

In the steering-gear designed by the writer, in conjunction with Messrs. Brown Brothers and Co., Limited, of Rosebank, Edinburgh, the control is by means of magnetic friction-clutches, which have several advantages due to the absence of external thrust, and the ease of control. A number of tests have been made on an experimental gear of fair size, and it is hoped that some particulars may be of interest. Figs. 1 to 3 show details of a proposed gear suitable for an 11½-in. rudder-post, to which reference has already been made in connection with the amount of power. Although the motor in this gear runs continuously, no gearing is kept in motion, as the motor-shaft is extended at either end to carry the two magnetic clutches. The driven portions of these clutches are carried on bearings, and are geared to the counter-shaft carrying the worm-gear in such a way that the rudder is moved to either port or starboard by bringing one or other of the clutches into action. The two parts of the clutch are drawn together by magnetic attraction, and a light spring is provided for withdrawing the clutch after the motion required is completed. The friction drive is transmitted by red fibre blocks bearing on the conical edge of the light steel disc that acts as the keeper of the magnet, and no thrust remains to be taken up by collars. Either ball-bearings, as shown in Fig. 1, or ring oiling journals may be used, provided the motor has not excessive end play. Provision is made for taking up wear on the fibre blocks by adjusting the inner ring on the clutch body to feed the blocks through holes in the outer ring. In the gear suitable for an 11½-in. rudder-post the clutch-coils are fed with a current of ½ ampere, this light current being supplied through slip-rings enclosed within the motor. No electrical parts are therefore exposed to the action of damp, for, as the motor is always running, it keeps itself dry. Should it be desired to remove the armature, the clutches are removed at the same time, after sliding the fibre friction-blocks back by turning both screwed rings on the clutch body. Impregnated fibre friction-blocks have the advantage of engaging silently, whereas wood, although in some cases having a higher coefficient of friction, appears liable to squeak painfully. The mechanical arrangement of the gear (Figs. 2 and 3), has certain novel features, and notably the use of two pinions engaging with the toothed sector. As these carry equal loads, the wear is distributed, and a lighter sector may be used with teeth of reduced pitch as compared with those necessary if only one pinion were provided. In this way a lower ratio of worm-gear is required, and a higher efficiency obtained. The loads on the two pinions are kept equal by using right and left-hand worm-gear, with an intermediate pinion to keep the directions of rotation right. The two worms are cut on a sleeve sliding freely on the shaft without thrust-blocks; and as a certain amount of end play is provided between the bearings, the teeth of the sector can be allowed a considerable amount of wear without disturbing the equal distribution of the load. The quick pitch of the worms and the absence of frictional loss at thrust-blocks ensures a very high efficiency being obtained.

The power required is further reduced by the use of variable leverage linkwork, in which the rudder crosshead and the dummy crosshead carrying the toothed sector are connected together at different radii, so that the connecting-rods do not form a parallel motion. The leverage, which in the midships position is 1.5 to 1, increases gradually to 2.2 to 1 at the hard-over position of 35 deg., so that the maximum torque is obtained with less current when the rudder is hard over, and, further, the gear responds more quickly in the ordinary working range amidships. As this linkwork is not a so-called "geometrical" motion, the position of the crosshead pins must be carefully chosen, and when this is properly done no difficulty is found in working over to 38 deg. of helm. In this way a saving of 30 per cent. can be made in the motive power, and taking account of the extra efficiency of the double-worm gear, the maximum torque of 175 ft.-tons is obtained from a current of 270 amperes at 100 volts instead of 450 amperes, as would be required with gearing





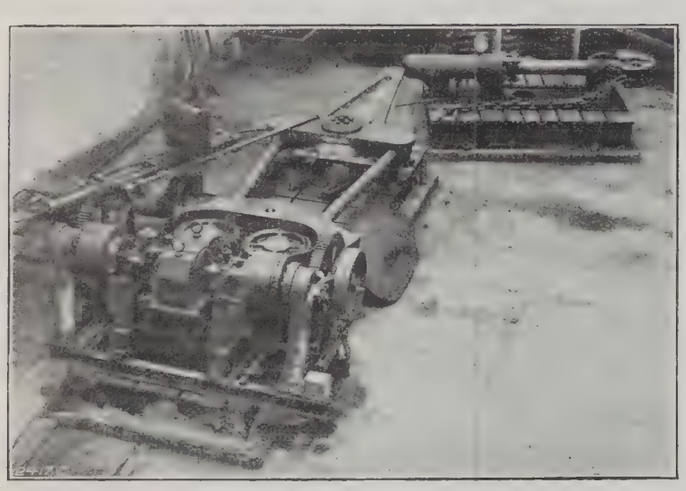


FIG. 4.

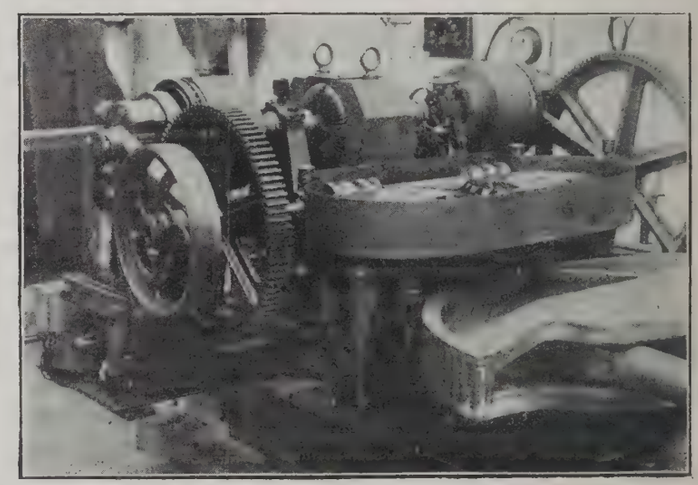


FIG. 5.

of the ordinary type. These features are incorporated in the experimental steering-gear shown along with testing apparatus in Figs. 4 and 5. The hydraulic cylinder for applying the artificial load is connected to the dummy tiller provided for test purposes by chain, and is so lined off that the tiller leverage is the same when the rudder is hard over at 35 deg. as when in the midships plane. It was found that the currents required to produce a pressure of 980 lb. per sq. in. on the 5-in. ram were 60 amperes when hard over, and 90 amperes when amidships, corresponding to a change of leverage of 1.5 to 1. The time required to cross from hard over to hard over was 23 seconds when moving against the above load for 35 deg. out of the total of 70 deg., the voltage of supply being 90 volts. At this load, which corresponds to a torque of 20.4 foot-tons in the rudder-post, the over-all efficiency is 48 per cent., indicating an efficiency of over 60 per cent. in the gear alone, without hydraulic cylinder or motor. Under normal conditions the slip of the clutches when engaging was found to be small, estimated by means of a contact-maker at between one and two revolutions, and up to the present, after a considerable period of testing in the works, no wear has had to be taken up on the fibre blocks. When the motor is loaded up to 150 amperes, corresponding to a torque of 50 foot-tons, the clutches slip, and this current is not exceeded, even when the tiller is butted against a solid obstacle, or when the chain is drawn taut from no load to full load.

The arrangements for controlling the clutches, also seen in Fig. 4, consist of one of Brown's improved hydraulic telemotors, with a cut-off attachment coupled to the tiller crosshead. The switch-gear, which is operated by mechanism equivalent to cam gear, is enclosed in the small case (14 in. by 12 in. by 4 in.) mounted above the telemotor. In many vessels the telemotors are now attached to the deck beams overhead, and this arrangement is very suitable for electrical steering, as it keeps the switch-gear free from water. Being fitted with carbon contacts, and dealing with such small currents, the switches should require but little attention. The cams require to be carefully arranged and free from backlash, to gain sensitive steering; and to stop the gear promptly a quick-acting brake, not necessarily very powerful, is used. The amount of stored energy is minimised by using light steel clutch discs, and a motor with shunt regulation, running at its lowest speed when engaging and disengaging.

In installing electrical steering-gear it is preferable to avoid the use of fuses or circuit-breakers in the supply mains, as these are liable to operate just when the use of the helm is most urgently required, and any possible damage to the electrical plant is greatly out-weighed by risks in navigation. When a gear with friction-clutches is used, a circuit-breaker, adjusted for something over the limiting current of the clutches, may be fitted in the engine-room along with an auxiliary motor starter, so that the gear may be immediately re-started without the engineer leaving the main switchboard.

In the foregoing notes it may be thought that the advantages of high efficiency are overrated, but economy is not only valuable in itself, and in the reduction of weight which it allows, but also on account of the increased reliability due to reduced wear and tear in the control gear and generating plant.

ST. GOTHARD RAILWAY.—The Swiss Federal Council has approved the convention concluded for the purchase of the St. Gothard Railway. The line has, accordingly, become the property of the Helvetic Republic.

ELECTROLYTIC REFINING OF IRON.—Some 3 tons of iron have been refined electrolytically in the laboratories of the University of Wisconsin. As a result of this work, it is concluded by Mr. C. F. Burgess that, starting from anodes of the purest commercial iron, and using every precaution, an iron of 99.97 per cent. could be produced, With anodes of mild steel the purity decreased by a few hundredths of a per cent. One kilowatt-hour would refine 2 lb. of iron. A solution containing 40 grammes of iron per litre as ferrous sulphate and 40 grammes of ammonium chloride is recommended, with a current density of from 6 to 10 amperes per sq. ft. of cathode surface at 1 volt. Chloride solutions, preferred by some electrochemists, were not found to answer so well. The electrolytic iron is brittle, owing to it containing hydrogen. Burgess considers this brittleness rather advantageous, because the iron can more easily be broken up for smelting in the steel crucible, and because the hydrogen would reduce any oxides present.

THE UNIVERSAL DIRECTORY OF RAILWAY OFFICIALS, 1911. Edited by S. R. Blundstone. London: The Directory Publishing Company, Limited, 15, Farringdon-avenue, E.C. [Price 10s.]—This directory is now in its seventeenth year. In addition to railways in all parts of the globe it includes, as far as the United Kingdom is concerned, nearly all the power-worked tramways. The directory matter is arranged according to countries and continents. The systems are arranged alphabetically in these divisions, but cross-indexes, giving railways and also the names of officials, are also provided, so that information may be looked up, starting from any of three bases. As changes are constantly occurring in the railway world, and this book deals with systems all over the globe, it is evident that revision of a work of this kind must be a very difficult matter, and it is highly creditable to those responsible for its accuracy that it has been found so reliable in the past. We do not doubt that in the future its reputation will be equally good. Particulars are given not only of the officials and their departments, but also of the size, &c., of the railways themselves.

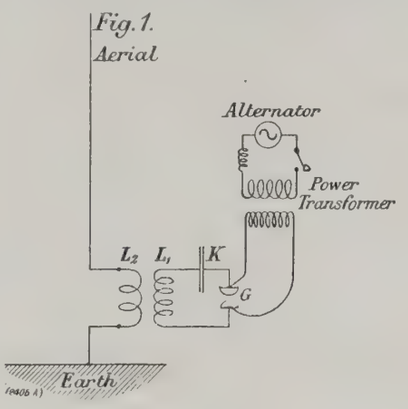
RECENT DEVELOPMENTS IN RADIO-TELEGRAPHY.*

By Professor G. W. O. HOWE, M.Sc., M.I.E.E.

DURING the last two or three years the number of radio-telegraphic installations has increased enormously both on land and sea. This increase has not been due so much to any new discovery or striking improvement as to several instances in which radiotelegraphy prevented what might otherwise have been terrible calamities at sea.

The total number of ships of the mercantile marine fitted with Marconi apparatus at the end of 1907—that is, after seven years of development—was 140; at the end of 1908 the number was 220; at the end of 1909 it was 330; while at the close of last year it had risen to 510. In addition to the mercantile marine, practically every ship in the British Navy has been fitted with the Marconi apparatus.

The Telefunken Company of Berlin carried out 106 installations last year, bringing the total number of stations using their apparatus up to nearly 1000. About 500 of these are warships, principally German and Russian, while 100 are portable military sets. Excluding



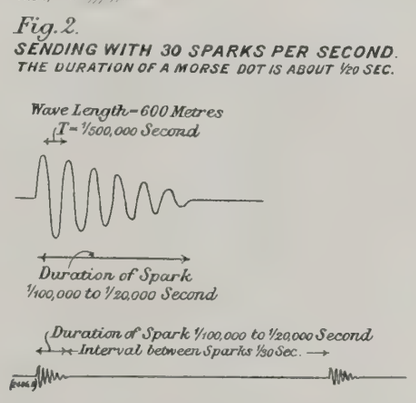


Fig. 2.
SENDING WITH 30 SPARKS PER SECOND.
THE DURATION OF A MORSE DOT IS ABOUT 1/20 SEC.
Wave Length = 600 Metres
T = 1/500,000 Second
Duration of Spark
1/100,000 to 1/20,000 Second
Duration of Spark 1/100,000 to 1/20,000 Second
Interval between Sparks 1/30 Sec.

German boats, only 13 ships of the mercantile marine are fitted with Telefunken apparatus.

Marconi's earliest experiments were made in 1895-6; and now, after fifteen years, every passenger ship of any magnitude has its wireless installation as a matter of course. There is every indication that very soon practically every ship will be so equipped. Some of the trawlers of the North Sea fishing fleet have recently been fitted with Telefunken apparatus, with a range of 100 miles. These boats receive the weather reports sent out daily from the coast stations, and are thus able to warn the fleet of approaching storms.

As was recently pointed out by Mr. Bradfield, of the Marconi Company, the increase in the number of installations will probably be cumulative, since each installation on sea or land increases the value of the service to every ship making use of it.

There is, however, another aspect to which I wish to draw attention, and that is, that the troubles due to interference between stations working simultaneously will also increase cumulatively. These troubles promise to become of the gravest importance in the immediate future. Before one can appreciate the developments that have taken place in the apparatus and methods of working, one must know something of the difficulties experienced in carrying on radiotelegraphic communications.

The nature of the telegraphic service which may be required of a station is very varied. A station may have to work with only one other station and never send to or receive from any other. This is practically the case with the trans-Atlantic stations. A station may work with a limited number of stations of definite and well-known characteristics, as in the case of the mail-boats running between England and the Continent. On the other hand, a station may have to correspond with all-comers.

One can easily see that apparatus which might be eminently suitable in one case would be very unsuitable in the other. Stations in the first category can use uncommon wave-lengths, and thus free themselves, to a large extent, from interference from other stations, besides being able to use a large amount of power without causing interference. The Marconi trans-Atlantic stations in Ireland and Nova Scotia use a wave-length of over 6000 m. (50,000 periods per second), and are thus free from disturbance from ships, which generally use 300 m. or 600 m Stations of the third class, on the other hand, should be able to call or be called by ships or land stations fitted with any make of apparatus covering a wide range of frequency.

To appreciate the difficulties due to interference, one has only to consider the case of a station on the Kentish coast, with half-a-dozen ships within range, all wishing to communicate with the land station. They can only communicate one at a time, and each operator naturally tries "to catch the Speaker's eye," which, in this case, is the coast operator's ear, by calling often and loudly, any regulations to the contrary notwithstanding. The same thing may be going on at other coast stations on both sides of the Channel. In addition to this we have English and French warships and dockyards working at the same time.

If it were possible for every station and every ship to have a different wave-length, interfering stations might be tuned out to a certain extent, but for the sake of uniformity and convenience in working, the majority of stations have about the same wave-length, so that when one is tuned to receive the desired message, one is also tuned to the disturbing stations. The result is that one station tries to shout the other down, and the successful working of all the stations is greatly hindered. At the City and Guilds College, at South Kensington, one of the aerials is a single wire 260 ft. high, and with this one can sometimes hear half-a-dozen stations sending simultaneously at approximately the same wave-length, making it absolutely impossible to read any one of them.

Apart from all this, there are the atmospheric disturbances, which vary very much from time to time. When a station is receiving from another station at a distance of 1000 miles, it will certainly "pick up" every lightning flash over a large part of the earth's surface. These atmospheric disturbances are often strong enough to make working impossible over any but very short distances, even when the weather conditions locally look ideal. Whether one can receive or not in spite of the atmospheric disturbances depends on the nature and loudness of the signals, so that one can become more and more independent of the atmospheric conditions by increasing the power employed, and by making the signals easily distinguishable from the sounds caused by the disturbances.

Recent developments in the sending apparatus have been largely directed towards obtaining freedom from interference. This has been sought in two ways: firstly, by sending out well-sustained trains of waves of one definite frequency, thus permitting sharper tuning; secondly, by giving the signals a high musical pitch, easily distinguished from the crackling noises caused by atmospheric disturbances, and also from other stations having notes of a different pitch. The spark-gap must be so designed that these characteristics are retained when very large powers are employed. A gap may give excellent results when the power is small, but fail entirely when the power is increased. Absolute reliability and constancy are of far greater importance than efficiency, although any improvement in the latter is naturally to be welcomed, not so much for the saving of power as for the reduction in size and cost of the apparatus.

Fig. 1 may be taken to represent diagrammatically the sending apparatus of almost every system, by whatever name it may be called. In all except the smallest installations, the sparking coil with hammer or mercury break has been replaced by an ordinary power-transformer supplied with alternating current, as shown in the figure. The coils L_1 L_2 constitute an air-core Tesla transformer of few terms. It is sometimes connected as an auto-transformer—*i.e.*, with a single winding tapped off at different points, but this alters nothing so far as the principle is concerned. If coil L_2 is far removed from coil L_1 each discharge of the condenser K across the gap G will cause a damped oscillation in the primary circuit G K L_1, as shown in Fig. 2. The rapid damping is mainly due to the dissipation of energy in the spark gap. The time T of a complete oscillation depends only on K and L_1, and is usually about $\frac{1}{500,000}$ second, corresponding to a wave-length in space of 600 metres. All the energy stored in the condenser at the moment of breakdown is dissipated as heat in the gap and in the remainder of the oscillatory circuit. The oscillatory disturbance caused by a single spark lasts about $\frac{1}{50,000}$ second. Nothing further happens until the condenser is charged up to the same potential difference as before. If the gap is made so long that the spark can only just jump it, the next spark may not occur until several half-cycles of the alternating supply have passed, the voltage across the secondary of the power-transformer gradually building up due to resonance. This resonance is obtained by adjusting the speed of the alternating-current generator. The result will be that, with the alternating-current supply of 50 cycles per second, the sparks may occur at intervals of $\frac{1}{25}$ to $\frac{1}{30}$ second (Fig. 2). This is the method which was largely used two or three years ago, and which is still used by the Eiffel Tower and many other stations.

If the coil L_2, which, with the aerial, constitutes an oscillatory circuit of the same frequency as the circuit G K L_1, is loosely coupled with coil L_1, so that about 5 per cent. of the magnetic flux of L_1 links L_2, a part of the oscillating energy will be transferred to the aerial, and there, partly radiated out into space, and partly dissipated in the aerial, coil, and earth connection. The oscillogram, Fig. 3, shows the nature of the primary and aerial currents accompanying each spark. Owing to the loose coupling between L_1 and L_2, the transference of

* Paper read before Section G of the British Association at Portsmouth.

energy is very slow, and the major portion is still dissipated in the spark-gap. From experiments made at the City and Guilds College it has been found that under the most favourable circumstances 30 per cent. of the primary energy can be transferred to the aerial. If the transfer of energy to the aerial is hastened by increasing the mutual inductance between L_1 and L_2, the energy surges backwards and forwards between the two circuits and gives us the phenomenon of beats. The oscillograms, Figs. 4 and 5, show the nature of the primary and aerial currents as the coupling is increased. Instead of a wave of one definite length—say, 600 metres—a pulsating oscillation is sent out, which may be looked upon as made up of two ordinary damped waves with lengths of, say, 500 and 700 metres. This will be received almost equally well on the receiving aerial, whether it be tuned to 400, 600, or 800 metres, or any other intermediate wave-length.

In Figs. 6 and 7 are plotted the currents in the receiving apparatus as its natural frequency is varied. The two figures refer to different installations; in each case a series of curves is given for different degrees of coupling

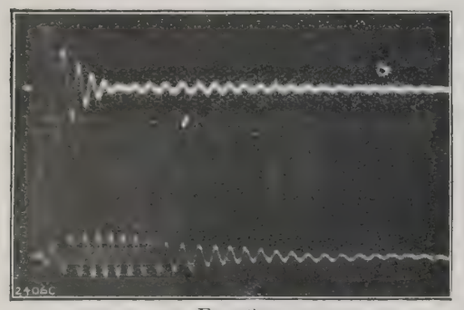


FIG. 3.

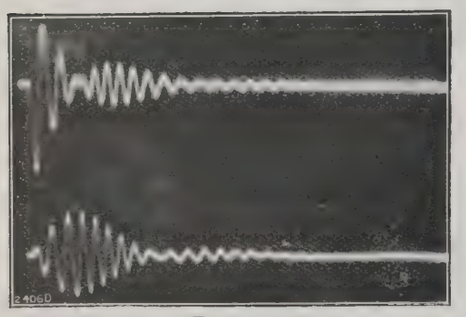


FIG. 4.

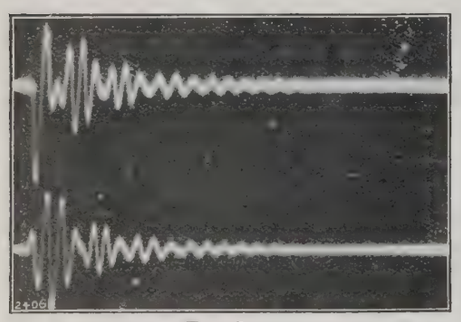


FIG. 5.

between the coils L_1 and L_2. With the ordinary spark-gap it is thus seen to be impossible to increase the coupling much above 7 or 8 per cent. without sacrificing sharpness of tuning, and thus causing undue interference with stations working at other wave-lengths. Apart from the question of interference, there is litttle increase in efficiency to be obtained by increasing the coupling beyond this value.

These are the conditions under which the majority of stations are working at the present time, but during the last three or four years a great amount of research work has been done with the object of improving these conditions.

In Fig. 7 it will be noticed that when the coupling is tight, the aerial oscillation contains waves of three definite frequencies—one high and one low, corresponding to the constituents of the beats—and one of the natural frequency of the aerial alone. This shows that during a part of the time the aerial oscillated freely, uncoupled from the primary circuit. The reason for this can be seen from the oscillogram, Fig. 8. In the experiment to which Fig. 7 refers, the spark-gap was exposed to an air-blast, so that whenever the amplitude of the current in the primary oscillating circuit was small, there was a tendency for the air-blast to remove the column of hot air and metallic vapour, and thus extinguish the spark. This will obviously occur at a moment when all the energy is oscillating in the aerial, and will prevent it surging back into the primary circuit. The aerial will now continue to oscillate at its natural frequency until the energy is all radiated or dissipated. In Fig. 7 not only was there an air-blast, but the electrodes were comparatively large, and the spark-gap short, so that no part of the spark was far removed from a large mass of cold metal tending to cool the heated air and condense the metallic vapour, and thus lower the conductivity of the spark.

This quenching of the spark was discovered in 1906 by Professor Max Wien, and was afterwards taken up by the Telefunken Company, who have evolved a form of spark-gap, in which the quenching is very effective. With this gap the primary and aerial currents will be as shown in oscillogram, Fig. 9. The gap acts as a very quick-acting minimum current cut-out, and opens the primary oscillating circuit at the first opportunity—viz., when all the energy has been transferred to the aerial The time during which the two circuits are coupled is very short, the loss in the spark-gap is reduced, and the major portion of the energy oscillates freely in the aerial, and is radiated as a damped train of waves at its natural frequency. In this way it is claimed that 75 per cent. of the output of the alternator is transferred to the aerial.

It is obviously advantageous to shorten the duration of the spark as much as possible by tightening the coupling between the coils L_1 and L_2, and thus hastening the transfer of energy to the aerial. If this be overdone, however, the gap will fail to quench at the first minimum, and we may get the conditions shown in Fig. 10, or even Fig. 8, with a great loss both in efficiency and in sharpness of tuning.

Wien first obtained quenching by the use of very short spark-gaps, and this is the method which the Telefunken Company has adopted, although other methods have since been discovered. The spark is made to occur between the parallel faces of discs of copper or silver, placed about $\frac{1}{10}$ in. apart, the discs being separated by thin annular rings of mica, which also serve to shut the sparking spaces off from the air. The number of these discs in series depends on the voltage and power required. This form of gap is undoubtedly complicated and expensive, not only in first cost, but also in upkeep. Those who have picked up the time signals and weather report sent out daily from Norddeich will have noticed that although, since the quenched spark was introduced, the signals are very clear and easily distinguished from extraneous sounds, they often decrease in strength after working for some time, and have been known to fail altogether for a few seconds, in spite of the efforts of the operator. This may have been due, of course, to some exceptional cause not connected with the spark-gap, but it is almost what one would expect when using such minute gaps as $\frac{1}{10}$ in. It seems, therefore, at present that the increased efficiency due to the quenched spark is obtained by the sacrifice, to a certain extent, of reliability and simplicity.

Turning now to the receiving apparatus, we find that the filings coherer has practically disappeared. The reception of the signals is now always aural. The detectors now employed in conjunction with the telephone receiver are not only much more sensitive than the filings coherer operating a Morse inker, but they enable the operator to discriminate between the signals being sent to him and the various disturbances picked up by the aerial, which, as we have already seen, is a matter of ever-increasing importance.

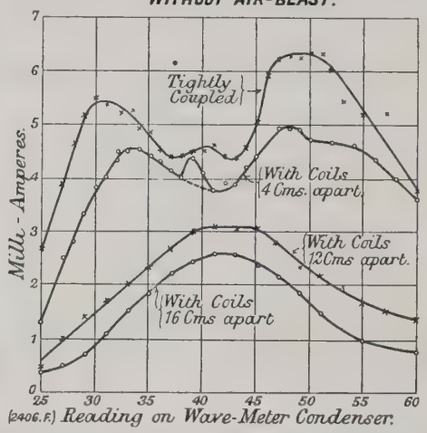
The magnetic detector used by the Marconi Company is ideal in its simplicity and reliability, but is not so sensitive as the electrolytic or the mineral contact detector. The Telefunken Company have recently given up the electrolytic detector in favour of a detector of the latter type. Another type of detector used to a certain extent is the Fleming valve, which combines extreme sensitiveness with comparative simplicity and reliability.

Although there are many ways of arranging the receiver connections, Fig. 11 may be taken as typical of the usual arrangements when using a mineral contact detector. The high-frequency oscillation picked up by the aerial is transferred by means of the oscillation transformer L_3, L_4 to the tuned oscillatory circuit K L_4. Shunted across the condenser is the detector—consisting simply of a piece of zincite in contact with a piece of pyrites—together with the telephone receiver of several thousand ohms resistance. The telephone is shunted with a condenser, which must have such a capacity that it acts as a conductor to the high-frequency oscillations, enabling them to pass through the detector without passing through the highly inductive telephone receiver, but as an insulator to currents of telephonic frequency, thus forcing them to pass through the telephone.

Fig. 12 explains the various stages from the alternating-current supply of the sending apparatus to the currents in the telephone receiver. Each spark causes a wave-train, and each wave-train causes a momentary heating of the point of contact of the detector. In the figure the duration of the wave-train has been greatly exaggerated for the sake of clearness. This will cause a momentary variation in the contact resistance and will also produce a thermo-electromotive force, with the result that a momentary current passes through the telephone, or if, as is sometimes found advantageous, a steady current is maintained through the telephone by means of the cell B, this steady current will suffer a momentary variation.

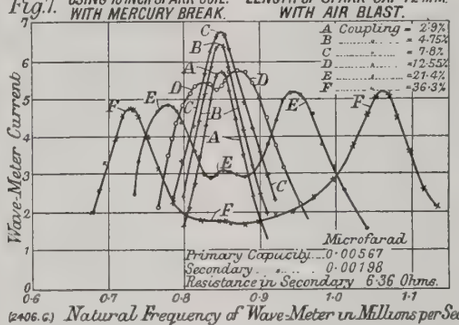
Thus each spark gives an impulse to the telephone diaphragm, and the pitch and nature of the note heard in the telephone receiver will depend entirely on the frequency and regularity of the sparks. It is here that one of the greatest improvements has taken place. Until recently the sparks followed one another so slowly or so irregularly that the sound heard in the telephone could not be called a note, but was merely a crackling noise. A great number of stations are still working in this way, and the signals they send out are very difficult to distinguish from atmospheric disturbances and other extraneous noises. It is now realised, however, that by giving the signals a pure musical note of high pitch they can be readily heard and distinguished above comparatively loud atmospheric disturbances, and in spite of

Fig. 6. SENDING ON 5-WIRE AERIAL. USING SMALL SPARK-COIL & PLAIN GAP WITHOUT AIR-BLAST.



(2406.F) *Reading on Wave-Meter Condenser.*

Fig. 7. USING 10 INCH SPARK COIL. WITH MERCURY BREAK. LENGTH OF SPARK GAP 1·2 MM. WITH AIR BLAST.



(2406.G) *Natural Frequency of Wave-Meter in Millions per Sec*

In all the oscillograms the upper curve refers to the current in the primary oscillatory circuit, and the lower curve to the current in the aerial.

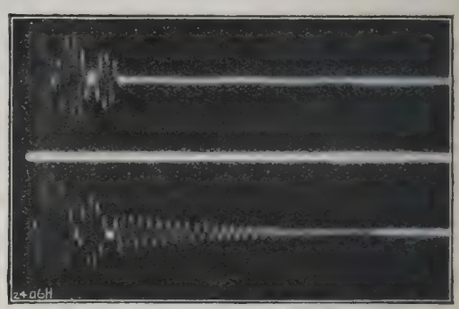


FIG. 8.

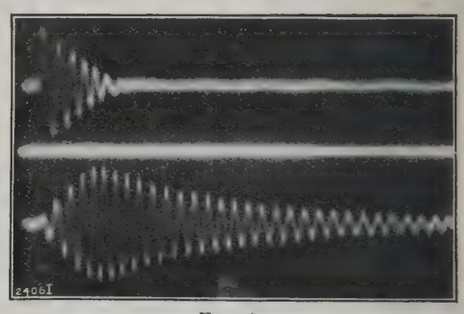


FIG. 9.

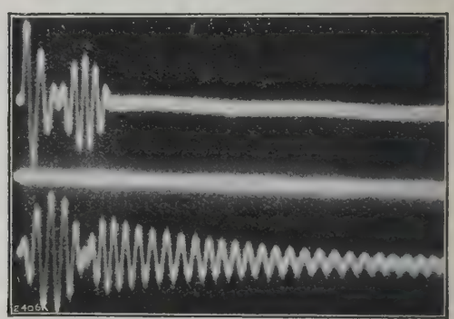


FIG. 10.

interference from other stations, unless these stations happen to be working with a note of the same pitch.

Another very important point in this connection is the great increase in the sensitiveness of the telephone receiver as the pitch of the note is increased.

To produce a musical note of high pitch it is necessary to make the sparks follow one another rapidly and with great regularity. When sending at a speed of twenty words per minute, the duration of a dot will be about $\frac{1}{20}$th of a second, so that with a spark frequency of thirty per second the dot will consist of one or, at the most, two sparks, whereas with a spark frequency of 1000 per second the dot will consist of fifty sparks. The former was quite enough to actuate a filings coherer, but would merely cause a blow on the telephone diaphragm, whereas the latter would give a short piping note in the receiver.

By increasing the alternating supply voltage or by shortening the spark-gap, a large number of sparks can be made to occur during each half-cycle, but they will occur too irregularly to produce a musical note, unless steps are taken to make the sparks occur at regular intervals. This can be done by replacing the stationary gap by two discs revolving at high speed, the rims of the discs being provided with projecting knobs, between which the sparks jump.

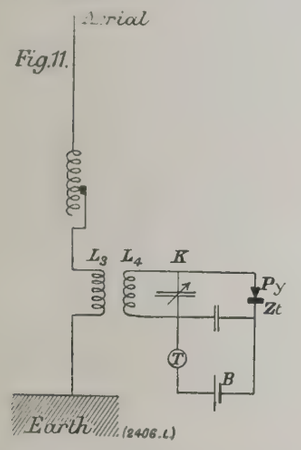


Fig. 11.

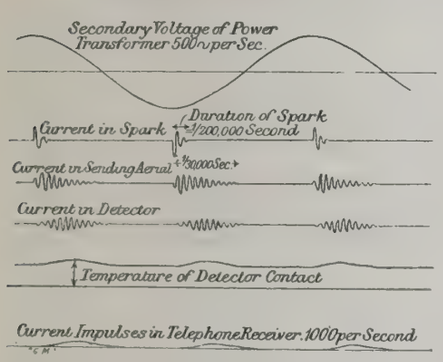

WAVE LENGTH = 600 METRES
A.C. SUPPLY FROM 500 CYCLE ALTERNATOR.
QUENCHED SPARK.
Secondary Voltage of Power Transformer 500 per Sec.
Duration of Spark 1/200,000 Second
Current in Spark
Current in Sending Aerial 1/1000 Sec.
Current in Detector
Temperature of Detector Contact
Current Impulses in Telephone Receiver 1000 per Second

Fig. 12

The simplest way of obtaining 1000 sparks per second with great regularity is to use an alternator giving 500 cycles per second, and adjusting the voltage until the gap breaks down once every half cycle, as shown in Fig. 12. To ensure regularity the gap must be kept cool, and the after effects of each spark quickly removed. With the ordinary stationary gap this can be done by means of an air-blast, but with the Marconi revolving discs the air-blast will hardly be necessary. In the new Telefunken gap the quenching action which we have already considered has to extinguish the spark $\frac{1}{200,000}$ second after it has jumped, so that after $\frac{1}{1,000}$ second the gap should have lost all traces of the spark. The quenching action has thus to play a double part, the first affecting the nature of each spark and the resultant oscillation, and the second affecting the regular succession of sparks.

One of the most recent developments, although hardly yet beyond the experimental stage, is the introduction of the telephone relay.

By placing one of the telephone relays, recently invented by Mr. S. G. Brown, between the detector and the telephone receiver, signals which are otherwise quite inaudible can be easily read. The Telefunken Company have recently experimented with an apparatus somewhat similar in principle and known as a tone-augmenter.

The distances over which communication can be maintained with a given supply of power depends on the height and size of the aerial, on the nature of the intervening country, and on the type of detector employed. A safe guarantee, under very unfavourable conditions, is about 50 miles per kilowatt of alternator output, but, with favourable conditions and sensitive apparatus, distances of over 500 miles per kilowatt have been covered.

Practically all the radiotelegraphic apparatus working commercially or being installed at the present time is based on the principles which we have considered; with the exception of the spark-gap and the detector employed, the differences are non-essential. No mention has been made of the generation of undamped waves by means of arcs, as this system has not yet made the revolutionary changes in radiotelegraphy which many anticipated.

PRINCIPLES OF FLIGHT.*

By ALGERNON E. BERRIMAN.

ONE of the greatest services that can be rendered to the science of aeronautics at the present time is to attract towards it the serious interest of minds that have matured in other departments of the world's work. With this object in view an attempt will be made to give a *résumé* of the more interesting problems as they are understood by the majority of students, in the hope that those taking part in the discussion may thereby be enabled to direct their remarks along such lines as shall add most to the sum total of our little knowledge in the short space of time available.

The present predominance of the military aspect in the perspective view of the immediate future of aeronautics serves also to draw a dividing line between different forms of aircraft, such as to group all systems essentially possessed of the ability to ascend vertically and hover stationary in the air on one side, and all those that can neither stand still in the air nor get up from anywhere, on the other.

Balloons and Kites.—Thus, the captive balloon and the man-lifting kite both perform useful work, although neither navigates the air at large. The free-moving aeroplane, on the other hand, is frequently criticised because it does not at present possess the potential qualities of the as yet unsuccessful helicopter.

The Helicopter.—It seems necessary to pay some attention to the problem of the helicopter, therefore, in order to see how far an elementary investigation of its principles supports the likelihood of realising the possibilities frequently assumed in its favour. It has been suggested that some insects fly on the helicopter principle.

It may be demonstrated that the very small helicopter is a remarkably successful toy, although the large helicopter is as yet an unsuccessful machine. A mathematical ratio (see the "two-thirds power law" in summary of formulæ) indicates that the application of increased power to a given screw is an insufficient method of increasing the lift. It is suggested that the ratio of the essential dead-weight to effective lifting area may also increase so disproportionately in large machines as to prevent the practical success of the helicopter class. Inasmuch as the largest screw for a given load is the most efficient, it is argued that the aeroplane is the helicopter of maximum efficiency, inasmuch as it represents a blade element flying on the straight-line periphery of a circle of infinite diameter.

Dirigibles.—Under the assumed division dirigibles and aeroplanes have to be compared as alternative machines for fulfilling the same purpose. Both navigate the air, but the dirigible, in addition, can ascend vertically and hover stationary above any given spot. Windy weather adversely affects both types of machines. In the aeroplane the gust is inimical to stability; in the dirigible a high wind exerts an enormous drifting force. Comparatively large sizes are necessary in dirigibles if they are to have a wide range of action. The more important disadvantages of dirigibles result from the permeability of the fabric to hydrogen, the costliness and inconvenience of using this gas, and the disturbing influences of sunshine and shadow on buoyancy.

Aeroplanes.—The aeroplane is the more interesting machine of the two in the eyes of the majority of students, owing to the popularity of flight as a sport. A broad treatment of the problems relating to this section divides them under two heads, one dealing with the lift and resistance of the cambered plane, the other dealing with stability, which has always been the most important factor making for progress in aviation.

Calculating Lift.—In the mathematical section, an hypothesis that aeroplanes are supported in flight by the inertia of the air leads to the necessity of finding plausible expressions for mass and acceleration.

Two dimensions of the mass of air deflected are plausibly functions of the span and chord of the plane; the third, which defines the depth of the stratum, and is known as the "sweep," is taken as an empirical function of the chord; but this connection needs discussion. Acceleration is obviously a function of the angle of the plane, but difference of opinion exists as to how that angle should be measured. A suggestion is put forward in favour of the "angle of deflection" measured at the point of intersection of tangents drawn to the leading and trailing edges of the plane, which needs discussion. From the assumed premises a rough-and-ready formula for lift has been evolved (see summary of formulæ).

Skin Friction.—In order to extend the premises to cover a plausible expression for the resistance to flight and the power expended thereon, it is necessary to adopt a value for skin friction. Zahm's experiments have been accepted as data (see summary of formulæ), but the whole subject needs discussion. Skin friction is of such fundamental importance in aerodynamics that it is imperative to put it upon an accepted basis analogous to the position occupied by normal pressure.

Coefficient of Flight.—The coefficient of flight, representing the resistance per unit load, may be shown to be independent of speed, but to depend on the angle of the plane, and to have a minimum value depending on the coefficient of skin friction. On the present hypothesis, the minimum coefficient of flight obtains with planes of a very small effective angle (about 5 deg.), such as would necessitate flying at much higher speeds than have hitherto been realised. The existence of an angle of least resistance is very important in connection with the problem of variable speed machines.

Body Resistance.—Body resistance in a practical aeroplane is a supplementary resistance to that of the planes, and should always be considered as such. It stands in the way of realising the higher speeds that would lead to the use of more efficient planes, but by enclosing all the principal masses in casings of stream-line form a plausible means is afforded of considerably reducing this quantity. A comparison of the coefficients of normal pressure and skin friction indicates a very large possible saving in this direction. In bodies of stream-line form the advantages of a hemispherical head are worthy of consideration.

Stability.—Stability in a flying-machine is either natural as a result of form, automatic as the result of self-acting mechanism, or controlled by human intelligence. No particular progress has been made along the lines of automatic stability, although the use of gyroscopes and wind-vanes to operate relay mechanisms has frequently been suggested. Natural stability has, however, been realised to some extent, and, coupled with modern expert control, the combined result has reached an extraordinarily high degree of perfection, considering the short period of evolution.

Natural stability in its elementary form may be readily demonstrated by means of paper models. In practical aeroplanes natural stability in the longitudinal vertical plane is mainly based on the principle of the dihedral angle. Natural stability in the lateral vertical plane is also commonly based on the same principle, but alternative systems, one of which is the arched wing, have been tried. The arched wing and the dihedral being apparently diametrically opposite in principle, attention is drawn to two orders of stability—"stiff" and "rolling." The relative possibilities of successful development along each line is well worthy of discussion.

The acentric centre of gravity, in which the principal masses are placed well below the centre of pressure, is frequently suggested as a stabilising principle; but the permanent existence of a couple between the centre of gravity and the centre of pressure indicates liability to pronounced oscillation, and the system does not find general favour. In connection with the under-carriages of aeroplanes, the advantage of landing direct on skids is urged; and in connection with the power plant, the possible disturbing influence of the gyroscopic force of heavy revolving masses is worthy of notice.

Conclusions.—Apart from the question of stability, progress in flying-machine design is mainly a problem of increasing the efficiency of the machine, just as it is in every other branch of mechanical engineering. It follows, therefore, that the need for further information on such subjects as the effective angle of a plane, sweep, skin friction, and other similar problems that come within the province of research work in physical science, is all important. If the aeroplane of the future is to carry heavy loads and to fly far and fast without interrupting its journey, it must be more efficient than the aeroplane of to-day. The air, like the ocean, permits of full speed ahead all the time, and a speed of 60 miles per hour through the air would halve the present latest crossing of the Atlantic. Before an uninterrupted journey across the 1700 miles that separate the nearest adjacent points of land could be accomplished by a machine carrying only two men, it would have to be shown that an aeroplane could be built capable of carrying at least 1500 lb. of useful load at 60 miles per hour, with a gliding angle more nearly in the order of 1 in 7 than the angle of 1 in 4 or 5, which at present represents the efficiency of a good modern flyer.

Except so far as a pilot might be able to economise power, as soaring birds do, by taking advantage of favourable air-currents, skilful control has nothing to do with the theoretical possibilities of the aeroplane in undertakings of this order, which may be investigated by the aid of simple arithmetic. In matters affecting the use of machines in bad weather, for dangerous purposes, and under difficulties generally, nothing in the world gives any clue to the future except the present state of the art, for which the intrepid practice of pilots and the care of those who build machines is wholly responsible, and deserving of the utmost credit.

SUMMARY OF FORMULÆ.

The Two-Thirds Power Law.—If thrust $\propto V^2$ and power $\propto V^3$, then thrust $\propto$ H.P.$^{\frac{2}{3}}$.

Mathematics of the Cambered Plane.—

$$\text{Lift} = \frac{V^2 \tan \beta}{200}$$

where V = flight speed miles per hour.
β = angle of deflection.

Skin Friction.—Zahm's formula—

$$R = 0.0000316 l^{\cdot 93} V^{1 \cdot 85}.$$

Where R = resistance of double surface lb./ft. of span.
l = chord.
V = velocity miles per hour.

Approximation (1 to 90 miles per hour and high aspect ratio).

$$R = 0.000018 V^2.$$

Coefficient of Flight.—

$$\text{Pounds thrust per lb. loading} = \left[\frac{\tan^2 \beta + 0.0072}{3 \tan \beta}\right].$$

Minimum value obtains when $\beta = 5$ deg. approximate, and gives least coefficient of flight = 0.085.

* Paper read at the joint meeting of Sections A and G of the British Association at Portsmouth, September 4.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below general data on several colonial and foreign engineering projects. Further information concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C. :—

New Zealand: The Imperial Trade Correspondent at Auckland reports that a scheme is under consideration by the Harbour Board of that place for the expenditure of 1,000,000*l.* on various works, including the following :—

	£
Quay-street jetty, No. 4, reclamation and extension	45,000
Queen-street wharf, with sheds, cranes, capstans, and equipment	261,500
Freeman's Bay reclamation (67 acres), walls, sewers, and shipbuilders' slope	122,000
Steam-tug, ladder-dredger, and suction dredger	62.500
Ferry building	64,000
80-ton floating crane	27,500
Railway wharf (completion), rock excavation, cranes, capstans, and equipment	39,000
Quay-street landing	41,000
Western tide deflector	25,000
Central wharf, with sheds, cranes, capstans, and equipment	240,000

The scheme is dependent on the passing through Parliament of an Empowering Bill.

Italy: The British Acting Consul at Naples reports that under the new law governing the subventions given by the Italian Government to private railway concessions the engineers Cuciniello and Tajani have been granted the maximum subsidy of 400*l.* sterling per kilometre, for a duration of fifty years, for the railways to be constructed by them respectively from Naples-Avellino to Atripalda and from Salerno to Amalfi.

Austria-Hungary: The following notices are extracted from the *Zentral-Anzeiger für das öffentliche Lieferungswesen*, Vienna. The Ministry of Railways has given permission to the Union-Baugesellschaft, of Vienna, to prepare plans for a railway from Abbazia to the Monte Maggiore. The town of Pressburg has raised a loan of 1,000,000 kr. (about 42,000*l.*) for the purpose of extending the municipal gas works. The Troppau gas works are to be extended in 1912 so as to have a daily capacity of 15,000 cub. m. In the retort-house new mechanically-equipped modern retorts are to be installed. The purifying establishment is to be enlarged, a new gasometer set up, &c. The municipal authorities of Smichov have decided to raise an additional loan of 4,032,000 kr. (168,000*l.*) in connection with the construction of water-supply works. In addition a sum is to be provided for the construction of the Pantosce aqueduct, and the extension of the aqueduct in the Neklaugasse in New-Smichov.

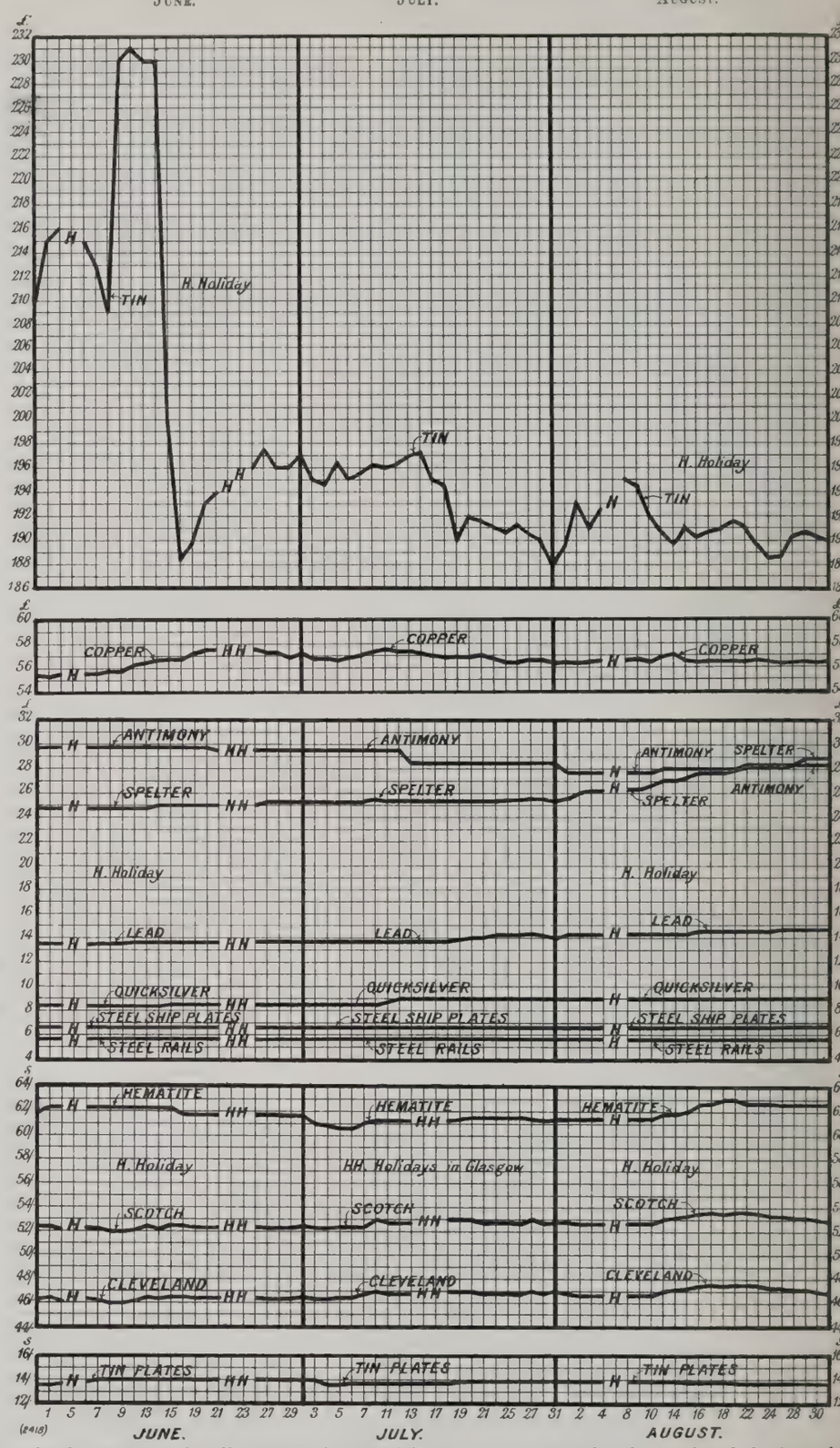
Panama Canal Zone: His Majesty's Minister at Panama reports that the Isthmian Canal Commission intend to construct, at the Atlantic entrance to the canal, a series of five reinforced-concrete docks at which ten 1000-ft. vessels will be able to berth at the same time. The plan provides for an anchorage basin east of the canal, an artificial mole projecting from Cristobal Point, and docks between this mole and the anchorage basin and around Cristobal Point, under complete shelter for vessels, which will thus be enabled to discharge and load cargo without entering the canal. It is stated that 675 steel cylinders, 152,565 cubic yards of concrete, 402,000 lineal feet of reinforced-concrete sheet piling, 1,498,560 lb. of steel girder, and 804,000 lb. of steel I-beam will be required for the construction of the docks. Twenty-two spillway gates are also required for the Gatun and Miraflores locks, and steel casings for the spillways, as well as steel material for bridges and hand-railings. In connection with these works and the locks of the canal there will be needed a quantity of subsidiary steel material, such as rising stem gate-valves, lower guard gate-valves, lateral culvert-valves, bulkhead gates, screens for the culverts of the locks, and castings. Tenders for all this material will be invited in the United States. Foreign tenders will be admitted, but, in considering them, the amount of duty payable on the article if imported into the United States will be added.

Colombia: The *Diario Oficial* publishes a decree authorising the Municipal Council of the district of Zipaquirá to raise a loan of 32,000*l.* for the construction of an aqueduct and sewers.

Lloyd's Returns of Shipwrecks, &c.—Lloyd's Register of British and Foreign Shipping have just issued their usual returns of vessels totally lost, condemned, &c., during the quarter ending March 31 last. The list first deals with steamships, the statistics including all vessels exceeding 100 gross tons. Altogether eighty-three vessels, totalling 104,553 gross tons, have been removed from the register, and of this number thirty-five were British and five belonged to the British Colonies. The aggregate tonnage of the thirty-five British vessels lost was 43,846, which is 0.26 per cent. of the total tonnage owned in the United Kingdom. The five colonial vessels totalled 6646 tons, or 0.51 per cent. of the whole colonial tonnage. Germany, having lost eight vessels, aggregating 8376 tons (0.21 per cent.), comes next on the list in numbers, although, curiously enough, her losses have been exceeded in tonnage by those of Brazil, whose casualties include five vessels, totalling 9209 tons; the percentage is not stated in the latter case. Greece has also suffered badly during the period, her losses including three vessels, which together account for 7591 tons. Spain, Norway, and Japan follow in order of tonnage, having lost, respectively, 6048 tons (0.81 per cent.), 4496 tons (0.32 per cent.), and 3594 tons (0.31 per cent.). The other losses exceeding 1000 tons are distributed as follows:—France, 2414 tons; Belgium, 2344 tons; Turkey, 2002 tons; United States, 1885 tons; Holland, 1824 tons; and Russia, 1815 tons. Coming now to sailing vessels, we find that altogether sixty-one ships, making 34,713 tons (net tonnage is referred to in the case of sailing vessels), have been lost. In this class the United States heads the list with seventeen vessels, totalling 9056 tons, while the United Kingdom follows with 8161 tons in eight vessels; the percentages of the total tonnage owned are 0.81 and 1.09 respectively. The British Colonies have lost four ships with an aggregate tonnage of 1356, which is 0.66 per cent. of the total tonnage owned in the colonies. The only other nations to sustain losses exceeding 1000 tons are Norway, Russia, Italy, and Denmark, their losses being, respectively, 5940 tons (1.0 per cent.), 3633 tons (1.85 per cent.), 2542 tons (0.76 per cent.), and 1713 tons (2.65 per cent.).

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



In the accompanying diagrams each vertical line represents a market day, and each horizontal line represents 1s. in the case of tin-plates, hematite, Scotch and Cleveland iron, and 1*l.* in all other cases. The price of quicksilver is per bottle, the contents of which vary in weight from 70 lb. to 80 lb. The metal prices are per ton. Heavy steel rails are to Middlesbrough quotations. Tin-plates are per box of I.C. cokes.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

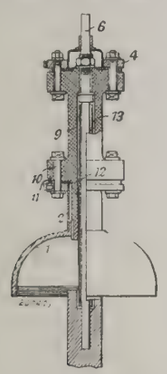
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

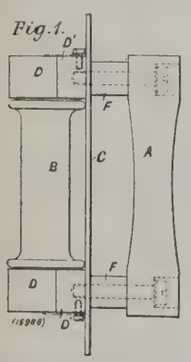
ELECTRICAL APPARATUS.

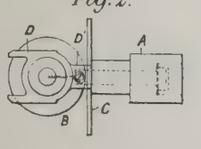
26,747/10. Hartmann and Braun Aktiengesellschaft, Frankfort-on-the-Main, Germany. Mercury-Vapour Apparatus. [2 *Figs.*] December 1, 1909.—This invention relates to the mounting of electrodes in mercury-vapour apparatus, and is especially adapted for employment where it is desired to prevent the gas penetrating to the chamber on a great change of internal temperature occurring. A packing embodying the present invention is not only gas-tight, but is readily interchangeable, and is adapted to withstand heavy loads. According to the construction illustrated, the extremity of the vacuum chamber 1 is produced in the form of a tube 2, composed of thin metal with a view to the dissipation of heat. Within the tube 2, one extremity of a hollow sleeve 9, composed of heat-resisting insulating material, is arranged in such a manner that a flange, in which the tube 2



terminates, faces a collar formed upon the sleeve 9. The flange and the collar are rigidly connected by means of the bolts 10, and between them are arranged packing-rings 11 and 12 of different diameters; the annular space between them being fully charged with mercury, and a thoroughly gas-tight joint resulting. Within the sleeve 9 is rigidly fixed the electrode 6; and in order to secure a gas-tight joint between these two elements, means of the same character as above described are employed; the place of the tube 2 being, however, taken by a thin metallic hood 4 soldered upon the electrode. In order to prevent the deposit of small mercury particles, which might occasionally lead to a diversion of the current, it is preferable to surround partially the electrode 6 with an insulating tube 13. This tube may be supported from below, or may be attached to the electrode 6 in any suitable manner. (*Sealed August* 10, 1911.)

15,988/10. M. J. Railing and C. C. Garrard, Birmingham. Electric Cut-Outs. [2 *Figs.*] July 5, 1910.—In electric cut-outs or fuse-holders of the type in which the fusible element is supported inside a porcelain or the like tubular structure, the handle and a shield are secured to the fuse-bobbin in a readily detachable manner. The handle A, which may be of insulating material, is attached to the fuse-holder B, the two being, preferably, parallel. Between the fuse-holder and the handle is placed a shield C of insulating material, such as vulcanised fibre, and the attachment of the shield and handle to





the fuse-holder is effected by providing a projection D^1 on each contact-piece D of the bobbin tapped to receive fixing screws which pass through the ends of the handle and through insulating distance-pieces F and holes in the shield. The handle, shield, and fuse-holder are thus firmly clamped together, and the handle A is readily detachable should this be required. The distance-pieces F may be of such length as to provide sufficient clearance for the hand between the shield and the handle, or they may be of any greater length as may be required, and, if desired, can be integral with the handle. (*Sealed August* 10, 1911.)

12,300/10. M. B. Field and Ferranti, Limited, Hollinwood. Motor-Starters. [11 *Figs.*] May 19, 1910.—A motor-starter, according to this invention, comprises means for closing the main circuit, a resistance varied by externally-applied compression, and means for effecting short-circuiting of the resistance when reduced to a minimum, the starter having not more than two contactors employed for these purposes. Upon a panel is mounted a resistance element *b*, a hand-operated element for gradually compressing the material of the resistance element, and contactors *d* and *e* operated by the hand-operated element. A no-volt release-coil *f* and an overload coil *g* adapted to cause short-circuit of the no-volt coil upon an overload, are also mounted upon the panel. The operating element consists of a cam-shaft *h*, adapted to be rotated in one direction by hand by the co-action of a worm mounted upon the shaft *l* connected to the handle *m*. The worm is held in engagement during the starting operation by pressure exerted by the operator upon the handle *p* on the shaft *q* carrying the arm *r* and spring *s*. The shaft *h* is caused to be brought back to its starting position by means of a coiled spring. The shaft *h* has also in connection therewith the arm *u*, carrying a loosely-mounted armature *v*, and a stop *w* adapted to co-act with the rubber-faced buffer *x* on the panel.

Fig.1.

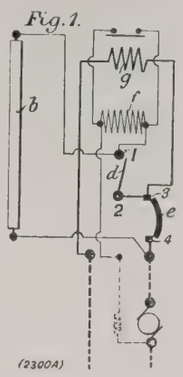


Fig.2.

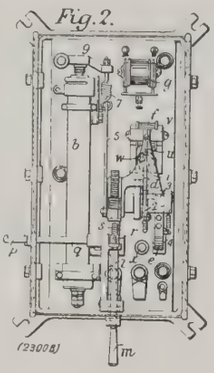
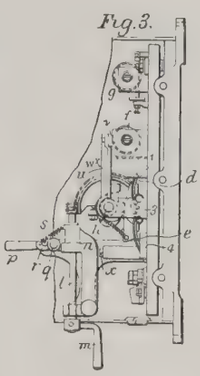
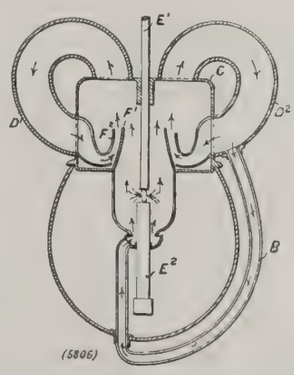


Fig.3.



The armature is held by the no-volt release-coil *f* when the motor is fully started. Cams on the shaft *h* press down in the proper order spring-arms carrying the contactors *d* and *e* upon the contacts 1, 2, 3, and 4. The action of the contactor *d* is to close the circuit with the resistance due to the element *b* at its maximum, and the action of the contactor *e* is to short-circuit the resistance when it has been reduced to a minimum. The resistance element is one of the compressible type—that is, the tube shown at *b*, which is preferably air-tight, contains graphite discs or compressible mixture of suitable resistance. Compression is gradually effected as the arm *u* is moved, by means of a connecting-rod 5 joining a crank upon the shaft *h* through a spring 7, the tension of which may be adjusted, to an arm 9 pivoted on the panel, and bearing upon the extremity of a plunger which bears upon the compressible resistance material. The plunger forms an entry for the currents into the resistance. (*Sealed August* 10, 1911.)

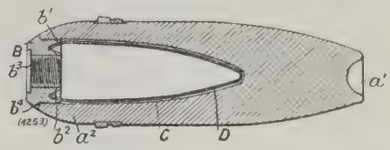
5806/11. J. O. Girdlestone and C. F. G. Thorkeln, London. Arc Lamps. [1 *Fig.*] March 8, 1911.—In an arc-lamp of the enclosed type, in which carbons containing chemicals are used, and in which a circulation of gases is maintained in order to avoid a deposit from the fumes on the transparent part of the enclosure, an enclosure is so arranged that the fumes and hot gases are led into a chamber, from the upper part of which the gases are led through metallic ducts or circulating pipes, which cool the gases and return the main flow of the cool and purified gases to the lower part of the chamber without re-entering the transparent part of the enclosure, a portion of the cooled gases



being led preferably from the lower part of one of the metallic ducts through a by-pass tube outside the outer globe to the lower end of the transparent part of the enclosure. The drawing shows the applicants' method of arranging the enclosure. E^1 and E^2 are the carbons, C is the chamber into which the hot gases pass from the arc, D^1 and D^2 are ducts connecting the upper with the lower part of the chamber C, F^1 is the funnel or opening through which the hot gases pass into the chamber C, F^2 is the funnel which surrounds F^1, and to which the main flow of the cooled gases is led from the ducts D^1 and D^2. B is the equalising tube or by-pass which connects the upper part of the enclosure with the lower part below the arc. (*Sealed August* 10, 1911.)

GUNS AND EXPLOSIVES.

4253/10. H. Stanbridge, Sheffield. Projectiles. [2 *Figs.*] February 21, 1910.—The invention has reference to the class of projectiles described in Specifications No. 16,707, of 1904, and No. 3033, of 1905. The hollowing of the head a^1 and consequent displacement of metal necessitates a long radius for the ogive that forms the continuation of the parallel walls of such projectiles; as a consequence they compare unfavourably as regards steadiness of flight with shells having a short radius for the ogive and a flat base. The applicant reduces the length of the parallel walls by forming a slope towards the base, and whilst retaining a flat base considerably diminishes the area thereof. The driving band is in consequence put much further forward, the proportion of slope at rear, parallel part and forward slope depending on the length of the shell, and this in turn depending on the capacity. This design allows the air to close in behind the projectile when in flight, an advantage over projectiles with bases at right angles to the walls, and also assists to steady it; further, the weight of base is reduced. The base plug B has in consequence to be



modified, the block which is inserted being shaped as follows:—It has a central hole (b^3), with threads for retaining the fuse, and lips inward (b^2) and outwards (b^1), or only outward and at an angle to conform to the curvature or slope (a^2) of the base of the shell, also a projecting flange (b^4) to stop it from being pushed in the shell on firing. The walls of the shell may be reduced at the base, so that the closing-in, similar to that described in No. 3033, of 1905, may be facilitated, and even done cold, and shaped as described in Specification No. 5393, of 1881, Fig. 2. Further, to prevent the heat on penetration from igniting the bursting charge, also to economise space, a non-conducting liner C, shaped to fit the interior of the shell, is combined with a non-corrosive metal liner D to keep the liner C firmly against the walls. This metal liner D serves also to prevent the powder being ignited prematurely should a live shell break up in store. In the case of a screw-base shell, the combined liners are easily inserted; in the case of shells with solid bases they are put in before closing down the walls of the shell. (*Sealed August* 10, 1911.)

LIFTING AND HAULING APPLIANCES.

22,807/10. Tangyes, Limited, and E. Johnson, Smethwick. Pulley-Block. [2 *Figs.*] October 3, 1910.—This invention relates to lifting appliances provided with worm and worm-wheel gearing, and in which the lifting and lowering chain-wheel is capable of free rotation on its spindle, and the worm-wheel of the gearing is arranged on a screwed portion of the spindle with a coupling device between the parts to ensure their rotation as one in the direction proper for raising the load when the hand-chain is operated, and consists in the combination, with the said mechanism, of a retarding device to retain temporarily the spindle stationary while the worm-wheel is performing its initial combined rotary and endwise movement on the spindle for effecting the coupling of the worm-wheel, lifting and lowering chain-wheel and spindle together. *a* is the wheel over which the lifting and lowering chain works, the wheel being capable of free rotation on the spindle *b*. The spindle *b* is screw-threaded for a part of its length, and on the screw-threaded part is a worm-wheel *c*, the periphery of which is of the same diameter from end to end, to permit a crosswise motion of the wheel with respect to the worm *i* gearing therewith. Between the worm-wheel *c* and the side of the wheel *a* is a series of friction discs *d*. Similar discs are also arranged on the spindle *b* between the wheel *a* and a ratchet-wheel *e*. A number of the teeth of the ratchet-wheel are somewhat larger than the other teeth, the larger teeth e^2 having a cam-like action on the spring-

Fig.1.

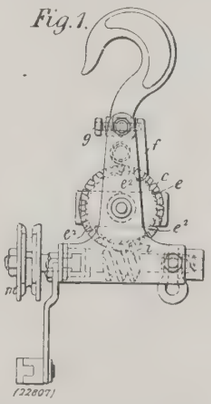
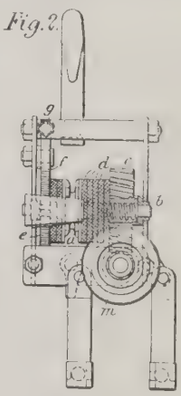


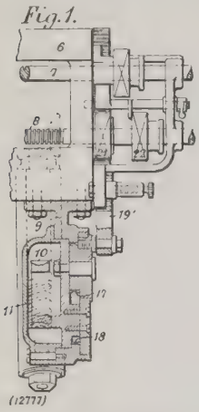
Fig.2.

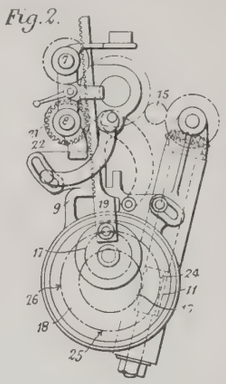


pressed pawl *f*. *g* is a screw-pin, by which the pressure of the spring may be adjusted within certain limits for the purpose of regulating the pressure of the pawl *f* on the ratchet-wheel *e*. The pawl can thus be arranged to slip at, or approximately at, any given load. The pawl *f*, when lifted by the cam-like part of the wheel *e* out of engagement with the ratchet-teeth, bears on the cam-like part with sufficient force to retard the rotation of the disc until the coupling together of the several parts on the spindle is effected, when the pawl performs the function of and acts as an ordinary pawl. The worm-wheel *c* is rotated by the rotation of the worm *i* driven from the chain-wheel *m*. The action is as follows:—When the wheel *m* is rotated in the direction for raising the load, the worm *i* rotates the worm-wheel *c* in the direction for advancing it endwise towards the wheel *a*, and when the requisite compression of the brake-discs has been effected, the worm-wheel *c*, brake-discs and wheel *a* will rotate as one, the load being thereby lifted. When it is desired to lower the load, the wheel *m* is operated in the opposite direction, and the worm-wheel *c* is caused to travel laterally on the screw-threaded spindle *b* in the direction for relieving the pressure of the friction-discs on the wheel *a*, thereby releasing or uncoupling the parts on the spindle; the load consequently descends quickly. A too rapid descent of the load can be checked by giving to the wheel *m* a movement in the direction for lifting the load when the coupling of the several parts on the spindle *b* is partially or completely effected, perfect control over the descent being thereby obtained. (*Sealed August* 10, 1911.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

12,777/10. A. E. Bennett and H. Thompson, Coventry. Turning-Mills. [3 *Figs.*] May 26, 1910.—This invention relates to the feed mechanism of turning-mills or lathes, and has reference to the automatic production of certain curved surfaces, such as are desired, for instance, upon the peripheries of belt-pulleys, or upon the face of buffer-plungers, and consists in the combination with mechanism which imparts the regular motion to the cutting-tool in one direction, of a train of gear-wheels for generating epicycloidal or hypocycloidal curves, by which a variable motion is imparted to the cutting-tool in the transverse direction. The drawings show the invention as applied to a turning-mill of the vertical type, in which 6 is the slideway upon which is carried the slide tool-rest. A vertical feed movement is obtained by the usual gearing through the spindle 7, which operates gearing connected to the vertical slide of the tool rest. Also the horizontal usual feed movement of the tool-rest as a whole is transmitted by the usual gearing through the screwed spindle 8. In operation, the spindle 8 is thrown out of action with the usual driving-gear, the spindle 7 being driven, however, as usual. The horizontal spindle 8 is driven as follows:—In a casing 9, carried from the framing of the machine, is a worm-wheel 10, which is driven by a worm 11, which by gearing is connected up to the usual speed gear-

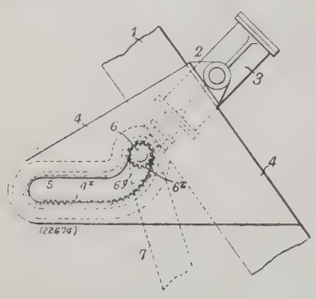




wheel 15. Eccentric upon the worm-wheel 10 is pivotally carried the rolling pinion 17, which gears into the internal teeth of the fixed wheel 18, formed in one with the casing 9. Crankwise connected to this rolling pinion is the rack-rod 19, the teeth of which gear with the wheel 21 keyed to the spindle 8. It will be noticed that when the rack 19 is connected with the wheel 21, the usual driving-wheel 22 is drawn to one side out of gear. Thus, as the usual vertical feed is taking place, there is also a horizontal feed due to the peculiar epicyclic gear movement which produces a relatively varying quick feed. As the wheel 17 travels from the position shown, the vertical movement of the rack-rod 19 commences very slowly, but increases, and assumes its maximum speed as it passes the point 24, when it again gradually slows down, until the minimum vertical speed of the rack-rod is reached as the wheel 17 passes the point 25, and, of course, in its further travel the maximum is again reached in the opposite direction as the point 26 is passed. Thus the desired varying speed is given to the tool to produce the desired curvature to the cut surface. The portion of such travel usually taken advantage of for the purpose hereinbefore named would commence between the position shown and the point 24, so that the initial feed movement would be an increasing one, and then a slowing down as the wheel 17 passed the lower part of the wheel 18, and *vice versâ*. (*Sealed August* 10, 1911.)

MINING, METALLURGY, AND METAL-WORKING.

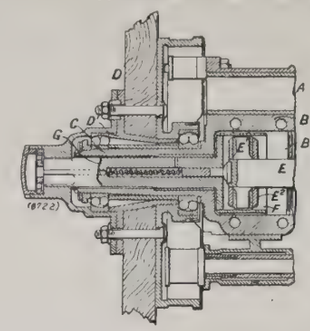
22,674/10. D. Whitaker, Leeds. Steam-Crane Excavators. [3 *Figs.*] September 30, 1910.—In steam-crane excavators, according to this invention, the jib 1 is provided with side extension brackets 4, having guide-slots 5 formed therein fitted with a transverse shaft or rod 6 carrying the bucket arms 7, and being attached to the piston-rod of a power-cylinder 3 pivotally mounted between side brackets 2 attached to the jib, the shape of the slots in the extension brackets being such as to cause the bucket arms to take a down and forward curve, and then follow a forwardly straight path, in conformity with the motion to be imparted to the bucket. At the commencement of the digging stroke, the shaft or rod 6 carrying the bucket arms 7



is situated at the top of the curved portions of the slots 5 in the brackets 4, with its spur pinions 6 *y* in mesh with the toothed racks 4 *x* of the brackets 4, and its loose rollers 6 *z* in engagement with the plain guides 4 *y* of the brackets 4; when, on the power cylinder 3 being brought into action, the shaft or rod 6 carrying the bucket arms 7 is caused to follow the path of the slots 5 in the bracket 4 to the opposite end of the slots 5, by which the desired motion of the bucket is ensured. The spur gearing employed in connection with the bucket-arms shaft or rod 6 ensures a correct or true movement being imparted to the latter when working, while the loose rollers 6 *z* prevent the toothed pinions 6 *y* engaging too deeply with the racks 4 *x*. (*Sealed August* 10, 1911.)

MOTOR ROAD VEHICLES.

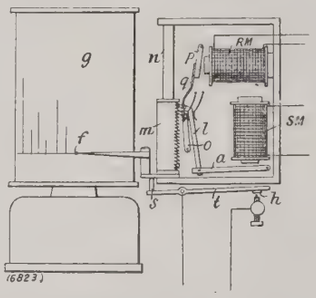
8722/11. De Dion Bouton (1907), Limited, London. (*Etablissements de Dion Bouton (Société Anonyme), Puteaux, France.*) **Transmission Gear.** [1 *Fig.*] April 7, 1911.—This invention relates more particularly to the method of mounting the cardan jaws in the well-known system of transmission by hollow axle and transverse cardans, and consists in mounting the outer cardan jaws solid with the driving-axles of the road-wheels in the cylindrical recesses of the centre brackets for the springs. A supporting axle A is fitted at its extremities into the brackets B carrying the suspension springs of the chassis. These brackets B are extended at their outer end by a hollow shaft C, on which is supported, the ball-races interposing, the hub



D^1 of the road-wheel D. The bracket B has a cylindrical recess B^1, of which the axis is an extension of the axis of the hollow shaft C. The driving-shafts E have trunnions E^1 at their extremities carrying the squares E^2 which are fitted into the cardan jaws F. The cardan jaws F on the road-wheel end are placed in the recesses B^1 of the brackets B, and are extended by the driving-shafts G inside the hollow axles C. The shafts G terminate in squares which drive the road-wheels in the usual manner. (*Sealed August* 10, 1911.)

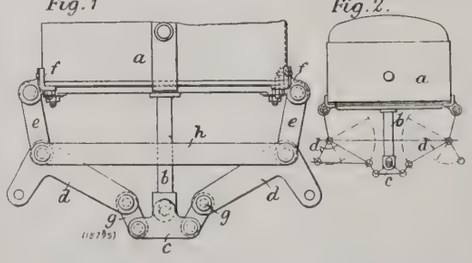
RAILWAYS AND TRAMWAYS.

6823/11. Siemens and Halske, Aktiengesellschaft, Berlin, Germany. Train-Recorders. [1 *Fig.*] April 30, 1910.—The present invention is a development of the apparatus described in Patent No. 376, of 1910, for automatically recording intervals of time between railway trains passing over a given length of track. In the present invention, the recording style is attached to a straight rack, which is guided vertically, the rack being controlled by a pawl which is actuated by the armature of the electro-magnet S M in shunt with the pendulum-controlling magnet. The rack returns to its initial position of rest by the action of gravity, being released by suitable means which are controlled by the armature of an electro-magnet R M, which is energised when the train actuates the second rail contact. When the train actuates the first rail contact the magnet S M and the pendulum magnet are excited. When the armature *a* is attracted, the rack *m* is raised step by step on the guide *n* by the pawl *l*,



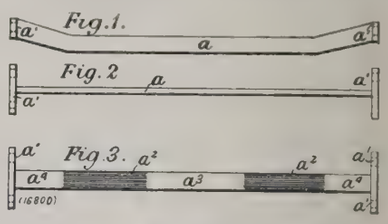
the detent *o* holding it in any position. The rack is thus raised until the second rail contact is closed by the train, the style *f* attached to the rack recording upon the drum *g* a longer or shorter line according to the speed of the train. At the first movement of the rack *m* the lever *t* rises and closes the circuits at contact *h* of the magnet S M, and the pendulum magnet. When the train reaches the second rail contact, magnet R M is excited, attracting its armature *p*, to which is fixed the extension *q*. The extension *q* presses against pins attached respectively to the pawl *l* and detent *o*, which are thus released from the rack *m*, which consequently drops by the action of gravity to its initial position, on to the pin *s* attached to the lever *t*, and by its weight thus opens the circuit of the magnet S M, and the pendulum magnet, until the sequence is repeated by the arrival of another train into the section at the first contact. (*Sealed August* 24, 1911.)

18,795/10. The Consolidated Brake and Engineering Company, Limited, and E. S. Luard, London. Brake Mechanism. [14 *Figs.*] August 9, 1910.—In brake mechanism for railway vehicles, the disadvantages which obtain when compensation for the unevenness of wear of the brake-blocks is provided, is avoided, according to this invention, by transmitting the motion of the brake-piston to the push-and-pull rod through the medium of levers or rods directly carried by a pivoted cylinder. *a* is the brake cylinder, mounted on trunnions,



and *b* is the piston-rod. *c* is a floating crosshead to which the lower end of the piston-rod *b* is connected; *d*, *d* are two bell-crank levers fulcrummed to the lower ends of links *e*, the upper extremities of the links being hinged to brackets *f* attached to the lower end of the brake-cylinder *a*. The inner ends of the bell-crank levers *d* are hinged to links *g*, also hinged to the floating crosshead *c*; the links *e*, *e* and the bell-crank levers are connected by links *h* and the outer or short arms of the bell-crank levers *d* are in communication with the push-and-pull rods of the brake mechanism. With this construction it will be obvious that when the piston is raised in the brake-cylinder *a*, the piston-rod draws up the crosshead *c* so as to lift the link-and-lever mechanism above described into the position shown in the broken lines in Fig. 2. It will be seen that the short arms of the bell-crank levers *d* are caused to move through a path which is for practical purposes of a rectilinear nature. (*Sealed August* 17, 1911.)

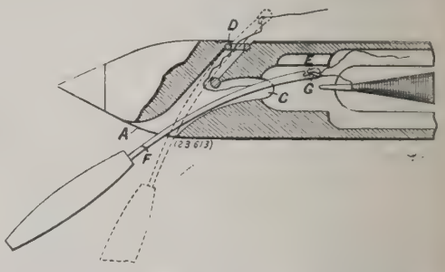
16,800/10. A. H. Johnson, Epsom, and L. W. Williams, Glasgow. Railway Switches. [8 *Figs.*] July 14, 1910.—This invention has reference to stretcher or gauge-bars for railway switches, and consists in a stretcher or gauge-bar rigidly connected with the necks of the rail-tongues or switch-blades, which is flexible in the horizontal plane, and so constructed or arranged and connected as to give and preserve extreme rigidity of the bar and tongues in the vertical plane. In carrying the invention into



effect, as illustrated by Figs. 1 and 2, the stretcher-bar *a* is made of spring steel, the ends of which are formed with flanges a^1 so as to give a rigid and secure binding to the switch-blades. The stretcher-bar may consist of one blade or of a number of laminated blades. If desired, and, as illustrated by Fig. 3, the laminated blades a^2 may be formed with a solid centre part a^3, to which the ends of the blades are welded, the other ends of the blades a^2 being welded to solid parts a^4 which are formed with flanges a^1 rigidly connected to the switch-blades. (*Accepted July* 5, 1911.)

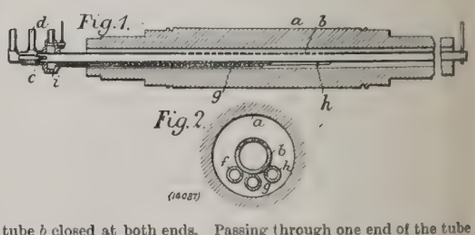
TEXTILE MACHINERY.

23,613/10. R. Starkie, Burnley. Loom Shuttles. [4 *Figs.*] October 12, 1910.—The invention relates to loom shuttles of the type formed with a passage leading to the eye of the shuttle from the back for the purpose of facilitating threading by means of a hooked device, inserted in a lateral slot forming part of the passage in the rear face of the shuttle, so as to seize the weft, and draw the end of the weft sideways by means of such hook in the lateral slot, until the hook is brought opposite the passage extending to the front of the shuttle, when the weft is pushed through such passage by another oppositely-placed hook on the threading device and out at the shuttle-eye. The invention comprises a loom-shuttle formed with a tunnel or other passage leading from the back to the eye of the shuttle and joining



another and central passage leading into the mouth of the shuttle. There is formed in the back of the shuttle near its tip end an oblong or other passage A, which merges into the mouth C of the shuttle, in a central position, and is also continued to the eye D of the shuttle, a drag-pin being located at the junction of the two passages. By this means the weaver can thread the shuttle by using a specially constructed hook F, provided with a T-slot G. This hook is first inserted though the passage or tunnel A and pushed out at the central mouth C of the shuttle as far as the recess E therein, and the loose end of the weft from the cop may then be seized and drawn by the hook through the mouth C and then pushed through the eye D of the shuttle, thereby threading it. (*Sealed August* 17, 1911.)

14,087/10. The Bradford Dyers' Association, Limited, and J. Graham, Bradford. Calender Bowls. [2 *Figs.*] June 10, 1910.—This invention consists in heating a hollow calender bowl having open ends by forcing air and gas into a burner tube within the bowl, the mixture escaping from small perforations in the tube and being burnt. The foul gases are withdrawn from the central portion of the bowl. The bowl *a* is open at both ends, and extending through it is a burner



tube *b* closed at both ends. Passing through one end of the tube *b* is a nozzle *c*, through which air is forced, gas being admitted through the side inlet *d* in rear of the mouth of the nozzle *c*. The mixed air and gas is forced through perforations in the tube *b* to be burnt, and so heat the bowl *a*. The foul gases are drawn from the bowl *a* through pipes *f*, *g*, *h*, which extend beneath the tube *b*, and a hollow collar *i* connected with suction mechanism. The pipes *f*, *g*, *h* are of different lengths, and have fluted mouths. (*Sealed August* 17, 1911.)

THERMAL COMPENSATION.—The combination of metals which W. Grix recommends in the *Physikalische Zeitschrift*, 1911, page 72, for compensating thermal expansion and for producing large movements by changes in temperature, consists of two strips soldered together, the one of brass, the other of a special steel containing 36 per cent. of nickel. He has studied such bars at temperatures up to 300 deg. Cent.

FEED-WATER HEATING AND SUPERHEATING ON LOCOMOTIVES.—No. III.

THE UTILISATION OF SUPERHEATED STEAM.

IN our last article on superheating on locomotives* attention was paid to the relative efficiency of various systems of generating superheated steam. The subject will now be pursued, as far as circumstances allow, to the use of superheated steam in the engine, or, in other words, to a consideration of the efficiency of utilisation of superheated steam. This part of the subject is unfortunately inextricably involved with many matters on which, even at the present day, comparatively little of a definite nature is known. Despite the prominence given to these points in much recent research, several theories, advanced as explanatory, have failed to carry conviction to many minds, neither have investigations as yet been advanced far enough to permit of anything in the way of a reduction of established data to general terms of fairly wide application.

Though the nature of many of the influences affecting the efficient utilisation of steam in the cylinders of a steam-engine is still indeterminate, the absolute necessity, in the meantime, of some working basis, for purposes of comparison, has promoted the general adoption of a style of statement in connection with engine-testing which implies definite knowledge, where actually the conclusions are largely hypothetical in character. Without further enlightenment on, and order in, these matters, many assertions which purport to be accurate representation of fact are, in reality, little else than compromises covering several unknowns, and they cannot be in any sense accepted as the last word in the interpretation of engine performance. One of the matters on which a dogmatic position is often taken up unconsciously, concerns the quality of steam in the cylinders. Since this is vital to the present investigation, some remarks on the position with regard to this point will not be out of place, though it is not proposed to treat at length matters which have been frequently discussed in other connections without anything definite resulting.

Statements of the wetness of steam in the cylinders are commonly based on the assumption that the balance of the measured feed, not shown to be present as steam by the indicator-card, is present in the cylinder in the form of water. In view, however, of the suggestive work done by Messrs. Callendar and Nicolson, Captain Sankey, Professor Capper, and others, it appears that the least that can be done, until some still further advance be made, is to refrain from adopting too strict an attitude in this connection, and to admit at any rate the possibility that this difference may not be conclusively indicative of cylinder conditions.

In attempts made to discover reasons for the discrepancy between the measured and indicated steam, leakage has often been advanced as one of the principal factors. A good deal of experimental work, corroborative to some extent of this contention, has been carried out. Leakage with ordinary slide-valves may be considerable, and such leakage may occur in several ways, all of which affect the investigation to a greater or less degree. It is supposed that in amount it bears some relation to the pressure difference on the two sides of the valve, &c. It might thus occur in considerable quantities from the cylinder to the exhaust, for instance, during the high-pressure period at the beginning of the stroke, or from the steam-chest into the cylinder towards the close of the expansion, on till the earlier stages of compression. Steam may also leak from the high-pressure side of the piston to the low, or direct from the steam-chest to the exhaust. Not enough on any one of these possibilities is known to furnish sufficient data on which to base a practically applicable theory, though, if existent, they cannot but have a bearing on deductions drawn in the ordinary way from indicator-cards.

For instance, it will be obvious that leakage directly through to the exhaust would vitiate an estimate of dryness, based on the assumption that all the missing quantity was present as water in the cylinder. To make suitable allowance for this particular factor is, however, well nigh impossible. Some recommend that it should be taken care of by means of a percentage deduction, but this is obviously an approximation; and as opinions vary both as to its amount and the influence on it of speed, allowance, by way of deduction from the measured feed per stroke, can only be regarded as a very rough working hypothesis. The theory was first based on experiments in which the leakage, found passing direct to the exhaust, was so considerable as to result in the conclusion that it could only occur in the form of water, to which steam may be reduced at the valve-face owing to the cooling action of the exhaust on the surfaces. On well-known phenomena it was computed that so large an amount could not have passed had the form of steam been retained. If such leakage, therefore, constitutes as important a factor as was then, and is still, contended by many, the situation would clearly be improved by hindering the condensation of the steam. Superheating would manifestly be of service in such a connection, for it enables a reserve of heat to be abstracted from the steam before the dew point is reached. The maximum preventive effect, so far as this factor is concerned, would be secured if superheat were retained down to the exhaust, for then the water formed would be the minimum possible without having resort to special types of engines. To what extent any intermediate degree of superheat would affect a reduction of leakage to the exhaust it is impossible to say, but it is quite conceivable that, quite apart from cylinder action, an amount sufficiently high to maintain favourable conditions in the steam-chest, by imparting reserve heat to the valve and valve-faces, might prove beneficial. Messrs. Callendar and Nicolson's experiments appear to support this view, and comparatively low degrees of superheat may therefore prove advantageous in this manner. The theory which holds that the reserve heat in superheated steam goes to improve conditions inside the cylinder is not necessarily antagonistic to this. It follows, as a matter of course, that if superheated steam improves cylinder conditions, it must have previously had some beneficial effect on those obtaining at the steam-chest, if the latter were susceptible of improvement.

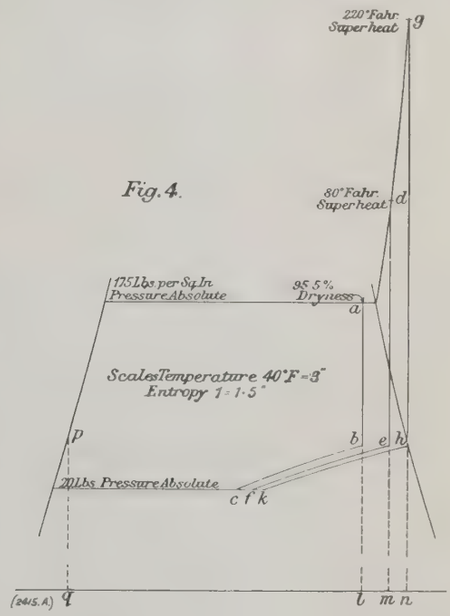
According to the leakage theory, conditions in a saturated-steam engine cylinder may thus be actually better than is often supposed, while also in an engine using steam moderately superheated a greater proportion of the measured feed may be put to useful work, although the conditions within the cylinder may not be very much improved. There are therefore two possibilities in connection with the reduction of the missing quantity noticeable when superheated steam is employed. It may be reduced because there is less valve leakage, though this may be unaccompanied by improved cylinder conditions: or it may be lowered, if the leakage be negligible, as the result only of improvement within the cylinder itself. It will be realised from the foregoing how important is this question of leakage, with regard to any conclusion, drawn from feed measurements, as to the dryness of steam at any point of the stroke. Any research which would throw further light on this matter would not be without value.

The other forms of leakage, if they occur to any serious extent, also affect the interpretation of cylinder performance. Indications of leakage into the cylinder during compression are not unknown, and it is quite possible that the expansion line may actually record leakage out of and into the cylinder. Steam leaking in would perform a certain amount of work, but this manner of introduction would be, of course, most inefficient. When, however, it is remembered that the compression curve is the starting line for all calculations concerning the indicated steam, the importance of definite knowledge as to what that line really represents is manifest. If a base point be taken on the curve at some place after leakage has occurred, calculation therefrom as to the indicated steam in the cylinder is misleading, the dryness fraction falsified, and a smaller amount of steam given as used per stroke, than is actually the case. The selection of this starting point affects all comparisons.

The usual practice is to determine and record the percentage of mixture present as steam in the cylinder at cut-off and release, by calculating from the card the indicated steam at these points, referring this to the amount shown as present at compression, and comparing the balance between these with the tank-measured feed, without allowance for leakage of any kind. The reports on the Purdue locomotive tests, to which reference has several times been made in previous articles, are drawn up in this manner, which, though probably unacceptable to those who believe leakage to be considerable, and the possible influence on it of superheating to be material, constitutes, in default of more concise knowledge on the many points involved, practically the only working hypothesis by which comparisons are rendered possible. The influence of these unknown variables remains as yet obscure, and until research shall have thrown greater light on them, it is clearly taxing credulity to assert dogmatically, as is sometimes done, that a certain number of degrees are necessary to ensure dryness at cut-off, or that so many degrees would result in such and such a reduction in cylinder condensation. The subject is yet in so vague a state that little is possible beyond over-all comparisons, though conjecture may attempt to allocate the improvement to various causes, according to the experience or belief of one analyst or another. It appears, indeed, that little definite knowledge of conditions within the cylinders, and especially of the effect there of superheated steam, will be possible until tests, including temperature measurements inside the cylinder, and covering a wide range of cut-offs and degrees of superheat, shall have been made. Something in this direction was done by Messrs. Callendar and Nicolson, and with modern facilities further work should not be very difficult. Such investigations would go some way towards showing how far the calculated and actual dryness agree, and it would contribute something to the solution as to how far reduced consumption in superheater engines is due to improved valve, or to better cylinder, conditions.

The temperature-entropy diagram affords the best means available of analysing the relative performance of saturated and superheated steam in the cylinders. Since the conversion from pressure-volume to temperature-entropy diagrams is dependent upon the correctness of the dryness fraction, it will be evident, in the light of the foregoing remarks, that the results arrived at will be of greater comparative, than of absolute, value.

Theoretical entropy cards are of little practical interest. They are, however, given in Fig. 4 for three different cases. The cases there taken are



supposed to be those of an engine having a non-conducting cylinder and no clearance. The lines *a b c* give the expansion and release lines of a saturated-steam engine, supplied with steam containing 4.5 per cent. moisture. The lines *d e f* show the case for a similar engine supplied, however, with steam superheated to 80 deg. Fahr., and *g h k* for an engine using steam of 220 deg. Fahr. superheat. Cut-off in the saturated-steam case has been taken as just under 25 per cent., expansion continuing down to about 36 lb. from 175 lb. absolute. If the release pressure be kept the same in all cases, the expansion in the superheated-steam engines will be slightly less, and the cut-off later. Back pressure has been taken in all cases as 20 lb. absolute. Area, it will be seen, is added to the diagram by the use of superheated steam, both along the adiabatics and along the release line.

The Carnegie Institute reports of Dr. Goss,

* See page 275 *ante*.

which are the only complete reports available regarding the use of superheated steam in railway service, render possible, in a limited degree, the comparison of temperature-entropy diagrams for locomotives working under various conditions. Having been drawn up on work done on the well-equipped plant at Purdue, the measurements recorded in these reports include all those usual in stationary tests, and they have, of course, been made with a similar degree of accuracy. The only matter of regret is that though the work has since been continued to include both higher and lower degrees of superheat, correspondingly full reports have not as yet been issued for these later investigations. It is certainly to be hoped that the generosity of the Carnegie or some other Institute may before long enable this to be done.

As typical of general service four sets of cards have been selected from these reports, and the equivalent θ ϕ diagrams are reproduced in Figs. 5 and 6 herewith. The diagrams in Fig. 5 represent four tests at the same speed and 160 lb. working pressure, two being made at early and two at a later cut-off, one of each for saturated-steam working, and one of each for superheated-steam conditions. The comparable diagrams are drawn in thick full and dotted lines (for early cut-off), and thin full and dotted lines (for late cut-off). In Fig. 6 four diagrams are shown representing tests at the same cut-off, but at different speeds. The thick and thin full lines here represent respectively tests under saturated and superheated-steam conditions at a speed of 50 miles per hour, and the thick and thin dotted lines similar tests at 20 miles per hour.

In working out these diagrams, in order to obtain comparable reproductions of the mean indicator-

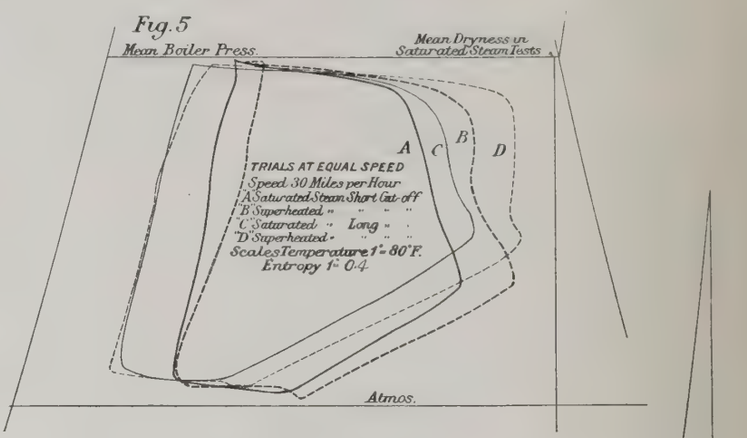


Fig. 5

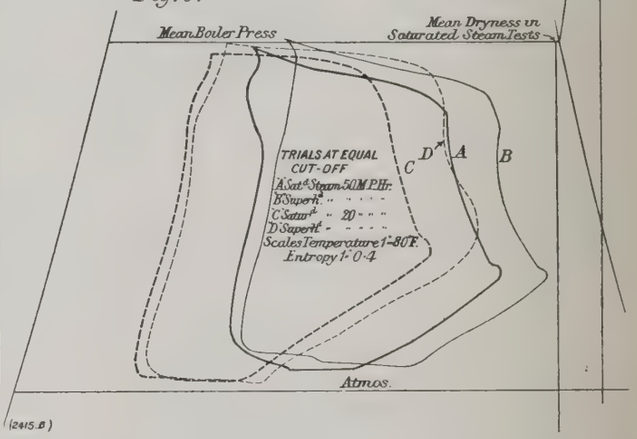
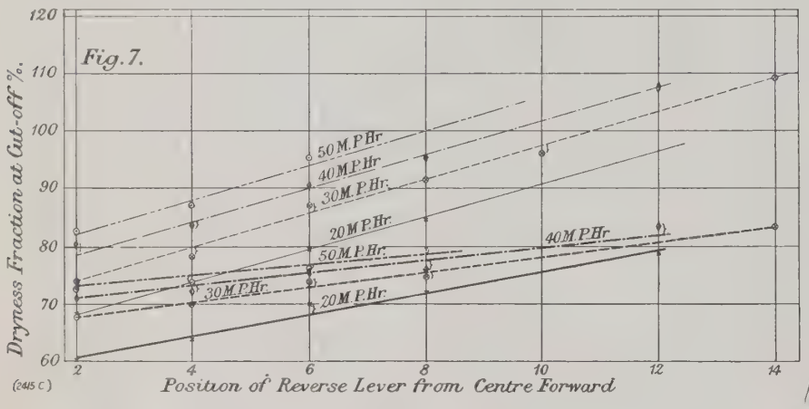


Fig. 6.



cards (omitting any deduction for leakage), the dryness fraction has in every case been obtained from two definite points. One of these has been taken on the expansion line at a pressure midway between those indicated at the points of cut-off and release, and the other on the compression line midway between those shown at compression and admission. These are not, of course, points of what might be termed "mean leakage," but the comparisons are better thus made with definite points than with bases arbitrarily chosen. Owing to this method of locating the base-points, the dryness fractions, &c, do not necessarily exactly tally with those given in Dr. Goss's report, while the probability of the introduction of some degree of error in conversion from reproductions of, and not the original, cards, must also be admitted.

In the trials represented by the diagrams in Figs. 5 and 6, the lever was kept in exactly the same position for the saturated and superheated-steam tests. The engine tested had slide-valves, and had been run a good deal between the time of the saturated-steam trials and those with superheat, so that in addition to lag, caused by the greater friction of the valve under the latter conditions, there was by that time also a certain amount of backlash in the gear. While, therefore, the cut-offs are approximately similar, the other valve events do not exactly coincide.

It will be noted from these diagrams that, except in one instance and to a minor extent in another, by far the greater part of the condensation occurred before the cut-off, after which re-evaporation commenced and continued to the end of the working stroke. The superheat was not sufficient in any case to result in dry steam at cut-off. At the discussion on Mr. Hughes's paper on "Compounding and Superheating" at the Institution of Mechanical Engineers,* a remark was made by one speaker implying that formerly it was considered sufficiently satisfactory if the steam were kept dry up to cut-off, whereas now it was realised that it should be kept dry throughout the stroke. This is rather too wide a generalisation to be strictly accurate. It may be supposed, in the absence of further explanation, that this reference to former practice related to degrees of superheat not exceeding the 100 deg. to 150 deg. Fahr. customary in land and early locomotive work, while evidently the present-day practice then referred to was the use of about 270 deg. Fahr. superheat. The superheat in Dr. Goss's Purdue tests ranged from about 123 deg. Fahr. at cut-offs of 15 per cent. to 180 deg. for longer admissions. In one case superheat of 214 deg. Fahr. was attained, and in two others about 190 deg. Fahr. Without leakage deductions, of all these tests, covering all average conditions, only two showed the steam to be dry at cut-off. The two exceptions were cases of rather long cut-off, so that it may be taken that with normal cut-off and piston speeds nothing in the neighbourhood of 100 deg. to 150 deg. Fahr. gives, or gave formerly, dry steam at cut-off. The figures in Dr. Goss's reports show that the dryness of the mixture at cut-off is often below 80 per cent. with 150 deg. Fahr. superheat. In relation to this point it must always be remembered that in locomotive work, unlike land practice, later cut-off is attended by a higher degree of superheat, so that there are thus two inter-dependent variables to be reckoned with. Table I. herewith gives two sets of figures taken from these reports, showing the additional per cent. dryness with superheating :—

TABLE I.—*Additional Per Cent. in Dryness at Cut-Off with Superheating.*

Position of Reverse Lever.	Speed, 30 Miles per Hour.		Speed, 40 Miles per Hour.	
	Superheat.	Additional per Cent. Dryness at Cut-Off.	Superheat.	Additional per Cent. Dryness at Cut-Off.
	deg. Fahr.		deg. Fahr.	
4th notch ..	141.9	10.66	154.0	13.13
6th "	162.9	11.21	164.9	15.39
8th "	172.9	15.55	180.1	21.05

* See ENGINEERING, vol. lxxxix., pages 357, 367, 396, and 431.

The table shows both the effect of later cut-off and additional consequent superheat, on the dryness fraction at cut-off calculated in the ordinary way. If, to obtain a rough approximation covering normal conditions of working, these figures be averaged, it will be found that an additional percentage of dryness of 14.5 may be expected from 163 deg. Fahr. This, it may be pointed out, is, though very approximate, in fair agreement with the estimates often given, as, for instance, that in "Steam-Power Plant Engineering," by Mr. G. F. Gebhardt, of the Armour Institute of Technology, Chicago, Ill., where (paragraph 102) it is stated that a reduction of 1 per cent. in cylinder condensation will result approximately from every 7.5 deg. to 10 deg. of superheat. The average dryness in the case of the cut-off in the saturated steam tests, here taken for a base, was 73.43 per cent., and the corresponding quality, therefore, in an engine using 163 deg. Fahr. superheat, would be 87.9 per cent. If the improvement be, as often contended, proportional to the superheat, a temperature in the neighbourhood of 300 deg. Fahr. would therefore appear to be indicated as necessary to ensure dryness at cut-off under ordinary conditions of service.

This, however, is not the whole matter. In Fig. 7 the dryness fractions at cut-off given by the mean for the Purdue tests have been plotted for various positions of the reverse lever. The lines are drawn in to agree as well as possible with the points, though since in some cases only one test is available, there are necessarily figures which do not fall into agreement with the generality. The heavy full and dotted lines show the dryness at cut-off for the saturated-steam tests at different speeds, and the light lines the dryness for the superheated steam tests. From these it is evident that while, in the case of saturated steam, speed has a considerable influence on the dryness at short cut-offs, at late cut-offs, although the dryness is in all cases improved, the relative improvement at high and low speeds is very much reduced. On the other hand, the improvement is considerably greater throughout at all speeds when using superheat, because, though at late cut-offs the heat absorbed by the cylinder-walls is greater, this is made up for by the higher degree of superheat then furnished. The improvement therefore in dryness at cut-off of the superheat engine over that employing saturated steam is greatest for any one speed at the latest

cut-off, or at any one-cut-off at the greatest speed. Both these reflection will show to be natural consequents, and the former accounts, to some extent, for the results reported regarding goods engines using moderate superheat, although the conditions of that class of traffic are unfavourable to superheating.

Before leaving this point return must be made again to the statement to which reference has been made above. That remark implies, and, indeed, it is often stated, that much greater degree of superheat is necessary to maintain steam dry throughout the stroke, than to the point of cut-off. In the case of the saturated-steam tests at Purdue no single test showed the steam to be wetter at release than at cut-off, though the difference between the percentages fell as the cut-off was increased. In the superheated-steam tests, however, the difference dropped more rapidly, with the result that after a certain point with the later cut-offs, the steam was wetter at release than at cut-off. As the dryness lines have not been worked out, it is impossible to say what occurs between the two points, but the entropy diagrams reproduced in Figs. 5 and 6 suggest that, for the most part, except in the case of the superheat trial at long cut-off, or apart, perhaps, from a very short space of time immediately after cut-off, re-evaporation proceeded throughout the stroke in the trials thus represented. The explanation presumably is that in the case of superheated steam with early cut-off, the heat added to the cylinder walls has ample opportunity of being returned to the steam before release, and of doing therefore useful work, while with the late cut-off the slight inevitable lag, before there is sufficient temperature difference to result in any appreciable return, has hardly been overcome by the time release occurs. The heat stored goes, therefore, in the latter case altogether towards keeping the cylinder walls up in temperature during the exhaust. In Fig. 8 are shown average lines for the difference in the dryness fractions of steam in the cylinder at cut-off and release, according to the Purdue tests, at all pressures, and for speeds of 30 and 40 miles per hour. Ordinates above the zero line indicate re-evaporation or increased dryness at release, those below increased wetness. No generalisation, such as that made during the discussion on Mr. Hughes's paper, is therefore permissible, unless consideration is restricted to engines working normally at the later cut-offs.

In the entropy diagrams reproduced in Figs. 5 and 6, in every case the difference between the expansion curves of corresponding diagrams is greater than that between the complete areas, the difference being greater at the higher speeds with short cut-offs than at low speeds or long cut-offs. The complete areas indicate in each case the thermal units actually utilised per pound of steam, and therefore show the advantage due to using superheated steam. Table II. gives the B.Th.U. equivalent of the areas of these figures, as measured by the planimeter, with the degrees of superheat, and the improvement worked out in each case as a percentage of the heat utilised in the saturated steam-engine, working with steam at a boiler pressure of 160 lb.

TABLE II.—*Improvement with Superheated Steam, expressed in British Thermal Units.*

Diagrams.	Speed.	Position of Reverse Lever.	British Thermal Units Utilised per 1 Lb.		Increase from Use of Superheated Steam.		Degree Fahr. of Superheat.
			Saturated Steam-Engine.	Superheated Steam Engine.	Increase.		
	miles p. hr.				p.c.		
Fig. 5 ..	30	8	81.1	99.3	18 2	22.45	173
Fig. 5 ..	30	4	68.7	77.3	8.6	12.54	142
Fig. 6 ..	20	4	68.1	82 1	14	20.56	133.5
Fig. 6 ..	50	4	63	71.6	8.6	13.68	152.5

The steam supplied to the engine in the saturated-steam tests here compared with the superheated-steam tests averaged, in quality, 99.25 per cent., and the error will not be great, therefore, if the improvement is compared with the degree of superheat instead of with the thermal units added. The average improvement is found to be one of 17.31 per cent. for 150.25 deg. Fahr. superheat, or 1 per cent. improvement for every 8.68 deg. Fahr. superheat. This is on a scale rather higher than that accepted as usual in either turbine or steam-engine performance, 1 per cent. for every 10 to 20 deg. being more commonly taken as typical. It will be shown immediately that, though this figure is large, it is more than substantiated by the results of the whole series of tests.

If it may be taken that every 8.68 deg. Fahr. superheat result in 1 per cent. improvement, with 220 deg. superheat 25.34 per cent. more B.Th.U. will be utilised per pound of steam, and 9.22 per cent. more in the case of steam superheated to 80 deg. Fahr. An increase of 25.34 per cent. in the B.Th.U. utilised means that for an equal number used only $\frac{100}{125.34}$, or 79.78 per cent. of the amount of steam consumed in the saturated-steam engine will be needed when using steam superheated to 220 deg. Fahr. There is thus a steam economy of 20.22 per cent. For 80 deg. superheat the steam saving is one of 8.44 per cent. compared with the saturated-steam engine.

Although these figures are worked out in a way that may seem to be not entirely free from error, owing to the small number of tests on which the argument is based, these savings are supported, as implied above, by the whole of the series of the Purdue tests, covering a large range of conditions. These tests have been interpreted by Professors Benjamin and Endsley as supporting the conclusion that the improvement in steam consumption

Fig. 8.

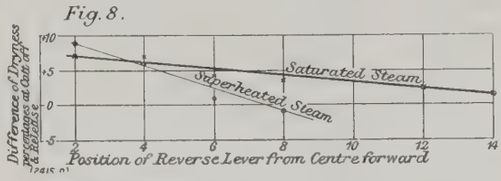


Fig. 9.

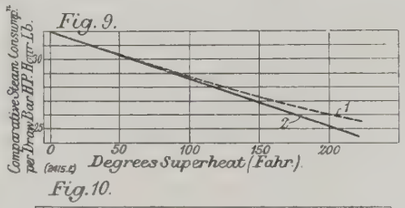
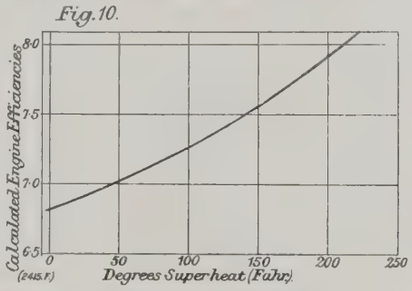


Fig. 10.



resulting from the use of superheat follows a straight-line law. In their report of 1911, an average line is given which is said to be in agreement with the steam consumptions as measured in these tests, though the points cannot be said to comply exactly with it, and would equally well suit a curve showing steam consumption to decrease at a rate slightly greater than the superheat. This line, for 160 lb. working pressure, shows a consumption per indicated horse-power of 26.75 lb. for saturated steam, 24.5 lb. with steam at 80 deg. Fahr. superheat, and 20.5 lb. with 220 deg. Fahr. superheat. With the lower superheat a saving of 8.41 per cent. would result, and with the higher one of 23.3 per cent. These results are conclusions derived from so large a number of tests that they are, of course, if anything, more reliable than those based alone on the $\theta\,\phi$ diagrams in Figs. 5 and 6, and should, if anything, be used in preference thereto.

The efficiency of the engine part of a locomotive is measured by the proportion the heat equivalent of a horse-power developed at the draw-bar bears to the heat in the steam used per draw-bar horse-power hour. It will be found in the first Carnegie report drawn up by Dr. Goss that the mean steam consumption for a number of tests at 160 lb. steam pressure works out, with saturated steam, at about 32.22 lb. per draw-bar horse-power hour. For tests at 180 lb. the mean value was 31.67 lb. A few of the St. Louis tests give, for simple 2-8-0-type locomotives, mean values of 28.5 lb. and 32.5 lb. for different engines, but the majority of these tests afford no assistance in this matter, since they were made on compounds. For the present purpose it will suffice to take a figure of, say, 32 lb. steam per draw-bar horse-power hour for the saturated-steam engine, and with this starting-point the two lines in Fig. 9 have been drawn to comply with the steam savings found above. Line No. 1 shows the reduction of steam consumption with superheat based on the $\theta\,\phi$ diagrams of Figs. 5 and 6; line No. 2 consumptions based on Professors Benjamin and Endsley's average line. Since all conditions, except superheat, are considered identical in all cases, the latter has been calculated on the assumption that the ratio of draw-bar horse-power to indicated horse-power is the same in all cases. The use of the higher degrees of superheat would probably actually make a small difference.

With feed at 60 deg. Fahr. and 160 lb. working pressure, the engine efficiency is expressed by

$$2546.61 \div [\text{number of pounds of steam per draw-bar horse-power hour} \times (h - 28.08)],$$

h being the total heat of the steam in B.Th.U. With this formula, and 32 lb. per draw-bar horse-power hour as the consumption of the saturated-steam engine as a base to work from, the following table, giving steam consumptions and engine efficiencies for different cases, has been arrived at :—

TABLE III.—*Calculated Engine Consumption and Efficiency with Different Degrees of Superheat.*

Condition of Steam.	Saturated.	80 deg. Fahr. Superheat.		220 deg. Fahr. Superheat.	
		*	†	*	†
Consumption per draw-bar horse-power hour lb.	32	29.3	29.3	25.53	24.54
Saving on saturated-steam engine .. per cent.	0	8.44	8.41	20.22	23.3
Efficiency per cent. ..	6.81	7.15	7.15	7.76	8.07

* Based on line 1, Fig. 9, and results of $\theta\,\phi$ diagrams, Figs. 5 and 6.

† Based on line 2, Fig. 9, and on average line for steam consumption per indicated horse-power, Professors Benjamin and Endsley's 1911 report, Am.R.R.M.M. Association Proceedings.

The engine efficiencies, based upon line No. 2, Fig. 9, are plotted in Fig. 10, and give a curve which shows the improvement to increase at a greater rate than the superheat.

To obtain the over-all efficiency of the locomotive the boiler and engine efficiencies must be combined. A difficulty now arises in that the boiler efficiencies worked out in the previous article were, for the greater part, taken for cases compared with a boiler producing saturated steam of 4.5 per cent. moisture, which we have shown may be taken as a typical figure. On the other hand, the foregoing arguments relative to engine efficiency have all been based upon comparisons with engines using dry, or practically dry, saturated steam. Of the effect of the presence of considerable quantities of moisture in the saturated steam supplied to an engine, there is very little information. It must, however, be considerable, though whether it is in proportion to the moisture present, or more or less than proportional to it, cannot be said, so that a comparison based on B.Th.U. added to the steam, in distinction from degrees of superheat, cannot be vouched for as altogether reliable, though apparently logical. One point, however, is clear—namely, that if the saturated-steam engine is supplied with steam containing much moisture, the saving by superheating is greater than above indicated, and, of course, the difference would be more pronounced in the case of low superheat than of high. The result will be, therefore, on the side of moderation if the engine efficiencies, as given by Fig. 10, be combined with the boiler efficiencies, as given by Fig. 3 of the previous article.

This is done in Table IV. herewith for the cases taken, while the result is given in more complete form by the heavy full and dotted line A B C D E, in Fig. 11.

TABLE IV.—*Possible Combined Boiler and Engine Efficiencies at Different Degrees of Superheat.*

Condition of Steam.	Saturated.	80 deg. F. Superheat.	220 deg. F. Superheat.
	per cent.	per cent.	per cent.
Boiler efficiency	65	69.92	66.3
Engine efficiency	6.81	7.15	8.07
Over-all locomotive efficiency	4 43	5.00	5.35
Improvement over saturated-steam engine ..	0	12.94	20.79

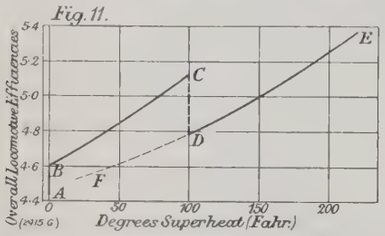
If the engine efficiencies for the lower degrees of superheat be combined with the possible efficiencies of generation, as denoted, by the prolongation towards 0 deg. Fahr. superheat of the line C D, Fig. 3, the light dotted-line curve F D, shown in

Fig. 11, is obtained. If the argument is in the main correct, the line A B C D E, in Fig. 11, shows the improvement that may be expected from superheating according to such theoretical indications as are available. It is clear that in the early stages the advantage is with the smoke-box superheater, and would continue so were it possible with this system to reach the higher degrees. With the lower degrees good boiler efficiency is obtained at the cost of engine improvement; with the higher, engine improvement of a much greater extent is secured, but only with a lower boiler efficiency. If the degree of superheat is carried far enough, the preponderance of the improvement in the engine more than makes up for the loss in the boiler, and with high superheat the economy resulting is much greater than is possible by any system producing only moderate temperatures, used alone.

At the lower temperatures it is evident that there is no question as to which of the two systems then available should prove the more efficient. The smoke-tube system does not compare at all favourably in these ranges with the waste-gas heater. It is equally certain also, both from the foregoing argument and from the official interpretation placed upon the Purdue tests, that the lower superheats secured with smoke-tube heaters are far less conducive to saving than the high, and of these two the former will, therefore, be dismissed from further consideration.

The improvement in efficiency denoted by the curve A B C D E is not actually on a scale equal

Fig. 11.



to that realisable in practice. It will be remembered that the above results have been arrived at by a combination (admittedly not wholly satisfactory) of data relating to comparison based on saturated steam of 4.5 per cent. wetness, so far as the boiler is concerned, and practically dry steam for the engine portion of the locomotive. Attention has already been drawn to the fact that if the comparison were completely possible on the former basis, superheating would show up to greater advantage. Again, reduction in the rate of coal consumption is accompanied by improved boiler efficiency. This is reflected in the fact that in the case of the superheater engines there is some evidence to the effect that the quantity of unburnt coal drawn through into the smoke-box, and probably the spark losses also, are considerably less than in ordinary engines, due to the easier work on the boiler at equal loads. Whether this is indisputably so in both systems cannot, unfortunately, be definitely asserted, though there are ample facts on record that in many cases the amount retained in the smoke-box is less. In view of the uncertainty of the value of this item, it has been thought well not to attempt to introduce it into the consideration of the subject at this stage. It suffices that it has been shown that both moderate superheating, properly applied, and high degree superheating may reasonably be expected to result in improvement equal to, or greater than, those denoted by the curve A B C D E in Fig. 11.

In our next article the effect of combining superheating with feed-water heating will be considered, with special reference to work carried out in this direction by Mr. F. H. Trevithick, Chief Mechanical Engineer of the Egyptian State Railways.

THE BRITISH ASSOCIATION.

(*Continued from page* 317.)

SECTION G.—ENGINEERING.

THE meeting on Tuesday, the 5th inst., was devoted to a discussion of the relative advantages of superheated-steam engines and of internal-combustion engines.

OVER-TYPE SUPERHEATED-STEAM ENGINES.

The first paper, by Mr. W. J. Marshall, described the semi-stationary superheated-steam engine as built by Messrs. Garrett and Sons, of Leiston. This paper we print on page 364. The engine, Mr. Marshall stated, was mounted on the top of the boiler, thus avoiding steam-pipe losses. It was a side-by-side compound engine having piston-valves, the steam being admitted at the centre of the valves and exhausted at the ends. The boiler was designed to admit of very easy access for cleaning purposes. By unmaking two joints the whole of the furnace and tubes could be removed bodily for cleaning. The superheater itself was, moreover, located in such a position that it did not in any way prevent access to the tubes from the smoke-box. In trials by Captain Sankey with a plant of but 58 horse-power the coal used was 1.21 lb. per brake horse-power per hour, and, taking into account the fact that ordinary steam-coal was used, the author claimed that the actual fuel cost of such a plant was no greater than that of a suction-gas engine using anthracite peas, which was the usual fuel. Whilst practically equal in fuel economy, the type of engine he described was, he claimed, superior in the matter of reliability and maintenance charges to internal-combustion engines. In fact, in certain cases he had replaced existing suction-gas plants with these over-type engines, to the great satisfaction of his customers.

SUCTION-GAS PLANTS.

Mr. W. A. Tookey next read his paper entitled "Suction-Gas Engines and Producers." This was essentially a comparison of the test performances of such engines with the results obtained in daily operations. We shall print an abstract of the paper in a future issue. It contained numerous tables of working costs. The author stated that it was quite common to estimate the fuel consumption of suction-gas plants as 1 lb. of anthracite per brake horse-power, but he brought forward figures to show that this greatly over-estimated the consumption in actual practice. Even a small plant of 10 horse-power took less than 0.9 lb., whilst with plants of 120 brake horse-power the consumption was only about 0.61b. of fuel per horse-power hour developed. Moreover, over a wide range on either side of the most economical rate of working, there was little variation in the fuel consumption per effective horse-power. The cost of plants of all sizes was, he found, well represented by a straight-line law. A plant of 20 brake horse-power cost about 210*l.*, complete with producer pipes and accessories, whilst a complete plant of 160 horse-power cost about 1120*l.* A remarkable feature of the figures he had collected was, he stated, the way in which the original efficiency was maintained in service. Again, with the smaller plants the services of an attendant were necessary during part time only, thus substantially reducing the wages bill. For the reasons given he concluded that in the future the demand for suction-gas plants would steadily increase.

THE DIESEL OIL-ENGINE.

Mr. Charles Day next read a paper on the Diesel oil-engine, which will be found on page 369. In this he had analysed the actual working costs of electric lighting stations of 1000 horse-power and under, driven by steam, suction gas, and Diesel engines respectively. His tabulated results were as follow :—

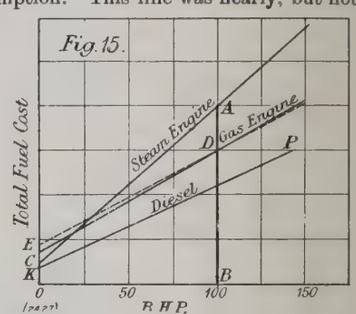
Average Cost in Pence per B.T.U. Sold.

—	Fuel.	Oil, Waste, Stores, and Water.	Wages.	Repairs and Maintenance.	Total Works Cost.	Load-Factor.
Steam..	0.45	0 06	0.25	0.26	1.02	14.7
Gas	0.43	0 09	0.24	0.24	1.04	15.3
Diesel..	0.23	0.04	0.07	0.07	0.53	14.3

He further gave a table showing how remarkably steam costs diminished as the size of the station went up, but until the station capacity approached 50,000 kw. the total works cost per unit was still greater, he stated, than that given above for the Diesel engine. One advantage of the Diesel engine, he went on, was that its efficiency was maintained over a very wide range of power. Thus at full load the consumption was 0.44 lb. of oil per brake horse-power; at three-quarter load, 0.45 lb.; at half load, 0.47 lb.; and at quarter load, 0.62 lb. per brake horse-power per hour. These figures, he stated, represented every-day results with engines of quite moderate size. As regards the question of reliability, he stated that four years ago a Mirrlees-Diesel engine was put down at the Birkdale Electricity Works. This had run on the average 23½ hours a day for seven days a week.

The discussion on the three papers was opened by Captain Sankey, who asked what was the rated load of the various engines. In the case of gas-engines, perhaps, Mr. Tookey would say whether the horse-power stated was the maximum the engine could carry for a period of 15 minutes, or whether it was the output corresponding to maximum economy. Steam-engines would carry 25 to 30 per cent. more than their rated capacity for a considerable time, and unless gas-engines would do the same, customers were not buying the same thing as when purchasing steam-engines. This question of what was the rated load was of the greatest importance from the economical standpoint, as would be evident if one considered the characteristic total consumption curves of the different engines. Thus, with a condensing steam-engine rated at, say, 100 brake horse-power, if the total fuel consumption at this output was represented (see Fig. 15) by the line A B, then making O C equal to ⅛ A B, the line C A would represent pretty accurately the consumption at all other loads. If the engine could carry a 25 per cent. overload, as was usual, the consumption per brake horse-power per hour would be less than at the rated load. Next, he would take the case of a gas-engine rated at 100 brake horse-power. Then at this load the consumption would be represented by, say, the line D B, and from many trials he had found that if O E were made equal to ¼ B D, the line E D would represent in this case the total fuel consumption. This line was nearly, but not quite,

Fig. 15.



straight, and it would be seen it crossed the steam line, showing the gas-engine to be less economical at low loads. If, however, the rated output of the gas-engine was the maximum it could give, and if, as was usual, times arose when the output needed was 25 per cent. more than usual, it would be necessary to put in a 125-horse-power gas-engine as the equivalent of a 100-horse-power steam-engine, and then the relative performance of this engine would be represented by the dotted line, which showed that the steam-engine became superior at a higher output than before. With the Diesel engine the total fuel-consumption line would be somewhat as shown by the line K P, the character of the curve being similar to that of the condensing steam-engine. The non-condensing steam-engine, he might add, gave a worse result, and the suction plant worst of all. The Standards Committee had discussed the proposal to rate gas-engines at 0.85 of their maximum possible output, but this proposal had not been definitely adopted. He wished therefore to know how gas-engines were actually rated nowadays.

Mr. Powell, called on by the Chairman, said it was seventeen years since he had had much to do with gas-engines, but at that time he was responsible for the largest built. Mr. Marshall had suggested that exhaust-valves gave trouble, but this was not his experience if their seats were properly water-cooled. In the engines referred to, the exhaust-valves could not be reached without removing the piston, yet they were so thoroughly jacketed that he had never known an instance of their causing trouble.

Professor Dalby, who followed, said he thought that the present was a very interesting period in the development of prime movers. We had in competition the steam-engine, the steam-turbine, the large gas-engine, the Diesel engine, and the suction plant. For small installations the only hope of the steam-engine lay in superheat, and he asked Mr. Marshall what degree of this was used in the engines described in his paper. Was the steam still superheated on exhaust, or was the superheat lost at the cut-off in the high-pressure cylinder? He should also like to know whether the superheater could be cut out in case of failure,

and the engine run with saturated steam without having to stop it to make the change. He could say that the application of superheat to locomotives had resulted in economies far in excess of what was thermodynamically due. This was, he thought, to be attributed to the circumstance that superheated steam was a very bad conductor of heat, whilst wet steam was a good one.

Mr. W. Y. Lewis said that he thought it would be found that the type of engine advocated by Mr. Day would generally carry off the victory. There were, however, conditions—viz., where steam was required for heating purposes—which would put either the Diesel or the gas-engine out of business. In such cases the type of steam-engine advocated by Mr. Marshall was indicated. In conjunction with Captain Sankey he had induced makers of this engine to challenge gas-engine builders to show equal economy in actual working, but this challenge had been ignored.

Mr. Kilburn Scott said that one advantage of the steam-engine lay in the fact that steam was always steam, whilst gas might be anything whatever, dependent on the fuel. Moreover, a steam leakage was easily seen, and the escape did no damage. A gas leakage was not easily detected and might cause loss of life. He knew of one case in which a man was merely "gassed," but not killed, but this led, nevertheless, to the throwing out of a large gas-plant and its replacement by steam, as the proprietors did not care to risk it any longer. The Diesel engine was free from this objection, but its manufacture being in few hands, it cost more than it should. It took up less space, and required less in the way of foundations than its rivals, and he should therefore plump for the Diesel engine where the conditions were suited to it. At Chichester there was a little electric station run with Diesel engines. These had given no trouble during the twelve months they had been installed; and, in fact, the attendant complained that he had nothing to do. He thought a visit to Chelsea or Chicago also gave promise of the applicability of the Diesel engine to large power-plants. It was true that turbines could be built in 20,000-kw. units, and occupied little space, but the boiler plant was enormous. Boilers could not be made big enough. Further, turbine stations needed ample supplies of water, and hence it was necessary, at times, to erect them on expensive sites, whereas gas-engines could be put anywhere. He had himself a prejudice against superheaters. A pupil of his had gone to a central station at Sydney, and the stoker ruined a separately-fired superheater, for which his assistant received the blame. He was all against any further extension of steam stations, since he wanted various electro-metallurgical products to be made in this country, which he thought would be possible only with cheap gas power. At the Daimler Works, he might add, it was found more economical to keep up the steam-heating over the week-end than start up all cold on Monday mornings.

Mr. H. Wimperis said that they had listened to a very interesting triple contest, but he rather thought that the youthful impetuosity of the internal-combustion engine would conquer, in the end, the cunning wisdom of its older steam rival. He suggested that the term "gas-engine" should be dropped, since superheated steam was a gas, and, in one respect, the best of all gases, in that it could be got rid of by condensing it. The real distinction was between internal and external-combustion engines. The possibility of condensing steam would, he thought, lead to its ultimate triumph, but not as used in an external-combustion engine. If the development of the internal-combustion engine were to follow that of the old steam plant in utilising the toe of the diagram, it would be impossible to retain the use of non-condensible gases, and some other medium must be used. As to the Diesel engine, he thought it gave promise of increasing present efficiencies. They had nearly attained the limit of what was possible in the constant volume cycle of the ordinary gas-engine, and with the Diesel system it might be easier to achieve further progress. There were, however, difficulties. In passing through a builder's works he had been struck with the fact that the Diesel engines were almost armour-plated with heavy steel bolts all round the cylinders, which, he was assured, were necessary, though the reasons were not forthcoming. The pressures inside the cylinder were not extraordinary, and would not in themselves need the quadrupling of the connections. Possibly it was difficult to keep the valves tight with the high pressures used, and a leaky valve might thus lead to a pre-ignition, developing forces which necessitated the enormous strength of the bolts. He would be glad if Mr. Day could throw light on this. He had, he might add, a personal interest in the Diesel engine, as he was called on to advise between this type and suction plants to be used in Crown colonies where white labour was unavailable. Hitherto he had not felt justified in recommending the installation of Diesel engines.

Captain Sankey, speaking again, said he was much interested in Mr. Wimperis's suggestion that superheated steam should be used as the working fluid in an internal-combustion engine, as he had before him at that very time a proposal of that nature.

Mr. H. S. Russell, who spoke next, said that certain points in Mr. Day's table of costs required further elucidation. The relatively low running cost of the Diesel engine in electric stations was to be referred to the load-factor, which did not exceed 15 per cent. The Diesel engine had a high thermal efficiency and no stand-by losses. Gas-engine and steam-engine makers might say that the stand-by losses were small, but in actual work Mr. Tookey's figures were not nearly approached, as was proved by the published costs, which would be much lower if these stand-by losses were smaller. In a factory with a good load-factor, a 500-horse-power plant, using Dowson pressure-producers, showed total costs equal to 0.7d. per unit. Owing to repair troubles the owners got tired, and replaced the whole by Diesel engines, which, on a year's running, showed a total cost of 0.3d. per B.T.U. The conditions were identical, and obviously it was the stand-by losses which were responsible for the relatively high working cost of the gas-plant. A Diesel engine, for instance, was stopped for the dinner-hour, but fires were not drawn in the case of a producer or boiler. He might add that some steam for heating purposes could be obtained from gas-engine exhausts. The amount was about 1 lb. of steam at 50 lb. pressure per brake-horse-power hour, or, alternatively, about 20 lb. of water could have its temperature raised by 50 deg. to 60 deg. The question had been raised as to the difference between results on test and in practice. On the Continent both Wolff and Diesel engines were used in comparable conditions. Inquiry showed that in actual practice the consumption of the Diesel engine was 13 per cent. more than the guarantees, whilst the Wolff type of engine took 140 per cent. more than the guaranteed consumption. Hence costs should be estimated from results obtained in actual work, and not from maker's tests. Mr. Marshall had suggested that the Diesel engine was unreliable and cost more for repairs than the steam-engine. He thought this charge was completely answered by Mr. Day's figures. He knew personally of a case in which a Diesel engine had been running now for nearly five years, and he had the data as to its performance up to December last. During that time the engine had averaged 23¾ hours a day, and often ran three or four weeks on end. In fact, the engines were only stopped for cleaning valves every third or fourth Sunday. Obviously there could not, in such a case, be room for costly repairs. On a battleship one engine had been run for 800 hours on end. The water cost, he might add, was very much less than with steam or gas. An engine running with producer-gas took about 2 gals. per brake horse-power per hour for scrubbing, &c., and the make-up to the cooling water was about 0.4 gal. per brake horse-power more, or a total of 2.4 gals. per brake horse-power per hour. A Diesel engine only required one-twelfth of this. As to wages cost, any plant of decent size required an engine-room staff as well as other men at the producers or boilers. The latter were dispensed with when Diesel engines were used, so that the total wages bill was less, and not more, than in the case of its rivals.

Professor Coker said that in conversation that morning Professor Perry had called his attention to the large negative work done on the compression stroke of the Diesel engine. As a consequence, the effective horse-power was merely the difference between two large quantities, and in this respect he thought the Diesel engine must suffer; and it might be, therefore, that in actual practice the ordinary gas-engine could beat the Diesel in efficiency.

A speaker, whose name did not transpire, suggested that no comparison between different plants could be fair which omitted the question of capital charges. In ordinary central-station practice these were double the fuel charges.

In reply, Mr. Marshall said that the rating of his firm's engines was really fixed by the boiler capacity. A plant rated at 140 horse-power would develop continuously 180 horse-power if needed, the coal consumption being practically constant between the limits stated. By forcing the boiler 200 horse-power could be developed for a period of six hours. The mean pressure reduced to the low-pressure cylinder was 40 lb. to 45 lb. per sq. in. with the engine running at its most economical load. As to Mr. Day's table, he would like to point out that no explanation had been given as to the types of steam and gas-plant installed, and this made the comparison absolutely valueless. Some of the steam-engines included would be old types, taking 20 lb. to 45 lb. of steam per indicated horse-power hour. Similarly, with respect to wages, none of the Diesel plants were more than five years old, whilst many of the steam-engines would be so old as to require general overhauls, which would be included in the wages bill. The comparison, therefore, was not fair. Similarly, Mr. Tookey had instanced a case in which a suction-gas plant replaced a steam-engine with great apparent economy. The conditions were, however, very special. The gas-engine used furnace coke at 8s. a ton, and the steam-engine, coal at 10s. Such a condition was most exceptional, as most suction plants had to work on anthracite. Moreover, the steam-engine removed, it turned out, was designed for 80 lb. working pressure only, and was obviously an out-of-date engine, taking, it appeared, from 5 lb. to 6 lb. of fuel per brake horse-power per hour. On the other hand, the speaker was prepared to supply engines which would run day and night on a fuel consumption of 2 lb. per brake horse-power per hour. Such comparisons as had been made were unfair. Modern plants should be compared with modern. In reply to Professor Dalby, he might say that their superheat was about 150 deg., and the working pressure 170 lb. per sq. in. The temperature in the cylinder was between 500 deg. and 600 deg. Fahr., but even 700 deg. Fahr. now caused no lubrication difficulties. They endeavoured to get their exhaust just dry, not superheated.

Mr. Tookey, replying to the criticisms on his paper, said that he had spoken throughout as a consultant, having nothing to do with the manufacture of gas or other engines. In order to make his comparisons fair, he had given every reference possible to the working conditions in each case, thus making evident what reservations should be made. In reply to Captain Sankey, he said makers now rated gas-engines at the maximum output they could maintain for 15 to 30 minutes. For his own part he disregarded makers' estimates entirely, and rated engines by the formula,

$$\text{Rated H.-P.} = \frac{\text{Piston displacement in cub. ft.} \times \text{R.P.M.}}{2\,C}$$

where C was 4 in the case of producer-gas and 3.5 for town-gas.

Mr. Day, in his reply, said that Diesel engines could develop, in the case of large sizes, 10 per cent. above their nominal rating. He fully admitted that there were cases where steam would always hold its own. In a sugar factory, for instance, all the exhaust steam was fully utilised for boiling purposes, and here nothing but a steam-engine could be fitted. The master patents on the Diesel engine had long lapsed, and makers now were numerous. Thirty new ones started in Germany last year, and on a visit to a Hungarian town on business, he found no less than five makers in that place alone. Mr. Wimperis had asked for an explanation of the very strong bolts he had seen used. All he could say was that his own firm did not use excessively strong bolts. The bolts were designed by them to take the normal pressures on the engine, and this had been found sufficient. As for the native labour difficulty, the engines they had heard least about were those thus run. An African nigger, it was true, was not good as an engine attendant, but a Chinese coolie was the very best to be had. He kept the engine clean and tidy, and did not try to improve the valve-setting as skilled fitters were inclined to do. In reply to Professor Coker, he believed that the high compression in the Diesel engine was theoretically right. In the Carnot cycle, which was the ideal, the rise of pressure on

compression was a maximum. Mr. Marshall had objected to his taking average figures of works' costs, but he did not see what else could be done; very few old engines were included in the list, and as regarded the Diesel engine, the figure given represented also an average, and not an optimum result. The steam-engines, he admitted, were older, but not seriously so.

Marine Oil-Engines.

Mr. J. H. Rosenthal then read his paper on "Crude-Oil Marine Engines," which we shall publish in a future issue. In this paper he expressed the view that even did the present conditions of oil supply admit of it, there was no present prospect of the oil-engine replacing the turbine for marine propulsion on large and fast vessels. It would, however, replace reciprocating engines in many cases. For small craft, crude oil had the advantage of being less dangerous than petrol or paraffin, and, as compared with steam, there was a saving of space and weight. Moreover, the radius of action was greatly increased, since the same weight of fuel developed much more power. In the case of the Toiler, built by Messrs. Swan, Hunter, and Wigham Richardson, which was of 2700 tons register, the oil used cost 45s. per ton, yet, as compared with a similar boat, steam propelled, using coal at 12s. 6d. a ton, the money saving amounted to 3*l.* 18s. 8d. per day. The Vulcanus, a 1900-ton boat, fitted with Diesel engines, ran 100 sea-miles for 1 ton of crude oil. The author described first the Bolinders two-cycle engine, which was illustrated in our issue of ENGINEERING, vol. lxxxviii., page 797, and in the remainder of his paper dealt with different types of marine Diesel engines. Of these he said the Nürnberg Company had now in construction two engines, each to develop 2400 horse-power. With double-acting two-cycle engines running at 125 revolutions per minute, and having three cylinders, 18.9 in. in diameter by 25.6 in. stroke, the output was 1000 horse-power. Single-acting engines of rather over 900 horse-power had eight cylinders. The manœuvring qualities of the engines were, he said, excellent. On trials with the Nürnberg, but 3 seconds elapsed from "full speed ahead" to "full speed astern," and from "stopped" the engines could be run up to full speed in $2\frac{1}{2}$ seconds.

The discussion was opened by Sir W. H. White, who said that he was inclined to agree with the author that the crude-oil type of marine engine showed the greatest possibility of success. He noted that 350 horse-power was the maximum output from a single cylinder recorded in the paper, but understood that larger sizes were being attempted, with great hopes of success. Those, however, who listened to the discussion on Mr. Milton's paper at the Institution of Naval Architects would remember that the necessity for careful experiment was admitted. What struck one most was the multiplicity of the moving parts, which would be a difficulty in developing large aggregates of power. This condition might not persist if it was found possible to develop more power in a single cylinder. At the best, however, it would be a far step from the biggest of the engines yet attempted to the supersession of the steam-turbine, which certain sanguine writers anticipated.

Professor Biles said he had roughed out from the weights given by Mr. Rosenthal a comparison between the Diesel engine and steam plants. On oil-fired torpedo-boat destroyers the total machinery weight (including boilers) was about 37 lb. per shaft horse-power, and this was apparently about the same as the best of the results obtained with the Diesel engines. Again, the weight given by Mr. Rosenthal for a 1000-horse-power engine was 78 tons, or 187 lb. per horse-power. In cross-Channel steamers the turbines and boilers weighed about 180 lb. per horse-power, so that the figures were again closely comparable. As to what could be done with these weights was another matter, and he did not see how it would be possible to put Diesel engines of the necessary power on a destroyer. The standard type at present displaced 700 to 800 tons, and had 12,000 to 15,000 horse-power installed. At 300 horse-power per cylinder 45 would be needed to develop this power. He would also like to know if the Diesel engines were noisy. He had recently had to test a launch with two four-cylinder 100-horse-power petrol-engines, and he had certainly not been impressed with its silence, and he could not imagine what sort of life the engineer would lead if there had been 45 cylinders in place of eight.

A speaker from the body of the hall said that he had been informed that with the Diesel engines installed in the Navy for electric lighting, there was interference with the gun-sighting, and consequently in firing practice the Diesel engine was stopped, and the electricity provided by the steam plant.

Mr. Day said that his firm had supplied the only Diesel engine used for lighting purposes in the Navy, and that gun-practice was in no way interfered with.

In reply Mr. Rosenthal said that in his paper he had been careful to point out the limits within which he conceived the crude-oil engine was adapted to sea service. His own main interest was in the steam-engine, but, as far as he could see, the Diesel system had great possibilities in certain cases. He did not think it would ever supplant the marine steam-turbine, since the latter had such advantages apart from all questions of fuel economy. The crude-oil engine really competed with the reciprocating engine, and had advantages where oil was readily obtainable and the lessened cost of running the ship was a consideration. He did not think that within the lifetime of any one present the crude-oil engine would replace steam on the larger class of vessel. As to the question of weights which had been raised by Professor Biles, he wished to point out that the output stated in his paper was based on a speed of 125 revolutions per minute, and that this speed might be greatly increased, to as much, perhaps, as 500 or 600 revolutions, in which case the comparison of weights would be much more favourable to the Diesel engine. Even so, however, there would be no saving as compared with the weight of destroyer machinery. The question as to the noisiness of the engine was difficult to answer. He had been alongside a 400-horse-power Diesel engine which made less noise than some steam-engines, but the Diesel engine would at the best always occasion more noise and vibration than a steam-turbine.

The Fixation of Atmospheric Nitrogen.

At the concluding meeting of Section G on Wednesday morning, September 6, the first paper taken was by Mr. E. Kilburn Scott, and dealt with "The Manufacture of Nitrogen Compounds from the Air."

In his opening remarks, Mr. Scott said that the manufacture of nitrogen compounds directly from the air seemed to be in operation in almost all parts of the world with the exception of the British Empire, which had consequently to import the combined nitrogen it required for manurial and other purposes. The two artificial manures he described were nitrate of lime, containing $12\frac{3}{4}$ per cent. of N, and calcium cyanamide with 18 per cent. of nitrogen. These compounds had, he said, the same price at the docks, reckoned on the basis of their nitrogen contents, as nitrate of soda and ammonium sulphate. The nitrate of lime was, he stated, made by fixing nitrogen directly from the air in an electric furnace; in the cyanamide process, on the other hand, the nitrogen was first separated from the air, and then absorbed by calcium carbide. Used as manures, he stated that both the products named had advantages over their older rivals, since, after their nitrogen had been absorbed, they left lime behind them in the soil. With sulphate of ammonia, on the other hand, the sulphuric acid left behind after the exhaustion of the manure combined with the free lime, and thus impoverished the soil. Though Great Britain had taken no part in the manufacture of these new manures, their production was, in the first instance, due to Sir William Crookes, who was the first to call attention to the proximate exhaustion of the Chilian nitrate-beds, and to suggest that the deficit should be made good by fixing the nitrogen of the atmosphere electrically. Nitrogen compounds were, the author stated, also required for the manufacture of explosives. In Germany, 2000 tons of nitrate of ammonia produced at the Loteringen Works at Gerthe from cyanamide were used for explosives by the German Government. Dycyanamide could also, he said, be made from calcium cyanamide, and this, he stated, had a special value in the manufacture of explosives, acting as a "deterrent," and reducing the temperature developed on firing, which had so destructive an effect on the rifling. He suggested that, in view of the importance of having a domestic source for the nitrates required for explosive manufacture, the Government should start a factory, if the prospect of profit would not permit of this being done by private enterprise.

The nitrate of lime was, he stated, made on a large scale at Notodden by means of the Birkeland-Eyde magnetic arc furnaces, the construction of which, he said, was represented diagrammatically in Figs. 16 and 17. Each furnace consisted of a circular drum of sheet-steel about 8 ft. in diameter and 2 ft. wide, lined with magnesia firebrick, and having in the centre a disc-like space $6\frac{1}{2}$ ft. in diameter by $1\frac{1}{4}$ in. wide. Air was supplied, he said, at the centre of the furnace by a Roots blower, and spread outwards to the periphery, where there was a channel, through which the gases and uncombined air were carried off. Two electrodes projected into the centre of the furnace, each being a copper tube 6 in. in diameter by $\frac{1}{2}$ in. thick, and kept cool by circulation of water. A magnetic field of about 4500 lines to the square centimetre was maintained between the electrodes. The latter were fed with alternating current at 5000 volts. Owing to the magnetic field, the arc produced spread out and travelled along the electrodes until the tension

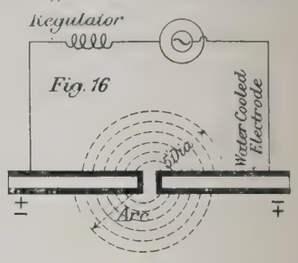


Fig. 16

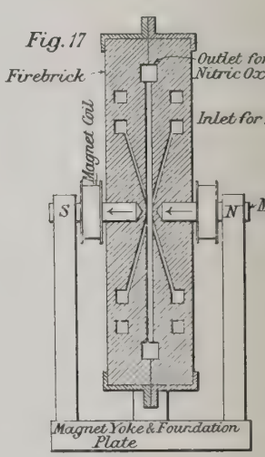


Fig. 17

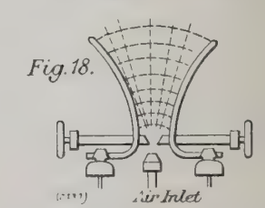


Fig. 18.

became too great, when a new arc formed near the points, to travel outwards in its turn. The motion was so rapid, the lecturer said, that the central space of the furnace appeared filled with a continuous sheet of flame. As indicated in Fig. 16, an inductive resistance was in series with the arc, the self-induction of which produced a displacement of phase according to the current flowing, and this caused the arcs to burn steadily. The temperature of the flame was 3500 deg. Cent., and the escaping gas had a temperature of between 500 deg. and 1000 deg. Cent. A furnace of 1000 horse-power cost 1000*l.*, but larger ones, taking 4000 horse-power, were now being constructed at a cost only about 50 per cent. more. The gases delivered from the furnace contained 1 per cent. of nitric oxide gas, which, by a series of cooling arrangements, was reduced to a temperature of 200 deg. Cent. A further reduction to 50 deg. Cent. was effected in aluminium tubes, and thence the gases passed into cylinders with acid-proof linings, in which the oxidised nitrogen gradually changed into nitrogen peroxide.

This was absorbed by water in a series of four towers, the liquor from the last containing 60 per cent. of the acid. This was distributed in jets

over limestone, giving the desired nitrate of lime. Another arrangement was due to Dr. Schonherr, who caused an arc of great density to burn steadily inside a long iron tube, air being blown through the tube with a whirling motion, so that the air moved in a path like a screw. The inventor first tried blowing the air straight through, but found that only a small proportion of air went into the sphere of action of the arc, and at the same time there was a difficulty in making the arc long enough, and keeping it in the centre of the tube. In a plant at work at Christiansand, the furnaces were worked in sets of three, one to each phase, each taking 600 horse-power at 4200 volts. Each tube was 16 ft. long, fixed vertically, and the electrode at the bottom consists of an iron rod which passed through a copper water-cooled tube. The iron rod was pushed upwards as it burnt away to ferric oxide, fresh rods being screwed on as required, so that the process was not stopped.

By an interchanger the air was heated to about 500 deg. Cent. before it reached the arc, where some of it was raised to about 3000 deg. Cent. Where the arc struck into the side of the tube there was a sudden mixing of the highly heated nitric oxide next to the arc, with the cooler air whirling past, and at this point the gas was permanently fixed. The balance-sheet of the heat energy was roughly as follows:—40 per cent. went in heating the water of the cooler; 17 per cent. in radiation from walls of furnace, pipes, &c.; 30 per cent. raised steam in the boilers.; 10 per cent. was lost by cooling with water after passing the boiler; leaving only 3 per cent. as directly employed for making the nitric oxide gas.

The inductive resistance was an important adjunct of this, as well as the Birkeland-Eyde furnace, preventing another arc starting at the bottom of the tube and running up.

The Pauling furnace (Fig. 18) was made on the lines of the well-known horn break lightning-arrester, and it consisted of two hollow iron electrodes (cooled with water) arranged to form a vee, which at the lowest point was about 4 cm. across. At this point there were two lighting-knives, which could be approached to within a few millimetres. The arc struck across these and ran up the diverging electrodes by reason of the natural convection currents and the repelling action of its own magnetic field, but principally because of a blast of heated air from a nozzle immediately below. The arc was caused to diverge so as to follow the shape of the electrodes, and attained a length of about a yard before it went out. At each half-period of the alternating current a fresh arc was formed, so that the result was the equivalent of a triangular sheet of flame. The furnace gases cooled off rapidly as they mounted upwards, and they were further helped by a draught of air introduced sideways into the upper portion of the flame.

In Norway, the speaker stated, there were cases where the total cost of water power did not exceed 30s. per kilowatt year, which was about one-third of the charge for power supplied to electric furnaces at Niagara. In this country the author thought that a waste-heat station might be erected complete at a cost of 6.5*l.* per kilowatt, though many small municipal plants had cost 50*l.* per kilowatt to instal. Very few hydro-electric plants could be put down at less than 10*l.* per kilowatt; and even in the United States, where there was much water power, it was often considered preferable to use steam. At Chicago a station now in construction would be equipped with six 20,000-kw. steam-turbine units. One great advantage of steam plants was that they could be located close to their markets, and the author accordingly thought it would be possible to establish in this country commercially successful electro-chemical plants drawing their power from fuel.

The discussion was opened by Sir William Ramsay, who said that he was quite in accord with the author in believing that by locating the factories close to the coal mines, and thus avoiding the use of long pipes for the conveyance of power gas, electro-metallurgy might be profitably worked here. The adoption of such a policy would lengthen the duration of our coal supplies.

Dr. Ernest Ekhardt, who followed, congratulated the section on the paper, which gave a very fair account of the competing processes. Generally the reader of a paper was more or less identified with one or the other competing systems described, and biassed accordingly. He did not, however, believe that the time was ripe for the introduction of any of them into this country. He might say that those interested had already considered this matter, but until more was known as to the practical results of the Norwegian development it would be foolish to go further. The 3000-horse-power plant at Christiansand was purely an experimental one, but arrangements had been made to set 250,000 horse-power at work at Ruhen, of which the first units should have been in operation some weeks ago, but delays had arisen through strikes. Still by next midsummer 125,000 horse-power should be in operation producing nitrates. He had no doubt but that there would be lots of trouble in perfecting details, and there would be much to learn before smooth working was assured. Hence it would, he considered, be merely common-sense to wait until the initial troubles had been overcome in Norway before attempting to start factories in England. The proprietors themselves were not clear as to which of the two processes they controlled was the better. Four out of the five units constituting the first half of the new plant were to be on the Birkeland-Eyde system, but with the second half, as the result of the experience gained, this proportion might be reversed. On another point also he was at variance with the speaker, and that was as to the necessity of starting nitrate manufacture in this country so as to ensure a supply for the manufacture of explosives. If the Navy could not keep the seas open for the passage of the nitrates fleet, it could not also protect the food supply, and the country would be starved into surrender.

Sir W. H. White said that he had given a good deal of attention to the relative cost of coal and water power, and he wished to recall the fact that, in evidence before the Parliamentary Committee which considered the London bulk supply, an eminent Swiss engineer had stated that in Switzerland itself it was often preferable to develop power by imported coal rather than by water. In the case of London, with a station properly located so as to get its fuel cheaply, the absolute cost with coal might be very small. No general rule could be laid down as to whether water or fuel power stations were the better. In some parts of Canada there was a wealth of water power and no coal, whilst in other provinces there was good coal but little water power. In Great Britain, with coal at present prices and a station suitably located, power could be produced as cheaply as anywhere in the world. Reference had been made to the large units at the Chicago power-station, but there was no need to go as far as that. In fact, when he visited Chicago no less than two-thirds of the power-plant in the large station was simultaneously under repair. With British stations, though they were the pioneers in the use of large power units, there had never been anything like so large a proportion of the plant out of use. On the Tyne could be seen one of the best illustrations in the world of the value of large units and of a well-considered scheme of power-supply over a large area. Mr. Merz had revolutionised the production of power in that district. As to the national question raised by Mr. Scott, he held himself that it would be a great advantage to have the means here of producing nitrates. As was well known, many of the British iron ores were not suitable for the production of acid steel, and, accordingly, when at the Admiralty he had encouraged the use of the basic process so far as was practicable. He quite agreed with a previous speaker that the life of the nation rested on the maintenance of its naval power, but he did not think that this touched the principle that it was well to have self-contained sources of supply. Indeed, when this was so he had found that prices were likely to be influenced in favour of the purchaser. He did not agree with some writers that the present impossibility of making explosives domestically was a national danger; but he did, nevertheless, think that the establishment of nitrate factories would be a good thing.

Professor Petavel said he had been struck by the figures given by the author, showing how very small a proportion of the power supplied went into the oxidation of the nitrogen. Apparently 97 per cent. was wasted, and it would appear at first sight that the chances were more hopeful for an improvement of the process, than for reducing power costs by adopting large units. He asked the author whether it would not be possible to save a large proportion of the energy now wasted. Some years since, in some experimental work conducted under a pressure of 3000 lb. per sq. in., he had found that the fixation of nitrogen was effected with greater efficiency. In one of his experiments a revolving disc, driven by a turbine working with air supplied at a pressure of 3000 lb. per sq. in., was employed. This drew out the arc into a disc of flame. A 20,000-volt arc was also tried in the same conditions as to pressure, and it was found that by working under pressure there was a fair increase in the yield. The experiments were not further pursued at the time.

Mr. H. Wimperis said that about three years ago he had looked into the amount of potential power attributable to the waste gases of our blast-furnaces and coke-ovens, which, it turned out, was equal to 1 million horse-power continuously. He had then suggested that this should be applied to the production of cyanamide. Since then on the Tyneside a considerable quantity of this waste heat had been utilised for ordinary electric-power purposes. Since, however, for electro-chemical purposes water was generally the cheap alternative, it was interesting to realise that there was 1,000,000 horse-power available in this country of which the fuel cost was zero.

Dr. Collins spoke as to the value of the artificial manures, and said that possibly the mixture suggested by the author would prove the most convenient. He suggested further that if cheap nitrates were produced in this country, the gas works might supply ammonium nitrate instead of ammonium sulphate, the sulphuric acid of which was objectionable.

A speaker whose name could not be obtained asked if the process described was a purely thermal one, as, if not, he thought there might be an economy in effecting the necessary heating non-electrically, and then using electric power to complete the reaction. Thus, in steel-making, the electric process had proved of most value in refining steel otherwise produced.

In his reply, Mr. Scott said that he could not feel that this country was keeping up to date in electro-chemical and metallurgical processes; and if the position was such that it would not pay private capital to do it, then the matter should be taken up by Government. He thought that Dr. Ekhardt was a little prejudiced in favour of foreign works, but the speaker wanted them here. As to the duties of the Navy, to which Dr. Ekhardt had referred, he thought the load on the latter would be relieved if the duty of protecting a nitrate fleet was removed. The isolation of Australia and New Zealand from the present sources of nitrates was also a very serious matter. New Zealand, he added, had more water-power than Norway or Sweden. At one time the Yorkshire Power Company had supplied power for carbide manufacture, but the control of that industry centred in the Continent, and the works had consequently been shut down, after less than two years' work. Hydro-electric power was subject to interruptions from ice and drought, and was, moreover, not capable of indefinite extension, whilst with steam fresh units could be added as required. The Newcastle-on-Tyne works were a magnificent illustration of what could be done by private enterprise when the latter was allowed the chance. Factories employing 5000 men, and having fully-equipped power stations of their own, had abandoned the latter and purchased current from the power company. With large towns like Glasgow and Portsmouth, fair results were possible even with municipal stations, but it was absurd for little towns of 25,000 people or so to put up their own generating plants, which on that scale were necessarily costly. In the north this had been largely recognised and the municipal stations turned into sub-stations retailing power from the large companies. A lot of the municipal stations had gone up simply to gratify the vanity of the respective mayor or town clerk. It was almost impossible to get a man of any good to stay on a town council. In one to three years he had usually seen enough, and, indeed, if he was any good, he would not be returned again in any case, as he would be sure to have said something to offend the electors. The whole ideal was absolutely silly, and if people had, like himself, had to get orders from the municipalities, they would begin to see other things too, to which he would not further refer. In reply to Professor Petavel he said that the actual waste was not quite 97 per cent., since the waste heat was utilised for evaporative purposes; but he agreed that the 3 per cent. directly applied in the conversion was exceedingly low. One reason was that air contained too large a quantity of nitrogen, which was not in the right proportion to the oxygen. Here he thought

THE CANADIAN LAKE AND RIVER TWIN-SCREW STEAMER "SAGUENAY."

CONSTRUCTED BY THE FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GOVAN, N.B.

(*For Description, see Page* 350.)

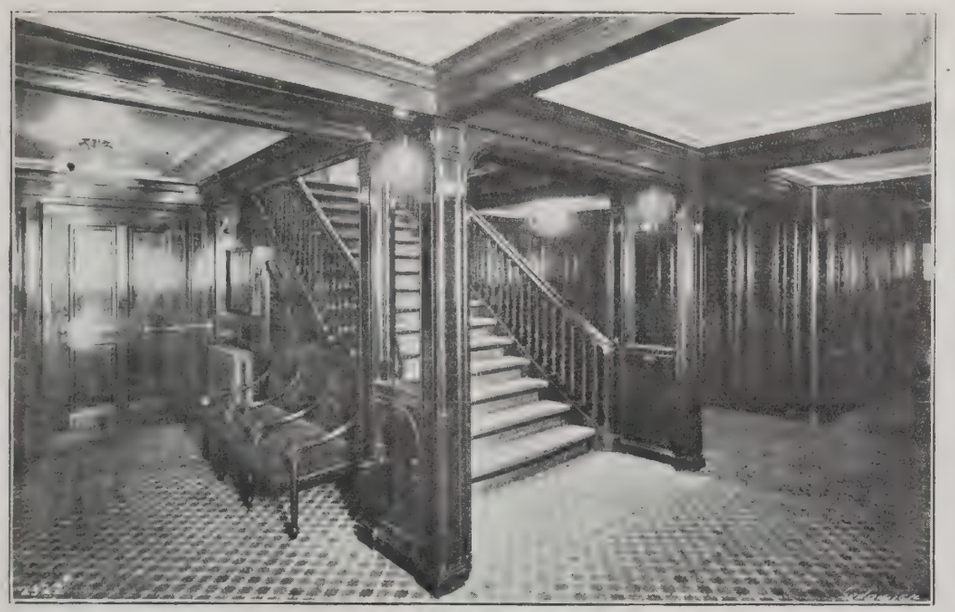


FIG. 8. ENTRANCE HALL ON MAIN DECK.

FIG. 10. AFT OBSERVATION TURRET ON GALLERY DECK.

FIG. 9. AFT GALLERY, WELL, AND COMPANION-WAYS, LOOKING FORWARD ON GALLERY DECK.

FIG. 11. FORWARD OBSERVATION TURRET ON PROMENADE DECK.

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(*For Description, see Page* 350.)

FIG. 12.

there was a chance of improving the yield, as also in the application of pressure. At the best, however, the proportion of energy directly used in the conversion would be small. The reaction was not entirely a thermal one, as was made evident on visiting a high-tension station, where there was a distinct smell of ozone, and also of nitric peroxide, the presence of which was further proved by the action of the nitric acid on the insulation. It was evident, therefore, that the process was not purely a thermal one, but he did not know what proportion of it was purely electrical.

A STANDARD TEST FOR FACTORY SMOKE.

Dr. John S. Owens then read his paper on "Smoke Abatement," which we publish on page 370. This described an instrument by which the relative density of smoke could be ascertained irrespective of the thickness of the column observed.

The discussion was opened by Sir W. H. White, who agreed as to the necessity of fixing standards, and suggested that to be satisfactory the committee charged with the duty should consist of representatives both of smoke producers and smoke inspectors. He further remarked that, in using the instrument described by the author, allowance would be necessary when the column of smoke was viewed obliquely. Having lived in a manufacturing district, he had been led to believe that the inhabitants were rather proud than otherwise of their smoke, holding it to be an indication of the amount of business they were doing; but there were, nevetheless, grave public reasons why the nuisance should be abated. In legal actions, however, two things were necessary: first, that there should be no doubt as to the facts, and, secondly, that the penalties should be substantial. As to the question of facts, this was now largely a matter of the personal equation, and the motor-car had shown how estimates might be influenced by this. He had himself been travelling at 35 to 40 miles per hour, which for official purposes was estimated at 15. As matters stood, there was as much contradiction in smoke prosecutions as in Admiralty cases where ships were in collision.

Mr. Mark L. Sykes, whilst agreeing with the object of the paper, had doubts as to the value of the instrument. The sole difficulty in abating the smoke nuisance was the impossibility of getting convictions. Magistrates were themselves manufacturers. The speaker lived at Leeds, where the smoke was dense, yet there had never been a prosecution for the production of black smoke. Manchester was nearly, but not quite, as bad, and the sole remedy was the prosecution of the "rascally" manufacturer. He was himself in favour of making imprisonment the penalty. He spoke as a manufacturer, and would give an instance where a large firm of rubber manufacturers, good customers of his own, were great offenders. He complained, and was told that remedy was impossible, and that the firm had spent 1000*l.* in trying to stop it. On inquiry it turned out that they had simply built a new chimney with the money, and might just as effectively have got a new cat. He accordingly took a series of daily observations and set the law in action. Two fines of 15*l.* each were inflicted, and the production of black smoke stopped at once. After some time it began again, and a fresh prosecution was instigated, this came before a sympathetic magistrate, who imposed a fine of 5s., which had absolutely no effect. He accordingly instigated another prosecution, when the penalty was two fines of 20*l.* each, and this permanently put an end to the nuisance. The evidence of an inspector ought to be received before that of any manufacturer, but as matters stood it was almost impossible to get convictions, as was proved time and again. Messrs. Watson, the soap-makers of Leeds, washed their smoke by passing it through towers 10 ft. high and 16 ft. in diameter, down which water was showered. Hence only clean gases left the chimney. Messrs. Rowntree, of York, did the same thing. He quite agreed that Dr. Owen's instrument could be of use if its evidence would be accepted by the magistrates as scientifically correct. The real causes of the smoke nuisance were bad fuel, careless stokers, the want of mechanical stokers, but, above all, the overforcing of boilers. New buildings were added to factories, and an attempt made to run all with one boiler, when perhaps three were really required.

In reply, Dr. Owens said he quite agreed with Sir William White that smoke producers should be represented on a committee appointed to fix standards. The fact that the line of sight through the smoke column might be oblique could be allowed for. The difficulty of getting convictions for smoke production lay in the absence of any proper standard. The Act said that the smoke must be black, and such a thing as truly black smoke did not exist. In using his instrument the light should come from the side opposite the user, otherwise the observations would not be comparable *inter se*.

CONTINUOUS TRACTION ON URBAN RAILWAYS.

The last paper taken, entitled "A New System of Continuous Transportation for Passenger and other Services," was by Mr. W. Y. Lewis. The author pointed out the large losses of time and power which arise with the present systems of intermittent traction. Even with the maximum density of traffic but 15 per cent. of the track on the District line was occupied by trains, and the periodic character of the service limited the schedule speed possible.

A distance between stations of half-a-mile was the minimum consistent with present schedule speeds. To get the same speeds with stations one quarter of a mile apart would be commercially impossible. The weight now hauled was 1200 lb. per seat, and with the present system, in which the acceleration was increased in jumps, it took 20 seconds for the train to travel the first 73 ft. By using gradually increasing rates of acceleration the distance travelled could be brought up to 135 ft. in 10 seconds, with less discomfort to the passengers. Again, just about half the power put into the trains was wasted in heat in applying the brakes. There was no return of energy to the line during the negative acceleration of the trains. Consequently the waste on the London system was 100,000 tons of coal per annum. The energy expenditure ranged from 40 to 60 watts per seat-mile. As a consequence of these various elements, urban journeys of 1 mile could not be made at a greater speed than 6 to 7 miles per hour, and for 2-mile trips the effective speed did not exceed 9 to 10 miles per hour. The lift equipment of the tubes also introduced delays, but the proposed introduction of escalators was a step in the right direction. At Paris and at Chicago a three-speed system of moving platforms had been set up to show the possibilities of continuous transport. No difficulty was found in getting on and off these. In London two continuous elevators were still in use, which carried 7000 passengers per day. They had been installed for twenty-five years, and were the last of about a dozen. Only one accident had ever occurred, which was a record unequalled by the intermittent system of lifts since introduced. With the multiple-speed platform a reasonably high speed was impossible, but with his own system very high speeds and accelerations were easily attained. His proposal was to lay a screw with a variable pitch between

the tracks, supported on rollers. This screw was continuous from end to end of the track, and was driven at intervals by motors. Separate and independent vehicles were used, which engaged with the screw by two rollers. At the stations the pitch of the screw was reduced, so as to bring down the speed of the car to three miles an hour, at which it could be easily boarded. In this deceleration 80 per cent. of the kinetic energy stored in the car was restored to the system. No brakes and no signals were required. The cars could not collide, being always a definite number of "pitches" apart. With this system he claimed that effective speeds could be increased 25 per cent., and operating costs diminished to one-fourth, and the initial to one-half of what was required with existing methods. It was possible to adapt the system to curves. Trials made with a plant erected at Messrs. Ransome's works, Ipswich, showed efficiencies ranging from 88 to 95 per cent., varying with the pitch of the thread. By the use of light independent cars, as proposed, the weight of the rolling-stock would be reduced to from 300 lb. to 400 lb. per seat. At the high-speed section of the track the load on the screw would be 20 lb., which during periods of acceleration would rise to a maximum of 600 lb. A length of screw could, he added, be taken out and replaced in two hours.

A letter from Captain Sankey was read by the Secretary. It stated that he had tested the plant at Ipswich, and had been surprised at the smallness of the power required, and at the large return of energy during periods of deceleration. There was no difficulty in getting on and off the cars, and accelerations as high as 4.5 ft. per second per second were realised.

Professor Coker asked what alterations would be necessary to fit the proposed system to the existing tubes. Probably this would be a simple matter, but from the diagrams shown the screw appeared to be large, and he asked what size would be required to drive the present trains. Were the screws, he asked, hollow tubes, and could the author give figures as to the efficiency attained?

Mr. H. Wimperis said that he had listened to the paper with interest, because the trouble on the existing lines lay in the acceleration, or rather in the high rates of change of acceleration. On the District line he had recorded accelerations of 3 ft. per second per second, and on the Hampstead Tube 2½ ft. per second per second, whilst on the electrified Brighton it was 2 ft. per second per second. These values, *per se*, caused no discomfort, but what was noticed by the passenger was the rate of acquiring acceleration, or of losing it in stopping, with which the biggest jars were experienced. In starting, the acceleration might jump suddenly from 0 ft. to 3 ft. per second per second, and in stopping from 5 ft. per second per second to zero. In such conditions passengers might be flung along the coach. In most tubes the rate of change of acceleration was as much as 20 ft. per second per second per second. His own experience was that a corresponding figure of 5 was all right, and of 1 was luxurious. The whole point involved was the rate at which acceleration came on and off. From this point of view he considered the author's proposals very promising, but there might perhaps be difficulty in adapting details.

Professor Dalby said that the author had not made clear the precise position of the system. In railways there were two kinds of passenger traffic—viz., express and stopping. As for express traffic the rate of getting up speed was of practically no importance. One of the best long-distance expresses did not reach full speed till it had covered 17 miles, which it took 20 minutes to do. This train weighed 400 tons, and attained speeds of 70 miles an hour. With local traffic, on the other hand, speed must be got up as quickly as possible, and this done, the brakes came on almost immediately. This, as the author pointed out, was where the ordinary system of electric traction failed, although it had beaten steam for this kind of service. With stations half a mile apart electric traction might earn a dividend, but could not do so with stations a quarter of a mile apart. Here the author stepped in with a system of independent carriages which automatically slowed down at stations and then gathered speed again. It was interesting to note that the system was entirely a mechanical one, and that it did not exist merely on paper, but could be seen in operation at Ipswich, the plant there being the result of seven years' development work.

In calling on the author to reply, Mr. Charles Hawksley, who occupied the chair in the absence of Professor Biles, said that the device would have a wide future if it attained the success the author anticipated.

In reply, Mr. Lewis said that he had to treat with the matter somewhat scantily, his paper having only been prepared the previous Saturday. In reply to Professor Coker, he said that there was no intention to apply the system to existing tubes, save, perhaps, as a substitute for lifts, but he did think that future urban railway services might be developed on the lines he had set forth. There were half-a-dozen schemes for which plans had been got out, and which were held up by the high capital cost involved in adopting electric traction, and matters were still more serious in New York and Chicago. He claimed that his system would give better results than the existing subways, both in facilities and in initial and operating costs. The screw, he said, was 2 ft. in diameter, and weighed about 100 lb. per foot. It would not matter if it cost a pound per foot run. With it he could, without a jerk, graduate the acceleration from zero up to its maximum value.

This concluded the business of Section G. We shall in our next issue commence our report of such other sections as lie within our province.

(To be continued.)

THE CANADIAN LAKE AND RIVER STEAMER "SAGUENAY."

WE illustrate by Plate XLI., and by engravings on pages 348 and 349, a somewhat novel type of steamer, so far as British experience goes, a vessel, named the Saguenay, which has just entered upon the service in Canada of the Richelieu and Ontario Navigation Company. The type is, however, familiar to travellers in America; but the vessels are, as a rule, constructed on the other side of the Atlantic. Indeed, this vessel, built and engined by the Fairfield Shipbuilding and Engineering Company, Limited, of Govan, is the first of the Richelieu Company's fleet to be constructed in this country.

The service conducted by the Richelieu and Ontario Company's fleet is that between Montreal and Quebec, and the many pleasure resorts on the St. Lawrence and its tributaries, a connection being formed from the Niagara and the beautiful Thousand Islands to as far north as the Saguenay River, the most northerly tributary of the St. Lawrence. This traffic is a quickly-growing one. It necessitates in some cases one or two nights on board ship, so that extensive sleeping accommodation has to be provided. As the scenery is specially attractive, the observation-rooms forward and aft constitute an important feature, as with many ships in the Western waters. The great variation of the temperature of the area in which the vessel trades necessitates not only promenades outside the deck-houses, but wide interior passages through which heated air will be circulated by adequate means. The elevation, Fig. 1, on Plate XLI., and the reproduction of a photograph in Fig. 12, page 349, give a clear idea of one of the peculiarities of the ship; that is, that instead of all the decks in the superstructure being of the same length, they are reduced towards the uppermost deck, and at the forward and after ends they are in all cases rounded off, which gives the ship an appearance unusual to the eye of the British shipbuilder and sea-voyager.

The dimensions of the ship had, of course, to be restricted to suit the special service, and thus the length is only 275 ft., the breadth 54 ft. 6 in., while the depth to the hurricane deck is 40 ft., the only structures above this being those associated with the navigation of the vessel. The vessel has been classed at Lloyd's, and the scantlings have been made light, to minimise the draught; but in all cases strength has been carefully considered. A notable feature is the heavy "guard," to act as a fender along each side above the water-line; this guard is reinforced by beams below, secured to the shell-plating and framing, and assists greatly in giving longitudinal stiffness.

There are five decks, and a plan of each is given on Plate XLI. In these—principally on the gallery and promenade decks—sleeping accommodation has been provided, mostly in two-berth cabins, for 240 first-class passengers, while on the orlop deck accommodation has been provided for a crew numbering 76. On the main deck there is a large space for freight, or alternatively for the accommodation of other passengers, while two rooms are provided for a few second-class passengers, the gentlemen being accommodated on the port, and the ladies on the starboard side. Special provision has also been made forward on this deck for the carriage of horses or cattle.

In describing the arrangement of these decks we may begin with the lowest—the orlop deck—the plan of which (Fig. 7) also shows the arrangement of the machinery, including three single-ended boilers and two sets of triple-expansion engines. These, it will be noticed, are brought closer together than is usual, in order to minimise the width of the engine-room ventilating-hatch. The same applies to the boiler-rooms, and thus the uptakes, as shown on the gallery and promenade-deck plans (Figs. 4 and 5), are narrowed, to give the maximum room for the cabins and for the promenade passages. Abaft of the engine-room, on the orlop deck, are the petty officers' and crew's mess-rooms; still further aft is the kitchen, the ventilation from which passes up in a shaft through the dining-saloon above and the cabins, right to the top of the ship.

The arrangement of the main deck has in part been referred to. It is the upper member of the moulded structure of the ship, and the side plating above it is pierced by large square openings at intervals right fore and aft. Most of these have glazed doors, others steel doors. There is a large freight space, with square doors, for the loading and discharge of the freight. There are coal-scuttles on the deck for filling the bunkers. The floor is laid with special chequered plating, which can be covered with wood when passengers are accommodated in this freight space. On this deck also are the baggage check-room—essential to all American craft—the chief steward's and purser's offices, and in the extreme after end the dining-saloon, which is reached from a large entrance-hall, with companion-way from the deck above, and with sliding-doors in the side of the ship for the ingress and egress of passengers. Of this entrance-hall a view is given in Fig. 8, on page 348. The dining-saloon is panelled in mahogany, and has seating accommodation for 100 passengers. The service is through a hoist from the kitchen and pantry below, and in this connection it may be said that the equipment of this department is more complete than is often the case with vessels of even larger size.

The promenade-deck, like the gallery-deck above, indicates the greatest departure from British practice. It will be seen that in both cases there is an outside passage extending from bow to stern. In this connection it should be noted that, as with the length of the deck structures so with their width, they narrow by steps at each deck towards the top of the ship, so that the promenade space in all cases is open overhead. These promenade-decks are covered with waterproof canvas in those parts where passengers promenade. The state-rooms are of somewhat novel arrangement. The beds are arranged athwart the ship. The upper and lower berths are in adjoining cabins, the division-wall being formed accordingly. If in any one cabin the berth nearest the door is on the lower level, that furthest from the door is on the higher level; in the adjoining cabin the bed nearest the door will be on the higher level, that furthest from the door on the lower level. The lower-level berth is in all cases so arranged that nearly one-half of it is open to the ceiling of the room, so that the sleeper is not so confined as where the berths superpose each other. This principle is adopted in the case of the double berths amidships on both the gallery and promenade-decks. Forward and aft there are two-berth cabins of the ordinary type, having an upper and a lower berth, but here the lower berth is of much greater width, an arrangement under which the occupant of this lower berth is not so "cribbed, cabined, and confined." The system is certainly worthy of a wider application. On the promenade-deck there are special suites, including a parlour, &c. Bath-rooms, toilet-rooms, &c., are arranged at convenient points.

The passage-ways from which access is got to the cabins are wide promenade spaces. In the gallery-deck there is a large well forward and another aft, giving light and ventilation to the deck below, and around it is the gallery from which the deck takes its name. This gallery, over which there is a series of skylights, is well illustrated in Fig. 9, on page 348, which shows also the promenade-deck below, with the companion-ways extending down to the main deck. This gallery, like that forward, is lighted by skylights piercing the hurricane-deck above. At the forward and after end of the promenade-decks there are observation turrets, which constitute a feature of the ship. Those on the promenade-deck are circular, while the two on the gallery-deck are elliptical, so that the deck structure in the latter case should be of less length than that of the promenade-deck. The appearance of the after observation turret on the gallery-deck is shown in Fig. 10, on page 348, the shaft at the after end being that for ventilating the dining-saloon below; the stairway leads down to the promenade-deck. The observation turret on the promenade-deck is illustrated in Fig. 11, on page 348. There are large upholstered settees with seats on the outer and inner curves.

The hurricane-deck (Fig. 3) is given up entirely for navigation purposes, although here passengers may promenade or lounge in deck-chairs, the only obstruction being the boats. In the centre of the deck, around the boiler and engine-room uptakes, is an observation cabin, where passengers may sit under shelter. At the forward end are the rooms for the navigating staff, with a pilot-house at the forward end. This has

THE CANADIAN LAKE AND RIVER TWIN-SCREW STEAMER "SAGUENAY."

CONSTRUCTED BY THE FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GOVAN, N.B.

(*For Description, see Page 350.*)

Fig. 1.

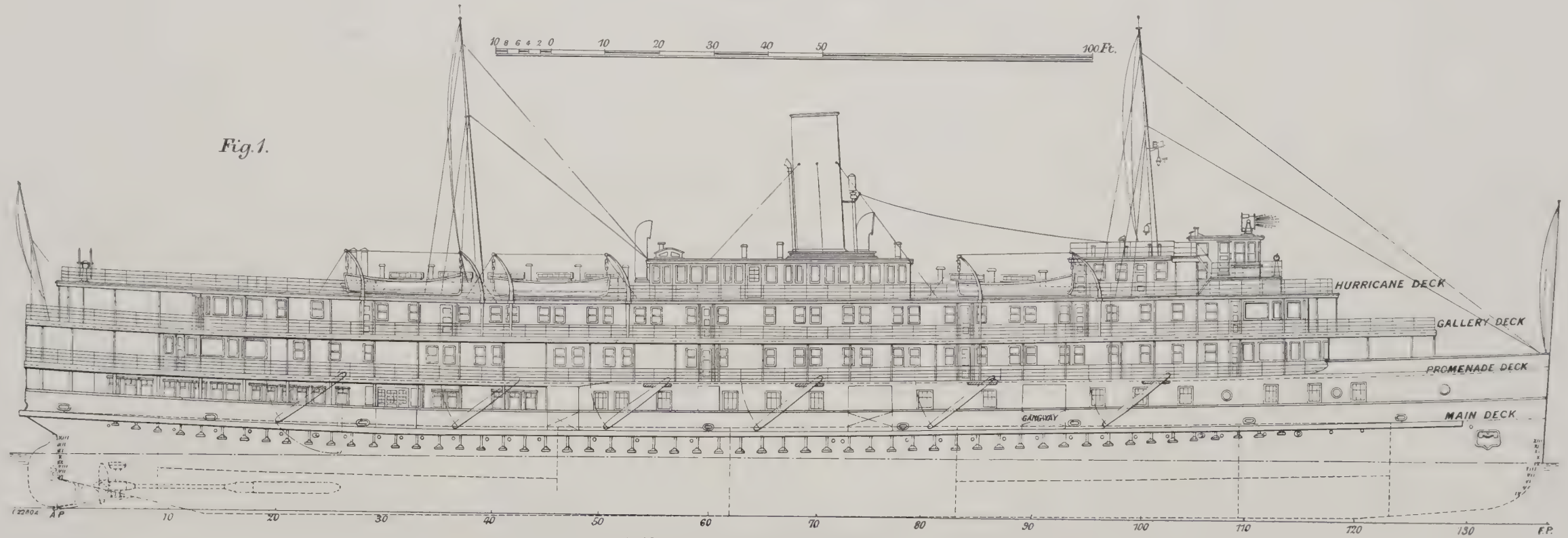


Fig. 2. HOUSE TOPS.

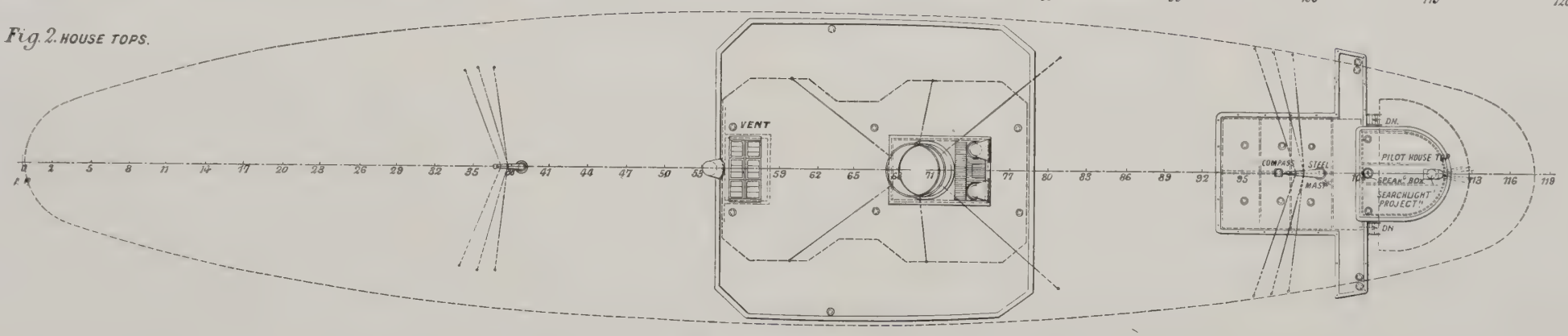
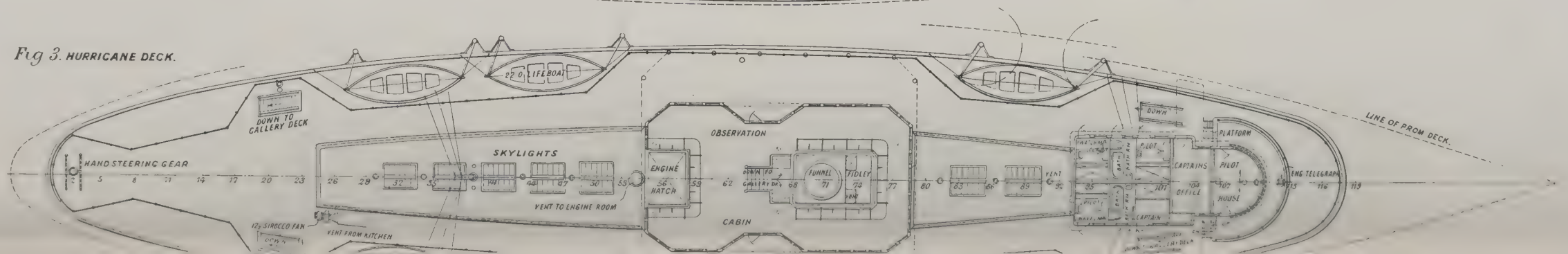


Fig 3. HURRICANE DECK.



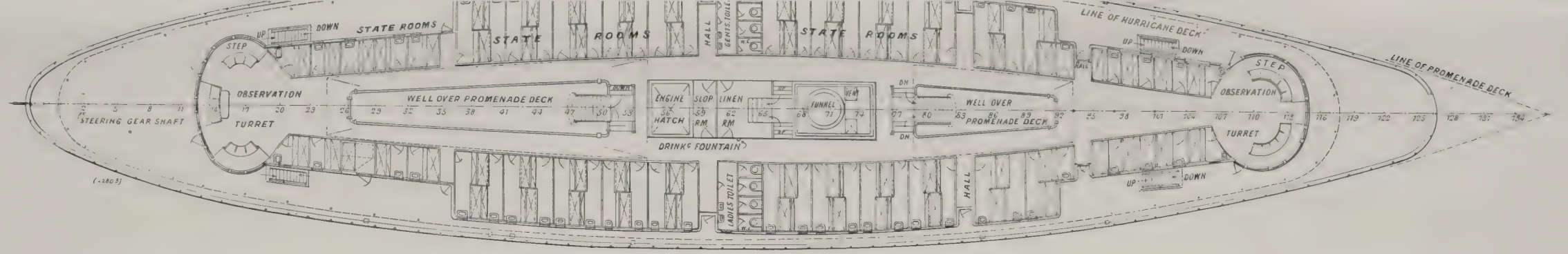


Fig.5. PROMENADE DECK.

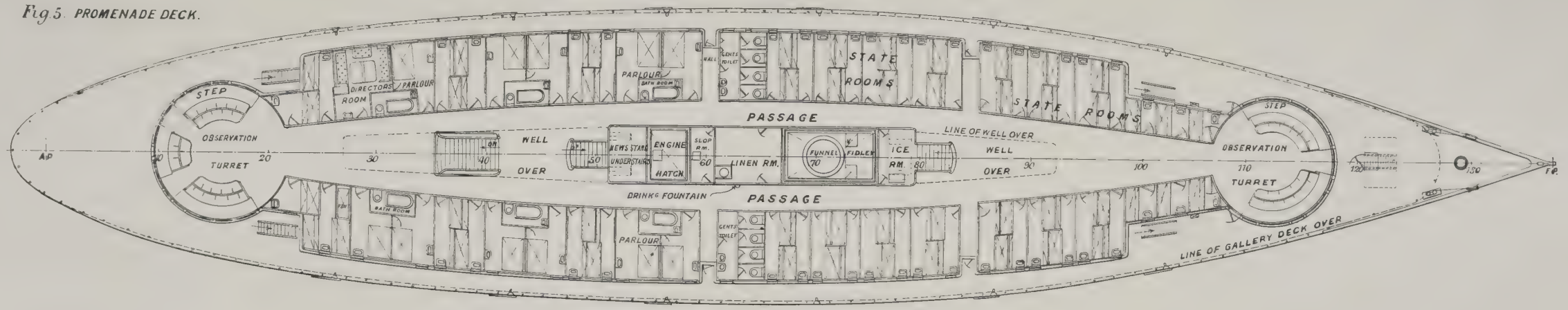


Fig.6. MAIN DECK

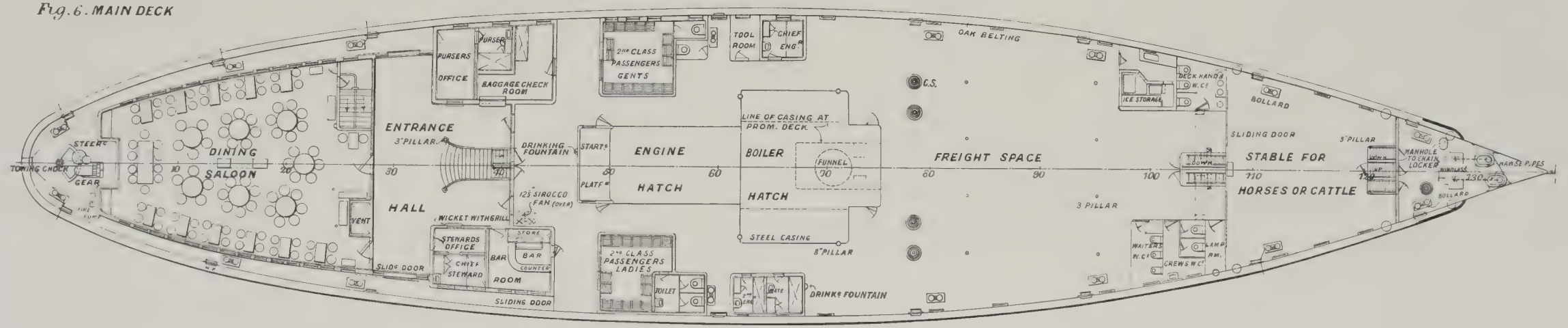
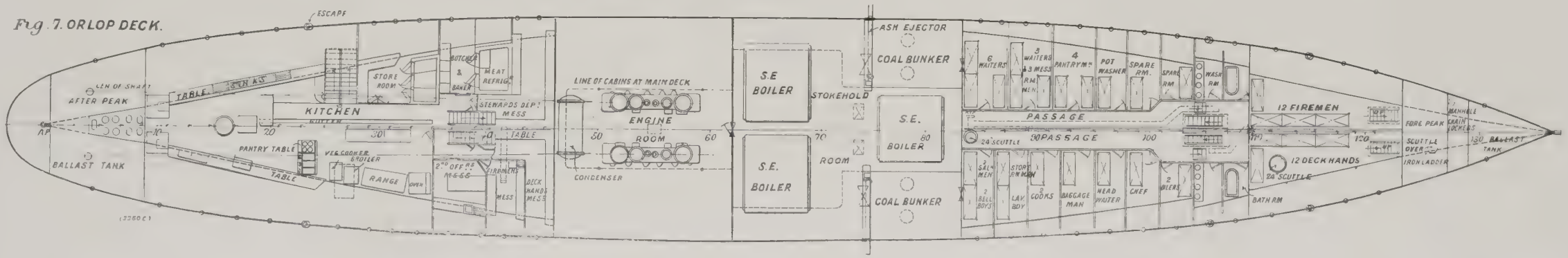


Fig.7. ORLOP DECK.



a semicircular front, with a platform, so that passengers may view the scenery from this vantage point. The navigation of the ship is conducted from the top of the pilot-house, where the compass is placed, and where also there is a searchlight for the discovery of buoys at the end of the journey, and for lighting the channel in the winter (Fig. 2).

The ship, it will be seen from Fig. 1 and the view, Fig. 12, on page 349, has two steel masts with the minimum of rigging. These masts are really only flagstaffs, and, with the single funnel, help to give the ship an attractive, if somewhat unusual, appearance to British eyes.

As regards the machinery little need be said, as it follows the usual merchant-ship practice of the Fairfield Company. The two sets of engines have each four cranks, with four cylinders, arranged for triple compounding, and on the Yarrow-Schlick-Tweedy balanced system. The screws are of the built-up type, with bronze blades. The engines are designed to run at high speed, the revolutions being 180 for 2100 horse-power. Special care has been taken in the design of the valve-gear to ensure quiet running, as well as to eliminate vibration. As is the case with all Canadian and American river passenger-steamers, the starting-platform, from which the main propelling engines are controlled, is situated at the level of the main deck, within the engine-room casing (Fig. 6). The whole of the gear is conveniently arranged here, and from this position both sets of engines can be easily manipulated by the engineer on watch. The three boilers supply steam at a pressure of 175 lb. per sq. in., and are worked on the Howden system of forced draught, for which there have been fitted two large steam-driven fans, located in the main engine-room. Each fan is sufficient for all the boilers when running at full power, so that one is a stand-by. It will be seen also that ash-ejectors have been fitted. Indeed, the auxiliary machinery is very complete, including two powerful electric-light engines and a refrigerating machine.

The refrigerating installation is extensive, on account of the high temperature during the summer season in the St. Lawrence. Provision is made for cooling the fish, meat, vegetables, and ice-storage chambers, while cold cupboards are arranged in the pantries, &c. In addition there is a large ice-making tank and a special water-cooler, with suitable pumps to supply ice-cold water through a special system of circulating pipes to the many drinking fountains and refreshment bars throughout the vessel. The steam-heating and cold-water services for baths, &c., are most extensive, and the sanitary arrangements are specially noteworthy because of the care with which they have been carried out.

The vessel before leaving the Clyde ran her steam trials on the measured mile at Skelmorlie, when, under service conditions, a speed of 16 knots was attained. This was regarded as specially satisfactory, the conditions of trials being arranged and carried out, like the design and construction of the ship, under the personal supervision of Mr. A. Angstrom, the consulting naval architect to the Richelieu and Ontario Navigation Company.

CATALOGUES.

Motor-Car Accessories.—From Messrs. S. F. Edge, Limited, 14, New Burlington-street, W., a catalogue stating prices of all kinds of accessories suitable for Napier motor-cars has come to hand.

Automatic Couplers.—We have received from the A B C Coupler, Limited, Queen Anne's Chambers, Westminster, S.W., a booklet, printed in English and Spanish, illustrating and describing the A B C automatic buffer coupler (Jepson's patent) for railway rolling-stock. This coupler was fully dealt with in our issue of June 23 last, on page 821.

Insulated Wires, Jointing Tools, &c.—From the India-Rubber, Gutta-Percha, and Telegraph Works Company, Limited, Silvertown, London, E., a price-list of insulated wires, &c., has reached us. The list deals with bell wires, telephone cords, flexibles, silk and cotton-covered wire of copper and German silver for winding coils, &c., gutta-percha insulated wires, shot-firing wire, jointing materials, tools, and accessories.

Grinding-Machines.—A pamphlet to hand from Messrs. Greenwood and Batley, Limited, of Leeds, illustrates and describes a new series of plain grinding-machines for cylindrical or taper work, they have recently introduced. These machines, which have several novel features, are made in six sizes. The smallest size listed takes work 12 in. in diameter and 6 ft. long, while the largest will accommodate work 16 in. in diameter and 10 ft. long. Particulars are also given of machines with gap-beds for dealing with crank-shafts and other work requiring a large swing.

Electric Lamps.—From the Linolite Company, 25, Victoria-street, Westminster, S.W., we have to acknowledge receipt of a little booklet relating to their well-known "Tubolite" lamps for shop-window, stage, and domestic lighting. These lamps are now supplied with metallic filaments for pressures ranging from 100 to 125 volts. They are each of 12 candle-power, and their efficiency averages about 1.5 watts per candle-power when tested apart from the reflector. Prices are stated for both metallic filament and carbon filament lamps alone or complete with the reflectors; in the latter case the prices quoted are per foot run.

Wire Guards, &c.—A catalogue, illustrating numerous examples of wirework they manufacture for industrial purposes, has been issued by Messrs. Richard Johnson, Clapham, and Morris, Limited, Newton Heath, Manchester. The greater part of the illustrations are reproductions from photographs, and in glancing through them we notice machinery-guards, window-guards, wire baskets, guards for radiators, locomotive spark-arresters, wire partitions and lockers, lamp-guards, letter and parcel racks, woven-wire sheets of all kinds, sieves, screens, coal-picking belts, and many other articles of a similar nature.

Glazing Bars of Reconstructed Stone.—A pamphlet relating to "Ferro-Stone" glazing bars has come to hand from the British Stone and Marble Company, Limited, Craven House, Kingsway, W.C. These bars are made of the firm's well-known reconstructed stone, strengthened by having a steel bar embedded therein. The glass rests on an asbestos cord placed in a groove, and is held in position by lead clips fixed to the stone by brass screws. The pamphlet describes the method of manufacturing these bars, and points out their many advantages. Among these we may mention that they are practically everlasting, require no painting or other treatment, resist chemical fumes, and are also light, strong, and of good appearance.

Gas-Holders.—We have received from Messrs. C. and W. Walker, Limited, Midland Iron Works, Donnington, near Newport, Shropshire, a copy of a catalogue illustrating examples of gas holders recently constructed and erected by them in various parts of this country and abroad. The illustrations, which are reproductions of photographs, show holders ranging in capacity from 38,000 to 8,000,000 cub. ft., and include some of the spirally-guided type, as well as several guide-framed holders; details of the spirally-guided holders are illustrated. The catalogue also contains a list of gas-holders made, erected, and repaired by the firm during the last few years.

Grinding and Polishing Machines.—The London Emery Works Company, Park, Tottenham, London, N., have sent us a copy of a supplementary list of grinding-machines. This catalogue illustrates and states prices of some of the smaller and more commonly used types, including several models of belt-driven double-wheel and disc grinders for bench use or mounted on stands to be fixed on the floor. Full particulars are also given of grinding-machines driven by foot-power, as well as of plane-iron grinders, twist-drill grinders, tool-grinders, polishing-lathes, and various accessories, such as countershafts, wheel-dressing tools, corrugated sheet-metal wheel-guards, &c. The catalogue also includes price-lists of the "Atlas" brand of emery wheels, emery cloth and paper discs, and other supplies.

Continuous-Current Transforming-Machine.—Messrs. Crompton and Co., Limited, Salisbury House, London Wall, E.C., have published a pamphlet relating to the "C.M.B." auto-converter. This machine, which was fully described in our issue of July 9, 1909, on page 60, is largely used for reducing the voltage of a continuous-current system to a pressure suitable for the supply of cinematograph arc-lamps, searchlights, metallic filament lamps, and also for depositing and welding processes. They can be constructed to produce a constant voltage or a constant current on the secondary side, the constant-current type being particularly suitable for the supply of large arc lamps. The machines can also be used as automatic balancers on three-wire distribution systems, and for the regulation of large motors. The pamphlet states prices of machines for outputs up to 25 kw. with a ratio of conversion of 2 to 1. Machines are also made in smaller sizes with ratios of conversion of 5 to 1 and 10 to 1.

BATTERSEA POLYTECHNIC.—The work of this institution, as set out in the calendar for the ensuing session, which commences on the 25th inst., shows a satisfactory degree of development and extension in nearly all departments. Details are given of day and evening courses for preparation for London University degrees in science, engineering, and other subjects, and as the lecturers in these subjects are recognised teachers of the University, students attending this Polytechnic may be registered as internal students of the University. In the day technical college three-year courses in mechanical, civil, electrical, and motor-car engineering, architecture, building, chemical engineering, and other subjects have been arranged, students receiving the college diploma after passing examinations at the end of the courses. Students are also prepared for university, Civil Service, and other examinations, as well as for secretarial and business appointments. Complete evening courses are also conducted in mechanical and electrical engineering, building, mathematics, chemistry, commercial, and other subjects. In the mechanical engineering department a course of lectures on illuminating engineering has been arranged for, and, if successful, these lectures will be continued and extended during following sessions. Special attention is being given to electric traction in the department of electrical engineering, and new machinery and apparatus is being purchased, so that this subject can be more fully dealt with. In the chemistry department a new practical class has been added to the course in chemical engineering, and in connection with the paper-making course a series of lectures by trade experts has been arranged for. It may also be mentioned that many additions have recently been made to the institution's library, which, although only opened in October last, has already proved to be of great utility to the students.

WORKMEN'S COMPENSATION CASES.

COUNTY COURT.

Separated Wife not a Dependant.—An interesting case was decided by the County Court Judge of Clerkenwell, when a claim was made against the London County Council, who were the employers of Mrs. Lewis's late husband. She claimed for herself and two children, who were alleged dependants of the man who met his death by accident in respondents' service.

The defence was that the claimant was living apart from the deceased, and was not dependent, with her children, on deceased's earnings at the time of his death. It was proved by facts that the claimant, in 1905, was separated from her husband, and went through a form of marriage with another man named Archer, who had been a lodger in deceased's house at the time the applicant left her husband. From 1906 the deceased had not contributed to the wife's maintenance. On hearing the whole of the evidence, the Judge held that the applicant had failed to prove that the applicants were dependent on the deceased's earnings at the time of his death. The award was in favour of the employers.

The woman may have had some excuse for going through a form of marriage with another man, for, as she alleged, her husband had not sufficiently contributed to her maintenance, but neither she nor the two children had any claim for compensation for her husband's death. The children, but for the mother breaking up the home and leaving her husband, might have proved their dependency on their father's earnings. They may have been victims of their parents' misconduct, but it would be unjust if, under the Workmen's Compensation Act, they were made dependants, with a claim for compensation for their father's death at the employers' expense.

Liability of Sub-Contractors.—An interesting compensation case was heard at Lambeth County Court, when the widow of James Reading applied for compensation for her husband's death while in the employ of Messrs. Young and Sons, contractors, Herne Hill. The deceased had been engaged in fixing the gutters of a house in Kensington, and a fatal accident happened to him owing to a faulty ladder. The respondents denied liability, because the work in which deceased met his death was being done for them by a sub-contractor, the father of deceased, trading as Charles Reading and Son, and that the deceased was Charles Reading's employee, and not theirs. The fact was proved that the deceased was neither a partner in the father's firm, nor his father's employee. The firm of "Reading and Son" was only so-called for appearance sake, and the deceased was a *bona fide* workman under Messrs. Young and Sons, and his widow was entitled to compensation of 234*l.* under the Workmen's Compensation Act from Messrs. Young and Sons, who had been the deceased's direct employers.

At Glossop County Court an applicant claimed 23*l.* 12s. compensation from Messrs. W. Cumming and Co., Limited, blacking manufacturers, in respect of injuries received while in their employment during the unloading of a truck. He was jammed by the truck, and his shoulder was crushed. The dislocation of his shoulder incapacitated him for his work, and when he applied for work the employer's foreman refused him. He had received 29s. 6d., and gave a receipt for that amount in full discharge of all claims.

The Judge held there should have been no compromise which might seem to interfere with the workman's compensation under the Act. The workman had given a most improper receipt, and the employers were responsible for compensation not alone for 1*l.* 9s. 6d., but for the result of the injury and the incapacity from August to February, and the Judge awarded the applicant 12*l.* 12s. 8d., the arrears of weekly payments, with 1d. per week subsequently, with costs, to keep the claim open.

It will be observed that it is a risk for employers to settle for a trifling amount with an illiterate workman when the injuries might eventually prove to be far more serious than was contemplated by the man himself or his employers.

The Effect of Shock.—An employee claimed compensation for injuries received under peculiar circumstances, which caused him no physical injury, but compelled him to suffer nervous shock, and to undergo treatment in hospital, as a result of being accidentally locked in the warehouse of his employers during the evening of Derby day, when an alarming thunderstorm came on. His fellow-workmen found him dazed and prostrate when they came to release him. This accidental injury was sufficient to incapacitate him, and his employers—city warehousemen—were made liable for half wages during incapacity, and the County Court Judge awarded him 9s. 6d. a week till further orders.

THE INCORPORATED INSTITUTION OF AUTOMOBILE ENGINEERS.—The first meeting of the session of the Institution of Automobile Engineers will be held at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W., on October 11, at 8 p.m., when the newly-elected president, Mr. L. A. Legros, will deliver his presidential address.

PERSONAL.—Messrs. W. T. Glover and Co., Limited, electrical wire and cable-makers, Trafford Park, Manchester, have removed their Glasgow offices and stores to 158, Hope-street, Glasgow, and the telephone number has been changed to 3856 Douglas, their telegraphic address remaining as before—viz., "Conductors," Glasgow.—We are informed by Messrs. H. A. Harvey and Co., of Norfolk House, Laurence Pountney Hill, E.C., that they have converted their business into a private limited company. The capital has been fixed at 22,000*l.*, and Sir William Brereton Hudson, K.C.I.E., is chairman.

MESSRS. ANDRÉ CITROËN & CO.'S DOUBLE HELICAL GEAR-CUTTING WORKS, PARIS.

Fig. 1.

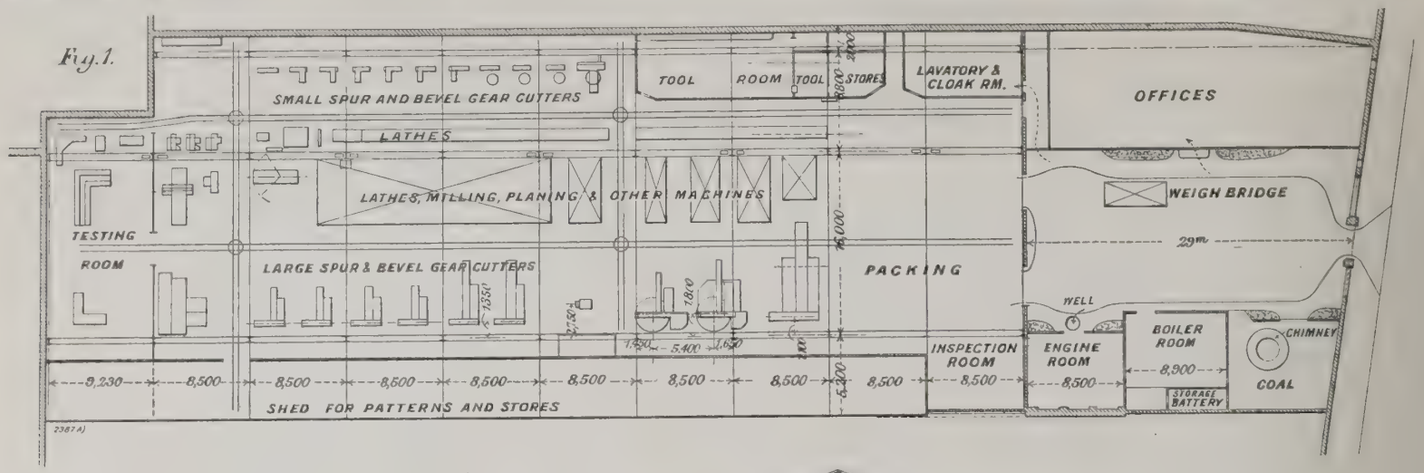
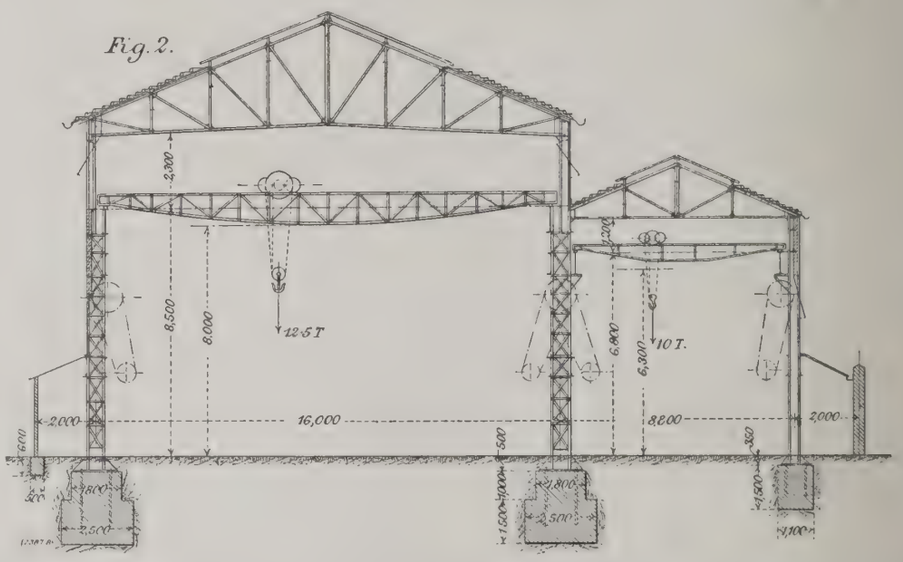


Fig. 2.



The firm André Citroën and Co. was established in 1901, with works at Essonnes, near Corbeil. Until 1904 the company did not carry out any great amount of business, practically the whole of their time being taken up in studying their speciality and the market for it. In 1904 the works were transferred to the Rue du Faubourg St. Denis, in Paris, at which time the company may be said to have started business. The shop at Essonnes covered about 150 sq. m. (1600 sq. ft.), and formed as it were a laboratory in which the machine-tools for gear-cutting were manufactured and improved with a view to increase their dimensions and their speed. The first machines made under the original patents were only able to deal with wheels made from blanks up to 500 mm. (19.6 in.) in diameter, weighing up to 150 kg. (3 cwt.), and to cut in these teeth up to 100 mm. (3.9 in.) in maximum length. The machines now built can take blanks 8 m. (26 ft. 3 in.) in diameter, weighing up to 15 tons, and can cut teeth up to 1 m. (39.37 in.) in length. The second shop in the Rue du Faubourg St. Denis was not equipped with modern lifting appliances; it has nevertheless frequently dealt with wheels weighing from 3 to 6 tons. The motive power was generated by a 30-horse-power producer-gas engine, to which had been added later two electric motors of 15 horse-power each. This second shop covered 450 sq. m. (4800 sq. ft.) and had two storeys. From very insignificant figures in the first, experimental years, the business of the firm rose in 1910 to a total of 40,000*l*.

Until 1905 Messrs. Citroën had in view more especially the French market; since that date, however, and owing to the excellent results obtained with their double helical cut teeth, they have found a large business in foreign markets. To deal with this they established an office in London in 1906, one in Brussels in 1907, one in Cologne and one in Turin in 1909, from which they have carried out important contracts, among which may be mentioned gearing for machinery for Transvaal gold-mines, for the steering-gear of the White Star liners Titanic and Olympic, for the steering-gear of Italian battleships, rolling-mill gearing for large German steel works, and so forth. At the same time the French business was being rapidly developed, and Messrs. Citroën were put on the French Admiralty and War Office lists; they have established also an extensive connection with French works and companies. A few months ago Messrs. Schneider and Co., of Creusot, ordered from them heavy gears for lathes for machining the new large-calibre gun tubes and jackets for the French navy. The latter ordered from them direct the gears for the steering of their 800-ton submarine-boats. These gears were designed in Messrs. Citroën's offices, and are based on the exclusive use of cylindrical and conical wheels, with cut double-helical teeth.

Messrs. André Citroën and Co. have gone fully into the question of driving rolling-mills by electric motors, the latter running at their normal speed, which speed on the rolls is reduced by gearing of their manufacture. The rolling-mills of Messrs. Campionnet and Co., Gueugnon, Messrs. Baraguey, Fouque, and Co., Neuve Lyre, the Forges de Basse-Indre, the Compagnie Electro-Métallurgique, Dives, in France, are so equipped.

Russia is also an important market to which they have given their attention. They have supplied their wheels in that country for use in conjunction with mining winches, and for speed reduction between the Diesel engines and the paddle-wheels of boats. Considerations of distance and high cost of transport, the high duty also which is charged in entering the country, have led the firm to establish a branch establishment in Russia. The works are being laid down in Moscow, and will start running in a few months.

The works in Rue du Faubourg St. Denis having become insufficient to cope with the increasing business, Messrs. Citroën decided to put down new ones. These are shown in the plan and in the cross-section, Figs. 1 and 2, and are situated at 31, Quai de Grenelle, Paris, near the Champ de Mars railway station, which is available for the transport of smaller machinery and goods, and close to the Seine, on which are carried the coal and the heavier pieces, blanks, and finished wheels. The site is that occupied formerly by the Cail Company; it measures 34 m. (111 ft.) in width, parallel with the river, and 113 m. (370 ft.) in depth, giving an area of 3860 sq. m. (41,500 sq. ft.), divided as follows:—Offices, 310 sq. m. (3300 sq. ft.); power-house, 145 sq. m. (1560 sq. ft.); shop, 2453 sq. m. (26,440 sq. ft.); non-covered area, 952 sq. m. (10,200 sq. ft.). Access is had to the factory through a courtyard; the offices are on the right-hand side, and the power-house and chimney on the left-hand side. The shop consists of two bays, as shown in the section, Fig. 2, the main bay, 16 m. (52 ft.) in width, the side bay having a width of 8 m. (26 ft.). The main bay is served by two 12.5-ton overhead-electric travelling cranes, and the side bay by a 10-ton similar crane. A lean-to is on each side of the shop. Land is available in the rear for future extension, should this become necessary.

The framework of the shop, power-house, and offices is of steel, the uprights being anchored down into concrete foundation-blocks sunk to a depth of 3.5 m. (11 ft. 6 in.) below the ground-level. The walls are built of brick; the outside is ornamented by varying grey and white tints, and has a very pleasing effect. The roofs are partly of tiles and partly of glass, and the lighting leaves nothing to be desired. The part covered with tiles is lined with wood to facilitate heating the shops during the winter months. The office building on the right-hand side on entering the works contains the drawing and commercial offices.

The power-house supplies 110-volt continuous current; this was selected to allow the utilisation of the electric plant which existed in the former shop—Rue du Faubourg St. Denis. As it was absolutely necessary to be able to count upon a perfectly regular and constant power supply, a steam-engine was selected for the prime mover. This was supplied by the Société Alsacienne de Constructions Mécaniques. The engine is a horizontal 200-horse-power uniflow engine, driving at a speed of 160 revolutions a 110 to 115-volt continuous-current dynamo, coupled to the flywheel shaft. The condenser is underneath, and is in connection with a well 40 m. (130 ft.) in depth, either directly when the water level reaches to the mouth of the well, or through the intermediary of a reservoir built of armoured concrete and of 12 cubic m. (2640 gallons) capacity, which acts as a suction tank and is fed by a centrifugal pump. The switchboard is double, one panel being set apart specially for the working of the dynamo and provided with the recording instruments for measuring the work supplied to the power circuit and the current supplied to the lighting circuit; the second panel serves for the distribution of the lighting current and for switching in the accumulators. Steam is supplied to the engine by two Garbe water-tube boilers having each 60 sq. m. (645 sq. ft.) heating surface; 2 sq. m. (21 sq. ft.) grate area, working at a pressure of 12 kg. per sq. cm. (170 lb. per sq. in.). One of the boilers is used more especially to supply the engine; it is fitted with a superheater of 28 sq. m. (300 sq. ft.) superheating surface, giving steam at 325 deg. Cent. The second boiler acts as a stand-by, and comes into use in the winter months also for heating the shop and offices. The chimney is built of bricks; it is 35 m. (114 ft.) high, 1 m. (39 in.) inside diameter and 1.45 m. (57 in.) outside diameter at top, the outside diameter at the base being 3.3 m. (10 ft. 10 in.). In winter the boilers are fed by the condensed steam (at about 60 deg. Cent.) proceeding from the heating apparatus for the offices and shop, and in summer by the condensed steam from the condenser (at about 35 deg. Cent.), this being previously filtered through coke. The works can also draw Seine water from the town main. The boilers are fed by a three-cylinder electric pump when the engine is running, or by a Worthington feed-pump when it is at a standstill. All the coal burned is previously weighed; the water vaporised is recorded by a Schmidt counter.

The main bay of the building contains the tools for cutting the gear-wheels which exceed 1.6 m. (63 in.)

MESSRS. ANDRÉ CITROËN AND CO.'S WORKS, PARIS.

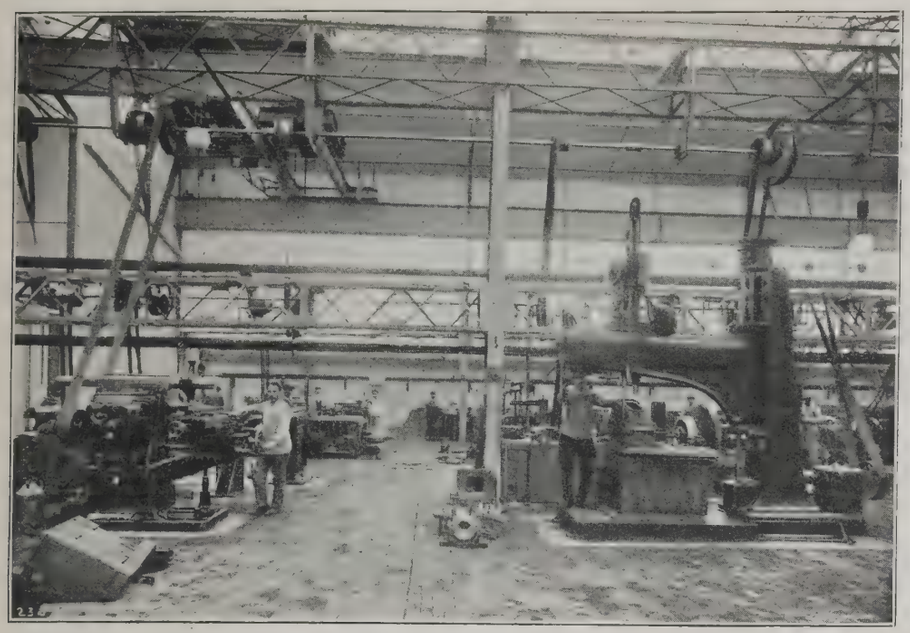


FIG. 3. VIEW SHOWING PLANING, BORING, AND MILLING-MACHINES.

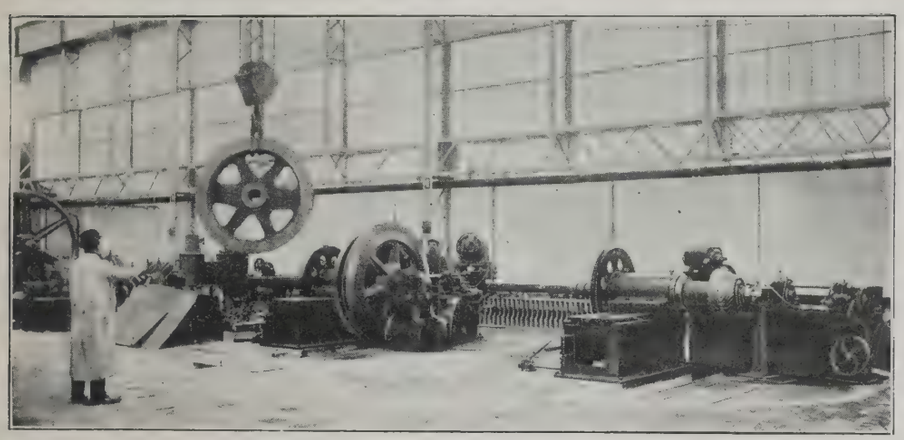


FIG. 4. BEVEL-GEAR CUTTING MACHINES.

in diameter, and the rolling-mill pinions. The smaller bay is equipped for cutting wheels less than 1.6 m. (63 in.) in diameter. The latter bay also contains the tool-making and hardening room, the tool-stores, the clothes-lockers, and wash-hand installation, all of which are to be removed ultimately to a separate bay, 7.2 m. (23 ft. 6 in.) in width, the construction of which is contemplated.

The ends of both bays opposite the entrance are set apart for turning, planing, boring, and generally machining the blanks when necessary, previous to their being placed on the gear-cutting machines. In this part of the shop are erected also the speed-reducing gear and other apparatus for the navy, the War Department, and others. Further to the rear is the testing-room, in which are tested the wheels and pinions to ascertain their accuracy and smooth running; the tests last several hours, the gearing being made to turn as near as possible under the load it will carry in actual service. There are in all six testing-beds for both cylindrical and bevel-wheels of large dimensions, and four for smaller gears, of which one is for spur-wheels, one for both spur and bevel-wheels, and two mostly for all smaller gear. All the beds are provided with separate electric motors with variable gear. The various departments are shown in the views, Figs. 3 to 6, on this page and page 356, Fig. 3 illustrating the planing, boring, and milling-machines, Figs. 4 and 5 showing some of the bevel-gear and spur-wheel gear cutting machines, and Fig. 6 a general view in the main bay.

Among the machines in the 16-m. (52-ft.) bay are four gear-cutting machines for spur-wheels up to 3 m. (9 ft. 10 in.) in diameter; two for spur-wheels up to 5 m. (16 ft. 4 in.) in diameter; one for spur-wheels up to 8 m. (26 ft. 3 in.) in diameter, and two for spur and bevel-wheels up to 5 m. (16 ft. 4 in.) in diameter. The maximum width of rim along which the teeth can be cut is 600 mm. (23.62 in.) for wheels up to 5 m. in diameter, and 1 m. (39.37 in.) for those up to 8 m. One of the machines taking the wheels up to 3 m. in diameter is built on a pit, and is provided with a device for cutting racks in lengths of 2.5 m. (8 ft. 2 in.). Each machine is provided with its own set of gear-wheels for varying the speed of the cutting-tool and for dividing. The machines are all built on a strong concrete foundation in which a gap is cut for allowing the machining of blanks exceeding 2 m. (6 ft. 6 in.) in diameter. Besides the above there are a key-way slotting-machine, and a boring-mill in close proximity. The first six gear-cutting machines above referred to, and the key-way slotting machine, are run together by belting from the same overhead shaft, driven by an electric motor. The three last gear-cutting machines and the boring-mill have each their own electric motor.

On the opposite side are five chuck-lathes for taking blanks or wheels up to 5 m. (16 ft. 4 in.) in diameter. There are also the following machines specially set apart for the manufacture of rolling-mill pinions:—A lathe for turning up to 1.5 m. (4 ft. 11 in.) in diameter, and 5 m. in length; a machine for cutting the wobblers at the ends of the rolling-mill pinions; and two heavy gear-cutting machines for taking the pinions up to 1.5 m. in diameter, and 5 m. in length. Also a series of accessory machines, and a laying-out table.

The smaller bay contains the following gear-cutting machines:—Two for light spur-wheels; four for spur-wheels less than 1.6 m. (63 in.) in diameter; one for light spur and bevel-wheels, two for spur and bevel-wheels less than 1.6 m. in diameter; and one for wheels of the same diameters, but of heavier patterns. All these machine-tools, together with those in the adjoining tool-room, are run from the same shaft driven by an electric motor. On the opposite side are several lathes and other machine-tools for preparing the blanks run from a shaft driven by an electric motor.

The main bay is served by two 12.5-ton overhead travelling cranes, the smaller bay by a 10-ton similar crane, as above stated. A fourth hand-operated traveller serves the test-room. A number of small hoisting jibs, to lift from 1 to 2 tons, are arranged near some of the machines. Narrow-gauge tracks run through the shops, as shown in the plan, Fig. 1; they communicate together by four turntables. The shop and yard are paved throughout with wood blocks.

The machines for cutting double helical-toothed spur-wheels consist mainly of two cast-iron beds at right angles one to the other, strongly connected together, and provided, one with the headstock, its face-plate, and the piece to be machined, and the other with the tool-carrying head and milling-cutter. The blank is carried in the same way as in an ordinary lathe, on a mandrel which ensures its perfect centering. The milling-cutter head travels automatically on its slide longitudinally and parallel with the generating lines of the wheel being cut. The setting of the tool for depth of cut., *i.e.*, in the direction of the radius of the wheel and towards the wheel-centre, is done by hand by means of a dial before starting the engine for the first cut. The milling-cutter takes the whole depth at one and the same cut; its axis is perpendicular to the work, and it is rotated by a shaft and gearing. The mandrel carrying the blank is made to rotate slowly or rapidly, and continuously in one direction or alternately in the opposite direction, at will, and according to the work to be done, but its action is always dependent upon that of the tool-carrying bed. The combination of the various motions, which are regulated by means of gearing, stop-catches, and quick-return mechanism, combined with a corresponding motion of the plate carrying the blank, makes it possible to cut on the latter either straight or helical teeth of any required shape.

When cutting double helical teeth V or N shaped to form spur-wheels, the blank is made to rotate very slowly; the tool-carrying bed moves in a direction parallel with the generatrix of the wheel being cut, and the milling cutter ploughs as it were on the rim to the full depth a helix the dimensions of which are governed by the selection previously determined upon of the ratio between the speed of the tool-carrying bed and that of the blank. The height of the helix equals half the width of the rim; as soon as the revolving cutter has reached the apex, the rotation of the blank is reversed automatically without a clutch, the speed remaining constant, and the other side is cut. The tooth consists, therefore, of two helices cut in one stroke without stoppage, the machine being adjusted for the work before starting.

As soon as the cut is completed over the whole width, the cutter is brought back, the blank turns through a distance corresponding with the pitch, and the cutting operation is repeated until the wheel is completed.

The machines cutting up to 2 m. (6 ft. 6 in.) in diameter, of the smaller pattern, and those cutting up to 5 m. (16 ft. 4 in.) in diameter, of the larger pattern, are of similar type.

Those for cutting bevel-gears are generally similar also; the main difference, as compared with those for spur-wheels, is that the two beds—the one carrying the blank and the one carrying the tool—are fitted to a common heavy bed-plate on which the former can travel in the direction of the axis of the mandrel, the latter being pivoted in such a way that the axis of the milling-cutter can always be placed perpendicular to the generatrix of the cone; this pivoting action allows the milling-cutter bed to turn through an angle of 90 deg. This applies to the larger machines for taking wheels up to 5 m. (16 ft. 4 in.) in diameter. In the smaller ones, however, for cutting bevel-wheels up to 2 m. (6 ft. 6 in.) in diameter, the bed carrying the milling-cutter and that carrying the blank are cast in one piece; the latter is provided with a turret made adjustable both in a direction perpendicular to the travel of the cutter and round the vertical axis of the turret. The turret carries the mandrel for holding the blanks.

Each tooth is cut in one stroke of the milling-cutter; a second, finishing cut is given, this being only a very slight cut, to rectify any irregularity which may have been caused in the first cut, and to correct any slight differences in the depth of the teeth due to the wear of the milling-cutter.

In appearance, the teeth used in the bevel gears resemble those adopted in ordinary double helical gearing, consisting of two portions meeting at the centre to form a V. Neither leg of the V is straight, and if the tooth be projected on the plane of the wheel, theory shows that the curve then obtained should be a portion of a spiral which may be either a logarithmic

or an Archimedean spiral. The latter form is adopted for the Citroën wheels, and enables them to be cut with absolute accuracy although one single milling-cutter be used, and the sides of the teeth be not touched up.

The new works in question were officially opened on July 22 last, in the presence of a large gathering of engineers; among the British engineers were representatives of the South African A.E.G. Company, of Messrs. Crossley Brothers, and other firms; the company's representatives in the various Continental countries, and several members of the Russian and American Citroën Companies were also present.

THE CANADIAN IRON INDUSTRY AND THE PREMIUMS.

A GERMAN expert, Dr. G. Koch, has investigated the influence of the premium policy, which has now come to an end, upon the development of the Canadian iron industry. This policy has existed, in different phases, for a quarter of a century, and prior to its introduction the industry was of but very small importance, the immediate reason for the adoption of premiums being the collapse of the then largest Canadian iron works at Londonderry, New Scotland. In order to enable this concern to resume working, the Parliament of the Dominion, at the instance of the Government, voted a premium of 1.50 dols. for each ton of pig iron produced in Canada. In the year 1874 the premium was increased to 2 dols., the same premium being granted for puddle iron and steel billets, subject to these articles being manufactured from Canadian raw material. In the year 1897 the premiums were extended so as to comprise also pig iron produced from foreign ore, the premium for such pig iron remaining at 2 dols., whilst that for pig iron from Canadian ore was raised to 3 dols. The premium for steel billets was discontinued, but steel ingots, made to the extent of, at least, 50 per cent. from Canadian pig, received a premium of 3 dols. per ton, as did puddle iron when made exclusively from Canadian raw material. In the year 1903 a fresh Bill was passed, which introduced a gradual modification of the existing premiums at the same time as it introduced a fresh series of premiums for more finished manufactures, 6 dols. per ton for round rolled wire bars, and 3 dols. per ton for rolled angular and T-iron, construction steel, and rolled plates, provided that the pig used for their manufacture was, at least to the extent of 50 per cent., Canadian, whereas the origin of the iron ore was immaterial.

The last regulation of the Canadian iron premium policy took place in 1907, taking effect from the beginning of the year, which introduced a sliding declining scale for the years 1907-10, the premiums terminating with the end of the latter year (with one important except on, which lasted another six months). The premiums were from 2.10 dols. to 0.90 dol. for pig iron of Canadian ore, 1.10 dols. to 0.40 dol. for pig iron of foreign ore, 1.65 dols. to 0.60 dol. for puddle iron of Canadian pig iron, and 1.65 dols. to 0.60 dol. for steel ingots made to the extent of at least 50 per cent. of their weight from Canadian pig. The premium for round rolled wire bars was fixed at 6 dols. per ton from January 31, 1906, to June 3, 1911.

The time affected by the premiums divides itself into two periods: the first to 1897, distinguished by a very small and tardy increase, and the second commencing with the year 1898. The following table shows the output of pig iron during several years:—

	Tons.
1898	77,015
1900	96,575
1902	366,197
1907	646,754
1908	509,957
1909	678,751

The decline in 1908 was caused by the general depression then prevailing. Otherwise the above figures show that the Canadian pig-iron industry during the last ten years shows a more rapid development, in per cent., than that of any other country. In the year 1909 Canada produced about the same quantity of pig iron per inhabitant as did France. No doubt this astounding growth to a great extent is attributable to the premium policy, which also benefited products manufactured from foreign iron ore after the passing of the Act of 1897. During the time when the premiums only referred to produce from Canadian iron ore, the premium policy may, in a measure, be said to have failed. In the year 1909 Canada's consumption of iron ore was only to the extent of 15 per cent. covered by Canadian ore, the bulk being imported from Newfoundland.

It would, however, be rash to draw conclusions from this fact as regards both the quality and the quantity of Canada's iron-ore deposits. In most parts of Canada's eastern States there are extensive deposits of iron ore, and the percentage of iron is fairly high—50 to 55 per cent. In addition, large deposits of hematite have recently been discovered in New Brunswick, but Newfoundland ore is generally preferred, being cheaper in transport.

It is not only the output of pig iron which has so greatly increased of late years. Thus the production of steel rails had reached 268,000 tons even by 1908. This development is also traceable to the premium policy, more especially to the law of 1903, as may be seen from the following instance. In the year 1900 the Algoma Steel Company was started on a large scale, more especially for the manufacture of steel rails, and, although the Government promised to buy 25,000 tons of rails annually for five years, the new concern made no headway. In the beginning of 1905 work was discontinued, not a single ton of steel rails having so far been manufactured. Then came the new law; fresh capital for the working of the Algoma Steel Company was at once forthcoming, and it is now by far the largest manufacturer of steel rails in Canada, having a capacity of 1000 tons per day.

Canada's wire-bar industry also dates from 1903, and by the year 1908 the Dominion Iron and Steel Company in Sidney, at Cape Breton, had an output of no less than 65,000 tons.

The above will show how much the Canadian iron industry of to-day owes to the premium policy, which during the last decade has meant an average of about 1,500,000 dols. in premiums per annum. It now remains to be seen how it will fare without this aid. There is a belief among those able to judge that Canada's iron industry has nothing to fear from the future, but will be able to hold its own, even against the most advanced countries within the iron industry.

THE NATIONAL ELECTRICAL MANUFACTURERS' ASSOCIATION (INCORPORATED).—The reorganisation of the work of the Association has now been successfully carried through, and will shortly be put into effect. It includes the alteration of the title of the Association, which will in future be known as "The British Electrical and Allied Manufacturers' Association (Incorporated)," the appointment of a new secretary, giving his whole time to the work of the Association, and of a larger working staff; the leasing of commodious offices in a central position; and certain necessary amendments of the constitution of the Association to meet the new conditions, including the revision of qualifications for members, associate-members, and associates; and the alteration in the rates of subscription and voting powers.

SMALL-POWER AND MODEL ENGINEERING EXHIBITION.—The third exhibition of small-power engineering appliances, models, and scientific apparatus, organised by the proprietors of the *Model Engineer*, will be held at the Royal Horticultural Hall, Vincent-square, Westminster, S.W., from October 13 to 21 next. As usual, it will contain a collection of high-class working and stationary engineering models of all kinds, and a display of small-power steam, gas, and oil-engines, lathes, and light machine-tools, electrical appliances, and scientific novelties. A feature of the show will be a completely equipped model engineering workshop, in which demonstrations of metal-working processes and small engine building will be given daily. Working model railways and numerous other interesting trade and private exhibits will be provided. Full particulars may be obtained from the organisers, Messrs. Percival Marshall and Co., 26 to 29, Poppin's-court, Fleet-street, London, E.C.

MUNICIPAL TRAMWAY ASSOCIATION.—The tenth annual conference of this Association is to take place in Glasgow, on the 27th, 28th, and 29th inst. A conference will be held at 11 a.m. in the Council Chamber; it will be opened by a presidential address by Mr. Jas Dalrymple, general manager, Corporation Tramways, Glasgow. The following papers will be read and discussed on the same day and following days:—"The Common Good of the City of Glasgow: Its Origin, History, and Present Position in Relation to the Tramways Undertaking," by Mr. Councillor Walter Nelson, Sub-Convener, Glasgow Corporation Tramways Committee. "Tramways Finances and Policy," by Mr. Councillor J. H. Rodgers, chairman of the Newcastle Corporation Tramways Committee. "Tramcar Meters," by Messrs. R. G. and J. G. Cunliffe, technical assistants, Manchester Corporation Tramways. "Report on Tramway Track: Methods of Construction and Maintenance," by the representatives of the Glasgow, Manchester, and Leeds Corporation Tramways. Other meetings to deal with different business questions, and excursions, have been arranged. Full data can be obtained from the secretary, Municipal Tramways Association, Division-street, Sheffield.

POWERFUL BRITISH DREDGER FOR THE PANAMA CANAL.—Messrs. Wm. Simons and Co., Limited, Renfrew, launched on Tuesday, the 12th inst., an extremely powerful bucket-hopper dredger which they have built to the order of the United States Government for carrying out some of the most arduous under-water cutting to be done in connection with the Panama Canal. The dredger is of the twin-screw type, and will make the voyage to the Pacific Coast under her own steam. She has a hopper capacity for 1200 tons of dredgings. The bucket ladder is designed for dredging to a depth up to 50 ft. The vessel is propelled at a speed of 10 knots per hour by two sets of triple-expansion surface-condensing engines, supplied with steam from two cylindrical multitubular boilers, constructed to Lloyd's requirements for a working pressure of 180 lb. per sq. in. The dredging gear is of the most massive description, and is arranged to give three speeds of buckets to suit the various kinds of material to be dealt with. It can be driven by either of the main propelling engines. Two sets of buckets are provided, one of 54 cub. ft. capacity for dredging soft material, and one of 35 cub. ft. capacity for dredging stiff clay. The bucket-ladder is a steel girder of exceptional strength; the ladder, with its chain of buckets, links, and pins, weighs upwards of 240 tons. The upper end of the bucket-ladder is supported on an independent pivot shaft, and the lower end is controlled by powerful steel-wire rope tackle and independent steam hoist-gear, which is designed for raising the ladder at a speed of 10 ft. per minute. Shoots are provided for loading into the vessel's own hopper, and also overboard shoots, controlled by independent steam-winches, for loading into barges alongside. The hopper-doors are controlled by independent hydraulic gear,

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was firm, and 3500 tons of Cleveland warrants were done at 46s. 10½d. cash, 47s. 1½d. one month, and 47s. 7½d. and 47s. 8½d. three months. Closing sellers quoted 46s. 11½d. cash, 47s. 2½d. one month, and 47s. 9d. three months. There was little change in the afternoon, when 1000 tons of Cleveland warrants changed hands at 47s. 9d. three months. The market closed with sellers at 46s. 11½d. cash, 47s. 3d. one month, and 47s. 8½d. three months. On Friday morning an easier tone prevailed, but business was limited to 1000 tons of Cleveland warrants at 46s. 11d. cash and 47s. 7½d. three months, and sellers' closing quotations were down to 46s. 10½d. cash, 47s. 1½d. one month, and 47s. 7d. three months. In the afternoon Cleveland warrants were again down in value, and the dealings consisted of two lots at 46s. 11½d. one month and 47s. 5½d. three months. Closing prices showed a fall of about 3d. on the day, with sellers at 46s. 9d. cash, 47s. one month, and 47s. 6d. three months. On Monday morning the market continued very weak, and the only business was one lot of Cleveland warrants at 47s. 5d. three months. The session closed with prices 2d. down from the previous close, sellers quoting 46s. 7d. cash, 46s. 10d. one month, and 47s. 4d. three months. The afternoon session was again dull and quiet, and Cleveland warrants amounting to 1000 tons were dealt in at 46s. 10d. one month and 47s. 4d. three months. Closing quotations were ½d. up from the morning. On Tuesday morning the market was dead idle, but sellers' quotations for Cleveland warrants were firmer at 46s. 8½d. cash, 46s. 11½d. one month, and 47s. 5½d. three months. The afternoon session was a repetition of the morning, and again no dealing took place, and at the close Cleveland warrants were quoted without change by sellers. When the market opened to-day (Wednesday) the tone was firm, but for the third successive session no business was recorded. Cleveland warrants were ½d. up, at 46s. 9d. cash, 47s. one month, and 47s. 6d. three months sellers. In the afternoon Cleveland warrants were again firmer, and 3500 tons were done at 46s. 9d. cash, 47s. and 47s. 0½d. one month, and 47s. 6d. three months. Closing sellers quoted 46s. 10d. cash, 47s. 1d. one month, and 47s. 7d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 60s. 6d.; Gartsherrie, 61s.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 63s.; Shotts (at Leith), 62s. 6d.; and Carron (at Grangemouth), 63s. 6d.

Sulphate of Ammonia.—The market for sulphate of ammonia is rather dull and quiet this week, with only a moderate demand. No change, however, falls to be noted in the price, which is still quoted at 14*l.* 2s. 6d. per ton for prompt delivery, Glasgow or Leith.

Scotch Steel Trade.—The Scotch steel trade continues to move along on satisfactory lines, and makers are being kept well employed. Specifications for both ship and boiler-plates are fairly plentiful, but the demand for angles is only moderate. Shipment inquiries have recently been very good, and quite a lot of general material has been booked. South America and Japan have each been good customers for plates and sectional material, and heavy deliveries are the order of the day, while Canada is presently inquiring for considerable quantities of light material to be delivered before navigation closes for the year. Some fresh business in ship and boiler-plates has just been fixed up with Continental buyers. For black and galvanised sheets the demand is still as large as ever, and a good trade—home and export—is being put through, and prices continue to have an upward tendency.

Malleable-Iron Trade.—Malleable-iron makers are fairly well employed, but specifications, which are mainly against old contracts, are hardly sufficient to keep the various establishments running full. No change has taken place in prices, which are so low that there is little or no visible margin of profit.

Scotch Pig-Iron Trade.—The trade in Scotch pig-iron has been very fair during the past week, with local consumers buying a little more freely, and with the orders from the South showing a slight increase. The export trade is about normal, and it falls to be reported that another cargo of Scotch iron has been sold for shipment to Russia. The hematite position is practically unchanged either as regards demand or value. The current price is quoted at 65s. per ton, but it is doubtful if more than 64s. needs to be paid at present.

THE STEAM-TURBINE: ERRATUM.—On page 308, column 1, line 24 from the bottom, in place of "The effect of tip clearance is to increase the weight of steam passed per horse-power developed," read "The effect of tip clearance is to diminish the horse-power developed per pound of steam passed."

UNIVERSITY OF LONDON, KING'S COLLEGE.—Particulars of the special advanced lectures and courses in civil, mechanical, and electrical engineering subjects, arranged for the forthcoming session, have reached us from King's College. The lectures, some of which commence early in October and others in January, are to be delivered in the evening, and, if desired, drawing and laboratory work in connection with them may be taken in the daytime. The subjects include irrigation, water supply and sewerage, internal-combustion engines, steam-turbines, electric generating-stations, electric traction and lighting, electric power in mines, &c. Full particulars may be obtained from the Secretary, King's College, Strand, W.C.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Steam coal is at present in a very good position. Not only is there a big demand for shipment, but the call for industrial purposes is steadily maintained in its recent strong volume, and several manufacturers are increasing their reserves in view of emergencies, such as trouble amongst the miners. The recent industrial upheaval lends an added force to the rumour of a colliers' strike, which generally begins to circulate at this period of the year. The rumour also appears to have caused considerable anxiety to householders, for house-coal merchants have been almost overwhelmed with orders during the past week. Of course, the decision to make a general advance of 1s. per ton in house-coal prices must also be taken into consideration in assigning the cause of the present heavy demand, with which collieries are having considerable difficulty to cope. The congestion at sidings and the scarcity of empty wagons has made it impossible for them to work full time. The demand, in the first instance, was responsible, with the conditions at collieries as described, for the decision to advance prices, but now that these advances are coming into effect the rush is, of course, even greater. The advances will not apply on contract deliveries until October 1. Reverting to hard coal, prices are very firm and have a tendency to increase. The inquiry for gas coals remains good, and many works are still adding to their stocks. Shipments also are good. Slacks are in a very strong position, and the coke trade is good. Week-end quotations on 'Change were:—Best branch hand-picked, 13s. 6d. to 14s. 6d.; Barnsley best Silkstone, 11s. to 12s.; Silkstone, 10s. to 11s.; Derbyshire house, 8s. 6d. to 9s. 6d.; best large nuts, 8s. 6d. to 9s. 6d.; small nuts, 6s. to 7s.; Derbyshire best brights, 10s. 6d. to 11s. 6d.; Yorkshire hards, 8s. 3d. to 9s. 3d.; Derbyshire hards, 8s. to 9s.; washed nuts, 7s. 6d. to 8s. 6d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. 3d. to 5s. 3d.; smalls, 2s. to 3s.

Iron and Steel.—Transactions in iron have been on a moderate scale during the week. Both the users of hematites and common irons manifest a tendency to hold out for price concessions, which all the makers are not prepared to give, particularly the Lincolnshire iron-producers, who are maintaining their policy of sacrificing business rather than under-cut official rates. There has, however, been some underquoting in hematites, which are not now in quite so good a position as a few weeks ago, when considerable buying rendered consumers temporarily independent of the market. Derbyshire forge is selling at a figure which, compared with the Lincolnshire brand, gives a decided advantage to buyers, but foundry sorts are about the same in the two counties. The majority of the local steel manufacturers continue to be absolutely fully employed. Many of them have not yet got abreast of work which was delayed by the strike, and as this was of unusual proportions for the time of year, the present briskness in trade is likely to continue for some little time. Also there are a fair number of new orders coming in. At the same time it is felt that the weight of forward orders being received is not what it should be to ensure a really prosperous winter. This, of course, may mean much or little. There is plenty of time for the work to come forward, and the indications seem to point to a continuance of the existing prosperity. In armaments, for example, conditions are excellent. There is any amount of work in the hands of the three Sheffield firms, not only for the home Government, but on foreign contracts as well. One very unmistakable sign of the position of affairs in this branch of local trade is the fact that the export of armour-plates has recommenced after a lapse of about three years. Subsidiary orders in this connection are also finding good work for the foundries and forges. The home engineering trade appears to be improving. A big order for hydraulic plant for a railway-wagon works, consisting of a 1500-ton press, with the necessary pumps and accumulator, the plant to be electrically driven, has just been booked by the Brightside Foundry and Engineering Company. The home demand upon makers of engineers' tools is considerable. Exports of the lighter steels and all kinds of tools are most gratifying, and markets in the Colonies and on the Continent, particularly Russia, are steadily expanding. Gas and oil-engines figure well in the export lists. A considerable weight of finished goods is still being held up at the ports, consequent upon the railway troubles, and several importers expect to have to face losses on foreign work of varying magnitude. Following upon the expected placing of orders for rolling-stock by the railway companies, the railway-steel manufacturers are pretty well occupied.

THE PENINSULAR AND ORIENTAL STEAM NAVIGATION COMPANY'S LINER "MALOJA."—This large twin-screw steamer, built by Messrs. Harland and Wolff, Limited, for the Peninsular and Oriental Steam Navigation Company, left Belfast, on the 9th inst., after adjustment of compasses and successful trials, and proceeded to London, from whence she will sail on her first voyage to the East on the 23rd inst. The Maloja is a passenger and mail steamer of the highest class. She is 569 ft. long by 62 ft. 9 in. beam, with a gross tonnage of 12,500. She has two steel pole masts and two funnels, ten watertight bulkheads carried up to the spar-deck, and seven steel decks. The double bottom extends right fore and aft, the depth and strength being increased under the engine-room, giving great rigidity to the structure. The Maloja has accommodation for over 450 first-class and about 220 second-class passengers. She has two sets of quadruple-expansion engines, arranged on the "balanced" principle, also constructed by Messrs. Harland and Wolff, Limited.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business is very slack for this season of the year, when there is usually brisk buying to meet autumn requirements. There is a want of confidence in the market, due chiefly to labour unrest, and buyers are holding off. Many traders, however, express the belief that improvement is at hand, and that consumers of pig will be compelled to come forward and purchase to satisfy their needs over the fall of the year. Quotations move very little. No. 3 g.m.b. Cleveland pig is 47s. for early f.o.b. delivery, at which figure both makers and merchants are prepared to sell. No. 1 is very scarce, and is quoted 51s.; whilst No. 4 foundry and No. 4 forge are each 46s. 6d.; and mottled and white iron each 46s.—all for early delivery. East Coast hematite pig continues very dull and difficult to sell. The generally recognised market quotation for early delivery of Nos. 1, 2, and 3 is 61s., but it is understood that producers, as well as merchants, would accept a lower price; and, in fact, a substantial sale has been made at 60s., but the transaction was under exceptional circumstances. There is little or nothing passing in foreign ore, and market rates remain nominally on the basis of 19s. ex-ship Tees for Rubio of 50 per cent. quality. There is a very plentiful supply of coke, with the result that quotations are easy, notwithstanding the heavy local consumption. Average blast-furnace coke is on sale at 14s. 6d. delivered here.

Stocks and Shipments of Pig Iron.—Stocks of pig iron in the public warrant stores are now slowly, but steadily, decreasing. This month Cleveland pig is being withdrawn at the rate of 370 tons per working day, but the stock still stands at over 590,000 tons. Shipments of pig-iron are on an excellent scale. To date this month they average 4612 tons per working-day, as compared with a daily average of 4134 tons to the same date last month, and 4301 tons for the corresponding part of September, last year.

Manufactured Iron and Steel.—Very satisfactory and encouraging reports continue to be given of the various branches of the manufactured iron and steel industries. A great deal of work is being turned out, producers have good contracts made, and there are fairly good inquiries in the market. Under these favourable conditions values tend upward, but up to the present no actual changes have been made. Principal market quotations stand:—Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron girder-plates, 6*l.* 17s. 6d.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 10s.; steel bars, 6*l.* 5s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and galvanised corrugated sheets, 11*l.* 5s.—sheets less 4 per cent. f.o.b., railway material net at works, and all other descriptions less 2½ per cent. discount.

NEW FLOATING DOCK FOR ROTTERDAM.—Messrs. Swan, Hunter, and Wigham Richardson, Limited, launched, on the 8th inst., from their Wallsend shipyard a new floating dock built to the order of Wilton's Engineering and Slipway Company, of Rotterdam, being the second that they have built for this company. The dock is 365 ft. long and 81 ft. wide. It is a double-sided self-docking dock of the type known as the "Bolted-Sectional," designed by Messrs. Clark and Standfield, of Westminster. It is built in three sections, which are bolted together, and are disconnected only when self-docking is required for painting or repairing the under-water parts. Any two sections of the dock can lift the third section to a height sufficient to allow barges and workmen to pass underneath. The pumps are centrifugal and are directly driven by electric motors. The installation is divided into three parts, each one working one of the sections of the dock independently. The three sections of the dock were launched separately, about half an hour elapsing between succeeding events, and shortly after the whole dock was bolted together in the river. The dock will be towed to Rotterdam.

DIESEL-ENGINE-PROPELLED TANK-SHIP.—We are informed by the Nederlandsche Fabriek van Werktuigen en Spoorweg-Materieel, Amsterdam, that the tank-ship Vulcanus, built by them in 1910, and propelled by a six-cylinder 500-brake-horse-power Werkspoor Diesel engine, has recently completed a journey from Rotterdam to London, Constantza (Roumania), Hamburg, returning afterwards to Rotterdam. The engine is in a very good condition. In Constantza the ship created great interest, and shortly after its arrival it took a number of local authorities for a trip on the Black Sea. The following are data concerning the journey in question:—

Trip.	Time.	Sea-Miles.	Displacement.	Fuel Consumption.
	days hrs. min.		tons	tons
Rotterdam to London..	0 19 45	141	2200	1.8
London to Constantza	19 4 15	3263	1480	37.5
Constantza to Hamburg	20 22 35	3595	2180	42.0
Hamburg to Rotterdam	1 19 0	360	1360	2.0

These figures show a remarkably low fuel consumption; the company estimate this to be less than one-fifth of the coal quantity which would have been required for a steamship having the same characteristic features and performing the same journey.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Business in steam coal has been somewhat restricted; arrivals of steamers have not come up to expectations, and it is feared that the tonnage position will remain unfavourable until the dislocation occasioned by recent strikes has been overcome. Should, however, the Morocco difficulty result in war, a heavy demand for Welsh coal would at once follow. It appears that the Lords of the Admiralty have been forwarding coal by railway to North-Eastern ports, so as to accumulate reserves to meet the requirements of British warships. The best large steam coal has made 18s. to 18s. 3d. per ton; ordinary qualities have ranged between 16s. and 17s. 6d.; best ordinary bunker smalls between 8s. and 8s. 6d.; and cargo smalls between 6s. 9d. and 7s. 6d. per ton. House coal has shown little change. The best ordinary qualities have been quoted at 14s. 6d. to 16s. 6d. per ton. No. 3 Rhondda large has realised 17s. to 17s. 6d.; and smalls, 10s. 3d. to 10s. 6d. per ton. No. 2 Rhondda large has brought 12s. 3d. to 12s. 6d.; and smalls, 7s. 3d. to 7s. 6d. per ton. Foundry coke has been making 18s. to 20s. 6d.; and furnace ditto, 16s. to 17s. per ton. As regards iron ore, Rubio has been quoted at 18s. 3d. to 18s. 9d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Welsh Coal for Italy.—Elaborate arrangements are being made for conveying Welsh coal to Italy for the State Railways and the Italian navy. The coal is to be carried only in Italian vessels, and the amount allowed for freight is to be 7s. 11d. per ton. Subsidies, amounting in all to 10,500*l.* per annum, are also promised.

More Welsh Coal.—The Cambrian Anthracite Company, Limited, has taken over the undertaking of the New Blaenaw Colliery, belonging to Mr. Griffith V. Davies, Llandebie. The old Pwllylord pit has been reopened by the company, a pit-head has been put up, and engines and boilers fixed, and the management has been successful in proving the well-known Triquart seam. The company has now under consideration the development of the taking either from Pwllylord pit, or from the plant on Dogsbrook Farm. A 3-ft. seam has been struck. At Wernos Colliery, Pantyffynnon, in driving down to the Stanllyd vein from the Pumpquart, a new vein has been struck and worked through.

South Wales Coal.—The exports of coal from the six principal Welsh ports—Cardiff, Newport, Swansea, Port Talbot, Neath, and Llanelly—in August were 2,215,764 tons, as compared with 2,419,959 tons in August, 1910. The shipments, accordingly, exhibited a decline of 204,195 tons last month—in consequence, no doubt, of the disturbed state of the labour world. The shipments of coal from Cardiff in the eight months ending August 31, this year, were:—Foreign, 10,196,417 tons; coastwise, 1,727,729 tons; total, 11,924,146 tons. Newport—foreign, 2,923,250 tons; coastwise, 435,926 tons; total, 3,359,176 tons. Swansea—foreign, 1,859,872 tons; coastwise, 172,379 tons; total, 2,032,251 tons. Port Talbot—foreign, 1,051,368 tons; coastwise, 103,974 tons; total, 1,155,342 tons.

EXHIBITION OF MARINE OIL-ENGINES.—Arrangements have now been completed for deferring the Newcastle Exhibition of Marine Oil-Engines and Shipping from November, 1911, to March, 1912. This will permit engines to be shown running under their own power, a feature that makes an exhibition particularly valuable.

OUR RAILS ABROAD.—It appears probable that our rail exports will show a marked contraction this year. The shipments in August only amounted to 21,071 tons, as compared with 47,624 tons in August, 1910, and 52,273 tons in August, 1909. There was a complete absence in August of shipments of rails to Argentina, and the Australian demand also exhibited a considerable falling-off. In the eight months ending August 31, this year, we sent abroad 237,104 tons of rails, as compared with 314,411 tons, and 400,081 tons in the corresponding periods of 1910 and 1909.

LONDON COUNTY COUNCIL SCHOOL OF BUILDING.—Particulars of evening classes and courses of instruction suitable for artisans and others engaged in the building and allied trades are given in the prospectus of this Institution, which is situated in Ferndale-road, Brixton, S.W. The fees charged are extremely moderate, and this fact should help to ensure a large attendance during the ensuing session, which commences on the 18th inst. The prospectus is divided into three sections, the first of which deals with trade classes in brickwork and masonry, carpentry and joinery, plumbing and sanitary engineering, painting and decorating, plastering, wood-carving, &c. The next section relates to lectures and classes in building construction and drawing, reinforced-concrete construction, and structural steel-work, building and quantity-surveying, land-surveying and levelling, valuation, builders' office-work, and the chemistry and physics of building materials. Section III. gives particulars of classes in architectural design and drawing. We note with interest that attention is being given to the theory and practice of reinforced-concrete construction, the scope of the course in this subject, which was only commenced last session, having been considerably extended. Apparatus and tools for practical work and testing have also been added recently, and a special feature is made of this part of the work. This activity is rather surprising in view of the fact that the Council's building regulations are so adverse to this method of construction.

MESSRS. ANDRÉ CITROËN & CO.'S DOUBLE HELICAL GEAR-CUTTING WORKS, PARIS.

(*For Description, see Page* 352.)

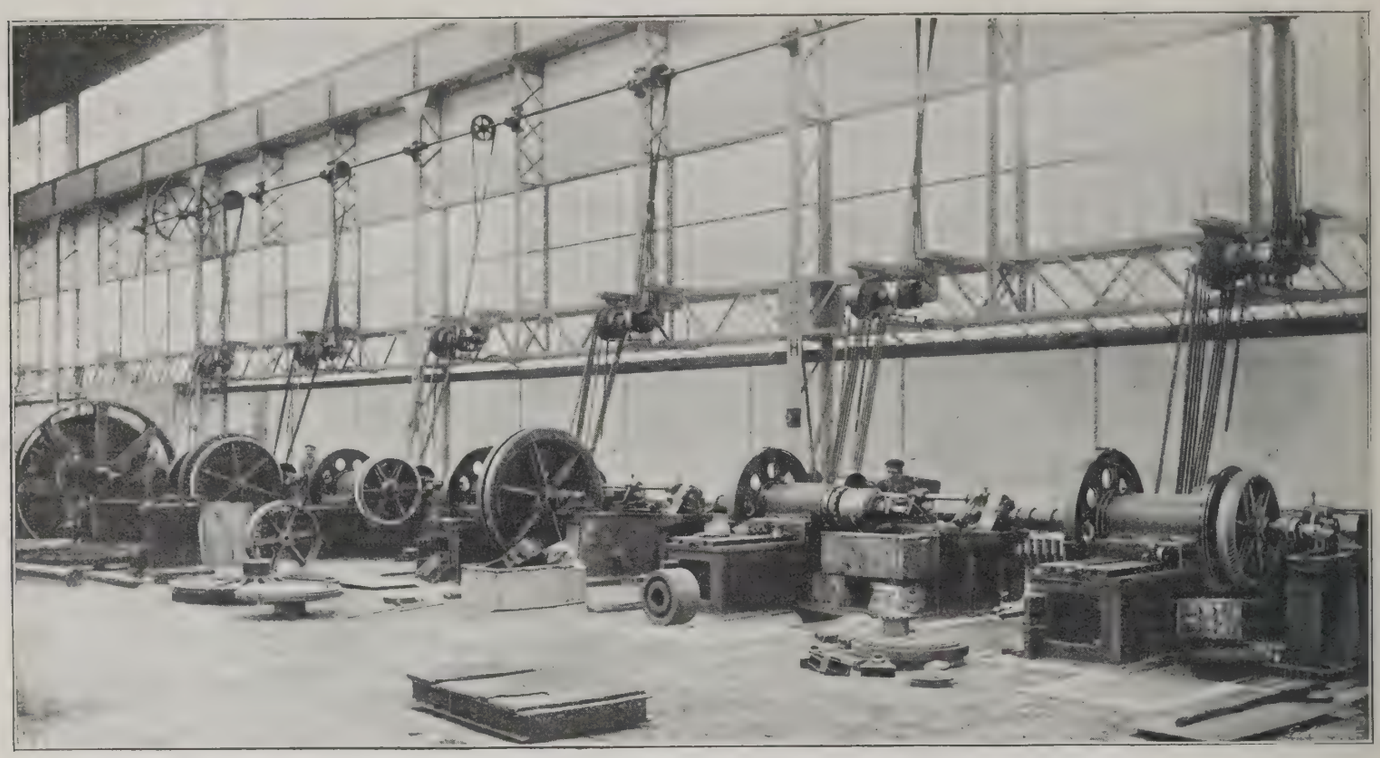


Fig. 5. Bevel and Spur-Wheel Gear Cutting.

Fig. 6. General View in Main Bay.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Thin paper copies	£1	16	0
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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

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We desire to call the attention of our readers to the fact that the above is our SOLE Address, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS—"ENGINEERING," LONDON.
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With a Two-Page Plate of the CANADIAN LAKE AND RIVER TWIN-SCREW STEAMER "SAGUENAY."

NOTICE OF MEETING.

THE INSTITUTE OF METALS.—Wednesday, Thursday, and Friday, September 20, 21, and 22. Autumn Meeting at Newcastle-on-Tyne. Wednesday, September 20, at 10 a.m., general meeting of members at Armstrong College; 10.30 a.m., after short addresses of welcome, a selection of papers will be read and discussed; 2 p.m., visits will be paid to certain works of metallurgical interest in Newcastle-on-Tyne and neighbourhood; 8.30 p.m. to 10.30 p.m., reception by the Right Hon. the Lord Mayor (Sir W. H. Stephenson, D.L., D.C.L.) at the Laing Art Gallery, followed by Conversazione. —Thursday, September 21, at 10 a.m., general meeting of members at Armstrong College; a selection of papers will be read and discussed; 2 p.m., visits will be paid to certain works of metallurgical interest in Newcastle on-Tyne and neighbourhood; 8 p.m., dinner given by invitation of the local reception committee at Tilley's Restaurant, to those members and their ladies staying for the river excursion on September 22.—Friday, September 22, river excursion in the s.s. J. C. Stevenson to the harbour mouth at Tynemouth and back. The steamer will leave Newcastle Quay at 10 a.m., and will arrive back in Newcastle about 1.30 p.m. The following is a list of the papers that are expected to be submitted: —"The Corrosion of Brass, with Special Reference to Condenser Tubes," by Mr. P. T. Brühl, M.Sc.; "Further Note on the Nature of Solid Solutions," by Mr. C. A. Edwards, M.Sc.; "The Electrical Conductivity and Constitution of Alloys," by Dr. W. M. Guertler; "Volume Changes in the Alloys of Copper with Tin," by Mr. J. L. Haughton, M.Sc., and Professor T. Turner, M.Sc.; "Non-Ferrous Metals in Railway Work," by Mr. George Hughes; "The Failure of a Brazed Joint," by Professor H. Louis, M.A., D.Sc., Assoc. R.S.M.; "The Mechanical Properties of Hard-Drawn Copper," by Mr. D. R. Pye, B.A.; and "The Alloys of Aluminium and Zinc," by Dr. W. Rosenhain, B.A., and Mr. S. L. Archbutt.

ENGINEERING.

FRIDAY, SEPTEMBER 15, 1911.

MOTION STUDY.

REFORMERS in all walks of life are apt to weaken the effect of their case by overstating it, and the authors and preceptors of the doctrine of motion study are no exception to the rule. This is well illustrated in a recent work, bearing the title "Motion Study," from the pen of Mr. Frank B. Gilbreth, and published in this country by Messrs. Constable. Mr. Gilbreth is one of the authors, or, at any rate, one of the protagonists, of motion-study ideas, and his pages presumably give a fair account of their scope and aim. The work is of much interest, but its value is impaired by the fact that many of the results claimed by it are clearly not due to motion study at all, while it carries an additional weakness in the sweeping and somewhat wild possibilities which it credits to motion study. These sweeping claims are likely to alienate the sympathy of any one making acquaintance with the doctrine for the first time through its pages.

Motion study has been much discussed and experimented with in America, while its general principles have been brought to the attention of the engineering profession in this country at various times, as, for instance, by Mr. F. W. Taylor at the summer meeting of the Institution of Mechanical Engineers at Birmingham. In approaching a discussion of the matter, it will, however, be well to state in brief what motion study actually is. The underlying idea of the system is that a workman, in carrying out any operation, is apt to, and normally does, make a large number of unnecessary and wasteful motions, so that he not only spends more time over the operation than is really requisite, but also wastes considerable muscular effort. The claim of the motion-study believers is that, by carefully observing and recording the workman's motions, it is possible to so rearrange them as to eliminate the wasteful ones, with the result that the operation may be carried out in much less time and with much less effort. The claims, of course, are not restricted to one operation, and it is held that, by suitable instruction, it is possible to at any rate double the work which a man can do.

It must be observed that the savings due to motion study are claimed in connection with the most obvious and simple operations. Mr. Gilbreth's own work in connection with the matter has chiefly had to do with brick-setting, in which he claims that he has enormously increased the output of work per man. But other examples are quoted in his book, as, for instance, a case of a girl putting papers on boxes of shoe-polish. She was observed by Mr. Gilbreth to complete twenty-four boxes in forty seconds, and by carefully noting her motions for a short time he was able to suggest a method to her on which she was able to complete the same number of boxes in twenty seconds. The girl was not working any harder, she was merely doing the same work with fewer motions. This, and other examples, which Mr. Gilbreth gives, are certainly very remarkable, and cannot be ignored; but in face of a series of such unusual claims, it is only reasonable and sensible to examine the evidence pretty closely to discover if there are any explanatory factors which are ignored or not dwelt upon by the witness. In the case of the girl with the shoe-polish it is impossible to offer any criticism, as no details of the matter are given; but in the case of the brick-setting, with which the book is mainly concerned, it is easy to show that the increased outputs obtained were by no means all due to motion study. We do not for a moment suggest that there is nothing in the underlying ideas of motion study, but, in view of the breadth of the general claims which are made for it, it is only ordinary sense to examine fairly closely the detail evidence which is put forward as proof of its value.

We take it that there is no unfairness in taking the data and arguments given in Mr. Gilbreth's book as representative of the essentials of motion study as practised, not only in bricklaying, and by Mr. Gilbreth, but also in other trades and by other believers. This being so, it is of much importance to note that two entirely different matters are confused throughout the book, and hence presumably throughout the whole theory and practice of the doctrine. One of these matters is new, the other is not. The first is motion study proper—*i.e.*, the study and regulation of the actual motions made by a workman in carrying out an operation. This is the essential matter of the motion-study doctrine, and all that is new in it. The second matter is concerned with the economy, both in time and labour, of production, which may be brought about by the use of suitable tools and labour-saving appliances. There is nothing new in this latter point. It is but one of the outstanding features of the development of modern manufacturing processes. None the less, Mr. Gilbreth claims to the credit of motion study the savings he has achieved by the introduction of new tools and appliances. We do not doubt that he has obtained the savings he claims; but our point is that these savings add not a jot of evidence towards the value of motion study. Mr. Gilbreth makes several references to a fountain-trowel for brick-setting, which he has introduced, to an adjustable scaffold, and even to such workshop details as drilling-jigs. The examples he refers to may be, and no doubt are, improvements over tools previously used, but they are only examples of a class of improvement which is being carried out every day and all over the world by people who never even heard of motion study.

In a sense, of course, all new appliances designed to save trouble and to enable operations to be carried out more quickly are developments due to motion study; but to refer to them under that name, in view of the special meaning which it has come to have, is simply to confuse the issues. The fact that one gives a fireman a shovel instead of a garden trowel to handle coal with is but an example of motion saving, since with the shovel he can do the same work with fewer movements and with less total effort. But Mr. Gilbreth and his compeers cannot claim saving due to the use of suitable tools for the work in hand—such as shovels instead of trowels for handling coal—or saving due to improvements in tools, and put it down to the credit of motion study. If he does this, he is merely giving a new name to an old thing, and his whole discussion becomes one of words, and not of things at all. That tools and labour-saving appliances owe something of their value to the fact that they save unnecessary motions on the part of those who use them is obvious. But that is not Mr. Gilbreth's point. His position is that, given the tool, then for the best effect the workman must be instructed exactly how he must use it, exactly how many motions he must make with it, where he must put his feet when he is using it, how he must place his hands. In fact, he must be instructed in every detail as to what he is to do. He must be drilled. He must be treated like a machine. If he is picking up a brick, he must do it with a certain hand in a certain way. He must be told where he is to put his thumb and where he is to put his fingers. This is motion study proper, and whether there is anything in it or not, it is certainly by no means the same thing as supplying bricks to a bricklayer in such a position that he can easily reach them without stooping or stretching. The failure to differentiate between the saving which has resulted from motion study and the saving which has resulted from the introduction of improved appliances, greatly lessens the value of the results of his methods which are given in Mr. Gilbreth's book. The distinction between the two types of saving is quite radical. At the present day, no one is going to suggest that for certain jobs pneumatic riveting is not better than

handwork, but many will be found to suggest that, given a pneumatic riveter, it is not desirable definitely to instruct a workman as to the way he is to use it, that it is not desirable to tell him where to put his right foot and where to put his left, what to do with one hand and what to do with the other. As we said, it is impossible to disentangle the savings which Mr. Gilbreth has obtained as a result of motion study and as a result of improved appliances; but one is quite ready to believe that some at least of his savings were due to the former, and some consideration of it divorced from the extraneous matter with which he has overlaid it will be of interest.

The truth of the matter as to the value of motion study, as with many other matters, probably lies in a compromise between complete acceptance and complete rejection. It is likely, indeed it is certain, that a careful study of the motions made by an average workman in carrying out a job will show that by slightly modifying his practice the time taken to do the job might be cut down. And if the results of such study are used in a moderate way, and as an aid to suggestion, and particularly as an aid towards improvement in the appliances the workman uses, they are likely to be of value. We doubt their efficacy, however, if they are to be used as the foundations for a cast-iron code, which is to instruct the workman as to what he is to do in every detail. A man is not a machine, and no good can come from trying to make him one. Mr. Gilbreth himself says, "nearly every proficient workman loves his trade. He loves the joy of achievement." We agree that largely this is so, but we do not agree that any workman, and more especially the better one, can love as well, or take the same interest in his work, when every possibility of personal initiative and individual treatment has been eliminated from it by a cut-and-dried accumulation of formulæ. The development of manufacturing processes is already rendering the worker's craft ever more and more mechanical. This is a development which appears to be inevitable in modern life, but in itself it has never appeared to have any virtue, and it is difficult to persuade oneself that good can come from going out of one's way to cramp the worker's personality, not only by means of the appliances he uses, but also by means of a rigid control of the motions of his body. Mr. Gilbreth mentions military training as an example of what can be accomplished by means of motion study, and suggests that the care and attention given to training the motions of men for the art of war may well be bent towards training others in the arts of peace. The point is superficially a good one, but in reality it proves nothing. Mr. Gilbreth should show that this military training leads to a better class of worker and better class of achievement than the more elastic methods of the workshop, if he is to make his point. But he does not show this, and we do not believe that he or anyone else could do so. The available evidence all tends to show that the drill-master methods of the Army would have no advantages over present ways in the training of workpeople, and that the only result of adopting them would be a depreciation in the personal ability and initiative of the workman. There is little enough room for the intrusion of personality in the manipulation of a capstan lathe as things are, and we do not and cannot believe that ultimate good can come from codifying every movement that is to be made in the operation of one, so that the man and machine together become a sort of automatic tool.

The ultimate results and developments which Mr. Gilbreth apparently expects, and certainly claims as possible for his methods, are remarkable. Indeed, they are more than remarkable; from the point of view of practice and common-sense they may well be described as naïve. We admit that, logically speaking, Mr. Gilbreth does not weaken his case by the excessive claims he makes, but he will certainly tend to rouse opposition and alienate sympathy. He suggests and states that his methods, if adopted, would result in such cheapening of production that half the workers of a country might be pensioned off under full pay. He claims that his methods would raise the standard of all classes, would do away with differences between employers and employed, would eliminate waste, raise the wages of all workers, and reduce the cost of living. These are brave sayings, but there is nothing very new in them. They are the commonplaces of poets and preachers without end. If men could but be got to adopt and live up to this theory or that, all the ills of life would disappear—no doubt they would; but men cannot be got to do things in the wholesale way that is necessary to bring in Mr. Gilbreth's or anyone else's golden age. We, too, could tell of all sorts of things that would happen if all men were brave and wise and all women true and beautiful, and if all geese were swans, and it never rained on Sundays.

The quite visionary nature of Mr. Gilbreth's ideas is perhaps best illustrated in the fact that one of the foremost of them is the reclassification of all the trades. His book is, of course, concerned with American conditions, and his idea is that the United States Government should investigate the motions made by workmen in all trades, and should investigate the ground the various trades cover, so that entirely new classifications could be made, and any operation now carried out by, say, boilermakers' platers which seemed to fall better within the scope of engine fitters would be turned over to the latter; in addition, detail instruction-cards would be published laying down the exact method in which every operation was to be carried out, and which would demand that a man, say, drilling a $\frac{1}{2}$-in. hole should put his left foot here and his right foot there, and so on. We do not wish to be unfair in connection with this matter, but it would obviously be very easy to make the whole of these proposals appear very ridiculous, and we think that Mr. Gilbreth seriously weakens the value of his book, and renders it liable to less attention than it deserves, by committing himself to flights of fancy of this order. The work he has done is of much interest and considerable value, and certainly establishes a very suggestive way of regarding manual operations; but he, and anyone el-e, will find quite enough difficulty in establishing his methods in the limited way which we hold to be valuable, without saddling themselves with the reorganisation of society in addition.

As we said, Mr. Gilbreth's book is written from the point of view of American conditions, and we are, of course, inclined to look at it with English eyes. As far as this country is concerned, he, or any of his disciples, will find that it will take more time than their lives can ever spare to persuade the workman that restriction of output does not increase employment; and yet the acceptance of this idea is but the most preliminary step in the introduction of modern-study methods. Although one having any knowledge of the mental attitude of labour in this country would have no difficulty in anticipating its general attitude towards Mr. Gilbreth's ideas, it is none the less interesting to have an official or semi-official pronouncement on the subject, and, fortunately, such is available. In the *Standard* during the early part of March of this year a series of articles appeared which described the essentials of motion study in a very fair way. These articles were followed up by reports of a series of interviews with well-known labour men, and their reception of the proposals did not suggest that Mr. Gilbreth, or any one else, would find it at all a simple matter to induce the workmen of this country to accept either motion-study ideas or the conditions which they stand for. Mr. George Barnes's attitude briefly was that if the adoption of the new methods would increase the productivity of labour, the only result would be that the employers would be able to do their work with fewer men, and that labour would obtain no advantage from the arrangement. Mr. John Ward, M.P., general secretary of the Navvies' Union, thought that labour would not profit by the scheme, and that it was doubtful if the employer would either. Mr. G. J. Wardle, M.P., condemned the whole of the proposal, and suggested that one might as well chain men to galleys at once if such methods were to be introduced. These ideas are but characteristic of the general attitude assumed by the labour men who were interviewed, and suggest that those who believe in motion-study methods have years of work before them if they are to introduce them into this country; while those who have no faith in them need have little fear that we are on the eve of a revolution in our industrial methods.

THE ADMIRALTY AND NAVAL ENGINEERING.

Now that the cadets who entered the Naval Service under the "common entry and training system" introduced in 1902 are about to attain official rank in the Fleet, the Admiralty have issued additional instructions regarding the preliminary work of these sub-lieutenants and the apportionment of officers to special duties in the engineering, gunnery, torpedo, navigation, and marine departments. These instructions, we may say at the outset, do not allay our anxiety, expressed time and again during the past seven years, as to the adequacy of the practical course of engineering embraced in the scheme of training for the specialised duties which devolve upon the engineers who have to deal with the extreme complications now common in warships. Resisting the temptation to enter once more upon this subject, upon which nearly all engineers are agreed, we content ourselves here with a consideration of the course now mapped out by the Admiralty for the immediate future.

For the next two years the embryo officer, irrespective of his ultimate function and position in the *personnel* of a ship, will serve afloat. During that period three weeks in every quarter will be served in the engine-room in the discharge of the ordinary duties of a junior engineer officer. For the officer whose later work is to be on the bridge, or on deck, this may suffice, especially as during the past nine years such officers have been devoting a considerable time to study of, and observational instruction in, various mechanical subjects. But for the officer who is, by choice, or by Admiralty selection, to be responsible for work in the engineering department of the ship in later years, the time stipulated is inadequate. It would seem from the amounts of time devoted to the various subjects that those in authority regard the relative value of the machinery in a warship at 23 per cent. of the entire structure. This is so obviously a depreciation of the importance of speed in tactics, to say nothing of other matters in which efficient engineering skill is all-important, that little argument is necessary to prove its fallacy. It is true that, as we shall presently explain, lieutenants selected for engineering duty will undergo a further specialised training; but in this two years' early course there will be consolidated that feeling, which has been suggested for nine years to the mind of young officers, that engineering is of secondary or tertiary importance, and unworthy of permanent acceptance as the subject of a life's work. That, indeed, is one of the strong reasons against the common entry and training scheme. Under it engineering has become a series of little by-paths on the climb up the hill of success in naval life; these are frequented by youths, at the command of the curriculum, for a short period, the main road to the admiral's bridge being always the dominant objective. A youth has always difficulty in concentrating effort until he is certain that he is working towards a definite goal. Indecision as to the ultimate destination breeds indifference.

One year after attaining the rank of sub-lieutenant—a year hence—choice may be made of one or other of the branches of the Service; but a definite confirmation, or compulsory selection, will not be made until two years from now. Each officer is to indicate his first preference, giving also his alternatives in order. The authorities will fill up the requirements of each branch, and it may—we should say it certainly will—result that many officers will be appointed to branches, especially to engineering, who have no great ambition in that direction. Time will tell; so that we need not discuss this question, nor enforce the view that the making of a man an engineer against his desires cannot conduce to efficiency in the Service. When nominated a lieutenant (E.) he is to attend special engineering classes at Greenwich College for six months. The engineering course at Greenwich has done wonders for the present engineers, but it must not be forgotten that they laid a splendid foundation in their previous training, in which practical work formed a most important part. Following the Greenwich course, a year is to be spent in practical work in one of the dockyards. If successful in examination at the end of this period, the lieutenant (E.) will go into the Service as a junior engineering officer afloat, getting 4s. per day. He will be a member of the military branch, conform to its regulations, and obtain promotion accordingly, his pay as commander becoming 5s. per day.

A few officers will be selected from the lieutenants (E.) to undergo a two years' course of scientific training at Greenwich College and a year at sea in order to provide a flow of engineering officials at the Admiralty and dockyards. Upon proving their

ability by examination they become specialists, and will be designated by E.† after their rank. These specialists will be paid 5s. per day as lieutenants, 7s. as commanders, and 7s. as captains plus 5s. as command money. In this case, as with ordinary officers (E.), charge pay, senior engineers' allowance and flag allowance will be paid as at present. The specialists will serve in ships if no shore appointment is available. Captains (E.†) may be promoted to flag rank, but will not take command of sea-going ships or fleets.

These specialists, as well as the ordinary officers (E), may, on passing the examination for commander, leave the engineering branch of the Service and take up deck duties. Here, as throughout the whole system, there is displayed a complete lack of appreciation of the importance of ripe practical experience in the engine-room. It is notorious that in the past the "loaves and fishes" have gone to the military officer. The Admiralty have encouraged this by the abundance of distinctions, decorations, and other honours conferred on the military officer, and by the neglect of the engineer when such recognition was made for faithful service. When distinguished visitors are received the engineer is forgotten; this is a small affair, but it is not without its effects. There are, too, many allowances to the navigating and bridge officers in pilotage money, &c., which materially increase their emoluments. And, finally, there is the higher rank, and the possibility of winning glory in the command of a ship or a fleet. These superior inducements of the military branch will be ever present to the engineering officer, especially if he has been forced to enter the department at the outset of his career as an officer afloat. His ambitious eye will, therefore, always be on the bridge, and thus it will eventuate that the engine-room will be for him "no continuing city," and he will be reconciled to his immediate surroundings only by the probability that service in the engine-room efficiently done will count in the promotion to that sphere which is higher, according to the world's opinion of the deck branch.

The advancement of the most efficient lieutenants (E.) or lieutenants (E.†) to commanders in the military branch will so seriously affect the machinery department as to be disastrous for the Service. One has only to reflect upon the great advance in marine, and especially naval, engineering during the past ten years to realise the enormous value of practical experience, as well as wider scientific knowledge, if the best is to be achieved from these improvements, and particularly if probabilities of breakdowns are to be anticipated on the spot. If, then, upon winning experience, men are to be permitted to desert the engine-room and to deplete the staff of its best officers, grave results must follow. The engineering profession is as honourable and as worthy of recognition as any other—fuller of interest than even the military branch of the Navy—and upon it depends the success of the Fleet in peace and in war. "The man behind the man behind the gun" can win or lose actions, and once an engineer always an engineer should be the rule. We can see no justification for this practice of first training officers as engineers and, when they are in the position to apply experience, to allow them to pass to another branch of the Service, where their special experience is inapplicable or of little avail. The idea is contrary to all the tenets of a successful commercial nation. If the engineering work is not as popular as the military branch, the remedy lies with the authorities, and we have indicated some directions in which the disparity may be lessened if not removed. The first step should be to equalise the conditions of the present engineering officers with the present military officers.

We are encouraged in the hope that the Admiralty will yet see their way to prevent this desertion of the engineering branch by the amendments they are now introducing in the case of Marine officers. Here the intention was to make the Marine not only co-equal with the others, but to permit the officers to pass at a certain stage of their career into the General Naval Service. This is changed. A lieutenant (R.M.) will, as a rule, remain attached to his corps throughout his career, gaining promotion as in the military branch. Only in certain cases can he pass to the military branch, and then solely at a later period in his service. Since this breach in the scheme has been made, there is hope that it will soon be applied to the engineering branch; the sooner the better for the Navy. Moreover, when it appears as if there would be a certainty of a paucity of volunteers for the Marine branch, a certain number of applicants are to be received into the branch without passing through Osborne and Dartmouth, a special course being provided for such. Here the principle of common entry and training is departed from. We do not blame the authorities. To profit by the teaching of experience is, on the contrary, praiseworthy. We hope the profit will yet extend to the engineering branch.

SAND SAFETY SIDINGS.

THE comparatively small number of installations on our railways suggests that the utility of sand safety sidings is not as widely realised as it deserves. Catch-points, of course, are common, being frequently provided with the object of removing from a running line, stock of which control may have been lost, on account of the failure of couplings, or for some other cause. Points of this description may lead into a dead end having a siding length determined by local circumstances. With the object of minimising damage at such sidings, and of reducing as much as possible the length needful, they are often laid, if possible, on a fairly steep rising gradient; but if this be done, there always remains the risk that the stock may run back out of the siding, and foul the running line, to the danger of other trains. The use of sidings partly laid in sand reduces such risks very considerably, and presents the further advantages that, with the same grade, the siding may be curtailed in length, or if equal length be retained, the grade may be safely reduced. The choice between these two alternatives would naturally depend on local conditions.

Sand sidings may also be utilised with advantage in other circumstances. In common with most safety devices, decision as to the necessity for their introduction must be arrived at from a consideration of the risks and probabilities, as far as they are capable of estimation, in each case taken by itself. The danger run without them, and the efficacy of such an installation to avert disaster, must be carefully weighed, for it is evident that they cannot be light-heartedly introduced wholesale. With careful arrangement they may be put down in what may seem rather unpromising situations, but their application in some directions is certainly limited, if not inadvisable.

Tests show that on a siding laid in sand, the retarding effect of the sand alone, unassisted by braking, may be from 7 to 9 per cent. and more, thus giving figures equal to good braking practice. With the assistance of braking at the same time, according to approximate calculation, the retardation may be above 21 per cent. These values, though very rough, give some idea of the service which such sidings might be expected to give.

A great deal of room need not be taken up by a siding of this kind. It need not always be laid like an ordinary siding alongside the running line, but may act as a useful check on faulty operation if the sand-track gauge overlap the running-line. An installation of this class has been laid down at Dresden A. station, in connection with a terminal line, on which there had been several accidents from trains running into buffer-stops. The installation has been recently described, with others, by Dr. Kopcke, in the *Zeitung des Vereins Deutscher Eisenbahnverwaltungen*, from which it appears that the siding track is only set over to one side about $5\frac{1}{4}$ in., the gauges overlapping. This line runs between passenger platforms, so that it was necessary to economise room and make the displacement as small as practicable. In order to do this, the siding-track has been depressed, the rail-heads being about $1\frac{3}{4}$ in. below the level of the running-rails. With the track thus lowered, it has been possible to utilise the running-lines themselves to form one side of the sand-troughs, in which the siding rails are embedded, the other side being formed of a high angle iron. The siding-rail is laid as close to the track-rail as spiking, and the flat base of the Vignoles section employed, will permit. The siding is controlled by a signalman, one of whose duties it is to set the points for it, if the driver of an incoming train signal to him, by whistle, to do so. The weak point of this system as a safeguard at a terminal station is, of course, in the fact that it is installed on the assumption that the driver will realise that his train is not under control, long enough before entering the station, for the points to be set for the siding. It is stated that there has so far been no occasion to use it. Probably its very presence has had a deterrent effect. Its use by a train would probably be followed by a stringent inquiry as to the justification of resorting to it, and a natural desire to shun inquisitions of this kind, with, perhaps, the risk of unfavourable records in a register, would make men additionally careful when running into the station.

Another installation has been made at the Dresden-Friedrichstadt sorting-yard, which is on a gradient of 1 in 100. Here the sand-trough was made of old rails spaced $8\frac{1}{2}$ in. apart, one of which also serves as a check-rail to assist in guiding. The sand track-rail is covered with $1\frac{1}{2}$ in. or $1\frac{3}{4}$ in. of sand. This seems now to be considered all that is necessary, though in former installations a depth of 2 in. or 3 in. was used. Other installations have been made in Germany and elsewhere on the Continent, while such sidings have also been laid down in America, as well as in this country, notably on the London and North-Western Railway.

As regards maintenance, sidings of this description do not appear to involve any abnormal expense, and as they can, of course, be made up mostly of second-hand material, their first cost need not be serious. For them to be really effective, care must be taken to utilise only a sand which will remain loose in all weather. It must be clean and of large enough grain to drain properly, so that it will neither pack very hard nor freeze in cold weather. Coarse river sand and crushed syenite have both proved satisfactory, grains of $\frac{1}{10}$ in. to $\frac{1}{5}$ in. apparently giving the best results. Finer sands simply get pushed off the rail-head, little remaining to effect the desired retardation, which is thus greatly below the possible amount. With suitable material consolidated, but not hard, sand to a depth of as much as $\frac{5}{8}$ in. may be found compressed on the rail-head after the passage of a vehicle. This additional thickness on the tread reduces the guiding effect of the wheel flanges, hence checking of some kind is advisable. It is absolutely necessary on curves, and though not quite so essential on the straight, the trough side can so easily be arranged to serve as a check-rail that it should not even there be neglected.

The great advantage of sand sidings is that they effect automatic braking. Catch-points alone, though cheap to instal, are very costly in their effect, and form a very drastic method of meeting an emergency. When brought into use they result in damage to the stock, its contents, and to the permanent-way. This is avoided by the use of a sand siding, which, moreover, minimises subsequent delay. The stock and contents are undamaged, and are immediately ready for further transit, providing the grit has not got into the boxes. The attention needed to the siding to return it again to a state of efficiency is insignificant.

INTERNAL WATERWAYS OF GERMANY.

GERMANY, for a series of years, has developed and extended her internal waterways with indefatigable energy and at immense outlay, and the labours in this direction are being continued in different parts of the empire. We have at various times given an account of the many undertakings that have been already carried out to facilitate internal transit. Prince Ludwig of Bavaria on a recent occasion gave an interesting survey of present plans and efforts, pointing out that the question of the perfection of the internal waterways was at present receiving much more attention in South Germany than in North, and more especially in East Germany. East of the Elbe all is at present stagnation, nor is any progress being made between the Elbe and the Weser; the extension of the Rhine-Hanover Canal has come to a complete standstill, and both the towns, especially Magdeberg, Hanover, and Bremen, particularly interested in the scheme, and the Rhenish-Westphalian industry appear to be doing nothing in the matter. The same may be said to apply to Oldenburg with regard to the canal from the town of Oldenburg to Nordörpen, on the Dortmund-Ems Canal, the opposition on the part of Emden, Osnabrück, and Hanover, having so far proved insurmountable. The construction of the Rhine-Hanover Canal is being duly proceeded with, but no result has been arrived at concerning the building of a harbour at Hanover. The canal is not to be opened until the question of the navigation dues has been settled, and by that time the harbour question, no doubt, will also have been arranged. The problem of the dues, however, is a very difficult one, and the

Government does not appear to be making any progress, either at home or in its relations with Austria and Holland.

In South and West Germany, however, great activity prevails. The parties interested in the canalisation of the Moselle have made good strides, and gained the support of the Government. It may be looked upon as practically certain that a proposal will be laid before the Prussian Diet, and that it will meet with no opposition there.

West Germany, undoubtedly the most flourishing part of the empire, reaps the advantages of the rapidly-developing Rhine waterway. Great works have been carried out, and the traffic has fully justified the labour. The Rhine is the most important internal waterway in Europe, and probably in the world. There might be a question of rivalry on the part of the Yangtsekiang and Hoangho, but owing to the entirely different conditions it is difficult to compare these rivers with the Rhine. As the canalisation of the Maine as far as Frankfort has proved such an immense success, other work in this direction is everywhere undertaken with zeal and energy. Baden and Wurtemberg have joined in the canalisation of the Neckar as far as Heilbronn. Technically speaking, the venture was a success, but the traffic remains unsatisfactory. Wurtemberg, however, is now pushing energetically ahead, and the Neckar will be carried as far as Kannstadt, the suburb of Stuttgart.

The canal connection from the Rhine to Karlsruhe is being less actively proceeded with. The capital of Baden does not seem to take any initiative in the matter, and it looks as if Mannheim had influenced it. Strassburg, on the other hand, has succeeded in bringing about a regular river traffic, and is so far the most important rival of Mannheim on the upper stream, and has still better prospects for the future, inasmuch as Germany and France appear to be arriving at an agreement about an improvement of the canal connection.

All this, however, becomes insignificant compared with the grand scheme of making the Rhine navigable as far as Basle, or even to Lake Boden. Technically speaking, there is no doubt whatever as to the plan being feasible as far as Basle, and Switzerland is offering generous co-operation. The question of climbing the mountain and passing the falls between Basle and Lake Boden is a more difficult one. Still more difficult problems have been solved in the Trollhattan Canal, in Sweden, and Canada has even circumvented Niagara. A canalisation as far as Lake Boden will, of course, open out wide fields for increased traffic, with the whole of East Switzerland and the Vorarlberg. Even beyond Lake Boden the Rhine can be utilised some considerable distance, as far as Granbundten, there being plenty of water and only few falls. The inclusion of Lake Boden in the Rhine navigation is by no means a Utopian idea.

Wurtemberg has the same end in view. Not content with carrying the Neckar so far as Kannstadt, to which reference has already been made, this country proposes to pass the Schwabian Jura and the Ranhe Alp, and to reach Lake Boden close to Friedrichshafen. It is not the plan to go straight south with steep combinations of locks, as was done at Niagara, and even at the Rhine Fall. There is no water in the watershed in that district, and as the Neckar and the Fils Valleys cannot be used, it will be necessary to utilise the Rems Valley so as to get eastward as far as Aalen, and from thence proceed in a southern direction as far as Heidenheim, using the Boenz so as to reach Ulm. Then it will again become necessary to ascend in order to reach the height of the Ranhe Alp at Biberach, from whence the canal will go downwards to the Danube by way of Ravensburg. It remains to be seen whether the traffic of this expensive canal will be in proportion to the labour and the cost.

As for Bavaria, Prince Ludwig has succeeded in gaining the assent of Prussia for a further canalisation of the Maine from Frankfort as far as Aschaffenburg, subject to the navigation dues asked for by Prussia being adopted. Bavaria wants again to join in the world's traffic, in which she played such an important part before the discovery of the way by sea to India, when the cities of Augsberg and Nuremberg left all other German towns behind. Bavaria knows that only internal ways can restore her to anything like her former position. The plan of connecting the Danube and the Maine is to be adopted with materially increased financial and technical resources. Nuremberg is to be retained as the centre of the Bavarian canal system, not only by means of its connection with the Danube, but a connection with Munich is also to be established.

From Nuremberg a connection with the Maine can be obtained in different ways, firstly, by extending the Ludwig Canal to the dimensions that may now be considered requisite; this leads as far as Bamberg, the Upper Maine, and the Maine must then be canalised in its whole length as far as Aschaffenberg. Secondly, a canal can be constructed westward as far as Uffenheim, a point which must be chosen for all the following three traces, inasmuch as there is a question of proceeding to Marktbreit, or to Eibelstadt, or to Wartheim, which latter is the lowest point for the canal to enter the Maine. There is, finally, the scheme of relinquishing the Maine, and going straight west from Uffenheim to Eberbach, on the already canalised Neckar; the latter plan, however, is hardly likely to appeal to Bavaria, on account of her districts along the Maine.

The Nuremberg-Bamberg project offers the possibility of an extension as far as the Werra, which is capable of canalisation, with connection with the Weser, which from Munden is navigable as far as the sea.

From Nuremberg to the Danube there is the old Ludwig Canal, which would have to be reconstructed, but in addition there is a southerly line by way of Weiszenburg and Stepperg (Danube), and then *via* Aichach to Munich, with a branch canal, Aichach-Augsburg. This is the great plan of an internal waterway system between Nuremberg and Munich (besides Regensburg, Vienna, Hungary), to the Lower Rhine and the North Sea. These comprehensive schemes are not loose projects, but they are carefully prepared plans, which are being strongly advocated and energetically pushed ahead by the State.

At a meeting held some little time ago at Posen, more activity was urged in connection with several East and North German canal schemes, more especially an extension of the Mittelland Canal from Hanover to Magdeburg, so as to bring the eastern provinces of the monarchy in connection with the different centres of the west. The corn and the flour of the east can, it was pleaded, only be favourably transported to the west when there is a waterway. The extension of the Rhine-Weser Canal to the Elbe was also insisted upon. In 1899 a projected connection between the Rhine and the Elbe was negatived, and in 1901 the Government introduced a new proposal concerning a Rhine-Elbe Canal, coupled with a plan for a large waterway, Berlin-Stettin, a canalisation of the Oder, and improvements of the Oder-Weichsel waterway. A bitter opposition encountered the proposal, which was only carried in part (Berlin-Stettin waterway and the Rhine-Hanover section). The connection between Hanover and Magdeburg, however, still remains a project; the Government has fully realised its importance, but party politics in Parliament have hitherto kept it back, but in the meantime the aspects have somewhat altered, and there is reason to expect that this canal will be built, and built soon. All railway experts of standing have stated that they have great doubts whether the railways will continue to be able to grapple with the increasing traffic. Then there is the question of freight; the railways must on an average have 3.5 pfennig per kilometre per ton, whilst the waterway is said to be able to handle the traffic at 1 pfennig, or, including the canal dues, from 1 to 1¼ pfennig. It has been calculated that the Mittelland Canal would mean a reduction in freight of 35,000,000 marks per annum, which sum German industry, &c., would save if the Mittelland Canal was extended to Magdeburg. The objection that the canals would do the railways harm has been overcome in many cases, and the opinion was expressed that the canals would benefit, and not do any harm to the railways. New waterways call forth new industries, and the greatest railway traffic is always to be found where there is the greatest water traffic. Magdeburg and Hamburg are more favourably located in regard to Landsberg, thanks to the water connection, than is Soldin, though only a few kilometres distant, and Calcutta is nearer to Hamburg than is Chemnitz to Allenstein, in the same way as Australasia is nearer to Hamburg than is Nuremberg to Allenstein. The freight for 100 kilogs. to Calcutta is 2.50 marks; from Allenstein to Chemnitz, 4 to 4.50 marks. It was also pointed out that the shipbuilder was not duly consulted in the matter of canal construction, of which fact the Dortmund-Ems Canal furnishes a proof. The connecting section between the Rhine and Westphalia can only accommodate vessels up to 1000 tons, but the Rhine is already traversed by vessels of 3680 tons. It is a mistake that there are no shipbuilders in the Ministry for Public Works, only mechanical engineers and financiers. A resolution was finally passed to the effect that the Mittelland Canal was of only local importance as long as it was not continued as far as the Elbe.

THE BALANCE OF ROTATING-CYLINDER ENGINES.

By H. Grinsted, A.C.G.I., B.Sc.

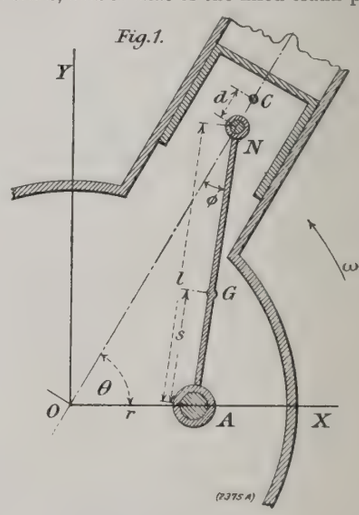
It is obvious that a symmetrical seven-cylinder engine is theoretically in perfect balance; the whole system completes one cycle of movement every one-seventh of a revolution—*i.e.*, after two-sevenths of a revolution the arrangement of the mechanism is exactly similar to its arrangement after one-seventh, and so on; hence there can be no unbalanced force of greater period than the time occupied by one-seventh of a revolution—that is, of less frequency than seven times the speed. As the ordinary reciprocating engine presents no inertia forces of appreciable magnitude having frequencies greater than twice the crank-shaft speed, and the rotating-cylinder engine has only a combination of reciprocating motion and circular motion of the same frequency, it is impossible for forces of a frequency of seven times the engine-speed to be produced in symmetrical engines of the rotating-cylinder type. So, if all the pistons and connecting-rods are exactly similar, the seven-cylinder rotating-cylinder engine is perfectly balanced.

In the usual methods of construction, however, it is found necessary to make one connecting-rod heavier than the others, so that actually the cycle of movement of the mechanism corresponds with one revolution of the engine; forces having frequencies of engine-speed, and twice and three times engine-speed, may therefore be developed.

To determine exactly the nature of the inertia forces set up by the extra weight of one piston or connecting-rod it is necessary to find the accelerations of the moving parts.

In Fig 1 let O A represent the crank-arm of a rotating-cylinder engine, O being the centre of the crank-shaft, and A that of the fixed crank-pin.

Fig. 1.



Let N be the gudgeon-pin centre and O N the cylinder centre-line at any time, the cylinder having turned through an angle θ from O A, the direction of rotation being counter-clockwise.

Let C be the position of the mass-centre of the piston, it being assumed to lie in the axis of the cylinder:—

Let

ω = angular velocity of the cylinders.
l = the length of the connecting-rod.
$2r$ = the stroke of the piston.
d = the distance of the mass-centre C from the gudgeon-pin.
ϕ = the angle between the connecting-rod and the cylinder centre line.

The method of determining the acceleration of the piston will be to find expressions for its component displacements along the two axes O X and O Y, respectively parallel and perpendicular to the

fixed crank-arm, and then to obtain the accelerations in these directions by the process of differentiating twice with respect to time. The resultant of the two component accelerations thus obtained will give the actual acceleration of the piston.

Let the displacement of C along OX = x
" " " C " OY = y

Then

$$x = ON\cos\theta + d\cos\theta \quad . \quad . \quad (1)$$
$$y = ON\sin\theta + d\sin\theta \quad . \quad . \quad (2)$$

But

$$ON = r\cos\theta + l\cos\phi \quad . \quad . \quad (3)$$

and

$$r\sin\theta = l\sin\phi.$$

Hence

$$\cos\phi = \sqrt{1 - \frac{r^2}{l^2}\sin^2\theta}$$
$$= 1 - \tfrac{1}{2}\frac{r^2}{l^2}\sin^2\theta \text{ approx.}$$

Substituting this value in equation (3) we have

$$ON = r\cos\theta + l - \tfrac{1}{2}\frac{r^2}{l}\sin^2\theta \quad . \quad . \quad (4)$$

Substituting for ON, equations (1) and (2) may be written :—

$$x = r\cos^2\theta + l\cos\theta - \tfrac{1}{2}\frac{r^2}{l}\sin^2\theta\cos\theta + d\cos\theta \quad . \quad (5)$$

$$y = r\cos\theta\sin\theta + l\sin\theta - \tfrac{1}{2}\frac{r^2}{l}\sin^3\theta + d\sin\theta \quad . \quad (6)$$

Differentiating, we obtain the component velocities :—

$$\dot{x} = -2\omega r\cos\theta\sin\theta - \omega l\sin\theta - \tfrac{1}{2}\frac{\omega r^2}{l}(-\sin^3\theta + 2\sin\theta\cos^2\theta) - \omega d\sin\theta = -\omega r\sin 2\theta - \omega l\sin\theta + \frac{\omega r^2}{2l}(3\sin^3\theta - 2\sin\theta) - \omega d\sin\theta \quad . \quad . \quad . \quad (7)$$

and

$$\dot{y} = \omega r\cos 2\theta + \omega l\cos\theta - \tfrac{3}{2}\frac{\omega r^2}{l}\sin^2\theta\cos\theta + \omega d\cos\theta = \omega r\cos 2\theta + \omega l\cos\theta - \tfrac{3}{2}\frac{\omega r^2}{l}(\cos\theta - \cos^3\theta) + \omega d\cos\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Differentiating these velocities, we obtain the component accelerations :—

$$\ddot{x} = -2\omega^2 r\cos 2\theta - \omega^2 l\cos\theta + \frac{\omega^2 r^2}{2l}(9\sin^2\theta\cos\theta - 2\cos\theta) - \omega^2 d\cos\theta = -2\omega^2 r\cos 2\theta - \omega^2 l\cos\theta - \frac{\omega^2 r^2}{2l}(9\cos^3\theta - 7\cos\theta) - \omega^2 d\cos\theta \quad . \quad (9)$$

But

$$\cos^3\theta = \tfrac{1}{4}\cos 3\theta + \tfrac{3}{4}\cos\theta$$

Hence

$$\ddot{x} = -2\omega^2 r\cos 2\theta - \omega^2 l\cos\theta - \tfrac{3}{8}\frac{\omega^2 r^2}{l}\cos 3\theta + \frac{\omega^2 r^2}{8l}\cos\theta - \omega^2 d\cos\theta \quad . \quad . \quad . \quad . \quad (10)$$

And

$$\ddot{y} = -2\omega^2 r\sin 2\theta - \omega^2 l\sin\theta - \tfrac{3}{2}\frac{\omega^2 r^2}{l}(-\sin\theta + 3\cos^2\theta\sin\theta) - \omega^2 d\sin\theta = -2\omega^2 r\sin 2\theta - \omega^2 l\sin\theta - \tfrac{3}{2}\frac{\omega^2 r^2}{l}(2\sin\theta - 3\sin^3\theta) - \omega^2 d\sin\theta \quad . \quad (11)$$

But

$$\sin^3\theta = \tfrac{3}{4}\sin\theta - \tfrac{1}{4}\sin 3\theta$$

Hence

$$\ddot{y} = -2\omega^2 r\sin 2\theta - \omega^2 l\sin\theta - \tfrac{9}{8}\frac{\omega^2 r^2}{l}\sin 3\theta + \tfrac{3}{8}\frac{\omega^2 r^2}{l}\sin\theta - \omega^2 d\sin\theta \quad . \quad . \quad (12)$$

Comparing the values of $\ddot{x}$ and $\ddot{y}$ in equations (10) and (12), it is obvious that the acceleration of the piston can conveniently be represented as the resultant of four vectors.

(1) of length $\left(\omega^2 l + \omega^2 d - \tfrac{1}{8}\frac{\omega^2 r^2}{l}\right)$ at $\pi + \theta$ with O X
(2) of length $2\omega^2 r$ at $\pi + 2\theta$ with O X
(3) of length $\frac{9}{8}\frac{\omega^2 r^2}{l}$ at $\pi + 3\theta$ with O X
(4) the projection upon O Y of a vector of length $\frac{1}{4}\frac{\omega^2 r^2}{l}$ at θ with O X.

No. (4) is so small in comparison with the others that it may be neglected.

The vectors representing the inertia force of the piston will be proportional to those representing acceleration, but in opposite directions—*i.e.*,

(1) of length $M\omega^2\left(l + d - \frac{r^2}{8l}\right)$ at θ with O X
(2) of length $2M\omega^2 r$ at 2θ with O X
(3) of length $\frac{9}{8}\frac{M\omega^2 r^2}{l}$ at 3θ with O X

where M = mass of one piston.

Thus these vectors rotate (1) with the cylinder, (2) twice as fast as the cylinder, (3) at three times the speed of the cylinder, all being coincident when θ is zero—*i.e.*, when the cylinder passes through the crank-arm direction.

Since the crank-pin is stationary, the motion of the mass-centre of the connecting-rod is similar to that of the gudgeon-pin N.

Let G be the mass-centre of the connecting-rod, distant s from the crank-pin, and let m be its mass.

Then acceleration of G = $\frac{s}{l}$ × acceleration of N ;

or the equivalent mass at the gudgeon-pin = $\frac{m\,s}{l}$.

The acceleration of N is the same as that of the piston if the mass centre of the piston lies in the gudgeon-pin axis ; that is, if $d = 0$.

Hence the inertia force of the connecting-rod can be represented as the resultant of the vectors :—

(1) of length $\frac{m\,s\,\omega^2}{l}\left(l - \frac{r^2}{8l}\right)$ at θ with O X.
(2) of length $\frac{2\,m\,s\,\omega^2 r}{l}$ at 2θ with O X.
(3) of length $\frac{9}{8}\frac{m\,s\,\omega^2 r^2}{l^2}$ at 3θ with O X.

Then the total inertia force due to the piston and connecting-rod together will be the resultant of the following vectors :—

(1) of length $\omega^2\left\{\left(l - \frac{r^2}{8l}\right)\left(M + \frac{m\,s}{l}\right) + M\,d\right\}$ at θ with O X.
(2) of length $2\,\omega^2 r\left(M + \frac{m\,s}{l}\right)$ at 2θ with O X.
(3) of length $\frac{9}{8}\frac{\omega^2 r^2}{l}\left(M + \frac{m\,s}{l}\right)$ at 3θ with O X.

In a multi-cylinder engine each piston and connecting-rod combination will have its three corresponding vectors ; when more than three cylinders are used, provided that the cylinders are equally spaced and all pistons and connecting-rods are exactly similar, the primary vectors balance one another, and, similarly, the secondary and tertiary vectors are in equilibrium ; the engine is therefore balanced.

When, however, one connecting-rod has a greater mass-moment about the crank-pin than the others, perfect balance is impossible.

Suppose the main connecting-rod of a seven-cylinder engine is slightly thicker than the others, its moment about the crank-pin being in excess of that of each of the others by an amount equivalent to $\frac{1}{2}$ oz. at 125 mm. radius.

In determining the unbalanced force set up by this extra weight, it can be considered by itself, as the mechanism would be in perfect balance were it absent.

Let

r = 60 mm. = 0.1968 ft.
l = 214 mm. = 0.702 ft.
ω = 1000 r.p.m. = 104.72 radians per second.

Then

$$\omega^2 = 10965.$$

$$\text{Equivalent mass at gudgeon-pin} = \frac{1}{2}\times\frac{1}{16}\times\frac{125}{214} = 0.01826 \text{ lb.}$$

The three component accelerations of the gudgeon-pin are first found.

$$\text{Primary component} = \omega^2\left(l - \frac{r^2}{8l}\right) = 10{,}965\,(0.702 - 0.00691) = 7615\ \frac{\text{ft.}}{\text{sec.}^2}$$

$$\text{Secondary component} = 2\,\omega^2 r = 2\times 10{,}965\times 0.1968 = 4315\ \frac{\text{ft.}}{\text{sec.}^2}$$

$$\text{Tertiary component} = \tfrac{9}{8}\frac{\omega^2 r^2}{l} = \tfrac{9}{8}\times 10{,}965\times\frac{(0.1968)^2}{0.702} = 680\ \frac{\text{ft.}}{\text{sec.}^2}$$

Multiplying these values of acceleration by the equivalent mass at the gudgeon-pin, and dividing by 32.2 to convert poundals to pounds weight, the unbalanced forces are obtained.

Primary force = 4.32 lb. weight.
Secondary force = 2.45 lb. "
Tertiary force = 0.39 lb. "

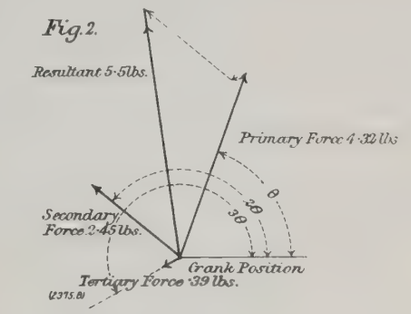
Fig. 2 shows these forces set out to scale for one value of θ, and their resultant graphically obtained.

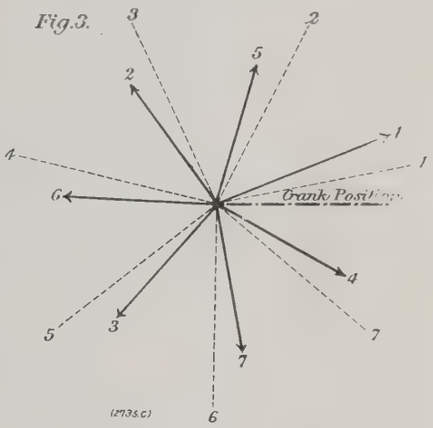
The primary component can be balanced by attaching a weight m_1 to the crank-case at 180 deg. with the cylinder having the heavy connecting-rod, at radius r_1 from the shaft axis, such that

$$\frac{m_1\omega^2 r_1}{32.2} = 4.32 \text{ lb. when } \omega = 1000 \text{ R.P.M.};$$
$$i.e.,\ m_1 r_1 = 0.0127 \text{ lb.-ft.}$$

Fig. 3 shows the secondary vectors for seven connecting-rods, No. 1 being of greater mass-moment than the others ; cylinder positions are shown by dotted lines, and are numbered consecutively, the full lines representing the connecting-rod secondary inertia forces being numbered to correspond with the cylinders ; thus vector No. 2 is the secondary force vector for the connecting-rod working with cylinder No. 2.

From Fig. 3 it is clear that the unbalanced portion of No. 1 can be balanced by attaching small weights to Nos. 3 and 6.





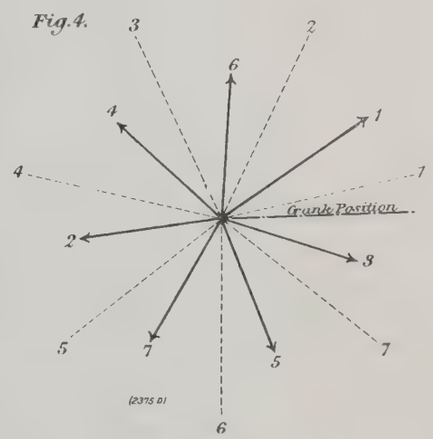


Fig. 4 shows the tertiary forces set out and numbered according to the cylinders to which they refer. It can be seen that the weights added to Nos. 3 and 6 to obtain secondary balance would increase the unbalanced tertiary force.

It is clearly seen to be impossible to obtain both secondary and tertiary balance, one being procured only at the expense of the other.

For perfect balance it is essential that the mass moment of each of the connecting-rods about the crank-pin should be the same, and all the pistons of equal weight.

It is interesting to note that in a two-cylinder single-crank rotary engine secondary balance is impossible, as the two secondary vectors become coincident ; similarly, in a three-cylinder engine the three tertiary vectors are coincident, and tertiary balance is therefore impossible.

NOTES.

RESISTANCE AND ARC SMELTING FURNACES.

LAST year W. Conrad, of Vienna, made an attack on resistance furnaces with special regard to the smelting and melting of iron and steel. He described, in *Stahl und Eisen*, some experiments conducted at the steel works of R. Lindenberg, of Remscheid; the experiments may not be conclusive, but they have scarcely received due attention. Conrad's argument is that, with the practically feasible current intensities, it is out of question to heat a liquid conductor like iron by using it as a resistance. The ordinary laboratory experiments are made in resistance furnaces rather than in arc furnaces, because the former are more convenient. Laboratory furnaces can be cooled, moreover, when the high temperatures make the walls conductive, but that is hardly possible in practice; hence carborundum furnaces are worked for a time and then dismantled. When the liquid resistance conducts much better than the furnace material, the objection that the walls also conduct would not be fatal. But when that is so, the liquid conductor does not absorb the current energy to a profitable degree. Pctential measurements which Conrad made in calcium carbide furnaces, in which arc and resistance heating are combined, convinced him that only 1 per cent. of the heat energy consumed was due to the conduction of the current through the mixture, whilst the arc supplied 99 per cent., and it could be seen that the carbide formation was taking place chiefly where the arc had been playing. In his experiments on iron he filled a furnace with 1300 kg. of steel (1 per cent. of carbon) after raising the two suspended electrodes. He inserted into the bath two oblique steel rods, 3 m. in length, 36 mm. in diameter, as test electrodes for the resistance determinations with direct currents. These determinations were made 28 and 53 hours after filling the furnace; the gradual heating of the furnace by the fluid metal, it was found, made very little difference in the resistance values. The cold electrodes had a resistance of 0.000117 ohm per metre; the total resistance of the bath was 0.00085 and 0.00080 ohm (first and second measurements), and the resistance of the bath alone 0.00027 and 0 00026 ohm. That would yield a specific iron resistance of 22 ohms per metre length and square millimetre section; and the liquid iron would therefore conduct only $\frac{1}{22}$ as well as mercury, and $\frac{1}{260}$ as well as cold iron. This conductivity of the iron was really lower than one should expect, supposing the resistance of iron with rising temperature to increase at the rate shown by ordinary experiments. But in any case the resistance would be far too small for efficient resistance heating. Since the liquid iron is no longer magnetic, it is the C^2R heat which is of moment, and for this particular arc-furnace, which is fed by two arcs in series at 3000 amperes and 110 volts, the 0.00027 ohm resistance would only absorb 2.4 kw., which means 0.73 per cent. of the energy which the two arcs could supply. The heat generated in this way would be about that of a small iron stove, and could easily be balanced by cooling. A resistance furnace with cooled electrodes would therefore be apt to lose more heat through the electrodes than they could introduce, and to secure efficient heating currents of enormous intensity would be required. These considerations would affect direct resistance steel furnaces of the Gin and also of the Girod types. Conditions are different and more favourable with induction furnaces, and also with furnaces of the Röchling-Rodenhauser combined induction and resistance heating type, in which electrodes of large surface, covered with a layer of material which only conducts when hot, are embedded in the furnace bottom for direct auxiliary heating of the bath.

THE CONFECTIONERS', BAKERS', AND ALLIED TRADES' EXHIBITION.

Although the greater portion of this exhibition, which was held at the Royal Agricultural Hal, Islington, last week, was devoted to subjects more intimately connected with the bakery and confectionery trades, certain features are of sufficient mechanical interest to be worthy of notice. The various trade exhibitions held at Islington and elsewhere give increasing evidence of the intimate connection of mechanical engineering to the progress of trade generally. The superseding of what may now be regarded as "old-time methods" of hand-mixing of the dough for bread-making, &c., is clearly evidenced in the case of this exhibition by the various types of mixing-machines shown. The general type shown consisted of the well-known revolving blade working in a closed cylindrical case, many of these being for hand-power. Two exceptions were to be seen in the machines shown by Messrs. Werner, Pfleiderer, and Perkins, Limited, of Peterborough, and by Messrs. Mario Frigerio and Co., of Lecco, Italy, whose London agent is Mr. A. G. Graziani, 22, Billiter-street, E.C. The former machine, known as the "Viennana" kneader, has a rotating covered pan, in which an arm, fitted with a pronged end, is given a reciprocating motion radially to the pan. It is claimed that this method gives a more uniform mixing, and this without exerting undue pressure on the dough. The second machine also has a rotating pan, but in this case it is open, and the mixing is carried out by one or more revolving arms of special form set at an angle to the plane of rotation. We intend in a subsequent issue to describe this machine more fully. The first-named firm also exhibited a complete bread-making plant capable of dealing with 2400 loaves per hour. In this plant a recent improvement is the introduction of metal-faced conveyor-belts for handling the dough, this construction resulting in the easier cleansing of the parts coming in contact with the bread. The two-tier steam-heated ovens shown also embody an innovation; they are heated by separate furnaces, and thus allow different temperatures to be maintained in each as may be required. The usual practice in the case of steam-heated ovens is to provide a series of straight tubes with welded ends, one end of which projects into the heating furnace, which extends the whole width of the oven. The tubes are partly filled with water, and the steam generated provides the requisite heat apparently by conduction, since no circulation is provided for. A distinct advance in this direction is shown in the case of the oven exhibited by Messrs. W. F. Mason, Limited, of Manchester, the heating being effected in their oven by a series of endless loops of tubing, so shaped as to bring the heating portion within the compass of a relatively small furnace. This furnace, by suitably shaping the tubes, can be placed in any desired position with regard to the oven-setting, whereas in the case of the straight-tube arrangement the furnace must of necessity be placed at the back. In the Mason oven, too, provision is made by a series of extra tubes inside the oven door to give extra heating surface to compensate for radiation at this point, and for loss of heat when charging and emptying the oven. On account of the circulation a very uniform heating effect is obtained, resulting in uniformity of baking in the batch, and, further, a considerable economy of fuel is realised. An exhibit of some considerable mechanical interest was given by Messrs. Rose Brothers, Limited, of Gainsborough, who showed several machines for wrapping up confectionery, tablets, &c., and an ingenious machine for labelling rectangular packets, such as tobacco, &c.

BELGIAN BLAST-FURNACES.—The number of blast-furnaces in activity in Belgium at the commencement of September was 44, as compared with 39 at the commencement of September, 1910. The number out of blast was six, as compared with five. The total of 44, representing the furnaces in blast in Belgium this month, was made up as follows:—Hainaut and Brabant group, 21; Liége group, 19; and Luxembourg, 4. The production of pig in Belgium in August was 183,290 tons, as compared with 162,990 tons in August, 1910. The aggregate output for the first eight months of this year was 1,385,320 tons, as compared with 1,231,470 tons in the corresponding period of 1910. The 1,385,320 tons, representing the output to August 31, this year, was made up as follows:—Puddling pig, 64,430 tons; casting pig, 31,990 tons; and steel pig, 1,288,900 tons.

ENGINEERING EXHIBITION AT BAKU.—Arrangements have now been completed by the Baku branch of the Imperial Russian Technical Society for the holding of an international Engineering Exhibition in April next year at Baku (Russia). The exhibits will comprise internal-combustion engines, air-compressors, electrical apparatus, &c., while there will also be a special section for motor-cars for both pleasure and business purposes. The exhibition will run for a period of six weeks. In order to induce English manufacturers to exhibit, Dr. P. Dvorkovitz, the well-known petroleum expert, of 1, Broad-street-place, E.C., has been appointed sole honorary representative for this country, and intending exhibitors should communicate with this gentleman for full details. The exhibits will be grouped in Baku, and attractively arranged by the workmen of the technical society, thus obviating the expense of each firm sending over a special representative.

INDUSTRIAL NOTES.

WE are informed that an agreement has been concluded with Messrs. Harland and Wolff and Messrs. Workman, Clark and Co., Limited, whereby a minimum rate of 38s. 3d. per week has been granted to engine-smiths, and 37s. per week to ship-smiths, the pay of men rated at and over the above-mentioned sums to remain undisturbed. A probationary period of two years is to be recognised in the case of young journeymen and improvers, starting at 24s. per week, their wages to be increased every six months until the minimum rate is reached. The majority of the jobbing and Corporation shops in the city have also agreed to these terms. This settlement has given great satisfaction to the Belfast members of the Associated Blacksmiths and Ironworkers' Society. The average rate for the district was formerly 35s. 11½d.

The Victorian Employers' Federation, Melbourne, has issued a pamphlet stating that over 15,782,648*l.* has been invested in land, machinery, and buildings in connection with Victorian manufacturing industries. The statistics for 1909-10 showed that 97,355 hands, both male and female, were in employment, and the wages paid amounted to 6,807,851*l.* Labour in all the principal industries was paid on the scales decided upon by the Wages Boards; there were about a hundred Boards in operation. The wages could not be below the rates fixed by the Wages Boards; many good workers, however, both male and female, were earning more than these rates prescribed.

It is announced that in consequence of the recent labour troubles the Liverpool shipping companies have decided to increase their rates of freight by 10 per cent. The date upon which this increase is to come into effect has, however, not yet been finally settled, but October 1 has been suggested as a likely date. The action is due to the demands put forward by the seamen for higher wages, which demands were granted, and to the loss from the delay caused in loading vessels owing to the congested state of the docks by the accumulation of goods during the three weeks' strike. This measure will probably not be confined to the Atlantic lines, for practically all the other companies also state that the concessions they have granted to the men, the dockers more especially, compel them to increase the rates for freight so as to counterbalance the increase in working expenses. Negotiations in the matter are proceeding between the Liverpool and the London companies.

The late seamen's strike has left many unemployed seamen at Cardiff; the books of the Sailors' and Firemen's Union contain the names of 622 white men and 232 coloured men, besides whom there must be, it is surmised, a still greater number who are not able to afford to be placed on the list. This has been caused by the decision of the leaders, who insisted upon a minimum wage of 5*l.* per month, whilst the wage which rules in most of the other ports is 4*l.* 10s. In order to avoid paying the extra 10s., the Cardiff shippers do not engage their crews at their own port. The number of unemployed at Cardiff is, no doubt, also due partly to the fact that seamen have congregated there from other ports in the hope of securing a higher rate of pay. The leaders would now seem willing to admit that the minimum rate of 5*l.* is too high; they are, however, rather in an *impasse*, since the decision arrived at provides that no alteration in the port wage shall be forthcoming until a three months' notice is given by either side.

The trade returns recently issued for August and for the eight months down to August 31, compared with the corresponding periods of 1910, show, in regard to August last, a falling off of 2.7 per cent. in the imports, of 6.6 per cent. in the exports, and of 17.9 per cent. in the re-exports, as compared with August, 1910; the imports for the eight months to end of August, 1911, were practically equal to those for the similar period of 1910, while the exports showed an increase of 4.5 per cent. and the re-exports a decrease of 2.6 per cent. as compared with those for the similar period of 1910.

We read in the *Machinery Market* that, so far as the home market is concerned, the textile machinery trade shows no improvement. A year ago the chairman of Messrs. Brooks and Dixey stated at the annual meeting of shareholders that the immediate outlook for their trade in England was the worst they had had to face in twenty years. Our contemporary pointed out at the time that much of the depression in question was due to reckless overbuilding of mills, to expansion facilities by the application of the joint-stock principle to mill ventures, and to the growth of machinery production abroad, and especially in the United States. The situation is practically unchanged. The value of textile machinery exports for the first seven months of the year was 3,954,923*l.*, as against 4,293,874*l.* in the corresponding period of 1910, and 4,910,150*l.* for

that of 1909. It is significant, however, that Russia continues to buy British textile machinery with unabated vigour. For some time now she has been the largest customer of this country, as far as textile machinery is concerned.

The Sheffield cutlery manufacturers have decided to advance the selling prices of all classes of cutlery by 5 per cent., the decision to take effect immediately. The step is due to the increased cost of manufacture, caused by the carrying out of the Home Office regulations for dust extraction from the grinding shops, the maintenance of the necessary new plant, the extra motive power required, added to heavy advances in the cost of raw material.

Representatives of various departments in the London and North-Western Railway works at Crewe waited upon the chief mechanical engineer and the manager of the works on Wednesday, the 6th inst., and laid before them a list of grievances, dealing mostly with wages. The trade unionists of the works recently took a ballot, and voted by an overwhelming majority to cease work failing recognition. Their leaders, however, advised them not to hand in notices until application had been made to the company to give the latter the opportunity first of redressing the men's grievances, leaving for the present the question of recognition until the outcome of the Royal Commission. The interview lasted several hours and the company's officials promised to lay the men's request before the directors immediately. The works have been on short time for over two years, but within the past fortnight about a thousand of the men had been practically put on full time.

Judging from a statement issued on Monday last, the 11th inst., by the men's representatives, the dispute between the London and North-Western Railway Company and their men is of a very serious nature; it is even feared that it may lead to a national strike. The men state that under the terms of settlement they have every right to reopen questions disposed of at previous meetings of the boards or covered by Sir Edward Fry's award. The company dispute this, and assert that employees' demands for better conditions for the various grades cannot be dealt with until 1913, when the award expires. Meetings are announced for next Sunday, the 17th inst., to consider the matter; the men are to ask the Board of Trade to insist upon a meeting between the company's and the men's representatives.

Much dissatisfaction exists among the men of the Midland Railway Company residing at Burton-on-Trent. At a meeting of all grades recently held a resolution was adopted unanimously calling upon the joint executive to bring immediately before the Board of Trade the fact that the company penalise the men who came out on strike. Should no satisfaction be granted, the men want a national strike to be declared until it is.

In their monthly trade report dated August last the United Pattern-Makers' Association stated that on the North-East Coast trade was exceedingly good, the number of members out of work throughout that district was an almost negligible quantity, whilst overtime was being worked to the full extent of the very limited amount allowed on the coast. Throughout the Clyde much the same conditions applied, and there was work in plenty for all who were able to work. At Barrow trade had picked up during the month, and things had resumed their wonted aspect in that important shipbuilding centre. The same remarks did not apply to Belfast; the falling off which took place some weeks ago still continued, and trade in that part showed no signs of immediate improvement. The Manchester reports were not so favourable as formerly. In the Midlands, taking Birmingham as centre, things were exceedingly good, with excellent prospects, Sheffield made a good showing, and reports from other Yorkshire centres revealed the condition of trade to be rather better than usual. A slight falling off was, however, noticeable in the Metropolitan area. The recent labour troubles had not seriously affected the members; those who had been thrown out had speedily obtained work again. The prospects of full employment were fairly well assured, so far as the immediate future was concerned.

We are informed that the Northumberland miners have recently met, with the object of recording their objection to the multiple-shift system of working introduced in consequence of the Eight Hours Act. They contend that this new system is greatly inconvenient to them; also that it is very detrimental to the health of the boys, and that it imposes much extra labour upon the women in their homes.

The Trades Union Congress, held this year at Newcastle, closed on Saturday last. The meetings were not conspicuous for dignity, and gave rise to several regrettable incidents. On Tuesday, the 5th, the Standing Orders Committee brought forward a resolution condemning the use of military forces during strikes. This was agreed to. Railway nationalisation was also the subject of a resolution which met with approval, as did also one dealing with the reversal of the Osborne judgment. A good deal of discussion was raised on Wednesday morning *à propos* of a labour newspaper, but nothing definite was reached. A proposal in favour of a citizen army as opposed to a standing army was rejected, but one embodying several suggestions on the question of workmen's compensation was carried. On Thursday, the 7th, the delegates had before them resolutions on the subjects of deductions from wages, the working of the Labour Exchanges, State insurance, and electoral reform. The first condemning deductions in any form was agreed to. The labour exchanges were condemned in the discussion, but an error on the part of the Miners' Federation delegates resulted in the resolution being rejected by vote. A proposal to make State insurance benefits on a non-contributory basis was rejected. The resolution on electoral reform was agreed to. On Friday last the Congress roundly criticised Mr. W. Crooks's Bill for the settlement of disputes by arbitration, and took Mr. Crooks to task for acting independently of the Labour Party. Several resolutions regarding "fair" and "minimum" wages were also adopted. The eight-hours day also came up again, and, of course, the proposal was received favourably. On Saturday the question of a federation of the unions occupied some of the attention of the Congress. In addition there were scores of resolutions on general topics dealt with during the week. In many cases there was no discussion at all, and in others the less said about the tone and quality of the speeches the better.

Difficulties have arisen with the workmen employed in cutting the tunnel under Mont d'Or, which is to connect Frasne directly with Vallorbe, leaving out Pontarlier and making of Vallorbe a through station on the Paris-Simplon line. The men, like those who worked at the Simplon Tunnel, are mostly Italians, and they have gone out on strike, objecting to the long hours they had to work. The authorities allow no demonstrations to take place, and the men appear to be returning to Italy.

A strike of about 200 men cutting a tunnel on the Jungfrau Railway is also announced. The men complained of the higher prices they had to pay for their provisions in that holiday district, prices which were absolutely out of proportion with their wages.

An important meeting of coal-trimmers was held at Goole on Sunday, the 10th inst. The meeting had been called to consider the question of the appointment of a Trimming Board and trimming tariff for the port of Goole. It was stated by representatives of the Goole Dockers' Union that since the recent dock strike at Goole conferences had been held with the Goole Steamship Owners' Association, and that body had agreed to the men's demands that a Trimming Board should be appointed. The Board is to consist of five representatives of the shipowners and five of the trimmers, and will settle any dispute arising in connection with the trimming or bunkering of any ship. Failing agreement, the dispute is to be referred to an arbitrator, whose decision will be final. No stoppage of work is to take place until the arbitrator's decision is known. The trimming tariff was also agreed upon. The meeting passed a resolution thanking the men's representatives, and stating that concessions had been obtained on almost every point at issue.

A conference called by the National Federation of Colliery Surface Workers is announced to be held on Saturday, the 23rd inst., at Sheffield, with the object of discussing and agreeing upon a definite application to the coal-owners of South Yorkshire for an improvement all round of the men's present position. The unions affiliated with the Federation are the National Amalgamated Union of Labour, the National Union of Gas-Workers and General Labourers, and the National Amalgamated Union of Enginemen. Efforts are being made to secure the attendance of the representatives from all collieries in the district. It is proposed to discuss the following questions among others:—The change of surfacemen's hours, and their reduced earning power through the introduction of the double-shift system for bank and screen-men and manipulators of coal. The desirability of applying for eight-hour shifts for bank and screen-men and general manipulators of coal at all collieries where the double-shift system has been introduced. The desirability of applying for an eight-hour day for enginemen and firemen and all men now working twelve hours per shift, seven shifts per week. The right to arrange price-list and discuss basis wages at all collieries where definite rates have not been agreed upon, and where persistent indirect reductions have been made.

A joint conference between the committee of the Coalowners' Association and the representatives of the Lancashire and Cheshire Miners' Federation was held at the Queen's Hotel, Manchester, on Monday, the 11th inst. For some time past the miners had been seeking an improvement in the pay of the day-wage men and boys, apart from their share in the national demand for a minimum wage of 7s. a day for coal-getters. At a former conference, held in Wigan in August, the Lancashire and Cheshire Miners' Federation decided, in view of the failure to obtain an immediate concession from the employers, to take a ballot of their members on the question of day-wage men and boys' wages. The ballot was to have been completed by the 23rd inst., and the officials of the Federation anticipated a declaration in favour of a strike, the immediate effect of which would have been the closing of the mines in the two counties, and unemployment for about 90,000 men.

The joint conference in question between the two sides has fortunately removed the immediate danger of such a development. At the close of the meeting, which was a private one, the following official report was issued:—"At a meeting held to-day of Coal-owners' representatives and Lancashire and Cheshire Miners' representatives, questions in difference between the employers and the men were fully discussed. A provisional agreement was arrived at, and the meeting adjourned for three weeks." Should the provisional agreement mentioned in the report be confirmed, as is expected, the dispute will be settled. This, however, is independent of the national agitation among miners for the minimum wage of 7s. a day, which is to come up at the meeting of the Miners' Federation of Great Britain, to be held at Southport on October 3.

A strike of all sections connected with the Manchester building trade is threatened for October 2. The executive committee of the National Association of Builders' Labourers has been holding a number of meetings in Manchester. At one held in St. Michael's Schools, George Leigh-street, on Monday, the 11th inst., it was announced that the masters had been asked to grant a minimum of 6d. an hour to all general labourers; of 6½d. to bricklayers' labourers; and 7d. to scaffolders, mill-men, iron-fixers, and other special labourers. Some employers pay a minimum of 6d., others are said to have a sliding scale under which the men cannot estimate their wages until the payment is made. Over 600 general labourers have recently joined the union; the further additions expected will show the majority of the labourers in Manchester to be union men. Joiners, bricklayers, and other grades are joining in the demand for increased pay.

An interview between the combined committee of the men and the management of the Lancashire and Yorkshire Locomotive Works, Horwich, which took place on Monday, the 11th inst., has resulted in disappointment to the men. At a former conference, grievances in regard to workshop conditions were all practically settled, with the exception of that dealing with prices for piece-work. Two other claims made after the men had ceased work—*i.e.*, a minimum wage of *l.* per week for labourers and the abolition of the present medical test—were not admitted. The committee, having obtained the necessary powers from the unions, wanted at the interview in question to discuss the various points in dispute, with the object of arriving at a settlement. The committee, however, met with a partial success only, a number of grievances being left over; they were also informed that unless within forty-eight hours notice was given for the resumption of work, all concessions would be withdrawn. A mass meeting was then held, at which the position was explained to the men; following this, it was unanimously decided to maintain the claims. The failure to reach a settlement causes general regret; but the skilled workmen declare themselves in honour bound to secure an advance to the labourers. The management, on the other hand, contend that the medical test and the labourers' wages were not in the original grievances, and they cover ground which extends beyond the Horwich works. They therefore stand for the original grievances being dealt with and work resumed before any other matters can be entertained.

CONTRACTS.—The Sheffield Corporation Water Works Department have just placed a contract for 32 mechanical pressure filters and auxiliary plant, capable of dealing with a flow of 6,000,000 gallons per day, with Messrs. Mather and Platt, Limited, of Manchester.

THE TURIN INTERNATIONAL EXHIBITION.—In one of our articles on this Exhibition, on page 234 *ante*, we stated that Messrs. Franco Tosi, Legnano, were exhibiting a Brown-Boveri Parsons (Tosi) turbine. Messrs. Franco Tosi inform us that they formerly constructed turbines of the Brown-Boveri Parsons type; now, however, they build steam-turbines of their own system only, on the Tosi patents, with which they have obtained exceptionally good results.

OVER-TYPE SUPERHEATED-STEAM ENGINES.

*Economical and Reliable Power Generation by Over-Type Superheated-Steam Engines.**

By W. J. Marshall, A.M.I. Mech. E.

A good many years ago an eminent engineer predicted that the power supply of the future would be generated by internal-combustion engines entirely. Although the last decade or so has seen wonderful developments in the design and application of such engines, this prophecy has not yet eventuated. On account of the severe competition which they have felt from internal-combustion engines, steam-engine builders have made renewed efforts, and are now able to produce steam plants having a fuel cost quite on a par with that of internal-combustion plants, and having other advantages, which will be gone into more fully later on, which, apart from fuel economy, make them preferable to internal-combustion plants where reliability, flexibility, and overload capacity are essential. The author's paper deals particularly with plants of comparatively small capacity—say, up to 500 brake horse-power.

The name "over-type superheated-steam engine," which is applied to the particular form of steam plant with which this paper deals, does not in itself sufficiently describe the plant, consisting as it does of engine, boiler, superheater, air-pump, condenser, &c.; in fact, all the integral parts which go together to make a complete steam plant. This form of plant is known by various names. In Germany the term "locomobile" has been applied to it; in France it is called "demi-fixé;" and in this country it is sometimes known as the "semi-stationary engine."

It is a direct development of the well-known semi-portable engine, but the element of portability which seems to be implied in the above names does not mean that it is an engine which is only to be used for temporary purposes, although the great simplicity of the foundation, and the arrangements generally of the plant, render it an easy matter to move the plant from one position to another should this be desirable at any time.

The over-type superheated-steam engine consists of a special tubular boiler, having the superheater placed in the smoke-box. The engine is mounted on the boiler, and the air-pump, feed-pump, &c., are attached to the side. The boiler forms the foundation or bed-plate for the engine. The arrangement is shown diagrammatically in

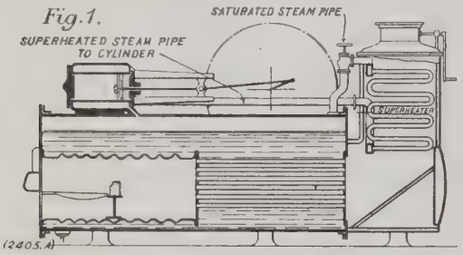


Fig. 1. Diagrammatic Arrangement of Engine.

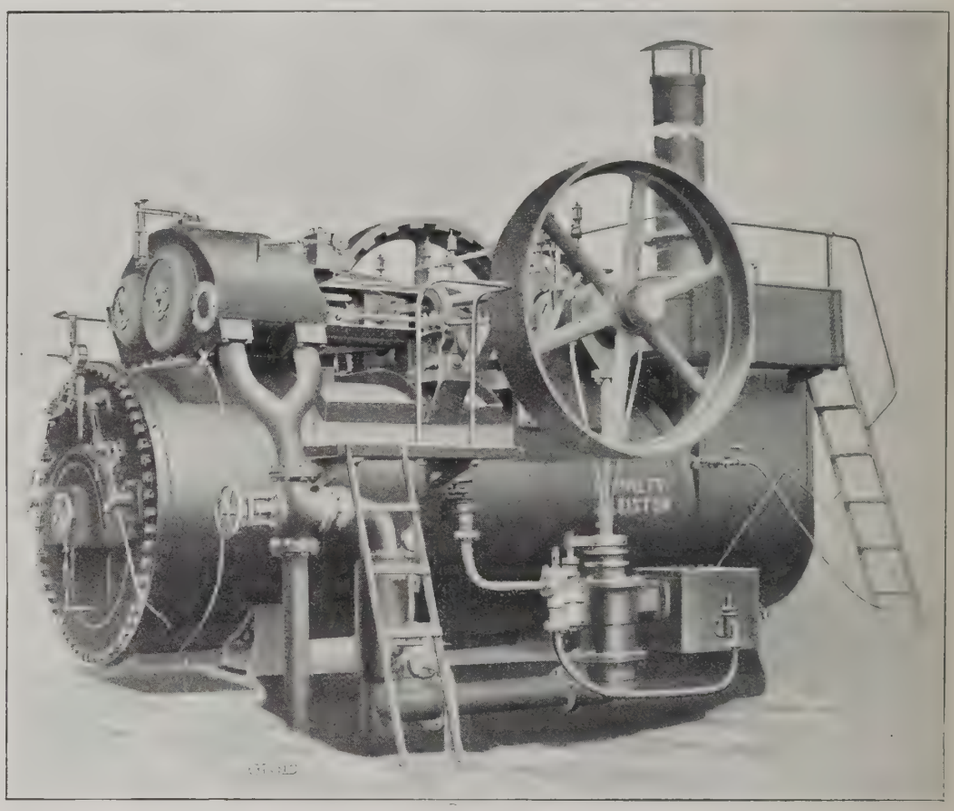


Fig. 2. General View of the Engine.

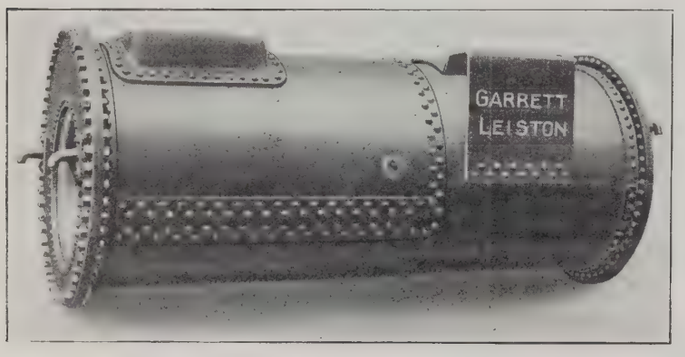


Fig. 3. General View of the Boiler.

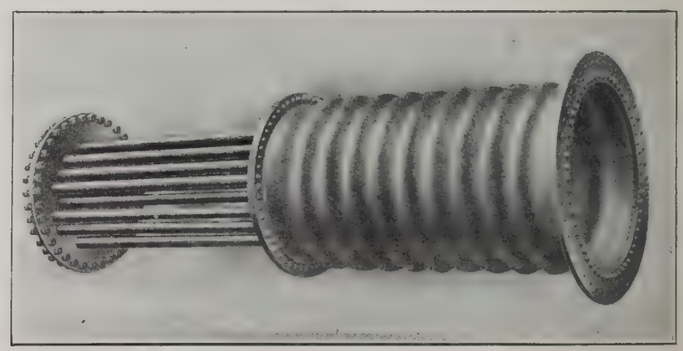


Fig. 4. View of Furnace and Tubes.

Fig. 1. The result of this arrangement is that the steam-pipe losses are reduced to a minimum, and the full value of superheated steam can be employed. The cylinders can also be jacketed with high-pressure steam from the boiler without any loss due to drains and steam-traps, as the cylinder casing forms a portion of the steam space of the boiler.

A number of eminent firms are now manufacturing this type of steam plant, but it should be recorded here that the German firm, Messrs. R. Wolf, of Magdeburg, was the first to apply this type of engine to any great extent, and they have now supplied a very large number of them driving important factories in different parts of the world. Messrs. Richard Garrett and Sons, Limited, of Leiston, Suffolk, were the first English firm to take up the manufacture of this type of engine, and they also have made a considerable number of these engines and have had great success with them.

In general principles the Garrett engine follows the lines laid down by our friends in Germany, but in actual point of details of construction the Garrett engine follows British practice, and, being more massive in construction, is more easily kept in good order and condition. In order to make clear the actual construction of these engines, a brief description of a standard Garrett engine will now be given. In Fig. 2 we have a photograph of the engine, which gives its general appearance, and also indicates clearly how the arrangement is carried out. Turning now to the details, Fig. 3 shows a general view of the boiler, with the various seatings riveted to it arranged to take the engine. The boiler is what is sometimes known as a "Cornish multitubular boiler," in that it has a single circular furnace and heating surface consisting of smoke-tubes, through which the products of combustion pass. This type of boiler gives the large steam and water space of the Cornish boiler, together with the high efficiency of the locomotive-type boiler. A special feature of the boiler, and one which does away with all the disadvantages of a tubular boiler, is that the whole of the furnace and the tube system can be readily withdrawn for cleaning and inspection.

Fig. 4 shows an illustration of the furnace and tube system withdrawn from one of these boilers, and it will be noted that a bolted joint is formed between the ends of the furnace-ring and the front end-plate, and between the back tube-plate and the back end-plate. By undoing these bolts the whole of the tube system slides out of the boiler, allowing all the heating surfaces to be very thoroughly cleaned, and giving free access to the interior of the boiler. Special jointing rings are used for this purpose, which, if carefully blackleaded, can be used over and over again. The actual time taken to withdraw the tube system and replace is from five to six hours, and the time occupied in cleaning depends on the amount of scale present, and on the number of men that can be employed. If it is a matter of urgency, a large number of men could be put on to chip and scale the heating surfaces, and the work carried out in a very short time. It is quite safe to say that the withdrawable-tube type boiler is superior to any other type of boiler as a steam-generator, in these features, for this class of work.

The saturated steam from the boiler is conducted first to a superheater, which is situated in an extension of the smoke-box, as shown in Fig. 5. This figure shows the superheater chamber arranged for a chimney to be mounted directly upon it. In cases where there is an existing chimney, the position of the superheater is reversed and the waste gases conducted to a flue below ground-level.

The superheater itself consists of a number of zig-zag coils of solid-drawn steel tubes expanded into cast-steel headers, and the steam in passing through these tubes travels in the opposite direction to the flow of the hot gases past the tubes, thus ensuring that the maximum efficiency of the superheater is obtained. The joints in the pipes connecting the superheater to the boiler and to the engine are situated outside the smoke-box, where they can be readily disconnected, and the superheater itself can be completely withdrawn from the chamber in a very easy manner. A notable point of difference between English and German design in respect to the superheater is that, in the former, the coils are more accessible for cleaning, and are placed in such a position that they do not interfere with the free use of a tube brush for cleaning the boiler-tubes. In the latter the coils are not so accessible, and the smoke-tubes of the boiler can only be cleaned by a steam-jet, which is not sufficient to remove the deposit, with many classes of fuel.

From the superheater the steam is conducted to the engine, which is a side-by-side compound engine fitted with piston-valves to high and low-pressure cylinders. Fig. 5 shows a vertical section through the cylinders of the engine, and Fig. 6 is a horizontal section through the cylinders. From these figures the construction will be clearly seen, and it should be noted that the cylinder casing forms a steam-jacket for both cylinders, the actual working barrel or liner of the cylinders being made of special cylinder metal pressed into this casing hydraulic-

* Paper read before Section G of the British Association at Portsmouth.

OVER-TYPE SUPERHEATED-STEAM ENGINES.

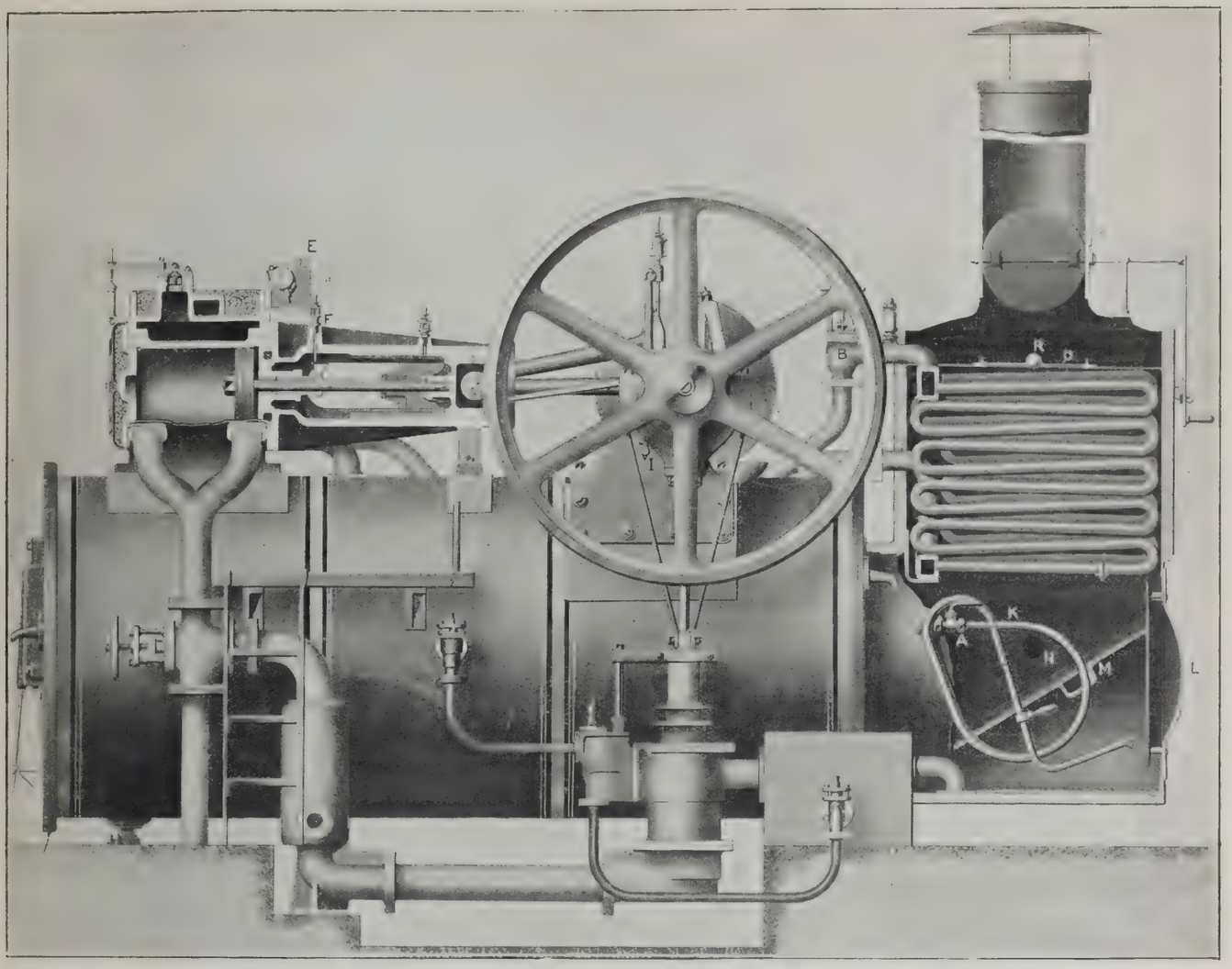


Fig. 5. Vertical Section through the Engine and Superheater.

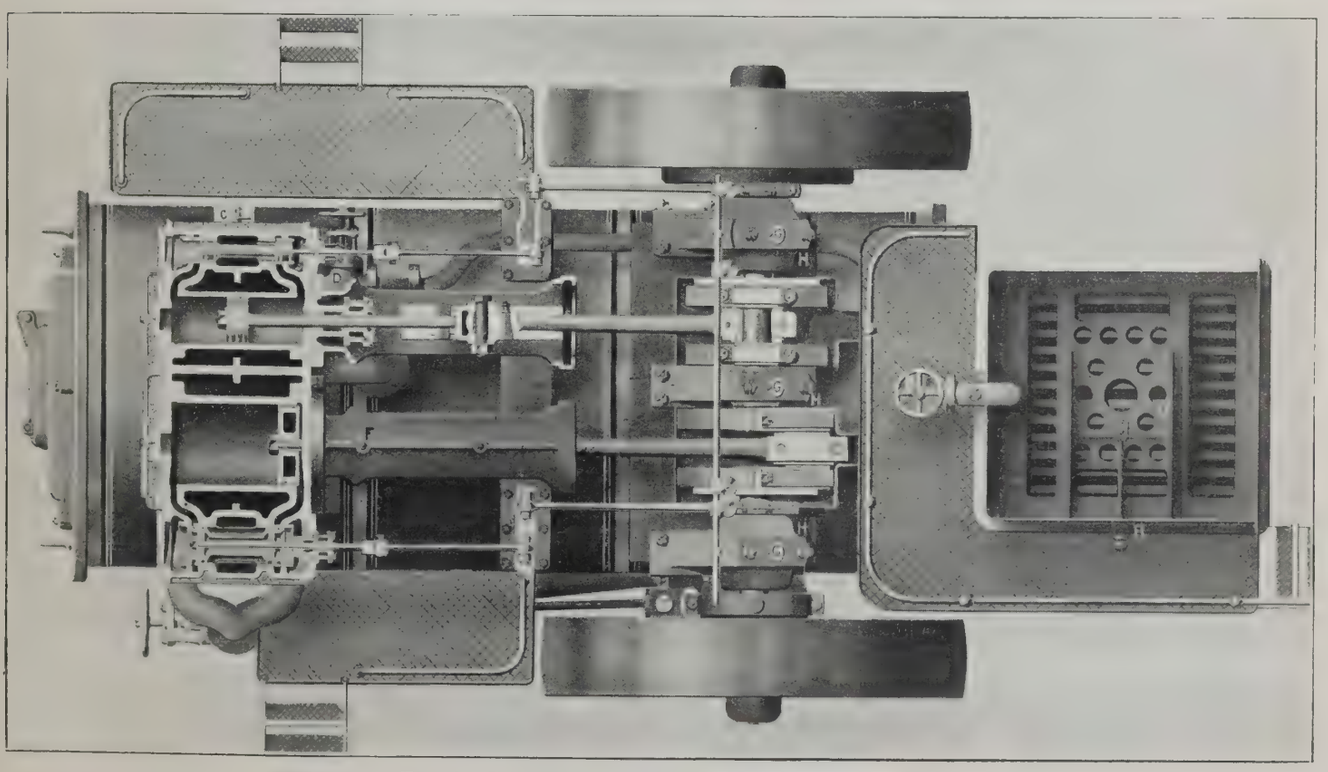


Fig. 6. Horizontal Section through the Engine.

ally. It is also to be noted here that no steam joint is formed between the casing and the pressed-steel saddle on the boiler to which it is fixed, the steam for the jackets being supplied by a separate pipe, which will be noticed in Figs. 4 and 5.

Lubrication is, of course, very carefully attended to, the main crank-shaft journals being the self-oiling type, and all other points being fitted with sight-feed lubricators. With superheated steam care must be taken that the cylinder lubrication is carried out properly, and to ensure this a positively-driven sight-feed lubricator is supplied, which forces the oil both to the high and low-pressure piston-valves, and thus the whole of the interior of the engine is efficiently lubricated.

The engine is governed by varying the cut-off in the high-pressure cylinder, a highly sensitive and powerful crank-shaft governor operating upon the high-pressure piston-valve. This arrangement gives high economy at light loads, especially as superheated steam is used, and initial condensation consequently reduced to a minimum. From the low-pressure cylinder the exhaust steam is led to a jet-condenser of a simple and efficient type; where necessary a surface-condenser can be employed. The condensed steam and vapour are drawn away by an air-pump, driven from the crank-shaft of the engine, which is clearly shown at the side of the engine in Figs. 2 and 5. To the air-pump crosshead is connected the feed-pump, which in Fig. 2 is shown with its suction-pipe connected to the hot-well, a plan that can be adopted when there is an ample supply of cooling water.

Where a cooling plant is used, it is not advisable to take the feed-water from the hot-well, as there is a chance of putting large quantities of oil into the boiler, but every engine is fitted with a Wilkinson's patent direct-contact internal feed-water heater, so that cold feed can be used without any fear of damage to the boiler, and with the highest efficiency.

TABLE I.—*An Official Trial conducted by Captain H. R. Sankey, R.E. (Ret.), M.Inst. C.E., on a Garrett Compound Condensing Superheated-Steam Semi-Stationary Engine of* 50-65 *Brake Horse-Power Capacity Continuous Working Load.*

Date of trial	October 16, 1909
Duration of trial	7 hours
Mean revolutions per minute	201.5
Mean temperature of feed-water	112 deg. Fahr.
Mean temperature of superheated steam	536.5 ,,
Average indicated horse-power	58.25 h.-p.
Average brake horse-power	55.6 ,,
Mechanical efficiency	95.5 per cent.
Water evaporated per pound of coal	8.91 lb.
Coal per brake horse-power per hour	1.21 ,,
Water per brake horse-power per hour	10.66 ,,
Calorific value of coal used	14,260 B.Th.U. per lb.

TABLE II.—*Test of Garrett Compound Superheated-Steam Semi-Stationary Condensing Engine of* 140-180 *Brake Horse-Power Capacity Continuous Working Load Installed in a Flour-Mill.*

Duration of trial	12 hours.
Total coal used	2150 lb.
Coal for heating	336 lb. to 450 lb.*
Net coal for power	1814 lb.
Coal per hour for power	164.5 lb.
Temperature of steam	540 deg. to 550 deg. Fahr.
Vacuum	24 in. to 24½ in.
Speed	170 r.p.m.
Calorific value of coal used	12,404 B.Th.U. per lb.
Moisture in coal	10.29 per cent.
Mean indicated horse-power	115.8 h.-p.
Mean brake horse-power at 92 per cent. efficiency (60 per cent. of full load)	106.5 h.-p.
Coal per indicated horse-power per hour	1.42 lb.
Coal per brake horse-power per hour	1.55 lb.
Corresponding consumption per brake horse-power per hour of dry coal of 14,000 B.Th.U.'s per pound calorific value	1.24

* This steam is used for conditioning purposes. The lower figure was ascertained on a previous trial. On actual day of trial more steam was being used owing to the class of wheat which was being ground, but the lower figure has been taken.

TABLE III.—*One Week's Test on a Garrett Compound Superheated-Steam Semi-Stationary Condensing Engine of* 65-88 *Brake Horse-Power Continuous Working Load, driving the Winding-Shed of a Weaving Factory.*

Date of test	October, 1910
Duration of test { Running time	49 hours
Duration of test { Standing time	119 ,,
Coal used while running	3420 lb.
Coal used while standing	1175 ,,
Power developed, calculated from the number of machines in use	45 to 50 b.h.-p.
Coal per brake horse-power per hour running	1.55 lb. to 1.4 lb.
Coal per hour standing by	10 lb.
Coal used	Whitehaven steam coal of calorific value of about 13,500 B.Th.U. per lb., costing 16s. per ton delivered.

NOTE.—During the week's run the engine was working non-condensing for 10 to 12 hours. If it had run condensing during the whole period, a still better result would have been obtained.

It will be seen from this brief description of the Garrett engine that the whole plant is a very straightforward design, and in no way is anything new or untried embodied in its construction, the various parts being made on principles which are well known and universally accepted. By combining these parts in the manner shown, all the fundamental losses of the steam plant are reduced to their minimum, and the result is a very striking economy.

In October, 1909, Captain H. Riall Sankey, M. Inst. C.E., carried out a seven hours' test on a standard Garrett engine of 50 brake horse-power rated output, and in Table I. will be seen some of the principal figures obtained on this test. It will be agreed that the figure of 1.21 lb. of coal per brake horse-power per hour is really an astonishing one for an engine of such small size. This is, of course, a test figure, but the engine was run exactly as it would be in practice, and no special arrangements were used in order to obtain an extraordinary result. The economy to be obtained in actual installations is indicated by tests carried out under running conditions on engines which have been at work some time, particulars of which are given in Tables II. and III.

It is not necessary to enter into a detailed examination of the reasons why such a high economy is obtained, but put briefly they are as follow:—

1. The boiler, superheater, and engine are carefully designed with regard to their proportions to each other for the output required.
2. The steam-pipe losses are eliminated.
3. Cylinder condensation is eliminated by the use of superheated steam and by jacketing the cylinders with live steam from the boiler without drainage losses.

It will be recognised that the field for such an engine is a very large one, and it will be of interest to here describe an actual installation of one of these engines.

OVER-TYPE SUPERHEATED-STEAM ENGINES.

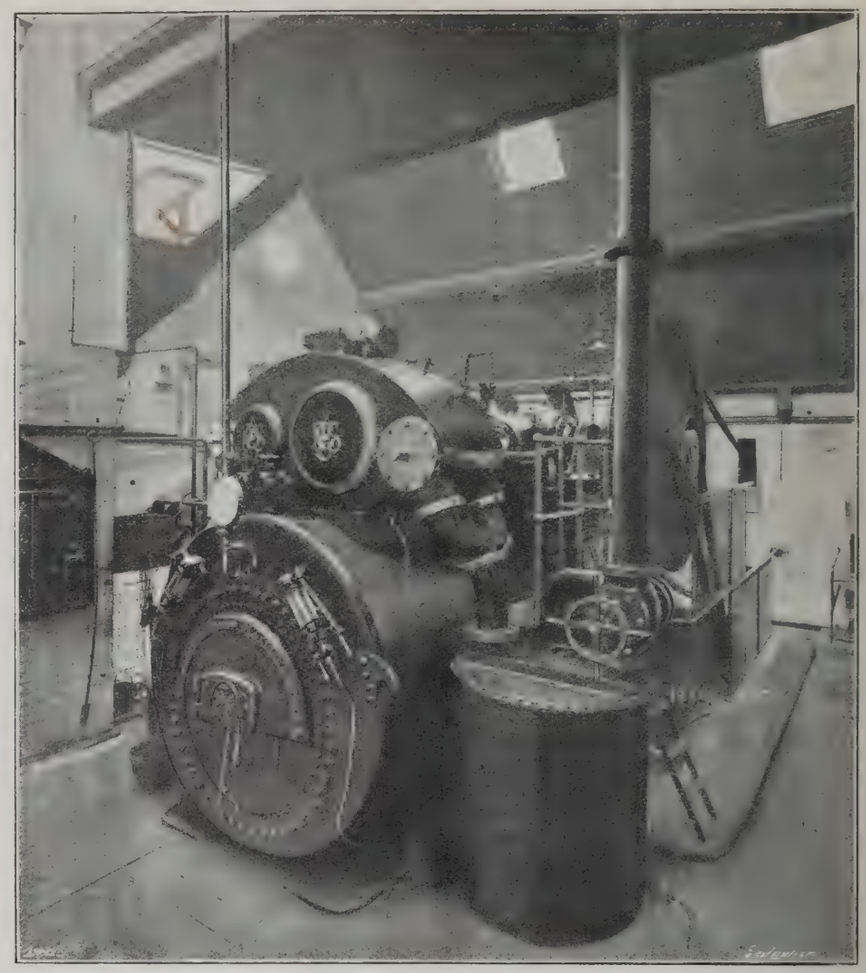


FIG. 7. 140-180 HORSE-POWER ENGINE AT FLOUR-MILLS, ALDERSHOT.

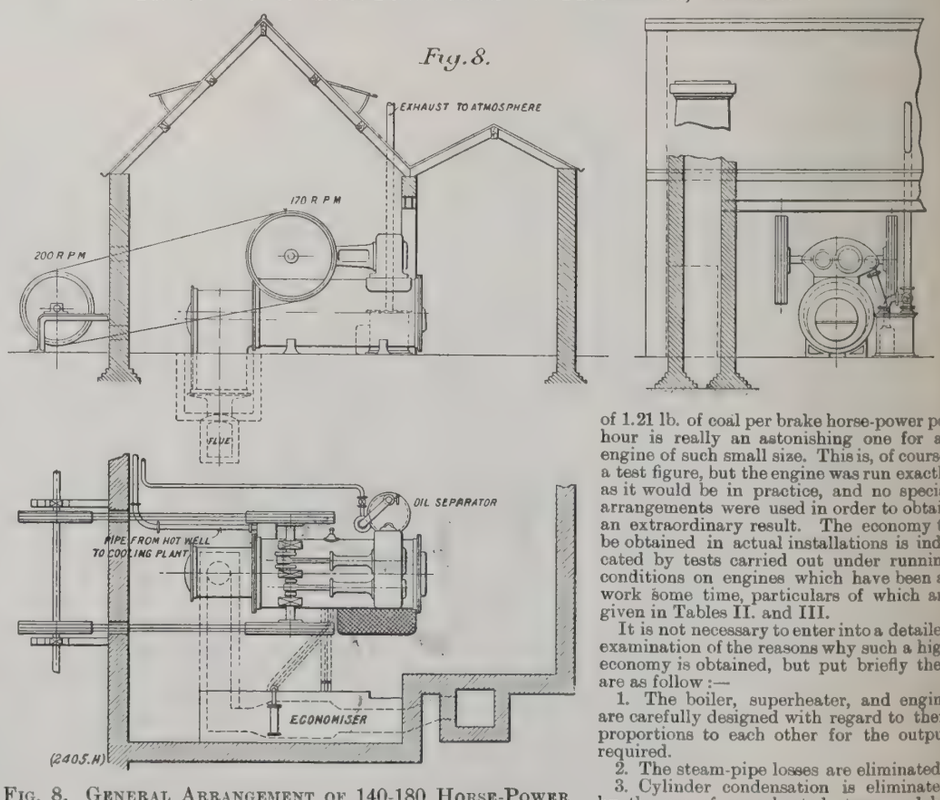


FIG. 8. GENERAL ARRANGEMENT OF 140-180 HORSE-POWER ENGINE IN FLOUR-MILLS.

Fig. 7 is a photograph showing an engine of 140 to 180 brake horse-power installed in a flour-mill. Fig. 8 is a diagram showing the arrangement of this engine. In a flour-mill the duties are severe, as the engine is required to run night and day for 140 hours per week, and to get the best results it is necessary to keep a steady speed and have an even turning movement. This particular installation is of especial interest, as the over-type superheated-steam engine was put in to replace a suction-gas plant. It was found with the suction-gas engine that a great deal of time had to be spent, overhauling and cleaning, in order to obtain a continuous run with it, and that even with this attention it occasionally failed during the week's run. It was also found that the speed was liable to vary considerably, and, in spite of a very heavy fly-wheel, the drive was somewhat irregular.

None of these difficulties are experienced with the superheated-steam engine, and since it has been at work it has actually been found that the cost of fuel per sack of flour made is lower than was obtained with the suction-gas engine. This is a very praiseworthy result, especially when it is taken into consideration that the steam-engine is at the present time running only about 0.65 of its full load, owing to additions to the mill not being yet completed.

In Table II. are shown actual figures taken from a day's run of this mill in ordinary work recently, and they show that the high economy obtained on the test-bed is still maintained under running conditions.

In Fig. 9 an illustration of an engine driving a weaving factory is shown, and the figures in Table III. were obtained from a week's run of this engine under ordinary conditions, which also show a very marked economy, considering that the average load of the engine was only about half its rated output. In Fig. 10 a photograph* of an engine of 88 to 118 brake horse-power capacity, driving a dynamo in the power-generating station of a factory, is shown, which gives a good idea of the workmanlike and compact installation one of these engines make.

One of the most important advantages of this type of engine is the readiness with which any type of fuel can be used, and the economy with the other types of fuel is proportionately as good as that obtained with steam-coal. Special furnaces have to be supplied for some of these fuels. Fig. 11 is an illustration of an engine arranged to burn wood refuse from lathes, planing-machines, and saws. This engine is fitted with an automatic furnace which sprinkles the refuse over the fire-bars and maintains a very steady combustion with very economical results.

A test on an engine of this type gave 1 brake horse-power per hour with a consumption of 3.9 lb. of wood refuse, consisting of shavings, chips, and saw-dust. The automatic portion of the furnace is only adapted to deal with the light stuff, but an ordinary fire-door is provided, through which lumps of wood can be fired when required. Figs. 12, 13, and 14, page 368, show various other types of furnaces for special use.

It has already been mentioned that the superheated-steam engine is a successful rival of the internal-combustion engine. The internal-combustion engine has achieved its success by reason of its very low fuel consumption, this fuel consumption being so much lower than that obtained with the ordinary type of separate engine and boiler using saturated steam that manufacturers are prepared to put up with a certain amount of unreliability in order to obtain the economy. This has not always been a wise procedure, as is indicated by the number of factories which have gone back to steam-engines after having adopted internal-combustion engines.

It must be universally admitted that the steam-engine is more reliable than the internal-combustion engine, and is more capable of performing its duty continuously without involuntary stops or bad starts. The reasons for this superior quality of the steam-engine are obvious. The successful operation of an internal-combustion engine depends on a high state of efficiency of a number of delicate parts which are subjected to rather severe treatment. On the other hand, the corresponding parts of a steam-engine are in no way delicate, and do not receive this severe treatment, and, in addition, a temporary loss of efficiency in such parts does not mean interruption to the supply of power.

Take, for instance, the exhaust-valve of an internal-combustion engine. Should it become worn, and not gas-tight, the engine is at once rendered incapable of producing the maximum power which is required from it, and is liable to be brought to an involuntary stop if even its normal full load were demanded from it. The exhaust-valve in an internal-combustion engine depends on its gas-tightness, on the close fitting of small metallic surfaces, and these surfaces are bathed during every exhaust stroke by the intensely hot products of combustion, and are brought together frequently with considerable force.

On the other hand, in the case of the steam-engine, loss of efficiency of the corresponding part does not necessarily mean a reduction in the capacity of the engine, owing to the flexibility of the system, and the engine can be depended upon to produce its full power without an involuntary stop until such time as the valve can be put right. Further, such loss of efficiency is not so likely to occur, as the tightness of the valve depends on the fitting of well-lubricated sliding surfaces of large area which are not exposed to temperatures anything like as high as obtain in internal-combustion engines. Involuntary stops and bad starts have a definite monetary value in any factory, depending on the nature of the factory, and the cost of these in most cases would bring the cost of power produced by internal-combustion engines very nearly up to that of power produced by an ordinary steam-engine of no great economy. It follows, therefore, that if a steam-engine can be obtained giving a fuel economy on a par with that of the internal-combustion engine, it will undoubtedly form the most suitable prime mover for installation in a factory or for power-gene-

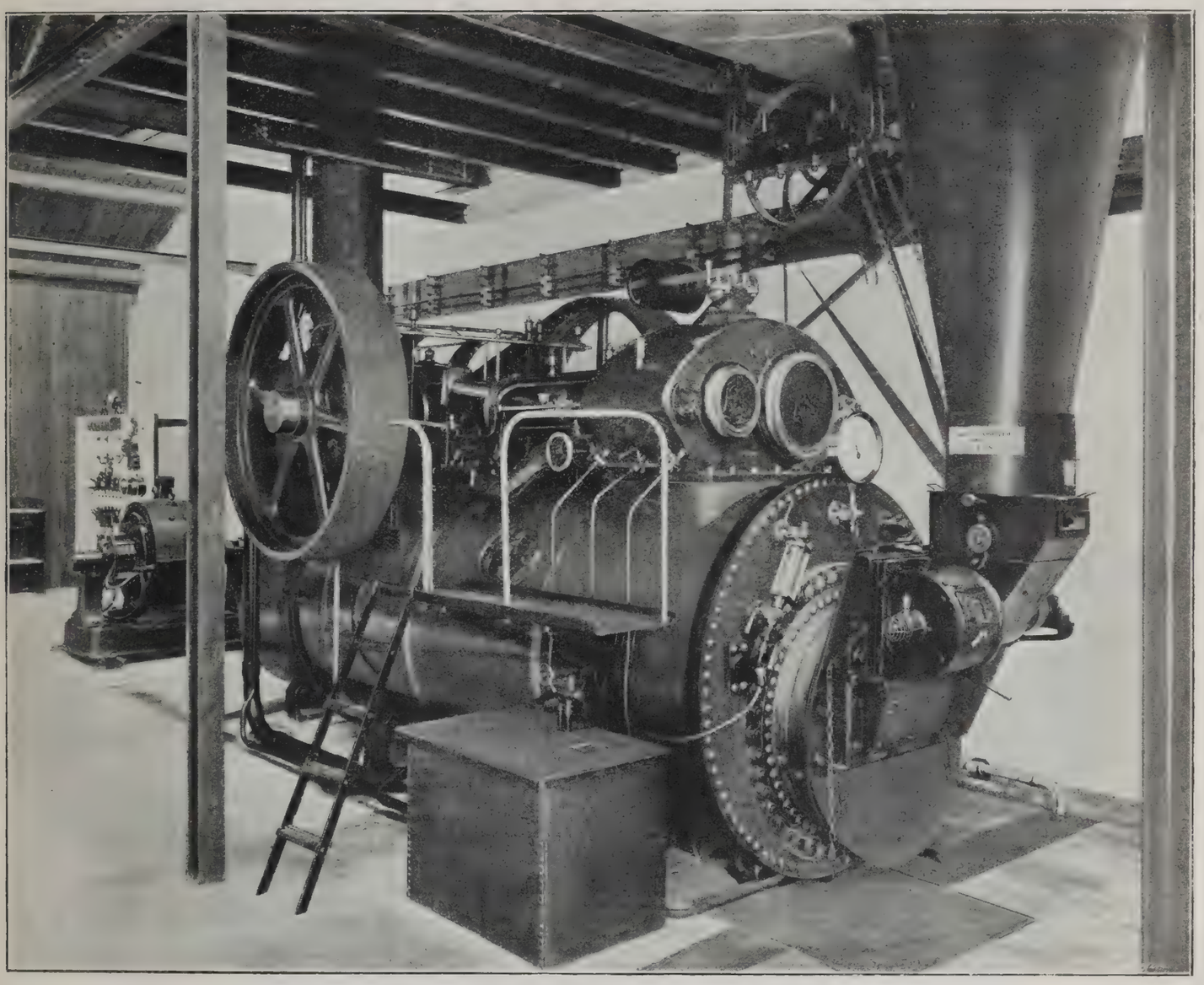


FIG. 11. ENGINE ARRANGED TO BURN WOOD REFUSE FROM MACHINE-TOOLS AND SAWS.

* [The demands upon our space do not permit us to reproduce Figs. 9 and 10.—ED. E.]

rating stations where economy and reliability are the principal considerations.

In comparing these two types of prime mover on the point of cost of fuel, it has been taken that the steam-engine is using steam-coal of fair quality, and the suction-gas engine anthracite peas. The latter is by far the most generally used fuel with suction-gas engines, although in individual cases good results have been obtained with gas-coke at a much lower figure. Gas-coke is only available in a few cases, and a comparison with it would not be satisfactory, especially as with its use the reliability question assumes another aspect still more in favour of the steam-engine, owing to the presence of tar and the liability of clinkering in the producer.

The actual cost of fuel in any factory is by no means the most important of the various items which make up the cost of power production, and its relative importance varies according to the type of factory. To discuss this point at length would make this paper unwieldy; in fact, it would form a suitable subject for a separate paper.

Including the stand-by losses per hour of the over-type superheated-steam engine plant at 10 per cent. of the total coal burnt per hour at full load, and those of the suction-gas plant at 5 per cent. of the same quantity, the Diesel engine having no stand-by losses whatever, the following is the cost of fuel for each type of engine:—

—	Over-type Superheated Steam Engine.	Suction-Gas Engine.	Diesel Engine.
Consumption per brake horse-power per hour	1.5	1	0.5
Consumption per week, running time	8100	5400	2700
Stand-by consumption per week	1710	570	nil
Total consumption per week ..	9810	5970	2700
Cost per week	3.5*l.*	3.46*l.*	2.7*l.*
Cost per annum	175*l.*	173*l.*	135*l.*

above comparison the load has been taken at an average of 100 brake horse-power. This average might be that of a very fluctuating load, which might range between 60 and 150 brake horse-power.

The greater the difference between the peaks and hollows of the load-curve the more striking is the advantage of the steam-engine, on account of the fact that the internal-combustion engine has a very definite limit as to the maximum load which it is capable of dealing with, and, consequently, engines sufficiently large to deal with the peak loads must be installed, increasing the capital cost and, in the case of the suction-gas engine, giving very poor results as regards economy on the lighter loads.

On the other hand, the steam-engine is capable of producing, when required, as much as 50 per cent. above its normal load for considerable periods, and, owing to its high mechanical efficiency, maintains a low consumption per brake horse-power over a wide range of loads. Fig. 15 illustrates this feature of the superheated-steam engine in comparison with the suction-gas engine very

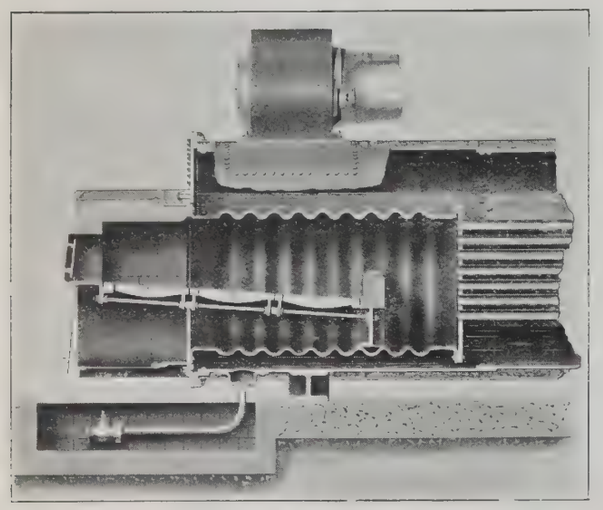


Fig. 12. Combustion Chamber with Extended Grate for Burning Wood Blocks and Inferior Coal.

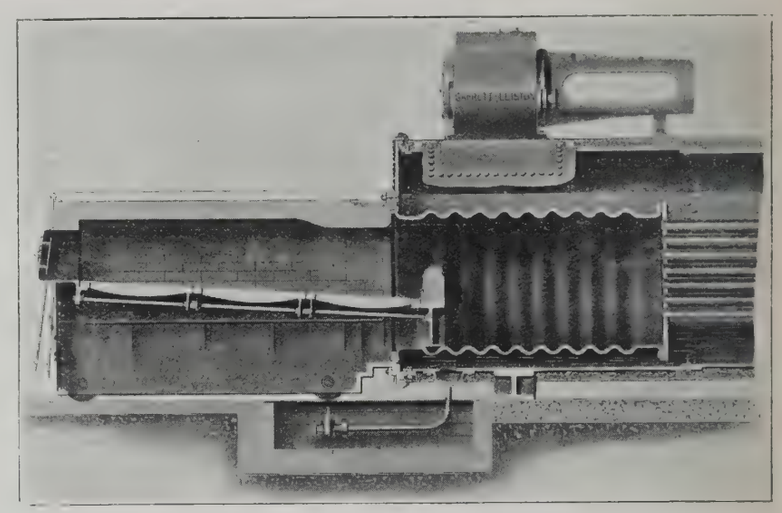


Fig. 13. Specially Long Log Combustion Chamber Mounted on Truck.

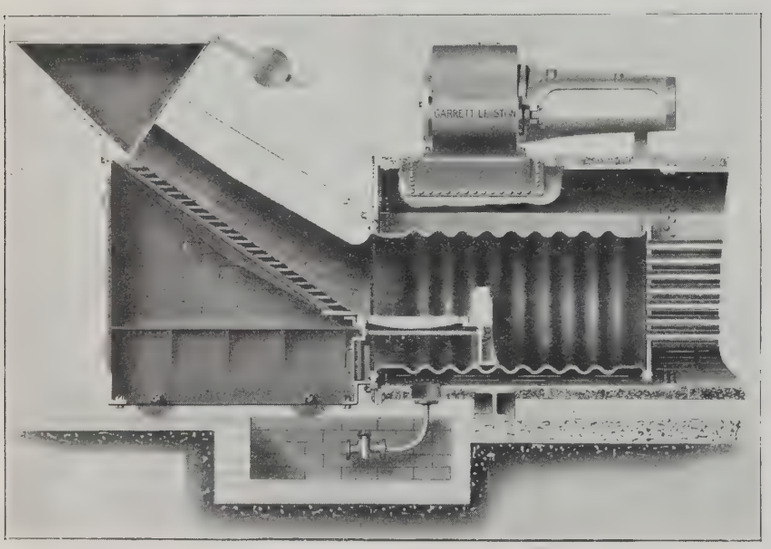


Fig. 14. Combustion Chamber for Burning Sawdust, &c.

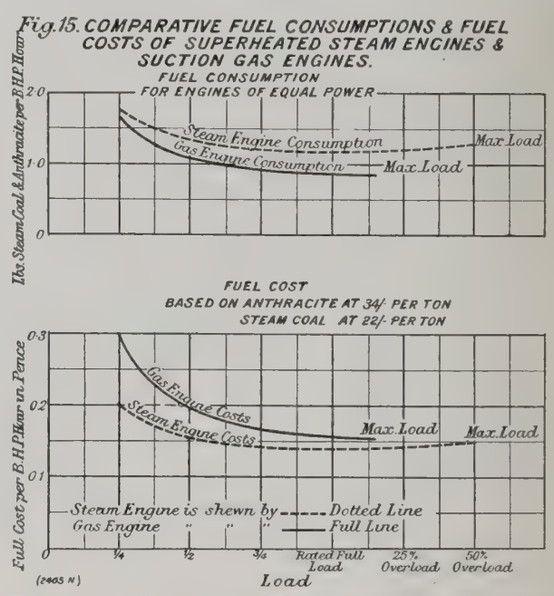


Fig. 15. Diagram of Comparative Fuel Consumptions and Fuel Costs of Superheated-Steam Engines and Suction-Gas Engines.

The author is of opinion that in almost every factory the most important item is continuity of running, or reliability. It is not an easy matter to set a definite value on this item, and it can only be approximated by estimating the actual loss incurred by any factory due to a breakdown which interrupts the supply of power.

The author has made inquiries with regard to this point from a number of power-users, and the following hypothetical case is a conservative estimate for an average example. It is a simple matter for any power-user to work it out for his own particular case.

Assume that a machine-shop employing 100 men, whose average wages are 7d. per hour, requires an engine of 100 horse-power to drive it. The total amount of wages per hour comes to 2.9*l.* For management expenses, &c., the usual figure to add is 100 per cent., making the prime cost of running the shop 5.8*l.* per hour. Taking a 54-hour week and 50 weeks per annum, and the following prices of fuel:—

	Per Ton.
Steam coal	16s.
Anthracite	26s.
Fuel oil...	45s.

This comparative statement shows that under the above conditions the plant having the lowest fuel cost is the Diesel engine, which shows a saving of 40*l.* per annum over the superheated-steam engine; but it should also be noted that if — through bad starts or involuntary stops — the power supply be interrupted to the extent of ten hours per annum, the prime cost of such stoppages would amount to 58*l.*, absolutely wiping out any gain due to lower fuel consumption.

If we carried this comparison still further, it would be found that the capital cost of the Diesel engine would be considerably higher than that of the superheated-steam engine, and, consequently, the capital charges per annum would be greater. These form a very considerable item in the cost of power. Further, the steam-engine can be run satisfactorily by a man of a lower order of skill than that required by Diesel or suction-gas engines, and his wages would consequently be less.

In addition, the wages required for maintenance would be less, as the parts requiring attention about a steam-engine can be attended to by an ordinary driver, whereas with the internal-combustion engines expert mechanics are necessary to effect adjustments and repairs. In the clearly. Two sets of curves are shown plotted on a load base. The upper set shows the actual fuel used per brake horse-power per hour at any load from a quarter of full load to the maximum overload of a suction-gas engine and also of a superheated-steam semi-stationary engine. The lower set shows the cost of this fuel for each type of engine for the same range of load, taking the average figures for fuel obtainable in the London district, of, say, 22s. per ton for steam-coal, and 34s. per ton for anthracite.

From these curves it is clearly shown that the cost of fuel per brake horse-power per hour with the superheated-steam engine is very nearly constant over a wide range of loads, and does not increase on light loads to anything like the same extent as with the suction-gas engine. A further advantage of the steam-engine is that the exhaust can very readily be used for heating purposes when required. In the weaving factory previously referred to, the exhaust steam, on its way to the condenser, is conducted round 600 ft. of the heating pipe during the winter months, and is sufficient to keep a room 300 ft. long by 75 ft. wide at the proper temperature. This heat is obtained at no cost.

The author feels that he has merely touched on the

fringe of a very large subject, but is confident that the few facts he has brought forward show that, as a prime mover, the steam-engine is still more than able to hold its own. Every case must be considered on its merits, and there are admittedly propositions which are very admirably filled by internal-combustion engines. He is, however, of opinion that the use of the internal-combustion engine has latterly become somewhat of a fashion, and is certain that when the over-type superheated-steam engine is more widely known it will take the place of the internal-combustion engine in a great number of power propositions.

THE DIESEL OIL-ENGINE.*

By CHARLES DAY, Wh.Sc.

THE economical generation of power for industrial purposes depends mainly upon the following factors :—

1. (*a*) The attainable economy of working at different loads of the prime mover itself, including boiler or gas-producer, and all accessories, such as condensers, feed-pumps, water-pumps, &c.

(*b*) The degree to which this attainable economy can be practically maintained under the conditions of working, and the load-factor.

2. The stand-by losses—*i.e.*, the expenditure necessary to keep the plant ready for work when wanted.

3. Wages of engine-room attendants, stokers, and other men employed about the power-house.

4. Expenditure on lubricating oil, cleaning waste, and sundry stores.

5. Cost of repairs and of the maintenance of all parts of the plant in good working condition.

6. The cost of water for condensing, and for boiler feeding in the case of steam plant, for the engine water-jackets, and for the gas-producer in the case of gas-plant, or for the engine water-jackets in the case of Diesel plant.

From the mere enumeration of these items it is very obvious that tests either at makers' works or on site, even though the tests extend for a week or so, do not form a sufficient guide as to the real value of the engines for industrial purposes, and that a far safer, in fact the only safe, conclusion can be formed from a study of results obtained in actual practice. For instance, it matters not how economical an engine may be in regard to fuel if the expenditure in other directions more than outbalance the gain in fuel consumption.

Take now the above-mentioned items in detail :—

1. (*a*) The attainable economy may be said to be that corresponding with the guarantees given by the makers, though many makers take the cautious policy of guaranteeing figures which leave them some margin in hand. The attainable economy must not be considered at full load only, but must be considered for varying loads, as it often happens that plant has to run for considerable periods at half load or even quarter load; in other words, the plant may have to operate with a poor load-factor. In the case of steam plant it is not sufficient to consider only the steam consumption of the engine and the evaporative efficiency of the boiler, but due allowance must be made for the power to drive accessories, such as feed-pumps, coal-handling plant, condensing plant, and other such accessories. At light loads the power taken by these accessories may easily represent a large proportion of the total power.

(*b*) In actual service it is not to be expected that power plant can always be kept and worked at its highest efficiency. For instance, in the case of steam plant the efficiency is much influenced by—

The skill of the fireman.
Variation in the quality of coal.
The condition of the furnaces and flues.
Deposits of scale in boilers.
Deposits of scale and grease in condensers.
The air-tightness of the condenser and of the exhaust-pipe and joints, &c.

With these and other adverse influences at work, the average results actually obtained over a term of years differ considerably from those attainable under the very best of conditions.

2. In certain factories, and particularly in electricity stations, the exact time at which a load will come on is not really known. For instance, the hour at which the lighting load comes on is affected by weather and clouds; it is therefore necessary as evening approaches to have plant ready for going on to load at a moment's notice, although the plant may not be required for an hour or more. With steam plants, this means that steam must be kept up on boilers and engines warmed up; with gas plants, producers must be alight and in working order. The cost of this cannot well be determined separately from the running costs, but experience shows that it is very substantial.

3. The cost in wages depends largely on the complexity of the plant, and on the amount of handling required by the fuel. It is also increased if the plant has to be got ready for running before being actually required.

4. The expenditure on lubricating oil and general stores depends also on the simplicity or otherwise of the plant and its character, actual practice being again the only guide. Of course, the figures may be much influenced by attention to little economies.

5. The cost of repairs mainly depends on the care and judgment exercised in the use of the plant, and on the quality of the design, workmanship, and material of the plant itself. In the case of steam plant, the use of corrosive or sedimentary water may cause great expense in repairs and upkeep, whilst with gas plants renewals of portions of producers are often necessary. Again, actual working figures form the only safe guide.

The great difficulty most buyers find is in securing reliable figures of power costs from people engaged in trade, except in the case of electric-supply stations. The writer does not know of any body of large power-users who systematically prepare accounts showing their power costs on a uniform basis, and publish them. This practice in connection with electric-supply stations fortunately does give an independent and authoritative basis, from which valuable deductions can be made. The figures published in the *Electrical Times* cover practically almost all the supply stations in Great Britain, and this information combined with information obtained direct from station engineers has enabled the author to determine the average results obtained in such stations with different types of plant. These averages for stations having a plant capacity not exceeding 1000 horse-power are as follow :—

TABLE I.—*Average Cost per B.T.U. Sold.*

Type of Engine.	Fuel.	Lubricating Oil, Waste, Stores, and Water.	Wages.	Repairs and Maintenance	Total Works Cost.	Load Factor.
Steam ..	0.45	0.06	0.25	0.26	1.02	14.7
Gas ..	0.43	0.09	0.28	0.24	1.04	15.3
Diesel ..	0.23	0.04	0.19	0.07	0.53	14.3

The limit of 1000 horse-power was fixed owing to there being as yet no large electricity supply stations equipped solely with Diesel engine or gas-engines. Of course, better results are obtained when driving machinery which gives a better load-factor, but the causes which produce loss are, as a rule, the same, though modified in extent. The general conclusion formed from a study of electricity stations holds good for the great majority of power-users, though perhaps not applicable to some special trades, where engines can be run continuously on almost uniform loads. It is also necessary to point out that the figures include some items which should not strictly be charged against the power plant. For instance, the wages items include figures for men working on cables, street-lamps, and in sub-stations, whilst the repairs items include repairs to such parts. Also it is necessary to mention that the figures give the costs per unit sold, and not per unit generated.

From the averages it is clear that a substantial gain is obtained by the adoption of Diesel engines as against either gas or steam-engines, the figures being beyond doubt substantially accurate. It is also noticeable that the gain is not only on fuel consumption, but is practically in the same proportion on the other items of expenditure.

The great saving shown by these average figures is confirmed by repeated experiences of the author. In many cases, although the figures guaranteed with Diesel engines have been no better than figures previously guaranteed and obtained on tests, with existing steam and gas engines, the Diesel engines have shown over extended periods a saving of 50 and 60 per cent., and in some cases an even greater percentage, the result being due to the fact that the Diesel engine's average working results were very much nearer to the guaranteed figures than with gas or steam-engines, combined with the fact that the relatively high cost of working at light loads with gas or steam had not been sufficiently taken into account when considering the guaranteed figures.

When going through cost records to prepare the average figures previously given, the author noticed very wide differences of cost per unit, particularly in the case of the steam plant. He therefore had the average cost calculated for steam stations of different capacity, and as the results are interesting, they are given separately in Table II.

TABLE II.—*Average Works Cost per B.T.U. Sold, on Steam Stations of Different Sizes.*

Capacity Station not Exceeding	Fuel	Lubricating Oil, Waste, Water, and Stores.	Wages.	Repairs & Maintenance	Total.	Load Factor.
250 kw.	0.63	0.09	0.35	0.36	1.43	13.2
500 ,,	0.56	0.06	0.27	0.29	1.18	13.3
750 ,,	0.43	0.05	0.23	0.24	0.95	15.4
1,000 ,,	0.40	0.05	0.23	0.21	0.89	16.8
1,500 ,,	0 42	0.04	0.17	0.18	0.81	16.9
2,000 ,,	0.37	0.04	0 16	0.21	0.78	17.7
3,000 ,,	0.33	0.04	0.15	0.17	0.69	17.4
4,000 ,,	0.40	0.03	0.14	0.20	0.77	18.8
5,000 ,,	0.34	0.03	0.11	0.16	0.64	18.7
7,000 ,,	0.36	0.04	0.13	0.20	0.73	17.9
10,000 ,,	0.26	0.03	0.09	0.13	0.51	22.6
20,000 ,,	0.30	0.03	0.11	0.16	0.60	19.6
50,000 ,,	0.23	0.02	0.10	0.11	0.46	20.56

The table shows the great improvement which follows increase of size with steam stations, or, expressed in the reverse direction, it shows how great is the disadvantage of small stations when steam power is used.

It is, further, to be noted that, even with the largest steam-stations, the costs per unit generated are no better than for quite small stations using Diesel engines, and this in face of the improved load-factor. This is a most important point, and shows that small Diesel stations can profitably supply current at prices hitherto thought to be obtainable only in densely-populated centres having large power-stations.

In all cases the figures which have been given are works cost, and do not include anything for interest on capital or depreciation. It is hardly possible to give a definite statement showing the cost of constructing and equipping power-houses of different types, as there are so many variable factors. However, the author's experience of a considerable number of estimates indicates that up to a capacity of, say, 1000 kw. there is generally little difference between the gross capital expenditure required, whether steam, gas, or Diesel engines be adopted.

Having now dealt with what may be termed the commercial aspect, it may be well to now briefly study the constructional features desirable in engines for dynamo driving. In the first place the dynamo should be coupled direct to the engine shaft, and not be driven by belts or ropes, as the up-keep cost of these is considerable; also, with belt or rope drive, the space occupied is considerable. Direct coupling of dynamos means that slow-speed engines are to be avoided, otherwise the cost of the dynamos is very high. For speeds which are not slow engines of the multi-crank type become desirable, otherwise serious vibration is likely to be caused. For the same reason it is important that the distance between the centre lines of the cylinders of an engine be reduced as much as possible. If far apart, as, for instance, in the case of a cross-compound steam-engine with dynamo between, then each cylinder or line of parts will produce its own vibrating effects on the foundation without being materially influenced or counteracted by the other.

For multi-crank engines with cylinders close together the vertical construction is much more suitable than the horizontal, and gives much better accessibility. Also any unbalanced inertia forces do not tend to slide the engine about, but merely increase or decrease the weight on the foundations.

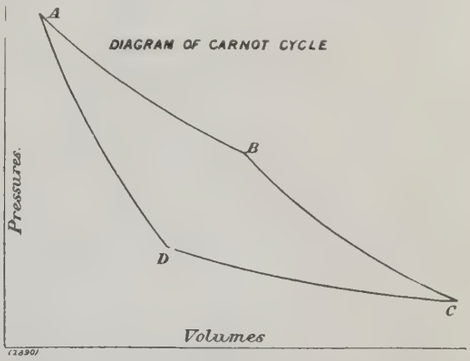
The vertical design is also better from the point of view of piston wear. Multi-crank engines are also advantageous as regards speed regularity during each revolution, which is a point of importance when driving alternators in parallel. When high-speed engines are adopted, the multi-crank vertical type becomes imperative, and experience has shown that forced lubrication to all bearings is very much better than any other system of lubrication. Also with high speeds the crank-chamber should be most completely enclosed, otherwise a lot of lubricating oil is thrown about, and damage to dynamos may occur, owing to oil getting on the insulation. Further, oil thrown about creates a general nuisance in the engine-house. This condition of very complete enclosing, combined with forced lubrication, is, in the author's opinion, an absolute essential for high-speed engines, whether steam, gas, or oil. With the first few oil-engines to which forced lubrication was applied a portion of the lubricating oil got drawn up into the cylinders. Detailed improvements in construction have, however, completely overcome this, and now the oil consumption is quite as low with the forced lubrication as with the ordinary systems. For moderate speeds of revolution, ring-lubricating main bearings are thoroughly satisfactory combined with centrifugal lubrication to crank-pins. With such an arrangement less complete enclosing meets all requirements of cleanliness.

There is another point in regard to the multi-cylinder design of engine which should be mentioned—viz, that with this design a smaller diameter of cylinder is required for a given power than with a single-cylinder engine. With internal-combustion engines this is of great importance, as after a certain size every enlargement of cylinder diameter brings with it increased constructional difficulties and a greater liability to breakdown.

Turning now to the particular features of the Diesel engine itself, it may be found interesting to trace shortly the development of the present Diesel cycle.

In 1824 Carnot enunciated the conditions required for a perfect heat-engine; and though Carnot's theories are well known, it may be well to briefly mention them here, so that the sequence may be more readily understood.

The Carnot cycle may be described thus :—



Point C (see diagram) indicates the volume and pressure of the working fluid when the piston is at the end of its stroke. From C to D the working fluid is compressed isothermally, the heat resulting from the compression being abstracted as it is added. From D to A the compression is adiabatic, no heat being abstracted or added during this period. From A to B isothermal expansion takes place, heat being added to maintain the temperature. From B to C adiabatic expansion takes place, the proportion of the various compressions and expansions being so arranged that the final volume, pressure, and temperature coincide with those at the commencement.

This cycle appears quite an impossible one, because during the one portion of the compression heat must be perfectly carried away—*i.e.*, the working fluid and the surrounding materials must be peffect conductors. Then during the second portion of the compression no heat must be carried away or added, meaning that the materials must now be perfect non-conductors; thus, one part of the compression period demands perfect conducting

* Paper read before Section G of the British Association at Portsmouth.

materials, whilst the other demands that they shall be perfect non-conductors, and similarly for the expansion period. With these opposing conditions it is not surprising that no application of the Carnot cycle appeared in practice for so long. Diesel, however, propounded a scheme which, to a certain degree, met the Carnot conditions. This scheme was as follows:—

The isothermal period of compression was obtained approximately by spraying water into the cylinder during compression, this water-spray being discontinued for the adiabatic compression. For the isothermal expansion fuel-oil was sprayed in to give the requisite addition of heat. The spraying in of fuel-oil for this purpose necessitated the adiabatic compression being carried to a high degree, so as to give a sufficiently high temperature to the air in the cylinder as to cause ignition of the oil sprayed in. Unfortunately, this cycle did not meet with success in practice owing to the very high pressure required, and to the small amount of work obtained, and gradually the original cycle has become modified to that now adopted, which may therefore be claimed to be the nearest to the Carnot cycle, which present-day practical limits admit. Briefly it is as follow:—

1. During the suction stroke air is drawn into the cylinder.
2. During the compression stroke this air is compressed to a considerable pressure and temperature.
3. For a short period during the next stroke oil is sprayed into the cylinder, and burns in consequence of the high temperature to which the air has been raised by compression. During the remainder of the stroke expansion takes place.
4. The products of combustion are exhausted.

The heat efficiency of the Diesel engine, though far from perfect, is still much better than any other heat-engine, as is readily seen from the fuel consumption, which is 0.44 lb. of fuel oil per brake-horse-power per hour. The fuel consumption is also low at partial loads—viz.:—

¾	load,	0.45 lb.	per B.H.-P. per hour.
½	,,	0.47 ,,	,, ,,
¼	,,	0.62 ,,	,, ,,

These are not records, but every-day figures, and are for engines of quite moderate size. With larger engines the fuel consumption per horse-power is rather lower, but increase of size does not give anything like the improvement in fuel consumption that occurs with steam-engines. This is a point to be remembered when fixing the size of engine to be adopted in a station. With steam plants the size of engine should be kept up, whilst with internal-combustion engines the size within certain limits can with advantage be kept down.

Owing to the high economy at light loads it is often found distinctly advantageous to run a Diesel engine in preference to using a storage battery.

From the description of the cycle the following advantages are obvious as compared with other gas and oil-engines:—

1. There is no sparking apparatus, lamp, or burner.
2. There is no carburettor, vaporiser, or mixing valve.
3. Owing to the absence of combustible gases or vapours during compression, back-firing or pre-ignition are impossible.
4. No warming-up is required, nor is there any fuel expenditure when not running.
5. The running of the engine is very smooth, owing to there being no explosion or sudden rise of pressure.

The oil generally used is residual petroleum—*i.e.*, the residue left from petroleum after the lighter oils have been distilled off. The increased demand for petrol will certainly tend to increase the further supply of residue; whilst the opening up of new oil-wells in various parts of the world is steadily increasing the oil supplies. Not only is residual petroleum used for Diesel engines, but residue shale-oil and gas-works tar-oil are now much used.

The fuel oil used can be almost any of the fuel oils which are used for boiler-firing, and a wide variety of oils can be used with no alteration of the engine; this being probably explained by the fact that a pulveriser which will sufficiently pulverise a thick viscous oil can easily pulverise the thinner oils. The use of oil fuel carries with it certain advantages in the way of ease of handling and of cleanliness. With coal it is difficult to avoid dust, and this must be particularly objectionable in the case of steam plant, where the engines are carried on the boilers, thus placing a considerable quantity of moving machinery in the neighbourhood of the coal. With oil there are no ashes to cart away, and thus handling of gritty materials is entirely eliminated. Usually the oil is pumped from an outside storage-tank to the small tanks near the engines.

The question may naturally be asked whether Diesel engines are suitable for long periods of continuous running. In reply to this the following instance may be quoted:—

At the Birkdale Electricity Works a Mirrlees-Diesel was put down a little over four years ago. The station engineer recently made a return which showed that the engine had, on the average, worked 23¾ hours out of every 24 hours throughout the four years, or an average stoppage of about 1½ hours each Sunday.

Numerous cases could be given of large savings effected, but the figures already given substantially prove this, and are perhaps more appropriate for a paper of this kind.

Diesel engines of the Mirrlees make have been fitted on board many warships and first-class cruisers, for driving dynamos; also some have been used for boat propulsion. It might be of interest to mention that the first Diesel engine made in Great Britain was a Mirrlees-Diesel engine, and was made over fourteen years ago; consequently the present Mirrlees-Diesel engines represent quite a long experience; and the present appreciation of this engine is not a temporary boom, but is based on substantial experience.

SMOKE ABATEMENT.

*The Possibility of Establishing a New Standard of Smoke Emission for Factory Chimneys.**

By Dr. John S. Owens.

My primary object in bringing this paper before you is to suggest the basis for a discussion of the question of a smoke emission standard, in the hope that some properly organised effort may be made to deal with the difficulties which have hitherto prevented the adoption of a proper standard.

I do not think that anyone will contradict me when I say that the emission of dense smoke from furnaces consuming bituminous coal is unnecessary and indicative of waste of fuel and bad furnace construction or working. It is true that there are a few special cases, such as heating brewery vats and pottery kilns, where the emission of dense smoke for short periods is by some still considered essential, but it is open to question if this opinion is justifiable. At the same time, it should be remembered that the total absence of all smoke is in practice usually impossible of attainment when the economy of manufacturing processes requires the burning of bituminous coal. An illustration of the difficulty of avoiding all smoke is provided by the large electric generating stations, where unforeseen variations of load occur, such as the increase due to a London fog, with its accompanying demand for artificial light. In such a case as this, it may be necessary to fire up fresh boilers very rapidly, and there is no known furnace which will admit of the smokeless combustion of bituminous coal, until the temperature of the combustion chamber has attained a sufficient height. Even in steady working it is practically impossible to avoid all smoke; a faint brown smoke is regarded as indicating more efficient working of boiler-furnaces than none at all. The emission of some smoke may, therefore, be regarded as inevitable.

The present position therefore is this: we know that dense smoke is unnecessary, and that entire absence of smoke is impossible of attainment, but we have not yet settled what, being fair and reasonable, should be permissible in the way of smoke, having regard to the improved methods of combustion which are now at the disposal of manufacturers. This is the question an answer to which is, I submit, within our reach and should be sought for.

The Public Health Act of 1875 supplies the present standard by which smoke is judged throughout the country, except in the case of a few important cities possessing special powers on the subject. In this Act it is stated that "Any chimney not being the chimney of a private dwelling-house sending forth black smoke in such quantity as to be a nuisance shall be deemed to be a nuisance liable to be dealt with summarily under the Act."

There is an alternative method provided by this Act, under which proceedings can be taken in respect of fireplaces or furnaces in connection with factories which do not "as far as practicable consume the smoke arising from the combustible used therein." In practice, however, it has been found that this method of abating smoke is unworkable, owing to the lack of some standard defining the meaning of the words "as far as possible."

The standard "black smoke in such quantity as to be a nuisance" takes cognisance of two separate things in relation to smoke: its quality—that is, it must be black; and its amount—that is, enough to cause a nuisance; but, while these two essentials are taken into account, it is done in such a way that it would be practically impossible to prove in any particular case, either that the smoke was black, or that it was in sufficient quantities to be a nuisance. The point I wish to make is that the two essentials, kind and quantity, form part of the standard.

Since the date of the Public Health Act of 1875, sufficient improvements in the methods of burning bituminous coal have been made to call for a reconsideration of the present standard, and the adoption of a more up-to-date one, which will conform in a reasonable way with the possibilities of modern practice. It is unnecessary to deal at length with the evils attending the emission of smoke, from the point of view of the public. They have to breathe the smoke-polluted air of cities, useful energy and money have to be expended in cleaning away soot, buildings are injured and blackened, the daylight and sunshine are cut off, and in many other ways harm is done which, to a great extent, might be avoided if we had a sound, legally-enforced standard for smoke emission, based on the known results which the proper application of modern methods of combustion give. Manufacturers would then use the best methods of combustion and the most suitable appliances. The loss to the manufacturer in soot, estimated as a percentage of his fuel bill, is probably not more than a ¼ to 1 per cent., and this is not great enough to induce much effort to save it. On the other hand, the loss to the public due to the injuries inflicted by smoke is certainly many times greater; hence it is more to the interest of the public than of the manufacturer to reduce smoke.

One difficulty which has always existed is that of dealing with large and small fuel consumers by means of a single standard, and this has militated against the establishment of a more rational standard than that laid down in the Public Health Act. Clearly we cannot limit a large manufacturer to the emission of the same total quantity of soot as a small one. His furnaces might be better designed, and combustion more perfect, than in the case of the small consumer, but the total quantity of soot emitted might be much greater. Such a limitation would therefore work unfairly against the large fuel consumer.

At first sight it would seem that the total quantity of soot emitted by any chimney would be the soundest thing to limit, since it determines the amount of pollution of the air by soot from a particular source; but on closer examination it appears that this is not really the best basis. What we are concerned with is the total pollution of the air by soot due to all chimneys in any particular neighbourhood. For example, the erection of an electric generating station where large quantities of fuel are burnt may, by displacing many small consumers who had previously to generate their own power, actually cause a great reduction in the amount of soot poured into the air. At the same time the total quantity of soot emitted from such a station might be many times greater than that previously emitted by any one of the smaller power units which it displaced; in spite of the fact that the combustion might be better and the amount of soot per ton of fuel burnt much less.

What we may reasonably ask for is, that the best and most smokeless methods of combustion should be used. If we could therefore fix a sound standard which would be some measure of the efficiency of the methods and appliances used from the present point of view, it would work no hardship against the large fuel consumer.

We come then to the conclusion that what is wanted is a standard of efficiency of combustion from the smoke-prevention point of view. This must clearly take into account the amount of fuel burnt, and, if we could measure it, the proportion of the fuel passing out of the chimney as soot would be the ideal standard.

It is the aim of engineers to provide a definite quantity of air for each pound of coal burnt, hence the amount of soot per unit volume of flue gases would vary approximately as the amount of soot per unit weight of fuel, when the air supply is so regulated to suit the amount of fuel burnt. In such cases the measurement of smoke density would be a sound basis for comparison as to efficiency of combustion. It would also be a fair standard to fix, since it would measure the polluting power of the smoke emitted so far as soot is concerned.

I therefore suggest that the word "black" in the present standard should be altered to "smoke of a density exceeding" some fixed standard. The standard should, however, also include a time of emission, and the form suggested is "smoke which exceeds a certain density (as measured in a way to be determined), and which is emitted for a period exceeding so many minutes per hour."

It is necessary next to consider the question of how the smoke is to be measured, since this is an essential part of the problem of establishing a sound standard.

We may set ourselves to measure any one of the following:—

1. Total quantity of soot emitted in a given time.
2. Weight of soot emitted as percentage of fuel burnt.
3. Density of smoke or weight of soot per unit volume of flue gases.
4. Ratio of density to a standard.
5. Colour.
6. Opacity, or degree of blackness.

In addition to deciding which of these objects to aim at we must keep in view that whatever method is used, it must give reasonable accuracy and a fair basis of comparison between chimney and chimney, or with a standard; it must also be easily applied from outside the factory by a single observer.

It may be mentioned here that the standard maximum adopted by the Alkalis Act of 1906 for the emission of muriatic acid in smoke or noxious fumes is one-fifth of a grain per cubic foot.

Considering now the various methods of measurement referred to above:—

Total Soot Emitted.—This measures the amount of pollution by a particular chimney, but takes no account of the amount of fuel burnt. As stated previously, it would be unfair to limit a large fuel consumer to the same total quantity of soot as a small one, even supposing we could measure it in a practical way. Its estimation implies access to the chimney and at least two measurements—that is, density of smoke and volume of flue gases.

Percentage of Fuel Lost as Soot.—To measure the weight of soot as a percentage of fuel burnt is open to the same objections as the measurement of the total quantity, but it implies at least the measurement of density of smoke, volume of flue gases, and weight of fuel. It would be a fair basis for a standard, but is quite impracticable as a method for the use of sanitary inspectors.

Density.—A quantitative measure of the density of the smoke might be obtained by the filtration method, in which the soot from a known volume of smoke is trapped and weighed, but it would be too cumbrous for general use. Density can also be measured optically, in which case access to the chimney or factory would be unnecessary. It would give a fair measure of efficiency of the plant, and a good basis of comparison whatever the quantity of fuel burnt or diameter of the chimney.

Colour.—The measurement of the colour of smoke may be dismissed as useless, since colour bears no relation to quantity of soot emitted or evil done by the smoke.

Opacity.—To measure the opacity of a smoke column or its degree of blackness, which is the commonly accepted method now adopted, is worse than useless, since it is misleading, because opacity alone, unless adjusted for thickness of column, is neither a measure of the density of smoke nor of the amount of pollution of the air. The smoke from different chimneys cannot be fairly compared on this basis because of their different diameters. All smoke-charts, such as the Ringlemann or Donkin, measure the opacity in a crude way; similarly, photographic methods, by which a photograph of the smoke-column is compared with standard shades, are open to the same objections. Instruments in which smoked glass is matched to the shade of the smoke, and in which no adjustment is made

* Paper read before Section G of the British Association at Portsmouth.

for chimney diameter, are equally objectionable. In a word, all these methods are only useful to compare chimneys of similar diameter, or the smoke from the same chimney at different times; when used for general comparison they are misleading.

We are thus reduced to a measurement of smoke density as the only satisfactory basis to work on. I will, therefore, go into this method in more detail.

Suppose we can measure the weight of soot in a column of smoke 1 sq. ft. in section, and the same length as the diameter of the chimney.

Let S = weight of soot in such a column.
V = velocity of flue gases in f.p.s.
D = diameter of chimney in feet.

The weight of soot in 1 cub. ft. of smoke will be = $\frac{S}{D}$, and the weight emitted per second—

$$\frac{\pi D^2 V S}{4 D} = \frac{\pi}{4} D V S,$$

or D V S × a constant; that is, it varies as the volume of flue gases × the weight of soot per cubic foot. The amount of soot emitted will therefore vary directly as the volume of flue gases, assuming the density to remain constant. Or if we measure only S, the amount of soot emitted will vary as S × V D. If we assume V to be a constant value, the weight of soot emitted will vary as S × D, and the density of the smoke as S ÷ D. This shows that the measurement of S alone is of little use unless an adjustment is made for D, and it must be noted that all smoke-charts now in use measure something which depends on S alone, but neglects D. It also points to the conclusion that with an adjustment for D, the measurement of S can be made to give a fair approximation to the relative weight of soot emitted or to the density of the smoke.

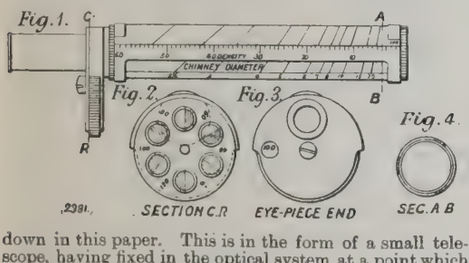
We can measure S indirectly on the basis of the light obstructed. For example, we may compare the degree of opacity of the smoke with a smoked glass which obstructs as much light as a smoke column of known density and thickness. Suppose, then, we take such a glass of an opacity equal to that of a column of smoke of unit thickness and standard density, we might prepare an instrument having several shades of such glass, the lightest being the standard for the smallest chimney, followed by other shades made by superimposing various thicknesses of shade 1, corresponding to various thicknesses of smoke-column or chimney-diameter. We could then by comparing the smoke at the top of a chimney with such a set say whether or to what extent the standard was being exceeded.

Suppose, for example, the smoked glasses are numbered in the ratio of their thickness, and that No. 1 matches a smoke of density G in a one-foot column, the density of smoke matching glass No. N in a column D feet thick will be $\frac{N G}{D}$; that is, the density will vary as $\frac{N}{D}$, and can be given quantitatively by calibrating shade No. 1 to correspond with a known density of smoke in a column one foot thick.

If we attempt to measure the opacity or light cut off by the smoke, we get a figure which does not bear a simple relation to the smoke density such as is borne by the thickness of the smoked glass which matches the smoke. I refer to this because attempts have been made to measure the light obstructed as a basis for comparison between smoke from different chimneys.

Assuming, then, that we can observe with fair accuracy the density of smoke by such a method as I have described, the next step is to fix a certain maximum density which must not be exceeded. This could probably be best defined as: Such a density as would, when viewed by transmitted light alone and in a layer of a certain thickness, permit to pass through it a certain percentage of the light falling on it. This might be referred to a standard density. With improvement in furnaces and appliances for the more perfect combustion of bituminous coal this standard could be altered so as to represent fairly what might be expected from the current state of knowledge and invention.

It would be necessary then to provide an instrument to enable a comparison with such a standard to be easily made. The accompanying drawing illustrates one which I have designed to meet the requirements laid



down in this paper. This is in the form of a small telescope, having fixed in the optical system at a point which may be brought into the focus of both object-glass and eye-piece, a revolving eccentric disc containing a number of graduated smoked glasses arranged in cells round the centre. The glasses only fill half of each cell so that by revolving the disc, as each cell with its glass is brought successively into the axis of the telescope, the smoke may be viewed through the open half of the cell and matched to the glass in the other half. The glasses are numbered in the ratio of their thickness, and a table is provided giving the number of the glass divided by the diameter of the chimney, and thus a figure which is a measure of the density of the smoke, and can be made to read the actual weight per cubic foot of soot in the smoke if desired. This necessitates the inspector knowing the chimney diameters in his district; but these may be tabulated once for all. I have found when, in instruments for smoke measurement, the smoke is viewed through a small aperture, as is essential in order not to take in too much background, that it is impossible to get true results owing to the eye being unable to focus at the same time the object aperture and the object; so that the edges of the aperture are hazy and ill-defined. This results in the whole aperture, when small, being overlaid by a hazy film, due to its ill-defined edges, which film prevents accurate readings of the smoke shade. The same applies to the aperture containing smoked glasses for comparison.

There are many difficulties remaining which apply to all optical methods of measuring smoke, but before enumerating these it is well to remind you that we have no other means of attaining our object, since all methods requiring access to a factory or a chimney are useless from the sanitary inspector's point of view. It is easy to imagine the welcome such an inspector would get on presenting himself at the door of a factory and announcing that he had come to measure the density of the smoke from the chimney; even assuming that he was given access to the chimney, it is unlikely that the dense smoke he had seen from outside would be permitted to continue for him to measure.

I draw attention to this so that while recognising the difficulties in the way of applying optical methods of measurement too much weight should not be given to such difficulties, nor should the presence of drawbacks to a method prevent its use if it fulfils its purpose, and a better is not forthcoming.

Turning now to a short review of these difficulties, it is well to consider what are the factors which influence the apparent density of smoke, as given by an observation based upon its degree of blackness; these are:—

1. The true density of the smoke.
2. Diameter of chimney.
3. Background of smoke and shade it is compared with.
4. The colour of the smoke particles.
5. The size of the smoke particles.
6. The amount and colour of the light falling on the smoke from the observer's side.
7. The direction of the line of vision,
8. Presence or absence of wind.
9. The observer's personal factor.

There is not time to discuss each of these in detail, but I may say that 1, 2, and 3 can be dealt with satisfactorily, 4, and 5, are probably sufficiently constant not to affect results seriously, excluding exceptional cases, 6 is the most difficult to deal with, and should be allowed for in making observations, 7 can be overcome, to a great extent, by keeping the angle which the line of vision makes with the horizon fairly constant, 8 would not, as a rule, be a serious obstacle, while 9 is not, I think, of great importance.

Assuming, then, that we have decided on the method of measurement to be adopted, and on the type of standard to be fixed, the question remains, how is the standard to be arrived at? It would seem that this might be done best by the appointment of a technical committee, which would make observations over a certain period, say a year, of certain selected representative chimneys, where up-to-date and well-designed furnaces are installed, and bituminous coal is burnt. A consideration of the results of such observations, both as to smoke density and time of emission, should enable the committee to fix a fair and reasonable standard, both as to the density of the smoke, and the time during which such density should be permitted.

Time does not admit of a consideration of the reasons for and against the legal enforcement of a standard. There is not, however, much room for discussion, for the fact that a legally-enforced, if unsatisfactory, standard has existed for thirty-six years proves that a standard is necessary, and that, to be of use, it must be legally enforceable. The present standard of "black smoke in such quantity as to be a nuisance" has utterly broken down, owing to the impossibility of proving to a magistrate's satisfaction that the smoke emitted was literally black. I have tried to show that it is now possible to fix a sound and workable standard for smoke emission, and to apply it in a practicable way.

THE STATE OF THE GERMAN ELECTROTECHNICAL INDUSTRY. — One of the best criterions of the state of an industry—though all the branches are, of course, influenced by the general conditions—is the number of candidates for vacant posts. In the first six months of the year 1910 the number of candidates for every 100 electrotechnical appointments varied between 284 and 524; the extreme numbers of the first six months of 1911 were 200 and 338, so that the number of applicants had decidedly diminished. In July, 1911, the shares of electrotechnical concerns were in general about 8 per cent. higher than in July, 1910, and the shares had been rising since January, 1911. Enterprise was brisk; the fresh investments amounted to 32,500,000 marks, and 14,000,000 marks of these investments concerned new electrical undertakings. The exports have steadily increased since 1907, with a slight drop in 1909; the increase is only in bulk, however; the value of the products exported fell from 101,500,000 marks in the first half of 1910 to 97,980,000 marks in the corresponding period of 1911. The imports had also risen by about 2000 dz. (of 100 kg. each) to 16,984 dz. While the shares of important firms were on an average about 10 per cent. higher in the first six months of 1911 than in 1910, the dividends paid in April, 1911, amounted to about 9 per cent., against 10.3 per cent. in April, 1910.

FOREIGN ENGINEERING PROJECTS.

We give below a few data on several foreign engineering projects. Further data concerning same can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C.

French Indo-China: An extraordinary session of the Superior Council of French Indo-China has recently approved of a loan of 200 million francs (8,000,000*l.*) being raised to finance a comprehensive scheme for the economic development of the country. It is proposed to spend over 1,000,000*l.* on irrigation and drainage works in Annam and Tonkin, and about 780,000*l.* on the construction of roads. 4,500,000*l.* is provided for the construction and equipment of new railways, including lines from Dong-ha — Vinh (1,800,000*l.*); Saigon — Pnompenh (1,100,000*l.*); Pnom-penh—Battambang (960,000*l.*); Mytho-Cân-tho (540,000*l.*). The bridges on these new lines will cost about 720,000*l.* It is intended to issue the loan in three portions in the years 1912, 1916, and 1920.

Morocco: With reference to the contracts for (1) the construction of the first section of the beach road at Casablanca, and (2) the construction of a sanitary station at Tangier, His Majesty's Consul-General at Tangier reports that these contracts have been awarded to M. Planès, a French citizen, at reductions of 15 and 20.1 per cent. respectively on the upset prices, which were 1600*l.* and 3400*l.*

Brazil: The *Diario Official* publishes a decree—No. 8860—approving the plans submitted by the Companhia Estrada de Ferro de Goyaz for a section, 224 km. (about 140 miles) long from Antas to Goyaz, of the main line of the railway. The cost of construction is estimated at 10,918,612 milreis (about 728,000*l.*).

Uruguay: The *Diario Oficial* publishes decrees approving the plans submitted by Messrs. Allard, Couvreux, Dollfus, Sillard, and Wiriot for sewerage and water supply works in the towns of Treinta y Tres, Melo, and Florida.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.—The seventy-third annual show of the Royal Agricultural Society of England will be held at Doncaster (on the Race-Course) from Tuesday, July 2, till Saturday, July 6, 1912.

WIRELESS TELEGRAPHY IN CEYLON.—Marconi's Wireless Telegraph Company, Limited, inform us that they have concluded with the Crown Agents for the Colonies a contract for the establishment of a radiotelegraph station in Ceylon. The station will be capable normally of sending a wave-length of 600 metres. In addition, however, with any wave between 1000 and 2000 metres, the station will maintain communication with any ship off Madras, or with any ship up to a distance of 450 miles over sea (except during periods of severe atmospheric disturbances), provided the ship is fitted with an aerial having a mean height of not less than 100 ft., and suitable receiving apparatus. The generator will consist of a 10-horse-power S.P. motor, taking power (alternating current at 100 volts, 60 cycles) from mains, direct-coupled to a 5-kilowatt alternator and exciter. The motor, alternator, and exciter will be protected against injurious induced effects from the high-frequency circuit by special shunting resistances. One 5-kw. iron-core low-frequency primary inductance will be provided for tuning the low-frequency circuit to the disc frequency. A high-tension transformer will be provided for stepping up the alternating current supplied by the generator to the voltage required by the battery of condensers. The latter will comprise eight whole glass-plate condensers in galvanised-iron oil-tight tanks, with the necessary insulating stands, bus-bars, high-tension bushed terminals, and other fittings. The bus-bars and connectors will be designed to provide for minimum inductance and damping, and with suitable arrangements for coupling up as required for the production of the various waves specified. In conjunction with the condenser battery, a high-frequency tuning inductance of the continuously adjustable type will be provided for tuning the high-frequency primary circuit to the aerial circuit. The discharger will be of the disc type direct coupled to the motor alternator, and designed to produce a musical spark enabling the transmitted signals to be distinguished from atmospheric disturbances when received in the telephone by a corresponding station. Two aerial tuning inductances will be supplied, each consisting of a multiple solenoid winding of stranded conductor, similar to that of the jigger secondary. The manipulating gear will consist of a Morse key to be placed in the operating-room to electrically actuate a relay key in the transformer primary circuit, the supply being taken for this purpose from the exciter of the alternator. One part of the receiving apparatus will consist of a magnetic detector in combination with a multiple tuner, which will be constructed to provide a highly syntonised circuit for all waves between 100 m. and 2500 m., and will be furnished with a change-switch to permit of the instantaneous change from "tuned" position to an "untuned" stand-by position, for the purpose of picking up signals of a widely different wave-length without variation in adjustment. The other receiver will be of the valve type; the valve detector will be used in place of the magnetic detector for wave-lengths in reception from 1600 m. to 4000 m. Two masts will be erected, each of sectional type tubular steel, with wooden mast, 270 ft. in height over all. They will have a factor of safety of 4, assuming a wind pressure of 40 lb. per sq. ft. One earth system will be provided for the use of all waves, consisting of galvanised iron plates arranged in a circle with radial conductors to the central apparatus. The earth-plates will be supplemented by additional radial wires underneath the transmitting aerial for the purpose of making better provision for the electric oscillation between the aerial and the earth.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

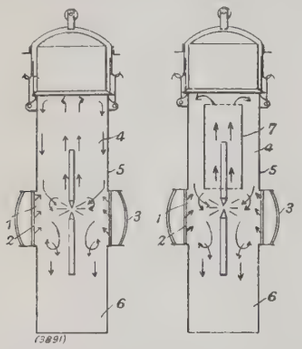
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

3891/11. Korting and Mathiesen, Aktiengesellschaft, Leutzsch, Germany. Arc Lamps. [2 *Figs.*] February 21, 1910.—The invention consists in an enclosed arc lamp for use with deposit-producing electrodes in which the globe-surface exposed to the deposit-forming fumes is protected as far as possible from cooling and the gases rising up from the arc are cooled off in a depositing chamber so that the gases flowing from above back into the combustion chamber are cooler than the inner surface of the glass globe, and therefore are repelled therefrom, forming eddy currents in the combustion chamber so that gravity acting on particles of deposit causes gradual settlement of these particles into the bottom depositing chamber. In the left-hand figure the combustion chamber 1 is enclosed by a glass globe which is surrounded by a second glass globe 3 as heat protector.



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Above the combustion chamber is a top depositing chamber 4, into which the gases rise upwards in the hot central zone, whilst they flow downwards along the outer walls 5 of the depositing chamber 4; these walls should be of metal of good heat conductivity. When the gases in their downward path impinge on the hot globe surface 2, they are repelled thence sideways towards the arc. The arrows show the direction and course of the gas currents. Below the combustion chamber is a bottom depositing chamber 6 into which particles of deposit can settle by gravity. In the right-hand figure the improvement in the depositing chamber by the introduction of a separating surface 7 is shown; this gives the path as near central as possible for the upward rising gases from the arc and one along the periphery of the depositing chamber cooling these gases in their downward path. (*Accepted July* 5, 1911.)

19,182/10. The Electric and Ordnance Accessories Company, Limited, and N. Collins, Birmingham. Electrical Switches. [11 *Figs.*] August 16, 1910.—This invention relates to quick make-and-break switches of that type in which the switch contact-arm is locked in its "on" or "off" positions by a series of balls or their equivalent located within housing in a suitable bracket. According to this invention, the contact-arm and slotted bracket are provided with a series of coincident and thoroughfare holes in which the locking-balls are

Fig. 1.

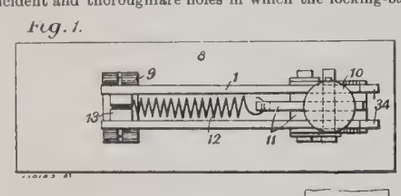


Fig. 2.

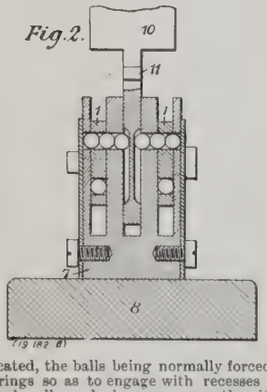
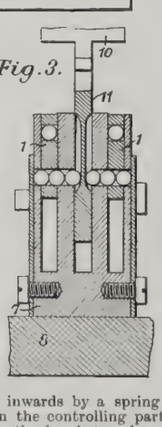


Fig. 3.



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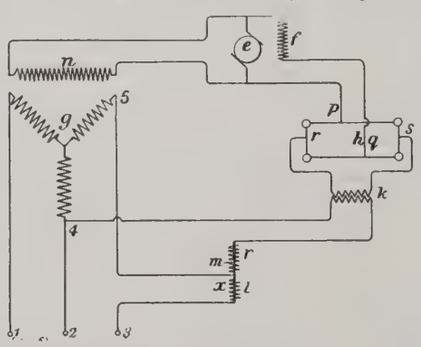
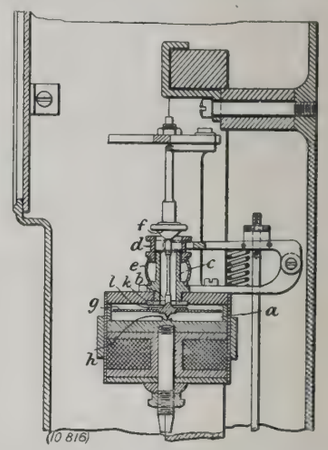
ocated, the balls being normally forced inwards by a spring or springs so as to engage with recesses in the controlling part of the handle and also engage partly with the bracket and partly with the contact-arm, which latter is thereby locked in its "on" or "off" position until the handle is operated so as to cause the end of the recesses to engage with the balls and force same outwards against the action of the springs and thereby unlock the switch-arm. The contact-arm 1 comprises two blades pivoted near their rear ends between two pairs of laterally separated cheeks of a slotted bracket 7 mounted upon the base 8. 9 are the fixed contacts between which the arm 1 is adapted to engage when in its "on" position. The handle 10 carries a blade 11 serving to control the position of the locking balls and by which the handle is pivoted between the bracket cheeks upon the same pivot-pin as the contact-arm. The one end of a spring 12 is attached to the forward end of the blade 11, whilst its other end is connected with a cross-bar 13 at the outer end of the contact-arm. In the four cheeks are formed thoroughfare or registering holes respectively, containing, when the contact-arm is unlocked, balls; and the opposite sides of the blade 11 are provided with curved recesses, whilst near the inner ends of the two sides of the contact-arm 1 are pairs of holes containing balls, of which two come opposite to the holes mentioned in the bracket 7 when the switch is "on" (see Fig. 2), whilst the other two balls come opposite to the holes in the bracket when the switch is "off" (see Fig. 3). There are thus six balls in line in either position of the switch. Carried upon the outer sides of the end cheeks are a pair of flat springs which act upon the balls and tend to force them inwards. Preferably the widths of the inner cheeks are exactly equal to the diameters of the balls, whereas the width of the outer cheeks and the depth of the recesses in the part 11 are of only half this diameter. The operation of the switch is as follows:—In the "on" position, the parts are as shown in Fig. 2, the balls being acted upon by springs, so that the innermost balls engage with the upper ends of the recesses in the part 11, whereas the balls engage half with the inner cheeks and half with the arm 1, and similarly balls engage half with the arm 1 and half with the outer cheeks. The contact-arm is thus securely locked in position, the balls being engaged by the two sides of the arm at their diametric centre line, so that all tendency for them to be pushed upon one side is avoided. To open the switch the handle 10 is drawn back, with the arm 1 remaining locked, until the lower ends of the recesses in the part 11 (which are bevelled) have engaged with balls and pushed the whole series laterally in an outward direction, the springs being deflected and the balls entirely filling up and occupying the holes in the arm 1. The latter is thus unlocked, and, under the influence of the spring 12, which has meanwhile been considerably extended, it is caused to fly into the "off" position; the rear ends 34 of the arm impinging upon the base of the bracket 7 and forming stops. In order to again close the switch the handle 10 is turned in a forward direction until the upper ends of the recesses force the balls outwards and unlock the arm 1, which is then quickly taken into engagement with the contacts 9 by the extended spring 12. (*Accepted July* 5, 1911.)

15,415/10. Aktiengesellschaft Brown, Boveri, et Cie., Baden, Switzerland. Alternating-Current Generators. [1 *Fig.*] July 10, 1909.—The invention consists in an arrangement for regulating the voltage of synchronous alternating-current machines in which the alternating current serving for regulating purposes is obtained by adding the terminal voltage and the main current of the generator vectorially, without the use of resistances in series or parallel, by a single transformer, one coil of which is fed by the terminal voltage and the other by the load current of the generator, and the resultant current, directly or by the use of a current-transformer, is supplied to the device which effects the corresponding regulation of the exciting current the device carrying the current without shunt and employing no resistances or other current-consuming devices in parallel with it. The drawing illustrates one manner of carrying the invention into effect. In this form, a three-phase alternating-current generator g feeds the mains 1, 2, and 3, and is excited from an exciting-machine e, supplying the generator field winding n. The field f of the exciter e is connected to the exciter terminals by way of two points p and q in a closed resistance system denoted by h, which points represent equi-potential points as regards alternating current. The resistance system h is a closed system, and in addition to the two connections already referred to, it has others r and s which are equi-potential points as regards direct-current, and are connected to the secondary of a transformer k. This transformer is connected to the generator as to one side, at 4, and as to its other side is connected to one terminal of a transformer generally referred to as x, and including two coils r and l, and a core m. The coil r, at the end which is not connected with the transformer k, is connected to the alternating-current generator at 5, so that it is excited according to the potential of



the generator, and the coil l is connected between the points 5 and 3, so that it is excited by the outgoing current of the generator. The number of the turns of the two coils r and k connected in series is such that the greater part of the terminal voltage of g is taken by r, so that the primary coil of k receives a certain current through r. This current depends, on the one hand, on the no-load current of the mixed transformer r, l; and on the other hand, on the load current of the generator, as the winding r receives the current flowing through l as well as the no-load current. The two windings of the mixed transformer r and l are so connected that with non-inductive load on the current generator their terminal voltages form an angle of more than 90 deg. to each other, whilst with increasing phase-displacement of the load this angle increases, and the resultant voltage thus decreases. Under the influence of this resultant voltage a current is generated which is conducted to the regulating resistances through the current transformer k. Thus the regulating resistances will be influenced accordingly by the voltage, current, and phase displacement of the current generator. The apparatus described operates as follows:—When the generator is running light, the voltage coil r receives a current which corresponds to the magnetisation of the transformer. This magnetisation current flows through the current transformer k to the regulating resistances, and is sufficiently high to cause the resistance of the latter to be so adjusted under the influence of the temperature, that the amount of direct current necessary for exciting the magnets f of the exciter machine e is automatically obtained. The current coil l is without current, and thus has no influence whatever on the regulation. It receives at its terminals from the winding r a low-induced voltage, which only influences the terminal voltage of the generator to an unimportant degree. If load be put on the generator, the load current flowing through the winding l causes, in the winding r, an equal current in the opposite direction, which current decreases the no-load current of r in proportion to the increase of the load current and its phase displacement. The regulating resistances h thus receive a weaker alternating current, so that their resistance decreases, the intensity of the direct current, however, increases, and the excitation of the generator is also increased. By suitably calculating the number of ampere-turns of l, an over-compounding may be attained. (*Accepted July* 5, 1911.)

10,816/11. Chamberlain and Hookham, Limited, and S. James, Birmingham. Electricity Meters. [1 *Fig.*] May 4, 1911.—The present invention relates to electricity motor-meters, and consists in providing a second seal below the level of the mercury, whereby the access of air into the mercury-chamber itself is prevented. The invention further consists in providing a suitable washer of cork, leather, or the like around the aperture in the mercury-chamber through which the armature passes, and in providing on the armature spindle a disc adapted to co-operate with this washer to form a second seal at the entry to the mercury-chamber itself. The mercury-chamber a is provided with a central aperture b in its upper wall, into which there is screwed the flange-tube c. On the outside of this tube there slides a sleeve d, the lower end of which is attached to a flexible tube e. The sleeve d is operated by a forked lever, for the purpose of sealing the mercury-chamber, and in its upper



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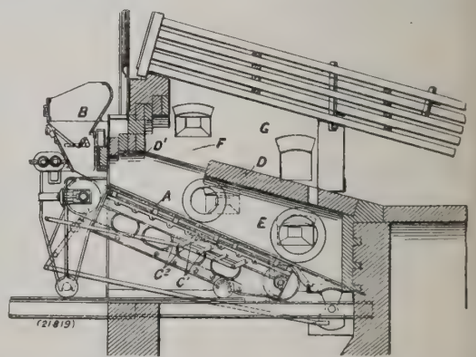
position bears against the conical piece f on the spindle which carries the armature g and lifts the armature spindle from its lower pivot h. On the lower face of the cover of the mercury-chamber there is provided an annular washer k of cork, which forms the seat for the second seal. When the sleeve d is lifted to seal the mercury-chamber it comes in contact with the conical piece f, and forms the first seal. The armature spindle is then lifted slightly by the further movement of the sleeve, and brings the disc l against the washer k, forming a second seal below the surface of the mercury, and effectually preventing the ingress of any air into the portion of the mercury-chamber which surrounds the armature. By this means the air, which is almost inevitably imprisoned below the ordinary seal between the sleeve d and the conical piece f, is prevented from entering that part of the mercury-chamber, where the presence of air-bubbles is a disadvantage. (*Accepted July* 5, 1911.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

21,819/10. Babcock and Wilcox, Limited, and J. Rosenthal, London. Water-Tube Boiler Furnaces. [2 *Figs.*] September 9, 1910.—This invention relates to furnaces of water-tube boilers, and consists in the combination with a uniformly-inclined chain-grate stoker, of a similarly inclined rear arch arranged to form a reverberatory chamber, a short front arch located nearer the grate than the rear arch, and vanes, or louvres, disposed beneath a portion of the grate located between the lowest part of the upper stretch of the chain and the feeding end of the grate. The drawing is a longitudinal section, showing parts of a water-tube steam-generator of the Babcock and Wilcox land type. The furnace comprises an automatic stoker having a uniformly-inclined chain-grate A for carrying the fuel, which is led into the furnace through the hopper B in front. The stoker is provided with a series of vanes or louvres, under the grate, connected and operated by lever C^1 and rods C^2 from the surface



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front, and while otherwise of a construction well known as used in Babcock and Wilcox boilers is highly inclined, and over its rear end is formed a fire-brick arch D, extending forward to a point about mid-way of the length of the grate, or even nearer the front. A short arch D^1 is also formed at the boiler front over the forward end of the grate, but closer to the grate surface. A comparatively large reverberatory chamber E is thus formed over the rear part of the furnace, the fuel in which is afforded a lively combustion by the regulated inflow of air through the vanes under the grate. The flame from this rear chamber is projected forward in its passage towards and through the opening F between the front and rear arches, and striking the comparatively green fuel on the forward part of the grate, ensures its proper combustion. The hot gases passing through the opening F circulate within a secondary combustion-chamber G below the water-tubes, and thence pass around these tubes, being guided by the usual baffles on their way to the chimney outlet. (*Accepted July* 5, 1911.)

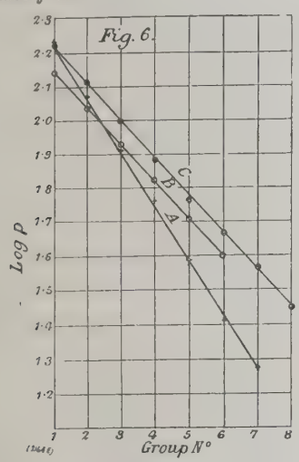
THE STEAM-TURBINE.

(*Continued from page* 309.)

ACTUAL experience with reaction steam-turbines, proportioned according to standard practice, shows that the distribution of pressure down the turbine when developing its designed power follows a geometric law. Thus, in the case of the high-pressure turbine for a large warship having seven groups of blades, ranging from $\frac{7}{8}$ in. up to 7 in. in height, and therefore increasing with a geometric ratio of $\sqrt{2}$, the following figures show the absolute pressures in front of each group at full load :—

Group No. ...	1	2	3	4	5	6	7
Absolute pressure, lb. per sq. in. ...	165.7	120.7	80.7	57.7	38.7	25.7	18.7

The average value of the ratio of the pressure in front of a group to that behind is thus very approximately $\sqrt{2}$, or equal to the ratio of successive blade heights. If the geometric law were strictly followed, the logarithms of the pressures plotted against the group number should fall on a straight line, and this, it will be seen from Fig. 6, line A, is very approximately the case.



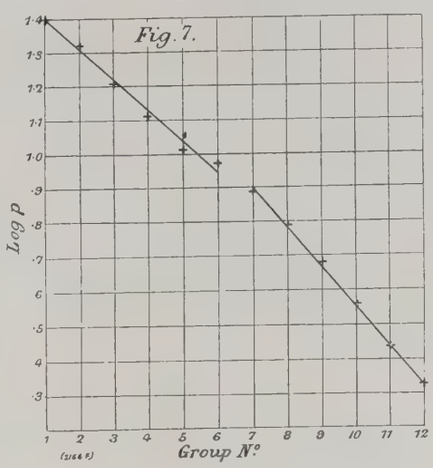
Along line B have also been plotted the logarithms of the pressures in front of each group of the high-pressure turbine of a large Atlantic liner. In this case the ratio between successive blade heights was $\sqrt[3]{2}$, and again it will be seen from the slope of the curve that this is approximately the ratio between successive pressures, though it will be seen that the pressure ratio is better represented by 1.29 than by $\sqrt[3]{2}$. The pressures of which the logarithms have been plotted along line C were observed on the Mauretania, and here also successive points fall very accurately in a straight line. In his paper, read before the Naval Architects in April, 1908, Mr. Thomas Bell gave the length of the shortest blades of the high-pressure turbines of these large Cunarders as $2\frac{3}{4}$ in., and the longest as $12\frac{3}{8}$ in. The heights, therefore, increase with a geometric ratio equal to 1.25, so that the complete blading of the rotors is as follows :—

Group No. ...	1	2	3	4	5	6	7	8
Blade height in.	$2\frac{3}{4}$	$3\frac{3}{8}$	$4\frac{1}{4}$	$5\frac{1}{4}$	$6\frac{3}{4}$	8	10	$12\frac{3}{8}$

As before, it will be seen from line C that the pressures also vary in a geometric ratio which is nearly the inverse of that of successive blade heights.

Coming to the low-pressure turbines, much less uniform results are obtained. There are two reasons for this, the main one being the utter unreliability, for exact measurements, of the ordinary Bourdon vacuum gauge. In fact, in the case of the large warship from which the results plotted along A were obtained, the actual pressure, observed at the inlet to the low-pressure turbine, was higher than that recorded at the outlet from the high-pressure turbine. For low-pressures the mercury column would give accurate results, but the use of this is forbidden on warships for fear of the mercury being drawn over and damaging the condenser tubes. Possibly the solution of the problem will be found to lie in measuring the temperature and taking the corresponding pressure from the steam-tables. Such measurements are not, however, free from difficulty. The logarithms of the observations made on one of the low-pressure turbines of the Carmania are plotted in Fig. 7. This turbine, which comprised twelve groups of blades, was fitted with two pressure-gauges only. The one gauge was used to measure the pressure in front of each of the first six groups, and the second was similarly used for the second set of six. It will be seen that the readings of each gauge are fairly consistent *inter se*, but are not consistent with those of the other.

The mean value of the pressure ratio in the case of the first six groups is about 1.23, and for the last six about 1.30, whilst the successive blade heights increase in the ratio of 1.26. However, the geometric law of pressure decrease cannot be expected to hold for the last groups of a low-pressure turbine when exhausting at high vacua. An increase of vacuum increases the ratio of pressures for the last one or two groups, but has no sensible effect



on the pressure distribution higher up the turbine. The foregoing results prove the statement made on page 246 *ante*, that in Parsons turbines, as usually proportioned, the pressure from group to group decreases in a geometric ratio, this ratio being approximately the inverse of that of the successive blade heights.

It will be evident, therefore, that if the steam expanded according to the relation P V = constant, the available energy accounted for in each group of blades would be constant. This, however, would not imply that each group did an equal amount of useful work, since with the shorter blades the clearances are proportionately larger, and the percentage of loss by leakage over the tips greater. In these short blades, therefore, a fair proportion of the available energy is simply expended in fluid friction, so that there would seem to be some advantages in increasing the proportion of energy accounted for in the groups with the longer blades. This would, however, involve a departure from the present standard practice of making successive blade heights increase in geometric ratio, and would thus complicate the lay-out of the turbine. Moreover, as will be shown in the sequel, the possible gain by the departure does not appear to be worth the change.

As a matter of fact, the steam passing through the turbine does not expand according to the law P V = constant, but according to a law which can be expressed with all necessary precision by the formula

$$P V^{\gamma} = \text{constant},$$

where γ is in practice always greater than unity.

If, therefore, P diminishes from group to group in geometric ratio, the energy accounted for per group diminishes with each successive group, provided the weight of steam passing through each is the same.

This energy is given by the well-known equation for the work done when the expansion of a gas follows the law $P V^{\gamma} = \text{constant}$. We have, in short, if P be the absolute pressure in pounds per square foot, work done

$$= \frac{\gamma}{\gamma - 1} \{P_0 V_0 - P_1 V_1\}.$$

If

$$\frac{P_1}{P_2} = x, \quad \text{and} \quad \frac{V_2}{V_1} = \rho,$$

we have

$$\rho = x^{\frac{1}{\gamma}},$$

and the above expression may be written as

$$\frac{\gamma}{\gamma - 1} \cdot P_0 V_0 \left\{1 - \frac{\rho}{x}\right\}$$

or as

$$\frac{\gamma}{\gamma - 1} \cdot P_0 V_0 \left\{1 - \left(\frac{1}{x}\right)^{\frac{\gamma - 1}{\gamma}}\right\}.$$

In the Parsons turbine the ratio of pressures at the opposite ends of a group seldom exceeds 1.4 or so, and in that case the value of the above expression cannot be obtained accurately without the use of five-figure logarithms at least, since $\left(\frac{1}{x}\right)^{\frac{\gamma-1}{\gamma}}$ does not then differ very greatly from unity.

It will be seen that for a given value of x and a given value of γ the work done depends upon the value of the product p V. But if γ is greater than unity, it is obvious that this product decreases as p diminishes; and since this is always the case in practice, it will appear, as already stated, that each successive group of a high-pressure reaction turbine, as usually designed, accounts for a smaller and smaller proportion of the total energy of the steam. Yet, of the groups having standard blades, it is the overloaded first group of blades which is the least efficient, and runs with the largest percentage of tip clearance, and with the lowest ratio of blade speed to steam speed. The wing blades in the low-pressure turbine are relatively inefficient for another reason; since, although the tip clearance is proportionately small, the angle of discharge is large, and it is, moreover, difficult at high vacua to provide as large a steam-way through these blades as is desirable.

The value of γ can, of course, be obtained from the temperature entropy diagram if the efficiency ratio of the turbine is known. In that case the dryness fraction at exhaust can be calculated by well-known methods, which have already been explained in ENGINEERING, and which, indeed, are to be found in most text-books on the steam-turbine.

It is, however, of interest to note that in certain cases it is possible to establish a formula by which the value of γ is directly connected with the average stage efficiency of the turbine.

At each stage of a steam-turbine part of the kinetic energy of the steam, instead of doing useful work, is absorbed in friction and returned to the steam in the form of heat. The consequence is that the steam is rendered drier than it otherwise would be, and is thus able to do more work in subsequent stages. The efficiency ratio of a turbine is equal to the actual useful work done, divided by the work due from the steam, did the expansion take place adiabatically. The average stage efficiency of the turbine, on the other hand, is the ratio of the actual mechanical work done to the work due, taking into account the fact that at every successive stage of the turbine the steam is drier than it would have been had there been no frictional losses in the preceding stages. The efficiency ratio therefore is always greater than the average stage efficiency. The latter may conveniently be called the hydraulic efficiency of the turbine.

Rankine, many years ago, pointed out that when steam expanded adiabatically, the relation between its pressure and volume could be expressed very approximately as

$$P V^{1.0} = \text{constant}.$$

Zeuner subsequently found that instead of 1.0 the index was better taken as 1.135. This value gives results accurate enough for most turbine work, though the index in question really varies slightly from point to point of the steam-table.

For superheated steam the law of adiabatic expansion may be written $P V^{1.30} = \text{constant}$ Superheated steam is a homogeneous fluid, and taking this value of 1.30, it can be shown that if the stage efficiency is η, the law of expansion is given by $P V^{\gamma} = \text{constant}$, where $\gamma = 1 + 0.3\,\eta$.

When η is unity, we get adiabatic expansion, and if η is zero, as when steam is wire-drawn through the baffles of a labyrinth packing, we get back to the hyperbolic law of expansion—viz.:—

$$P V = \text{constant}.$$

The formula above given may be established as follows :—

If a quantity of heat q is added to a gas, this heat in general goes partly to increase the internal energy of the fluid and partly to effect external work. Hence we may write :—

Heat added = increase of internal energy + external work done by the expansion of the gas.

Now the total internal energy of a gas is equal to the work which it could effect on expanding down to zero pressure, without receiving further energy from outside; that is, the internal energy of a gas is equal to the work it can accomplish by adiabatic expansion down to zero pressure. Experience shows that this law of adiabatic expansion is very approximately of the form $P V^{\gamma} = C$.

At the initial state, then, let P be the pressure of the gas in pounds per square foot, and V its volume, and let this initial state be represented by the point A in Fig. 8. Then the work done in the expansion of the gas is equal to the hatched area to the right of A B. In the usual indicator diagram we have also, of course, to add the area A C D B, but this does not

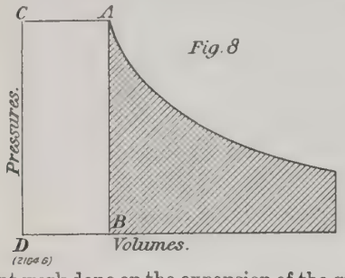


Fig. 8

represent work done on the expansion of the gas, but work done before the cut-off takes place. The hatched area is, of course, equal to $\int P\ d\ V$, which, if $P V^{\gamma} = C$, becomes

$$\int \frac{C}{V^{\gamma}} . d V,$$

of which the integral is

$$\frac{1}{\gamma - 1} \left\{ P V - P_n V_n \right\}.$$

When n is ∞, the product $P_n V_n$ is zero, and the total internal energy of a gas is thus equal to

$$\frac{1}{\gamma - 1} . P V.$$

Take, now, the general equation for the effects of adding heat to gas—viz.:—

Heat added = increase of internal energy + external work done.

Let the quantity of heat added (expressed in foot-pounds) be $d q$. This will, in general, cause a change to take place both in the pressure and in the volume of the gas. The internal energy, which originally was

$$\frac{1}{\gamma - 1} . P V,$$

will become

$$\frac{1}{\gamma - 1} \left\{ P + d P \right\} \left\{ V + d V \right\},$$

where $d P$ and $d V$ represent the changes in P and V produced by the added heat.

Hence the increase in the internal energy is

$$\frac{1}{\gamma - 1} \left\{ (P + d P) (V + d V) - P V \right\}$$
$$= \frac{1}{\gamma - 1} . \left\{ P d V + V d P \right\},$$

the small quantity $d P d V$ being of the second order, is, of course, neglected, as usual.

The external work done will be $P d V$.

Hence, equating the heat added to the sum of the increase in the internal energy and the external work done, we get the equation

$$d q = \frac{1}{\gamma - 1} . \left\{ P d V + V d P \right\} + P d V.$$

Now, in a steam-turbine, the external work done on expansion at each stage appears, in the first place, in the form of kinetic energy. A certain fraction of this energy, which we may call $k P d V$, is destroyed by friction, and returned to the working fluid in the shape of heat.

The efficiency of the stage is obviously $\eta = 1 - k$, since the kinetic energy not destroyed by friction appears as mechanical work.

Putting

$$d q = k P d V$$

we get

$$k P d V = \frac{1}{\gamma - 1} . \left\{ P d V + V d P \right\} + P d V,$$

rearranging this becomes

$$0 = \frac{1}{\gamma - 1} . V d P + \left\{ \frac{1}{\gamma - 1} + 1 - k \right\} P d V$$
$$= \frac{1}{\gamma - 1} V d P + \left\{ \frac{1}{\gamma - 1} + \eta \right\} P d V.$$

Multiplying by

$$(\gamma - 1) V^{\eta (\gamma - 1)}$$

we get

$$0 = V^{1 + \eta (\gamma - 1)} d P + (1 + \eta (\gamma - 1)) V^{\eta (\gamma - 1)} d P.$$

The integral of this is obviously

$$P V^{1 + \eta (\gamma - 1)} = \text{constant},$$

as can be readily proved by differentiation. The result, it will be seen, is quite general; and if for any homogeneous fluid the law of adiabatic expansion can be expressed as

$$P V^{1 + c} = \text{constant},$$

then, if the expansion occurs with an efficiency equal to η, the law of expansion is

$$P V^{1 + c \eta} = \text{constant}.$$

A special case arises when the expanding gas is wire-drawn, as in passing through a labyrinth packing. Here no useful work is done, and the whole of the kinetic energy of the gas as it passes the baffles is returned to it as heat. We then get

$$\eta = 0, \quad \text{or} \quad P V = \text{constant}.$$

This result was proved to hold, in the case of the so-called permanent gases, by the famous porous-plug experiment of Kelvin and Joule, for in that case $P V = c T$. From the foregoing, however, it will be seen that it is also true for the more compressible gases to the same degree of accuracy as that by which the law for adiabatic expansion can be expressed by the relation

$$P V^{\gamma} = \text{constant}.$$

Unfortunately, the same reasoning is inapplicable to the case of wet steam, which, being a mixture of water and steam, is non-homogeneous. In fact,

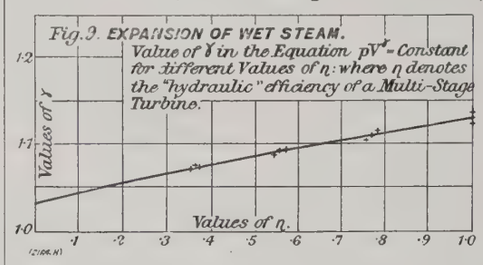


Fig. 9. EXPANSION OF WET STEAM.
Value of γ in the Equation pV^γ = Constant for different Values of η: where η denotes the "hydraulic" efficiency of a Multi-Stage Turbine.
Values of γ
1·2
1·1
1·0
Values of η.
·1 ·2 ·3 ·4 ·5 ·6 ·7 ·8 ·9 1·0
(21064)

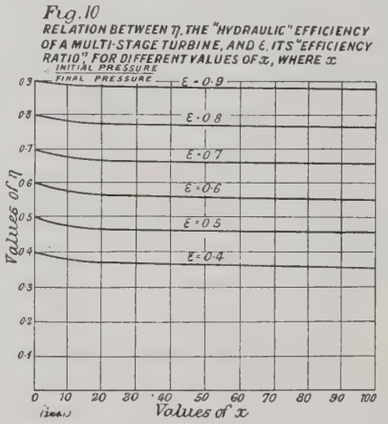


Fig. 10
RELATION BETWEEN η, THE "HYDRAULIC" EFFICIENCY OF A MULTI-STAGE TURBINE, AND ε, ITS "EFFICIENCY RATIO" FOR DIFFERENT VALUES OF x, WHERE x = INITIAL PRESSURE / FINAL PRESSURE
ε·0·9
ε·0·8
ε·0·7
ε·0·6
ε·0·5
ε·0·4
Values of η
0·9 0·8 0·7 0·6 0·5 0·4 0·3 0·2 0·1
0 10 20 30 40 50 60 70 80 90 100
Values of x
(21064)

when such steam is wire-drawn, a reference to the temperature entropy tables shows that the law of expansion is in this case not $P V = \text{constant}$, but $P V^{1 \cdot 035} = \text{constant}$, so that the value of γ corresponding to zero efficiency is 1.035 in place of 1.0. As already stated, for unit efficiency the index has a value which averages about 1.135, being greater the less the ratio of expansion, and *vice versa*. The curve in Fig. 9 shows how γ varies with different values of η; the three sets of points plotted correspond respectively to cases in which the ratio of the initial to the final pressure is respectively 9, 81, and 243. It will be seen that for such efficiencies as are usual in turbine practice the index has but a small range of values. As one consequence of this, it turns out, as will be proved in the sequel, that the velocity of flow of saturated steam through a group is almost independent in practice of the actual law of the expansion within the group.

We have stated above that in a compound steam-turbine the efficiency ratio ϵ is always greater than the stage efficiency η, and the relation between the two for different values of $x = \frac{p_0}{p_n}$ has been plotted in Fig. 10. The stage efficiency, and not the efficiency ratio, is what is analogous to the efficiency of an hydraulic turbine. With the latter, values of η exceeding 80 per cent. have been authoritatively established. About the best efficiency ratio yet obtained with steam-turbines is 71 per cent.

Assuming the ratio of initial and final pressure as 150, it will be seen from Fig. 10 that this value of ϵ corresponds to a value of η of less than 67 per cent., so that there is yet much leeway to make good before the efficiency of the steam-turbine becomes equal to that of the water-operated type.

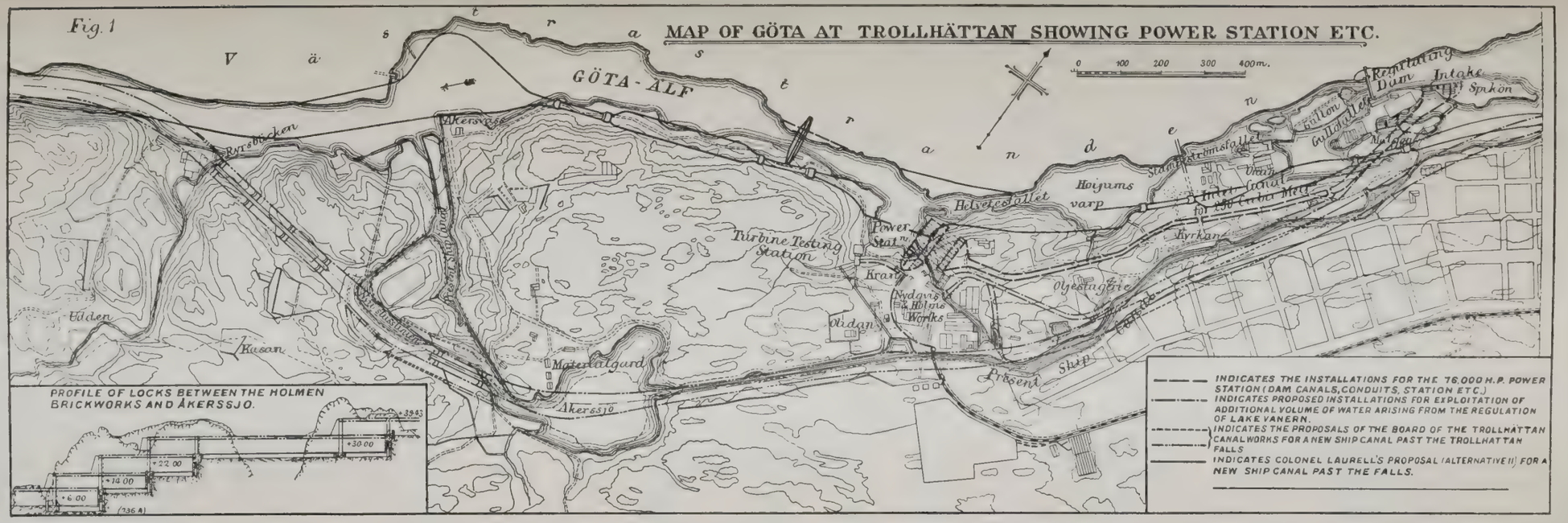
(To be continued.)

THE TROLLHÄTTAN HYDRO-ELECTRIC POWER-STATION, SWEDEN.

MENTION has on several occasions been made in the columns of ENGINEERING of this important installation, which, when completed, will represent an aggregate of 100,000 horse-power, half of which has just been installed. The Trollhättan Falls are situated in the Göta River, which connects Lake Vänern, the largest lake in Sweden, with the sea. The Vänern covers an area of 5570 sq. km. (2180 sq. miles), and it is the largest of the European lakes but two. The aggregate difference in level between the sea and Lake Vänern is about 44 m. (144 ft.), of which some 33 m. (108 ft.) occur in the Trollhättan Falls, which comprise a series of cascades. The legal position as to the ownership of the water rights was exceedingly complicated at the time their value began to dawn upon the people, but in the year 1901 the Swedish State became the undisputed owner of the greater portion of Trollhättan's vast water power. Through subsequent purchases the State has acquired the waterfalls at Vargön, between Lake Vänern and Trollhättan Falls, and those at Ström and Lilla Edet, below the Trollhättan Falls, so that the State now controls the entire water power of the Göta River. The present low-water volume is 320 cub. m. (11,520 cub. ft.) per second, and the high-level volume of water is about 900 cub. m. (32,400 cub. ft.) per second. Through the regulation of Lake Vänern, the low-level volume of water, however, can be materially increased, and for the future the State may reckon on having at its disposal in its falls in the Göta River an aggregate of not less than about 200,000 horse-power, and this, too, in a district having excellent means of communication and at no great distance from Gothenburg, the leading commercial centre on the west coast of Sweden, and in the midst of a populous part of the country. The State power-station at Trollhättan is constructed for the exploitation of 250 cub. m. (9000 cub. ft.) water per second, representing 80,000 turbine horse-power. This important installation, which is located on the eastern bank of the river, as shown in the map, Fig. 1, page 375, was taken in hand towards the end of 1906, and occupied some four years in construction. The map is reproduced from an earlier article published by us on December 18, 1908.

The regulating dam across the river, which we illustrate in Figs. 2 to 5, page 377, is situated at the threshold of the upper fall on firm rock. The dam is constructed with four openings, separated by piers of granite. The two central openings each have a free width of 20 m. (65½ ft.), and are closed by means of bear-trap or roller-dams, as seen in Figs. 3 and 4. The most westerly opening, which was first constructed, and which is placed at the side of the river course proper, is 19.7 m. (64 ft. 8 in.) wide, and is closed by means of five sluices, 3.7 m. (12 ft.) wide, which are constructed of iron with wooden boarding; these sluices are divided in two, in the direction of their height, as shown in Fig. 5, and can be drawn up or let down at will. They are not fitted with anti-friction rollers. The eastern outlet is 3.4 m. (11 ft. 2 in.) wide, and is fitted with a similarly constructed door. Both the roller-dams and the sluices can be operated by electric motors as well as by hand-power, and all the outlets can be closed for repairs by means of steel needles or tube-pins, resting partly against the bridge-way on the pillar and partly against the sill. This construction of the dam has been chosen on account of the quantities of ice which, during the winter, are carried down by the river. If there be ice when there is plenty of water in the river, the ice makes its escape through the fully-opened central outlet. With lower water-level the ice is led away under the partly raised rollers or through the sluices.

The intake of the water to the power-station



lies about 120 m. (394 ft.) above the dam, and consists of six openings, 12 m. (39 ft. 6 in.) broad, separated by brick piers. Its position with regard to the regulating dam is shown in Fig. 2, and its construction in Figs. 6 and 7, page 377. In front of the openings is placed a securely anchored floating ice-guard, which is made of strong timber and fitted with a screen commencing 90 centimetres (36 in.) below the surface of the water. As there is no loose floating timber in the river, there consequently is no risk of any timber diving under the guard; no wreckage guard will, at first, be erected, as a guard always gives trouble when coated with ice, and the ice-guard is expected to yield sufficient protection. Should, however, a wreckage guard subsequently prove necessary, there will be no trouble in attaching one. The inlet openings can be closed by a form of sluice, consisting of loose doors, about 4 m. (13 ft. 2 in.) wide. The fixing and removal of these sluices, as well as of the steel tube-pins, is effected by means of a portable crane on wheels. The intake is calculated for a volume of water of 350 cub. m. (12,600 cub. ft.) per second, which volume, in all probability, after the regulation of Lake Vänern, may be reckoned as available for power purposes under all circumstances throughout the 24 hours. The speed of the water at the inlet is about 1 metre (3 ft. 3 in.) per second. The intake canal is about 1300 m. (1418 yards) long, and through its entire length is blasted in rock or lined with brickwork. The portion nearest the intake is proportioned for the same volume of water as the inlet, or 350 cub. m. (12,600 cub. ft.) per second. About 350 m. (1148 ft.) from the intake the section of the canal is reduced so as to correspond with a volume of 250 cub. m. (9000 cub. ft.) per second. When the regulation of the Vänern has been completed, another canal, of 100 cub. m. (3600 cub. ft.) of water per second, will be constructed from that point to the power-station, partly by using the present traffic canal, which, after an impending thorough reconstruction, will be at the disposal of the power-station for some distance. Immediately below the future branching-off point, a gate will be arranged in the now constructed canal, consisting of one large sluice of the Stoney type, 17 m. (55 ft. 9 in.) broad and 9 m. (29 ft. 6 in.) high. Below this door the canal, which is calculated to have a speed of water of 2.2 m. (6 ft. 7 in.) per second, has a sectional area of 114 sq. m. (1225 sq. ft.) below low water. The form of the section, however, is somewhat variable; generally it is shaped with the view of obtaining a maximum of hydraulic average depth, corresponding to a bottom breadth of 14.2 m. (46 ft. 6 in.) and a depth of 7.7 m. (25 ft. 3 in.); but for a portion, where space is very limited and the natural rock surface is high, the bottom width has been reduced to 10.5 m. (34½ ft.), with a depth of water of 10 m. (33 ft.). The change from one section to another takes place gradually, whereby the formation of whirlpools is avoided.

At the deepest point of the canal is a discharge opening, which is closed by means of a tightly-fitting door. The latter portion of the intake canal, over a distance of about 35 m. (115 ft.), has smooth vertical sides, faced with bricks below the water, and with heavy granite at the water-line. When the turbines were tested, the measurement of the water-flow was taken by means of the well-known method invented by Professor E. Andersson, of Stockholm. Three bridges lead across the canal, two of which are iron bridges, and the third of reinforced concrete. The canal walls are partly built of granite in cement up to a height of from 6 m. to 7 m. (20 ft. to 23 ft.), and partly of concrete at greater heights than 7 m. (23 ft.). The concrete walls are made of concrete of the following mixture:—1 cement, 5 sand, 7 stone. Nearest the rock, however, there is a layer of a mixture of 1 cement and 1 sand, and then a 10-cm. (4-in.) layer of fat concrete (1 cement, 2½ sand, 2½ broken stone), and outside this cement rendering up to 4 m. (13 ft. 2 in.) from the top of the wall. Behind the tight surface of the wall are inserted 50-mm. (2-in.) brick drain-pipes at 0.5 m. (1 ft. 7½ in.) distance from each other, besides requisite collecting-pipes, so that the wall will not be subjected to water pressure from below. The surface, by means of a 0.5-m. (1-ft. 7½-in.) coating of stone set in cement, is protected against the wear and tear of the running water. In order to avoid cracks, which would affect the tightness, the wall is built in monoliths of not more than 10 m. (33 ft.) length. These are grooved into each other, some American asphalt cloth being inserted as packing.

The distribution reservoir is situated at the top of the mountain east of the so-called Olidehalen. In the sides of the distribution basin are wooden outlets of an aggregate length of 72 m. (236 ft.), to provide an outlet for the water flowing through the canal, and thus to prevent an inundation of the power-station, in case the majority of the turbine regulators should be simultaneously closed. The water is led in tunnels from the above-mentioned outlets into the river. Besides the inlets to the conduits there is further an ice-escape at each end of the distribution reservoir. The doors and the guards in front of the conduit inlets are under cover of a building constructed of granite and concrete. A separate tube leads to each turbine, proceeding from a separate chamber, with a double closing arrangement. Within the chamber is the ice-guard, which, if the chamber be closed, can be cleaned independently of the other guards. The sluice of the Stoney type has a width of 8 m. (26 ft. 3 in.) and is supported by the grooves in the wall, and by two intermediate supports in addition; it is operated by means of an electric winch or by hand-power. The lowering of the door can be promptly effected by means of an electric arrangement in the switchboard-house. The speed of the water through the free opening of the ice-guard is about 1 m. (3 ft. 3 in.) per second; and in order to incur the smallest possible risk from ice-coating, special types of ice-guards have been designed. Fish which reach the ice-guard through the inlet canal can, by means of a passage in the bottom, immediately in front of the ice-guard, go through tubes to a collecting-groove running along the distribution reservoir, and from there again to the river. The arrangement may be seen in Fig. 8, page 377. From the intake building the water is led to the power-station through eight large and three smaller tube-conduits. The former, which have a diameter of 4.25 m. (14 ft.), lead to the eight large turbines, and the latter, which have a diameter of 1.2 m. (4 ft.), to the three exciting turbines. The tube-conduits are placed in tunnels in the rock,

lined with sheet-iron, and encased in concrete. Each tube-conduit has a length of about 60 m. (197 ft.). The suction-conduits are shown in Fig. 26, page 379.

The power-station (Figs. 22 and 25, Plate XLV.) contains the turbines and the generators, which are direct coupled. The arrangement of the power-station will be understood from the illustration opposite (Fig. 8), which is a vertical longitudinal section through tube-intake, tube-conduit, machine-house, and outlet tunnel. Fully equipped it can yield 100,000 horse-power under the existing condition of water, and when Lake Vänern has been regulated, as already mentioned, a considerably larger power. The turbines are the so-called twin turbines with horizontal axles direct coupled to the generators. They have rotors of the ordinary Francis type and are fitted with adjustable bearings. Each turbine with a head of water of 30.4 m. (100 ft.), and with a speed of 187.5 revolutions per minute, has a capacity of nominally 10,000 horse-power and a maximum capacity of 12,500 horse-power, measured at the coupling to the electric generator. A vertical longitudinal section through the turbine is shown in Fig. 12, page 378, and an end elevation in Fig. 13. The turbines are enclosed in cylindrical cases of steel, one of which is shown in perspective in Fig. 9, and are directly connected with the tube-conduits, so that the water, without any alteration in its direction, is led from the tube-conduits on to the turbine-wheels. The smallest interior diameter of the surrounding cases is 5 m. (16 ft. 6 in.), and the largest diameter is 5.5 m. (18 ft.). The thickness of the plates varies from 22 mm. to 23 mm. (about $\frac{7}{8}$ in.). The turbines may also be seen in Figs. 15 and 16, Plate XLII., and in perspective in course of erection in Figs. 17 to 19, Plate XLIII., and Figs. 20 and 21, Plate XLIV.

In the construction of the turbines the greatest care, in the first place, has been bestowed upon making the casing of the turbine as smooth as possible inside. Most parts, especially those exposed to the severest strains, are made of steel, as are also all the cast parts, which by riveting are connected with the casing. Each turbine has been tested at 75 metres (246 ft.) water pressure. The turbine shaft is of nickel-steel, made in three parts, which are connected by means of couplings, forged on the shaft. It is supported by three bearings, with ring lubrication; two of them are placed against the turbine-case and are accessible for inspection by means of vertical pits. All the bearings are water-cooled, and fitted with thermometers, which indicate the temperature at a convenient place outside the turbine-case. The rotors, which have a diameter of 1800 mm. (6 ft.) on the inlet side, are made of cast steel and are very securely attached to the shaft.

In order to obtain a construction which combines the greatest possible reliability in working with easy management and durability, all the parts belonging to the governing mechanism have been located outside the turbine-case, so that all the journals can be lubricated and inspected during working. Special interest attaches to the construction adopted in these turbines, which makes it possible to take out each guide-blade separately without causing any serious disturbance beyond the removal of the box belonging to the blade in question, and the uncoupling of the small chain between the crank and the regulator. The guide-blades are of steel, and cast in one piece with their respective shafts.

The governor, which is worked by belting from the turbine shaft, together with the pressure bell, is placed in a cast-iron box, fixed in concrete, which also serves as an oil receptacle; pipes, 100 mm. (4 in.) in diameter, connect the governor with the servo-motor, which acts upon the middle of the governor shaft. The oil-pump is worked by belting from the turbine axle. The brake intended to bring the turbine to a standstill is hydraulic, and is worked from the starting-platform.

In order to give some idea of the large dimensions of the turbines, we append the following particulars of weight:—

	Kg.	Tons.
The front ring, of steel ... about	12,000	(12)
The suction-case parts ... about	14,000	(14)
The turbine-wheels, of steel, each weigh ... ... about	5,000	(5)
The turbine-axle, of nickel-steel, about	14,000	(14)
The cast-iron upper part of the suction-case ... ... about	32,000	(32)
The front portion of the suction-case, with part of suction-case about	28,700	(28¾)
Conical portion of case ... about	10,200	(10¼)

The diagram, Fig. 14, shows the satisfactory results of the tests undertaken at the instance of the buyer.

At the tests, which were carried out with the greatest care, the quantity of water was measured by means of a floating screen in the inlet canal, and the effective height of fall was ascertained by the difference in level between the upper and the lower water surfaces. The generator, which is shown dotted in Figs. 15 and 16, was loaded with a water-resistance, and the effect was measured by means of two precision watt-meters. In the results are included the loss of efficiency arising in the inlet-tube, and the influence of this is shown in curve B, which shows the efficiency that would be registered if the head were measured through a manometer placed in the turbine-case or in the way such tests are generally carried out.

The generators, one of which is shown in perspective in Fig. 24, Plate XLV., produce three-phase current, 25 periods, and 10,000 volts. They are entirely encased so as to obtain efficient cooling. The generator rotors draw by suction the cold air through spacious conduits, which pass within the walls of the power-station and underneath its floor. The air, heated in the generators, is also led away through conduits; during the winter it is used for warming both the generator-station, the tube-inlet building, and the switchboard building; in the summer it is led away, so that the attendants shall not be inconvenienced by it.

For exciting the generators, for lighting purposes, and for power to the auxiliary machines, there is a continuous-current installation for a voltage of 220 volts. This is worked by the three 500-horse-power turbines already referred to, which are placed in the centre of the power-station. Each turbine is direct coupled to a continuous-current generator of 350 kilowatts for 220 to 300 volts. Parallel with these generators is an accumulator battery of a capacity of 4800 ampere-hours, which serves as a reserve and for counteracting the voltage variations. The switchboard for this installation is placed on a balcony in the centre of the power-station, close to the generators in question.

The regulation of the generator excitation does not take place in the ordinary manner, by means of main-current regulators, but by direct-coupled additional machines or boosters; and the voltage, with separate excitation, can vary from −220 to + 110 volts. By this arrangement the exciting voltage of the generators can be varied from 0 to 330 volts. The alternate current is conducted from the power-station through a tunnel to the instrument house. The tunnel is divided into four separate passages, in each of which there is room for the cables from two generators. It was originally planned to place the instrument-house in the immediate vicinity of the power-station, but various considerations have led to the adoption of the present location, which is some 200 metres (653 ft.) distant from the power-station. The instrument-house, which may be seen in Fig. 23, Plate XLV., contains transformers, which transform the alternate current from 10,000 volts to 50,000 volts. The building further contains main switches, laboratory, lightning-dischargers, and all other appliances for the handling and distribution of the energy. In the centre of the house is the room (Fig. 27, page 379) from which the controlling and working of the station is carried on. In this room, on marble switchboards and desks, are placed all the instruments necessary for ascertaining the load distribution within the alternate-current system, as well as all the requisite signal and warning appliances. The voltage of the current is regulated from the controlling-room. From here, too, the oil-switch of the alternate-current installation is worked electro-magnetically by means of auxiliary switches. The auxiliary switches on the switch-desks are included in a miniature scheme of the alternate-current installation, with movable marks for all the apparatus and fixed marks for the lines, the generators, and the transformers. The movable marks, or miniature apparatus, are partly worked automatically and partly by hand, so that it is at any time possible to ascertain the position of the main switches.

In the switch-room is a telephone station, connected with the power-station and the transformer-stations. The requisite orders for the ordinary working of the power-station are transmitted by means of an electric machine telegraph, as the telephonic connection suffers from the noise of the machinery. The upper story of the instrument-house is used for a repair-shop for the transformers, for laboratory, store-rooms, &c. This portion is entirely separated from the high-voltage installations.

The transformers are placed in a series of rooms on the north-western side of the instrument-house, four cells on each side of the central part. Each cell is calculated for one transformer group, and each transformer group consists of three one-phase transformers, each of 3670 kva. maximum capacity, thus corresponding with a three-phase generator. The transformers are oil-insulated and water-cooled. In order to minimise the risk of fire, which can never be fully removed from the use of oil-insulated transformers, the rooms are entirely closed in, and arrangements are made for the free escape of oil. In order to maintain the water-cooling there are signal contacts in the cooling-water pipes to each transformer. These signal contacts give an alarm as soon as the cooling water ceases to circulate. As soon as the temperature in any of the transformers exceeds the permissible limit, the thermometer placed in the transformer gives an alarm. The water for cooling the transformers is circulated by pumps in the cellar of the instrument-house. This installation consists of four pumps worked by electric motors. They lift 1500 litres (333 gallons) per minute to a height of 15 m. (49 ft.) respectively; and 500 litres (111 gallons) per minute to a height of 25 m. (82 ft.). These pumps are also used for the extra-voltage precaution appliances, of which more will be said later. Only two pumps are required for the maintenance of the working. The other two are reserve. Two water-tanks of an aggregate capacity of 50 cub. m. (11,250 gallons) serve as an additional reserve for the cooling of the transformers, and one tank of 10 cub. m. (2250 gallons) capacity as a reserve for the extra-voltage protective appliances. There is a special pipe system for conducting the oil into the transformers, and for emptying them; there are also tanks for the reception of the used oil from the three one-phase transformers, and also for supplying clean oil, as well as appliances for cleaning and drying the transformer oil.

The energy is distributed from the instrument-house partly at 10,000 volts and partly at 50,000 volts. The long-distance lines are generally calculated either for the output of a complete generator or half generator; in the latter case they are in pairs. This makes it possible for each generator, with or without transformation of the voltage, to supply energy for a fixed number of lines, and to work independently of the other generators. In other words, the installation can be divided into several systems independent of each other, which fact, to a very great extent, increases the safety. The switchboards are constructed with a special view to this arrangement. They are therefore also divided into eight compartments, each of which corresponds with a generator. The different units, by means of oil-switching, can be switched into collective systems for 10,000 volts, and also into a collective system for 50,000 volts. This makes it possible, at will, to switch any long-distance line on to any transformer or generator. All the switches intended for on-and-off switching of the generators, the transformers and the long-distance lines, are fitted with starting rheostats and dimensioned for the temporary current which might arise from a short-circuit, when all the eight generators work in parallel. The machines and the long-distance lines are protected against overloading by means of relays, which are built on the principle of the induction motor.

The extra-voltage protection for the long-distance lines consists of water-jets for the dispersal of the static charge and of horn lightning-dischargers with two horns switched in series with a resistance formed through running water as a rough protection. For smaller quantities of energy there are horn lightning-dischargers with oil-resistances switched in series, and there are roller lightning-dischargers as a finer protection for high-frequency extra-voltage with smaller quantities of energy. Apart from the cables in the tunnels between the power-station and the instrument-house, the high-voltage lines for 10,000 volts are arranged as bars, and those for 50,000 volts as tubes on insulators. The different phases are separated from each other by fire-proof intermediate

walls, which principally consist of concrete plates, set in iron grates. The distance between the lines and the constructive parts connected with the ground amounts to 200 mm. (8 in.) for the 10,000-volt system, and 400 mm. (16 in.) for the 50,000-volt system. The cables in the cable tunnels are each placed separately in a brick channel, and covered with sand.

The various high-voltage rooms are separated from each other by fireproof material. The lines are, therefore, carried through by means of through-insulators. Special attention has been bestowed on the cells for the oil switches which are made in concrete. They are entirely closed, and fitted with drain-pipes, which, should an explosion in an oil-switch occur, quickly lead away the oil. The current, as already mentioned, proceeds from the instrument-house, partly with a voltage of about 10,000 volts for places in the vicinity of the station, and partly with a voltage of 50,000 volts for more distant places. The 50,000-volt current, however, is not supplied direct to the consumers, but is led to large transformer-stations (secondary stations) which belong to the State, and are situated at convenient distances apart In these stations the energy is again transformed down to a more convenient voltage. This is generally 10,000 volts, and only in isolated cases current of 3000 or 6000 volts is supplied. The energy of this low voltage is supplied from the secondary stations to the surrounding consumers. The State provides the lines as far as the place of consumption, but the consumers must themselves defray the cost of the requisite transformation from high voltage to a serviceable voltage. In more populous districts energy of such serviceable voltage, however, is distributed by the same means as are used by municipal electric stations. All 50,000-volt lines are of copper, generally six copper lines and one iron line for earth connection. Lines of 50,000 volts were first installed to Skara, Gothenburg, and Allingas. On the Skara line (the one first completed), the copper lines were laid on support-insulators of porcelain ; on the other lines suspended insulators have been adopted, except on the tightening-masts, where support-insulators are used.

The insulators are attached to iron trellis poles placed on concrete foundations. The poles are partly tightening-poles and partly support-poles. The former are constructed very strongly, and are placed at a distance of 1 km. from each other. Between two tightening-poles are placed as many support-poles as is economically advantageous for each respective section of the line. The support-poles are designed with due regard to the weight of the line and the wind pressure. The number of poles per kilometre is four for 70 sq. mm. (0.112 sq. in.) line, and six for 16 sq. mm. (0.026 sq. in.) line. For 35 sq. mm. (0.06 sq. in.) line the normal span is 170 m. (557 ft.). Of the 10,000-volt lines, those intended for very large currents are made of aluminium, those for smaller currents of copper wire. The insulators are support-insulators of porcelain. The poles, where it is a question of large currents, are trellis masts of iron, built on the same principle as those for the 50,000-volt lines ; whilst creosoted wooden poles are used for the smaller currents. The secondary stations are arranged on the same principles as the instrument house. The circuit-switch is shown in Fig. 28.

A portion of the energy having been reserved for railway traction, the remainder is sold to municipalities and private concerns, and has met with a very lively demand. There has even been a question of disposing of a considerable quantity of the energy to Copenhagen. The plan is considered quite practicable, but has not yet passed beyond a preliminary stage. As the cost of the Trollhättan power-station, &c., is unusually low—

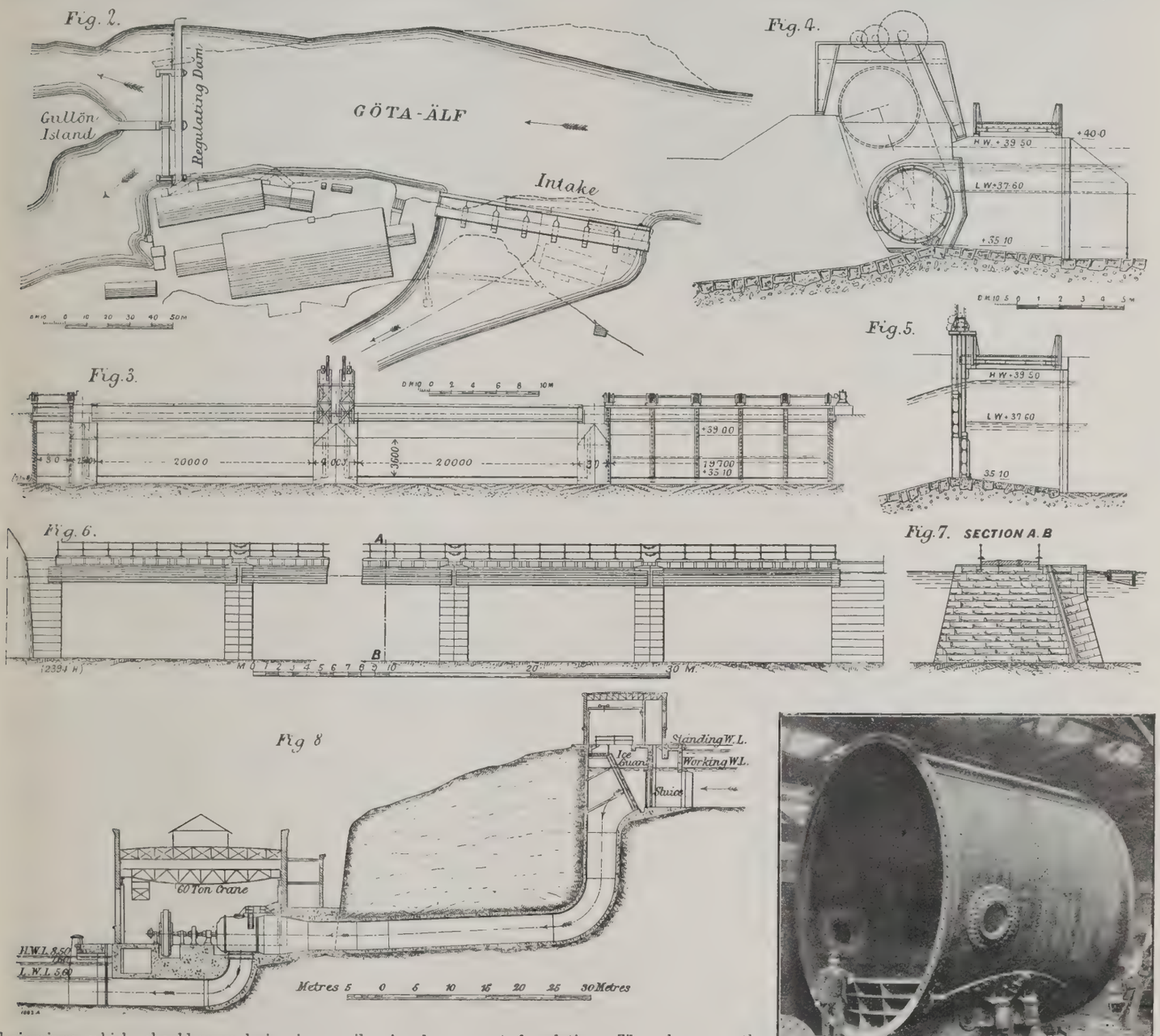


FIG. 9.

11,500,000 kr. (638,888*l.*) for 80,000 turbine horse-power—and as the State can obtain money at a small rate of interest, and be content with a moderate profit, the price for the energy has been fixed at an unusually low figure. Amongst the first to contract for electric current were the towns of Gothenburg, Skara, Sköfde, Allingas, &c., including several smaller places, and amongst the customers of the Trollhättan power-station are also a number of industrial concerns. The State provides suitable sites at Trollhättan, at the canal or the railway, for such industries as require electric energy at a particularly low price, and which therefore, so as to

12,500-H.-P. TURBINE; TROLLHÄTTAN HYDRO-ELECTRIC POWER-STATION, SWEDEN.

CONSTRUCTED BY MESSRS. NYDQVIST AND HOLM, ENGINEERS, TROLLHÄTTAN.

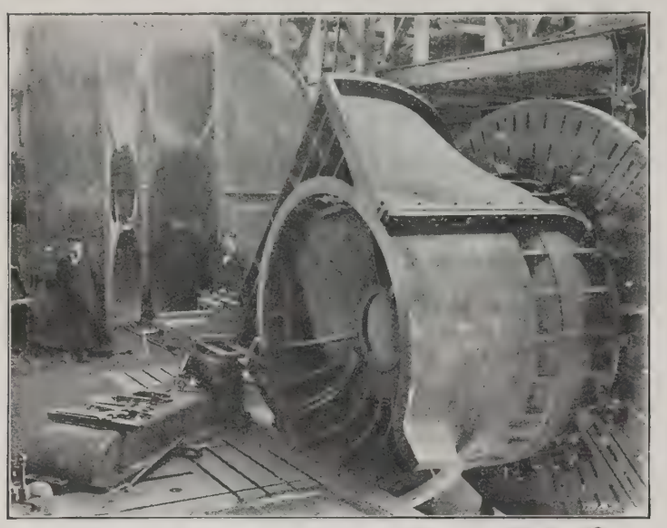


FIG. 10. CONICAL PART OF CASING OF TURBINE.

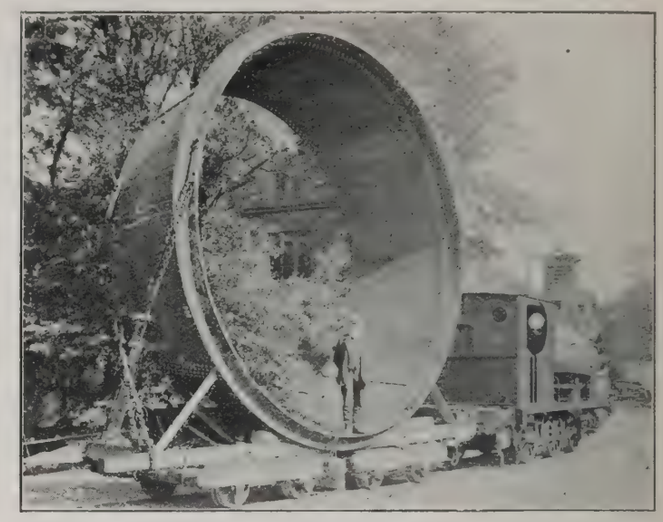


FIG. 11. UPPER PORTION OF SUCTION CASING.

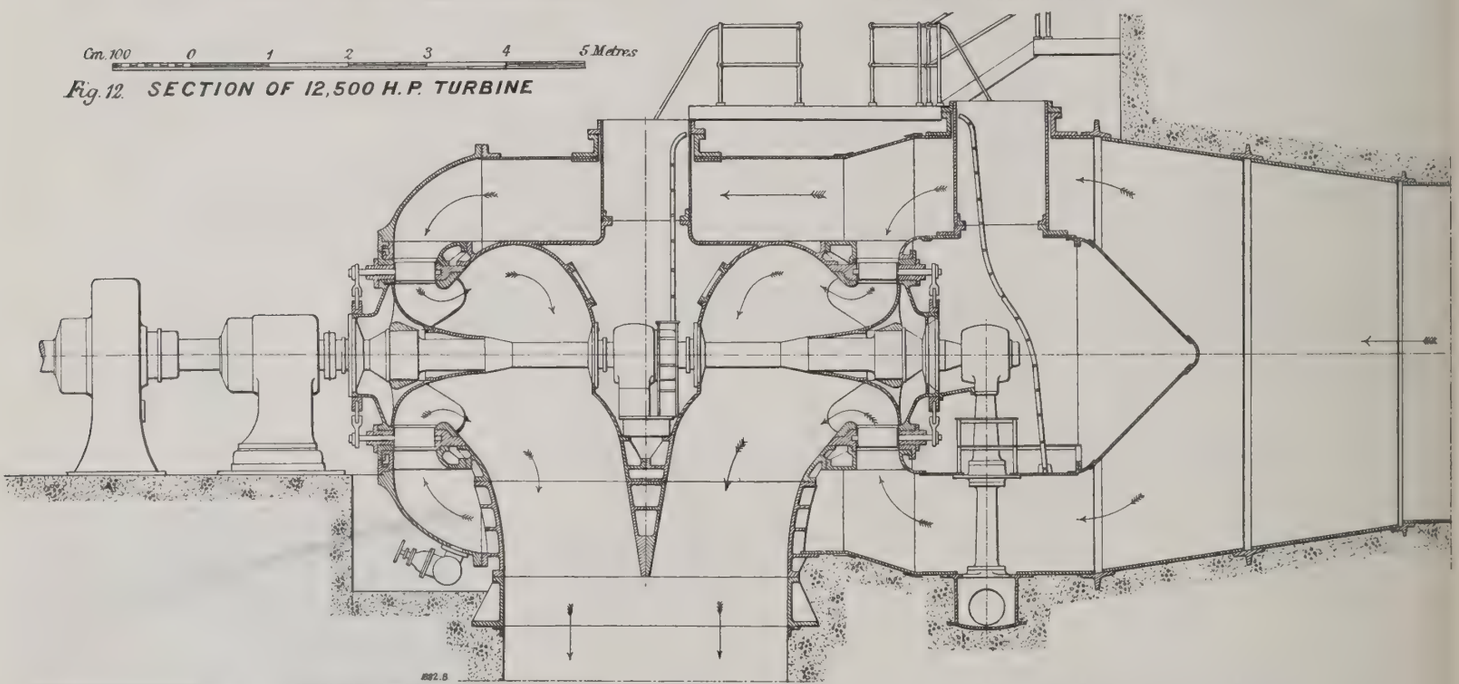


Fig. 12. SECTION OF 12,500 H.P. TURBINE

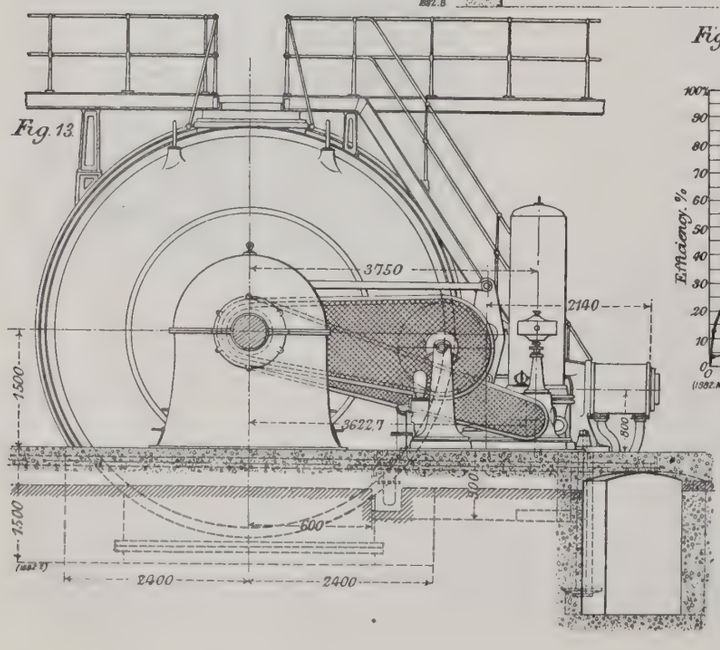
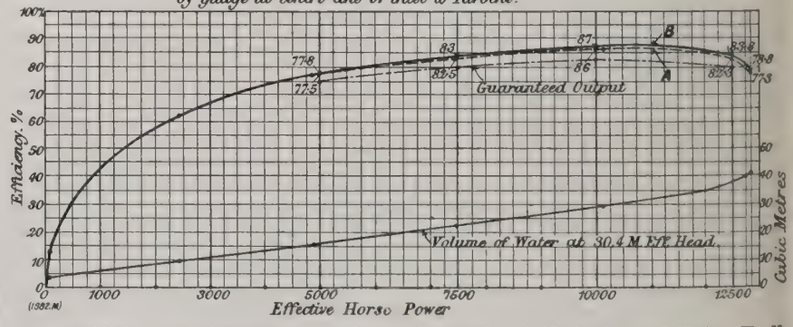


Fig. 13.

Fig. 14. RESULTS OF TRIALS OF 12,500 H.P. TURBINE

Curve "A"....Efficiency obtained during Trials

" "B"....Efficiency deducting pipe losses; head measured by gauge at centre line of inlet to Turbine.



avoid the cost of transmission over a distance, should be located quite close to the station.

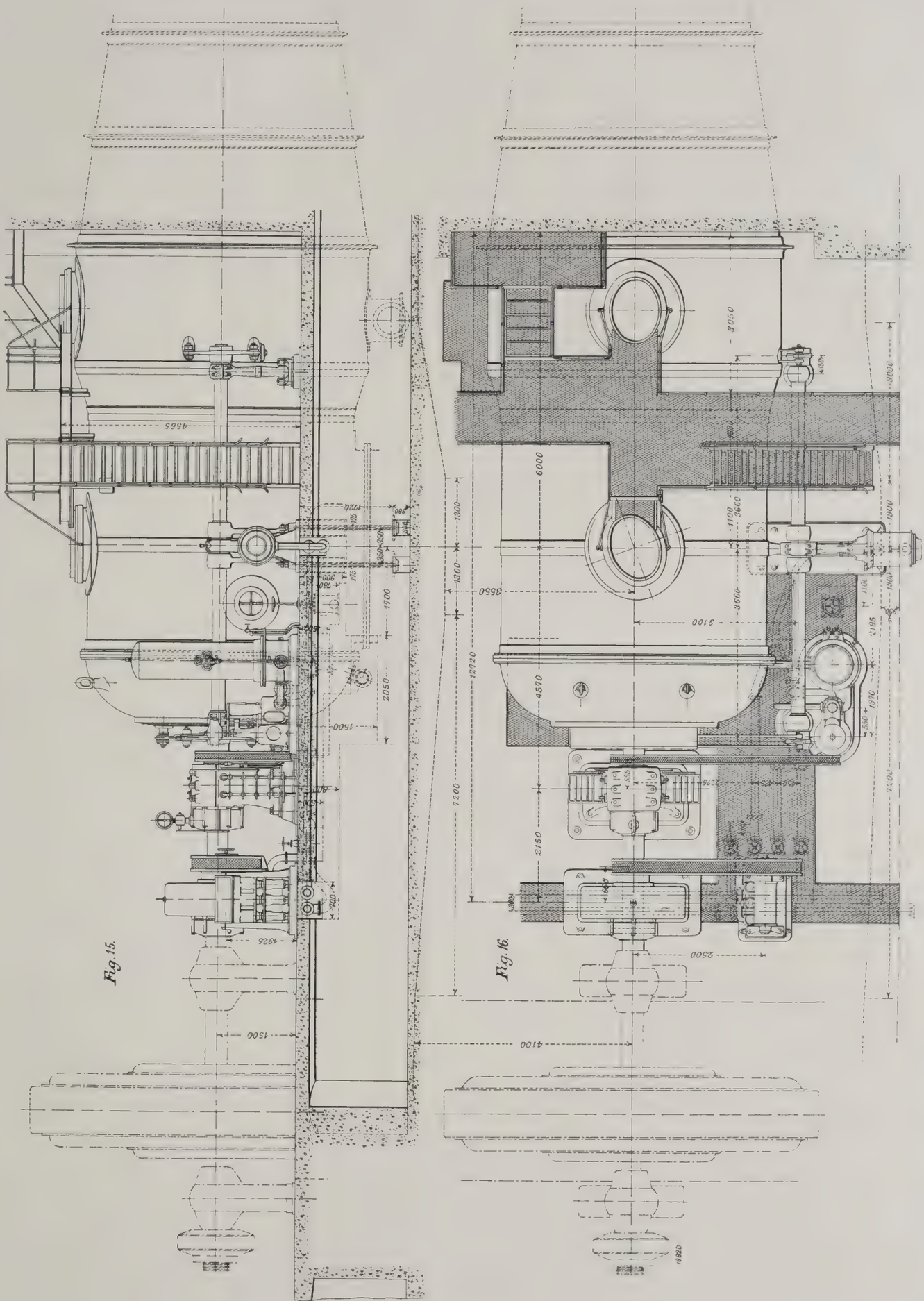
The greater portion of the plant for the power-station at Trollhättan has been supplied by Swedish manufacturers. Thus two of the large turbines which were first installed were made at the works of Nydqvist and Holm, Trollhättan; the particulars given in this article, as well as the illustrations, refer to the turbines from this firm. The other two large turbines came from the Kristinehamn branch of the Karlstad Engineering Company, Karlstad. The generators and the greater portion of the instruments have been supplied by the General Swedish Electric Company, Västeras.

The management of the State waterfalls in the Göta River, as well as of the Trollhätta Canal between Lake Vänern and the sea, which is Sweden's

12,500-H.P. TURBINE AT THE TROLLHÄTTAN HYDRO-ELECTRIC POWER-STATION.

CONSTRUCTED BY MESSRS. NYDQVIST AND HOLM, ENGINEERS, TROLLHÄTTAN.

(*For Description, see Page 374.*)



(*To face Page 378.*)

TROLLHÄTTAN HYDRO-ELECTRIC POWER-STATION; DETAILS OF 12,500-H.-P. TURBINE.

CONSTRUCTED BY MESSRS. NYDQVIST AND HOLM, ENGINEERS, TROLLHÄTTAN.

(*For Description, see Page 374.*)

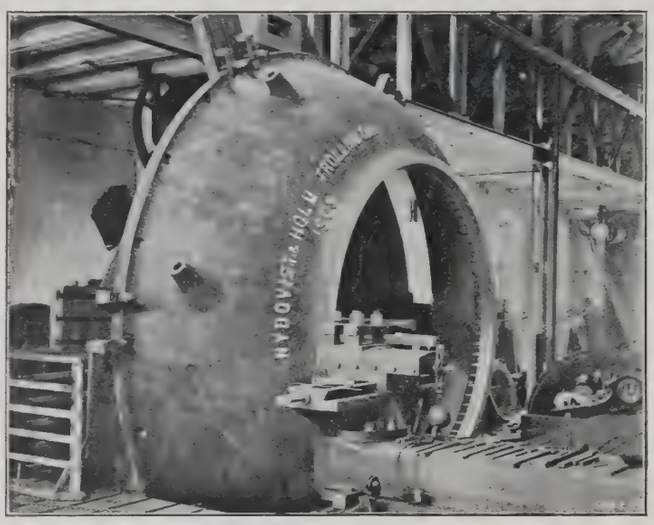


FIG. 17. FRONT OF TURBINE CASING.

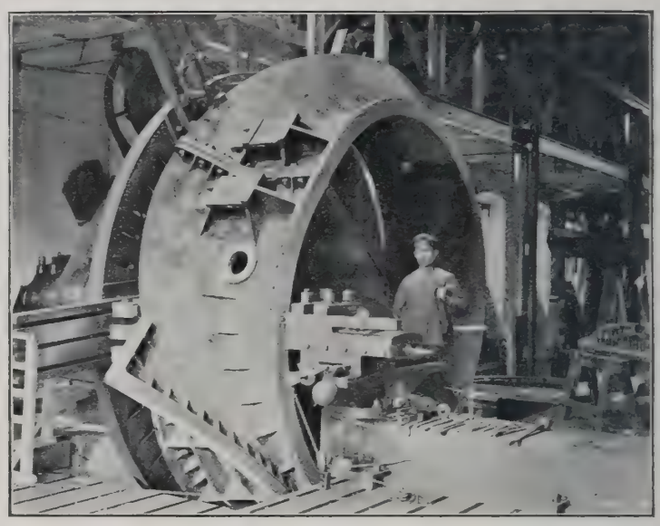


FIG. 18. PORTION OF SUCTION CASING.

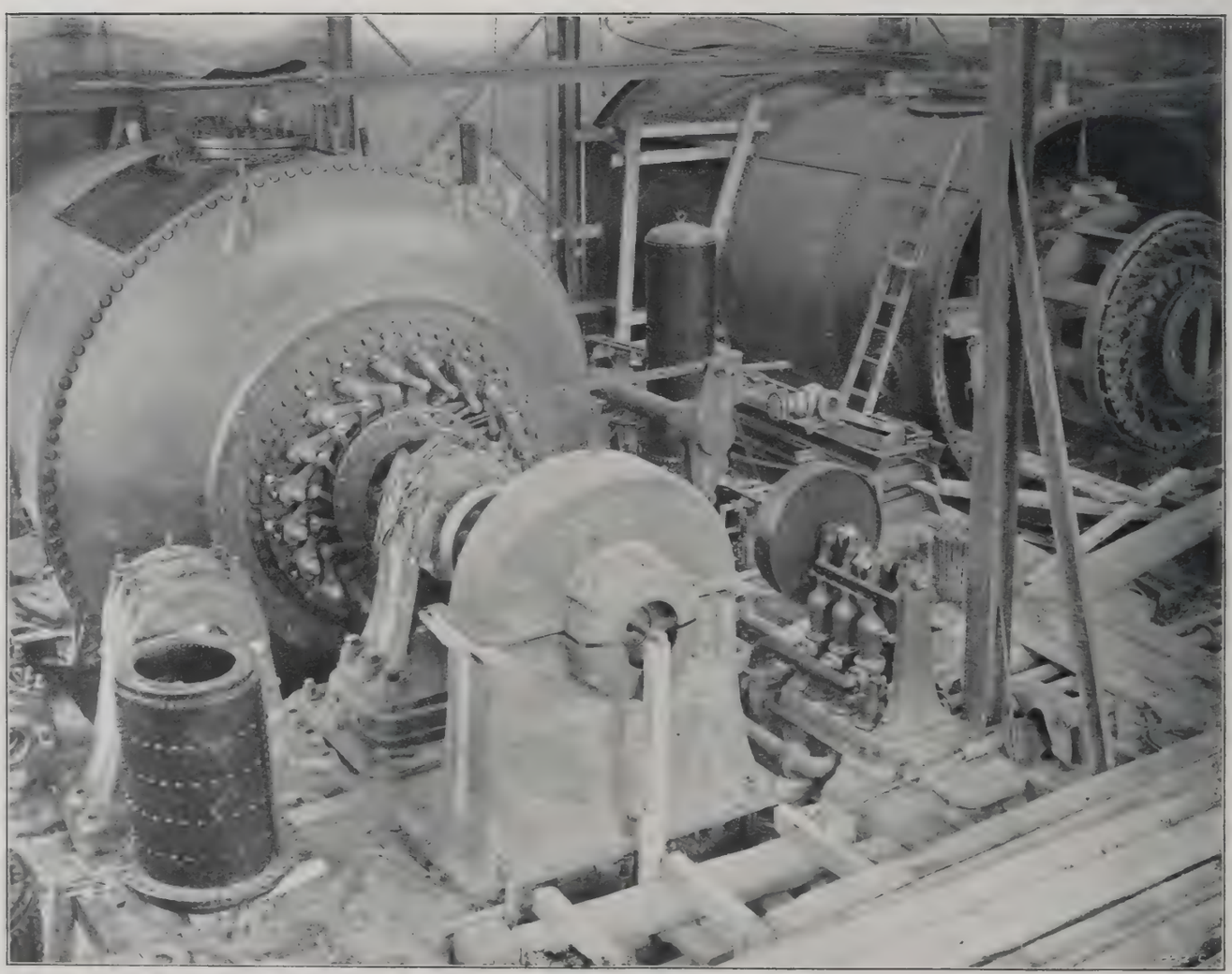


FIG. 19. VIEW OF TURBINE DURING ERECTION.

THE TROLLHÄTTAN HYDRO-ELECTRIC POWER-STATION, SWEDEN.

(*For Description, see Page* 374.)

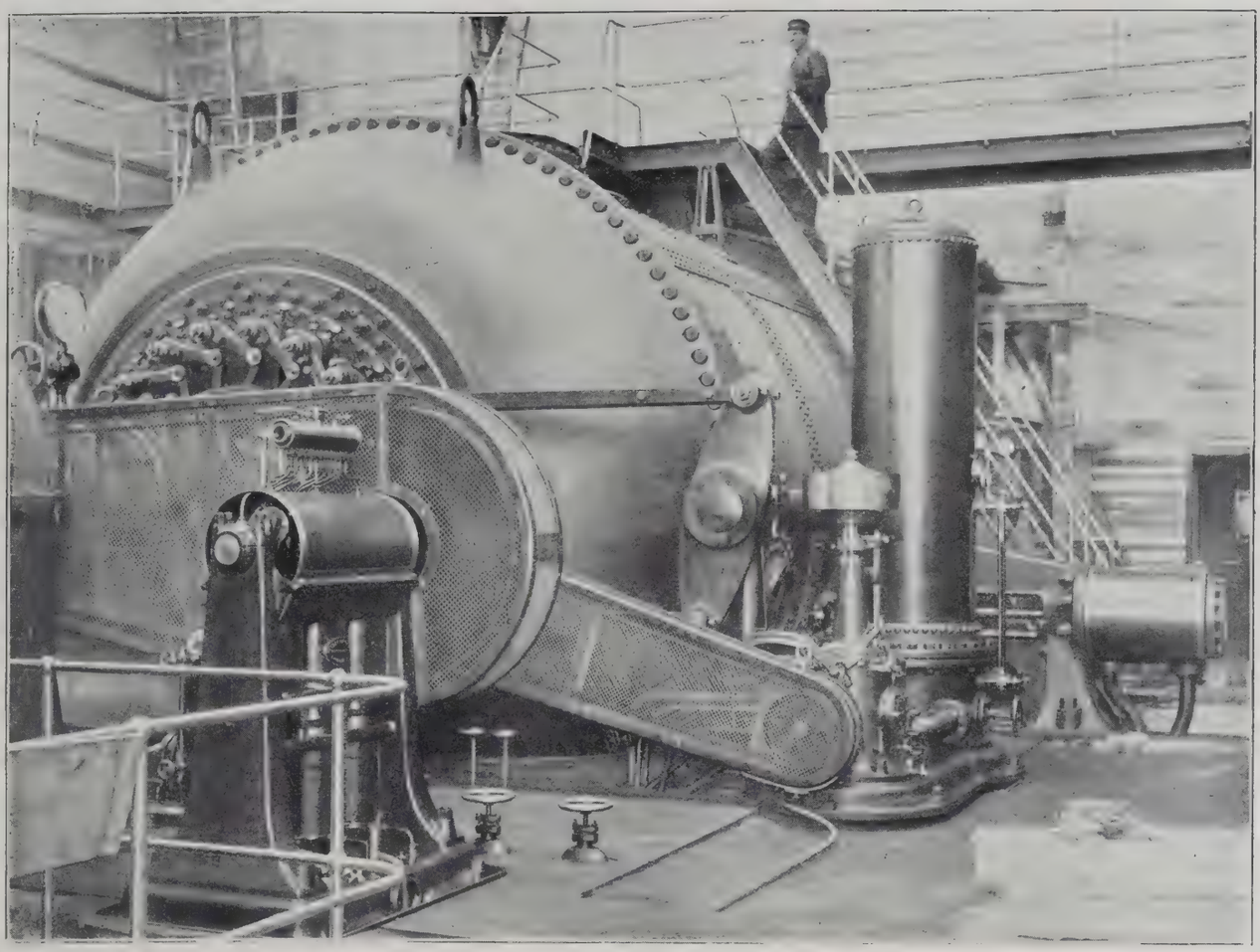


Fig. 20. Completed Turbine.

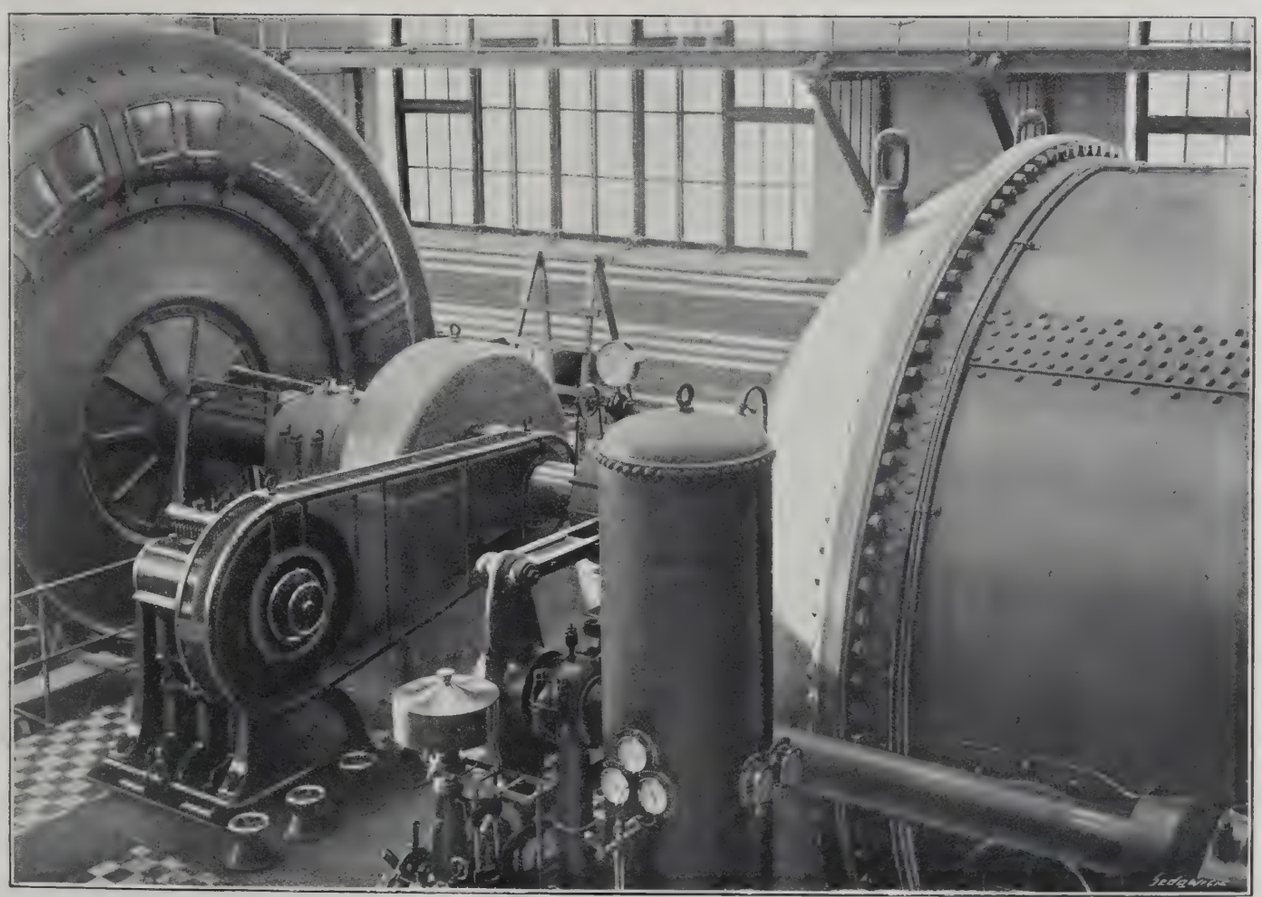


Fig. 21. Turbine and Generator.

THE TROLLHÄTTAN HYDRO-ELECTRIC POWER-STATION, SWEDEN.

(*For Description, see Page 374.*)

FIG. 22. POWER-STATION.

FIG. 23. INSTRUMENT HOUSE AND POWER-STATION.

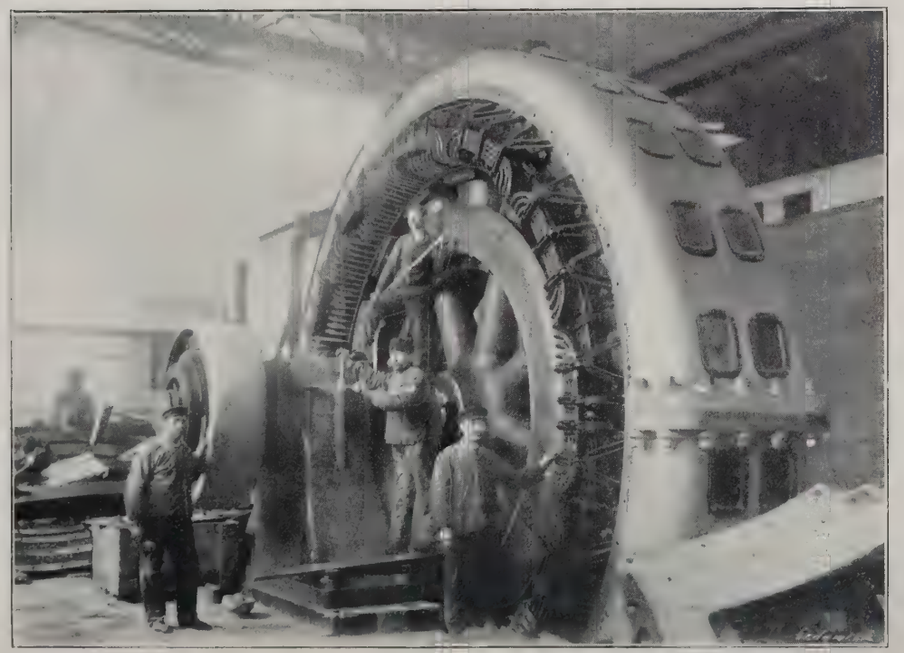


FIG. 24. ELECTRIC GENERATOR IN COURSE OF ERECTION; GENERAL SWEDISH ELECTRIC COMPANY, VÄSTERAS.

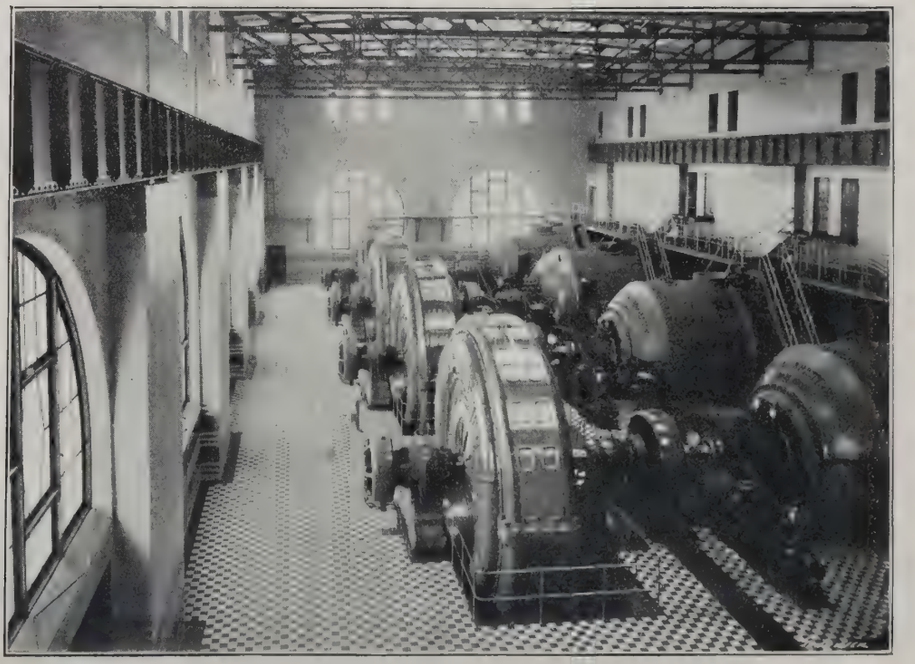


FIG. 25. THE MACHINERY HALL.

TROLLHÄTTAN HYDRO-ELECTRIC POWER-STATION, SWEDEN.

FIG. 26. SUCTION CONDUITS.

FIG. 27. CONTROLLING-ROOM.

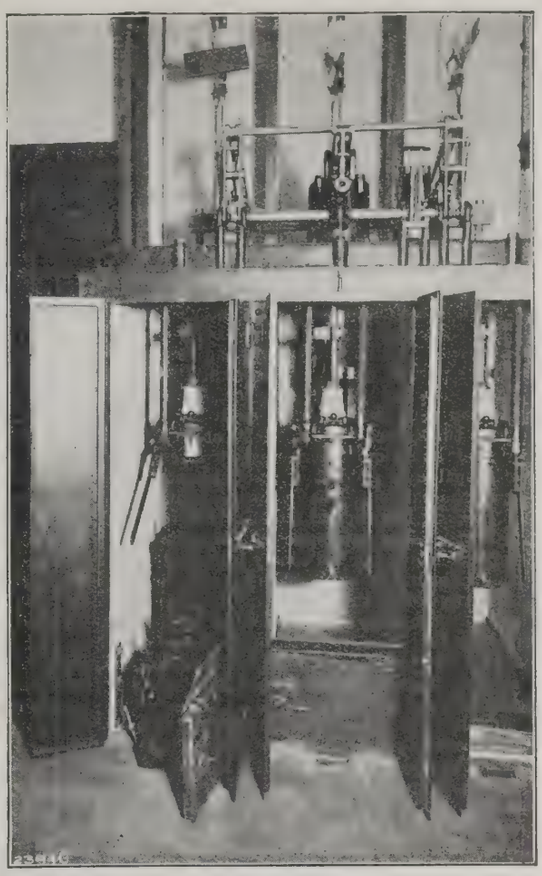


FIG. 28. CIRCUIT SWITCH.

most important waterway, has hitherto been vested in a special local board, domiciled at Trollhättan; but, on the formation of the Royal Waterfalls Board, which has the management of all other State waterfalls in Sweden, the Trollhätta Falls were also transferred to this board.

THE BRITISH ASSOCIATION.

(*Continued from page* 350.)

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

SECTION A met in the Examination Hall of the Portsmouth Municipal College, a handsome, spacious room, the designers of which had successfully dealt with the question of ventilation, but had not mastered the acoustical problem. On three days the Section had to subdivide, twice into two and once into three departments: mathematics, general physics, cosmical physics or meteorology. The subsections found accommodation in adjoining rooms. It looks once more as if this now customary and possibly unavoidable subdividing would lead to a splitting of the Section, which we should regret. We shall revert to this point in our concluding remarks. The provisional programme, issued on the Thursday of the meeting, suggested subdivision on one day only, and mentioned 42 papers; the number of papers and reports rose, however, to 49. The Section sat on five days, only in the mornings. On Thursday, August 31, the communication of some mathematical speculations, suggestive, but of inordinate length, was allowed to disarrange the programme; a time-limit was afterwards enforced where necessary. The absence of men like Sir J. Larmor, whose refreshing manner of focussing lengthy communications used to stimulate the discussions, Sir J. J. Thomson, Sir David Gill and others, was felt, of course; but the attendances were good, and the proceedings of the Section may well compare with those of previous years, in quality and quantity. There were several important general discussions; the one on "Aeronautics," for which Sections A and G united, has already been noticed in our columns. The fact that detailed papers on radiography were not offered does not, of course, indicate any slackness in this field; nor is it much to be regretted, for the details are not always particularly interesting, or of a kind to dispel the doubts of the uninitiated. The astronomers did not forget that their communications were not addressed to their colleagues.

The officers of the Section were:—President: Professor H. H. Turner, D.Sc., F.R.S., of Oxford. Vice-Presidents: Professor J. C. Fields, of Toronto; Dr. W. N. Shaw, F.R.S., Director of the Meteorological Office; Professor F. Trouton, F.R.S., of University College, London. Secretaries: Professor A. W. Porter, F.R.S., of University College, London (Recorder); Messrs. H. Bateman, M.A., of Cambridge; P. V. Bevan, Sc.D., of Egham; A. S. Eddington, M.A., M.Sc., of Greenwich Observatory; E. Gold, M.A., of the Meteorological Office; and P. A. Yapp, of His Majesty's Dockyard, Portsmouth.

THE CHARACTERISTICS OF THE OBSERVATIONAL SCIENCES.

Professor H. H. Turner had taken "The Characteristics of the Observational Sciences" as the subject of his presidential address, and we might say that he pleaded for an appreciation of observations as such, without regard to hypotheses and to results achieved, and irrespective consequently of any particular object. Professor Turner opened his address by saying that it would startle his audience to hear that the Section had only once been addressed by an astronomical president upon an astronomical subject—namely, by Dr. De La Rue, in 1872, on astronomical photography. Other astronomical presidents—Airy, Lord Rosse, and Robinson—had, in their formal and brief addresses, only made allusions to astronomical matters. Johnstone Stoney had, in 1879, spoken of the valuable training which the study of mechanics and chemistry afforded; Sir Robert Ball had, in 1887, selected the costume of a geometer from his ample scientific wardrobe. The addresses of Sir George Darwin (1886) and Professor Love (1907) on the past history of the earth, as well as Professor Schuster's address of 1892, had certainly had an astronomical bearing, but they should rather be assigned to modern expansions of classical astronomy than to classical astronomy itself. There was thus a curious neglect of astronomy by Section A, which was all the more curious when it was remarked that the neglect did not extend to the Association, seeing that there had been three astronomical Association Presidents who had not previously chosen to fill the chair of Section A. The neglect had not been confined to astronomy, but had extended to the other sciences of observation, and it had been thought that the Section should divide; the Section had decided against this suggestion, and Professor Turner had, he said, no intention to appeal against this decision.

His late Oxford colleague, the Rev. Bartholomew Price, had, in his address to Section A at Oxford in 1860, remarked that the area of scientific research

covered by Section A was very large; some of the papers presented possessed the characteristics of perfect and necessary science; others were little more than a conglomeration of observations, made, indeed, with infinite skill and perseverance and of the greatest value, but as yet in their infancy; the facts of meteorology had scarcely yet been brought within any law at all. There seemed to be, Professor Turner thought, a rather unnecessary social scale in this. Was it not a dangerous doctrine to regard the work done previous to the formulation of a law as in any way inferior? Was the astronomy of Tycho de Brahe, which did not bring the science of astronomy within any law at all, socially inferior to that of Kepler? Stephen Groombridge had made thousands of accurate observations of stellar movements in the early part of last century; fifty years later some of the value of his work had begun to emerge from a comparison with later observations; but nearly a century had elapsed before something of the laws of stellar movement had been extracted from his patient work with the skilful assistance of Mr. Dyson and Mr. Eddington. Teisserenc de Bort had sent up his balloons to investigate the upper atmosphere, not to test some formulated law; he had almost immediately discovered the isothermal layer; "but was not the merit in sending up the balloons, whatever came of it?"

Sir G. H. Darwin had said in 1886, at Birmingham: "A mere catalogue of facts, however well arranged, has never led to any important generalisation. For in any subject the facts are so numerous and many-sided that they only lead us to a conclusion when they are marshalled by the light of some leading idea." That opinion had also been held by Charles Darwin. With the utmost respect Professor Turner wished to question whether that criterion went deep enough.

Advance was not only dependent on the existence of a theory; Tycho had had no theory, but had perceived the need of observation. Mr. W. W. Campbell, when appointed director of the Lick Observatory in 1900, had observed the line-of-sight velocities of as many stars as possible, and the mass of observation had told a wonderful story. When the stars were grouped according to their spectral types, the average velocities differed; and when the spectral types were arranged in the particular order, which for quite independent reasons was believed to be that of the development of the stars, there was a steady increase in the velocities; to put the matter in a nutshell, the older a star was, the quicker it moved. Thus the catalogue of facts accumulated by Mr. Campbell had led to a most important scientific generalisation—a direct negative to Sir G. H. Darwin's opening sentence. In commenting upon his observations Mr. Campbell had said in the Bulletin of the Lick Observatory of April 20, 1911: "That stellar velocities should be functions of spectral types is one of the surprising results of recent researches, for we naturally think of all matter as equally old gravitationally. Why should not the materials composing a nebula or a class B star have been acted upon as long and as effectively as the materials in a class M star? . . . The established fact of increasing stellar velocities with increasing ages suggests the questions: Are stellar materials in the ante-stellar state subject to Newton's law of gravitation? Do these materials exist in forms so finely divided that repulsion under radiation pressure more or less closely balances gravitational attraction? Does gravity become effective only after the processes of combination are well under way?"

This scientific advance, Professor Turner continued, was not suggested by any leading theory; but would the merits of the observational work have been less if no such immediate induction had presented itself? "It is so natural to judge by results, and so difficult to look behind them to the merits of the work itself, that I shall not easily carry others with me in claiming that the merits of the observer shall be assessed independently of the results." Proceeding, Professor Turner referred to Professor Kapteyn's division of the great mass of bright stars into two distinct groups, flying one through the other, and to the discovery by Professor Boss of a special cluster in the constellation of Taurus, moving in parallel lines like a flock of migrating birds. There was a large flat cluster migrating just over our heads so that one member of it (Sirius) was only three or four light years from the sun, the cluster itself being about a hundred light years from end to end. It was true, however, that, according to Mr. Campbell, the observations of this cluster (made largely at Lick) appeared to be vitiated by a systematic error, which would assign a spurious velocity of 5 km. per second to stars of the B spectrum type in their apparent outward motion from the sun.

Continuing his main line of argument Professor Turner pointed out that Bradley had discovered the aberration of light and the nutation of the earth's axis, and had been on the track of the discovery of the variation of latitude, not by any help from Newton, but by accumulating a mass of observations. In his "Budget of Paradoxes," de Morgan had written that, if it had not been for Newton, the whole dynasty of Greenwich astronomers, from Flamsteed to Airy, might have worked without any remarkable result; and as to meteorological observation, he had said with Biot that nothing would ever come of it. Commenting upon the latter investigations, Professor Turner dealt at length with the method of discussing meteorological observations suggested by Professor A. Schuster in his memorable address to the Department of Cosmical Physics at the Belfast meeting in 1902. In opening this subject, Professor Turner compared the gramaphone records of a single instrument with those of an orchestra. A single instrument gave a relatively simple record. When a whole orchestra was playing, the needle again made only one record, but it was the sum of all the individuals. The mathematical analysis of these records by Fourier's theorem was simple in conception, though laborious in execution. Now science had so far only dealt with the easy record; the hard work had to come. If a number of deaf persons were turned loose among a miscellaneous collection of gramaphone records, with instructions to make what they could of them, they would pick out those of single instruments first. "We must make the researchers deaf, so that they may not use the beautiful mechanism of the human ear, which has as yet no analogue in scientific work."

With respect to the exceedingly complex temperature and rainfall curves, Professor Schuster had given the vitally important advice to disregard all hypotheses—most of those tried had failed—and to make a complete analysis of the records. The labour was great, of course. When a 90 years' record was tested for a frequency of 9 years there would be 10 periods; when tested for 10 years there would be only 9 periods, and one period was thus lost; a frequency of 9 years and one day would not be distinguishable from that of 9 years, since the phase would only change 1 deg. in the whole available series of observations. In the course of time, however, when the 90 years had become 900 years, the differences of phase would approach a complete cycle. Thus the length of the series was an important factor. Professor Schuster had indicated a beautiful analogy. Testing for a periodicity was like examining a source of light for a definite bright line; the length of the series corresponded to the resolving power of the optical apparatus, and in that respect the optical instrument offered superior ease and simplicity. Ultimately an instrument of the greatest possible resolving power would be needed; but it would be advisable to begin with a small instrument. A large instrument would, *e.g.*, be required to decide whether a yellow line was due to sodium or to helium; a small instrument might suffice to demonstrate the absence of any yellow line and to rule out both possibilities. But the resolving power and the length of observations had to be increased as the investigation proceeded. When Professor Schuster began that research, a sun-spot period of $11\frac{1}{8}$ years had been considered as established; he found other periods of 4, 8, 14 years, however, and some of these were possibly harmonics of a major period of some 33 years. In any case, however, his conclusion had resulted from a mere examination of observed facts, while previously scientists had hunted for particulars to account for the 11-year period. Professor E. W. Brown had in 1900 ascribed the 11-year period to the tidal action of Jupiter altered by Jupiter's eccentricity and by the motion of Saturn, and had believed he could account for the anomalies of the observations by this hypothesis.

Turning to stars again, Professor Turner mentioned that N. R. Pogson had, in 1853 to 1860, conducted a series of excellent observations on the variable star *R. Ursæ Majoris;* he had then unfortunately assumed that he knew all about this star, and had taken only sporadic observations in the succeeding years. But he had overlooked that the interval between two successive sunrises was not constant; the average was 24 hours, and it had exactly that value at midsummer; in March the interval was two minutes less, and there was a regular swing backwards and forwards, with a sensible halt at the extreme values. Pogson's first observations had been made at the time of halt, and he had concluded that the eleven-times repeated variation would continue in the same way. Unfortunately, the period had just then been beginning to change sensibly, and the break in the observations had been disastrous. Professor Turner was sorry to find Professor Schuster himself "tinged with heresy;" for Schuster had suggested the dropping of observations for a time in order to apply the method to accumulated observations.

Another method for dealing with large masses of observations was that of Professor Karl Pearson, who likewise ceased to look for one principal factor, and examined all possible factors (instead of Schuster's frequencies). When Professor Pearson's method was applied to Chandler's catalogue of variable stars, which gave particulars of each star in separate columns, not grouped to leading ideas, correlations were at once indicated. A variable-star maximum appeared, subject to a swing to and fro like the time of sunrise. If the average interval were called the *day* of the star, the period of the swing its *year* (without implying anything more by these names than appeared in the analogy), Professor Turner had found that the *day* and *year* were correlated, the value of the coefficient being $r = 0.56 \pm 0.08$. The *days* of many stars were much better known than their *years*; and the revision of the years tended in the direction of his formula; in the case of our sun, the *day* would apparently be eleven years, and the *year* amount to seventy-five years.

"Let us admit frankly," Professor Turner proceeded, "that there is an appearance of brutality about such methods. Is our method of search to be merely the old and prosaic one of leaving no stone unturned? We have been led to believe that there should be more of inspiration in it, that a true man of science should have some of the qualities of that fascinating hero of fiction, Mr. Sherlock Holmes, who picks up his clue and follows it unerringly to the triumphant conclusion." Professor Turner went on to show how the picking up of a correct track in this way involved, more or less, the exploration of other tracks by which the right trail might be intersected, and, in referring to the maxim of "leaving no stone unturned," he quoted the geologist, Professor T. C. Chamberlin, of Chicago, and his "Method of Multiple Working Hypotheses":—"Unless the theory happens perchance to be the true one, all hope of the best results is gone. To be sure, truth may be brought forth by an investigator dominated by a false ruling idea. His very errors may indeed stimulate investigations on the part of others, but the condition is scarcely the less unfortunate. To avoid this great danger, the method of multiple working hypotheses is urged. In developing the multiple hypotheses, the effort is to bring into view every rational explanation of the phenomenon in hand, and to develop every tenable hypothesis as to its nature, cause, or origin, and to give all of these as impartially as possible a working form and a due place in the investigation."

Professor Chamberlin did not shirk the consideration of the drawbacks of this. "No good thing is without its drawbacks," and, Professor Turner added, no good thing was entirely new or entirely old, or, it might be better to say, that it was generally both new and old. When he (Professor Turner) had began to make physical measurements under Mr. J. G. McGregor (now Professor of Physics at Edinburgh), he had learnt the golden rule: "Reverse everything that can be reversed." That was the rule of multiple hypotheses. For when the current in a wire was reversed, the hypothesis was tacitly made that the effect observed might be due to the direction of the current; and when a measured spectrum-photograph was turned and re-measured, it was an admission of the hypothesis that the direction of measurement might partly be responsible for the observed displacement of lines. Coming to his conclusion, Professor Turner alluded to the discovery of the eighth satellite of Saturn by Professor W. H. Pickering. It had led directly to the recognition of the retrograde motion and to a revision of the past history of the solar system. Incidentally it had stimulated the search for other

new satellites, resulting in the discovery of a curious pair to Jupiter and of the eighth satellite to that planet, which had again suggested an eminently successful method of work on cometary orbits. "If we judge scientific work by its results, we must take into account all this subsequent history in our appreciation of Professor Pickering's achievement. But whether we do or not is probably a matter of indifference to him; for the true observer is, above all things, an amateur, using the word in that splendid sense to which Professor Hale had introduced us: 'The amateur is the man who works on astronomy because he cannot help it, because he would rather do such work than anything else in the world, and who, therefore, cares little for hampering traditions or for difficulties of any kind.'"

The vote of thanks for the address was proposed by the Astronomer Royal, Mr. F. W. Dyson, and seconded by Sir William White.

Stellar Distribution and Movements.

Grouping the papers as to subjects, irrespective of the order in which they were read, we pass to the discussion on "Stellar Distribution and Movements," which was very lucidly opened by Mr. A. S. Eddington, M.A., M.Sc., of Greenwich Observatory. In introducing his memoir, which is to be printed *in extenso*, Mr. Eddington regretted the absence of K. Schwarzschild (of Potsdam), who had hoped to attend the meeting. The last years and months had brought to light many new facts, and it was opportune to take stock. It was believed that the great mass of the stars (excluding the Milky Way) was arranged in the form of a lens or bun-shaped system, in which our sun occupied a nearly central position, at least midway between the two flattened surfaces. The thickness of the lens, though enormous, was not so great as to prevent the telescope from detecting the absence, or, at any rate, a gradual thinning, of stars beyond when looking towards the poles of the Milky Way. When looking along the plane of the Milky Way, in the direction of the perimeter of the lens, the thinning out was much less marked, though probably not beyond the power of the telescope. Near the sun the stars appeared to be distributed in a fairly uniform manner; in the remoter parts series of clusters forming the Milky Way were observed. As regards the galactic plane, two distinct phenomena (sometimes confused) had to be distinguished; it was, firstly, the plane in which the clusters of the Milky Way were coiled, and, secondly, the median plane of the lens-like arrangement of the nearer stars.

The study of the movements of the stars had to be confined to the central system, and perhaps to the inner parts of it. The remarkable result was that the stars seemed to move with a strong preference in two opposite directions in the galactic plane, as Kapteyn showed in 1905. The two streams seemed to be more or less independent, but intermixed for the time being, and to move to and fro along a particular line; and it was a significant fact that this line was lying in the galactic plane, suggesting a connection between the phenomena of stellar distribution and stellar motion, though it remained to be explained why there was a plane of symmetry in the one case and a line of symmetry in the other. The next noteworthy feature was the moving clusters—groups of stars which, though widely separated in space, moved with equal velocities in parallel paths. There was the Taurus cluster of 40 members; the Ursa Major cluster, now known not to be confined to the one constellation, of 13 known members; the Perseus cluster of 17 helium stars; a very large ill-defined cluster in Scorpio, &c. In each case the members moved with apparently identical velocities, ignoring, as it were, other stars interspersed between them. The peculiar movements had in many cases afforded means of detecting distances and absolute luminosities of stars far too remote for ordinary methods of measurement.

The stars of the Orion or helium type of spectrum stood out exceptionally. They did not share in the stream motion, had in fact little individual or systematic movement; many of them were of enormous intrinsic brilliancy and probably lay beyond that part of the Universe generally considered; others tended to form moving clusters, which gave out diffused nebulosity of enormous extent (Orion and Pleiades clusters). The strangest result was connected with the study of their spectral types. Stars had been arranged by their spectra in what astrophysicists believed to be successive ages of evolution, and stars of early types of evolution had much slower motion than those of later stages. It seemed as if a star were born with no motion at all and gradually acquired a motion.

Having given this outline of the Universe, Mr. Eddington proceeded to details. According to parallax measurements, a sphere of a radius of 95 billion miles (one million times the radius of the earth's orbit roughly) seemed to contain 17 stars, including our sun; a few members might be missing, but they could only be small. Those stars were rather tightly packed; 7 of the 17 were double stars, possibly a high proportion; in intrinsic luminosity they ranged from 48 times the luminosity of our sun down to $\frac{1}{100}$th that value. Five of the 17 were more luminous than the suns. Stars as bright as 10,000 suns existed in space, but were probably very rare. Comparing the stars of this sphere with others, it would appear that stars of the M type were abundant, but faint, and stars of the Orion B type very rare, but prominent because brilliant; the frequency figures deduced from star catalogues were misleading. Parallax measurements did not carry the astronomer far out into the Universe; there were 300 stars of more or less trustworthy parallax, but that number contained many cases of parallaxes of 0.1 second and less. In order to go beyond the limits of parallax measurements, the astronomer had to examine statistics of magnitude and motion. This brought out the crowding of stars near the Milky Way, partly accounted for by the lens shape of the Universe. A peculiar distribution rule had long been known. In an unlimited Universe the number of stars of one magnitude, *e.g.*, the eighth, should be four times as great as that of stars of the next magnitude above, *i.e.*, the seventh [the brighter the stars, the lower is the figure denoting magnitude.] The star ratio fell short of the theoretical value, however, at greater distance, especially in the polar direction of the galactic plane. Having given particulars of these statistics and of the work done by Schwarzschild, by Pickering, and at Greenwich (on the basis of Pickering's photometric scale), Mr. Eddington turned to the question, where the Milky Way began. It probably did contain stars visible to the naked eye, even if the parallax was only 0.001 second.

Passing to star streams, he thought that at least half a million stars belonged to the two streams. Those researches had been based upon star catalogues, and a great advance had last year been made by the appearance of the general catalogue of Professor Boss. Mr. Eddington then indicated the way in which the directions of the two streams are determined; it is an exceedingly laborious deduction, and the uninitiated might suspect that the computators were arguing in a circle. It is evident, however, that the stellar movements are not haphazard in all directions. The conversion of the angular motions into linear motions, the star distances being unknown, Mr. Eddington stated, required an integral equation for which Schwarzschild had given an elegant solution, which, unfortunately, became divergent on small provocation. When plotted on a globe the two streams converged to two points, not diametrically opposite one another, but 110 deg. apart. On the globe was also marked the solar antapex, the direction in which all the stars appeared to move in consequence of the solar motion through space. It was owing to this motion of the solar system that the favoured directions did not appear exactly opposite, as they would from an absolute standpoint. Mr. Eddington himself suggested two streams in really opposite directions. Schwarzschild, he remarked, showed that this interpretation went beyond the actual observations, and proposed an ellipsoidal theory in which duality was not evident. J. Halm, of the Cape Observatory, had a three-drift theory. Neglecting the ulterior consideration, Mr. Eddington thought the distinctions between those theories surprisingly small.

Streaming in two directions, Mr. Eddington continued, had now been detected in the radial motions by Hough and Halm and by Campbell. It was curious that the helium stars did not share in the stream motion, whilst those of the A spectral type, next to the helium stars in the order of evolution, showed the streaming in its purest forms. The anomaly might be explained by the great distance of these stars. As to clusters, Boss had pointed out that the Taurus cluster would appear globular in the distant future, whilst the stars of the Ursa Major and of the Perseus stream were, according to Turner, nearly in the same plane. According to Hinks all the globular clusters were found in one hemisphere.

The most startling result of the most recent observations (long foreshadowed, however) was that stars of the later spectral type had larger motions than those of earlier types. In the Orion type the individual movement was only a third of what it would ultimately become. How was the individual motion to be accounted for? The assumption that stars were developed from a primordial matter not subject to gravity was unwelcome and also unnecessary. Suppose a star were formed by lumping together the meteors or gases of some portion of space. If a thousand stars were lumped together, their individual motions might cancel, and the resultant super-star might be at rest; similarly, the motions might cancel in a single star. Mr. Eddington did not find difficulties in this view. It was more difficult to explain how the star acquired motion, and how clusters moving through space filled with stars not belonging to their system retained their equal and parallel motion. Mr. Eddington suggested, it was a necessary conclusion, that the forces which produced the individual velocities were nearly constant over large volumes of space —*i.e.*, large with regard to the distances from their neighbours. That meant that the central gravitational attraction of the Universe, and not the casual interference of neighbours, had been effective, and it agreed with calculations. The nearest neighbour of our sun was α Centauri, on which the sun acted with a force which would take 400 million years to produce a velocity of 1 km. per second. In close approach the velocity would temporarily be much greater; but there would be a subsequent loss on receding, and the effect of such an encounter would only be a slight change in the direction of motion.

On the other hand, a resultant force of all the matter of the Universe seemed adequate to produce stellar motion, though one might look for more definite traces of a central force and of radial movement. The Universe, of course, did not act as if it had a centre of gravity. A rough idea of the force could be gained from a comparison of light and gravitation. Both varied as the inverse square of the distance, and roughly the attraction towards any part of the sky might be measured by the total light of the sky at that part. That total light was estimated at 2400 stars of the first magnitude, and the total gravitation would probably bear the same ratio to that of a star of the first magnitude. Owing to the central position of the sun the pull was pretty uniform in all directions, and there was little resultant force, which would, however, be considerable on an eccentrically placed star. According to another suggestion, due to Halm, the Orion stars were slow, not because young, but because they were heavy. A third possibility was that the great distance of the Orion stars was the cause.

Coming to his conclusion, Mr. Eddington threw a picture of a spiral nebula with a bun-shaped centre on the screen—multitudes of such nebulæ were known—as representing a great stellar system. The idea was old and had been revived by Gill. There was great force in it, though he was not convinced. In the first picture the nebula was seen edgeways, in another normally. The spiral nebula was always double; why matter was rushing in along the two branches (it might be rushing out) was not understood. But there was evidently a current of matter in one direction at one end, and in another direction at the other end. Towards the centre of the bun-shaped mass, the two currents would be in exactly opposite directions. The nebulæ must be very remote on this theory; but there was recent evidence that the light from these nebulæ suffered enormous selective absorption, which had been taken to indicate enormous distances. Though all this was speculative at present, it opened up a magnificent vista of system beyond system, universe beyond universe, in which the great stellar system of hundreds of millions of stars (which had formed the theme of his paper) would form an insignificant unit.

In inviting discussion of this "delightful" report, Professor Turner showed a model of the flying cluster of Ursa Major, to which R. A. Proctor had first drawn attention; it had been examined by Ludendorff, and Hertzsprung had afterwards shown that other stars, including Sirius, belonged to the same stream.

Mr. A. R. Hinks, of the Cambridge Observatory, said that he had little to add to the masterly opening. As to terminology, the expression "bun"

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(*For Description, see Page* 386.)

Fig. 1.

for the central aggregation of stars did not seem happy ; the irregularities in that aggregation were probably greater than Mr. Eddington had indicated. It was premature to speak of only seventeen stars in that sphere, since parallaxes had not been determined in sufficient numbers; and the fact that the absorption of light need not be the same in all directions had to be considered in this and other cases. Astronomers, like other people, wanted some return for their labour, and observed stars of large proper motion by preference. The grandiose idea to represent the Universe as a spiral nebula was at least a century old ; but it remained unwarranted, and one could not follow up the steps of the argument. A spiral nebula always appeared much brighter near the centre and in the numerous condensations along the arms ; but the better the photograph, the less marked the distinction between

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Fig. 2.

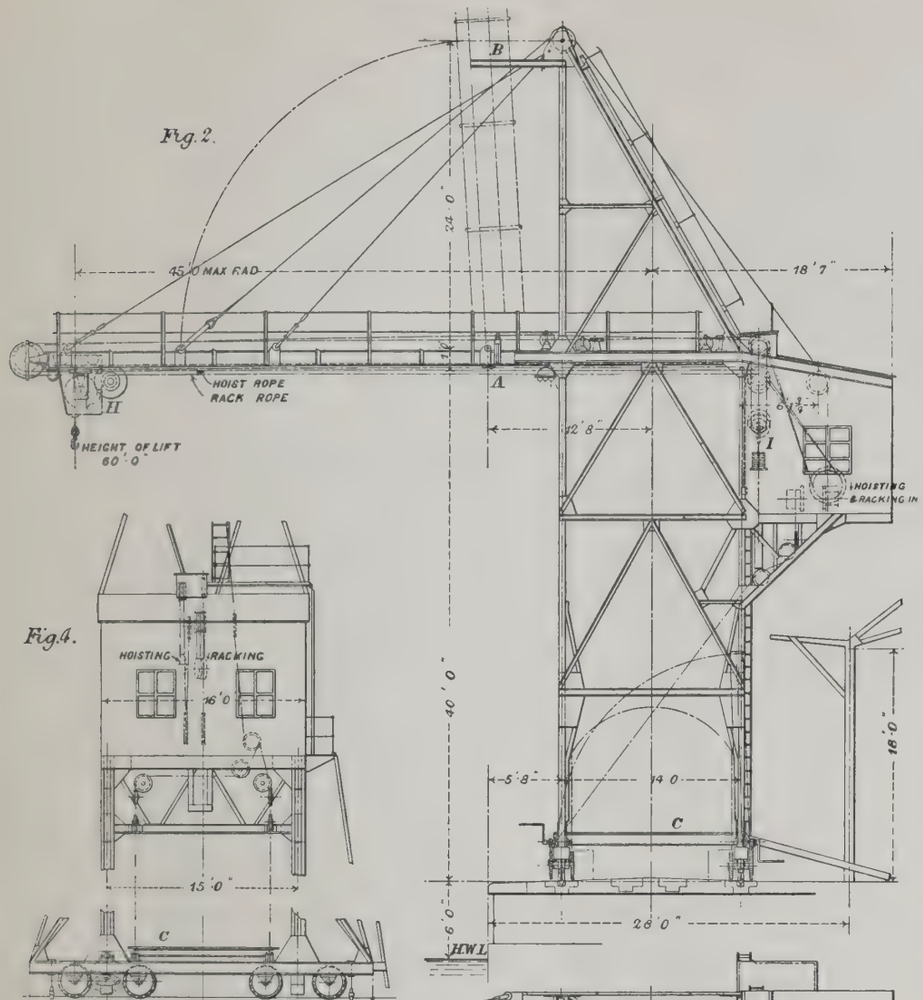
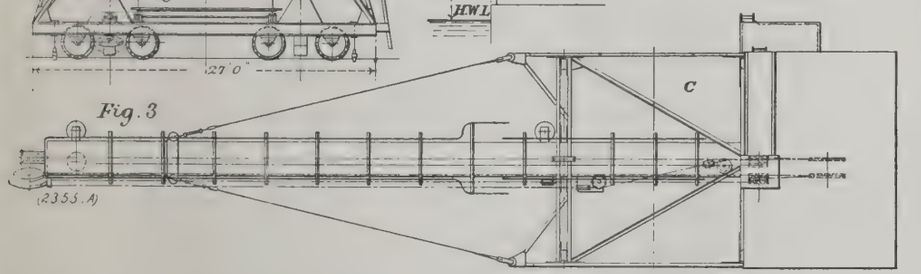


Fig. 4.

Fig. 3



(2353. A)

the smooth nebulosity and the bright spots, and Mr. Hinks did not know of any dynamical reason for the supposed inward or outward movement along spirals.

Mr. F. W. Dyson, F.R.S., the Astronomer Royal, emphasised the essential difficulty—the want of knowledge of the distances of stars. The most reliable knowledge was derived from parallax determinations; on that estimates of intrinsic luminosity could be based, which would simplify the interpretation of statistics referring to the magnitudes of stars. Lord Kelvin had, at the Glasgow meeting of 1901, calculated, supposing the total amount of matter in a sphere of radius 3.10^{16} km. (at which distance the parallax would be 0.001 second) to be equal to 1000 million suns, the velocity acquired by a body, originally at rest at the surface of the sphere, after intervals of five millions and of twenty-five millions of years. The time of fall to the centre would be about 25 million years, and the velocity acquired about 50 km. per second. This velocity was of the right order, and led astronomers to look to gravitation for the explanation of the peculiarities in stellar velocities. There were, however, considerable difficulties to be overcome. Professor Turner commented on the same difficulty concerning general estimates of stellar motion. Some stars would be coming up to the centre of attraction, others returning, and they would increase in speed like comets approaching the sun, and decrease in speed afterwards. It was unfortunate that the general survey had not been commenced earlier; a ten or twenty years' interval was very short. But they considered at Oxford that the portion near the sun was not ellipsoidal in the way indicated; there seemed to be more stars in the polar direction. Mr. F. A. Bellamy, of Oxford, gave some particulars of this Oxford survey. They had examined 183 plates after an average interval of 13½ years. The Rev. Father A. L. Cortie, S.J., of Stonyhurst, inquired about the manner in which Mr. Eddington computed his stream direction, and remarked that, according to Keeler, half of all nebulæ were spiral. It also seemed anomalous that the slower moving stream of the two should contain more stars of later spectral types. Perhaps the earlier types were not younger. Mr. F. J. M. Stratton, of Cambridge, pointed out that the foreshortening, which would make clusters like that of Taurus finally appear as a nebula, would not show in stars moving in the direction of the axis. Professor Hilton inquired whether the furthest stars should not move most rapidly instead of those near the central portion.

Mr. Eddington replied briefly. As regards the last question, the orbital motion of stars at great distance would be small, and the velocity which he meant resulted from the conversion of potential energy into motion, and would be large near the centre.

In thanking Mr. Eddington for his interesting report, Professor Turner remarked that not the least merit of the discussion had been that it had been finished within the time limit of 1½ hours.

Solar Observatory in Australia.

Dr. W. G. Duffield, now of University College, Reading, for some time in Australia, secretary of the Committee on "Establishing a Solar Observatory in Australia," urged the importance of this project, which had the strong support of Australian scientific societies and the Press, as well as of the British scientific societies. The Australian Government had promised to provide for the upkeep of the observatory, on the condition that 10,000*l.* were privately collected for its equipment; 4000*l.* had been subscribed. As members of the deputation to the Australian Premier when in London, Sir David Gill had emphasised the unique position of the contemplated observatory which was required to fill up the gap in longitude before the complete scheme of solar research could be effected, and the Astronomer Royal had dwelt on the excellent climatic conditions and on the high value of such an observatory for the promotion of science in Australia. The British Association, we may add, renewed its grant of 50*l.* to this committee. On the invitation of Professor Turner, the Rev. Father Cortie, S. J., who had recently returned from Australia, made a few remarks. He inquired whether the projected site at Yass Canberra was really the best, taking altitude, water supply, and all features into consideration.

The Recent Eclipse.

Two brief communications on "The Recent Eclipse" were made, the one by Mr. J. H. Worthington, who was given precedence, as he had to leave, the other by Father Cortie. Mr. Worthington spoke more on the history of the expedition, Father Cortie chiefly on the results, which were explained by photographs. The British Government expedition, the French expedition, the Australian expedition, and Mr. Worthington's expedition had all had their stations on a bay on Vavau (Tonga Islands), the extreme stations being about two miles apart; they had all been rather unfortunate as to weather, but the luck had increased in the order stated. The special objects of the British expedition had been the photographic study of the corona and its streamers, and in particular of the ultra-violet spectrum of the corona. Mr. Worthington had used exposures of 4, 8, 24, 40 and 200 seconds; the time available for the study of the corona was 217 seconds, and Father Cortie and Dr. Lockyer had lost two minutes of that time by bad weather. The eclipse had made its own clouds, and the humid atmosphere had blotted out the ultra-violet rays. The corona had been decidedly of the minimum type, as in the case of the three preceding eclipses, occurring, at eleven-year intervals, in 1900, 1889, 1878, both to the eye and to the camera; this recurrence of the type indicated that the coronal atmosphere was non-continuous. Father Cortie had been very successful in one respect; with his prismatic camera he had secured a photograph of the red end of the flash spectrum, and had for the first time obtained the $H\alpha$ line in an eclipse photograph. He also exhibited the photographs of the Australian expedition.

The Radiation Producing Auroræ.

Mr. L. Vegard, of Southsea, explained, in his paper on "The Radiation Producing Aurora Borealis," that he had started from the view advocated by K. Birkeland that the sun sent out electric radiations which caused auroræ and the magnetic disturbances. He had attempted to determine the physical properties of these rays, and he concluded that α rays would produce such effects, whilst there would be serious difficulties with regard to β rays. His deductions were based upon the observations and experiments of Birkeland and their mathematical analysis by Stormer, upon auroræ records from Greenland, and upon the radiation curves of Geiger, Bragg, and others; Mr. Vegard did not say that he had himself studied auroræ. Two types of auroræ, he pointed out, might be distinguished; the one was characterised by radial streamers sometimes coupled with a corona; the other, drapery, type recalled the appearance of curtains hanging down in more or less straight folds or taken in below at the hem. When α rays were shot out into the

air, their ionising power increased to a certain maximum and then fell off very rapidly to zero. The relations between range and velocity suggested that α rays would, in the terrestrial atmosphere, be stopped at a height ranging from 70 km. to 300 km., which was the interval observed for most auroral forms. The α rays would also strike the atmosphere at about 17 deg. from the magnetic axis which gave the right position of the zone in which auroræ were most frequent. Whether or not a positive charge of the rays, which produced ionisation and thus the luminous auroral effects, would explain the diurnal maxima and minima, which differed at different localities, was not yet certain. But Stormer's calculations of the deflections which particles should undergo when approaching the magnetic field of the earth seemed to account for the thin drapery bands. The equidistant bands suggested that the radiation consisted of homogeneous groups starting under equal initial conditions. Such radiations necessary for the formation of parallel bands would be present if the sun contained a radioactive substance and its various disintegration products. The parallel bands would give a kind of magnetic spectrum of α rays characteristic of the radioactive substances in the source; Mr. Vegard exemplified this by showing radiation curves from radium, polonium, thorium, &c.

Magnetic Observations at Falmouth Observatory.

In presenting the report of the Committee on "Magnetic Observations at Falmouth Observatory," Dr. W. N. Shaw, F.R.S. (Secretary of the Committee), made a warm appeal to the Section to support this important work, the continuation of which was seriously threatened. The work was maintained by grants from the Royal Cornwall Polytechnic Society, from the British Association (25*l.* were allowed at Portsmouth), and an annual Government grant of 100*l.* But regular magnetic observations at Eskdalemuir had been carried on since the beginning of this year, and the Falmouth allowances might be stopped. The first-mentioned Cornwall society, which had built the observatory in 1868 and maintained it as a first-order magnetic station since 1887, relied on an annual contribution of 250*l.* from the Meteorological Office. The Committee recognised the importance of having a magnetic observatory in the South of England, undisturbed so far by electric tramways, which had forced Kew partly to emigrate to Eskdalemuir, especially as the Falmouth Observatory was directly available for comparisons with observations made at sea. Of the report itself we only mention that the suspension of the horizontal force magnet, which had been in use since 1891, broke last October, so that a few days of horizontal force records were lost.

Seismological Investigations.

Mr. John Milne, F.R.S., restored from the illness which prevented his attendance last year, gave a far too short report as Secretary of the Committee on "Seismological Investigations." It was the sixteenth report of this Committee; but the seismological work of Mr. Milne and the British Association began 48 years ago. Mr. Milne was able to announce the installation of many new instruments and the enlistment of official and private co-operation in the British Colonies on both sides of the Atlantic; he also drew attention to the seismological section which he had organised in the Shepherds Bush Exhibition. The Central Bureau of the International Seismological Association at Strassburg offered to test instruments, free of charge, in the case of countries belonging to the Association. Reverting to Professor Turner's address and catalogues, he explained how he had learnt from a study of his catalogues that in 77 per cent. of 14,000 earthquakes (leaving the unimportant British earthquakes out) one earthquake seemed to originate other disturbances which might be of greater intensity even than the parent, one megaism causing a relief of seismic strains throughout the world. Earthquakes occurring in widely separated districts frequently occurred in groups, and as the different waves P_1, P_2, P_3 . . . travelled at different speeds and might reach the same point by having travelled in two directions round the earth, the phenomena were very complex. The records of the Guatemala earthquake of 1902, for instance, Mr. Milne showed, had all been referred to Guatemala as the origin, but might have had secondary origins, and such questions became of practical importance when it was to be decided whether fires accompanying an earthquake had or had not broken out before the disturbances. Earthquakes were more intense after long periods of rest; forty days constituted a long period of rest, and earthquakes apparently did not like to cross the Equator, perhaps, because the earth was, according to Hecker, stiffer east-west than north-south. The report embodied analyses on the synchronism of seismic activity and catalogues of earthquakes by F. M. Walker, by F. H. Reid (United States and Dependencies since 1663), H. Hope-Jones, of Lima (Peru and North Chili since 1578), and Mr. Milne's detailed list for the period 1899 to 1903.

Special sections dealt with the sensibility of smoked-surface records, which fail to register before a certain amplitude of motion of the writing levers is obtained, and with tidal loads and other subjects. At Ryde, Mr. Milne had installed one of his instruments in a cellar with a concrete floor, 12 ft. below ground, 138 ft. from the sea wall. There a 10-ft. tide produced a deflection of 0.85 second of arc, while at Bidston a 10-ft. tide gave a deflection of 0.2 second only; the rocks of the bed of the Solent seemed to be more yielding than the Bidston rocks, and the flatness of some of the curves seemed to indicate that, from time to time, the water remained high or low for several hours. Other tidal load curves had been obtained in the Pennsylvania Railway tunnels under the Hudson River by Mr. Forgie. Tubes were sunk to a depth of 200 ft. beneath the tunnel bed down to the solid rock; a 2-in. iron rod passed down each tube, the rod being firmly fixed in the rock, and passing through a stuffing-box at the top. Assuming that the rock and rod remained stationary, the magnified relative movements recorded would indicate that the tunnel bed rose and fell with the superincumbent tidal load in regular curves which corresponded in time with the records of the tidal gauge in the river. Loads passing through the tunnel set up a wave, a depression beneath the load, and a rise 200 ft. in advance of the load.

The report also mentioned experiments, made since June, 1910, with a horizontal pendulum at Sandwell Park Colliery, in a chamber 1960 ft. below ground, by Mr. J. J. Shaw, of West Bromwich; Mr. Shaw spoke of them during the discussion of the report. The chamber was lined with several feet of concrete, but the traffic passed near it, there was blasting, and water was pumped from a sump 100 ft. distant every night. Thus the boom was constantly disturbed, and the pendulum was, therefore, shifted to a new colliery at Baggeridge, near Dudley, where it was put up in a *cul de sac*, concrete-lined, 100 ft. from the traffic, at a depth of 1800 ft. As in Bromwich, the boom tended to wander in the direction of the dip, which was towards the west, and had been towards the east at Bromwich. Even at considerable depth, it resulted, observers would not be immune from continual changes in level. In order to record earthquakes down in the pit the rate of the film was accelerated to 12 in. per hour, but no great earthquakes had so far been recorded. The saline atmosphere had corroded the instrument, until the connection between the style of the boom and the multiplying lever was made by a small pendulum of shellac and a quartz fibre.

Mr. Milne also communicated a paper by Mr. F. Napier Denison, of Victoria, British Columbia, on "Horizontal Pendulum Movements in Relation to Certain Phenomena." Observing the exact position of the boom every day at noon, he found that the movement was towards the side of the greatest barometric pressure, and this frequently commenced before the local barometer indicated the change. There are also a marked semi-annual and an annual movement, and earthquakes and colliery explosions were rarest when this curve deviated but little from its mean path. A pendulum 979 ft. below ground behaved similarly to one on the surface. Although temperature, barometer, tidal loading, and local forces would affect these curves, Mr. Denison suggested that the curves partly represented the presence of slow earth strains, which were pronounced at Victoria, because it was situated on a great line of weakness. Professors Perry and Turner afterwards agreed with Mr. Milne that a continuation of those experiments was very desirable.

Solar and Earthquake Cycles and Rainfall.

In a paper on "The Solar Cycle, the Jamaica Rainfall, and Earthquake Cycles," also read by Mr. Milne, Mr. Maxwell Hall had tabulated sun-spot maxima and minima, the rainfall of Jamaica and earthquakes (all observed in Jamaica, apparently) since 1870 with the object of establishing certain periodicities, such that according to which earthquakes should follow sun-spot maxima within two years, &c.

Periodograms of Earthquake Frequency.

Professor H. H. Turner communicated a "Note on the Periodogram of Earthquake Frequency from Seven to Twenty Years." The catalogue recently edited by Professor Milne, he said, made it possible to examine the periodogram, and as the methods of Professor Schuster were not generally known, and were capable of a variety of forms, he gave enough of the detail to enable others to apply the method. The note was restricted to the portion from seven years to twenty years. The process is very laborious, but Professor Turner could state with tolerable confidence that no period of from seven to twenty years existed; that would rule out the so-much-quoted sun-spot period of eleven years and the lunar nodes of nineteen years. With regard to the paper by Mr. Maxwell Hall, Professor Turner remarked that those coincidences were accidental.

In the general discussion of these communications on seismic and allied phenomena, Mr. Milne informed the Rev. J. Gill, S.J., that reports on these phenomena were issued every three years by the International Association at Strassburg. Father Cortie pointed out that any relations between sun-spots and other phenomena should, of course, be universal, and not local. Mr. J. J. Shaw (already referred to) said that one object of his experiments had been to separate the lunar attraction from other sources, as Hecker had done in Germany; but the attempts appeared hopeless in pits. Hecker had informed him that he had experienced similar trouble even at a depth of 3000 ft., whilst another installation of much smaller depth was hardly disturbed; hence the disturbances were not universal apparently, but dependent upon certain conditions of the strata, probably a gradual slipping of one stratum upon another. As regards the flat tidal curves mentioned by Mr. Milne, Mr. Shaw thought that the water lagged due to a double tide, one up the Solent and one up Spithead. Professor Perry had suggested the possibility of fatigue in the rocks; in support of that view Mr. Shaw said that the observer's own weight disturbed his instrument, and that fully an hour elapsed before the trace quite recovered. Mr. R. D. Oldham, of Shawford, Hampshire, remarked that it was a common occurrence in mines that the floor rose up, and seismographs would naturally tilt in the one or other direction, unless instruments of the Gallitzin type were used. Mr. W. E. Rolston, of the Solar Physics Observatory, South Kensington, said that he had tried experiments in a mine with a Milne seismograph years ago, and had found that local shakes and the settling of the floor made it impossible to register any but the greatest earthquakes. There had been audible movements in the superposed strata, and the pressure was so immense that the three-brick arch of the main way had its upper two layers crushed to powder at the end of three months; the arch had been rebuilt quarterly, and on chipping out the face layer the powder of the upper layers had fallen out. The merely local movements in a portion of the earth's crust recently cut through would be fatal to the working of a seismograph. Professor John Perry remarked that he was exceedingly interested in hearing of these crushed bricks; he had imagined such effects, but had not been able to obtain evidence of them.

Great Boundary Waves.

Professor Otto Pettersson, of Stockholm, made a brief, but important, communication on "Great Boundary Waves, Parallactic Tides Set Up on the Bottom Layers of the Sea by the Moon." He brought the same subject before the Geographical Section, E, with special regard to the herring fishery. He said that a prominent feature in the hydrographic state of the eastern side of the North Sea, the Skagerack, Kattegat, and the Baltic, was the stratification of the water in layers of different origin, distinguishable by differences in temperature and salinity. The boundary between two layers could, as a rule, be located with considerable accuracy by means of floats, copper vessels containing half a ton of water with a vertical indicator rod attached, and the currents be studied with the aid of an automatic registering water-gauge and a current-measurer, used from a pier or an anchored ship or bridge; these instruments—which were not described—are made by L. M. Ericson and

Co., of Stockholm, and they give photographic records every half hour for fourteen days. The study of these changes conducted between Skagen north point of Jutland) and Bornö, suggested a train of big boundary waves which seemed to originate in deep water, as the surface water entered or left the fjord whenever there was a subsidence or upheaval of the deep water. The movements were probably tidal seiches, movements of the water of a limited basin, caused by the passage of the oceanic tidal waves over its threshold. A ridge at the entrance of the bay was essential; tank experiments suggested that the original tidal wave was modified by its impact upon a submarine ridge. There were small boundary waves of two or three days' period, and large waves of thirteen or fourteen days. The latter corresponded in their period with the position of the sun and moon; the regular train of waves began with the autumnal equinox and ended the following April, the biggest wave occurring when the earth was in perihelion; and the phases, declination, and distances of the moon had influence. The interesting features are the observation of a semilunar period of fourteen days, and the fact that these waves do not show on the surface of the sea, but are only noticeable in the deep water; why the waves are not observed during summer has not so far been explained by the observations, which extend over 2½ years.

The Earth as a Radiator.

Professor W. J. Humphreys, of the Research Staff, Mount Weather, Virginia, U.S., presented a very interesting paper on "The Earth as a Radiator." Since climates were not at present growing perceptibly colder or warmer, he pointed out, the total amount of heat received by the earth during the course of a year must be substantially equal to the amount lost through radiation. But this did not hold for limited areas. The rate of gain was very variable, and ranged from zero to 2 calories per minute per sq. cm.; the instantaneous maximum was on the southern tropic. The rate of loss was more regular than the gain, owing to the storage of heat in the soil, air, and water, and because of the latent heat of fusion and evaporation. A considerable amount of heat received in a warm district was entrapped and carried to colder portions of the earth, where it was radiated into space. The nature, height, and distribution of the clouds were important factors in these considerations. The low-lying clouds of high latitudes were below the radiating level, while the very high clouds of the tropics were above it; on account of the strong absorption of waves of great length by water vapour, the clouds allowed solar radiation to enter, but prevented loss of radiation from the earth. In the isothermal layer radiation alone was the controlling factor. The temperature of the isothermal layer was now known for many localities, and it was hence possible to compute the absolute intensities of the earth's radiation for different latitudes. Assuming that these intensities varied as the fourth powers of the temperature of the isothermal layer, Professor Humphreys calculated the following table for the outgoing radiation in gramme calories per sq. cm. per minute:—

	deg.	deg.	deg.	deg.	deg.	deg.
Latitude ..	0–10	10–20	20–30	30–65	65–70	70–90
Intensity ..	0.26	0.27	0.31	0.34	0.31	0.27

As a radiator, the equatorial zone was the least effective.

The Vertical Distribution of Water Vapour.

Professor Humphreys' second paper, on "The Amount and Vertical Distribution of Water Vapour on Clear Days," concerned the general aspect of the same problem. It was important, he explained, for anyone using a bolometer or pyrheliometer to know the approximate amount of water vapour through which the radiations reaching his instrument had passed. To determine this value, he had examined the records from 74 balloon flights, manned and unmanned, on clear days. The amount of water vapour per unit volume seemed to decrease with altitude in an approximately geometric ratio, and the thickness of the layer of water that would result from a condensation of all the water vapour in the atmosphere above a given level, whatever the season, on cloudless days, might be expressed by the equation $d = 2e$, where d indicated the thickness of the water layer in millimetres, and e the partial pressure of the vapour in millimetres of mercury. The resulting figure was about 13 per cent. smaller than the average of Hann (of Vienna) for all kinds of days, which had so far been used in bolometric work.

Investigation of the Upper Atmosphere.

The tenth report of the Committee on "The Investigation of the Upper Atmosphere," which works in conjunction with a committee of the Royal Meteorological Society, was read by its secretary, Mr. E. Gold, M.A. It stated that during the international ascent week, August 7 to 13, 1910, thirty-one balloons were liberated in the British Isles, nineteen of which were recovered. Successful ascents had also been made on these and other days by Captain Ley at Oughterard, in Western Ireland, and from Mungret College, Limerick. The curves of height and temperature obtained during these ascents all agreed in their main features. Disregarding certain local irregularities close to the ground, the temperature fell steadily up to a height of about 12 km.; then the temperature fall was checked; the temperature either remained stationary or it actually rose again in this isothermal layer; there was hardly any further change in the temperature beyond 14 km. up to the maximum heights reached, 17 km. and 21 km. in two of the Limerick ascents of the past summer. The temperature reversal might amount to 5 deg. or 6 deg. Cent., and it was assumed that in the highest strata the radiations, upwards and downwards, finally balanced one another, tending to a definite temperature. The lowest temperatures observed in Ireland, just before entering the isothermal layer, were 212, 213, 216, 217 deg. Cent. absolute, about 60 deg. Cent., or 108 deg. Fahr., below freezing point, starting from about 290 deg. Cent. absolute or 17 deg. Cent. (62.6 deg. Fahr.) on the ground. Pilot balloons being thought desirable in addition to registering balloons, a special theodolite was designed for the work; this theodolite was exhibited by Dr. W. N. Shaw, together with "Models Representing Air-Currents up to a height of 9 km., based upon Pilot Balloon Observations." The peculiar changes in the direction of air currents have been noticed by us on other recent occasions.

A paper on "The Planetary Circulation in the Atmosphere" was read by Dr. H. N. Dickson, of Reading.

Classification of Climates.

Mr. J. I. Craig, of the Egyptian Meteorological Service, made a very interesting communication, on behalf of Dr. John Ball and himself, on "The Use of Diagrams in the Classification of Climates." Dr. Ball, he explained with the aid of many slides, plotted two of the chief meteorological elements—so far, temperature and humidity—on rectangular co-ordinates. Means for the different months then gave polygonal figures or curves, sometimes fairly regular, sometimes quite irregular, which at once told the inquirer what kind of climate he had to deal with. The trend of the curve was generally clockwise, but it might be anti-clockwise. The two slopes of the Alps near the St. Gothard; Helwan, near Cairo; Taschkend, in Central Asia; Ascension Island; San Francisco; Sacramento, &c., indicated well-marked types of different climates—dry and wet, moderate and extreme, Continental, insular, and the influence of altitude could be recognised in diagrams from Lucerne and the Rigi Kulm. Other diagrams from Khartoum, Darjeeling, &c., illustrated the influence of the monsoons; Davos and Toronto gave regular, very similar, overlapping diagrams, Toronto apparently enjoying a similar, but more extreme climate. That Moyolla was altogether too damp, and Death Valley far too dry, could be seen at a glance, and Mr. Craig thought that these diagrams would be useful to farmers and be appreciated in guide-books. Mr. Craig was fully aware, of course, that the climate did not depend only upon temperature and humidity. Professor Turner, Mr. Gold, Father Cortie, and others, welcomed the method; Mr. Gold remarked that the people might be trained to examine simple diagrams; tables of figures were useless to them.

The Labrador Current.

Commander M. W. C. Hepworth, C.B., R.N.R., contributed a paper on "The Effect of the Labrador Current upon the Surface of the North Atlantic, and of the latter upon Air Temperature and Barometric Pressure over the British Isles," a continuation of his studies on the trade winds. The Labrador current, he pointed out now, was the most potential cause modifying the Gulf Stream influence in the North Atlantic. In the years 1903 and 1907, the increased activity of this current, evinced by an increase of ice in the North-Western Atlantic, had lowered the surface temperature in the North Atlantic, made the British Isles colder, and raised the air pressure; this was shown by comparing data from Valencia, Sunburgh Head, and North Shields, and the correlations were well marked, particularly in 1903 and 1906.

The Thunderstorms of July 28 and 29, 1911.

Dr. W. N. Shaw, F.R.S., showed by a large number of diagrams how the thunderstorms of July 28 and 29 had been studied at the Meteorological Office. It was an instructive exemplification of the correlation of the meteorological elements, well worth a detailed examination. The British Isles were on a low-pressure area (or a "low," as it is now generally called, after the American fashion), with highs on both sides; the general wind was easterly to start with, and changed into southerly, while the storm advanced in a curved path from the south-west of Ireland. One of the interesting features was that with the squally storms advancing from the south-west the microbarograms marked a sudden peculiar rise in a kind of M curve, while with storms from the north-west the barogram change had somewhat the shape of a square root symbol, $\sqrt{\ }$.

Two papers by Mr. F. Stratton, on "Possible Relations between Sun-Spot Phenomena and the Planets," and on "An Unusual Type of Meteor Observed at Portsmouth, August 31, 1911," were finally taken as read, after being twice postponed, owing to the author's unavoidable absence.

(To be continued.)

NOTES FROM THE UNITED STATES.

PHILADELPHIA, September 13.

STEEL manufacturers, when they can be induced to express a frank opinion, say that the margins in steel-making are below legitimate limits. They see no present signs of improvement as to margins, but they recognise the strong probabilities of expansion of business, which, however, does not necessarily mean wider margins until demand approaches more nearly productive capacity. This is in sight in the case of the Republic Iron and Steel Company, which for a short time past has been operating at 90 per cent., which is about 10 per cent. more than the other large concerns are doing. All the blast-furnaces of this company are in operation. The greatest competition for business comes from what is known as the Chicago district, which embraces nearly all the north-west. Competition for business has reduced margins very low, and while there has been quite an expansion of demand, business is done at unsatisfactory margins. Business in all kinds of wire has been improved by a cut of 1 dol. per ton for delivery this year. The demand for wire has been held up in expectation of such a cut. The tin-plate trade continues to enjoy its healthy run of orders, notwithstanding the closing up of demand which comes from the canning industry. To compensate for this the export demand has very largely increased, and the excess of export business this year over last is in the neighbourhood of 100,000 tons. The mills have enough work to keep them running quite steadily until winter. The latest large tin-plate order comes from Cuba. The Erie and the Pennsylvania railway companies are soon to be in the market for a very large number of freight-cars, and this business is anxiously awaited by the builders. During the past week car contracts amounted to 1600. The Western Maryland Railroad will soon contract for 1500 cars, and the Wabash Railroad, which asked figures on 2000, has withdrawn the inquiry for the present. There are fewer idle cars in the country than at any time for years.

THE JUNIOR INSTITUTION OF ENGINEERS.—Commendatore G. Marconi, D.Sc., LL.D., has been elected President of the Junior Institution of Engineers, in succession to Sir J. J. Thomson, F.R.S.

LONDON SCHOOL OF ECONOMICS.—Particulars of lectures and classes on railway and cognate subjects, to be held during the session commencing on the 5th prox., have been received from the London School of Economics and Political Science, Clare Market, Kingsway, W.C. Both elementary and advanced lectures will be delivered in such subjects as rates and fares, organisation, economics, law, accounting, &c. Full particulars of these and other courses of lectures, together with information relating to prizes and scholarships offered by the school and the University of London, are given in the calendar, a copy of which can be obtained from the Secretary, price 1s. 4½d., post free.

30-CWT. ELECTRIC "BARRY" SINGLE-BEAM TRANSPORTER.

CONSTRUCTED BY MESSRS. STOTHERT AND PITT, LIMITED, ENGINEERS, BATH.

Fig. 5.

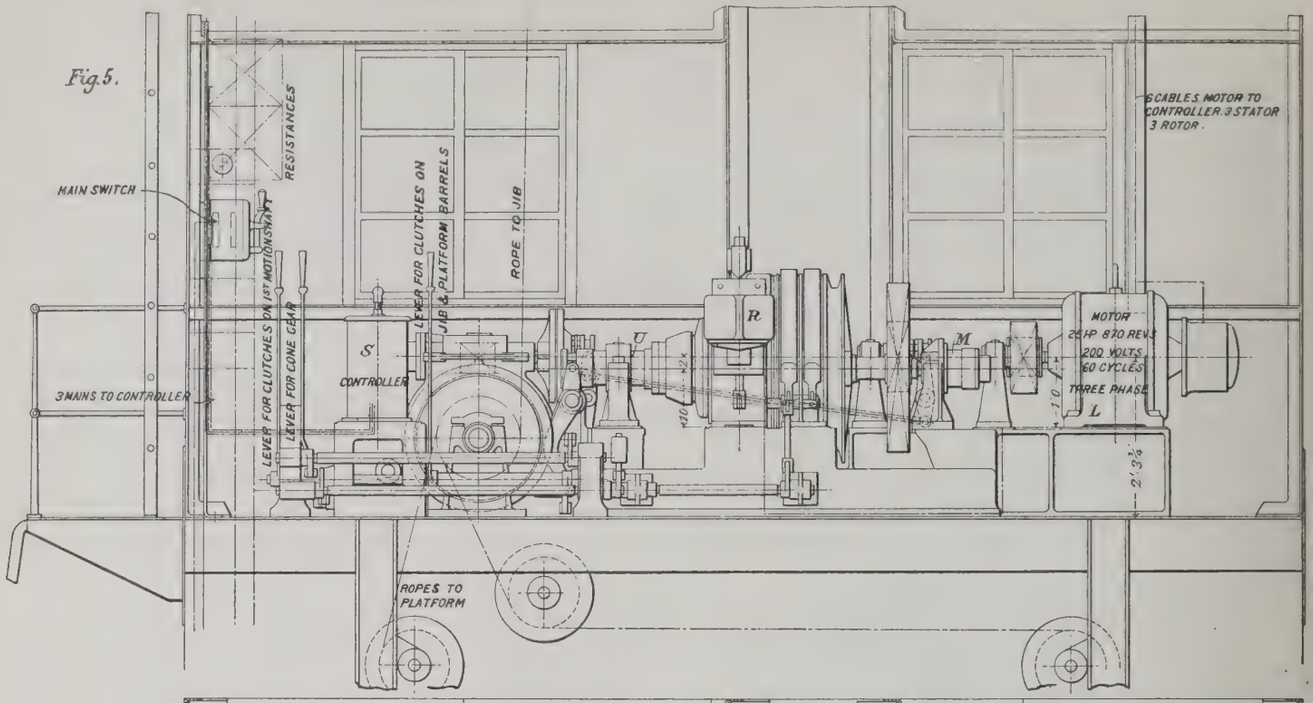
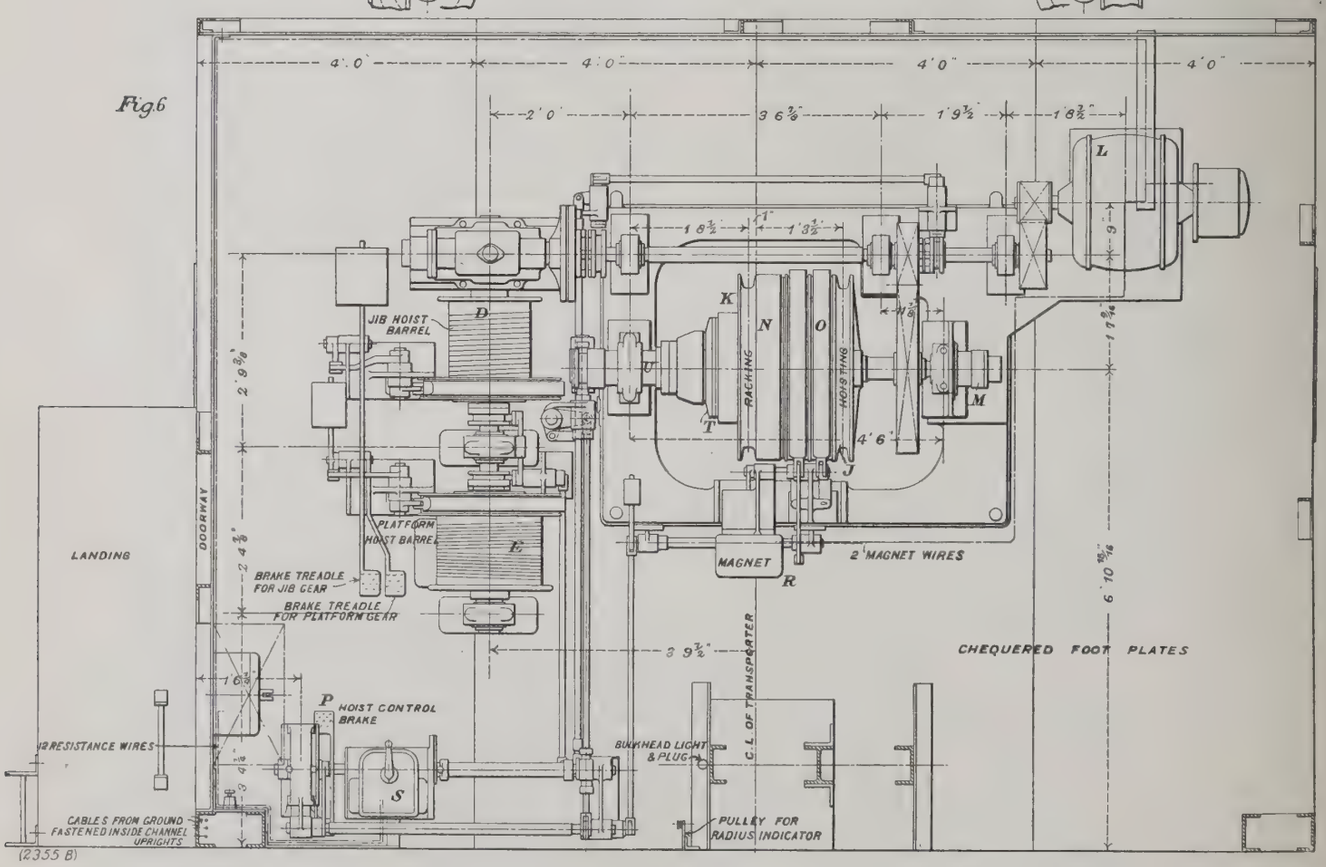

MAIN SWITCH
RESISTANCES
LEVER FOR CLUTCHES ON 1ST MOTION SHAFT
LEVER FOR CLUTCHES ON JIB & PLATFORM BARRELS
ROPE TO JIB
6 CABLES MOTOR TO CONTROLLER. 3 STATOR 3 ROTOR.
3 MAINS TO CONTROLLER
LEVER FOR CONE GEAR
CONTROLLER
MOTOR 25 HP 870 REVS 200 VOLTS 60 CYCLES THREE PHASE
ROPES TO PLATFORM

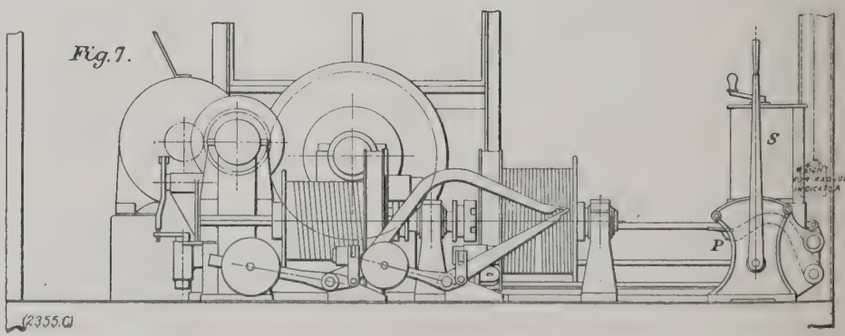
Fig. 6



ON pages 314 and of our eighty-seventh volume we described and illustrated a "Barry" single-beam transporter, the success of which has been such that since it was delivered a number of them have been installed. That they should prove very useful for many situations is not surprising, as they possess some distinct advantages over ordinary types, the chief of these, perhaps, being that with them the load can be taken round corners, and that the track can, if required, be inclined.

Six of the latest of these transporters have been constructed by Messrs. Stothert and Pitt, Limited, of Bath, for the Japanese Government, one of them being illustrated in perspective on page 382, and by line drawings on page 383 and on this page. This transporter is in principle exactly like the one we previously described, so far as the arrangements for lifting and

Fig. 7.



50-HORSE-POWER OIL TRACTION-ENGINE.

CONSTRUCTED BY MESSRS. JOHN FOWLER AND CO. (LEEDS), LTD., ENGINEERS, LEEDS.

FIG. 1.

travelling the load in and out are concerned. There is, however, the difference that at the bottom of the tower there is a tilting platform which can be raised up so as to allow room for railway trucks to pass between the legs of the tower, or it can be removed altogether. An inclined plane can be used for transferring goods from the shed to the platform, as shown in Fig. 2. The jib is hinged so that it can be raised in order to clear the masts of ships, &c.

The transporter is capable of dealing with loads up to 1½ tons at an outreach of 45 ft. from the centre line of the runway track, and there is a clear height under the runway beams of 40 ft. from the rail level. The framing is built up of rolled-steel sections rigidly braced together, the design being such that there is ample stability under all conditions of working. As before stated, the cantilever boom is hinged, the hinge being at A, Fig. 2, a distance 12 ft. 8 in. from the centre line of the machine, and the boom can be lifted up until it rests against two stops B, when it will clear any shipping coming alongside the quay. The platform is shown at C, Figs. 2, 3, and 4, and will admit of the passage of trucks when turned up. It is covered with chequered plates, and is capable of carrying a distributed load of 15 tons. The whole of the transporter can travel along parallel to the quay by means of mechanism actuated by winch-handles, seen in Fig. 2, through which power is transmitted through gearing to the wheels.

The machinery for working the transporter is fixed on cantilevers at the back end of the tower, and is housed-in, as shown in our illustrations. This machinery consists of the gearing for hoisting and traversing the load, for raising the front portion of the cantilever or boom, and for raising the hinged platform at the base of the tower; details of the arrangement being shown in Figs. 5, 6, and 7, opposite. Independent barrels are provided for hoisting the hinged boom and the platform (these being shown at D and E, Fig. 6).

The hoisting and traversing motions consist of a jenny H, Fig. 2, carried on four cast-steel wheels, and running on the boom. In this jenny there is a crab which is actuated by the hoisting-rope shown. The hoisting-chain passes over a sprocket-wheel (which really forms the lifting-drum in the jenny), and the loose part of the chain as it is drawn up is wound on a drum contained in the jenny. The rope actuating the lifting-drum is endless and spliced, and is kept in light but definite tension by a weight I, the tension being only necessary to give the required grip on the sheave J of the driving-winch, as shown in Fig. 6, and on the wheel of the jenny. The rope for traversing the load is practically endless also, because both ends are secured to the jenny, one end being fixed to the front end of the jenny-frame, from which it is passed over the pulley at the nose end of the cantilever, then by lead off pulleys to the driving-sheave K on the winch, and from there round pulleys of the tension device, and returning to the jenny, where it is finally coiled round a small drum which actuates the storage drum of the hoisting-chain. The machinery for driving the lifting and traversing motions is self-contained on a bed, as shown in Figs. 5, 6, and 7.

The hoisting motion is connected to the motor L, as shown in Figs. 5 and 6, by spur-gear, and to the traversing motion by a friction-cone device. This friction-cone device cannot be seen in the illustration, being enclosed in the parts N and O. The driving-sheaves are placed side by side, and are so designed that the drive is transferred from one to the other without shock. The two sheaves J and K can be clutched together so that they revolve as one, and the jenny travels in either direction, carrying the load. If, however, the traversing rope drum is held still (by means of the braking device) while the other wheel revolves, the load will be hoisted or lowered. The braking device for the traversing gear consists of wood blocks secured to a circular plate cast to a sliding sleeve, which latter is feathered in a pedestal to prevent twisting. The sleeve drives a disc which bears on a nest of springs, the springs being strong enough to give the necessary frictional resistance to hold the jenny when hoisting; and when put further into gear by a hand-lever the driving-drum is coupled up for racking. The arrangement is contained inside N and O. At M, Figs. 5 and 6, there is a Hoffman ball-bearing, which takes the pressure on the adjustable collar of the disc. The end thrust on the hoisting or traversing shaft transmitted by the driving-cones is also taken by a ball-bearing. The arrangement of the various brake-levers is shown in Fig. 6.

The hoisting and the traversing gears are worked by the lever shown on the right hand of the engraving, Fig. 7, its action being as follows:—When it is moved in one direction the cone disc T couples the two sheaves J and K, so that they revolve together. The ratio of the speed of the traverse over that of the lift is as 6 to 1. When the lever is moved in the opposite direction, the traversing cone is disconnected from the lifting-cone, and is held by a cone fixed on the sliding sleeve U. A holding-brake with a foot-treadle P, Figs. 6 and 7, is provided for the hoisting gear, and, in addition, there is a solenoid brake R provided, which comes into action in case the current fails.

The gear is driven by a reversing-motor, the speed being regulated by the controller S. The traversing can be performed at any position in the height of the lift, and the load can be hoisted or lowered at any point in the boom. The change of motion from lifting to traversing, or *vice versâ*, can be performed at any moment. A plain hook is used on the hoisting-chain without a pear weight, as a weight is found to be not necessary. The speed of hoisting can be regulated up to the maximum of 200 ft. per minute, and the racking up to 1200 ft. per minute.

The jenny is made of steel plates and angles, rigidly braced together, and runs on four cast-steel wheels, keyed to axles revolving in bearings on the jenny-frame. A pulley and storage drum are contained in the jenny, the drum being capable of receiving $\frac{5}{16}$-in. diameter chain; it has a storage capacity sufficient for a total height of lift of about 60 ft. The lifting cup-drum on the jenny is connected to the bevel spur-wheel and the driving-pulley connected to the bevel pinion. The ratio of the gear between the rope-driven pulley and the cup-drum is 6 to 1. There is a cast-steel chain guide on the lower portion of the jenny which may be seen projecting in Fig. 4. This guide prevents the chain from twisting or getting across.

The motor L is of 25 brake horse-power, of the enclosed ventilated type, suitable for three-phase current, 60 cycles, 200 volts, and is fitted with reversible controller and metallic resistances. A switch with fuses, pilot lamp, &c., is provided in the driver's cabin. There are two cargo lamps on the jib, one at the nose and the other at the inner end, as well as a sufficient number of incandescent lamps in the driver's cabin. The winding-drums for raising the boom and the platform are put in and out of gear by means of clutches. The driver's house is of galvanised corrugated sheeting, carried on a steel framing. All the shafts are of steel, and are machined where necessary, and all the bearings are bushed with gun-metal and have efficient means of lubrication.

50-HORSE-POWER OIL-TRACTOR.

ON this page, Fig. 1, and on page 390, Figs. 2 to 8, we illustrate a powerful oil traction-engine recently constructed by Messrs. John Fowler and Co. (Leeds), Limited, of the Steam-Plough and Locomotive Works, Leeds. The engine is intended to do the work of an ordinary steam traction-engine, whilst having the ability to carry a supply of fuel sufficient for two or three days' work. It has undergone an exhaustive series of tests at the hands of its builders, the programme gone through comprising the driving of a thrashing-machine, the hauling of a five-furrow balance plough, working 6 in. to 8 in. deep, and the taking of a load of 10 tons up an incline of 1 in 10. Moreover, on a test made with one of the engines at the builders' works, a pull equivalent to the hauling of a load of 32 tons on the level was measured by a dynamometer brake. A 10 hours' continuous run with a gross load of 10 tons behind the draw-bar was made without replenishing the supply of cooling water, so that the tractor is obviously well adapted for service in regions where fresh supplies of water and fuel are only obtainable at a few widely-separated points.

As our engravings show, in general appearance the tractor resembles a steam traction-engine somewhat closely, but the "boiler" barrel is really a fuel tank, and serves at the same time as a support for the forward end of the engine proper, whilst the "fire-box" supports the other end of the engine, and at the same time forms a rigid support for the various gears and shafting in a position where they are well protected from dust.

The engine has four cylinders, arranged in pairs *vis-a-vis*, but on opposite cranks, so that the reciprocating parts are practically perfectly balanced. The cylinders are each 6½ in. in diameter by 7 in. stroke, and can develop an aggregate of 50-brake horse-power when run at 750 revolutions per minute. The valves are all of a special quality of nickel steel, and both inlet and exhaust-valves are mechanically operated. Special care has been taken to ensure that the valve-seatings are as effectively water-jacketed as are the bodies of the cylinders. The circulating pump is of the rotary

type, driven by a pitch chain, as indicated in Fig. 2. The crank-shaft is of chrome steel, ground to size at each pin and bearing, and is drilled for forced lubrication. At one end of the crank-shaft is the fly-wheel, which is a steel casting turned all over, and at the other is a leather-faced cone friction-clutch, which is operated by a hand-lever, much the same in position and movement as the regulator lever of an ordinary steam traction-engine.

This cone-clutch couples up the engine to the change-gearing, which, as already stated, is located in what would be the fire-box of a steam-tractor. The whole of these change-gears are of forged steel, with cut teeth. Three changes of speed forward—viz., 1½, 3, and 6 miles per hour—are provided, in addition to a reverse. Changes of speed are effected by a single lever working on the gate principle. With the low gear in operation a motion of the change-speed lever from the neutral position into the forward notch sends the tractor forward, whilst pulling it back to the rear notch reverses the direction of motion. The operation is therefore much the same as that of the reversing lever of a steam-tractor, and, as will be seen from Fig. 2, the position of the two levers also corresponds. To get the other speeds of three and of six miles an hour the lever is taken through a gate.

The engine is fitted with a Davis carburettor, specially designed for the purpose. This is driven by belting, and a governor is provided which automatically adjusts the mixture according to the demand. The carburettor is kept hot by the exhaust, and the paraffin is very thoroughly gasified before it enters the cylinders. The plan view of the engine, Fig. 4, shows how the inlet-pipe is jacketed by exhaust.

Normally the engine is started by compressed gases stored in a rear tank, as shown, and kept pumped up through non-return valves connected to the cylinders. Some of the cylinder gases pass through this valve into the tank whenever the pressure there falls too low. In starting, a special valve is employed, the construction of which is shown in Figs. 5 and 6. The normal position of the starting-lever when running is in the line marked No. 3, Fig. 5; but when the engine has been stopped, and it is desired to re-start it, this lever is moved over into position No. 1. In this position it holds open the admission-valve, which is coupled up to the compressed-air tank, and at the same time, by means of the spiral spring shown, forces home on to its seat the conical distributing-valve. This, as indicated, is rotated by an axial shaft geared to the engine, and as it turns allows the compressed air to pass in turn through the ports numbered 1, 2, 3, and 4 in Fig. 6. These ports are connected to the cylinders through non-return valves, and the engine is thus set in rotation by the stored gases, which are exhausted through the ordinary exhaust-valves. Once the engine is fairly away, the starting-lever is moved over to No. 3 position, and the supply from the carburettor then enters the cylinder, and is compressed and fired in the usual way. Double ignition by magneto and by coil is provided for. The engine can also be started by hand, using a handle geared 1 to 2 by pitch chain to the crank-shaft, as indicated by the dotted lines in Fig. 2.

A very efficient silencer is provided in the funnel, as shown in Fig. 2. The radiator, it will be seen, is in two sections, the air being drawn at the front through the one section by the action of the fan shown, whilst a further supply is taken through the water-cooling tower by a second fan, as indicated. Forced lubrication is provided to all the cylinders, the spent oil being passed through a strainer and used over again. The road-wheels are 3 ft. 6¾ in. by 5 in. wide at the front, and 5 ft. 6 in. in diameter by 12 in. at the back. The final drive to the wheel is fitted with the standard differential-gear used on the makers' steam-tractor.

The rings of gear on the driving-wheels and the spur-pinions engaging with them are steel castings, and are protected from dirt by sheet-steel castings. Powerful brakes are arranged to act on the external faces of the gear-rings. The back axle is spring-mounted, the details of which are shown to an enlarged scale in Figs. 7 and 8. A winding-drum is also provided, and is fixed at the middle of the frames, giving a central lead to the winding-rope. In ordinary work the engine consumes about 3 gals. of oil per hour.

CANADIAN RAILWAY PROGRESS.

The progress of the Canadian Pacific Railway Company in the first half of this year was highly satisfactory, the company being able to exhibit an abounding prosperity in all directions. The working expenses certainly show a slight tendency to increase; but they are relatively moderate as compared with those of the still incomplete Grand Trunk system, the ratio coming out at 64.77 per cent. of the receipts, as compared with 64.38 per cent. in the corresponding period of 1910. The gross earnings of the system in the first half of this year were 104,167,808 dols., the net earnings being 37,818,180 dols. Of the surplus remaining after provision had been made for fixed charges, it was decided to devote 1,000,000 dols. to the steamer replacement account, and 80,000 dols. to the pension fund. After this had been done the amount available for dividend upon the company's stocks was 26,727,109 dols. The land grant of the Canadian Pacific Railway has been of immense service to the undertaking, and largely explains its relative prosperity, as compared with the long suffering and still depressed Grand Trunk Railway Company, which was not similarly assisted. The Canadian Pacific Railway sold 650,874 acres of its land grant in the six months ending June 30 for 9,558,427 dols., being an average of 14.69 dols. per acre. The areas sold included 19,097 acres of irrigated land which realised 33.63 dols. per acre. The plus value resulting from irrigation was, of course, satisfactory; but it was not obtained without considerable expense and effort, an outlay of 5,018,953 dols. having been made by the company upon irrigation works. It is, of course, only fair to add that the full results of this outlay have not at present been realised. The Hudson Bay Company had parcels of land scattered through the irrigation belt; and in order that the company might control the belt and receive the full advantage of its expenditure for irrigation, the Canadian Pacific Railway directors decided to acquire these Hudson Bay lands, and 102,174 acres were purchased at 13½ dols. per acre. It is expected that all these lands will be sold later on at a substantial profit. The land grant originally made to the Canadian Pacific Railway proper was 26,710,400 acres, reduced to 19,917,386 acres by an arrangement made with the Dominion Government under an agreement of March 30, 1886. The quantity of land sold to the close of June, 1911, was 13,156,224 acres; and after allowing for the lands acquired from the Hudson Bay Company, 6,863,336 acres still remained unsold. The value of this asset may be roughly estimated at 18,000,000*l.* sterling. At the close of June, this year, the Canadian Pacific Railway had also 97,118 acres of land unsold in connection with the Manitoba South-Western Railway, and 100,730 acres unsold in connection with the Great North-West Central Railway, so that altogether it still owned agricultural lands at the close of June, 1911, to the extent of 7,061,184 acres. This total does not include lands owned by the company in British Columbia, where it is proprietor of a further 4,427,811 acres. Altogether, the Canadian Pacific Railway has still lands in hand to the approximate value of 30,000,000*l.* sterling. That this is no idle estimate is shown by the fact that the 13,156,224 acres sold from the original land grant to the close of June this year in Canada, properly so called, realised 85,377,178 dols., giving an average of about 6½ dols. per acre, while, as we have just shown, more recent sales have been made at an average of between 14 dols. and 15 dols. per acre. Our estimate of 30,000,000*l.* sterling as the present value of the company's unsold lands is thus probably considerably below the mark, since, as Canada fills up, Canadian land has an irresistible tendency to appreciate in price.

The Canadian Pacific Railway Company has acquired 30,000 shares in the Alberta Railway and Irrigation Company, the coal-mines, lands, and other assets of which have been taken over by the Canadian Pacific Company upon a lease. The undertaking of the Alberta Company has, indeed, been virtually transferred to the Canadian Pacific Railway Company during the life of the lease; and, worked in conjunction with the Canadian Pacific system, the Alberta undertaking is not only expected to be profitable in itself, but to be useful in connection with all future extensions in Southern Alberta. By the construction of a line, 16½ miles in length, between Hamilton and Guelph Junction, in the province of Ontario, the distance from Hamilton to points on Canadian Pacific lines in Western Ontario will be materially abridged, and a provisional agreement has accordingly been entered into with the South Ontario Pacific Railway for the construction of the line, and for a lease of it to the Canadian Pacific Company for 999 years.

In order to provide transport facilities for incoming settlers the Canadian Pacific directors consider that the following branches should be constructed without delay:—Moose Jaw, south-west, 35 miles; Kerrobert, north-east, 25 miles; Weyburn branch extension, 21 miles; Esteran branch, 55 miles; Swift Current, south-east, 45 miles; Swift Current, north-west, 35 miles; Wilkie, north-west, 32 miles; Wilkie, south-east, 31 miles; Kininvie branch extension, 37 miles; Bassano to Kininvie Junction, 36 miles; Kipp branch extension, 27 miles; or, altogether, 379 miles. The Canadian Pacific Railway Company has placed an order with the Fairfield Shipbuilding Company, of Glasgow, for two steamers 570 ft. long and 68 ft. beam; these vessels are to steam at the rate of 18 knots, and are intended to supplement the company's fleet now engaged in Pacific trade between Vancouver, Yokohama, and Hong Kong. The approximate cost of the new steamers will be 440,000*l.* each, and they are to be delivered early in 1913. During the past year the Canadian Pacific Railway Company added 103 locomotives, 204 passenger-cars, and 3808 freight cars to its equipment at a cost of 9,000,000 dols. in round figures; and the company has further orders outstanding for cars and locomotives to the amount of 7,000,000 dols. At the close of June, 1911, the Canadian Pacific Railway was equipped with 1637 locomotives, 1689 passenger, baggage, and sleeping-cars; 318 first-class sleeping, dining, and coffee-cars; 67 parlour, official, and paymaster-cars; 52,602 freight and cattle-cars; 923 conductors' vans; and 3896 boarding, tool, and auxiliary cars and steam shovels. The enlargement of terminal yards and the providing additional shops and machinery, laying many miles of passing tracks, extending telegraph lines, and generally providing additional working facilities, is receiving careful attention; the amount expended for this purpose during the past year was 18,000,000 dols. in round figures. A double track between Winnipeg and Brandon is approaching completion, and a further second track is in contemplation on some portion of the main line between Brandon and Calgary.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was quietly steady, and the dealings consisted of 2000 tons of Cleveland warrants at 46s. 9d. cash and 47s. one month. For these positions closing sellers quoted ½d. more, and 47s. 7d. three months. In the afternoon the market was decidedly weaker, and only one lot of Cleveland warrants changed hands at 46s. 8d. cash, with sellers over at that figure, and at 46s. 11d. one month, and 47s. 5d. three months. On Friday morning there was nothing doing, and business was at a standstill. The closing quotations for Cleveland warrants were firmer, sellers quoting 46s. 9d. cash, 47s. one month, and 47s. 6d. three months, while buyers named 1d. less in each case. In the afternoon there was little change in the tone of the market, and a small business of 1000 tons of Cleveland warrants was put through at 46s. 8d. cash and 46s. 11d. one month. At the close of the session there were sellers at 46s. 8½d. cash, 46s. 11d. one month, and 47s. 6d. three months. On Monday morning quietness again ruled, and only one lot of Cleveland warrants changed hands at 46s. 9d. eight days, and closing sellers quoted 46s. 9d. cash, 47s. one month, and 47s. 7d. three months. In the afternoon the dealings were limited to 1000 tons of Cleveland warrants at 46s. 8½d. cash, with sellers over. For the other positions sellers quoted 46s. 11½d. one month and 47s. 7d. three months. On Tuesday morning the market was idle, but Cleveland warrants were nominally steady, with sellers quoting 46s. 9d. cash, 47s. one month, and 47s. 6½d. three months. There was again nothing doing at the afternoon session, and prices were the turn easier. Closing quotations for Cleveland warrants were 46s. 8d. cash, 46s. 11½d. one month, and 47s. 6d. three months sellers. When the market opened to-day (Wednesday) there was still no improvement, and Cleveland warrants continued in a dull and lifeless condition. No dealings were recorded and prices were easier, with sellers quoting 46s. 7d. cash, 46s. 10d. one month, and 47s. 4½d. three months. The afternoon session was another blank as regards business—the fourth in succession. The tone of the market was a shade better, and closing sellers of Cleveland warrants quoted 46s. 7½d. cash, 46s. 10½d. one month, and 47s. 5d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde, 61s.; Calder, 61s.; Gartsherrie, 61s. 6d.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 63s.; Shotts (at Leith), 62s. 6d.; and Carron (at Grangemouth), 63s. 6d.

Sulphate of Ammonia.—The demand for sulphate of ammonia has not appreciably increased since last report, and the market remains quiet. The current price is 14*l.* 2s. 6d. per ton, Glasgow or Leith, for prompt lots. The amount shipped from Leith Harbour last week was 4226 tons.

Scotch Steel Trade; Proposed Preference Scheme.—The severe foreign competition which has been experienced by Scotch steel-makers for some years has been a great source of annoyance, and although grumbling has often been indulged in, little has yet been done to try effectively to overcome the trouble. The matter has frequently been discussed, and a scheme has now been formulated which will have, it is believed, the effect of checking a good part of the foreign competition, which has been severely felt by local producers. The scheme, which it is proposed to adopt, is to be sent out in circular form to the various users of steel, but as yet the proposals have not been adopted by the Scottish Steel Trade Association. Considerable opposition to the scheme has been made during the past few days; even the members of the association are not all in favour of the arrangements proposed, and at a meeting on Monday no definite conclusion was arrived at. The proposed circular is as follows:—Notice to Shipbuilders, Bridge-builders, &c.—"Shipbuilders, bridge-builders, and other consumers of steel are respectfully informed that the Scottish Steel-Makers' Association will pay them a rebate of 5s. per ton on all steel bought and received by them after July 1, 1911, which has been manufactured at any of the associated makers' works, and controlled by the association, whether such steel has been bought direct from the associated makers or otherwise, subject to the undernoted conditions:—(1) The rebate will be computed for twelve months, say up to June 30, and be payable six months afterwards, but only to those consumers who have up to

that date, and since, confined their purchases and use of steel (to the class or classes manufactured by the associated makers) to that manufactured by such associated makers. (2) Statements of claim for such rebate must be made on a form as annexed within three months from the date for which payment falls due, and sent to the Secretary of the Scottish Steel-Makers' Association, accompanied by certificates of deliveries issued by the respective associated makers with their consignments. (3) Consumers will understand from above that the rebate will only be payable on contract or purchases made after the date of this circular, and on production of Associated Steel-Makers' certificates, which should accompany their claims." The general state of the Scotch steel trade shows little change from last week, and rolling-mills are turning out a lot of material. The demand for delivery, which has recently been rather pressing, is now less active, but nevertheless producers are well supplied with specifications, although fresh business is again on the slow side. Sheet-makers continue to be actively employed, and good inquiries are in the market for thin plates and angles for Australia, Japan, and South America, while structural sections are in demand for Canada.

Malleable-Iron Trade.—The malleable-iron trade of the West of Scotland is unchanged, and although a fair amount of work is going through, prices are still based on 6*l.* per ton, less 5 per cent. for crown bars.

Scotch Pig-Iron Trade.—A steady business is being put through in Scotch pig iron with local consumers, and a fair amount of shipping is taking place. There are inquiries in the market at present for moderate quantities of Nos. 1 and 3 iron for the Continent and for India, Canada, and South America. The demand for hematite is quiet, but the general consumption is fairly large. The price named for fresh business is 65s. per ton, delivered at the steel works, but buyers decline to give that figure.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Coal and Iron Companies' Reports.—In the report on the year's working of the Sheepbridge Coal and Iron Company, to be presented to the directors at the annual meeting next week, stress is laid upon the increased costs of production which have been added to considerably by the expense entailed through the Eight-Hours Act and the Workmen's Compensation Act. In iron the higher prices of raw material have also augmented working costs. As the company had made many contracts prior to the fall in the value of coal at the end of last year, the realised price was not seriously depreciated for the whole of the year. The company were able to make a net profit of 96,716*l.*, and recommend a dividend for the year of 10 per cent. The dividend for the past two years has been 7½ per cent. The report also states that the development of the Maltby Main Colliery has made good progress during the year; that the company has been admitted into the South Yorkshire Steam-Coalowners' Association, and that the directors have, in conjunction with Messrs. John Brown and Co., Limited, formed a company called the Rossington Main Colliery Company, Limited, for the purpose of acquiring and developing about 9000 acres of Barnsley coal near Doncaster. The Stavely Coal and Iron Company, in their annual report recently issued, show a balance of net profit, after meeting certain claims, of 127,125*l.*, which is a slight increase on the previous year, and the directors recommend a dividend of 10 per cent.

South Yorkshire Coal Trade.—Hard coal continues to occupy a very strong position. The demand both for shipment and from manufacturers is, in fact, so considerable as to cause a good deal of difficulty both at pits and at ports, where the effects of the recent labour disturbances have not yet subsided. In some instances buyers are having to wait six or seven days for wagons to be got through from the pits. This means a scarcity of wagons and consequent interference with the normal working at the collieries. The market in its present state has probably benefited from the holiday at the South Yorkshire pits during Doncaster race week. A good deal of the coal being obtained for industrial consumption is going into stocks. Prices generally are firm. Slacks are well placed, and there is a keen competition for the supplies available of best qualities. The better conditions at house-coal pits are responsible for a bigger weight of coking smalls on the market. Inquiries for house coal are coming forward in very satisfactory quantity, although there is not so much pressure upon merchants now as a couple of weeks ago. The largest inquiry is for best qualities. The higher prices now ruling are probably checking some of the rush of orders. Large supplies are being taken on contracts. There is a possibility of a further price advance shortly. Quotations on 'Change at the week-end were:—Best branch hand-picked, 14s. to 15s.; Best Barnsley Silkstone, 11s. 6d. to 12s. 6d.; Silkstone, 10s. 6d. to 11s. 6d.; Derbyshire, 8s. 6d. to 9s. 6d.; best large nuts, 8s. 6d. to 9s. 6d.; small nuts, 8s. to 9s.; Derbyshire best brights, 11s. to 12s.; Yorkshire hards, 8s. 3d. to 9s. 3d.; Derbyshire hards, 8s. to 9s.; washed nuts, 7s. 6d. to 8s. 6d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. 3d. to 5s. 3d.; smalls, 2s. to 3s.

Iron and Steel.—Business in the iron market is still in a dull state. Hematites are decidedly weaker. The official quotation for East Coast mixed numbers is not a very strong one, and a good deal of material has changed hands at an even lower figure. It may be pointed out that this is not due to any limiting of demands in the Sheffield district, but to other causes. As a matter of fact, the prosperity of the steel trades of the city is responsible for a very heavy consumption of hematite. Notwithstanding the apathy of buyers, the Lincolnshire and Derbyshire common iron producers decline to bid for business by reducing their quotations. Derbyshire forge, however, is considerably cheaper than the Lincolnshire brand. Evidence as to the general prosperity of the Sheffield industries accumulates in abundance. Practically all the branches of the heavy and light trades are fully occupied. Certainly, in heavy forgings the weight of orders is hardly satisfactory, owing to causes over which makers have little or no control. The fact is that keen competition has to be faced from producers who are more favourably situated. On the other hand, the foundries are particularly well engaged, and a few of them are experiencing a difficulty in getting through the work on their books up to contract time. The rolling-mills also are exceedingly busy, and the amount of work at present in hand seems to foreshadow extensions of plant in the near future. The activity in armaments is, of course, responsible for a good deal of the prosperity in the dependent trades, and the armament firms appear to be well secured in regard to orders for several months to come. At the same time manufacturers in many of the local industries are not without anxiety as to how far trade may be affected by the shadow of labour unrest, which is still cast over the market, and which may materialise into an unpleasant reality. The railway steel manufacturers are in receipt of good orders, both on home and foreign account. Manufacturers of tools and tool steel report favourably upon their position. Most of them are doing a very big export trade. The agricultural implement branch continues to receive large orders from Russia, not only for implements themselves, but also for steel to be used in the construction of these articles over there. There is a satisfactory output of mining tools and machinery.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Quietness continues to characterise the pig-iron trade. Statistically there is some improvement, but business, especially on forward account, is seriously hampered by the political situation, and by the great unrest in the labour market. Traders are not likely to operate to any extent so long as labour troubles threaten industrial undertakings. With the opening out of the inland waterways abroad after the prolonged drought, deliveries of pig to the Continent are expected to increase, for they have been delayed for long owing to the shortage of water in the rivers and canals. Demand for pig iron delivered over the fall of the year threatens, however, to be less than usual. That there is still some confidence in the early future, however, is emphasised by the fact that both makers and merchants ask rather more on forward account than for early delivery. Values of Cleveland pig have fallen a little. No. 3 g.m.b. is on sale at 46s. 10½d. f.o.b.; sellers are quite prepared to accept 50s. 9d. for No. 1, and some would not refuse 50s. 7½d.; whilst No. 4 foundry and No. 4 forge are each 46s. 4½d.; and mottled and white iron, each 45s. 10½d.—all for early delivery. There is little or nothing doing in hematite pig iron. The general market quotation for early delivery of Nos. 1, 2, and 3 East Coast brands is 61s., but it is understood that purchases could be made at a little below that figure. Foreign ore continues very quiet, and consumers declare that rates will have to be substantially reduced before business to any extent can be done. Market rates were still nominally based on 19s. ex-ship Tees for best Rubio. Coke was plentiful and rather quiet, notwithstanding heavy local consumption. Average blast-furnace qualities are put at 14s. 6d. delivered here.

Stocks and Shipments of Pig Iron.—Stocks of Cleveland pig iron in the public warrant stores are being reduced a little, but they still stand at over 590,000 tons. To date this month the warrant stores have been drawn upon at the rate of 175 tons per working day. Shipments of pig iron this month are on a very satisfactory scale. To date they average 4133 tons per working day, as compared with a daily average of 3900 tons to the same date last month, and an average of 4113 tons per working day for the corresponding part of September last year.

Manufactured Iron and Steel.—Producers of nearly all descriptions of manufactured iron and steel are well placed. Most of them report a very large output, good order-books, and continued inquiries. Under such conditions values are stiff, and advances are looked for, but up to the present prices have not been actually raised. Principal market quotations still stand:—Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and galvanised corrugated sheets, 11*l.* 5s.—sheets less 4 per cent. f.o.b., railway material net at works, and all other descriptions less 2½ per cent. discount.

PRACTICAL STANDARDS FOR ELECTRICAL MEASUREMENTS.—Mr. A. P. Trotter informs us that his name has been attached to the Report of the British Association Committee on Practical Standards for Electrical Measurements without his authority, and doubtless as the result of a mistake. But it compels him to state that he withdrew from the Committee in July, 1910, because he strongly disagreed with some of their resolutions, and with the mode in which their business was conducted.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has ruled quiet, upon the whole, although chartering has been more active. Some arrears of deliveries have been cleared off, but stocks are still in excess of current requirements. The best large steam coal has made 17s. 6d. to 17s. 9d. per ton; while secondary qualities have ranged between 15s. 9d. and 17s. 6d. per ton; best bunker smalls between 9s. and 9s. 3d. per ton; and cargo smalls between 6s. 9d. and 7s. 6d. per ton. The best ordinary household coal has been quoted at 14s. 6d. to 16s. 6d. per ton; No. 3 Rhondda large at 17s. to 17s. 6d. per ton; and smalls 10s. 3d. to 10s. 6d. per ton. No. 2 Rhondda large has made 12s. to 12s. 6d. per ton; smalls, 7s. to 7s. 6d. per ton. Foundry coke has brought 18s. to 20s. 6d. per ton; furnace ditto, 16s. to 17s. per ton. As regards iron ore, Rubio has realised 18s. 3d. to 18s. 9d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Messrs. Pearson and Knowles.—The profits of Messrs. Pearson and Knowles, Limited, for the past year amounted to 70,977*l.*, and the balance brought forward was 15,968*l.*, making together 86,946*l.* A dividend at the rate of 4 per cent. per annum is proposed on the ordinary shares, 15,000*l.* being added to the reserve fund. The expenditure on capital account for the year (19,500*l.*) has also been written off, leaving 13,359*l.* to be carried forward. The company, in common with other members of the coal trade, has suffered from an increased cost of production resulting from recent legislation.

Welsh Coal for the Navy.—With regard to recent Admiralty purchases of Welsh coal, it appears that the Lords of the Admiralty are not buying more than the usual quantities, but that they are taking the coal in a different way. Hitherto the coal has been sent to north-eastern ports by sea, but recently it has been despatched from Wales by railway. Apparently the Admiralty are trying an experiment to ascertain what time can be gained by rail over sea transit.

Welsh Railway Traffic.—Welsh railway traffic makes but a poor showing thus far this half-year. The aggregate receipts of the Barry Railway come out at 114,248*l.*, as compared with 149,993*l.*; those of the Brecon and Merthyr Railway at 21,927*l.*, as compared with 23,926*l.*; those of the Rhondda and Swansea Bay at 25,092*l.*, as compared with 26,584*l.*; those of the Rhymney at 60,673*l.*, as compared with 70,481*l.*; and those of the Taff Vale at 170,500*l.*, as compared with 200,777*l.*

Dowlais.—The blast-furnaces have had a large output of late. On Monday, however, the rail-bank men struck for an advance in their wages, the result being that the Bessemer furnaces were blown out, while the Goat Mill was brought to a standstill. About 700 men have been affected by the strike already.

THE UNIVERSITY OF BRISTOL.—A copy of the calendar of this university for the session 1911-12 has just been received. The book is bound in crimson cloth, and contains nearly 300 pages, among which are to be found an almanack for the session, lists of authorities and members, the charter, statutes, and ordinances of the university, as well as the regulations for degrees in arts, science, engineering, medicine, &c. Particulars of scholarships, exhibitions, and prizes are also included.

WESTMINSTER TECHNICAL INSTITUTE.—We have received from this Institute a copy of a prospectus and time-table of evening classes for the session which commenced on the 18th inst. Instruction is given in civil engineering, gas engineering, heating and ventilation, architecture and building construction, cabinet making, &c. Full particulars of the classes in these subjects are contained in the prospectus, copies of which can be obtained on application to the Principal. The address of the Institute is Vincent-square, Rochester-row, S.W.

NORTHERN POLYTECHNIC INSTITUTE, HOLLOWAY, N.—We have received from this Institute a copy of its prospectus for the session 1911-12, which commenced on the 20th inst. Classes and courses of study are arranged for day and evening students in all the subjects required for London University degrees in engineering, science and arts, and, as the lecturers in these subjects are recognised teachers of the University, students may be registered as internal students. Full day and evening courses are also conducted in the architectural and building trades departments. Workshop classes for artisans in the engineering, metal-working, and building trades are also held.

SOUTH-WESTERN POLYTECHNIC.—Particulars of the work of this Institute, which is situated in Manresa-road, Chelsea, S.W., are set out in the prospectus, a copy of which has been forwarded to us. All the subjects required for London University degrees in science, arts, and engineering can be taken in the day college and evening classes, under lecturers recognised by the University, so that students can be registered, and are thus enabled to take the "internal" degree. Full technical courses in mechanical and electrical engineering, architecture and building construction, chemistry, metallurgy, and other subjects, are also arranged for both day and evening students, except in the case of architecture and building construction; in these subjects evening courses only are held. The prospectus also gives full particulars of commercial and art classes, and other branches of the Institute's work which do not come within our province. The evening classes commence on the 25th inst., while the work of the day college starts a week later.

50-HORSE-POWER OIL TRACTION-ENGINE.

CONSTRUCTED BY MESSRS. JOHN FOWLER AND CO. (LEEDS), LIMITED, ENGINEERS, LEEDS.

(*For Description, see Page* 387.)

Fig.2.

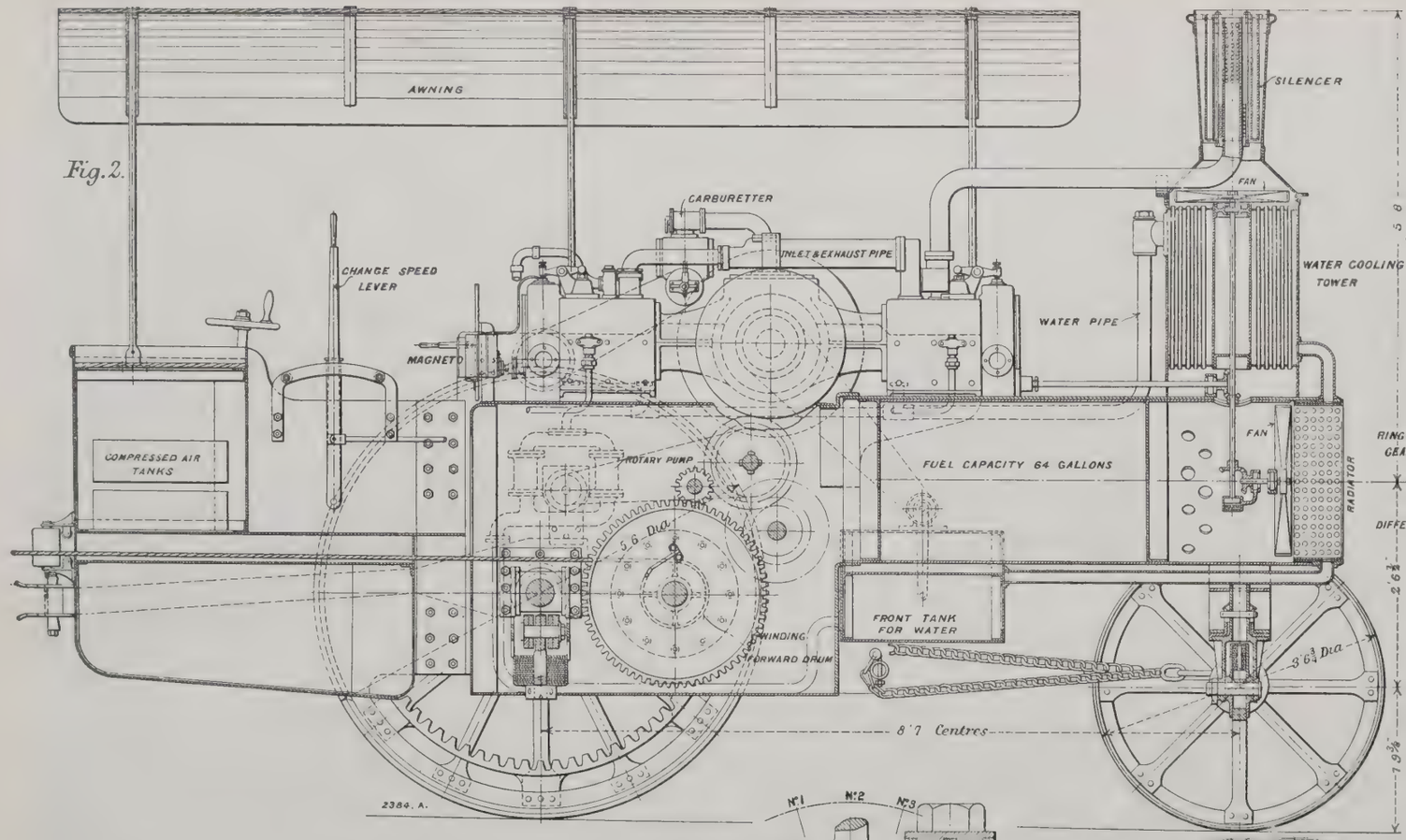
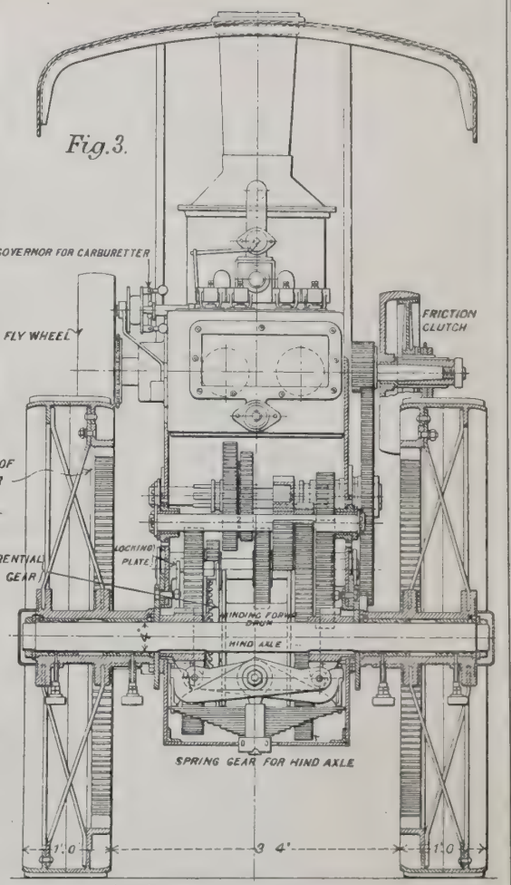


Fig.3.



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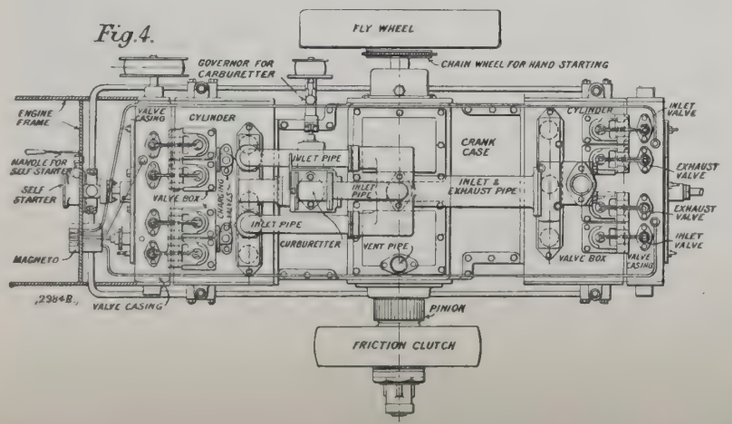

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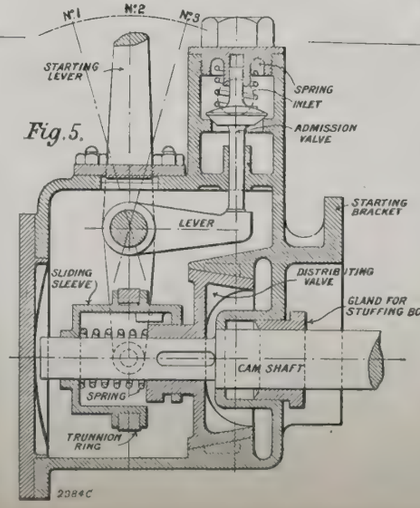

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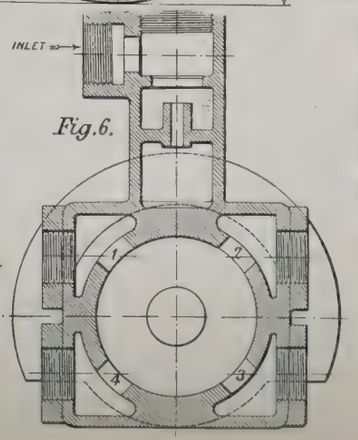

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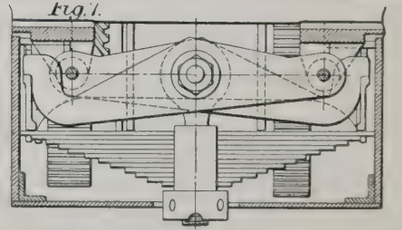

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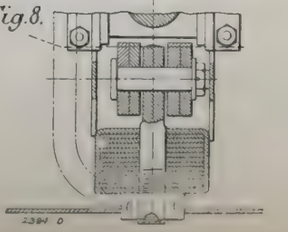

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The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Thick ,,	£1	16	0 ($8.75)
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Thin paper copies	£1	16	0
Thick ,,	£2	0	6

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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

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We desire to call the attention of our readers to the fact that the above is our SOLE Address, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS—"ENGINEERING," LONDON.
TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With Four One-Page Plates of the TROLLHÄTTAN HYDRO-ELECTRIC POWER-STATION, SWEDEN.

NOTICE OF MEETING.

THE JUNIOR INSTITUTION OF ENGINEERS.—Tuesday, September 26, at 6.30 p.m., visit the Electrical Exhibition at Olympia, under the guidance of members of the committee.

ENGINEERING.

FRIDAY, SEPTEMBER 22, 1911.

THE COST OF LOCOMOTIVE REPAIRS.

THE full measure of the economy of operation expected from the introduction of locomotives of great hauling power has not yet been realised in practice, and, especially, the cost of repairs per unit of useful work performed has not been reduced *pari passu* with the growth of the revenue per train-mile. The practice of to-day as regards these large engines is founded upon precedents established by experience gained in the working of earlier locomotives of small capacity. The growth of dimensions of individual parts, and the employment of higher pressures, have, however, been accompanied by an increase in the importance of secondary stresses, involving a reduction in the useful life, and an addition to the frequency of detentions for repairs.

First, as regards fire-boxes, the failure of water-space stays is usually attributed to the bending stress induced by the differential expansion of the plates of the box and of the shell. If this were the whole story, the life of such stays might be indefinitely prolonged, either by increasing their length or by reducing their diameter, with a proportionate reduction of the pitch in the latter case. The stress induced by a given bending movement, due to the differential expansion of the plates, varies directly as the diameter of the stay and inversely as second power of its length. Any arrangement for increasing the flexibility, such as the provision of ball-and-socket bearings under the external heads, would also be beneficial. The arrangement of the fire-boxes in current use involves bending moments on certain of the connections, the intensity of which will be found to have a surprisingly high value; a detailed examination enables one to predict with some certainty the positions where stay troubles may be expected to develop.

During a recent inspection of the work in progress in the boiler-shop of one of the largest American locomotive builders, it was observed that the detail of every type of fire-box then in hand involved bending stresses of some magnitude up each of the four corners and on the stays adjacent thereto. In many cases the upper rows of stays at each side were also likely to give trouble. Flexible stay-bolts were freely used in these positions. Modern American designs provide for the renewal of any stay without dismounting the boiler; hence the cost of this class of repair is greatly reduced.

When the width of the front and back water-spaces is increased from the foundation-ring upwards, and when the radius of the flanges of the shell-plate is not varied so as to be concentric throughout with the corner of the box, the areas of the flat plates connected by individual stays are not equal, and the resultant outward pull exerted on each of the upper corner stays is transmitted from side to side through the indirect line comprising the stay and the adjacent end-plate. This involves bending moments of sufficient intensity to account for breakages and for the development of cracks in the plates. Any system for supporting the crown of the box by means of so-called radial, direct, or sling stays necessarily balances the vertical components of the internal pressures in a round-topped shell. When no precautions are taken to balance the horizontal components, the variation in the tension around the shell-plate imposes bending moments on the stays attached to the latter; the most severe stress comes upon those which are adjacent to the shoulders of the box.

The cracks which are frequently observed at the root of tube-plate flanges are caused by the outward pull exerted by the pressure on those flat portions of the shell-plate which have no equivalent in the form of the inner wrapper-plate. The radius of the throat-plate flanges diminishes to zero at the part where the plane of the shell-plate is tangential to the circumference of the barrel. There is thus an area at each side, and, in the case of flush-topped Belpaire boxes, a third area vertically above the tube-plate, the pressure upon which exerts a pull on the adjacent stays which is only partially equilibrated by the pressure on the inner box. The resultant acts with sufficient leverage to ensure distortion of the tube-plate after a limited life. The excess of area thus securing support at the expense of the tube-plate increases with the length of the radius of the throat-plate flanges. The failures of stays near the expansion-angle brackets, which are experienced with certain classes of engines, are due to the fact that the boiler is relied upon to brace the frames for the transmission of the lateral forces arising from the axles towards the trailing end. When the frames are well braced beneath or around the fire-box, the breakages referred to do not occur.

Next as regards valve-gear: cylindrical slide-valves have sometimes failed to effect a marked reduction of friction with consequent absence of wear. The diameter is not always sufficiently great to afford a reasonable range of elastic adjustment with the pattern of packing-ring employed. When the steam and exhaust edges are provided with light split-rings of angle section separated by tubular sleeves or distance-pieces, and when the diameter is not less than 11 in., there is little appreciable wear. Suitable rings for valves of small diameter are not easily designed. The long split sleeve which is occasionally employed has a marked tendency to grip the liner at its front and back edges, and the consequent wear rapidly changes the original form to a barrel shape. The action of rings of this kind may be compared to that of a roll of drawing-paper when withdrawn from a card-board tube by a purely axial movement.

When the joints of the gear are not in the same plane, the pins are cross-bound in the bushes, resulting in a rate of wear and an expenditure of lubricant many times greater than is the case with a straight-line gear. In some recent examples of link-motion the extension-arm of the intermediate spindle is thrown out to one side. It is fitted with a single-eye bossed out and secured to a crosshead of which the jaws are not symmetrical with the shank, the total set from the centre line of the intermediate guide to that of the valve spindles being about 4½ in. The arrangement is flexible laterally; there is cross-binding on the pin connections and on the valve spindle. In the result the maintenance of the rod-packings is costly and the gear does not work sweetly at high speed. Eccentric-rods which are cranked to clear axles, and which are not efficiently stiffened, are also a cause of deterioration. In American practice few new engines are built with inside valve-gear; the cost of running and maintaining an outside gear is appreciably less.

The adaptation of standard valve-gears to meet the altered conditions due to the adoption of slide-valves having inside admission, involves the introduction of short-armed rockers and a multiplicity of pin-joints. A gear designed on the simplest possible lines to suit the general lay-out of the engine would save maintenance charges.

The frame of a locomotive is the foundation of the entire machine. In order that the maximum power may be transmitted with the greatest efficiency and least wear and tear, it is essential that the frame should be built square, true, and out of winding, and that it should keep so when subject to the shocks of high-speed work, and to the lateral impact due to interaction of the rails and flanges. It is important that definite allowance should be made for end movement of the axles in order that the wheel-base may be self-adjusting to the sharpest curve without springing the frame. The springs should also be arranged to permit the wheel-treads to accommodate themselves to points of contact which may be considerably divergent from a single plane surface. This divergence may be due to the conical form of a superelevated track, to changes of inclination, and to unequal resisting power of the rail-joints and of individual sleepers and the like.

Bar-frames are consolidated against lateral and torsional deflections by cross-stays united to the boiler by means of expansion-plates, but there is little provision to resist diagonal deflections in a horizontal plane. The thickness is sufficient to transmit lateral forces from the axle-boxes to the cross-stays without necessitating a large amount of material or the provision of special reinforcement in the shape of hornblock castings. The centre line of each side-frame is coincident with that of the bearings, springs, and equalisers, so that the transference of the load does not impose any torsional

stresses on the springs or frames, and the cost of maintenance of the suspension rigging is reduced.

Plate-frames of British design are sometimes deficient in the matter of effective transverse bracing. In order that the lateral pressures on the horn-blocks may be safely transmitted through the thin slab, it has been found necessary to employ plates of excessive depth, to reinforce them by means of heavy cast-steel axle-guards, or by the use of liner plates. One half of the additional weight, used in the form of effective bracing, would give a vastly stronger frame, with improvement in the riding, and a reduction of the frictional losses. The frame-plate is usually without reinforcement in the neighbourhood of the projecting spring brackets, or of the fulcrum brackets of the equalising levers, when these are employed. The lack of rigidity causes cross-binding in the pin-joints, and torsional stresses in the springs and frames.

When the frame-plates are set in between the cylinders and the driving-axle, in order to give greater clearance for the bogie wheels, it is important that the joggle of the plate should be supported; otherwise the alternating stress produced by the steam pressure in the cylinders will cause variable deflections, with eventual increase of work in the repair-shop. Modern Continental practice provides for a more complete system of frame bracing, but due provision is made for the endwise movement of axles, which would otherwise cause lateral deflection of the frame or of the road when the engine is passing over a sharp curve.

In their essential features the frames of the larger engines of the present day, whether of the bar or plate variety, do not materially differ from the practice of a past age, excepting only in the matter of increased weight and dimensions. With fuller knowledge of the character of the working stresses, and of the disposition of the material necessary to afford the maximum efficiency with minimum dead-weight, it is probable that by a complete revision of current practice a considerable reduction in the first cost, and a saving in running and maintenance costs, could be readily effected.

On certain British railways the numbers of spring failures amount to from 10 to 15 per cent. per annum. The hangers are of expensive type, and frequent adjustment of the weight transmitted to individual axles is required. When the engine passes over a crossing at moderate speed, or when it travels fast over a good road, experiment has demonstrated the occurrence of a variation of 100 per cent. over the statical loads indicated on the weighbridge. Equalisers are not generally fitted, as it is difficult to make a satisfactory attachment of the heavily-loaded fulcrum-bracket to an unstiffened plate-frame, and the appearance of the beams and springs when tilted out of the horizontal line in the performance of their duty is objected to.

When the entire spring-base is connected up in two independent groups, one of them being also cross-equalised, there is no further need for the use of the weighbridge, or for hangers with screw adjustment. The distribution of the weight depends only on the position of the centre of gravity, and on the proportions of the levers; any further adjustment that may be attempted is secured only by reason of the friction in the pin-joints, and by the grip of the horn-blocks on the axle-boxes. The modulus of elasticity of spring steel supplied by different makers has been found to vary from a minimum of 10,000 up to 12,000 tons per square inch. The equalisers will compensate this variation without other inconvenience than the tilting referred to. The chief trouble resulting from their use is that they tend to encourage the employment of materials and workmanship of low grade in order to effect an unduly great saving in first cost.

If at any large running-shed the annual cost of attending to springs and weighing engines, of making good hot boxes, broken axles, and the effect of derailments, when such may be directly attributed to defects of adjustment, were carefully ascertained, a good case would be established for revising the design of spring suspension. It is essentially necessary for the springs to be equalised in two groups, neither more nor less, and that the detail of the arrangement should duly provide for limitation of the possible amount of movement when dealing with a derailed engine, or when renewing any one part of the connected system. Plates of different thickness should never be built into a spring unless the initial curvature is varied for each, in such a manner as to ensure equality of stress for all plates under the maximum working deflection. Such springs cannot be supplied at the minimum cost per hundredweight.

There are also certain points connected with the draw-gear which are, perhaps, not always borne in mind. When the reciprocating masses are imperfectly balanced, the connection between the engine and tender is subject to alternations of stress, the magnitude of which may be many times greater than that due to the tractive force developed at the wheel-treads. In long engines, especially those of the 4-4-2 or 4-6-2 type, the lateral displacement of the draw-bar pin when on curves may be considerable in amount; unless proper provision is made to allow the tender to accommodate itself thereto under all conditions, severe lateral pressures will be set up, with consequent troubles due to hot boxes.

When working heavy trains fitted with continuous brakes, the maximum load comes on the tender draw-bar when the brakes are applied. It is due to the fact that, with few exceptions, the percentage of retardation given by the engine brakes is very low. The brake-blocks should be so mounted on the lever as to receive the pressure from the pin, and not from the contact of the lever with the toe of the block, and the bogie-wheels should be braked up to at least 75 per cent. of the weight upon them.

A latent prejudice against fitting brakes to bogies still exists, despite the fact that the all-modern locomotives on the Great Western Railway—working, perhaps, the finest passenger service in the world—are so fitted. The leading bogies of electric and auto-car trains are braked as a matter of course, and some further assurance may be gained from the fact that a long vehicle which persists in climbing the outer rail, when an attempt is made to push it around a sharp curve, may usually be got round quite comfortably when the leading wheels are spragged to prevent them from rotating. In American and Continental practice the wheels of engine bogies are commonly braked.

The materials employed in the construction of British locomotives, and the character of the workmanship, are rarely equalled, and never surpassed, elsewhere; but there are still distinct possibilities for the drawing-office to introduce modifications of detail which shall give a greater output of power per unit of weight and cost, with a substantial reduction in the running and maintenance charges per unit of gross revenue earned.

THE "FORESHORE."

THE rights of the public and other questions relating to the "foreshore" are rather complicated, and on the whole somewhat obscure. A large number of central and local authorities are concerned in the control of the foreshore and of the coast line and tidal waters; but the jurisdiction and powers of these authorities vary considerably. The law throughout the United Kingdom is not uniform, being different in England and Wales, Scotland and Ireland, in many respects. Even the meaning of "foreshore" is not always clearly defined. In England "foreshore" is that portion of the seashore covered by the tides up to the mean line of high tides at springs and neaps, but no definite seaward limit has been laid down. In Scotland the limits of the foreshore lie between high water and low water of ordinary springs. In Ireland no limits have been formally fixed, but the foreshore generally may be taken to be the same as in England. According to the Crown Lands Act of 1866, however, "foreshore" includes the bed of the sea within the three-mile limit, and the bed of channels, creeks, bays, estuaries, and navigable rivers in the United Kingdom, as far up as the tides flow.

The ownership of the foreshore is vested in the Crown except where such ownership has been alienated. To establish a claim to ownership in England, it is necessary to prove an express grant from the Crown, or to produce evidence on which such a grant will be presumed. The same applies generally to Ireland. In Scotland, however, the matter is different. To establish a claim to ownership a title, duly recorded in the proper register of Sasines, is requisite, which is capable of explanation as a grant conveying the foreshore. Title may be proved by showing an express grant from the Crown, and also by proving a grant defining the boundary to be the sea or a tidal river, or a grant of land adjoining foreshore *de facto*, bounded by the sea or a tidal river, which, by possession for the prescriptive period, is taken to include the foreshore. In Scotland title may also be established by proving a grant, not from the Crown, but from someone else, even if the latter had no Crown grant, provided proof is forthcoming of the possession of the foreshore for the prescriptive period. In England and Ireland the prescriptive period is sixty years, and in Scotland continuous possession without lawful interruption for twenty years. The taking of wreck or Royal fish, removing materials, making erections, &c., are in England and Ireland evidence of possession of foreshore as against the Crown, but this is not so in Scotland.

Accretions may come about by alluvion—the accumulation of alluvial deposits, and by dereliction—the recession of the high-water line. If the accretion is by small degrees, the gain is the adjoining owner's; but if it be sudden and extensive, the area gained belongs to the Crown. Where the original boundary can be clearly defined, however, by marks, maps, or other evidence, the principle by which the gain belongs to the adjoining owner may not hold good. If accretion be caused by works undertaken on the foreshore, it does not follow that the party constructing the works becomes the owner.

Encroachment by the sea does not necessarily effect a change of ownership to the Crown, particularly if subsequently accretion takes place, and the boundary of the original property before encroachment can be defined. The law is not quite the same in Scotland, and apparently accreted areas become the property of the adjoining owner in any case.

The rights of the public or individuals over foreshore, except where extended by statute, grant, long use, or established custom, are limited to the rights of navigation and fishing. In Scotland these rights appear to be more than those of navigation and fishing only, and to include the right of passage. No grant of foreshore can be given which permits any work prejudicial to navigation.

Jurisdiction over the foreshore, and in the interests of sea defence, throughout the United Kingdom rests mainly with the Board of Trade and the Commissioners of Woods and Forests. Other departments exercise a limited jurisdiction, as, for instance, the Board of Agriculture and Fisheries and the Local Government Board in England and Wales, and the Commissioners of Public Works, Department of Agriculture, and Local Government and Congested District Boards in Ireland. The Secretaries of State are vested with certain powers in connection with the sanctioning of bye-laws under various Acts of Parliament, &c. The two Duchies of Cornwall and Lancaster control the foreshore (except where alienated) within their respective jurisdictions.

Formerly, with the exception of the Duchies, the Commissioners of Woods and Forests looked after the rights of the Crown in the foreshore and the bed of the sea to the three-mile limit. In 1866, however, with certain exceptions, the control exercised by the Commissioners was transferred to the Board of Trade. The Crown has a right of property in the soil of the foreshore, which is alienable, and a right of jurisdiction for the protection of public rights, which is inalienable, except by Act of Parliament. The exercise of the latter right was transferred in 1862 from the Admiralty to the Board of Trade.

The Duchy of Lancaster claims the bed of the sea below low-water mark, as well as the foreshore, under its jurisdiction; but the Board of Trade disputes the claim, and the proceeds from sales of portions of the sea-bed are paid into a joint account. In the case of the Duchy of Cornwall, the foreshore limits in the County of Cornwall have been adopted as low water of highest ordinary spring tides and high-water mark of ordinary tides. In regard to the areas remaining under the control of the Commissioners of Woods and Forests, this department inserts, in conveyances and leases of foreshore, clauses preventing the construction of works below high-water mark which might affect navigation, without the consent of the Board of Trade. The Board of Trade in respect of public works demands small consideration—money or rent—under lease, and occasionally issues licences on payment of a nominal sum. The Board does not attempt to raise revenue out of the foreshore. In cases, however, where the public is to be excluded or private profit made, the Board demands full commercial value.

When licences only are granted, and no Crown

rights alienated, the Commissioners of Woods and Forests only require a small acknowledgment; but when the property is conveyed or leased, full value is demanded. The terms of the conveyances and leases of the two departments are, however, very similar. Neither as a rule disposes of foreshores except for purposes of useful works. They both grant leases to local authorities, enabling the latter to undertake the regulation of foreshore adjacent to their districts. These leases are usually granted for one year, and renewed from year to year at a rental of 1*l.* per year. The local authorities in possession of leases are empowered to make bye-laws for the regulation of the user of the foreshore, but not as to the removal of material. The removal of material has been responsible for much damage and encroachment on many parts of the coast. The law is not quite clear on this question, and it is desirable that it should be improved, and the powers of the Board of Trade or other authorities in prohibiting or regulating the removal of all descriptions of material from the sea-shore brought into line and be clearly defined and strengthened.

The Board can prohibit the removal of shingle, but its powers are by no means clear and definite over all parts of the coast. It has been claimed that orders of the Board in this respect cannot be enforced in areas under private or corporate ownership. The Board has power to issue licences dispensing with the prohibition order in areas where such freedom is admissible; but this is limited to "ballast"—*i.e.*, for ballasting ships—and does not include power to permit the removal of material for other purposes, such as defence works. The only defence works undertaken by the Board of Trade are the groynes for the protection of Spurn Head. These works were started by the Admiralty, and taken over by the Board when the jurisdiction of the foreshore was surrendered by the Admiralty. It was an exceptional case, and the work was undertaken more for the maintenance of the channel in the Humber than for coast protection.

Certain powers in connection with the foreshore in England are vested in the Board of Agriculture and Fisheries and the Local Government Board. The Board of Agriculture has statutory powers permitting it to sanction loans for sea defence works. Under these powers owners may charge their property with repayment of the loans, and trustees and universities may raise money for, or spend capital on, sea defences. The maximum period allowed for repayment is 30 years.

The Board of Agriculture is concerned with the formation of commissions of sewers and drainage districts, and with the appointment of the commissioners. In connection with drainage districts provisional orders may be issued by the Board. The members of the drainage boards are elected by those who will be liable to the sewers rate of the district. In districts where there are a number of small holders, drainage boards are more usually constituted, and commissions of sewers where there exist large owners of areas to be protected from inundation. Since 1861 the Board has formed only two commissions with jurisdiction to the coast or banks of tidal rivers, and fourteen drainage districts. The only other powers of the Board with respect to these authorities consist in the authorisation, after inquiry, of the purchase of land for new works, and the commutation of the obligations of any persons to repair walls or maintain sewers, &c., and the borrowing of money to meet expenses on the security of the sewers rates. The jurisdiction of the Local Government Board consists chiefly in the sanctioning of loans by local authorities, and in approving the bye-laws of these authorities as to the user of the foreshore. A number of other authorities have jurisdiction over foreshore in different parts of the Kingdom. These include special commissions appointed by award under the General Enclosure Acts or other Acts of Parliament, or by Provisional Order, and certain harbour authorities, county, borough, and urban councils.

The origin of Commissions of Sewers dates back to very early times. The powers exercised by and the administration of commissions are very various, and great diversity of practice prevails. They are founded on a number of statutes dating from the time of Henry III., though before that period commissions were in existence, some of whose customs were even then immemorial. The commissions are not so much concerned with protection against erosion as with prevention of flooding. No doubt many of these authorities have carried out the duties placed upon them satisfactorily; but many have not adequate or sufficiently clearly-defined powers, and the areas of jurisdiction require alteration or enlargement. The question of rating is also of great importance. No uniform system is in force, and the whole matter requires revision. Some areas benefit from the expenditure incurred by the commissions without bearing a portion of the burden.

The general powers of county and municipal authorities do not cover specific duties of sea defence, but where a local authority owns the foreshore, or is responsible for the maintenance of public roads, for the preservation of which protection from the sea is necessary, it has been held that the authority has an implied power to undertake works to protect such property or roads. Local authorities have obtained in some instances Parliamentary powers to deal with such cases.

In the Highways Act, 1835, as applicable to England, the right of removal of materials is conceded from waste or common lands, rivers, or brooks, for highway repairs, but it is provided that this right shall not include the removal of materials thrown up by the sea where such action would cause injury to adjoining land, or encroachment by the sea. In Scotland and Ireland the law is not the same, and difficulties have been encountered by county councils in preventing the removal of beach materials. On the other hand, some county councils in Scotland, by taking material from the foreshore for roadway purposes, have caused damage to private property.

Want of combination on the part of local authorities and private owners, and of the means whereby such combination could be adopted in their efforts to fight the sea in their common interests, has been a source of difficulty and lack of efficiency in schemes of sea defence. One owner may suffer injury owing to the neglect of another, and erosion at some point of the coast may be directly responsible for damage to the property of somebody else in the vicinity. Again, an authority or owner maintaining efficient works on the foreshore may by so doing afford protection to large areas of the property of adjacent owners who bear no part of the cost or upkeep of such works.

THE INSTITUTE OF METALS.

THE Institute of Metals has adopted the capital system, inaugurated fifty-five years ago by the Institution of Mechanical Engineers, of holding one of its general meetings annually at some important industrial centre, and this year the choice fell upon Newcastle-on-Tyne, where, through the courtesy of the University authorities, every facility was provided in the rooms of the Armstrong College, which is the seat of the scientific faculty of the University of Durham.

The proceedings at the inaugural sitting comprised a welcome, on behalf of the Municipality, by the Lord Mayor, Sir William Stephenson, whilst the hospitable feelings of the University authorities were voiced by Principal Hadow. The thanks of the Institute for the courtesies extended to them were expressed by Sir Gerard Muntz, the retiring President, who said that they hoped to gather in many recruits from the Newcastle district, as much of the work of the Institute would be more directly applicable to marine engineering than to any other industry.

THE NEW OFFICERS.

The Secretary next read the official list of new officers which would be balloted for at the next meeting. These included the names of Professor W. Gowland, F.R.S., as President, and of Mr. Summers Hunter, Admiral Sir Henry Oram, K.C.B., and Sir Henry Wiggin, as Vice-Presidents.

Sir Gerard Muntz next deplored the loss the society had suffered by the death of Mr. Ristori, whose place on the Council had been filled by the appointment of Mr. Panizzi Preston. The society, he added, now numbered over 600 members.

THE CORROSION COMMITTEE.

Continuing, Sir Gerard Muntz said that, most unfortunately for all, Mr. Bengough was laid up and unable to be present to describe personally the proposals of the Research Committee on Corrosion. Briefly stated, however, they were erecting at Liverpool a plant which comprised four small surface-condensers, each having a cast-iron body and 12 tubes. Through these condensers sea-water was to be circulated, a supply of 300 gallons being provided in the first instance; but this would be changed at frequent intervals. Provision was made for altering the speed of the water through one or more of the small condensers independently of the rest. Steam would be supplied from the engine driving the circulating pump, and condensed inside the four models, being then returned to the boiler. At the outset four metals of different compositions were to be used in the four condensers. In No. 1 Admiralty practice was to be followed, the tubes, $\frac{5}{8}$ in. in diameter, containing 70 per cent. copper, 29 per cent. zinc, and 1 per cent. tin, whilst the tube plates were to be of Naval bronze. The whole would be fitted up on Admiralty lines. This model was intended to serve as a standard with which the other three would be compared. Of these, No. 2 was to follow best commercial practice with $\frac{3}{4}$-in. tubes of the 70-30 alloy and plates of yellow metal. In models 3 and 4 commercial practice was also to be reproduced, but the tubes in the case of No. 3 would contain a certain percentage of lead. As for No. 4, the composition of the tubes to be used had not yet been settled. Special attention would be paid to the effect, on local corrosion, of particles of scale adhering to the tubes. Provision was made also for measuring temperatures by thermo-couples at a number of different points. To complete the experiments further substantial subscriptions, in addition to the 251*l.* already received, were badly wanted. The initial cost of the plant had been 200*l.*, and the annual outlay in operating it would be 50*l.* or 60*l.* No results could be expected under two or three years' time, and the money so far received would soon be exhausted, the amount now in hand being merely sufficient for a few months' work. The University of Liverpool, he might add, had been most generous, finding house room, skilled assistants, and half the cost of the coal used. In reading the correspondence from those asked to subscribe, he had been amazed in some cases at the way the writers had failed to grasp the value of the research. One firm of shipowners, for instance, wrote that they had no interest in the inquiry, which was an affair of the engineers and tube-makers. The speaker could not imagine how any shipowner could make such a declaration. He wanted the shipowner to realise that the research was very much his affair. If tubes failed, he might no doubt in some cases squeeze the cost of replacement out of the engineer or the unfortunate tube-maker, but he would have considerable trouble at the best. He thought, therefore, they should have a more generous response from shipowners and shipbuilders, as the inquiry was going to be of very great value to both. Papers to be read at that very meeting showed how necessary was such an investigation, carried out by an independent body, on which all interests concerned were fully represented. The final report was bound to carry weight, and to help the engineer to specify, and the shipowner to acquire, tubes of the best possible nature.

NON-FERROUS METALS IN RAILWAY WORK.

In calling on the Secretary to read in abstract a paper by Mr. George Hughes, of the Lancashire and Yorkshire Railway Company's locomotive works at Horwich, entitled "Non-Ferrous Metals in Railway Work," Sir Gerard Muntz expressed the regret of the meeting that the author had been prevented from attending by a strike at Horwich, where 3200 men were out. He understood that Mr. Hughes was experiencing great difficulties, and had been threatened with rough treatment by the strikers; the speaker had, indeed, advised him to come to Newcastle for safety.

We commence the publication of this very important paper on page 399 of this issue.

The discussion was opened by Sir W. H. White, who said that it was a considerable source of satisfaction to him that Mr. Hughes's membership of the Institute had resulted from a visit of the speaker to Horwich. One object of the Society was to record the experiences of users, and at the first meeting two valuable papers of this class had been read. It was only by means of information of this kind, the result of users' experience and uninfluenced by commercial considerations, that advances were likely to be made and difficulties minimised. The paper summed up the results of a vast mass of experience, and represented years of work by Mr. Aspinall and Mr. Hughes. As the author had been careful to point out, different results might be realised in different service conditions, but the speaker was certain they would all be unanimous as to the value of the mass of information contributed to their proceedings by Mr.

Hughes, and that to him were due their most cordial thanks.

Mr. A. V. Hussey, who followed, said that he wished to refer to the question of soldering aluminium. Two years ago, at a meeting of the Institute, it was stated that a satisfactory solder for aluminium did not exist, and this was still the case. Recently, however, autogenous welding of aluminium had come into extended practical use. Dr. Seligmann had mentioned the process in the paper to which he had already referred, but it was not then in general use ; now it had been practised on a large scale, and had proved most satisfactory. He was therefore surprised that the author had not referred to it. Very large panels had, perhaps, no advantages ; but he might state that the size of sheet which could be obtained by using autogenous welding was almost unlimited. At the same time, moreover, all other joints could be made in the same way, thus dispensing with the use of solder, of which, in the true sense of the word, a satisfactory type did not exist.

Mr. Allen, who followed, said that as a marine man he had been much interested in the author's record of the excellent results obtained with bronze slide-valves. In 1893 he had fitted valves of this type to the low-pressure cylinders of destroyer engines, and these had given the utmost satisfaction. He had not, however, hitherto seen any record of the use of such valves on high-pressure cylinders, and was correspondingly interested in the author's satisfactory experience with them.

Dr. Cecil Desch said that Mr. Hughes's paper was one of the most valuable yet brought before the Institute. It gave authoritative data in a very clear and systematic way. He wished to allude to two points only. In the first place, the author said that he had found copper, or rather copper with 0.3 per cent. of arsenic, to be of most value for fire-box stays. This statement was very interesting, considering its source, and the speaker would be glad to have it confirmed, since this view was contrary to that held by some others, who claimed that for such purposes an alloy had distinct advantages. Again, as regarded the white metal C, be noted that no figures of results with this alloy were given in Table VIII. Its composition led one to expect rather poor results, and a tendency to brittleness, so he would like to know whether systematic tests had been made with it. The paper mentioned that it was a very stiff alloy, but he should, from its composition, expect it to develop defects in course of time.

Mr. Hanna, who spoke next, said that he was specially interested in the author's remarks on bearing metals, since the speaker was the inventor of a system by which any bearing of any size could be cast true to dimension within $\frac{1}{2}$ mil if necessary, and from any alloy. This method was in use on certain railways ; and such brasses, prepared without any tooling whatever, had three or four times the ordinary life. In his experiments he had, however, got some very curious results. A certain composition at one time would give most excellent results, but the next batch of the same metal, whilst still casting correct to size, would have so many imperfections as to be useless. He had been puzzling himself to find out the cause, and would like to get some information as to why one batch should, as stated, give beautiful results, whilst with the next there would be numerous draws and other imperfections. The system of casting was not yet generally known ; but, as stated, it was possible to produce by it, without tooling, bearings to any degree of fineness desired.

Mr. H. L. Woore, who followed, said that in using phosphor-bronze slide-valves running on cast-iron valve-faces he had known wear to take place at the rate of $\frac{1}{8}$ in. in a fortnight, whilst in other cases months would elapse without notable wear. The bronze mixture was the same, and he was therefore inclined to attribute the difference in results to differences in the cast-iron valve-face, and he would like to ask if the author had had corresponding experiences.

The next speaker, Professor A. K. Huntingdon, said that the use of aluminium for railway carriage fittings was new, but he thought it would greatly extend within the next few years. The author's experience with bronze slide-valves worked with superheated steam had been very fortunate, but the speaker did not think that others had been equally so, and he expected that the subject would crop up again at the meetings of the Institute in the next year or so. It would be most satisfactory if ordinary mixtures would work satisfactorily under high superheats.

Mr. J. A. Boeddicker said that he thought the author's title rather too comprehensive, and that it should have read, "the use of non-ferrous metals on the Lancashire and Yorkshire line." He was himself specially interested in nickel alloys, but to these the author made two references only. One of these contained 98 per cent. of copper and 2 per cent. of nickel, and this addition had certainly greatly improved the copper. As received the alloy had a tensile strength of 15.2 tons, which, after annealing for 10 hours at 750 deg. Cent., was raised to 16.1 tons, and after being heated for nine hours in a locomotive fire-box the tensile strength was 17.1 tons. Under similar conditions the strength of all other copper alloys decreased. The only other reference was to Argozoil, used for ornamental fittings. Nevertheless, nickel alloys were largely used for lavatory fittings, and he would much like to have an opportunity of showing the author at Birmingham what could be done in this way with German silver.

Professor Henry Louis observed that whilst the author had compared copper fire-box plates with those of steel, he had made no mention of the use for this purpose of the best Yorkshire iron ; and if comparative data did exist, the speaker would be glad to have them supplied.

Professor R. C. Carpenter said he had been struck by the fact that in the specification for copper boiler-tubes it was definitely laid down that the ends were not to be annealed. He thought this remarkable, in view of the pointed statements of Dr. Beilby as to the mechanical instability of hard-drawn metal. Dr. Beilby recommended, therefore, that all copper exposed to superheats should be thoroughly annealed at 300 deg. to 350 deg. Cent., so as to destroy the amorphous surface film. The speaker thought, in view of this unqualified expression of opinion by Dr. Beilby, that the specification should be reconsidered.

In closing the discussion, Sir Gerard Muntz said that he had been specially interested in the points raised by Dr. Desch and Mr. Boeddicker. Mr. Hughes's preference for copper stays was, so far as his own experience went, generally held by locomotive engineers, who told him that they found this material the most suitable. The copper-nickel alloy referred to by Mr. Boeddicker was receiving attention in various locomotive shops, where it was being compared with the ordinary plate containing arsenic. It was still an open question as to whether the nickel alloy was not superior. Once it had been adopted, there appeared to be no question of going back to the copper-arsenic plates. His own firm supplied both, but without any pressure on their part; if the CuNi plates were once tried, orders for them came again. This alloy, containing 2 per cent. nickel, gave phenomenal results. At high temperatures, such as 700 deg., it had still a tensile strength of 12 to 14 tons per sq. in. At the same temperature that of pure copper had fallen to 6 tons, and of the usual copper-arsenic plate to something between the two. In copper fire-boxes very high temperatures were attained, and it was quite evident that something was wanted which would withstand them. Again, oxidation was much more severe with the copper-arsenic and copper plates than with the CuNi plates. Another point which must not be lost sight of in discussing copper was the influence of oxygen, the value of which had, he thought, not come home to the practical user. Two alloys, each containing copper and about 0.5 per cent. of arsenic, but with 0.02 of oxygen in one case and 0.002 in another, showed startling differences as to rate of oxidation, tensile strength, and elongation, and also as to wearing qualities generally. Mr. Hughes's paper was, he considered, a most useful one, and one of the clearest he had read for some time, and he moved that the Secretary should send the author an expression of their thanks and of their regret at his absence.

Electrical Methods of Determining the Constitution of Alloys.

The President next called on Dr. W. M. Guertler, of Berlin, to read his paper, entitled "The Electrical Conductivity and Constitution of Alloys." In this paper the author dealt with the limitations of the system of "thermal analysis" of alloys, introduced by Tamman, and suggested as an alternative the measurement of the electrical conductivity. The determination of the equilibrium diagram of a series of alloys depended, he said, upon the possibility of plotting down against temperature and concentration, as two co-ordinates, a third co-ordinate showing the variation of some third property as the two former were changed. A surface was thus obtained which, in general, exhibited marked breaks along certain contours, the projection of which, in plan, gave the equilibrium diagram. In Tamman's method the third property plotted against composition and temperature was the heat developed on solidifying, or in the completion of other changes. The difficulty was that many of these changes took place with extreme slowness, and it was thus impossible to measure the corresponding liberation of heat. As a substitute for this procedure he proposed to plot as a third co-ordinate both the electrical resistance of a series of alloys and the electrical conductivity, and in the latter case direct evidence of the existence of intermediate compounds was, he stated, readily obtained. The resistance of a true solution, Dr. Guertler stated, was much higher than that of a conglomerate of the two components merely mixed together. In the former case the total resistance consisted of two parts, one of which was independent of the temperature, and as a consequence it appeared that the "absolute" temperature coefficient was unchanged by the formation of solid solutions, though the "relative" value decreased enormously. Hence this temperature coefficient might also be taken as a third co-ordinate to plot against temperature and concentration in determining the boundaries of the equilibrium diagram. In conclusion, Dr. Guertler emphasised the impossibility of discovering any alloy which should have a greater conductivity than the least resistant of its constituents. The most that could be hoped for was the production of alloys in which the gain in mechanical properties was sufficient to overbalance the loss of conductivity.

The discussion was opened by Dr. Rosenhain, who expressed the view that the paper was most interesting and extremely valuable, as it drew attention to the limitations of the methods generally used by metallurgists, and in particular to those of the system of "thermal analysis." Everyone who had used this latter method must have been impressed by its limitations. In practice, if the liberation of heat was to be measured, it must be developed at a finite rate, whereas certain changes took place with extreme slowness. The limitations thus arising were very serious, but it had proved possible to get over the difficulty by a study of the changes wrought in the micro-structure by prolonged annealing. In a sense, perhaps, this constituted a qualitative method of research, but certainly not as regarded the detection of the phases, where it had proved very accurate and useful in filling up the gaps left by thermal analysis. An additional method was very welcome, and that dependent on the determination of temperature coefficients of resistance seemed specially valuable. It had, however, he thought, its own limitations. The specimens used must be of geometric form, and free from blow-holes, and this was not possible with the majority. One was thus reduced to make measurements on mere fragments. If these were of reasonable size and shape, success might be possible ; but when it was a case of determining the resistance of powders, the coherer had shown us that in such a case the resistance was by no means a constant quantity, but subject in many cases to seriously large variations. Again, he thought that the electrical measurements would not be easily made at temperatures above the solidus, so that the method would seem to be largely confined to an examination of the changes which went on in solid alloys, which, however, were the most difficult to determine by the methods ordinarily used. Again, it was necessary to have the alloy in a state of complete equilibrium, which was only attainable after prolonged heating at the right temperature. Thus, if an inversion occurred at 600 deg. Cent., it would be necessary to get within 15 deg. of this to effect the change. Nevertheless, those using thermal analysis had, he thought, neglected other methods too much, possibly because few had the necessary appliances ; but he did not question that Dr. Guertler's methods would be largely used in the future.

Dr. Desch, who followed, said that all metallurgists had many reasons to be grateful to the author for his original contributions to their science, and for the publication of his admirable text-book. That day he had raised questions of the utmost practical and theoretical importance. One funda-

mental question involved was, however, still unsolved—viz., In what way should a mixture affect the conductivity? It was not even settled whether a plot of the resistance or of the conductivity most nearly followed a straight-line law. This affected the whole idea as to what was the constitution of alloys. Mathiessen had defined his compositions on a volumetric basis, but it did not appear that this plan gave at all the best results. In other cases alloys had been specified by their atomic percentages, but whether this was justifiable or not still remained unsettled. It had, at one time, been held that in heterogeneous bodies the conductivity should be proportional to the composition, but actual experience showed this was not the case. As to solid solutions, Rayleigh's theory, by which the increase of resistance was attributed to the sum of innumerable Peltier effects, had been proved wrong. Drude's theory gave better results, but could not be applied satisfactorily until the best plan of plotting results had been settled. He had been interested in the author's remark that the methods he advocated gave direct evidence of the existence of intermetallic compounds in solid solution. This observation had been extended above the solidus curve by Miller, who had shown the presence of compounds in the liquidus, but the importance of the observation had not been appreciated. The definite proof of the existence of intermetallic compounds had, however, a very important bearing on the whole theory of solution.

Professor Thomas Turner wished to join the previous speakers in expressing his pleasure at seeing the author, and having so important and suggestive a paper from him. With part of it they were already familiar from previous publications, but much was new. He was glad that attention had been drawn to the hopelessness of the attempts to obtain an alloy of good conductivity, and to the fact that all that might be possible was to improve the mechanical qualities to a greater extent than the electrical properties deteriorated. This, in short, was the bearing of the paper from the practical side. As for the theoretical, all engaged in research were indebted to the author for pointing out the importance of electrical conductivity as a guide to constructing the equilibrium diagram.

Professor R. C. Carpenter said the paper was difficult to discuss verbally, but he thought that it fitted in well with Mr. Edwards's views on the nature of solid solutions, which was to be discussed next day; and he believed that the determination of conductivities might throw much light on the question as to how far solid solutions were really homogeneous.

In reply, Dr. Guertler said he agreed with nearly every word which had been spoken in the discussion. He had not enlarged on the uses of micrography, as his paper was devoted to a discussion of the properties of alloys, but he recognised its enormous importance. In micrography the phase itself was seen, in all other cases its existence was more or less an indirect inference. He quite agreed as to the necessity of reaching a state of equilibrium before determining final values of the conductivity, but this, in fact, constituted one of the advantages claimed. If, after a few days' annealing at a certain temperature, the conductivity was changed, it showed that equilibrium had not been attained, and that the experiment must be continued till the resistance was constant. It was not, he might add, very difficult to measure the conductivity of alloys in the liquid state, provided the temperature was not high. He used for this purpose quartz tubes in which the alloys were melted. On cooling, the conductivity curve showed all the well-known breaks. Dr. Desch had suggested that difficulties might arise in plotting when intermetallic compounds were formed. In that case, however, the diagrams should be divided into sections, and atomic percentages used until the first break was reached, after which percentage volumes should be used.

Hard-Drawn Copper.

Mr. D. R. Pye's paper on "The Mechanical Properties of Hard-Drawn Copper" was next read by the author. This we publish in full on page 403.

The discussion was opened by Mr. A. P. Trotter, who said that the author had already expressed the speaker's own view that further information was highly desirable. The tests of Bolton were, it was true, very concordant, but were confined to material supplied by one maker. Others, who perhaps made just as good copper, were more diffident when it came to publishing their results. Additional tests might afford further information. For example, the effect of dissolving off the hardened skin might be investigated, and micrographic examination of the cross-sections might also prove valuable. Again, the whole process of wire-drawing was largely a mystery to outsiders. There was a difficulty in getting makers to describe their processes, and one had to take what could be got, and not what one wished for. The process was not suitable for being conducted in the laboratory, but it would be of great interest to have it examined from the scientific standpoint. It was known, for example, that the wire was "slack" in the hole through which it had been drawn, but why this was so no one had discovered. In some cases "ripples" had been seen on the shoulder of the wire on its way through the die. Apparently the phenomena were allied to the formation of a *vena contracta* with jets of liquid.

Mr. Gaywood said that the only point which he desired to raise was that an overhead trolley-wire had to stand wear, and therefore it was advisable to fix a maximum limit to the elongation, in order to avoid the risk of a soft wire. Professor Henry Louis asked why the ordinary system of wire-testing had not been followed. In practice no importance was attached to elongation, but tensile and torsional tests were made, and the number of twists determined which the wire would stand without fracture. In some cases a "to-and-fro" bending test was also employed, but generally reliance was placed solely on tension and torsion tests. The view of wire-makers was that the amount of extension was of very little importance, and he would therefore like to know why the torsion test should not be applied to hard-drawn wire.

In closing the discussion, Sir Gerard Muntz said that, as a manufacturer, he considered the paper to be of a highly desirable type. It was, indeed, curious how desirous most people seemed to be to omit from their specifications all mention of the work put on a metal. For wires of No. 16 gauge and of $\frac{1}{2}$ in. in diameter the specification was often precisely the same. This sort of error was particularly frequent when one engineer borrowed another's specification. A recognition of the effect of differences of diameter was absolutely essential, and Mr. Pye had been very right in insisting on it.

In reply, Mr. Pye said that the use of rolled rods had made it necessary to insist on a minimum of extension. The specification of the tensile strength would in itself suffice to guard against the supply of unduly soft wires. If the strength specified were secured, the hardness would be satisfactory, however great the extension. As to Professor Louis' suggestion that torsion tests should be included, the plan actually followed had been adopted for simplicity's sake; and he thought, moreover, that there would be a difficulty in devising grips which would allow of a satisfactory torsion test on hard-drawn wires.

Volume Changes in the Copper-Tin Alloys.

A paper entitled "Volume Changes in the Alloys of Copper and Tin" was then read by Mr. J. L. Haughton, who was joint author with Professor Thomas Turner. It described further developments of Professor Turner's method of measuring volume changes of cast alloys. The bar was cast in the form of a T, and an extensometer applied to the stalk, and the indications of this extensometer were claimed to be proportional to the actual changes in volume, which may result in solidification or in inversions occurring later. Mr. Haughton had modified the apparatus so that both the pyrometer and extensometer could be simultaneously read by the same observer. The materials used in the research were pure electrolytic copper and tin, assaying 99.9 per cent. The T-bar was $\frac{3}{4}$ in. square in section, and extensions were read by a mirror extensometer. The bars varied in composition from pure copper up to pure tin in steps of 5 per cent. The results obtained agreed well, it was stated, over certain ranges with the equilibrium diagram as established in other ways, but in other places there were marked divergencies, though the authors claim that every important line crossed in the equilibrium diagram was accompanied by a change in the rate of contraction as shown by the extensometer.

Professor Turner, who spoke next, said he need not remind members of the importance of the alloys investigated in this research, many of which had been in use for over 2000 years, the bronze, bell metal, and speculum metal of the Romans being the same as used to-day. Heycock and Neville had, he said, studied them very minutely, but there was still room for much further research. About twenty-five years ago he had examined the researches of Riche to try to find some connection between composition and the density of the alloys examined, but could find none. This he considered to some extent due to the presence of blow-holes in Riche's castings, but this explanation was not sufficient. The divergences were also due in part to differences in crystal sizes and in the rate of cooling, and further to changes occurring after solidification. The divergences of the equilibrium diagrams of Heycock and Neville, Shepherd and Blough, Giolitti and Tavanti, particularly at 70 per cent. copper, showed how complicated the research was. The speaker further stated that all the alloys used in Mr. Haughton's research had been analysed after manufacture, as serious error arose when it was attempted to realise definite compositions by pure synthesis. In some cases, he might add, Mr. Haughton's observations were not clear. This arose from the rapid rate of cooling, since with the copper-zinc series certain changes only developed when the cooling was very slow.

Dr. Rosenhain, called on by the President, said he had not intended to speak, but, if he must do so, he could only say that if the method were offered merely as a rough means of analysis in practical foundry work, it might have its uses; but as a method of studying the constitution of so complicated a series of alloys as those of copper and zinc, he felt it was entirely out of court. The rate of cooling was too rapid for equilibrium to be attained, and the temperature was not constant throughout the bar. Something no doubt was observed which might serve certain practical ends, but this was all. He was very loth to speak in this way of a paper on which so much work and ingenuity had been expended, but as he had been called on for his opinion, he felt bound to say that he thought the energy shown might have been expended to more useful purpose.

Dr. Cecil Desch, who followed, said that his criticism of Birmingham methods of measuring volume changes threatened to become an annual event. He did not think the method was capable of measuring volume changes at all, and in particular those ensuing on solidification. After the outer shell was formed, the extensometer simply measured changes in this outer shell, and any volume changes down to complete solidification would not necessarily be recorded. The defect of the method was well shown by bismuth. With this metal the apparatus failed to record any expansion on solidification, though that such an expansion actually occurred was now undoubted, and could be easily observed by placing melted bismuth in a quartz tube, in which case the changes could be read as easily as a thermometer. In this way it had been found that Bi expanded 3 per cent. on solidification. This, however, was not recorded on the Birmingham apparatus, which appeared to be correspondingly untrustworthy. He believed the whole effect observed was due to crystal thrust, as those metals which showed most expansion with the apparatus were just those which gave most thrust.

As the time set for the conclusion of the sitting had been reached, the author's reply was postponed till the next day.

(*To be continued.*)

HEAT-INSULATING MATERIALS: THE RELATION BETWEEN SURFACE TEMPERATURE AND EFFICIENCY.

By Chas. R. Darling, A.R.C.Sc.I., Wh. Ex., F.I.C., &c.

The surface temperature of a lagging, when in use, is commonly supposed by engineers to furnish a clue to its efficiency, and conclusions are often formed from the sensation of heat experienced when the hand is placed on the surface. Another test, frequently employed, is to make a small hole in the lagging, into which the bulb of a thermometer is inserted; and it is then assumed that the material in which the lowest reading is obtained possesses a superiority in respect to insulating power. Whilst a correct measurement of the temperature of the surface is of value in conjunction with other tests, it will be shown that if taken alone an entirely erroneous opinion of the merit of the material may be formed.

The important factor which is not taken into

account in the above rough-and-ready test is the nature of the surface with respect to its radiating power. A lagging with a rough exterior radiates heat with much greater freedom than one which is finished smooth, and the latter, which is superior as an insulator, owing to retention of heat by the surface, will feel hotter than the former when touched by the hand. Hence it follows that a given non-conducting coating, if improved by painting and varnishing the surface, would appear to have suffered in insulating power if judged by its surface temperature only. To avoid such a fallacious conclusion, it is evident that the radiating power must also be taken into account, and only when this is done can a correct inference be drawn. During a general investigation of the efficiency of heat-insulating materials (the chief results of which were published in ENGINEERING for July 9, 1909), the author obtained a number of results bearing on the question of surface temperature, which serve to show the extent to which this particular measurement may act as a guide, and a description of these experiments will now be given.

A pipe was coated with a lagging 2 in. thick, and small thermal junctions were inserted at intervals of $\frac{1}{4}$ in. through the material. The junctions were made by soldering thin iron and constantan wires to a thin iron disc, and were connected to a cold junction and mirror galvanometer, the scale of which was calibrated to read temperatures directly. In taking the external temperature, a junction was pressed on the surface until the reading became stationary. In the first trial the surface of the lagging was composed of thin untreated asbestos cloth ; in the second the surface was covered with a coating of aluminium paint. The readings of the various junctions are shown in the accompanying figure, in which A represents the untreated and B the painted lagging. The internal temperature of the covering was brought to the same point in each case by regulating an electric heater in the pipe, thus enabling the effect of the aluminium paint to be deduced from the temperature gradient.

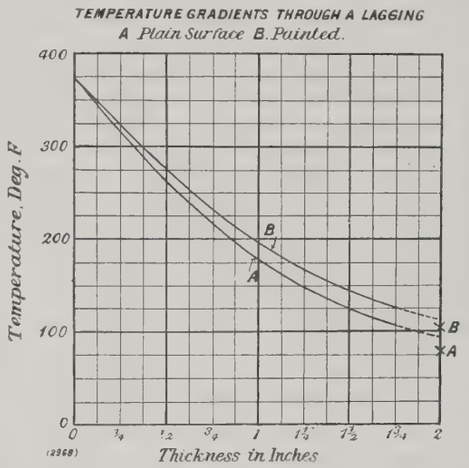
Several interesting points are disclosed by the two curves. The gradient, in the case of A, would, if produced, cut the line corresponding to the exterior at a height representing 96 deg. Fahr., whereas a junction applied to the surface recorded only 80 deg. Fahr., as indicated by the X. Similarly, in B, the respective temperatures are 115 deg. Fahr. and 105 deg. Fahr. The differences are, no doubt, due to the loss of heat by surface radiation, the higher figures, obtained by producing the gradient, representing temperatures on the inner side of the surface, and the lower values those on the outer side. It will be noted that the effect of the metallic paint has been to produce a less steep temperature gradient throughout the material, and although the surface temperature, as measured directly, was 25 deg. Fahr. higher than before, the actual quantity of heat escaping was 7 per cent. less. Assuming that the law of thermal conductivity holds in this case—that the quantity transmitted varies directly as the difference in temperature between the hot and cold faces—it follows that, with a constant internal temperature, the heat escaping will diminish as the external temperature rises, a result quite opposite to the idea entertained by many engineers on this point.

When two different materials, possessing the same radiating surface, are tested, however, it may legitimately be concluded that the one possessing the hotter surface is permitting the greater escape of heat. This may readily be shown by reference to the Stefan-Boltzmann radiation law :—

$$E = 1.28 \times 10^{-12} \times (T_1^4 - T_2^4) \times K$$

where E = heat radiated in calories per square centimetre per second ; T_1 = absolute temperature of the radiating surface in deg. Cent. ; T_2 = absolute temperature of surroundings in deg. Cent. ; and K = a constant, which expresses the ratio of the radiating power of the surface to that of a "black body." Evidently, if K be identical in the two cases, the quantities of heat radiated per unit of area will be proportional to $T_1^4 - T_2^4$; and if T_2, the absolute temperature of the surroundings, be also the same for both, it follows that more heat is leaving the hotter surface per second, and therefore more heat must flow through the lagging per second. Moreover, a small difference in surface temperature indicates a considerable divergence in the quantity radiated, as will be seen by reference to a numerical example. Taking T_1 as 40 deg. Cent. in one case, and 50 deg. Cent. in the other, and T_2 as 27 deg. Cent. for both, the relative amounts radiated are as 1 : 1.8, a difference of 10 deg. Cent. thus representing nearly twice the amount of radiation. It follows, therefore, that when the radiating surfaces are identical, the surface temperature furnishes a reliable and delicate guide to the insulating powers of different materials. The above formula also explains why a smooth metallic surface, such as aluminium paint, may be hotter than an unprepared surface, and yet radiate less, for in this case the value of K may be only a quarter or less than that which holds for the unpainted lagging.

A further reference to the curves in the figure will make clear the unsatisfactory nature of the test in which a thermometer bulb is placed in a hole made for the purpose in the outer part of the lagging, into which it is customary to pour mercury to secure a good contact between the material and the bulb of the thermometer. It is difficult to say what the reading indicates, as the temperature recorded will be the mean of that existing between



the end of the bulb and the surface ; and, moreover, the normal condition of the lagging at this part is entirely changed by the introduction of the mercury and thermometer bulb. One thing is certain : that the reading affords no clue to the surface temperature it is supposed to measure ; and in this respect the test is inferior to the application of the hand. The thermal-junction method is undoubtedly the best for obtaining a definite reading of the surface temperature ; and as it is now possible to obtain cheap portable indicators for use with a junction, it is to be hoped that other so-called measurements will be definitely abandoned.

The relations between surface temperature and efficiency may be summarised in two statements, as follow :—

1. When the surface of a given insulating material is treated so as to reduce its radiating power, the temperature is higher although the heat escaping is less.

2. If two different materials possess identical surfaces, that which has the higher surface temperature, under given conditions, is the worse insulator.

A recognition of these two points will prevent engineers from being led astray by the extravagant claims frequently put forward for compositions, based entirely on imperfect surface temperature measurements. It is also hoped that the advantage of finishing the surface with aluminium paint, instead of ordinary paint and varnish, will be recognised, as not only is the insulating power improved, but the finished work has a better appearance. The fact that such a surface feels warmer to the touch is in this instance not a proof of inferiority, but of the contrary.

NOTES.

THE DEEPENING OF THE CLYDE.

THE Clyde is recognised as the world's greatest shipbuilding centre, and upon its waters have been first borne the greatest of merchant and naval ships ; but the navigation authorities have not been too ready to recognise the demands of increasing size and draught of ships until this was brought home by the needs of the shipping frequenting the port. The explanation is to be found in the fact that shipping provides an enormously greater revenue than shipbuilding, and it is always difficult for patriotism to triumph over financial commitments. That such great work has been possible to the Clyde shipbuilders is, perhaps, some proof of satisfactory, if tardy, progress. The requirements, when clearly demonstrated, have been met in a way, although the navigation of great new ships down the channel has been an anxious process, and several of them have had to go elsewhere to be dry-docked. For the present, however, a more generous policy is being pursued. A graving dock of adequate dimensions is about to be constructed, the worst bend in the river is being cut away, and now there is for that part of the river—nearly 20 miles long—within the jurisdiction of the Clyde Navigation Trust, a minimum depth of 24 ft. 6 in. at low water of spring tides, and ships drawing 30 ft. are trading to and from Glasgow. With these and other improvements, and the really admirable harbour and dock facilities, the Clyde will maintain its traditional place as a shipbuilding and shipping centre. But, unfortunately, the jurisdiction of the Trustees does not extend to the sea. The channel past Port Glasgow and Greenock, with separate harbour authorities, and beyond these ports to the Firth and thence to the sea, is under the Clyde Lighthouses Trustees, who have only power, obtained in 1880, to deepen the channel to 23 ft. It is now proposed to apply to Parliament to enable the depth of this part of the channel to be increased to 27 ft. at low water of spring tides, so that the heaviest laden vessels may leave Glasgow at high water without fear of being prevented from reaching the sea before the tide ebbs too far. An interesting engineering question is raised, as the channel passes close to wharves in Greenock, and the question arises as to what effect the dredging will have on the foundations of these wharves and the adjoining docks. The engineers of the Clyde Lighthouses Trustees and of the Greenock Harbour authorities are considering the question, and no doubt a means can be found, by underpinning if necessary, to preserve these foundations, and thus obviate the opposition of the Greenock authorities. This preservative work is imperative, for, as it is, Greenock Harbour will be further injured commercially by this improved facility to ships passing their dock-gates on their way to the harbour of their great and rich neighbour further inland.

THE SECRETARY OF THE ADMIRALTY.

To the student of administration methods the organisation of the Admiralty seems at first most complex ; but fuller knowledge discloses a well-defined scheme, whereby work is accomplished with remarkable exactitude, so long as each unit in the *personnel* fulfils his function with precision, forethought, and accuracy. As in all large institutions, there may be weak links in the chain, and thus, even at the Admiralty, delays arise, sometimes with far-reaching effects. But it may be claimed that, for many years, the Admiralty has been exemplary among Government departments, and this superiority can be attributed in great part to the Permanent Secretary, who is, in brief, the medium through which co-ordination of different, and sometimes conflicting, departments is achieved. It is true that the Permanent Secretary in this case is not the sole link of continuity during change of Governments, as in some other departments, since, fortunately, the Sea Lords and the Controller do not change with each Government, as was once the case, and these members of the Board, and particularly the latter, exercise great influence in ensuring continuity. The technical officers, too, are more or less permanent, and their work conduces to the same end ; but they are not concerned with questions of policy, naval or administrative, so that with changes in the constitution of the Board, due to Governments passing, to Sea Lords resigning or going afloat, the secretarial department exercises a great influence. Moreover, it falls to the Secretary to promulgate the decisions of the Board ; no decision is valid unless issued by him. The holder of this important office must possess not only complete knowledge of Admiralty work and great organising ability, but must have also in a high degree judgment, tact, firmness, and a full sense of justice, since in many ways he can influence the Board, and must communicate unpleasant decisions as well as gratifying announcements. It must be confessed that in recent appointments those responsible have been specially felicitous. Sir Evan MacGregor, after holding office for twenty-three years, was succeeded by Sir Inigo Thomas, whose retirement is now announced,

and Sir William Graham Greene now succeeds worthily to the high office. Sir Inigo Thomas, although he has only been Secretary for little more than four years, has won high repute. He has given forty-six years' useful work to the Service. He entered it in 1865, and, his merits being recognised at an early date, he became private secretary to Lord Hood of Avalon and Sir E. Commerell, when these distinguished admirals were First Lords. He was for a long time head of the secret and political branch—than which there are fewer better posts of training within the Admiralty. It was for his work here that he earned his C.B. in 1900, and his promotion in 1902 to be Assistant Secretary. When in 1907 Sir Evan MacGregor retired, there was no difficulty in the choice of a new secretary. No appointment has been more fully justified by results, and, in view of Sir Inigo's age, he will be able, doubtless, to devote some of his energy and great ability to the advancement of some other department of naval activity for the benefit of industry and of the Service. He was advanced from K.C.B. to G.C.B. at the time of the coronation. With equal appropriateness will the Service and the country welcome the promotion of Sir W. G. Greene, who was made a K.C.B. at the coronation. Like Sir Inigo, he entered the Service when young, in fact at twenty-two years of age, and has already thirty-two years of service to his credit. He was private secretary to four successive First Lords, and after serving in several departments, succeeded Sir Inigo as Assistant Secretary in 1907. The shipbuilding and engineering contractors to the Admiralty will find in him as desirable a Secretary to the Admiralty as his predecessor; more cannot be wished for.

INDUSTRIAL NOTES.

ACCORDING to the *Board of Trade Gazette*, issued on the 16th inst., the state of the labour market in August was as follows:—

Employment was, on the whole, not quite so good as in July, and many industries were adversely affected by the disputes in the railway and other transport trades.

As compared with a year ago, employment in most of the principal industries showed an improvement. There was, however, a marked decline at blast-furnaces and in the jute and lace industries.

In the 394 trade unions, with a net membership of 769,367, making returns, 25,075 (or 3.3 per cent.) were returned as unemployed at the end of August, 1911, compared with 2.9 per cent. at the end of July, 1911, and 4 per cent. at the end of August, 1910. Returns from firms employing 447,200 workpeople in the week ending August 26, 1911, showed a decrease of 3.7 per cent. in the amount of wages paid compared with a month ago, and an increase of 1.8 per cent. compared with a year ago.

The changes in rates of wages taking effect in August affected 228,600 workpeople, who received a net increase of nearly 940*l.* per week. The principal increases affected 2700 building trade operatives in Southampton, 15,000 workpeople in engineering works at Leeds, Oldham, and Leicester, and 68,000 transport workers in London. The principal decreases affected 130,000 coal-miners in Durham and 4700 blastfurnacemen in Scotland and North Lincolnshire. Amongst those whose hours of labour were reduced during the month were 39,000 carters, &c., and lightermen in London.

The transport trades were much affected by disputes during August, the most important being those involving about 140,000 railway workers, 78,000 dock labourers, carmen, and other transport workers in London, 35,000 dock workers, seamen, &c., at Liverpool and Birkenhead, 3000 carters at Manchester, and 2500 and 1000 tramwaymen at Glasgow and Leeds respectively. Other important disputes were those involving 12,000 coal-miners in the Rhondda Valley, 1400 coal-miners at Wigan, 3000 engineering apprentices at Leeds, and 1500 cotton operatives at Skipton. The number of new disputes beginning in August was 100, and the total number of workpeople involved in all disputes in progress during the month was 373,615, or 184.507 more than in the previous month, and 356.256 more than in August, 1910. The total number of working days lost during the month by these workpeople was 2,323,800, or 1,050,500 more than in July, 1911, and 2,183,300 more than in August, 1910.

Cases dealt with under the Conciliation Act include those affecting the railway workers of the United Kingdom, transport workers in London, Liverpool, Manchester, Cardiff, and Grangemouth, coal-miners at Bristol, plumbers at Glasgow, confectionery workers in London, warp weavers at Skipton, tube workers at Landore, machine tenters at Cleckheaton, and boot and shoe operatives in London.

We understand from the monthly report of the Amalgamated Tool-Makers' Society for September that the steady growth of membership in the society continues, the membership having increased from 5000 in April last to nearly 5500 at the present time, while the increase since August, last year, to August, this year, was 1120. There was, however, an increase of 12 in the number of the unemployed, the numbers being 83 and 95 in 1910 and 1911 respectively. In the same time the reserve funds increased from 17,200*l.* to 23,200*l.* respectively.

The monthly returns of the United Society of Boiler-Makers and Iron and Steel Shipbuilders for August show an increase in the number of the unemployed during the month; but this is said to be due, to some extent, to the members in various districts being idle on account of disputes of helpers, heaterlads, &c. It is also an unfortunate circumstance that in some districts there are men out of work while in others there are not enough men to fill the vacant jobs. The expenses in August were higher than in July, the increase amounting to 1442*l.* 11s. 3d., and the total increase in membership was 389.

Not willing, apparently, to be left behind in the desire to disturb what remained of industrial peace on the termination of the late railway strike in this country, Ireland is now to the front, having engineered a railway strike of her own. It appears to have originated in the strike of two railway men in the goods department of the Great Southern and Western Railway at Kingsbridge on Friday last. This soon developed, and assumed proportions that caused alarm. The original cause of the trouble was the fact that two men objected to handle some timber from a firm in the city whose men were on strike. This ridiculous attitude was unfortunately supported by all the men in the goods department, numbering about 400, who stopped work, being joined at night by the majority of the platform men, including the checkers. On Saturday and Sunday the passenger traffic was carried on by the clerical staffs. In reply to a request from the men that the company should not require them to handle any traffic from firms in the city whose men were on strike, Mr. Dent, the general manager, naturally pointed out that, having regard to their legal obligations, it was quite impossible to accede to such a request. It was therefore announced that a general strike would be proclaimed on the Great Southern and Western Railway, and the men at the Inchicore works left work. The strike spread to the men at the North Wall Station, who marched to Kingsbridge Station, and at 3 o'clock on Sunday they were followed by the goods staff of the Great Northern Railway Company, and the Midland Railway men followed suit. The platform men on the Midland and the Great Northern Railways remained at work, neither did the Broadstone employees of the Midland Railway come out. It was stated on Monday that the drivers, firemen, and cleaners had decided to cease work, and there was no improvement generally in matters on Monday, the strike continuing to spread, with consequent dislocation of traffic. There was a meeting in Dublin on Tuesday of the executive committee of the Amalgamated Society of Railway Servants to consider an appeal made to them from the members of the society that their interests should be safeguarded by rallying other workers to their aid. It is reported that the railway companies, with the exception of the Dublin and South-Eastern, are quite firm in their determination to adopt an attitude of resistance towards the demands of the men. There is little doubt that a general strike is threatened, but if it take place it will not be on the question of wages or hours, nor even on an absurd demand for "recognition;" the issue at stake being whether the Irish companies are, or are not, to fulfil their obligations to the public. It is said that public sympathy is on the side of the employers who refuse to accept the intolerant demand of the men. If the public are really on the side of the companies, the strike is doomed to a speedy termination. There is, indeed, a very clear indication that the public are becoming heartily sick of these constantly recurring strikes, and will, if things go much further, take means of putting an effectual stop to them.

Things were very bad at Limerick on Monday, the strikers having matters pretty much their own way. The difficulty of the companies was the old one—namely, insufficient protection, for although in many cases plenty of men can be obtained to do the work, there is difficulty in obtaining protection for them. Men who are intimidated, assaulted, and injured, are allowed in many cases to be so treated because the authorities are either too weak or are unwilling to protect them.

By the middle of this week the strike had spread throughout Ireland, some of the lines being almost at a standstill, and many tourists in the district of Killarney found it impossible to get home, and agriculturists and traders are in many cases placed in a most serious position, for they cannot get their perishable goods to England. As a natural consequence of the Trades Disputes Act, as in England so in Ireland, there has been molestation and intimidation where the men still remain loyal, so that drivers, firemen, and others are afraid to work. It is the same story that we became so accustomed to during the late railway strike in this country, and strengthens (if anything were needed to strengthen) the opinion that the law relating to "peaceful picketing" requires speedy revision.

At the time of going to press matters appear to have come to a deadlock, inasmuch as the directors and managers of the railways affected have definitely refused to reply to the ultimatum sent them by the Executive of the Amalgamated Society of Railway Servants.

There was another outbreak of trouble in the Clyde shipbuilding trade on Monday last, owing to the action of about 1000 holders-on employed in the shipyards declining to start work. The men who caused the trouble were practically all at work in the federated yards. The strike was a direct refusal to obey instructions, as they were officially asked to remain at work until last night, when there was to be a conference between the representatives of the two sides. The men's union is in rather a dilemma, because if the men go out they ought to be fined, under the national supplementary agreement, whereas if the men refuse to pay the fines they ought, according to the rules of the society, to be excluded from membership, in which case it is thought that the men might organise a trade union of their own.

The telegraph lads in the West Riding of Yorkshire have been moved by a desire to improve their condition, and, apparently acting on the example of other sections of the industrial community, have drawn up a programme setting forth their grievances. Among other things they claim that lads commencing between the ages of fourteen and fifteen years shall receive not less than 12s. a week, with 1s. a week increase per annum, and receive the minimum of 14s. a week on attaining the age of sixteen years, irrespective of the date of the last increase they received. Lads commencing between the ages of fifteen and sixteen years to receive not less than 13s. a week, and the minimum of 14s. a week on attaining sixteen years of age, irrespective of the date they commenced in the service. If they enter at the age of sixteen years, the minimum wage to be not less than 14s. a week, and 1s. a week increase on attaining the age of seventeen, and an additional 1s. a week increase per annum until they attain the age of nineteen years. An eight hours' day is also claimed, with all overtime at the rate of time and a quarter. Sunday duty to be paid at the rate of time and a half from twelve midnight Saturday to 12 midnight Sunday. The lads maintain that at the age of nineteen they should be allowed to pass the doctor at once, and be paid from that date at the rate of a man porter's ordinary wage, irrespective of the position held.

In his evidence before the Railway Commission on Monday last, Lord Claud Hamilton, M.P., the chairman of the Great Eastern Railway Company, declared in no uncertain words his opinion of the methods of the Amalgamated Society of Railway Servants, and his remarks formed one of the severest indictments of trade unionism ever framed. Moreover, what he said was not the opinion of a man of little experience and small knowledge of his subject, but the ripe conviction of one who for thirty-nine years has been a director of one of the important railways of the country, during which time he occupied the position of deputy-chairman for eighteen years, and chairman for eighteen years, and he claimed to speak not only on behalf of his company, but on behalf of the great majority of his men. His indictment was that the railwaymen's unions exercise intolerance and intimidation. They work for war, and not for peace, because in peace they languish. They have forfeited all right to be trusted in the future. Their actions are calculated to bring discipline into disrepute by holding up directors and officials to the hatred and execration of the staff, and encourage men to be disloyal and unfaithful to those who employed them; they are also controlled by Socialist agitators.

There is apparently a strong feeling growing amongst a large section of railway workers themselves against the intolerable tyranny of trade unions, apropos of which there was a meeting of non-union railway men held last Monday night at Widnes to protest against this tyranny. The principal speaker stated that the time had come when non-unionists should combine against the force of State Socialism, with which trade-unionism was synonymous. The resolution passed was the following:—"That the continued attempts of coercion on the part of trade unions make it imperative for workers who desire to

FOUR-CYLINDER PASSENGER LOCOMOTIVE: LANCASHIRE & YORKSHIRE RAILWAY.

(For Description, see opposite Page.)

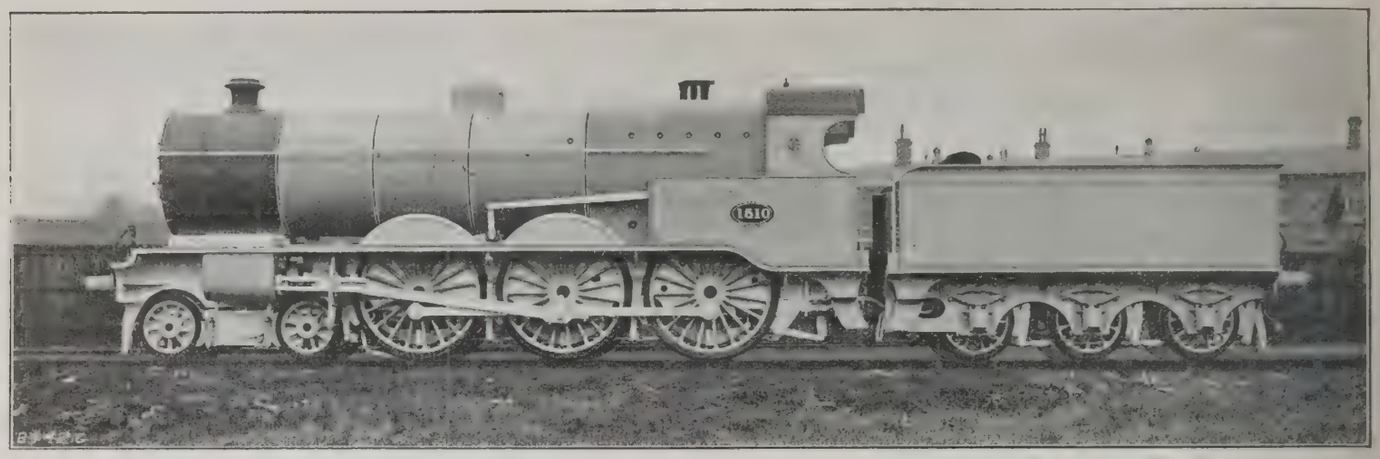


FIG. 1.

remain free to organise in self-defence, and it is resolved to establish a society called the Lancashire Railway Society of Free Workers, for the purpose of maintaining the principles of personal responsibility, and especially to protect by every means in its power the right of individual members to live and work in freedom, so long as they do nothing to interfere with the enjoyment of a like freedom by all others."

Under the present state of labour in this country and the unruly condition of the trade unions, it is almost tragic that we should have to announce the death, on Saturday last, of Mr. Robert Knight, one of the very ablest, and certainly one of the strongest, leaders of trade unionists there has been. Unlike many of those now in office, he was able to control his men, and he would tolerate no insubordination in the ranks of unionists with whom he was connected. We say it is almost tragic because such men are now so much needed that the removal of one of them is a serious loss. Mr. Knight was an old man, having been born on September 8, 1833, and he had therefore completed his seventy-eighth year. He was the son of an engineer and general smith at Lifton, in Devonshire, and served his apprenticeship at the Royal Steam Factory at Keyham, Devonport, where he remained fourteen years. He was, from the commencement of his career, connected with labour matters, and during his time at Keyham was appointed one of two delegates to attend before a Select Committee of the House of Commons to advocate the claims of his fellow-workmen for superannuation. He also was for some time a strong supporter of the wages movement committee in Devonport. It was not until March 1, 1871, that Mr. Knight became general secretary of the Boiler-Makers and Iron-Shipbuilders' Society, a position which he ably filled until the time of his resignation in 1899. He was a governor of Newcastle Infirmary, and of the Armstrong College, at Newcastle, and was also closely associated with the co-operative movement, as well as that of the friendly societies. He was a Liberal in politics, and became a magistrate in 1892. He, some years ago, refused the offer of an appointment under the Board of Trade. Probably Mr. Knight's most remarkable characteristic was the power of control over the men of the society whose secretary he was, and if there were more men of his stamp among trade-union leaders of the present day, we should hear less of the disloyalty to the wishes of the executive, and less of the breaking of solemn agreements than we do at present. Mr. Knight leaves a widow, two sons, and one daughter.

Last week the boiler-makers' dispute at Lincoln was settled, and the men returned to work on the Thursday. By the agreement arrived at the men secure 1s. a week advance and 2½ per cent. on piece-work rates. The agreement is to remain in force for two years.

The wages of shipyard skilled workers are to be increased by 1s. a week on time rates and by 5 per cent. on piece prices from about October 11, according to the days on which the pays are made up. This is the result of a confirmation by the Newcastle associations connected with the Shipbuilding Employers' Federation of the recommendation of the executive board formulated at a meeting at Edinburgh on August 30 last.

AERONAUTICAL RESEARCH SOCIETY, EAST LONDON COLLEGE.

TO THE EDITOR OF ENGINEERING.

SIR,—May I avail myself of the publicity of your columns to make it known that, owing to the generosity of Mr. P. Y. Alexander and of the Governors of the East London College, the aero-dynamical laboratory in that college will again be open for experimental research during the winter.

The Council of the Aero. Research Society would gladly welcome a few gentlemen desirous of experimenting. Application for admission to the society should be made to the hon. secretary.

Thanking you in anticipation,

I am, Sir, yours truly,

R. H. WALTERS, Hon. Sec.

"THE ROYAL ENGINEERS OF THE TERRITORIAL FORCE."

TO THE EDITOR OF ENGINEERING.

SIR,—Your issue of August 25 contained an article of much interest on the question of the supply of duly qualified engineers for the commissioned ranks of the Royal Engineers of the Territorial Force. As a commanding officer of a unit of Territorial Royal Engineers I shall be grateful if you will allow me to make a few observations and a suggestion on the subject.

As you pointed out, the bulk of the Territorial force is organised into fourteen divisions, of approximately 17,000 men, and included in each division is the proportion of engineer units, corresponding to that laid down for the regular army, and each division has to depend for its engineer services upon these units.

A few years ago I devoted some time to comparing carefully the commissioned ranks of the various engineer units (apart from the engineer and railway staff corps), as set out in the army list, with the lists of members of all grades of the Institutions of Civil Engineers, Mechanical Engineers, and Electrical Engineers, also the Royal Institution of British Architects. I found that of the officers serving in all the engineer units (with the exception of the staff corps I have mentioned) at that time only 5 per cent. belonged to one or other of the great professional bodies, and of these the Institution of Electrical Engineers held the foremost position.

Without going over the work again, I cannot say if the same proportion holds good to-day, though from my knowledge of the subject, I believe I am right in asserting that things are much as they were ; but even assuming 10 per cent. as being the correct proportion (and this, if anything, errs on the side of liberality) it means that out of 465 officers of the Territorial Royal Engineers serving at the present moment only 47 are connected with the leading professional institutions, each of which numbers its membership by thousands. This condition can scarcely be described as satisfactory, and I venture to make a proposal which I think may bring about some improvement.

My suggestion is that the councils of the engineering institutions favourably consider a scheme whereby the professional examinations for admittance to the various grades of membership be either modified or dispensed with for engineers who hold commissions for a term of years in the Territorial Force, and who pass the examinations, including attendance at the School of Military Engineering at Chatham, laid down in the Territorial Regulations.

It must be remembered that the duties of an officer in the Territorial Force are very different from those required in the Volunteers of twenty-five years ago, and if a young officer in an engineer unit does his work properly, he finds that drills, musketry, riding, attendance at camps, and examinations, absorb all his spare time ; and doubtless many young men working as engineers, with examinations to pass, feel they are unable to undertake the duties which a commission in the Territorial Royal Engineers entails.

If, with proper safeguards, a scheme of this kind were adopted, it would enable young engineers who desire to serve their country to do their share without disadvantage to themselves.

I trust nothing in this letter will be taken as suggesting that officers who at present constitute the commissioned ranks of the Territorial Royal Engineers are in any degree incapable. Speaking for my own unit, I can strongly testify to the contrary, and it is surprising how quickly young and zealous officers attain a sound knowledge of their duties ; but, as you have already pointed out in your article, a trained engineer naturally has special qualifications for Royal Engineers' work, which it is not reasonable to expect in a man engaged in business or in another profession.

Your obedient servant,

September 20, 1911. E. S. SINNOTT, M. Inst. C.E.

PERSONAL.—Mr. Philip Kemp, M.Sc. Tech., has been appointed lecturer in electrical engineering at the East London College (University of London) in succession to Mr. L. Murphy, who has resigned to take up the position of managing engineer to the Perry Barr Fan Works, Birmingham.—Messrs. Dunlop, Bremner, and Co., Limited, have acquired the shipbuilding, engineering, boilermaking, and repairing business established by Messrs. Cunliffe and Dunlop in 1871, and since 1882 carried on by the late Mr. D. J. Dunlop, under the title D. J. Dunlop and Co. Mr. Donald Bremner, who was associated with the Clyde Shipbuilding and Engineering Company, Limited, for nine years, and formerly for many years associated with the Clydebank Shipbuilding and Engineering Works, is the managing director. The engineering director is Mr. Thos. Paton, lately engineering manager to Messrs. D. and W. Henderson and Co., Limited, Glasgow, and formerly with the Clyde Shipbuilding and Engineering Company, Limited, Port Glasgow, Messrs. Dunsmuir and Jackson, Govan, and Messrs. D. Rowan and Co., Glasgow. The shipbuilding director is Mr. Geo. G. Parker, lately with the Clyde Shipbuilding and Engineering Company, Limited, Port Glasgow, and formerly with Messrs. Raylton Dixon and Co., Limited, Middlesbrough, and Messrs. Harland and Wolff, Limited, Belfast.

THE IRON AND STEEL INSTITUTE.—It is announced that the Italian meeting of the Iron and Steel Institute has had to be abandoned, and that all arrangements for holding it have been cancelled. When the preparations were first begun a large attendance was anticipated, but it appears that, owing to various circumstances, numerous withdrawals have been notified within the last fortnight, by which the numbers were very seriously diminished. It was felt by the Council that to hold a meeting at which only a small number of members was present would not form an adequate response to the extremely hospitable intentions evinced by all those concerned with the reception of the Institute in Italy. Under these circumstances, and with extreme reluctance and deep regret, the Council has therefore decided that it would be undesirable to hold a meeting in Italy this year. The falling off is attributed largely to the disturbed labour conditions in Great Britain and, more recently, to the present political situation in Europe. The somewhat exaggerated rumours which have lately been current as to the prevalence of cholera in Italy may also have had some effect in deciding those who were already hesitating to withdraw. At the same time, the statutory requirements of the charter necessitate a meeting being held in the autumn, and arrangements have been made with this object. The meeting will be held on Thursday, October 5, at the Institution of Civil Engineers, by kind permission, when the usual autumn ballot for membership will take place and the papers down for reading at the Turin meeting will be read and discussed.

NON-FERROUS METALS IN RAILWAY WORK.

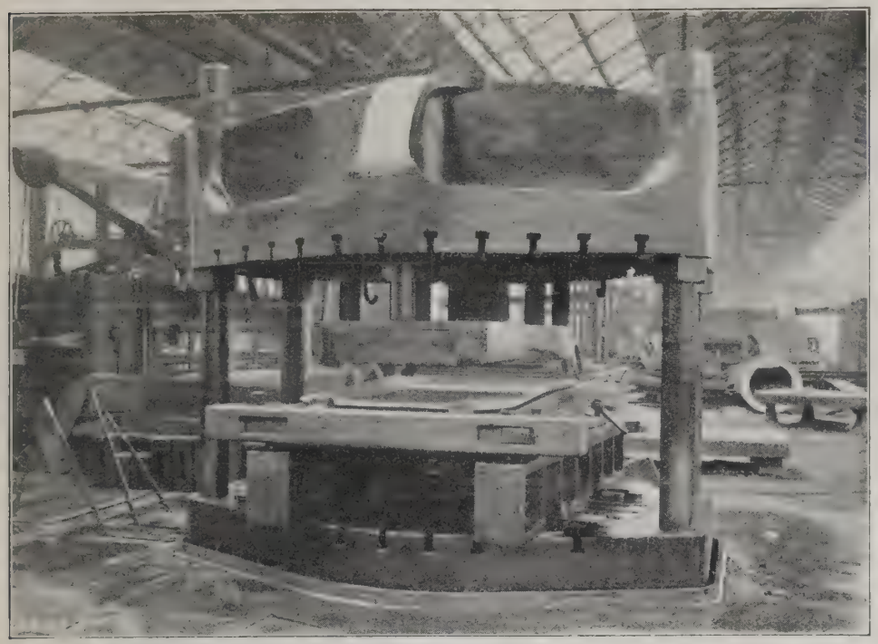


FIG. 2. HYDRAULIC FLANGING-PRESS.

FIG. 3. COPPER WRAPPER-PLATE BEING BENT TO SHAPE.

FIG. 4. FORMATION OF WAIST IN COPPER WRAPPER-PLATE.

NON-FERROUS METALS IN RAILWAY WORK.*

By GEORGE HUGHES, M. Inst. C.E., M.I. Mech. E., Member of Council (Chief Mechanical Engineer, Lancashire and Yorkshire Railway).

INTRODUCTION.

IN order that this paper may be confined to reasonable limits, the author proposes to state exactly the proposition he intends to submit. He does not design to go beyond the locomotive and carriage departments—that is to say, he will exclude the use of non-ferrous metals in the hydraulic, goods yards machinery, gas, electric telegraphy, electrical traction, and marine departments. He cannot avoid the occasional mention of the ferrous metals, where it is necessary to give reasons for the use of the non-ferrous.

The whole scheme is to lay before the members the practical side of the subject, stating difficulties in manufacture, and some means of overcoming them ; wear and tear ; and the life of the various non ferrous component parts of rolling-stock, with the object of eliciting a combined practical and scientific discussion, and specific points in the paper will be emphasised in order to bring this out.

The author has given attention to the valuable uses attending the employment of copper in the shape of the plates, stays, and tubes, particularly in the forms under which this material is actually obtained from contractors and used in locomotives. Analyses, tests at normal, and at temperatures equivalent to modern locomotive boiler conditions, are shown, together with life of material, worked up into fire-boxes, and some samples of wear and failure are brought forward and exhibited on the table.

A section on some of the various brass-foundry alloys used as brass castings on the Lancashire and Yorkshire Railway rolling-stock has been added, together with information regarding manufacture, composition, tests, and life, under every-day conditions of railway service.

Finally, a short account of the bearing metals used, under the name of white metals and other alloys, has been included, together with a notice of non-ferrous metals in the carriage and wagon departments.

The modern British locomotive, as exampled in Fig. 1, page 398, is one of the four-cylinder passenger engines of the Lancashire and Yorkshire Railway. In the design and construction of this type of engine the author, moved by commercial considerations, has kept down the use of copper and brass mainly to those parts for which no reliable substitute has yet been obtained.

On this locomotive, having a total weight of 87 tons 15 cwt. empty, the weight of copper and brass is as follows :—

	Tons	Cwt.	Per Cent.
Copper plates	2	15	3.1
,, stays	0	16	0.9
,, pipes	0	5	0.3
Brass-work	2	2	2.4
Total brass and copper ...	5	18	6.7
Other material	81	17	93.3
Total ...	87	15	100.0

This table excludes copper tubes, which are only used on some engines of this class. When copper tubes are included, the weights and percentages become :—

	Tons	Cwt.	Per Cent.
Total brass and copper ...	11	7	12.9
Other material	76	8	87.1
Total	87	15	100.0

COPPER.

Plates for Locomotive Fire-Boxes.—Although steel has been used experimentally, more or less, copper is the standard practice for Great Britain, the Colonies and Dependencies, the Eastern Hemisphere, and South America, whilst steel is the practice of the United States and Canada. The experience of the Eastern Hemisphere in regard to steel fire-boxes is that, owing to serious corrosion on the water side, and cracking of the plates after a very short service, this material has been abandoned. Copper plates used on the Lancashire and Yorkshire

TABLE I.—*Tensile Tests.*

Description of Materials.	Maker.	Length of Specimen.	Tons per Sq. in.	Per Cent. of Original Length.	Contraction of Area per Cent.	
		in.				
Copper tube-plates ..	"A"	8	15.2	41.6	43.7	Close bend test double.
		8	14.8	45.0	40.7	
		8	14.9	40.6	44.5	
Copper wrapper-plates :— 18 ft. 10½ in. by 7 ft. 6 in. by $\frac{9}{16}$ in.	"B"	8	14.24	39.0	37.8	
		8	14.28	39.5	44.3	
		8	14.22	40.0	48.4	
Copper wrapper-plates :— 15 ft. 6 in. by 12 ft. 10 in. by 5 ft. 2 in. by $\frac{9}{16}$ in.	"C"	8	14.4	46.0	47.9	
		8	14.6	45.0	46.0	
		8	14.8	43.0	46.5	
Copper wrapper-plates ..	"D"	8	14.81	45.5	45.9	
		8	14.85	49.5	54.5	
		8	14.96	45.5	50.8	
Average test	..	..	14.66	43.36	45.9	

* Paper read before the Institute of Metals at Newcastle, September 20, 1911.

Railway are purchased to Specification No. 1, shown in the Appendix, which is identical with Class A of the Engineering Standards Committee's Specification of 1906, and includes chemical analyses and tensile and bend tests, every plate being annealed by the maker.

Table I. gives examples of the tests obtained from four separate makers, the minimum specification of 14 tons tenacity with 35 per cent. elongation on 8-in. specimen being readily met.

Typical analyses of plates are :—

Copper.	Arsenic.	Combined Oxygen.
99.30	0.46	0.1
99.32	0.43	
99.3	0.51	

Impurities, chiefly antimony, lead, iron, nickel, tin, and sulphur, not exceeding 0.25 per cent.

Flanging.—Copper fire-boxes are normally made up of three separate plates—viz., firehole door-plate, tube-plate, and wrapper. The two former are flanged by hydraulic press (Fig. 2), the latter plate being bent cold to shape, by pulling over a shaped block (Fig. 3), and the waist is formed as shown in Fig. 4. As an example of hydraulic flanging, the tube-plate for Belpaire boilers may be noted. This plate is obtained from the makers as shown in the specification, Appendix I. It is left 1 in. thick in the area marked for the tube-holes, the rest of the plate being hammered down to $\frac{5}{8}$ in. and annealed by the maker. It is flanged in the cold state under a 750-ton press, using 2000 lb. per sq. in. hydraulic pressure, with the aid of cast-iron blocks (Fig. 2), care being taken to allow an easy flow of material round the flanges, which are formed without difficulty as regards tearing of the material. The plate is then annealed to a temperature of 700 deg. Cent. in a reversible gas-fired furnace, and finally cooled in water. It is next taken in hand by a plater, who inspects it for correctly squared flanges, and sets up any part which may not be to gauge. The copper scale from the cooling bosh is periodically taken out, collected, and dried, when it is found to contain 80 per cent. metallic copper. This scale is sold to contractors, or, on occasions, reduced to a metallic state in the foundry.

Life of Fire-Boxes.—It is difficult to make just comparisons. The life of copper boxes and component parts is influenced by many contingencies, such as pressure, constant employment, and the admittedly more severe use during the past few years; that is to say, the life depends more upon the tons hauled than the actual miles run, and during the past few years more tons have been hauled per train-mile than formerly. Copper fire-boxes on the Lancashire and Yorkshire Railway have a life of from 10 to 16½ years. The older engines, with 140 lb. pressure, are found to run their fire-boxes up to as much as 500,000 miles, an average figure for seventy engines being 310,000 before replacement by new ones. In standard engines, such as the radial-tank and six-wheeled coupled goods classes, working at 160 lb. pressure, the average life of a copper fire-box is 11 years, with average mileages of 272,000 and 235,000 respectively. These figures are based upon records of 120 locomotives. The author has not as yet any authoritative figures to put forward as to the life of fire-boxes of the larger Belpaire type of boiler of 180 lb. pressure. Individual copper tube-plates in the fire-boxes above named require renewing during the life of the box, and here again the older engines show longer mileages for the lower pressures. In the radial-tank class records of fifty-three tube-plates show an average life of 7¾ years with 205,000 miles before renewing, whilst the six-wheeled goods average 135,000 miles for 144 tube-plates. The remaining plates—viz., door and wrapper-plates—practically do not require replacing during the life of the fire-box, but certain repairs and patches are fitted if necessary. Some of these are shown in Figs. 5 to 8, below, which illustrate various methods of patching, due to grooving, wear, and other causes. These illustrations cover the whole system of patching; but such a combination never occurs in one box. Each case is carefully gone into, and decided as to whether it is commercially sound to patch or not.

Referring to the illustrations, patch A is used for vertical fractures, due to expansion in the copper tube-plate flange, and it is placed inside the fire-box and fixed by steel rivets. The tube-holes are tapped, and brass bushes screwed in and beaded over. The tube ends, after drawing down, are finally expanded to the holes. (Sample of a fractured plate is shown on the table.)

Patch B is placed on the water side of the tube-plate, and is used to strengthen the copper tube plate when fractured between the tube-holes. The tube-holes are bushed similarly to those in patch A.

Patch C is a half-side of copper, and used in exceptional cases when the plate has worn thin below the brick arch, at which part the wear is greatest, caused by abrasion and contact with the fuel. A sample shown on the table illustrates the heavy wear, mainly in the centre of the plate immediately adjoining the foundation-ring, as well as certain fractures about the stay-holes.

Patch D is used occasionally for sides, front, back, and roof of fire-box wherever a plate is locally cracked or become thin either on the fire or water side. (For example, the thinning of the specimen exhibited would be a case for patch D.)

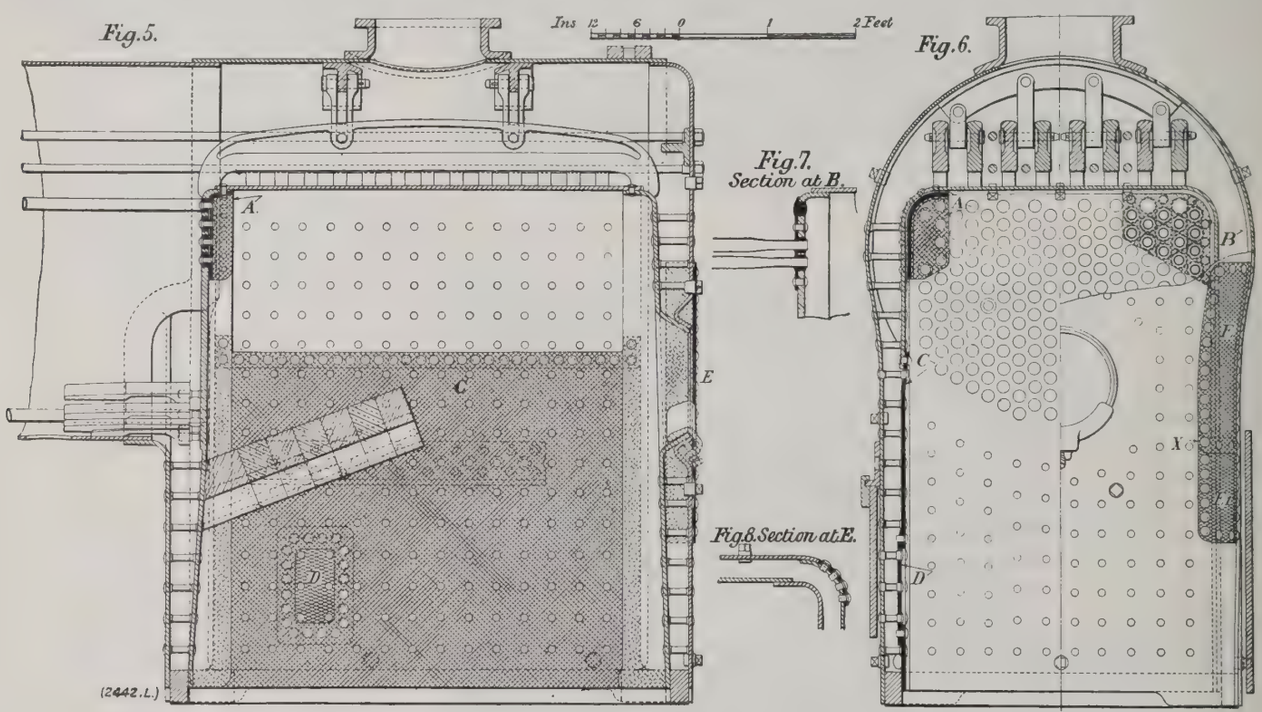
Patch E is a shoulder patch of copper placed on the outside of the steel fire-hole door-plate. Expansion in this plate produces vertical fractures or grooves which may even slowly extend from the inside right through the $\frac{5}{8}$-in. plate.

Similarly E1 is an extension piece used very occasionally to continue the previous patch. Like the plates, the heads of the stays in the fire-box wear by abrasion and the action of the fuel, mainly below the brick arch, the specimens showing this very clearly.

TABLE II.—*Test of* 1-*In. Diameter Copper Bolt. Length of Specimen,* 8 *In.*

Maker.	Tons per Square Inch.	Description.	Per Cent. of Original Length.	Percentage Contraction of Area.	Remarks.
"A"	15.2	Tensile	43.0	68.64	Close bent test double
"A"	14.8	,,	45.0	71.6	Ditto
"A"	14.9	,,	47.0	68.64	Ditto
"B"	14.8	,,	51.0	68.8	Ditto
"B"	15.0	,,	49.5	70.0	Ditto
"B"	15.06	,,	49.0	68.8	Ditto
"C"	14.53	,,	46.5	64.4	Ditto
"C"	14.62	,,	47.5	60.6	Ditto
"C"	14.59	,,	45.0	56.7	Ditto
"D"	14.82	,,	45.0	58.1	Ditto
"D"	14.72	,,	47.0	60.6	Ditto
"D"	14.82	,,	47.5	65.5	Ditto
Average	14.82	..	46.9	65.19	—

Table III. records tensile tests of this material taken at 200, 300, 400, 500, and 650 deg. Fahr. The apparatus employed (Fig. 9) consists of a sheet-steel tank A riveted to the base B. The test-piece T P is coupled to the tank and tension-rod T 1 by the nut C, which also carries the tube D serving to isolate the test-piece from the heating medium. The upper end of the test-piece is coupled to the tension-rod T 2 by the nut E, which fits sufficiently close in tube D to prevent free circulation of air. A thermo-couple or thermometer inserted through tube F has its end in actual contact with the test-piece up to the moment of testing. A Bunsen burner serves to heat the tank and contents, which may be oil, or, for temperatures over 550 deg. Fahr., some metal having a low melting-point, such as tin. The material used in the tests consisted of a bar of 1-in. diameter copper bolt. This was annealed by the particular manufacturers from whom bolt bar of slightly higher tenacity than usual is regularly obtained, this accounting for the 15.3-tons tenacity in the normal temperature.



FIGS. 5 TO 8. PATCHES ON FIRE-BOX PLATES.

FIRE-BOX STAYS.

Copper Bolt.—With the exception of the United States, copper is the universal material employed for this purpose. It is the most reliable. Some proprietary articles or mixtures have been tried from time to time, but so far without success. In regard to bronze stays of varied compositions, they get slack in the plate by reason of the different expansions, and the heads burn and drop off much more readily than copper. There is a tendency for the copper plate to bulge round the head of the stay, and copper stays withstand this much better than an alloy.

Copper bolt for stays is specified (Appendix II.) to contain slightly less arsenic than in the case of plates. Table II. shows tests from various consignments, which consignments regularly comply with a specified minimum tenacity of 14 tons per sq. in., and a 40 per cent. extension on 8 in.

Typical analysis :—

Copper.	Arsenic.
99.4	0.33
99.2	0.37
99.42	0.27

TABLE III.—*Temperature Tests of* 1-*In. Diameter Copper Bolt. Length of Specimen,* 3 *In.*

No. of Test.	Temperature.	Section. Dimensions. Inches Diameter.	Section. Area. Sq. In.	Stress. Total Tons.	Stress. Tons per Sq. In.	Strain. Description.	Strain. Ultimate Set.	Strain. Per Cent. of Original 3 In.	Fracture. Area in Sq. In.	Fracture. Percentage Contraction of Area.	Remarks.
	dg. F.										Fibrous
1	Normal	0.66	0.342	5.24	15.3	Tensile	1.41	47.0	0.126	63.2	Silky
2	200	0.66	0.342	4.75	13.9	,,	1.38	46.0	0.120	64.9	,,
3	300	0.66	0.342	4.34	12.7	,,	1.25	41.5	0.120	64.9	,,
4	300	0.66	0.242	4.36	12.8	,,	1.37	45.5	0.120	64.9	,,
5	400	0.66	0.342	4.10	12.0	,,	1.29	43.0	0.113	66.9	,,
6	400	0.66	0.342	4.07	11.9	,,	1.28	42.5	0.113	66.9	,,
7	500	0.66	0.342	3.68	10.8	,,	1.22	40.5	0.152	55.6	,,
8	650	0.66	0.342	3.32	9.7	,,	1.01	33.5	0.196	42.7	,,

The figures show a reduction in strength of practically

TABLE IV.—TABULATION OF COPPER TESTS FOR COMPARISON.

Mark	Description.	Analyses. Copper.	Nickel.	Tin.	Lead.	Arsenic.	Bismuth.	Phosphorus.	Manganese.	Iron.	Combined Oxygen.	As Received, Annealed. Tensile, Tons per Sq. In.	Elongation per Cent. in 8 In.	Contraction, per Cent.	Fracture.	Heated Ten Hours at 750 deg. C. (In Laboratory). Tensile, Tons per Sq. In.	Elongation per Cent. in 8 In.	Contraction per Cent.	Fracture.	Heated Nine Hours in Locomotive Fire-Box. Tensile Tons per Sq. In.	Elongation per Cent. in 8 In.	Contraction per Cent.	Fracture.
A	Phosphorised, 1 in.	99.8	trace	..	trace	0.12	..	0.06	..	trace	..	14.3	57	81.0	Silky fibrous..	14.7	58.9	79.3	Fibrous distressed	14 6	51	79	Fibrous distressed
B	Ditto 1⅛ in.	99.9	..	..	0.03	trace	..	0.05	..	0.01	..	14.8	52	79.9	Ditto ..	14.7	67.3	83.6	Fibrous red	14.6	49	94	Ditto
C	Copper-manganese	90.4	..	..	..	..	..	..	7.78	1.82	..	25.1	29	57.6	Brown dark fibrous	24.7	35.5	57.3	Brown dark fibrous	24.5	36	60.6	Fibrous
E	High arsenic ..	99.3	0.05	..	0.07	0.48	..	..	..	..	0.11	14.7	50	59.4	Silky fibrous..	14.6	48.5	55.1	Fibrous glossy	14.5	45	60.6	Fibrous distressed
P	Ditto ..	98.94	0.05	..	0.09	0.87	..	..	..	0.05	..	15.8	54	78.4	Spiral fibrous	15.3	53.0	77.2	Fibrous brown distressed	15.5	53	79	Ditto
H	High tensile..	99.7	0.01	..	trace	0.20	..	0.04	..	0.03	trace	15.2	53	77.3	Ditto ..	15.5	54.3	76.8	Spiral fibrous	14.5	45	75	Ditto
N	Copper-nickel ..	98.05	1.92	..	..	trace	..	0.09	..	..	..	15.2	49	78.2	Ditto .	16.1	43.0	75.2	Silky conchoidal	17.1	48	83	Ditto
F	Copper to L. and Y. specification	99.4	0.04	0.03	0.05	0.45	..	..	..	..	0.07	15.4	52	63.5	Silky fibrous..	..	..	..	..	15.0	46	60.6	Fibrous

Fig. 9. HEATING APPARATUS FOR TENSILE TESTS.

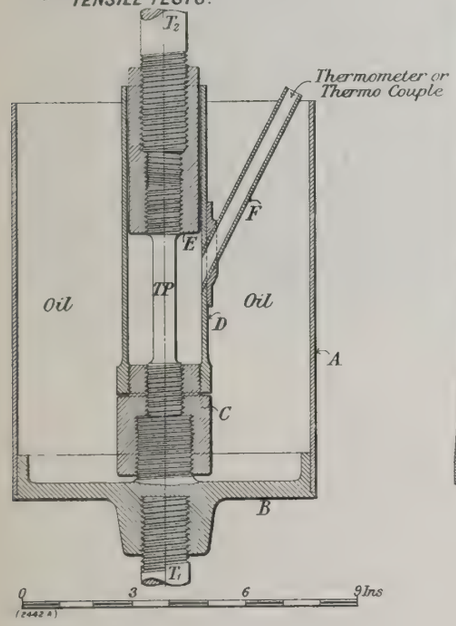


Fig. 10. POSITION OF BROKEN COPPER STAYS IN FIREBOX.

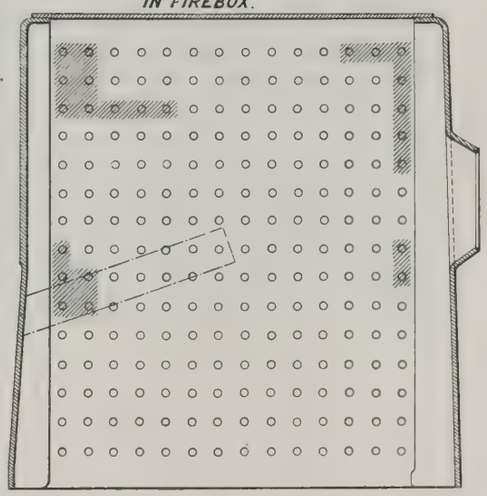
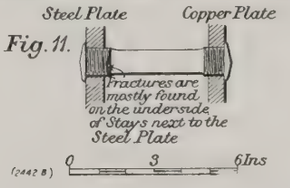


Fig. 11.



COPPER STEAMPIPE IN SMOKE-BOX.

Fig. 12.

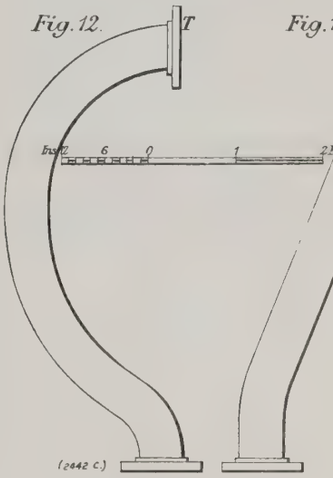


Fig. 13.

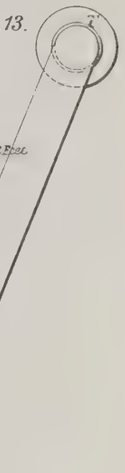


Fig. 14.

METHOD OF DETERMINING THE TEMPERATURE OF BRAZING.

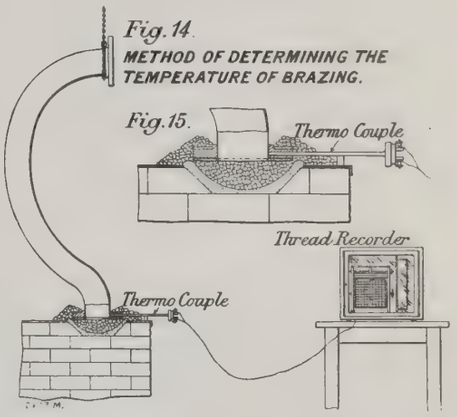
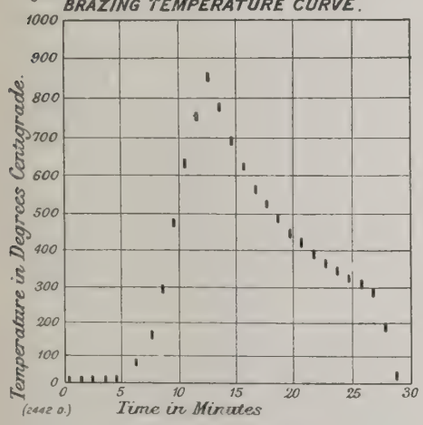


Fig. 16. BRAZING TEMPERATURE CURVE.



1 ton per sq. in. per each 100 deg. Fahr. increase of temperature up to 650 deg. Fahr., and the author gives them in this manner for easy digestion. He has every reason to consider them accurate, and they confirm his earlier experiences.

Broken copper stays are found chiefly in the top corners of the side wrapper-plate, near the fire-hole door, and at the brick arch. These positions are indicated in Figs. 10 and 11. If any of the proprietary alloys now on the market have any decided value, it is chiefly in these local areas that their advantage will be most apparent, and trials to ascertain this are proceeding.

Table IV. gives particulars of composition, and some tests as compared with arsenical copper, but no definite success has as yet been recorded. The author leaves for discussion the consideration of a higher percentage of arsenic in copper stays than the limits of 0.15 to 0.35 per cent. stated in Appendix, Specification No. 2.

Manufacture.—Copper stays, 1 in. in diameter, screwed eleven threads per inch, are the standard practice. They are screwed at both ends, the centre being turned down below the bottom of the thread to $\frac{7}{8}$ in. diameter. The over-all length varies from 4½ in. to 7½ in., according to their position in the fire-box. They are turned direct from the bar on modern automatic machines from round annealed bars supplied by the makers and passed through the reeling mill before turning. The stays are inspected for ragged threads, flats and seams developed after screwing, and correct pitch of thread, a limit of $\frac{12}{1000}$ in. being allowed at the ends.

The total rejections are about 2 per cent., the greater part being due to the material, and not to the inaccuracy of the machines themselves. Broadly speaking, the bolt-bar which screws best is that which has the slightly higher tenacity after annealing.

Copper Pipes.—Copper pipes are invariably solid drawn and seamless; they range from small lubricating pipes of $\frac{3}{8}$ in. in external diameter and No. 16 I.W.G. to main steam-pipes $6\frac{3}{8}$ in. in external diameter of No. 5 I.W.G. The external pipes of the boiler consist of solid-drawn tube, $\frac{3}{4}$ in. to $2\frac{1}{2}$ in. in diameter, and of No. 10 and 11 I.W.G. for the injector and ejector, steam, exhaust, and delivery pipes. Pipes and tubes are obtained to Specification No. 3 in Appendix. The internal main steam-pipe is a straight piece of 6 in. diameter No. 6 I.W.G., with brass cone and flange at the ends. The smoke-box steam-pipe (Figs. 12 and 13) is 5½ in. inside diameter, No. 5 I.W.G., with flanges brazed at each end. These pipes are received hard from the makers, and cut to lengths at the railway company's works.

Brazing.—Flanges of brazing metal (copper 84 per cent., zinc 16 per cent.) are machined inside and on the front face. Before brazing, the copper pipe is first annealed to a temperature of 650 deg. Cent. and allowed to cool. After filling with molten resin, and plugging each end with lead, it is bent cold to template in an hydraulic press, being afterwards hammered to remove slight kinks. After warming to melt the resin out, it is heated a second time in a furnace to a blood-red heat and allowed to cool. It is then fitted with loose flanges whilst in its position in the template smoke-box in the copper shop, after which the flanges are brazed to the pipe.

BRAZING.

The flange having been fixed to the pipe, as described, and backed over at the front with a pæning hammer, a covering of fireclay is placed on the top and bottom of the flange to protect it from the coke fire. Granulated brazing solder (copper, 58.3 per cent.; zinc, 41.7 per cent.) is then put on the top joint, a clay channel being formed on the top between the flange and the pipe, and ground borax is used as a flux to assist the solder to run freely. The pipe and flange are embedded in clean foundry coke and air-blast applied; liberal use of flux and solder is made, and the pipe is heated until the metal runs in the joint satisfactorily, the copper pipe attaining a good red heat for about 6 in. above the joint. The operation takes 15 minutes. Pyrometer readings show a temperature in the centre of the brass flange of 865 deg. Cent. as the highest during the operation. The brazing solder used has a melting range of 780 deg. to 790 deg. Cent. The pipe is now taken off, allowed to cool (the fireclay cover and superfluous metal being removed), and subjected to an hydraulic test of 350 lb. per sq. in.

Cold bend tests on strips sawn close to the brass, when the brazing has been carefully performed, show no deleterious effects on the material, the strips bending close double, as good copper should which has not been spoiled. Owing to the fact that copper loses its tenacity at high temperatures, and that the range between the brazing heat and the melting-point is narrow (865 deg. Cent. and 1050 deg. Cent.), it follows that the value of a brazed joint is in proportion to the skill of the workman, and perhaps no operation depends so much upon the operator; consequently this is a valuable point for discussion.

To further illustrate the time and temperature conditions during this important operation, the author has recorded a heating and cooling curve taken by means of a platinum-platinum-iridium couple working in conjunction with a thread recorder. In the experiment (Figs. 14 and 15)

a ½-in. hole was drilled through the brass flange, and after fixing the copper pipe ready for brazing, a thermo-couple was inserted at the junction of the pipe and flange, and attached to the recorder. Both instruments were calibrated before and after use.

The operation of heating up and brazing occupied a period of 8 minutes, the maximum temperature attained being 865 deg. Cent. (Fig. 16). The pipe was then withdrawn from the hearth and allowed to cool down to 300 deg. Cent. before finally cooling off.

WEAR AND TEAR OF COPPER STEAM-PIPES.

Failures of copper steam-pipes may be classified under three heads:—

1. *Cracks in the Pipes Close to the Top Flange.*—It is particularly noteworthy that these cracks occur at the top flange (Figs. 12 and 13), connecting to the boiler T-pipe. This suggests that the "breathing" action which occurs is concentrated at this spot, instead of the whole length of pipe taking its share; the bottom flange, being more in the line of direct stress, does not flaw, the expansion occurring at the top, and the remedy is to make an easier sweep in the pipe instead of a short, stiff bend.

2. *Wear or Abrasion of the Pipe Body.*—Abrasion of the body of the pipe is the result of the blast action on the fire, both gases and cinders meeting the pipe on their passage to the chimney. The greater wear takes place about half-way down, and to alleviate this action, pipes are bent as much as possible out of the line of draught.

3. In cases where a brass nipple is brazed in the middle of the pipe for lubrication connections, trouble with cracks in the pipe has been experienced, but this practice is discontinued. Some of the cracks which the hydraulic test disclosed in steam-pipes taken from engines undergoing repairs were possibly due to workmanship in stripping the connections; others were caused by local hardening, due to brazing at this point, and to resistance which the nipple would set up to wriggling—*i.e.*, a considerable number of small changes of position.

Steel steam-pipes are now being used to replace copper on engines fitted with steam-superheaters which attain temperatures of 650 deg. Fahr. When the engines are at work the smoke-box temperature is from 700 deg. Fahr. to 900 deg. Fahr.

BOILER TUBES.

Copper and steel tubes are used, and their life in locomotive boilers, taken over a period of eight years, is as follows:—

	Miles.
Copper, first period (new)	110,000
Copper, second period (drawn) ...	80,000
Copper, third period (pieced)... ...	50,000
Total	240,000

and subsequently 30 to 40 per cent. of those pieced are treated so again.

	Miles.
Steel, first period (new) ...	70,000 to 80,000
Steel, second period (pieced) ...	30,000 to 40,000

Copper tubes are obtained to Specification No. 4 in Appendix, Table V. giving representative tests. They are used extensively in this country, although mild steel is now the standard practice.

TABLE V.—*Tensile Tests of Copper Boiler-Tubes.*

Sizes.	Specimen. Length of Inches.	Section. External and Internal Diameters. Inches.	Section. Area. Sq. In.	Stress. Total Tons.	Stress. Tons per Sq. In.	Strain Per Cent. of Original Length.
14 ft. 10¼ in. × 2 in. × 9/11 I.W.G. ..	8	1.990-1.767	0.658	11.80	17.70	31.25
14 ft. 10⅛ in. × 2 in. × 9/11 I.W.G. ..	8	1.995-1.755	0.707	11.97	16.93	32.50
14 ft. 10⅛ in. × 2 in × 9/11 I.W.G. .	8	1.990-1.754	0.721	11.71	16.24	32.50
10 ft. 11½ in. × 1⅞ in. × 10/12 I.W.G. ..	8	1.738-1.524	0.548	9.50	17.33	29.00
10 ft. 11½ in. × 1⅞ in. × 10/12 I.W.G. ..	8	1.738-1.525	0 546	9.70	17.76	26.00
10 ft. 11½ in. × 1⅞ in. × 10/12 I.W.G. ..	8	1.738-1.523	0.550	9.55	17.36	30.00
14 ft. 10¼ in. × 2 in. × 9/11 I.W.G. ..	8	1.997-1.764	0.688	13.07	19.01	32.00
14 ft. 10⅛ in. × 2 in. × 9/11 I.W.G. ..	8	1.993-1.762	0.682	13.05	19.13	32.50
14 ft. 10⅛ in. × 2 in. × 9/11 I.W.G. ..	8	2.000.1.762	0.684	11.20	16.37	39.00
0 ft. 11½ in. × 1⅞ in. × 10/12 I.W.G. ..	8	1.749-1.541	0.537	9.31	17.33	26.20
10 ft. 11½ in. × 1⅞ in. × 10/12 I.W.G. ..	8	1.749-1.542	0.535	9.28	17.32	25.60
10 ft. 11½ in. × 1⅞ in. × 10/12 I.W.G. ..	8	1.749-1.541	0.537	9.26	17.24	26.90
Specification		..	..	..	17.00	25.00

Brass tubes are used in India, and there exclusively, on account of the high percentage of pitting and corrosion in steel tubes.

COPPER ALLOYS.

Before considering specifically these alloys, the author thinks it will be interesting to preface this section with the method of dealing with the large amount of scrap, which, in all large establishments, is of considerable quantity and importance per annum. This comprises articles which, worn out in service, are sent in to the central dépôt for utilisation and disposal. The economical working up of this material presents a problem to those responsible for the brass-foundry costs and workings, and some account of its disposal may be of interest.

Considered under the headings of "home" or "rolling-stock" scrap, and "outside" material from all other departments, the first is fairly readily accounted for by separating all articles whose composition is known, and using them over again as an addition to the new mixture. Slide-valves, for instance, are branded by distinguishing marks cast on, and are used again together with the shop gits in proportion of half old valves and half other constituent metals, these latter not usually new ingots. Scrap of unknown value from "outside," as well as borings and turnings from the machine-shops, cannot be dealt with so directly. Brass borings received from the machine-shop are generally contaminated with iron and steel turnings and sweepings, and also may be mixed with white metal from the boring-machines.

In order to separate these ingredients, borings containing white metal alloy are heated on a sloping hot plate over a coke fire, so inclined that as the white metal softens and melts, it gradually runs off into a receptacle, leaving the brass to be scraped over the top of the plate.

The whole of the brass borings received for melting-up are passed over a magnetising machine to extract the iron particles, which are collected and taken away. This makes for cleaner castings and more homogeneous material.

It is then customary to work this up by melting in an air-furnace of 25 cwt. capacity, fired by producer-gas. A definite composition is arrived at, and subsequently cast into iron chill-moulds in the form of ingots. Such ingots, after their composition is ascertained by analyses, can then be profitably used in many directions, by forming the basis of fresh charges, along with other small amounts of new metal, to give the desired result.

With the scrap is charged 400 lb. of scrap copper shearings obtained from old fire-box plates in the boiler-shop, and 30 lb. of block tin, the whole charge amounting to 20 cwts. This is melted in two to three hours, and covered with a small quantity of sawdust to reduce oxidation. Samples are withdrawn and their fracture noted, and slight additions of tin or other metal made to bring them to one standard fracture; then the charge is tapped out into a 5-cwt. ladle, and run into ingots. As showing how closely a charge can be represented by indication of fracture tests, analyses in Table VI. are given of consecutive casts as determined by drillings.

This metal is also used for the smaller brass axle-boxes, radial and tender brasses, and for this purpose is poured direct into green sand-moulds, and also cast into ingots to form the bulk of many mixtures.

The metal for the ordinary run of castings is melted in a modern type of tilting crucible furnace (Fig. 17) of 400 lb. capacity, fired by coke and worked by air-blast from a small motor-blower attached to the furnace. The crucible is permanently fixed in the furnace, thereby reducing the risk of cracking due to cooling and handling, and careful records of 45 crucibles show an average life of 39.6 heats before renewal. This method is found to be a distinct improvement over the usual 120 lb.

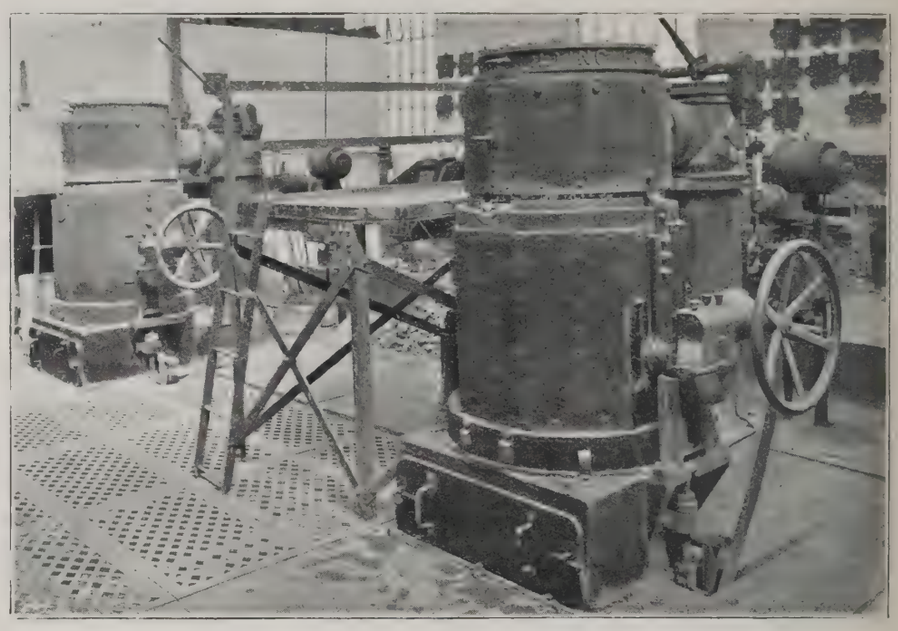


FIG. 17. TILTING-FURNACE.

TABLE VI.—ANALYSES OF BRASS INGOTS MADE FROM SCRAP.

Constituent.	A.	B.	B¹.	C.	C¹.	D.	D¹.	E.	E¹.	F.	G.	G¹.
Copper	86.36	87.15	86.56	86.75	86.95	87.35	87.15	88.53	85.57	86.56	86.36	87.15
Tin and antimony	7.88	7.80	8 35	7.72	7.64	7 41	6.54	5.91	7.96	7.88	7.09	7.09
Lead	3.21	3.00	3.21	2.87	2.87	2.59	3.62	2.73	3.89	3.35	3.41	3.14
Zinc	2.33	1.93	1.77	2.49	2.33	2.41	2.49	2 57	2.41	1.93	2.97	2.41
Iron	0.21	0.14	0.14	0.14	0.21	0.21	0.21	0.21	0.14	0.28	0.14	0.21
	99.99	100.02	100.03	99.97	100.00	99.97	100.01	99.95	99.97	100.00	99.97	100.00

Average of six (A, B, C, D, E, and F): tin, 7.49 per cent.; antimony, 0.08 per cent.
" six (B¹, C¹, D¹, E¹, G, and G¹): tin, 6.93 per cent.; antimony, 0.16 per cent.
" the twelve ingots: tin, 7.21 per cent.; antimony, 0.12 per cent.

TABLE VII.—SAMPLE DAY'S WORK ON MELTING IN A TILTING-FURNACE, NOVEMBER 29, 1910.

Day dry and bright. Fuel used, Durham coke.

No.	Heat. Kind.	Time. Start.	Time. Finish.	Anmeter Reading.	Inches of Water. Blast.	Details of Charge. Cu.	Pb.	Sn.	Zn.	Ingot Metal.	Scrap.	P. Cu.	Charge.	Yield.	Per Cent. Loss on each Heat.	Coke Used.	Remarks.
													t. qr. lb	t. qr. lb.		t. qr. lb.	
1	Gun-metal ..	6.30	7.30	1.6	2½	352	..	40	8	..	..	..	3 2 8	3 2 3¾	1.06	0 2 2	Coke used for starting
2	Slide-valve ..	8 a.m.	9.15	1.6	2¾	160	10	20	..	48	200	10	4 0 0	3 3 24	0.90	0 2 9	Scrap = old slide-valves
3	Injector metal..	10.0	11.15	1.6	2¾	164	5	20½	10½	250½ (special)	..	.	4 0 2½	3 3 27	0.77	0 2 9	
4	Brazing metal ..	11.30	12.25	1.6	2¾		..	..	2	448½			4 0 2½	3 3 17½	2.88	0 2 9	
5	Copper	1.10	2.15	1.6	3	345	..	..	5	..	..	..	3 0 14	3 0 11	0.85	0 2 9	For tube-hole bushes and plugs
6	Injector metal..	2.45	4.15	1.6	3	164	5	20½	10½	248	..	..	4 0 0	3 3 24	0.90	0 2 9	
		7 hours = 2.8 h.p. hours.				..	..	..	..	..	..	.	22 2 27	22 1 23½	7.36	4 0 0	= 19.69 lb. of coke per cwt. of metal melted

crucible heated in a coke "pot" fire and withdrawn for casting purposes, both in life of crucible and amount of coke used per cwt. of melted metal.

Table VII. records a day's run of such a furnace at Horwich. The coke used was of an average Durham quality, having the following composition :—

	Per Cent.
Carbon...	89.24
Sulphur	0.86
Ash	9.35
Moisture	0.55
	100.00

Loss in Melting.

Careful check-weighings have been made of metal used and melted, together with loss due to oxidation. The various charges of metal described in Table VII. have been poured into the ladle with an average loss in furnace of 1 per cent., excepting charge No. 4, containing a high percentage of zinc, which came out at 2.9 per cent. Also it may be stated that 450-lb. charges can be cast with a further, but recoverable, loss of metal of 31 lb. in the form of shots, skimmings, &c., equal to 0.75 per cent.; this is dependent upon the form and quantity of the moulds, proportions of gates, &c.

Brass-Foundry Shot and Sweepings.

All fettler's dust, moulder's spent sand, furnace ashes and slag, are systematically collected and riddled through a ½-in. riddle to collect coke and clean shot-metal, which is separated. Shot-metal and slag or clinker is sent to the pug mill and crushed wet, the recovered shot-metal being stored separately for disposal, whilst the powdered slag, &c., settles and is collected in a water-tank for subsequent sale. The spent sand containing metal particles is also passed through a riddle to collect the larger shot, and afterwards washed in warm water in a hair sieve, thereby collecting every particle of metal, whilst the sand and any oxide dust is likewise washed off and collected for disposal; thus no particle of sand, scale, or dust is thrown away by this procedure.

Slide-Valves.

Slide-valves are made to the following composition :—

	Per Cent.
Copper	84.5
Tin	10.0
Lead	5.0
Phosphorus	0.5 (added as 15 per cent. phosphor copper).

Tensile tests taken normally and at temperatures up to 400 deg. Fahr. do not indicate any particular loss in the strength of this alloy at these temperatures, as compared with the cold state.

Other mixtures containing as much as 13 per cent. lead have been used with fair results, whilst gun-metal valves of an alloy of 86 per cent. copper, 12 per cent. tin, 2 per cent. zinc, and therefore containing no lead, have not justified expectations under comparative tests in service.

The mixture used is made from half old worn-down valves and half new metal, the copper being obtained from clean scrap-plate shearings cut from old fire-box plates. These plates are bought to specification containing arsenic, 0.35 to 0.5 per cent., with other elements (exclusive of combined oxygen), not over 0 25 per cent. This mixture was adopted after trials to find the best wearing properties both of the valve and the cast-iron cylinder port faces. Such valves of varying designs, from the simple "D" valves to the balanced types, have given satisfaction, working under temperatures of from 450 deg. to 600 deg. Fahr. in the steam-chests. They do not fracture in service, and an unbalanced "D" slide-valve ⅞ in. thick will run 1000 miles with a wear of 0.035 in. on the face. The wear of the balanced valves is not so much as this, careful measurements showing (in the case of valves working in a vertical position, known as back-to-back balanced valves) a wear of 0.0055 in. per 1000 miles run. These valves are allowed to wear down § in. for both valves, the total mileage being 114,266.

Modern conditions of superheat have caused the question of valves to again come under revision. The author has pleasure in stating that he has had running for two years a pair of ordinary slide-valves at a temperature of 600 deg. Fahr., with only a wear of 0.013 in. per 1000 miles. He has also just turned twenty engines into traffic with a modified form of slide-valve for superheat. In the strict sense of the term these are slide-valves, and, so far, have given good results. Slide-valves are moulded in sand from plate-patterns. Considerable care has to be exercised in moulding, rapping, and drawing the patterns, as the valves when cast must pass limit-gauges of $\frac{1}{16}$-in. margin before proceeding to the machine-shop for grinding on the face, and to fit the buckles.

(To be continued.)

Canadian Trans-Continental Railway.—The National Trans-Continental Railway in Canada is making rapid progress. The expenditure made on capital account during the fiscal year ending March, 1911, was 23,487,853 dols., making the total construction expenditure since the organisation of the commission in September, 1904) to March, 1911, 95,406,697 dols. The total grading done to the close of March, this year, was 1388 miles. The track laid at the same date was over 1064 miles of the main line and 199 miles of sidings. The total contracts let for steel superstructures, bridges, and viaducts to the close of March, this year, amounted to 49,084 tons. The completed portion of the system has thus far been worked by the Grand Trunk Pacific Railway Company.

THE MECHANICAL PROPERTIES OF HARD-DRAWN COPPER.*

By D. R. Pye, B.A., Stud. Inst. C.E.

Although the possibility of increasing the tensile strength of copper wire by the process known as "hard drawing" has been utilised so universally for trolley wires and overhead power transmission lines, yet any satisfactory standard specification for the properties of hard-drawn copper seems in this country not to exist. The result is considerable confusion, and the application of the term "hard drawn," by different manufacturers, to copper of very various properties.

The General Post Office some years ago drew up a specification for the hard-drawn copper wire made use of by them for telegraph and telephone construction; this specification, while serving admirably to define the properties of the small sizes of hard-drawn copper wire required by the Post Office, becomes inadequate, and even misleading, if applied to the larger sizes of wire.

The most important points in the Post Office specification are, firstly, a minimum tensile strength (varying, roughly speaking, from 27 tons per sq. in. for wire 0.2 in. in diameter to 29.5 tons per sq. in. for wire 0.08 in. in diameter); and, secondly, "the wire shall be capable of being wrapped in six turns round wire of its own diameter, unwrapped, and again wrapped in six turns round wire of its own diameter in the same direction as the first wrapping, without breaking." This wrapping test is insisted upon to guard against the possibility of the wire being hard-drawn to such an extent as to become brittle in an attempt to obtain the requisite tensile strength.

It should be noticed that although the Post Office specification contains no reference among the mechanical tests to any elongation which the wire may undergo before breaking, a limit of elongation was introduced in the electrical tests. It became necessary, in defining the electrical resistance of copper wire, to recognise the difference between soft or annealed wire and hard-drawn wire. Matthiessen's standard of the resistance of pure copper hard-drawn was 0.1469 B.A. ohm (0.1449 ohm) for a wire 1 m. long weighing 1 gramme.† The Post Office, allowing for a difference between Matthiessen's "pure" and commercial copper, gave 0.1539 ohm for the metre-gramme hard-drawn wire, and 0.1508 ohm for the annealed wire. For the purpose, then, not of a mechanical, but of an electrical, specification, the term hard-drawn copper was defined as "that which will not elongate more than 1 per cent. without fracture." That definition, forming as it did the second resolution of the Report of the Committee of the Institution of Electrical Engineers‡ of 1900, was adopted by the Electrical Plant Committee of the Engineering Standards Committee, July 26, 1904. It is true that the British standard tables of copper conductors issued by this Committee deal only with weights, sizes, and insulation resistances, and relate to copper wires and cables in which low resistance of the conductor is desirable, and its mechanical strength is of no importance, but, nevertheless, this apparently mechanical definition, vaguely as it was expressed, was misleading. Nor was it improved by a note added in 1909. "N.B.—The elongation referred to in Clause 2 is the permanent elongation at maximum load exclusive of the extension at fracture." This seems to suggest that the general stretch of the wire was to be regarded as the elongation, and would, perhaps, excuse the omission of the length of the test-piece.

Meanwhile a need was becoming felt for some specification of the mechanical strength of copper wire for purposes where strength is needed. In 1904 the demand for trolley wire had led to the production of a rolled-rod instead of a drawn wire. As an electrical conductor it was no doubt excellent, it could stand the ordinary stresses of tramway work, but it was so soft that it wore quickly. It was not necessary to ask for a high tensile strength, but since the testing of hardness by the sclerometer is not common, and the units in which such tests are made are not well understood, the sub-committee on Electric Tramways of the Engineering Standards Committee fell back on minimum tensile breaking strength as a means of specifying for the desirable hardness, since these two properties are roughly related. Their report (No. 23), perhaps the shortest that has been published by the Committee, is as follows :—

"The following figures are recommended as the minimum tensile breaking strengths, in tons per square inch, for standard trolley wire :—Up to and including 00 S.W.G., not less than 24; above 00 S.W.G., not less than 22."

This recognises that high tensile strength is more easily secured with smaller sizes than with larger.

In another branch of electrical engineering—namely, overhead lines for the transmission of power—no great tensile strength is needed for moderate spans, but it is very desirable that the wire should not be brittle. In the sizes commonly employed, from No. 6 S.W.G. (say 0.03 sq. in. section) to 000 S.W.G. (0.1087 sq. in.), a wire which would break before it elongated 1 per cent. in the usual test-length of 10 in. would be a very brittle wire. But in the absence of other information, many engineers adopted the second resolution of the Report of the Engineering Standards Committee on Copper Conduction, and specified that the elongation should not exceed 1 per cent. This conflicted with a requirement of the Board of Trade, that the elongation should not be less than 2 per cent. in a length of 10 in. This led to another revision of the report, and after much discussion the separate resolution about maximum elongation disappeared, and the following sentence was tacked on to the first resolution which deals with the resistance of the metre-gramme hard-drawn copper wire :—"For the purposes of this definition the term 'hard-drawn copper wire' shall apply to copper wire which does not elongate more than 4 per cent. on a gauge length of 10 in. when broken by tension." The note excluding the extension at fracture disappeared, and the statement, whatever value it may have "for the purposes of this definition," is of no possible use for engineers who have to specify for the mechanical properties of copper wire where strength is a consideration.

No doubt the engineers of the Post Office, when copper wire came into use for telegraph work, first sought for a kind of wire which would suit their purpose, then found the elongation on breaking, and thereupon defined what they meant by hard-drawn copper. The distinction between hard-drawn and soft-drawn copper wire is purely arbitrary. Thirty years ago wrought iron was supposed to be a distinct material from steel, to-day it is hardly possible to discriminate between them, for all intermediate qualities exist. Similarly, copper wire passes from the annealed, high conductivity, weak, soft, and inelastic kind to the hard-drawn, lower conductivity, higher density, strong, elastic, and even brittle kind, through all the intermediate stages. In the process of wire-drawing the material goes through these changes, and at any point it can be restored to the soft kind by annealing.

Modern high conductivity copper is always obtained electrolytically, and there is probably very little difference in the material; the differences depend almost entirely on processes of manufacture—that is to say, in rolling and drawing.

To emphasise more clearly this relationship between the various properties of copper, it may be expressed in tabular form as follows :—

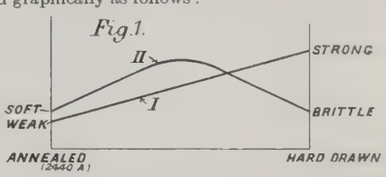
Annealed Wire.		*Hard-Drawn Wire.*
High conductivity	passing to	Lower conductivity.
Low tensile strength		Higher density.
Plastic		Higher tensile strength.
Soft		Elastic.
		Hard, and possibly becoming brittle.

A wire-drawer can therefore supply almost any kind with equal facility so long as only one characteristic is asked for, or several characteristics which are to be found in any one kind. The term "hard-drawn" is only recognised by the makers as a general expression covering one end of the various kinds with annealed wire at the other.

Although in tramway work the question of tensile strength is not of great importance, since the limits of strength are not seriously approached, yet in overhead transmission lines, where an increase of span would involve reduction of expense, it is important to consider what combination of desirable properties can be attained.

The danger to be guarded against in an attempt to obtain high tensile strength is the possibility of the wire becoming brittle.

The variation of the mechanical properties of copper, after various degrees of "hard-drawing," may be illustrated graphically as follows :—



The straight line I shows the increasing tensile strength as the wire passes from the annealed to the hard-drawn condition. The line II represents the desirable property which may be called "toughness;" at one extreme toughness diminishes until softness is reached, in the other direction it diminishes until brittleness is reached.

The most useful quality would be a combination of tensile strength with toughness. Now, it is evident that it is the diminution of toughness in the direction of brittleness which must be guarded against, and it is in connection with this that the vexed question of extension at fracture is of value.

The wrapping test of the Post Office specification, though it serves admirably to guard against brittleness in the small sizes of wire, becomes impossible for the larger sizes, and some other test must be resorted to.

Extension per cent. at fracture may be considered, roughly speaking, as the inverse of brittleness, and the logical specification for good quality wire would therefore fix a minimum tensile strength and a minimum extension per cent.

On inquiry among the leading manufacturers, it became evident that considerable vagueness exists in this country as to the properties of hard-drawn copper wires, and there is no standard specification to act as a guide as to what may be expected in point of tensile strength and elongation before fracture.

The important point is that tensile strength per square inch and elongation are both functions of the diameter for similarly manufactured wires of different sizes. Whereas the Post Office specification of a tensile strength of 27 tons per sq. in. is quite normal for wires of 0.2 in. diameter, a strength of 23 or 24 tons per sq. in. is scarcely ever attained in wires of 0.5 in. diameter. Again, with wires of the above diameters and similarly manufactured, the larger one would probably give an elongation per cent. on a 10-in. test-piece of more than double the smaller size.

Mr. A. P. Trotter, electrical adviser to the Board of

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* Paper read before the Institute of Metals at Newcastle, September 20, 1911.

† *Philosophical Magazine*, May, 1865, B.A. Report, 1864, Latimer Clark's "Metric Measures," page 20.

‡ Journal of the Institution of Electrical Engineers, vol. xxix., page 170.

Trade, urged the desirability of adopting a comprehensive definition for hard-drawn copper which would be applicable to wires of all sizes. He further pointed out that such a definition, instead of fixing a maximum elongation at fracture, should rather state a minimum, since elongation, provided the necessary tensile strength is obtained, is undoubtedly a desirable property.

The advantage of having a standard specification for hard-drawn copper wires of all sizes is obvious, for there would then exist a fixed standard representing good manufacturing practice, and the engineer has merely to insist that the material supplied shall conform to this standard. At the present time a number of different specifications are in use, almost every tramway or other system having one peculiar to itself.

After studying an account by Mr. Thomas Bolton (*Electrical Review*, January, 1907), of tests upon hard-drawn copper wires, Mr. Trotter came to the conclusion that not only was the tensile strength per square inch dependent upon the diameter, but that there was a linear relation between the two; he suggested that the tensile strength might be expressed by a formula of the form

$$T = a - bD,$$

Having no facilities for conducting experiments on his own account, he forwarded all his data to Professor C. F. Jenkin at the new engineering laboratory at Oxford University, suggesting that he should make a thorough investigation of samples of hard-drawn copper, and so produce reliable evidence upon which a definition could be framed. This investigation the author undertook.

The unsatisfactory part of such experiments is, of course, that the hard-drawn copper produced by no two manufacturers is identical; that therefore no experiments can be said to give accurate information of the material as a whole. Moreover, it is not possible, as a rule, to obtain exact information as to the process which the copper has undergone, since most manufacturers have secret processes which are jealously guarded.

On the other hand, if a set of experiments were made on a number of samples supplied by the leading manufacturers, it was thought that the information obtained would be of real value to engineers, since it would give a definite guide as to what may be expected in the way of strength and elongation from first quality hard-drawn copper. It would establish a standard of manufacture obtained by the best makers, below which material should not be allowed to fall.

Specimens of hard-drawn copper wire were obtained from four leading firms of wire-drawers, the size of wire ranging from 0.079-in. diameter up to 0.5-in. diameter. As will be seen later, with the exception of the material supplied by one of these firms, which fell considerably below the others in tensile strength, very satisfactory uniformity of properties was observed.

The experiments were carried out on a 5-ton Buckton testing machine, and special grips were used for holding the specimens at each end. This was found to be necessary, since, with the ordinary grips, the specimen almost invariably broke close up to them, thereby precluding satisfactory measurement of the extension over a marked length at fracture. The reason for this yielding in the grips is probably that, as will be shown later, the greater part of the tensile strength of hard-drawn copper wire is due to the existence of a hard superficial skin; where the skin is injured by the ordinary method of gripping, rupture occurs. In the grips used the holding surfaces were of chilled steel, and of the nature of a smooth file; moreover, several different sets of grips were made for different sizes of rod; only for sizes less than $\frac{1}{4}$ in. in diameter were the grip faces flat; for larger sizes they were grooved, thus giving four holding surfaces instead of two.

With these special grips the trouble of yielding in the grips, though not eliminated, was much reduced. Fracture, of course, never occurs actually in the grips. In the worst case a neck forms on the stretched rod just outside the grips, and the only real inconvenience caused by this happening is that the extension, which is almost entirely local, cannot be measured on a 10-in. length marked off at the centre of the rod (the total length of the specimens was 14 in. in every case). It might be thought that the breaking near the grips would give a false value of the breaking stress—that the rod, in fact, would be weakened by wounding of the surface in the grips; this, however, was proved conclusively with the special grips not to be the case. In a number of cases two identical rods would yield, one of them well in the centre and one near the grips, at the load not differing by 1 per cent. In some cases the one yielding near the grips supported a slightly greater load. The reason for this satisfactory result is po sibly that with the special grips, when yield took place close to them, this was not so much to wounding of the surface (since the neck usually formed just clear of such wounds), but rather to slight obliquity of fixing, which would give rise to slightly increased stress at one side of the rod near the grips. As before stated, with the special grips the greater number broke satisfactorily in the centre, but in order to obtain evidence of the extension on the ones that did not, the specimens were all marked at 2 in. and 4 in. from each end; three 10-in. lengths were thus obtained, in one of which the local extension at the point of fracture must necessarily fall. The grips were arranged so that after the shock of fracture the two halves of the specimen were still held in position, and the section remained perfectly uninjured. The two halves were then fitted together again, and measured for extension. It should be mentioned, perhaps, that preliminary tests were made to determine the satisfactoriness of this method of measuring the extension. It was found that measurements of the extension taken just before fracture, and those taken after fracture, were often indistinguishable, and never varied by an amount of any importance.

The extensions were obtained by direct measurement between fine scratches on the specimens, so that the lengths could be decided with certainty to $\frac{1}{100}$ of an inch.

A large number of specimens of the hard-drawn copper were tested to breaking point, and the results of these tests as to tensile strength, and extension per cent. on a 10-in. length, are plotted on Figs. 2 and 3.

It must be understood that on these diagrams are illustrated every specimen tested; no sort of selection has been made to obtain uniform results. In the light of this it will be evident that the material supplied by these three firms shows very satisfactory uniformity, besides interesting properties which will be referred to later.

Before considering the diagrams in detail, one or two words should be said. In the first place, it is stated above that the diagrams show the results of every specimen tested; Messrs. Thomas Bolton and Sons kindly supplied the various sizes in three different qualities, each perfectly distinct and differently manufactured. On the diagram only the first-quality specimens are plotted,

Fig 2 THE VARIATION OF TENSILE STRENGTH WITH DIAMETER.

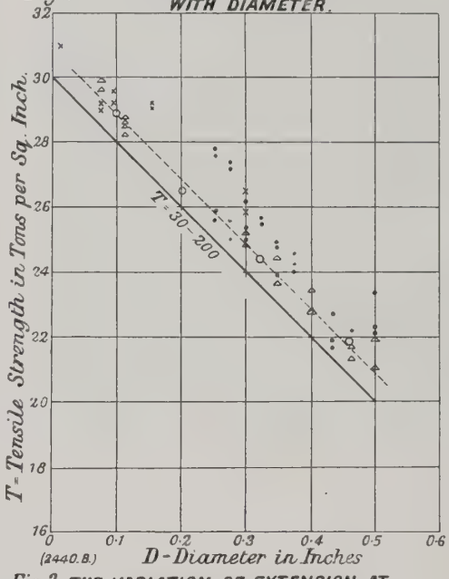
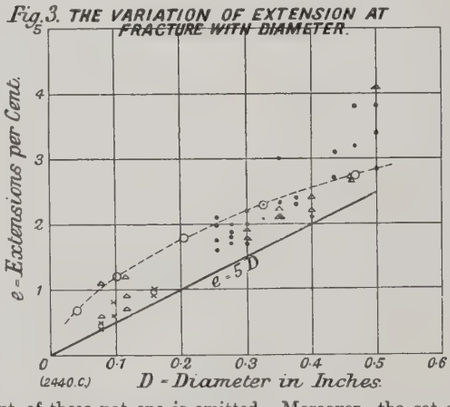


Fig 3. THE VARIATION OF EXTENSION AT FRACTURE WITH DIAMETER.



but of these not one is omitted. Moreover, the set of specimens supplied by one of the firms all fell so far short of those of the other three that these results have not been included. It will be understood that the above is a reasonable course to adopt; what it is desirable to do is to obtain information of what the best hard-drawn copper is or should be. The second and third qualities of Messrs. Thomas Bolton, together with the other set of specimens omitted, were regarded as not representing a desirable standard of quality from the point of view of tensile strength.

A word should perhaps be said of the nature of the yield of the specimens. In all the tests shown on the diagrams—*i.e.*, for all the good-quality hard-drawn copper—the breaking load was perfectly well defined; as the load approached the breaking point there was, of course, a certain amount of plastic yield; this was, however, very slow indeed until the breaking load was reached, when this creeping was greatly accelerated; moreover, when this point is reached it is at once noticeable that the yield, instead of being uniform, gets faster and faster, until all of a sudden a "neck" forms, and the beam of the testing machine falls on to the stop. Except in the case of small diameter wire with very slight extension, fracture has not yet occurred; but the specimen will no longer support the load, and breaks after a further extension, the amount of which depends upon the diameter.

To return to the diagrams:—On Fig. 2 are plotted the breaking stresses in tons per square inch of original section against the diameter in inches. The wires of the different manufacturers are distinguished by the symbols ●, X, Δ. This diagram shows a remarkably regular falling off in tensile strength with increase of diameter, the entire number of observations being included between two straight lines whose distance apart corresponds to a variation of about 4 per cent. above and below the mean. Moreover, the diagram shows that the tensile strength per square inch decreases lineally with the diameter—that is to say, the yielding load, instead of increasing proportionately to the area of cross-section (*i.e.*, proportionately to (diameter)^2) only increases proportionately to the diameter. The load which the hard-drawn copper wires of various sizes will support is proportional to the circumference of the wire instead of the area. We may seek the reason for this in the process of manufacture. Hard-drawn copper is forced through dies of progressively smaller size; during this process the outer skin loses its plasticity, becoming hard and of great tensile strength. This hardening is confined to the surface layers, and subsequently the effective strength of the whole wire is due to this circumferential hard skin, and becomes proportional to the length of the circumference.

The important point in this result is that it shows up the obvious insufficiency of any specification of hard-drawn copper which does not differentiate between the strength per square inch to be expected in hard-drawn wires of different diameters.

There is drawn on the diagram a straight line represented by an equation of the form suggested by Mr. Trotter—namely,

$$T = 30 - 20\,D,$$

where

T = tensile strength in tons per square inch.
D = diameter in inches.

This straight line lies just clear below every point on the diagram, and would afford an admirably simple and efficient definition of hard-drawn copper from the point of view of tensile strength. It should be specified that hard-drawn copper wire shall in no case have a breaking strength of less than that given by the formula:—

$$T = 30 - 20\,D.$$

In this way we have a criterion of strength applicable to all sizes, and easily obtainable in first-class manufacture.

The possible objection to the above definition—that it is absurd, inasmuch as it would make a wire of no diameter have a strength of 30 tons per sq. in.—is really no objection at all. The above formula is given as a definition of copper wires which holds good within the limits of the experiments. For sizes larger than 0.5 in. in diameter it may not be expected to hold; such sizes are, however, of infrequent occurrence, and can scarcely be considered "wires" any longer.

Next as to the extension per cent. at fracture. Fig. 3 shows this property plotted exactly as before against diameter in inches. The definition of hard-drawn copper adopted by the Engineering Standards Committee is that it shall at fracture have an extension of not more than 4 per cent. on a 10-in. length. Now apart from the fact, pointed out by Mr. Trotter, that extension is a desirable quality provided sufficient tensile strength is obtained, it will be evident after looking at Fig. 3 that it is thoroughly misleading to have one fixed maximum extension for all sizes of copper wire. The diagram shows that, for copper of the same quality, the extension per cent. increases with the diameter.

It is not contended that the Engineering Standards Committee's definition is in any way contradictory of the true properties of hard-drawn copper; as will be seen on Fig. 3, none of the specimens did, in fact, have an extension greater than 4 per cent. What is most strongly urged is that in a definition of hard-drawn copper a minimum extension per cent. should be given. If copper is sufficiently hard-drawn to give the requisite tensile strength, sizes up to 0.5 in. in diameter never will have an extension greater than about 4 per cent.; but what is desired is tensile strength and at the same time an absence of brittleness. To ensure these properties a minimum tensile strength should be given coupled with a minimum extension per cent. on a 10-in. length.

Again, Fig. 3 shows that it would be obviously insufficient to have one fixed minimum extension for all sizes of wire. On the diagram is drawn a line represented by the equation

$$E = 5\,D,$$

where

E = extension per cent.,
D = diameter in inches.

This straight line lies just clear below all the observed extensions, and would serve as an excellent minimum limit. What simpler definition could be desired than that "hard-drawn copper shall have an extension per cent. over a 10-in. length, including the point of fracture, of not less than 5 D, where D is the diameter in inches?"

Roughly speaking, it may be said that as the tensile strength is increased by more severe hard-drawing, the extension at fracture decreases; that on the one hand extreme tensile strength can only be obtained at the price of brittleness, while, on the other, very large extensions are obtained if the copper is left soft.

The foregoing experiments have shown what can be accomplished in good general practice in the way of providing the necessary tensile strength while avoiding undesirable brittleness.

On the basis of these results, it is suggested that a satisfactory definition of hard-drawn copper should run somewhat as follows:—"Hard-drawn copper, when in the form of circular wires, shall have a tensile strength not less than that given by the formula $T = 30 - 20\,D$, and an extension per cent. on a marked 10-in. length, including the point of fracture, of not less than that given by the formula $e = 5\,D$, where in the foregoing formulæ

T = tensile strength in tons per square inch of original section;
e = extension per cent.;
D = diameter of the circular rod in inches.

Since these experiments were carried out, Mr. A. P. Trotter called the writer's attention to the specification for hard-drawn copper drawn up by the Wire Committee of the American Society for Testing Materials, and published in the *Electrical Engineer*, October, 1909. In the American specification a minimum tensile strength and minimum elongation at fracture are given for many different sizes of wire varying from 0.46 in. to 0.04 in. in diameter. When the strength and elongations given in these tables were plotted against the diameters, as in the foregoing experiments, it was found that the American specification followed very closely the suggestions given above. The open circular points marked on the diagrams are the American specifications for a few sizes of wire, and the dotted lines are drawn as nearly as possible through these points.

On the diagram of tensile strengths the line is very nearly parallel to the line $T = 30 - 20\ D$, but slightly above it. It may be represented approximately by the formula $T = 31 - 20\ D$. As to the elongation, the points lie very closely on a curve represented by the expression $e = 4\ \sqrt{D}$.

It should be noticed that the specifications are for minimum tensile strength and minimum elongation, and are not given as standard values with a margin of allowable variations above and below. In view of this, it will be seen that, although nearly all of the specimens tested come up in point of tensile strength to the American specifications, yet only a few of the larger sizes show the required elongation at fracture.

The specification states that "the elongation shall be determined as the permanent increase in length due to the breaking of the wire in tension measured between two bench-marks placed upon the wire originally 10 in. apart. The fracture shall lie between the bench-marks, and not less than 1 in. from either of them."

The American Committee, moreover, deprecate the use of a wrapping or twisting test as being very difficult to carry out satisfactorily upon hard-drawn wire, and express the opinion that a combination of tests for minimum tensile strength and elongation will ensure a quite satisfactory standard of quality.

APPENDIX.

The Effect of "Hard-Drawing" upon the Electrical Properties of Copper.

Two papers have recently been published* in America, giving the results of some valuable experiments upon the electrical properties of copper. In these experiments, besides making an accurate determination of the resistance of annealed copper wire, the authors carried out a number of experiments to determine the effect both upon resistivity and temperature coefficient of hardening the wire by bending or drawing through dies.

Messrs. Wolff and Dellinger conclude that the best value to be assumed for the resistivity of annealed copper of specific gravity 8.89 at 20 deg. Cent., for use in the preparation of wire tables and in the expression of per cent. conductivities, is 0.153022 ohm for a wire 1 m. long and weighing 1 gramme; this is equivalent to 1.72128 micro-ohms per centimetre cube.

The resistivity in the case of annealed wire was found to be independent of the size of the wire, as would be expected; for the hard-drawn wire, however, the resistivity varies considerably with the size of the wire.

Taking the above value of the resistivity as representing copper of 100 per cent. conductivity, and expressing the conductivity of hard-drawn copper wires in this way, the mean of the results obtained were as follow:—

B and S. Wire Gauge.	Diameter in Inches.	Per Cent. Conductivity.	Per Cent. Conductivity (Annealed) – (Hard-Drawn).
No. 6	0.162	97.7	2.3
,, 12	0.0808	97.3	2.7
,, 18	0.0403	96.9	3.1

These results show a marked decrease of conductivity as the diameter of the wire decreases, and it is unfortunate that the figures are not given for a greater variety of sizes. In the light of the linear relation between tensile strength and diameter, the above evidence of the dependence upon diameter of the reduction of conductivity due to hard-drawing is of especial interest. Messrs. Wolff and Dellinger's comment upon their results is as follows:—

"Only a few No. 6 and No. 18 wires were experimented upon . . . The values are not considered as having much weight, being based on such limited experimental evidence, but they show, as was to be expected, that the difference between the conductivity of annealed and hard-drawn copper was increased as the diameter of the wire decreased. This general conclusion is, however, complicated in any particular case by the particular practice of the wire drawers in regard to the number of drawings between annealing, amount of reduction to each drawing, &c."

Dr. Beilby, in a recent lecture, gave 2.5 per cent. as the reduction of conductivity due to the hard-drawing of copper wire; the size of wire upon which this figure was observed was not given, but the value seems to agree well with those given above.

Turning now to the temperature coefficient of the resistance of copper, the experiments show that the temperature coefficient is proportional to the conductivity independently of the mechanical treatment of the wire.

* "The Temperature Coefficient of Copper," by J. H. Dellinger; "The Electrical Conductivity of Copper," by F. A. Wolff and J. H. Dellinger, *Bulletin of the Bureau of Standards*, February, 1911, Washington.

The following figures refer to the same samples of wire:—

$$\left[a_{20} = \frac{R_t - R_{20}}{R_{20}(t - 20^\circ)} \right].$$

	Per Cent. Conductivity.	a_{20}	$C = \frac{a_{20}}{\text{Per Cent. Cond.}}$
(*a*) When annealed ..	100.24	0.003952	0.003943
(*b*) Hardened by drawing through dies ..	98.96	0.003902	0.003943

And again a second sample of wire:—

	Per Cent. Conductivity.	a_{20}.	C.
(*a*) When hard-drawn ..	97.46	0.003843	0.003943
(*b*) After annealing ..	100.15	0.003948	0.003942

The result of these investigations may be expressed in the following practical rule:—

"The 20 deg. Cent. temperature coefficient of a sample of copper is given by multiplying the number expressing the per cent. conductivity by 0.00394."

This rule may be expressed otherwise, thus:—

"The change of resistivity of a sample of copper is 0.000598 ohm per metre-gramme, or 0.00681 micro-ohm per centimetre cube."

A conclusion which follows from these results is that the resistance added to that of pure copper by hardening or the presence of impurities has no temperature coefficient; that is, when the resistance is changed by the presence of impurities or hardening, the absolute change of resistance with temperature is unaffected, while the per cent. change of resistance is affected.

Finally, Messrs. Wolff and Dellinger give as the best values for the temperature coefficient of good commercial annealed copper:—

$a_0 = 0.00428$ $\quad a_{20} = 0.00394$
$a_{15} = 0.00402$ $\quad a_{25} = 0.00386$

And in the light of the above results we can calculate as the temperature coefficients of good commercial hard-drawn copper, taking the mean conductivity as 2.7 per cent. less than for the annealed material:—

$a_0 = 0.00415$ $\quad a_{20} = 0.00383$
$a_{15} = 0.00391$ $\quad a_{25} = 0.00376$

FOREIGN ENGINEERING PROJECTS.

We give below general data on several foreign engineering projects. Further information concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.:—

Argentina: With reference to the notice on page 168 of the *Board of Trade Journal*, of April 28, 1910, relative to the proposed construction of a commercial port at San Borombon, H.M. Minister at Buenos Aires now reports that, as work has only been started on a small scale, a decree was issued recently by the Minister of Public Works by which a period of 120 days is allowed within which a proper commencement of the work is to be made; in default, the concession is to be declared null and void. H.M. Minister also reports that a Bill has been introduced to provide for the construction of a bridge over the River Paraná in order to place the provinces of Entre Rios and Corrientes and the territory of Misiones in direct communication with Buenos Aires, the present connection by means of trains transported by ferry boats being unsatisfactory. The project is one of considerable magnitude, and would involve a large capital outlay.

Morocco: H.M. Consul-General at Tangier (Mr. H. E. White, C.M.G.) reports that tenders are invited by the Special Committee of Public Works for the extension of the beach road at that port over a distance of 380 metres. The estimated value of the contract is placed at 18,600 francs (744*l.*); a deposit of 200 francs (8*l.*) is required with each tender, to be increased by the successful tenderer to 1000 francs (40*l.*). Tenders will be received by M. le President du Comité Spécial des Travaux Publics, Dar En-Niaba, Tangier, up to 10 a.m. on October 30. The contractor must elect domicile in the neighbourhood of the works. Copies of the specification, conditions, and general regulations (in French) may be seen, and copies of the form of tender to be used may be obtained, by British contractors at the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C.

Italy: The *Gazzetta Ufficiale* of August 28 contains a notice, issued by the Ministero dei Lavori Pubblici, Rome, stating that tenders will be opened on September 26 for the carrying out of harbour works at Viareggio. The upset price is put at 973,700 lire (about 38,950*l.*). The *Gazzetta* of September 2 notifies that tenders will be opened on October 3 at the offices of the Ministero dei Lavori Pubblici, Rome, for the carrying out of harbour works, including the construction of breakwaters, &c., in the harbour of Ortona. The upset price is put at 2,700,000 lire (108,000*l.*). Although the above two contracts will doubtless be awarded to Italian firms, nevertheless the carrying out of the works may necessitate the purchase of some materials out of Italy. The *Gazzetta* of September 7 contains a decree granting to the Società Italiana di Industrie Elettriche, Spezia, a concession for the construction and working of an electric tramway from Spezia to Cadimare.

Spain: The *Gaceta* of September 9 contains a notice, issued by the Ministry of Fomento, awarding to the "Sindicato Asturiano del Puerto del Musel" a contract for the carrying out of extensive harbour works at Gijón Musel. The cost of the work is estimated at 2,513,000 pesetas (about 93,000*l.*).

Christiania: The Commercial Intelligence Branch of the Board of Trade is notified by H.M. Consul at Christiania (Mr. E. F. Gray) that tenders are invited by the Norwegian State Railway authorities for the supply of 324 axles with wheels, 630 wheel tyres ("Hjulbandager") and 40 axles without wheels. Sealed tenders, marked "Hjul," will be received at "Styrelsens Expeditionskontor, Statsbanerne," Christiania, up to 10 a.m. on October 7. It should be noted that in all Norwegian Government contracts a preference (apart from Customs duties) is given to Norwegian manufacturers, and that it is obligatory that a resident agent (not necessarily a Norwegian firm) should act for tenderers not residing in Norway.

CATALOGUES.

Electric Lifts.—We have received from Messrs. Marryat and Place, 28, Hatton Garden, E.C., a circular dealing with "M.P." electric passenger lifts. This publication contains a general specification of the lifts, and gives particulars of standard sizes arranged for push-button, car-switch, and hand-rope control. Electrically-operated goods lifts with hand-rope control are also listed.

Carbon Brushes for Electrical Machinery.—We have received from Messrs. William Geipel and Co., Vulcan Works, St. Thomas's-street, S.E., a price-list of Henrion graphitic carbon brushes for dynamos, motors, &c. Several different qualities are made to work under all conditions. The price-list also contains illustrations of carbons for lightning arresters, battery carbons, carbon contacts for circuit-breakers, &c.

Ball-Bearings.—From the United Motor Industries, Limited, 45 and 46, Poland-street, W., a catalogue of "D.W.F." ball-bearings has reached us. The catalogue, after describing the bearings generally, and giving some notes on fitting and lubricating them, deals with their application to motor-cars, machine-tools, electrical machinery, and line shafting. Prices and dimensions are then given of journal and thrust-bearings in three patterns for light, medium, and heavy loads; a special type of bearing for line shafting is also listed. The catalogue also quotes prices for steel balls from $\frac{1}{16}$ in. to 4 in. in diameter, and mentions that the firm supplies balls of phosphor-bronze, brass, copper, aluminium, and other metals.

Electrical Equipment of Cinematograph Theatres.—A special publication to hand from the British Westinghouse Electric and Manufacturing Company, Limited, of Trafford Park, Manchester, relates to the electrical equipment of cinematograph theatres. It is addressed principally to proprietors and managers of these entertainments, and first explains, in a simple manner, the necessity for converting the public supply to a suitable voltage for the arc lamps, afterwards giving some brief general particulars of motor-generator sets for this purpose; gas-engine sets, and petrol-electric sets, for use in districts where there is no public electric supply, are also mentioned. The book also recommends the use of Westinghouse apparatus for interior and exterior lighting and ventilation of the building.

Polyphase Induction-Motors.—Messrs. Bruce Peebles and Co., Limited, of Edinburgh, have recently issued a publication dealing with large polyphase induction-motors. A general specification of the machines is included, and tabulated particulars are given of three-phase, slip-ring motors for 50-cycle and 25-cycle circuits, at all pressures between 110 and 6600 volts. The capacities of these machines range from 45 to 1750 horse-power. They can be supplied with two or three bearings mounted on the bed-plate; the smaller sizes are also made without a bed-plate, the bearings being supported by the end hoods. The latter arrangement makes a very compact motor particularly suitable for direct coupling to fans, pumps, &c.

Arc-Lamp Carbons.—We have received from Messrs. William Geipel and Company, Vulcan Works, St. Thomas's street, S.E., a price list of Henrion carbons, for which they are the sole agents for the United Kingdom and the Colonies. The list includes solid and cored carbons suitable for open and enclosed arc-lamps burning on continuous-current or alternating-current circuits. Carbons for all types of flame arc-lamps, and mineralised carbons for use in ordinary open-type lamps, are also listed. It is stated that these mineralised carbons give four times as much light as ordinary carbons, will burn for long periods, and also enable three lamps to be run in series on a 110-volt circuit. The list also gives particulars of carbons for searchlights, cinematograph and theatrical lamps, welding and other special purposes.

Gears and Gear-Cutting.—Messrs. Marryat and Place, 28, Hatton Garden, E.C., who are the sole agents for London and the South of England for the Reid Gear Company, of Linwood, near Paisley, have sent us a copy of the revised catalogue and price-list of all descriptions of gearing manufactured by the latter firm. The catalogue states prices for cutting teeth of spur-wheels, annular gears, racks, mitre and bevel-wheels, worm-wheels, spiral gears, sprocket-wheels, &c., on blanks supplied by customers. Prices are also quoted for complete cast-iron spur-wheels and raw-hide and compressed-paper pinions. Besides the foregoing, the catalogue includes illustrations and particulars of worm and spur-speed reduction gears, and also gives many rules, formulæ, and useful tables relating to gearing generally. For example, the pitch-line and outside diameters are given for cut spur-wheels having from 10 to 120 teeth, with circular pitches ranging from $\frac{1}{4}$ in. to 4 in.

Paris Metropolitan Railway.—The revenue of the Paris Metropolitan Railway for the first eight months of this year showed an increase of 337,079*l.*, as compared with the corresponding collection for the first eight months of 1910. This increase is attributable, to some extent, to the opening of additional sections; but the general business of the undertaking is also steadily growing.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

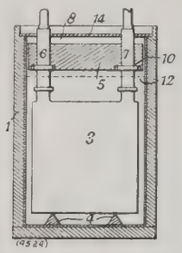
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

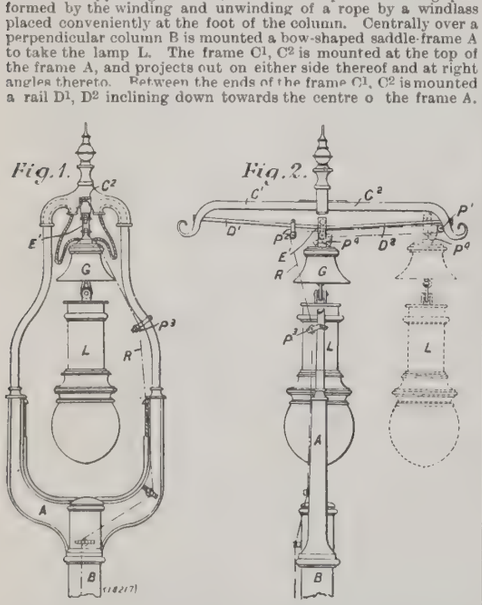
ELECTRICAL APPARATUS.

4524/11. G. E. B. Pritchett, London. Accumulator Boxes. [2 *Figs.*] February 22, 1911.—The invention relates to electric accumulator-boxes. 1 is a box having the usual lead lining therein. 3 is an electrode supported upon blocks 4. 5 is a plate through orifices in which pass the terminals 6 7. The plate 5 is so placed as to leave only a shallow space 8 below the upper edge of the box In the case illustrated, the terminals have shoulders 10 which fit into annular recesses in the plate 5, but these shoulders and recesses may be dispensed with. When so dispensed with any other convenient means may be employed for retaining the plate 5 in position. The level of the electrolyte is shown at 12, and is slightly below the under surface of the plate 5. 14 is an upper plate resting on the rebated shoulder of the box. When such a box is in use and is subjected to vibration



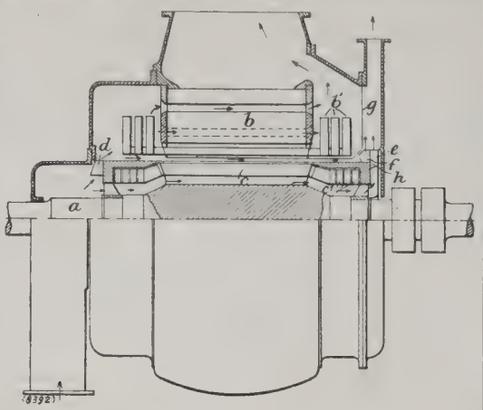
or concussion, the liquid passes a little way up into the narrow space between the edge of the plate 5 and the inside of the box lining, and the tighter the fit the less far will the liquid penetrate upwards into this space. When, however, the vibration or shock is great some of the liquid may come above the upper surface of the plate 5 into the shallow space 8, but owing to the presence of the upper plate 14 any liquid so passing above the plate 5 will not be projected above the edges of the box. It will simply be projected against the under surface of the upper p ate 14 and trickle back to its proper position below the plate 5. Owing to the depth (thickness) of the plate 5 any liquid projected against the upper plate 14 as just described will have lost its force so that this upper plate may be a comparatively light one and in ordinary cases need not necessarily be screwed down or fastened but simply rest in position by its own weight. (*Accepted July* 12, 1911.)

18,217/10. J. Stevenson and O. R. Williams, Glasgow. Arc-Lamp Suspension. [2 *Figs.*] August 2, 1910.—This invention refers to means for automatically taking an arc-lamp out of a central carrier-frame placed at a height, lowering it to the ground, raising it and returning it to its frame centrally over the supporting column, the whole operation being performed by the winding and unwinding of a rope by a windlass placed conveniently at the foot of the column. Centrally over a perpendicular column B is mounted a bow-shaped saddle-frame A to take the lamp L. The frame C^1, C^2 is mounted at the top of the frame A, and projects out on either side thereof and at right angles thereto. Between the ends of the frame C^1, C^2 is mounted a rail D^1, D^2 inclining down towards the centre o the frame A.



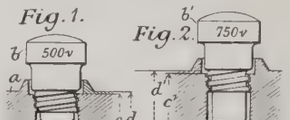
On the rail D^1, D^2 is mounted a carriage saddle E^1, with a pulley mounted to run free thereon and below the rail, and mounted, free to swivel in the saddle E^1, is an automatic suspension device G, which is fitted with a side pulley To the lower lowering flange of this suspension device is fitted the lamp L. Guide-pulleys P^2, P^3 are provided to guide the rope R to the winch, placed conveniently at the foot of the column. This rope passes from the winch up over the pulleys P^3, P^2, and runs across to and over the pulleys P^1, P^4, and is attached to the lower lowering flange of the suspension gear. The action is as follows :—When the rope R is wound, the trolley and lamp is pulled up the inclined rail D^2 until it reaches the end of its travel and butts against a stop formed on the pulley-frame P^1. A further slight pull on the rope lifts the lamp off its suspension clutches and frees it for lowering. (*Accepted July* 12, 1911.)

8392/11. Siemens Brothers' Dynamo Works, Limited, and C. A. B. D. Koettgen, London. Dynamo-Electric Machines. [1 *Fig.*] April 4, 1911.—In alternate-current turbo-generators, on the rotors of which are situated the excitation windings, there are, according to this invention, three separate sets of axial cooling channels, one through ducts in the stator core, another axially along the air-gap between stator and rotor, and another through ducts in the rotor core, and each is provided with a fan. *a* denotes the shaft, *b* the stator core, b^1 the stator winding, *c* the rotor core, c^1 the rotor winding, *d* the



fan for forcing air through the stator air-ducts, *e* the fan for drawing air through the rotor air-ducts, *f* the fan for drawing air through the air-gap, *g* a partition dividing that part of the dynamo into which the stator air-currents are discharged from that part into which the rotor and air-gap currents are discharged, *h* a partition separating the fan-blades of *e* from those of *f*. The paths of the air-currents are shown by arrows, and the action need not be further explained. The partition *h* is not essential, and it could, if desired, be dispensed with. (*Accepted July* 12, 1911.)

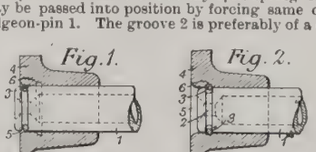
10,113/11. Siemens Brothers' Dynamo Works, Ltd., London. (*Siemens Schuckertwerke G.m.b.H., Berlin, Germany.*) **Fuses.** [2 *Figs.*] April 26, 1911.—This invention has reference to non-interchangeable electric fuses, a characteristic feature of the invention being that the non-interchangeability for voltage is ensured by a relative displacement of the screw-threaded parts of fuses for different voltages, this being effected by altering the depth of the fuse-socket and the length of the screw-plug. Thus, for high voltages, sockets of considerable depth with long screw-plugs can be employed, whereas for low voltages, sockets of less depth with short screw-plugs can be used, the displacement or the difference in the size or graduation for different consecutive voltages being at least equal to the length of the screw-threaded part of the screw-plug. Referring first to Fig. 1, *a* represents the socket and *b* the screw-plug of a safety-fuse suitable for employment in installations of 500 volts, for example, *c* representing the effective depth of the fuse-socket and *d* the effective length of the



plug. Referring now to Fig. 2, the safety-fuse with the screw-plug b^1 is intended in contrast to that shown in Fig. 1, for employment in installations of 750 volts, for example. In this safety-plug, according to the present invention, the depth c^1 of the fuse-socket is greater than the depth *c* in the safety-plug, according to Fig. 1, by an amount equal at least to the length of the screw-threaded part of the screw-plug. Consequently the effective length d^1 of the screw-plug for 750 volts is greater by at least this length than the effective length *d* of the screw-plug for 500 volts. In other words, owing to the relative displacements of the screw-threads, the plug shown in Fig. 2 could not be pushed sufficiently far into a socket, such as in Fig. 1, for the screw-threads to engage properly. The new arrangement therefore has the advantage, on the one hand, that the screw-plug for low voltages (Fig. 1) cannot be used in sockets for high voltages (Fig. 2), and, on the other hand, that the screw-plug for high voltages cannot be screwed into sockets for low voltages. (*Accepted July* 12, 1911.)

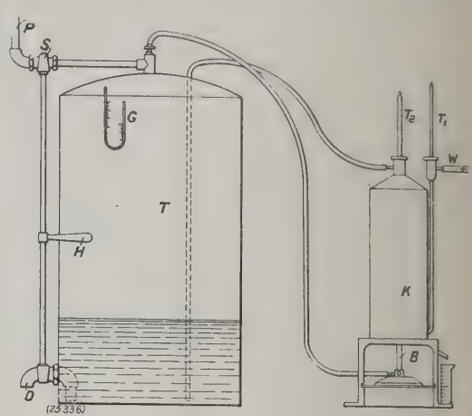
GAS ENGINES, PRODUCERS, HOLDERS, &c.

21,435/10. The Birmingham Small Arms Company, Limited, Birmingham, and R. Nicholls, Redditch Internal-Combustion Engines. [4 *Figs.*] September 15, 1910.—The invention has more particular reference to the method of attachment of the gudgeon-pin to the piston of internal-combustion engines. According to the present invention, a plain parallel pin 1 is provided near the one outer end with a groove 2 adapted to receive a radially-split spring ring 3. The ring 3 may be passed into position by forcing same over the end of the gudgeon-pin 1. The groove 2 is preferably of a depth equal



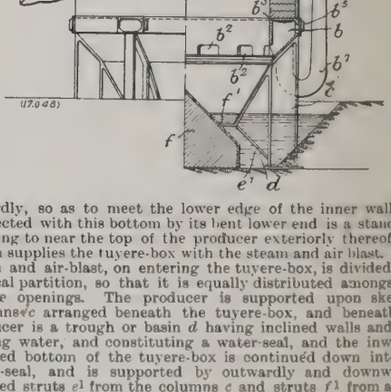
to the sectional thickness of the ring 3, and the latter in its normal condition is of an external diameter greater than the diameter of the gudgeon-pin 1, but capable of being compressed into its groove to a diameter equal to that of the gudgeon-pin 1, as shown in Fig. 1 for the purpose hereafter explained. The piston 4 is provided with transverse holes 1 in its outer walls to receive the gudgeon-pin 1, and in one of the said holes is formed a groove 6, corresponding in shape to the ring 3 and adapted to be engaged by the ring 3 when the gudgeon-pin is in position. To place the gudgeon-pin 1 in position, the plain end thereof is passed through the transverse holes in the piston and through the bush of the connecting-rod. During its passage the ring 3 is first pressed into its groove 2 in the pin 1, as seen in Fig. 1, and is held compressed in the groove until it comes into alignment with the groove 6, when it immediately clicks or expands thereinto, as shown in Fig. 2. Approximately one half of the ring 3 is then in each groove, thus forming a collar or stop, and effectively securing the gudgeon-pin 1 to the piston 4. When it is desired for any purpose to remove the gudgeon-pin 1 from the piston 4, it can be readily effected by a smart blow on the plain end thereof, which presses or moves the ring 3 from its groove 6 and compresses it into the groove 2 in the pin 1, thus permitting the latter to be readily removed. (*Accepted July* 12, 1911.)

25,336/10. A. Macklow-Smith, London. Gas Calorimeters. [1 *Fig.*] November 1, 1910.—This invention relates to gas-calorimeters of that kind in which the calorific value of a gas is determined by passing water or other liquid through an ordinary gas-calorimeter into a closed vessel containing the gas, thereby displacing an equal volume of the gas which is burnt in the calorimeter in the usual way. According to the present invention, the cock for controlling the flow of gas to the closed vessel, and the cock to control the water passing away from the tank, are connected so as to be regulated simultaneously. The apparatus comprises a closed tank T, to which the gas to be tested is supplied through a pipe P provided with a suitable cock S. The



upper part of the tank is fitted with a pipe leading to an ordinary Bunsen or other burner B, in which the gas is burnt in the calorimeter K. Water enters the calorimeter at W and passes from the calorimeter along a suitable tube to the tank T, thereby displacing an equal volume of gas at any desired pressure, which is measured by means of a pressure-gauge G. When the tank is full, the drain cock D is opened by means of the lever H, which will also open at the same time the gas-cock S, thereby allowing a fresh sample of gas to enter the tank as the water passes away. When the tank is full of gas, both cocks S and D are closed, and the temperature of the water noted as it enters and leaves the calorimeters by thermometers T^1 and T^2 or other means. (*Accepted July* 5, 1911.)

17,048/10. W. Jones, Middlesbrough. Gas-Producers, [2 *Figs.*] July 18, 1910.—This invention relates to gas-producers, and according thereto the walls *a* of the producer are constructed of fire-bricks, which may be contained in a casing of iron a^1, and at one side of the producer, and at or near to the top thereof is a valve-controlled outlet for the gas, consisting of a vertical pipe a^3 connected with the producer by a narrow neck a^2, and provided with a cut-off or regulating-valve, whilst at the top of the producer is arranged the usual valve-controlled feed-hopper a^6 for the fuel. Around the base of the producer, and beneath the brick walls, is formed an annular chamber or tuyere-box *b* of cast iron, the inner wall of which is, at suitable intervals, provided with tuyere openings b^2, and the outer wall b^3 is provided with openings closed by doors b^5 arranged intermediately of the tuyere openings, and through which the tuyere openings are visible and easily accessible to the operator, so that any two tuyeres can be pricked from one door. The bottom of the annular chamber or tuyere-box *b* is inclined downwardly and



inwardly, so as to meet the lower edge of the inner wall, and connected with this bottom by its bent lower end is a stand-pipe b^7 rising to near the top of the producer exteriorly thereof, and which supplies the tuyere-box with the steam and air blast. The steam and air-blast, on entering the tuyere-box, is divided by a vertical partition, so that it is equally distributed amongst the tuyere openings. The producer is supported upon skeleton columns *c* arranged beneath the tuyere-box, and beneath the producer is a trough or basin *d* having inclined walls and containing water, and constituting a water-seal, and the inwardly inclined bottom of the tuyere-box is continued down into the water-seal, and is supported by outwardly and downwardly inclined struts e^1 from the columns *c* and struts f^1 from a cone *f* in the centre of the trough *d*. The ashes travel down this cone, and are directed towards the side of the trough, so that they can be easily raked out between the columns *c* at all parts of its circumference when working at full pressure. The tuyere-box *b* is formed in sections, the joints of which rest upon the supporting columns *c*. (*Accepted July* 5, 1911.)

THE INSTITUTE OF METALS.

(*Concluded from page* 395.)

WE have now to deal with the proceedings of the Institute on the second day of the meeting at Newcastle. When the Institute met on Thursday, the 21st inst., Professor Thomas Turner replied to the discussion which took place on the previous day on the paper by Mr. Haughton and himself describing experiments on "Volume Changes in the Alloys of Copper and Tin." He said that two points had been raised by Dr. Rosenhain and Dr. Desch. The first of these bore on the method of work, and the second on the results secured. He, however, claimed that there could be no doubt but that the expansions and contractions measured had their exact counterpart in practical foundry work. In the second place, he contended that the measurements did accurately represent a real change of volume. This had been confirmed, not only in his own laboratory, but also by Keep in America and Wurst in Germany, though the apparatus and methods used were not identical with his own. Hence they were dealing with facts which were of importance, both from the practical and the theoretical points of view. He would further point out that many of the important expansions observed occurred at temperatures far below the point of complete solidification—in some cases as much as 400 deg. below. Hence they were not dealing with cases of crystal thrust. If, as was the case, they could take the bar from the mould and break it in two without liquid metal running out, they must be dealing with solids, yet in some cases such a bar showed expansions at three different temperatures. Again, that the changes were true changes was indicated by the fact that other experiments, particularly those on iron and steel, showed the metal to be specifically lighter after the expansion. In the case of cast iron the decrease of density was 5 per cent. Where no expansions were recorded by his apparatus no change of density was observed, so that the two hung together. Dr. Rosenhain's criticism was based on a misapprehension. He assumed that they were using the process to determine the constitution of the alloys, but this was not the case. He had never published an equilibrium diagram based on this class of experiment. But whilst he had no desire to determine by an observation of volume changes the constitution of the alloys, there must be some connection between the two. It was impossible, for instance, to determine the geological structure of a region from a contour map, yet there should be a close connection between the two, as there was between the authors' experiments and the constitutional diagram. Unfortunately, however, they found that the diagrams constructed by different experimenters differed at important points, but they went to these merely to explain their own experiments, and did not propose to use the latter to correct the diagram. The existence of crystal thrust was not denied. An immediate expansion of small amount was, he thought, often thus occasioned, but in the majority of cases it was, he considered, out of question in cast bars. It had been suggested that the method was faulty because it did not show any expansion in the case of bismuth. The authors, however, did not deny that bismuth expanded on solidification, but it did so as water, and not as cast iron. The latter expanded little, if at all, at the actual moment of solidification, but increased in volume considerably after it was solid. Water and bismuth expanded on solidification, but subsequently contracted. In conclusion, he said that they quite appreciated the criticism of their friends, and frank criticism would never interfere with his friendships.

THE FAILURE OF A BRAZED JOINT.

Professor Henry Louis then read a paper on "The Failure of a Brazed Joint." This described the results of an examination of a joint which failed last year on the s.s. Craven. The pipe was 5½ in. in diameter and carried 175 lb. steam. The joint, which was at the bottom of the pipe, opened for a length of 3 ft. 6 in., and the braze was found to be extensively corroded. The sound portion of the braze showed on analysis Cu, 66.60; Zn, 31.30; Sn, 0.77; Pb, 0.40; As, Sb, and Fe, traces; oxygen and loss, 0.63. The analysis of the corroded portion showed Cu, 78.40; Zn, 13.50; Sn, 0.78; and lead, nil; oxygen and loss, 7.32. When etched and examined under a high power, the metal was seen to consist of crystals of brass embedded in reticulations of a whitish alloy, along which all the fissures and lines of corrosion passed. The production of this reticulated structure was traced by the author to the presence of lead, or, rather, of an alloy of lead and tin much more fusible than brass, and which solidified about the crystals of the latter.

The discussion was opened by Mr. J. T. Milton, who said that the paper was of extreme interest to marine engineers and copper-pipe makers, as it showed the possibility of very serious corrosion where it might not be expected to exist. Failures of brazed joints occurred more frequently than many suspected. His attention had been first drawn to the subject by the failure of a brazed pipe on the s.s. Prodano, which almost exactly paralleled that described by the author. The net result of the Board of Trade inquiry then held was the conclusion that the seam was defective *ab origo*. His own opinion, however, was that in this the assessors were absolutely wrong, because both this pipe and a sister-pipe on the same steamer were in such a condition at the time of the inquiry that the brazing cracked at the least touch. Nevertheless, when new, both pipes had been bent cold to a sharp curve. As he could not account for the accident, he suggested to his Committee that further assistance should be obtained, and specimens were accordingly sent for report to Professor Arnold at Sheffield, who made chemical and micrographic examinations of the deteriorated metal, and arrived independently at about the same conclusions as the speaker. In a preliminary report, Professor Arnold said that he had observed reticulations in the metal which apparently corresponded to those noted by Professor Louis. These, however, were ignored in the final report, where the failure was shown to be due to the brass being dezincified. In some cases Professor Arnold had made sketches showing the progress of the decay in between the grains of the alloy, but he did not then attribute it specifically to the lines of the eutectic. When an alloy solidified, it did not do so *en masse*, but the action commenced at a point. In crystallising, any impurities present were thrown out, forming a reticulated structure between adjacent crystals, as was well shown in the case of copper contaminated by bismuth. Apparently the decay proceeded along these lines of division. The fact of this decay was a very serious one, but Arnold had traced it to another cause than the author. By examining the decayed metal he had shown the presence in it of organic acids derived from the oil, since the steamer was not using pure mineral oil for lubrication. In his first analysis he found that the decayed metal was very low in zinc, so he fused some of it containing 78 per cent. of copper and 12 per cent. of zinc under borax, with the result that the resultant button of metal proved to be 98 per cent. of copper, thus showing that even the 12 per cent. of zinc present was not in the metallic state, but existed merely as an oxide. Being much concerned at the failure, which he thought might be possibly due to defective methods of brazing, he had applied to manufacturers for particulars of the methods used. He then learnt that several attached great importance to the composition of the brazing metal, holding it to be essential not only that the copper should be free from antimony and arsenic, but had got the proportion of copper and zinc worked out to two decimal places. In brazing a joint, however, the first thing that happened was that part of the zinc volatilised. Next the brazing metal dissolved further copper from the pipe, so that finally the metal left in the joint had a very variable constitution, ranging from the intended 55 Cu and 45 Zn up to two of copper and one of zinc. In the case of the Prodano's pipes, the flanges were brazed on by the engine builders, and there was absolutely no corrosion in these joints. The pipe seam, however, though the corrosion was worse inside, was also corroded externally; and the fact that the flange brazing had not suffered, though exposed exactly the same way as the outside of the pipe seam, led the speaker to think that there might be something in the constitution of the brazing metal. Professor Louis had attributed the failure described by him to the presence of lead. At the time of the Prodano inquiry the Admiralty had in use a test for ascertaining the freedom of copper-zinc alloys from antimony and arsenic, which was known as the Muntz metal test. This was carried out by adding to the alloy sufficient pure zinc to make the composition 60 copper and 40 zinc. Ingots of this were cast in iron moulds and then broken when cold. From an examination of the fracture the presence of antimony and arsenic could be absolutely determined. The difference in the fracture was very perceptible even to a novice. Good metal broke right through the crystal grains and was thus fine in texture; but if antimony and arsenic were present, it separated with a much coarser crystallisation. Microscopically, however, the two fractures appeared to him to be very similar. With certain impurities there was a segregation round the crystal grains which constituted planes of weakness and led also to corrosion taking place along these reticulations. The position of a brazed seam in a pipe depended, Mr. Milton continued, on the design of the pipe. With large 4-in. to 6½-in. pipes which had to be bent, the braze must be kept in the neutral axis, so that there was not full freedom of choice as to the position it occupied. Hence it was quite possible that in the case described by Professor Louis the builders had, in placing the joint at the bottom, done the only thing open to them. In the case of the flange-joints of the Prodano, which did not decay, the builders told him that they considered that the best copper they could obtain for the solder was old copper fire-boxes, in which case, the speaker believed, there was likely to be a certain amount of arsenic present.

Professor A. K. Huntingdon, who spoke next, congratulated the meeting on having a paper so well suited to provoke discussion. Not long ago he had himself had to investigate some Naval brass which had gone wrong. He had shown a piece to Sir Gerard Muntz, who said that it looked as if the material were either too low in copper, or that antimony or arsenic was present. As a matter of fact the speaker knew that the copper was particularly pure. He had it examined microscopically on July 7, this year. This showed the α phase to be present with flakes of a bluish-white constituent, which was $\alpha + \delta$ eutectoid, containing 21 per cent. of tin. He had been struck, even at low powers, with the presence of this, but it was not until he tried 500 diameters that he succeeded in getting at the structure of the material between the crystals. When he saw the illustrations in Professor Louis's paper he recalled that he had seen something like it before, and had it looked up. What had happened in this case was the Naval brass was too low in zinc, and this view was confirmed by analysis. In this condition an alloy of tin with copper had separated (there was no lead, as in Professor Louis's specimens), and this was of a very brittle character. The microphotograph taken corresponded almost exactly with Fig. 4 of the author's paper. The white body was tin-copper, as stated, and something of this kind was at the root of the whole mischief in brazing. That operation was a very uncertain one in its results. At the start the solder contained a large proportion of zinc, whilst at the end there might be hardly any. The whole operation was both unscientific and unpractical and ought not to be permitted, as there were other methods of doing the work, even if a little more expensively. Professor Louis had stated that the first illustration in his paper showed the structure of a typical brass. If, however, it were examined closely, it would be seen that all the reticulations shown with the higher magnification were quite visible, and hence it could not be described as a typical brass. The dark masses were cores of α metal, and it was quite probable that these were themselves a source of corrosion by setting up electrolytic action between the copper-zinc and the rest. In fact, there were all possible causes of corrosion present, and he thought that the whole trouble was due to the uncertainty of the method. If tin were present, and the zinc were burnt out, a copper-tin eutectic would separate.

Sir Gerard Muntz said that the Muntz metal test mentioned by Mr. Milton was used to test every heat made in his works, and could be relied on for estimates to an accuracy of ½ of 1 per cent. One point which had been raised was as to whether the trouble arose from lead or from tin. Practical experience said it was the latter, and not lead. If shop foremen were allowed their own way, they would always add tin to the brazing metal, as the solder was then easier to use, melting and running more readily; but it was, at the same time, more brittle and more liable to corrosion. He thought, therefore, that the trouble lay with the tin in the case of steam-pipe joints which had failed. The presence of this metal produced the lines of separation between the crystals along which the corrosion took place. Mr. Milton had raised the point as to whether copper fire-box material was suitable for the production of brazing metal. The speaker thought that tough copper was quite unsuited for

the manufacture of any brass whatever, and of brazing metal in particular. On the other hand, copper pipe material if electrolytic might be quite suitable, but the use of old "tough" copper pipes would be highly dangerous.

Mr. J. M. Allan said, as a maker of bronzes, he had found that the use of electrolytic copper reduced the tensile strength of the resultant alloy, as compared with those made with "tough" copper.

In reply, Professor Louis said he did not deny that the presence of tin might give rise to the failure of brazed joints. His paper, however, dealt solely with one particular case, in which the proportion of tin present was insufficient to account for the trouble. As would be seen on reference to Fig. 6 of his paper, the tin alone did not give rise to marked reticulation, but required for this the addition of lead. He felt, therefore, that the latter was at least equally guilty. In the decayed metal, moreover, the lead was completely dissolved away, but only one-seventh part of the tin. Hence, in the particular case to which his paper referred, it was evident that lead played a very prominent part in the disintegration. He fully agreed that brazing was an unsatisfactory procedure, and as, moreover, the risks attaching to it could be avoided by using solid-drawn pipes, there was no reason why it should be employed. Mr. Milton had suggested that the speaker's samples should have been fused, so as to determine the condition of the residue of zinc. This, however, he had not considered necessary, since, as one-third of the zinc had disappeared, it could not matter whether what was left was or was not in the metallic state.

The Alloys of Aluminium and Zinc.

Dr. Rosenhain then read a paper by Mr. S. L. Archbutt and himself, entitled "The Alloys of Aluminium and Zinc," giving the results of a very prolonged research carried out at the National Physical Laboratory by the authors. This paper we print in full on page 438 of the present issue. The alloys were investigated by Tamman's system of heat analysis, combined with careful micrographic investigations. On the basis of their results, the authors have prepared an equilibrium diagram for the series, which we reproduce on page 439, Fig. 2. In introducing the paper, Dr. Rosenhain drew attention to the fact that there was a line missing from the diagram, which, as it stood, failed, on the right-hand side, to satisfy the phase rule, but he had been unable to discover the position of the right-hand boundary of the δ and $\gamma + a$ areas. Two hypothetical positions might be assigned to this line, but he preferred not to draw in any line for which he had not secured definite experimental evidence. The new points in the diagram, he stated, were the horizontals at 443 deg. and 250 deg. Cent. respectively, showing evolutions of heat at these temperatures. The upper of these terminated in a small notch in the liquidus curve at C, which was so small that Shepherd had failed to detect it, and arose from the formation of a metallic compound having the formula Al_2Zn_3, which in the diagram was denoted by β. This compound was, he stated, unstable, breaking up with evolution of heat at a temperature of 256 deg. Cent. It was incapable of dissolving zinc, but formed an unbroken series of solid solutions with aluminium. To the right of the points H and L, the speaker stated, the alloys were difficult to polish, and the microscopic evidence was thus inconclusive, and the pyrometer gave no evidence of the evolution of heat between K and L. Hence G, H and K, L were continued as dotted lines.

The discussion on the paper was opened by Dr. A. G. C. Gwyer, who said that he had had the pleasure of examining the complete account of the research in the Philosophical Transactions. The paper recorded the most careful and accurate application yet made of Tamman's method of heat analysis. Professor Tamman himself used but small quantities of metal, and his results were in no way comparable in accuracy with those recorded at the National Physical Laboratory. Much interest attached to the discovery of the compound Al_2Zn_3. This was, he believed, the first case recorded in which an intermetallic compound decomposed on further cooling. Another interesting point was, that the composition of this compound was not given by the point C on the diagram, but by the point G, there being thus about 78 per cent. of zinc in it. The reason why the corresponding break in the liquidus curve did not occur at the point of the diagram where the composition was that of the compound, had been explained in text-books, but was still not clearly understood by many. A noteworthy point about this compound was its small heat of formation, the arrest in the cooling curve being so small as to have escaped the attention of Shepherd. The authors, he noted, had refused to plot in even provisionally the limits of the phase fields, since they could find no evidence of a duplex structure in the δ region.

Dr. Guertler, who followed, congratulated the authors on the excellent and accurate work they had accomplished. He was, however, very glad that they had not done it earlier. The method used was so accurate that every small evolution of heat was detected, and if it had been applied earlier, would have made the equilibrium diagrams so complicated that no one would have dared to pursue the research. It was interesting to note how diagrams originally simple were, with further research, becoming more and more complicated; that of steel was particularly so, mainly because it had been the most completely investigated. It would not do, however, to be too discouraged. The results so far obtained certainly did give at least those phases and curves which were most characteristic of each series of alloys; and to have, for example, proved the existence of the compounds Cu_3Sn and Cu_4Sn was much. As to the authors' diagram, he hoped they would pursue the research, and fill in the boundaries of the phase regions, because, as it stood, the diagram formed really a difficulty, and it should be definitely settled whether the phase rule really would not fit or whether some other explanation was possible.

The next speaker was Mr. A. V. Hussey, who said that, as one interested in the practical applications of aluminium, he had turned to the paper for useful facts. It seemed, however, that the series of alloys at the most interesting end of the diagram were unserviceable. Most of the useful alloys contained from 10 to 30 per cent. of zinc; that was, they belonged to, say, the δ, γ regions. These were used for light castings. One of their drawbacks was that they were very subject to corrosion, and possibly this was due to lack of homogeneity, since the corrosion of aluminium sheets seemed to originate in differences in the hardness of different parts. Hence he thought that if the authors could suggest a method of getting more homogeneous alloys, these would be found more resistant to corrosion.

Dr. H. C. H. Carpenter said that he thoroughly agreed with the authors in only drawing in the lines which could be fixed by actual experiment. In too many diagrams lines were put in without sufficient evidential basis. As to the evolution of heat at 256 deg. Cent., he thought credit ought to have been given to Professor Turner and Mr. Ewan, who had independently observed it. He also asked within what limits of temperature had the line at 443 deg. Cent. been fixed. From the paper it appeared that here was another case in which the β phase was stable over but a comparatively small range of temperature—less than 200 deg. Cent., decomposing into two on further cooling. As other β phases acted similarly, he suggested that there might be some general principle underlying the phenomenon.

In reply, Dr. Rosenhain said that his opening remarks, as to lack of accord between the authors' diagram and the phase rule, had been prompted by a discussion he had had with Dr. Gwyer on the previous evening. Dr. Gwyer had also drawn attention to the smallness of the evolution of heat which accompanied the formation of the Al_2Zn_3 compound. This body, however, gave out heat very vigorously when it decomposed, so that the actual liberation of heat at 443 deg. Cent. was in reality the difference between the heat of solidification and that taken up in the combination which occurred endothermically. As to Mr. Hussey's desire for facts likely to be useful in practical metallurgy, he would ask him to wait till the publication of the next report to the Institution of Mechanical Engineers. He might say, however, that apparently some of the alloys rich in zinc would also prove useful, as they had many interesting mechanical properties. The corrodibility of the alloys would also be dealt with later. If, however, the zinc were pure enough, it was not serious; and, in fact, it was the impurities which were to blame for the rapid corrosion which sometimes occurred. Dr. Carpenter had suggested that, in connection with the heat evolution at 256 deg. Cent., mention should have been made of the work of Turner and Ewan, but the latter had never claimed priority in this matter, and the publication had been first made by the speaker. In determining the solidus curve the alloys were generally annealed for 6 hours, though in some cases the annealing was prolonged for 100 hours. The position of the line was fixed with certainty within a limit of 3 deg.

Professor Turner then rose, and said that, whilst he claimed no priority *re* the result in debate, he might state that this had been observed six months before he published it, and that the work of his collaborateur and himself, though not so complete as that of the authors of the paper just read, had independently resulted in the same discovery.

Solid Solutions.

Mr. C. A. Edwards then read his paper entitled "Further Notes on the Nature of Solid Solutions." This was intended as a reply to some criticisms made on a paper read by the same author last January. In that paper the author contended that solid solutions of two metals or intermetallic compounds were intimate crystalline mixtures, the crystals being so small that the mass appeared quite homogeneous, but that nevertheless the crystals were large enough to retain their individuality. The objection raised to this view was that it was opposed to the phase rule, which required that a solid solution should be homogeneous. In his Newcastle paper Mr. Edwards argued that in a gaseous solution such as air each constituent retained its individuality. This was also the case where a gas was dissolved in a liquid, and similarly certain salts in aqueous solution underwent with changes of temperature similar transformations as if heated in the solid state. These results, he argued, led to the view that the molecules of each constituent of a solution remained unchanged by the fact that they were dissolved and that no association with the molecules of the solvent occurred, and that, finally, the molecular aggregates of one metal dissolved in another were actually minute crystals.

The discussion was opened by Dr. Guertler, who said that he thought thanks were due to the author for raising the question, as there was, perhaps, a tendency to believe too implicitly in accepted theories. Two points might be advanced in favour of the author's views. For example, sugar dissolved in water could not pass through a wall which the water molecules could traverse, and it retained the power of rotating the plane of polarisation of light which it possessed in the solid form. It had not, therefore, given up all the properties which it possessed as a solid. Again, sodium dissolved in metallic silver retained the power of decomposing water. Sulphur in the form of S_6 dissolved in carbon bisulphide still acted as solid S_6, and mercury dissolved in gold evaporated as ordinary mercury did. Mr. Edwards, however, said that solid solutions were not homogeneous, and in a sense this was necessarily true, as ultimately we must come down to the individual atoms. The general opinion was, however, that until this limit was reached the solution was homogeneous. Further, the author raised the question whether a dissolved body retained all its properties in the solid. If he was right, with bismuth dissolved in solid copper the melting-point should show up just as if the metal were isolated, and similarly with mercury in solid solution. The general opinion was opposed to this view, and changes of this kind could not be recognised in the homogeneous field of the equilibrium diagram. In fact, if the accepted view was wrong, all equilibrium diagrams were wrong. It was true that solid solutions might not be built up from atoms in as simple a fashion as had often been assumed, but there was as yet no evidence of the discontinuous changes required by the author's theory.

Mr. O. F. Hudson, who spoke next, thought the paper of great value as emphasising the importance of obtaining a true view of the nature of solid solutions, and in drawing attention to the possibility of many substances preserving their individuality when dissolved. He could not, however, accept the author's view that the solute existed as small crystals, as, if so, the solution could not be considered homogeneous.

Dr. Gwyer, who spoke next, said he thought there was no evidence in favour of the author's views. In gaseous mixtures it was the molecules which remained unchanged; but the point disputed was not that the molecules might remain unchanged when dissolved, but that the constituents of the solution were molecular aggregates of particular orientation.

Dr. Rosenhain, who spoke next, said that in so

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(*For Description, see Page* 410.)

FIG. 1.

far as the author had abided by what he said last January, he was not one bit more in agreement with him. A crystal was a large molecular aggregate of, perhaps, hundreds of thousands of molecules. Now in solid solutions diffusion took place, and he did not see how such large units could diffuse, and this, he thought, was a final objection to the author's view. The phase rule did not apply to molecular mixtures, such as air, but it did to crystal boundaries.

Professor A. K. Huntingdon said that from the practical standpoint he did not believe in the author's ultra-microscopical crystals. A crystal was a living thing, the essence of it being that it would grow. Hence if such existed in solid solutions, the homogeneity would soon be done away with.

Dr. Cecil Desch, who spoke next, said that the dispute as to whether or no solid solutions were built up of crystal elements was really old. Mr. Edwards's view was that the structure resembled that of a wall built up of red and white bricks. Some direct evidence on the point at issue was, he thought, provided by recent experiments on colloids. One consequence of Mr. Edwards's view would be that transformations would be carried on in the same way when a body was in solid solution as when free. The only evidence in support of this was that a change occurred with brass alloys in the α region at the same temperature as a change in the β area of the diagram. It was not proved, however, that the change was the same, and the coincidence of the temperatures might be accidental. Mr. Edwards, moreover, definitely denied that particles of a solute could be in union with particles of the solvent. This view was in conflict with what was known as to the constitution of aqueous solutions, where it was more and more clearly established every day that such an association was frequent.

In reply, Mr. Edwards said that he admitted that the acceptance of his views required the exercise of a good deal of imagination, and as the objection that his proposals were in conflict with the phase rule had not now been urged, he considered that he had gained one point at least. As to Dr. Rosenhain's objection that the speaker's elementary crystals would be incapable of diffusion, his own view was that each crystal was necessarily surrounded by an atmosphere of its vapour phase, and probably of its liquid phase also, both no doubt in very minute quantities, but sufficient to permit of diffusion taking place. He did not, he added, wish to alter the equilibrium diagrams, and could get along well with the term "solid solution," though he claimed that the meaning commonly attached to the term was not necessarily correct.

THE CORROSION OF BRASS.

In the absence of the author, Professor Turner then read in abstract a paper by Mr. Paul T. Brühl, on "The Corrosion of Brass, with Special Reference to Condenser-Tubes," of which we commence the publication on page 436. Professor Turner asked the meeting to take into consideration in their criticisms the fact that the paper was the work of a student. Much of the work described in the paper was carried out on old condenser-tubes supplied by Admiral Sir Henry Oram. The author stated that the corrosion of such tubes might be due to four agencies—viz. : 1. Corrosion proper, where the metal was uniformly removed over the whole surface. 2. Dezincification, where the zinc was preferentially dissolved. 3. Pitting, which was, he said, the most serious form, greatly curtailing the life of the tube. This, he stated, was due to galvanic action between a deposit on and the metal of the tube. 4. Erosion, where the mechanical effect of the stream of water came into play. As to preventive methods, the author stated that the use of protective coatings gave little promise of economic usefulness. The principal evils arose from the presence of iron hydrate and carbonaceous matter.

In the course of his research the author measured the position on the electro-chemical scale of substances likely to come in contact in practical condenser practice, using sea-water as the electrolyte. The order found was as follows :—

1. Brass.
2. Zinc oxide.
3. Oxychloride.
4. Iron oxide.
5. Cuprous oxide.
6. Cupric oxide.
7. Iron hydrate.
8. Basic zinc carbonate.
9. Coke.
10. Basic copper carbonate.
11. Tin oxide.

The specific resistances measured in the moist state were also observed, the results being as follow :—

	Ohms.
1. Coke	< 1,000
2. Cuprous oxide	< 1,500
3. Iron oxide	2,800
4. Basic zinc carbonate	4,000
5. Basic copper carbonate	6,500
6. Zinc oxide	7,000
7. Oxychloride	7,500
8. Cupric oxide	10,000

The effect of impurities on the surface of the brass were also investigated, though in measuring the potential differences difficulties arose from the effects of polarisation. In these experiments the areas in contact were kept approximately the same for each impurity. The effects were found to depend on the magnitude of these contact areas, and the author concluded accordingly that for a given area of protective metal only a definite amount of the other metal could be protected.

The author's final conclusions he summarised as follows : —

1. That the presence of air or an increase of temperature up to a certain point accelerates corrosion.

2. That iron, nickel, and small amounts of lead are injurious ; tin up to about 1 per cent., large amounts of lead, and aluminium are useful in diminishing corrosion.

3. That the inlet pipe and the condenser plates should preferably be made of brass.

4. That the condenser should be protected against stray currents.

5. Protective coatings are not recommended.

6. The importance of "spills" cannot be exaggerated.

7. That the tubes should be flushed with clean water after use.

The discussion on the paper was opened by Sir Charles A. Parsons, who said that he had unfortunately seen hundreds of defective tubes. In view of the importance of electrolytic action, it had occurred to him some years ago that it might be worth while experimenting with two tubes, one of which telescoped tightly into the other. In such a case it was very improbable that the hard spots on the two tubes would coincide. He believed that bi-metallic condenser-tubes had been tried without success ; but if anything could be done to stop the corrosion of condenser-tubes, it would undoubtedly be a great boon to all engineers.

Mr. F. A. Anderson, who followed, said that the paper had a special interest for him, as he had been for several years at work on the subject of preventing the corrosion, and had succeeded in devising a system which had found many successful applications. His starting-point was the old work of Davy on the importance of the protective effect of the more electro-positive metals. He had tried zinc, but this had proved quite unsatisfactory ; but, on the other hand, aluminium and some of its alloys had given good results, being superior both to zinc and to iron. Further, the protective powers of aluminium were retained until it was completely dissolved away. It, moreover, left no deposit. Its superior protective power was curious, in view of the fact that zinc stood higher in the electro-chemical scale. Nevertheless, as stated, he had installed it with success in situations where zinc had wholly failed. In using blocks of protective material, it was, of course, essential to secure metallic contact between these and what had to be protected. He could fully corroborate the author's statements as to the damage that might be done by stray currents of electricity, and as to the advantage of giving these alternative paths. In some cases the plan of passing a mild current through the condenser in such a direction as to protect the tubes had been tried, but apparently with not much practical success ; but he was himself then engaged in studying the possibilities of this method of protection. In all cases, he might add, corrosion was easier to prevent than to check once it had started, but he had proved that the latter operation was feasible.

Mr. Gerald Stoney said that he had been trying to collect evidence to ascertain whether in times past tubes stood better than now. He was not a metallurgist, but he believed that nowadays electrolytic copper was so pure that a nominal 70—30 tube had actually that composition. In times past there might have been $1\frac{1}{2}$ per cent. of impurities ; and he might say that such evidence as he had been able to get seemed to indicate that such tubes stood better, and there was reason to suppose that the presence of arsenic was particularly favourable.

One of the difficulties he had met with was that on sending tubes for analysis, the chemist simply determined the copper, and put down everything else as zinc. If, however complete analyses were made of some specimens of the old type of tubes, he thought very valuable results might be attained.

Professor H. C. H. Carpenter, who spoke next, said he agreed that the paper must be judged as the work of a student, but much of the work described had been already much more thoroughly carried out in America, especially that portion which had relation to electrolytic actions. Reference had been made by the author to work done by the speaker and Mr. Edwards, but the latter's name had been improperly omitted. The table showing the electro-chemical scale of various substances in sea-water would, he thought, be useful; and this he could say was also the opinion of Mr. Bengough. The author had been very bold in formulating conclusions on a small amount of experimental evidence, though these conclusions were in some cases in conflict with the long experience of the Admiralty.

Mr. J. M. Allan said that he would confine his remarks to the case of corrosion due to mechanical defects. He believed that could these be eliminated, a considerable step would have been made towards the cure of corrosion.

Professor Henry Louis said that the author had treated corrosion almost wholly as the result of galvanic action, but the speaker was quite convinced that this was not always to blame. Where lead was present, it was dissolved out first, which would not be the case if galvanic action were involved. He believed, therefore, that there were innumerable other agencies at work, and that those who fixed their attention exclusively on galvanic action would miss a lot.

Sir W. H. White said he wished to raise a point as to the procedure of the Institute. Indulgence had been claimed because the paper was the work of a student, but surely the Institute did not exist to publish students' work which required a plea of that kind. He hoped that the Publications Committee would therefore edit the paper thoroughly before it appeared in the Proceedings.

Sir Gerard Muntz, in reply to Sir William White, said all communications offered came before a committee, who sent them to different referees. If there was any fault in this case, it lay with the referee. As for himself, he thought the paper of a highly desirable type, containing many valuable suggestions. Its fault was that it covered too wide a ground, but in spite of this his own view was that with but slight modifications it was a good paper.

Concluding Proceedings.

Sir Gerard Muntz then said that he was glad to inform the meeting that Mr. Bengough was improving in health, and to add that arrangements had been made by which 10 per cent. of any surplus realised on the exhibition of non-ferrous metals, to be held soon in London, would be given to the funds of the Corrosion Committee. He then moved a vote of thanks to their hosts in Newcastle, the Corporation, the authorities of the Armstrong College, and the various firms who had permitted members to visit their works. This was seconded by Sir W. H. White, who next moved a vote of thanks to Sir Gerard for his services in the chair, in which he had, the speaker said, more than fulfilled every anticipation. He would not, however, say more then, as Sir Gerard's retirement in January next would be a more fitting occasion for acknowledging how effectively, in spite of his many engagements, he had served the Institute.

ELECTRICAL PLANT FOR DRIVING THE REVERSING ROLLING-MILL AT THE SKINNINGROVE IRON WORKS.

The works of the Skinningrove Iron Company are situated on the north-east coast of Yorkshire, as shown in Fig. 1, page 409, which is a general view looking east to west, the building for the new steel works being on the left side. The company, in constructing their new steel works, have taken the utmost care to use to the fullest extent the blast-furnace gas and the heat which may be regarded as the natural resources available from their existing iron works, so that the cost of making steel can be reduced to a minimum. The whole of the new steel works is driven electrically, including the 36-in. reversing rolling-mill, the electrical power being generated by gas-engine-driven alternators, working on blast-furnace gas. A definite volume of gas thus yields three times the power that could be produced if the gas were burnt under boilers and the power generated by steam-engines or turbines.

The soaking-pits are heated with blast-furnace gas—an application of blast-furnace gas which has not been previously made in England, although this has been done on the Continent. It is interesting to note that in starting up the rolling-mill not a single pound of coal was used, although, up to the present time, whenever a new mill has been started in this country a considerable quantity of coal has been needed. Steel is made by the Talbot continuous process, which uses molten iron from the blast-furnaces. The ingots can be rolled down to the finished sections in the mill without being re-heated, and this is largely made possible by the rapidity with which the electrically-driven reversing rolling-mill can work.

The distance between the present cogging-mill and the soaking-pits is 300 ft., the ingots being brought from the soaking-pits by an electrically-driven ingot chariot; so that should it prove necessary to increase the output in the future, there is plenty of space to put down a new cogging-mill between the soaking-pits and the present cogging-mill, when the present cogging-mill would probably be used as an additional roughing-mill.

A Siemens-Ilgner electrical equipment is used for driving the reversing rolling-mill. This system has already been applied for driving twenty-two other reversing rolling-mills. The mill consists of a 36-in. cogging-mill, a 36-in. roughing-mill, and a 36-in. finishing-mill, all arranged in a line, coupled together, and driven by one reversing-mill motor. This plant is designed for rolling down ingots, weighing from 2 to 4 tons, to rails, beams, angles, &c., and to give an output of about 30 tons per hour. If a larger output should be desired at a later date, a second reversing motor could be put down at the opposite end of the mill to the present motor, to drive the roughing and finishing-mills separately from the cogging-mill, the spindles coupling the cogging-mill to the finishing-mill being removed.

Fig. 2 shows in diagrammatic form the arrangement of the electrical plant for driving the reversing rolling-mill, and the method of connecting up the various machines. By its aid the general principles of the system can be set forth before the detailed explanation is entered upon. The reversing motor, which is coupled to the mill, is shown at the top left-hand corner. This reversing motor is not supplied directly from the power-house, but a fly-wheel motor-generator set is interposed, so as to prevent the large variations in current taken by the reversing motor being transmitted to the power-house, and to ensure that the power-house shall only give the average current required, which may be only one-seventh of the maximum current required by the reversing motor.

The fly-wheel motor-generator set comprises two fly-wheels, a three-phase motor, which is supplied with current from the power-house, and two variable-voltage dynamos, which supply the mill-motor. The reversing-motor is reversed, started, and stopped by controlling the field current of the variable-voltage dynamos, the speed of this reversing motor being proportional to the magnitude and direction of the voltage of the variable-voltage dynamos. At the lower right-hand side of Fig. 2 is shown the main control-lever which reverses the mill-motor by reversing the field circuits of the variable-voltage dynamos, and increases the speed of the mill motor by cutting out the resistances in these field circuits. The main control-lever has a further action in inserting resistances into the mill-motor field when it is required to speed up this machine still further. The variable-voltage dynamos are normally connected in series, but at the top left-hand corner of the diagram is shown a series parallel switch which can place these dynamos in parallel when the mill is required to give an increased turning moment at a lower speed for special purposes. The exciter, which is shown coupled to the fly-wheel motor-generator set, is for supplying excitation for the mill-motor and for the variable-voltage dynamo fields.

At the lower left-hand corner is shown the intermittent slip-regulator which reduces the speed of the fly-wheel motor-generator set when the reversing-motor requires a large power, so as to enable the fly-wheels to give up part of their stored energy to supply this power and to prevent the demand on the power-house increasing.

Fig. 3, Plate XLVI., shows one of the larger gas-engine-driven alternators in the power-house, the output of which is 1600 k.v.a. normal at 109 revolutions per minute, three-phase, 40-cycles, 2750 volts. In order to ensure satisfactory parallel running the weight of the revolving field is 86 tons. The gas-engine is a two-cylinder tandem, double-acting four-cycle machine, manufactured by Messrs. Ehrhardt and Sehmer, of Saarbrücken, the makers of the large generators being Messrs. Siemens Brothers Dynamo Works, Limited, Stafford.

Figs. 4 to 7 show general views of the electrical plant in the mill-motor house. The reversing-motor, which is seen in the background in Fig. 5, and is shown separately in Fig. 6, Plate XLVII., is a direct-current machine, and is direct coupled to the bottom pinion of the mill. In the foreground of Fig. 5 is seen the fly-wheel motor-generator set, consisting of a three-phase driving motor, two direct-current variable-voltage dynamos, and a pair of heavy fly-wheels. This set is interposed between the power-house and the mill-motor, and, as already explained, owing to the effect of the fly-wheels, enables the power from the power-house to be maintained at a small steady value, although the mill-motor may be taking very large powers intermittently. It also enables the speed of the reversing-motor to be controlled by varying or reversing the direction of the current in the fields of the variable-voltage dynamos, so that there is no loss of power in controlling the speed of the mill-motor, and the size of the controlling mechanism can be kept small. If some adaptation of the ordinary form of motor-starter were made for starting and stopping the mill-motor, it is obvious that it would be very large and cumbersome, as it would have to deal with currents exceeding 8000 amperes, rendering it impossible to stop and start rapidly. Further, as the reversing motor has to be reversed under normal conditions ten to twelve times per minute, the loss of power in the starter would be about as great as the power used beneficially. The use of the motor-generator set avoids these difficulties.

The reversing-motor is a double-armature machine capable of giving a normal turning moment of 312 foot-tons, and a maximum turning moment of 475 foot-tons at all speeds between 0 and 60 revolutions per minute, when the armatures of the variable-voltage dynamos are connected in series. At 60 revolutions per minute the corresponding outputs are 8000 and 12,000 horse-power respectively. To enable even larger turning moments to be obtained at slow speeds during the first few passes in the cogging-mill, the two armatures of the variable-voltage dynamos can, as already explained, be put into parallel by a simple movement of the control gear, when a normal turning moment of 425 foot-tons and a maximum turning moment of 520 foot-tons can be obtained at all speeds between 0 and 30 revolutions per minute.

To provide for the finishing passes, in which large turning moments are unnecessary, but high speeds are required to get the rails, &c., which have become elongated to a considerable length, rapidly through the rolls before they have time to cool, the speed of the mill-motor may be increased by reducing its field current up to 120 revolutions per minute, the turning moment being gradually reduced as the speed increases to a value of 137 foot-tons at 120 revolutions per minute.

It is possible to increase the speed of the mill-motor from 0 to 60 revolutions per minute in one second, so that a remarkably rapid reversal can be obtained; this materially increases the tonnage which it is possible to roll. In order to obtain this rapid reversal the fly-wheel effect of the motor armature must be kept as low as possible, and to do this the motor is built with two armatures coupled together and carried in two bearings, which permits the diameter of the armature to be kept small, while the active length of the armature is increased.

As the armatures of the reversing motor are rapidly reversed and are seldom running at full speed, the ventilation is not so efficient as that of armatures which are constantly running at their top speed; and to overcome this difficulty motor-driven fans are provided to give forced-draught ventilation. This forced-draught ventilation (Figs. 9 and 10, page 412) is introduced in the motor between the two armatures, and the current of air is guided so that part passes radially through the armature and through the field-coils, while the remainder

circulates under and through the commutator. A commutator is provided for each armature, and each commutator is constructed in two parts, separated by a space of about 2 in., so that the cooling air can pass outwards through this space. This commutator construction gives four points of support to the commutator-bars, instead of the two in the ordinary construction, so that there is four times the mechanical strength, and, owing to the short length of the bar and the efficient cooling, the possible expansion of the bars is reduced to a minimum, ensuring good commutation under the most severe conditions. The reversing motor is provided with commutation-poles and compensating windings. As the motor is constantly starting and stopping, it is not possible to rely on oil rings for properly lubricating the bearings, and so two motor-driven pumps are provided for keeping the bearings flooded with oil, one of these being a spare. The reversing motor weighs approximately 194 tons. It is 27½ ft. long by 14 ft. wide, and the shaft is 30 in. in diameter at the largest part.

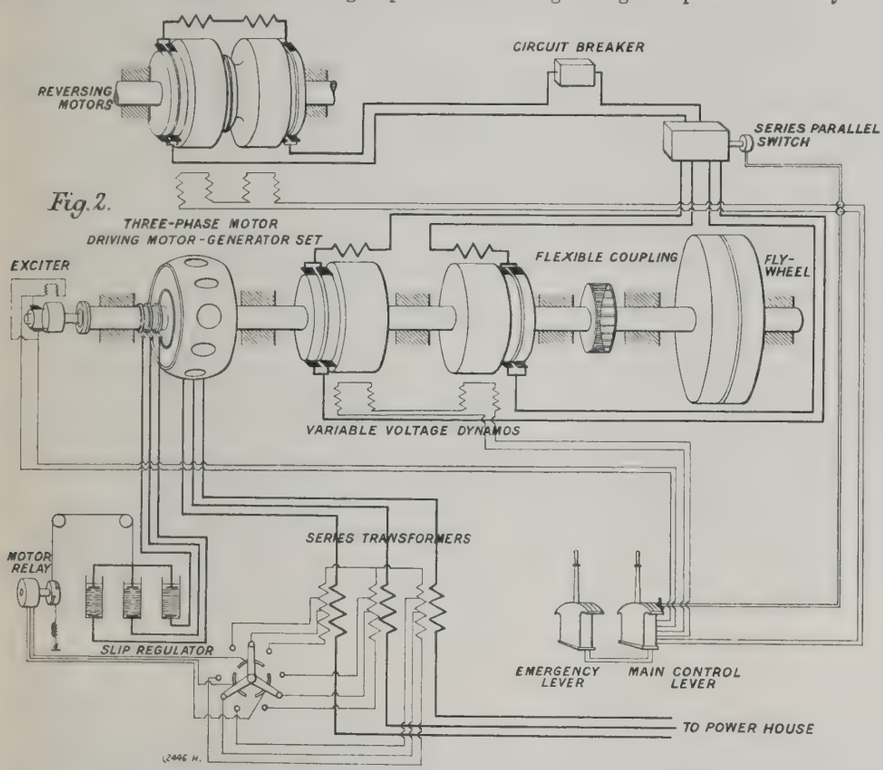


Fig. 2.

Each armature is wound for 530 volts, so that the maximum voltage supply is 1060 volts. The maximum current is 8400 amperes.

Figs. 4, 5, and 7, Plates XLVI. and XLVII., show the fly-wheel motor-generator set, Fig. 4 being taken from the fly-wheel end, and Fig. 7 from the three-phase motor end. This fly-wheel motor-generator set may be considered as consisting of two parts—namely, the fly-wheels and the electrical machines—and these two parts are not rigidly coupled together, but are connected by a flexible coupling of the steel-needle type (see Fig. 12, page 412). This avoids any difficulties in securing proper alignment, which might occur owing to the weight of the fly-wheels employed, and to the fact that the total length of the fly-wheel motor-generator set is about 50 ft.

There are a pair of fly-wheels mounted side by side, and supported by two bearings, each wheel weighing 23 tons. This arrangement was adopted to avoid the difficulty of transporting a single solid wheel weighing 46 tons. The fly-wheels are 12 ft. 8 in. in diameter, and, at the maximum speed of 475 revolutions per minute, the peripheral speed is 19,000 ft. per minute; the stored energy of the two fly-wheels is 178,000 horse-power seconds. Each fly-wheel is a steel casting having a solid web and no spokes, and is machined all over and carefully balanced to secure both equal distribution of weight and homogeneity of the material.

As the fly-wheel motor-generator set is driven by a three-phase motor, the set cannot run away, as it is physically impossible to exceed 480 revolutions per minute, the synchronous speed of the three-phase motor. The fly-wheel bearings are lubricated by oil under pressure, which is supplied by duplicate oil-pumps, one set of oil-pumps being belt-driven from the fly-wheel shaft, while the other set is separately driven by an electric motor. In addition to the pressure lubrication, the bearings are provided with oil-rings, and if the oil-pressure should fail from any cause, these oil-rings provide sufficient lubrication to keep the fly-wheels running for half an hour without the bearings overheating. If the oil-pressure should fail, a loud gong is automatically set ringing to call the driver's attention, so that he has ample time either to set the other set of oil-pumps going, or else to stop the fly-wheel motor-generator set before the bearings can overheat.

Far greater precautions are thus taken to prevent damage if the oil-pressure should fail than is usual with other machinery having forced lubrication, and the arrangements described above are well tried, as they have been used for the fly-wheels of over 100 electrically-driven winding-engines and a number of reversing rolling-mill plants with every success.

If the power were switched off from the motor driving the fly-wheel motor-generator set, the set would run for about two hours before coming to a standstill; a band-brake, having wood blocks on the friction surface, is therefore provided for the fly-wheels, which enables the fly-wheel motor-generator set to be brought to a standstill in less than two minutes. The fly-wheel motor-generator set can be started and brought to full speed in about four minutes without exceeding the full-load current of the driving-motor.

The windage of the fly-wheels causes a certain loss of power, which adds to the friction of the motor-generator set, so that care must be taken to reduce this loss as far as possible, and the most effective means has been found to be that of placing a sheet-metal casing round the outside of the rims of the fly-wheels. Practically all the windage of such a fly-wheel is found to be caused by the outside surface of the rim; and where a sheet-metal casing is placed, as described above, to prevent the air being driven away by the fly-wheel, thus preventing the fan action of the fly-wheel, the loss due to windage is reduced to quite a small value. The fact that the webs of the fly-wheels produce practically no windage can be shown in a striking manner by holding a handkerchief against the web, near the inner surface of the rim, when the fly-wheel is running. It is then seen that there is not enough wind to blow the handkerchief out. Some of the earlier fly-wheels were entirely cased in sheet metal, but this has been found to be unnecessary, while a fly-wheel has been built to run in a cast-iron case from which the air was exhausted, so that the fly-wheel ran in a vacuum. It was found, however, that more power was required to maintain the vacuum than was saved by reducing the fly-wheel windage. The provision of the sheet-iron casing to prevent the fan action of the rim of the fly-wheel has been found to be the most practical method of producing fly-wheel windage.

Fig. 12, page 412, shows the steel-needle coupling which is used for coupling the fly-wheels to the electrical machines forming the motor-generator set. It consists of two steel discs about 4 ft. in diameter, one of which is keyed to each of the shafts; the discs are connected together by forty-four nickel-steel rods, which are arranged round the periphery of the discs, and whose axes are parallel to the axis of the shaft. These nickel-steel rods are rigidly bolted to one disc, and rest in spherical seatings in the other disc. This steel-needle coupling has to transmit powers of about 12,000 horse-power at speeds varying between 475 and 380 revolutions per minute. The first coupling of this type was set to work about four years ago, and a number of others are in operation with good results. Such couplings have been found to work satisfactorily when the shafts which they connect are as much as 2 mm. out of line.

The two variable-voltage dynamos of the motor-generator set are placed next to the fly-wheel, and the three-phase motor driving the motor-generator set is placed at the opposite end of the variable-voltage dynamos to the fly-wheel. This arrangement was adopted because at times the fly-wheel has to give about 12,000 horse-power to the variable-voltage dynamos, so that it is naturally desirable to transmit this large power as short a distance as possible. The three-phase motor, on the other hand, does not give more than 1825 horse-power to the variable-voltage dynamos or the fly-wheels, as the case may be.

Two variable-voltage dynamos are installed in the motor-generator set instead of one machine, because the high speed at which this set runs is too high for the size of dynamo which would be required if one machine only were employed. The maximum speed of the motor generator is determined by the fly-wheel, and such a high-speed wheel cannot be built up in sections, but must be a single piece. The largest diameter fly-wheel that can be carried by rail is 12 ft. 8 in.; as the maximum peripheral speed of such a cast-steel wheel is 20,000 ft. per minute, this gives a maximum speed for the fly-wheel motor-generator set of 500 revolutions per minute; 480 revolutions per minute is a synchronous speed for a 40-cycle motor, so that slightly under 480 revolutions per minute—namely, 475 revolutions per minute—was chosen as the maximum speed of the fly-wheel motor-generator set. If a lower speed were chosen, so as to enable one variable-voltage dynamo to be used, considerably heavier fly-wheels would have to be used in order to obtain the same stored energy, and the saving in capital cost that could be made by using one variable-voltage dynamo, instead of two, would be less than the increased cost due to the extra fly-wheel weight. The maximum speed of 475 revolutions per minute is therefore the most economical. Each variable-voltage dynamo gives 8400 amperes as a maximum at a voltage varying between zero and 540 volts, and it should be particularly pointed out that when the mill-motor is just commencing to move, the variable-voltage dynamos have to give this current at practically zero voltage.

As mentioned above, these variable-voltage dynamos can be connected in parallel or in series according to whether the mill-motor is required to give a high turning moment at a low speed, or a lower turning moment at a higher speed. Each variable-voltage dynamo is provided with a double commutator, commutation-poles, and compensating windings; but as these machines run at a considerable speed, forced-draught ventilation is unnecessary, nor is oil pressure lubrication required for the bearings, which are provided with the ordinary type of oil-rings.

The three-phase motor driving the fly-wheel motor-generator set has a normal output of 1825 horse-power on a three-phase 40-cycle circuit, 2650 volts, and is provided with a slip-ring rotor.

A small exciter (Fig. 7) is coupled to the three-phase motor end of the motor-generator set, in order to supply the excitation current for the fields of the mill-motor and of the variable-voltage dynamos.

The fly-wheels prevent the power taken from the power-station from varying. The reversing motor may be taking up to 12,000 horse-power

for a few seconds, and then may require no power for a number of seconds, while the motor driving the motor-generator set is taking a steady power of something less than 1825 horse-power from the power-house. The speed of the fly-wheels—that is, the speed of the fly-wheel motor-generator set—must fall when the reversing mill-motor requires a large power, in order that the fly-wheels can give up some of their stored energy, and must rise again when the mill-motor requires no power, so that the constant power supplied from the power-station may go to increase the stored energy of the fly-wheels. The speed of the fly-wheel motor-generator set rises and falls between 475 and 380 revolutions per minute—that is, by 20 per cent.—rendering 36 per cent. of the stored energy of the fly-wheels—that is, 64,000 horse-power seconds—available for neutralising variations in power.

Fig. 13, page 413, shows the intermittent slip regulator, which is used to cause the rise and fall in speed by increasing or diminishing the resistance in the rotor circuit of the three-phase motor. This regulator consists of three liquid resistances enclosed in an iron case, one resistance for each phase of the rotor circuit. The lower plates of these resistances are fixed, and the top plates are movable, being arranged so that they can be moved by a motor relay. This relay consists of a small three-phase motor, the stator of which is connected to a series transformer placed in the stator circuit of the main three-phase motor, so that the current flowing in the stator of the motor relay is proportional to that taken by the main three-phase motor.

The rotor of the motor relay is restrained from freely moving by a spring attached to a lever keyed to its shaft. When the turning moment of the motor relay exceeds the value which corresponds to the average current in the main three-phase motor, the turning moment of the motor relay overbalances that of the spring, causing the rotor to move, thereby drawing the movable plates away from the fixed plates. This increases the resistance of the rotor circuit of the main three-phase motor, and the fly-wheel motor-generator set falls in speed, enabling the fly-wheels to supply the excess of power required above the average power which is given by the main three-phase motor. On the other hand, if the average power required by the mill-motor falls away, so that the current in the main three-phase motor tends to fall slightly below the average value, the springs overbalance the turning moment of the motor relay. The movable plates are then brought nearer to the fixed plates, and the motor-generator set is speeded up, so that the power of the driving-motor is taken to increase the stored energy of the fly-wheel.

The average power required to drive the reversing rolling-mill plant naturally varies with the shape and section rolled, and the tonnage obtained. In order to enable the motor relay to keep the power taken at the average value, whatever this average happens to be, the series transformer is wound with a number of separate coils connected up to a dial-switch. By moving this dial-switch the ratio between the motor relay and the current of the main motor can be altered, and the motor relay set to maintain various average currents in accordance with the requirements of the reversing rolling-mill plant.

Fig. 8, Plate XLVIII., shows the control gear which is placed on the driver's platform, and which consists of two levers carried in suitable quadrant frames, and a small case containing instruments. The lever on the right is the main control-lever, and that on the left the emergency lever. The main control-lever controls the direction of rotation and the speed of the mill-motor by varying the resistances in the field circuits of the variable-voltage dynamos and of the reversing motor. When this control-lever is in the middle position the mill is at a standstill. As it is moved in one direction from the middle point the mill-motor increases in speed in one direction, and as the control-lever is moved in the other direction from the middle point the mill-motor increases in speed in the other direction.

It will thus be seen that the control of the mill-motor is most simple, being effected by the plain backwards and forwards motion of the control-lever in a straight slot. As the control-lever is moved from the middle position the speed of the mill-motor increases, because the resistances in the field circuits of the variable-voltage dynamos are gradually cut out of circuit. The voltage of these machines therefore rises, which, of course, increases the speed of the mill-motor until the lever is half-way between the middle and the end position, when the voltage of the variable-voltage dynamos has reached the maximum value and the speed of the mill-motor has reached 60 revolutions per minute. During this period the field of the mill-motor is maintained constant, so that the maximum turning moment which the mill-motor can give is also constant.

As the main control-lever is moved further over resistances are gradually cut into the field circuit of the mill-motor, thus increasing the speed of this machine. But as this reduces the field of the mill-motor, the turning moment is reduced inversely as the speed increases until the speed has reached 120 revolutions per minute, when the normal turning moment is 137 foot-tons. The field resistances are so graduated that equal displacements of the main control-lever cause equal increases of speed, while on account of the very rapid acceleration of the mill-motor, obtained by special devices, the speed of the motor increases as fast, or even faster, than the control-lever can be moved. The speed of the mill therefore exactly follows the movement of the control-handle, making the mill very easy to control.

As the control-handles are placed opposite the cogging-mill, Fig. 9, Plate XLIX., it may be found desirable to place an additional control-lever opposite the finishing-mill, so that the driver can get a good view of this mill. Arrangements have been made so that this can be added if required. There will therefore be two sets of control-levers, either of which may be used for controlling the mill-motor, and they would be so arranged that when one control-lever is in use the other one is disconnected.

The control-handle on the right of the main control-lever works the motor-driven series parallel switch shown in Fig. 14, page 413, putting the variable-voltage dynamos in series or parallel, according as high turning moments at low speeds, or *vice versâ*, are required. This handle is interlocked with the main control-lever by a small locking-bar, so arranged that the handle cannot be

Fig. 10.

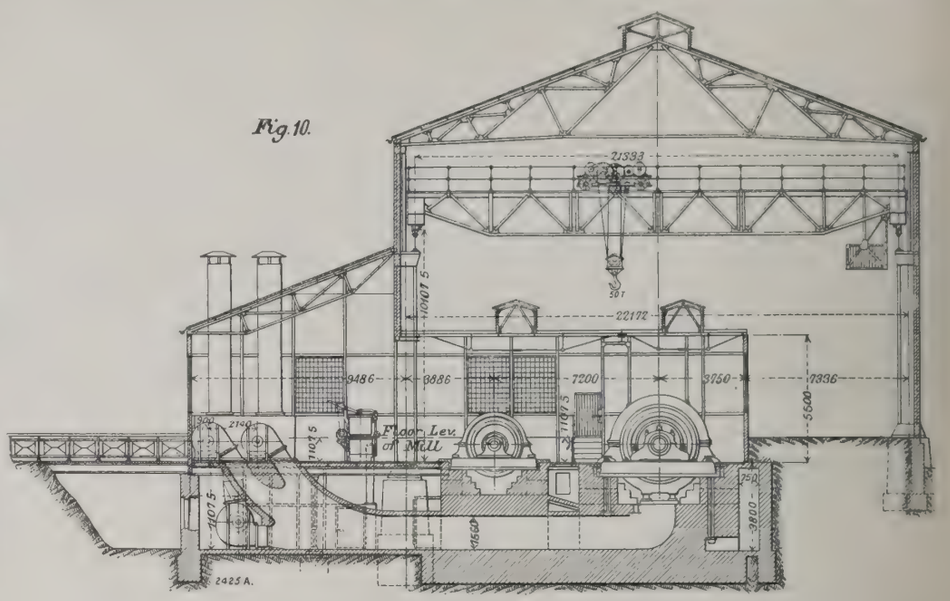
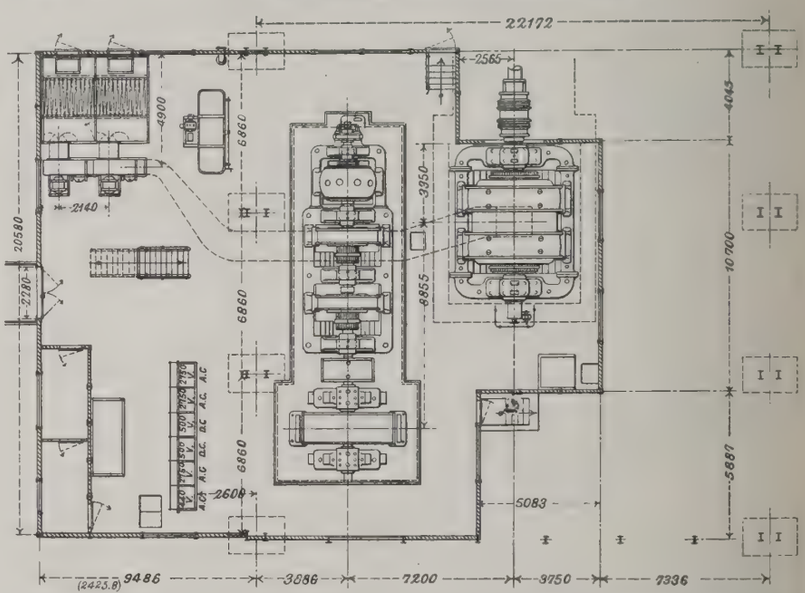


Fig. 11.



FIGS. 10 AND 11. ELEVATION AND PLAN OF ELECTRICAL PLANT FOR DRIVING REVERSING ROLLING-MILL.

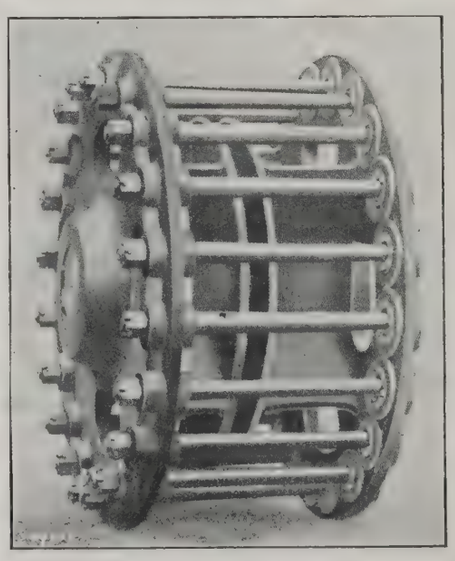


FIG. 12. NEEDLE COUPLING.

ELECTRICAL PLANT FOR DRIVING THE REVERSING ROLLING-MILL AT THE SKINNINGROVE IRON WORKS.

CONSTRUCTED BY SIEMENS BROTHERS DYNAMO WORKS, LIMITED, ENGINEERS, STAFFORD.

(*For Description, see Page* 410.)

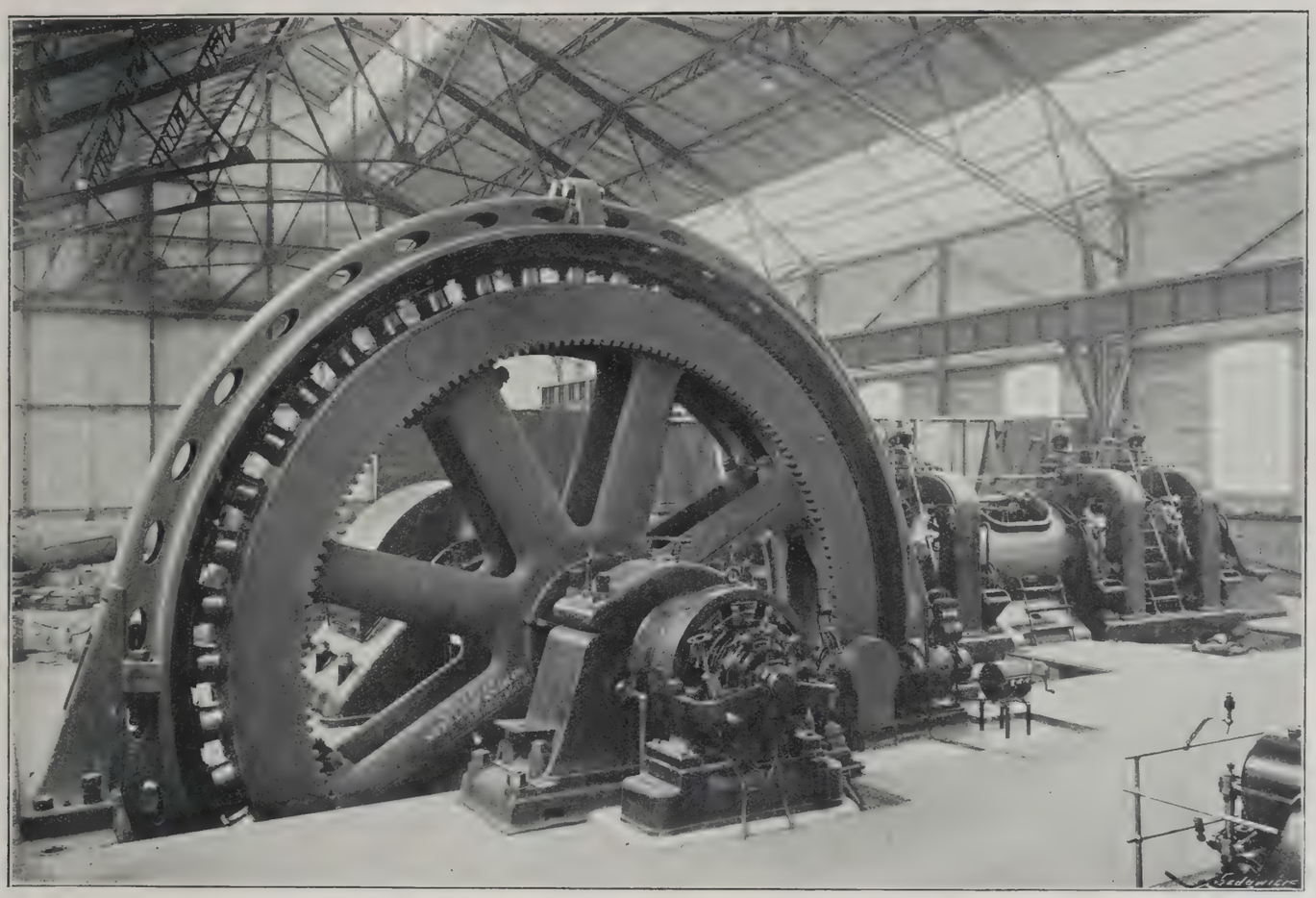


Fig. 3. Gas-Engine-Driven Alternator of 1600 K.V.A.

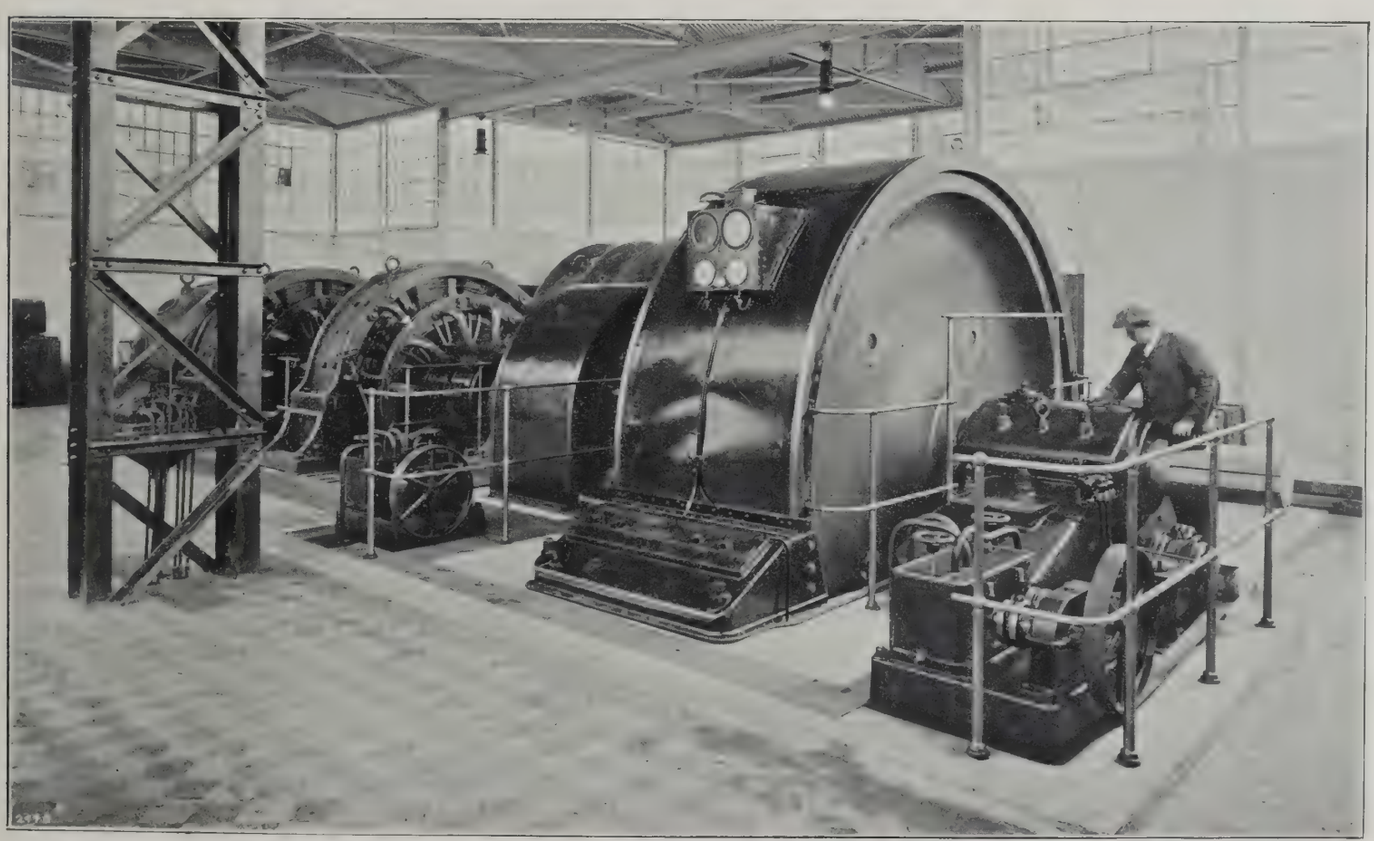


Fig. 4. Fly-Wheel Motor-Generator Set from the Fly-Wheel End.

(*To face Page* 412.)

ELECTRICAL PLANT FOR DRIVING THE REVERSING ROLLING-MILL AT THE SKINNINGROVE IRON WORKS.

CONSTRUCTED BY SIEMENS BROTHERS DYNAMO WORKS, LIMITED, ENGINEERS, STAFFORD.

(*For Description, see Page* 410.)

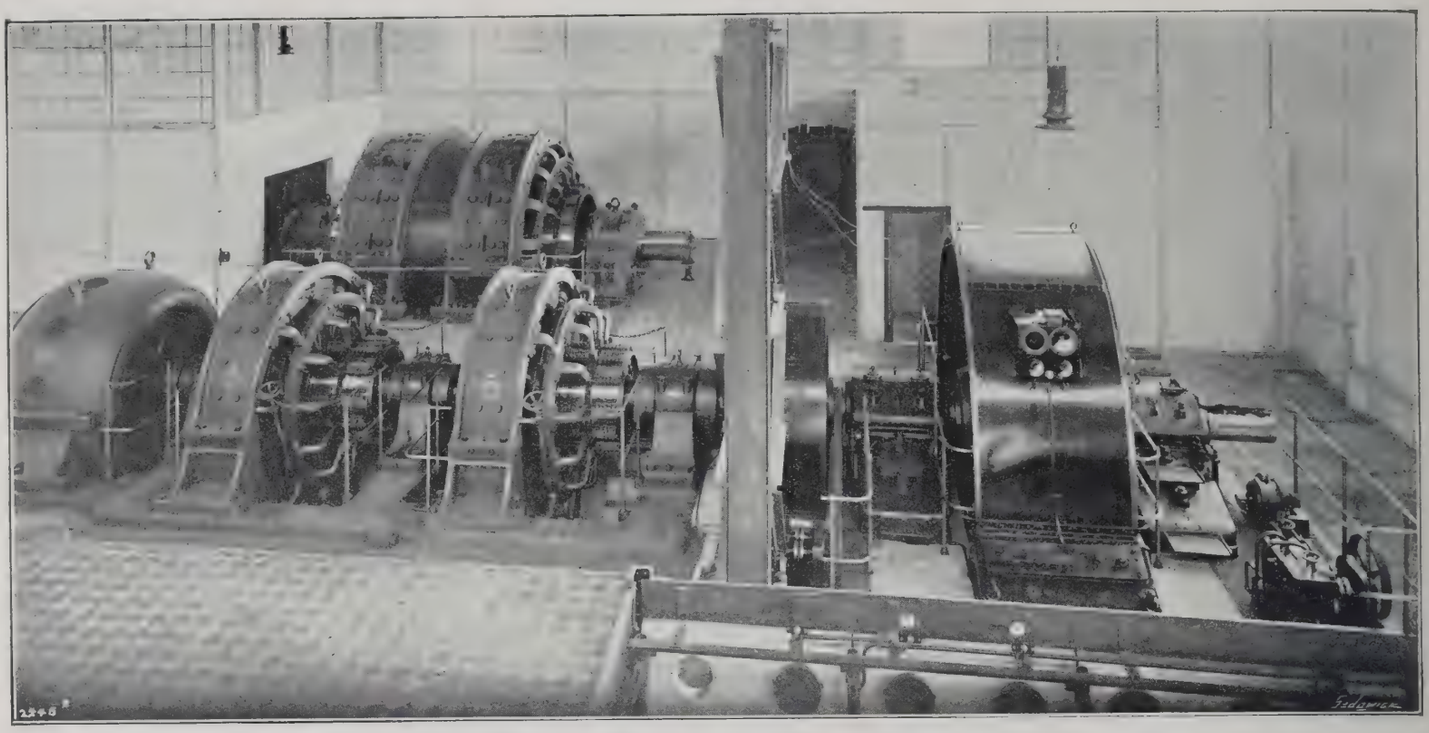


FIG. 5. REVERSING-MILL MOTOR AND FLY-WHEEL MOTOR-GENERATOR SET.

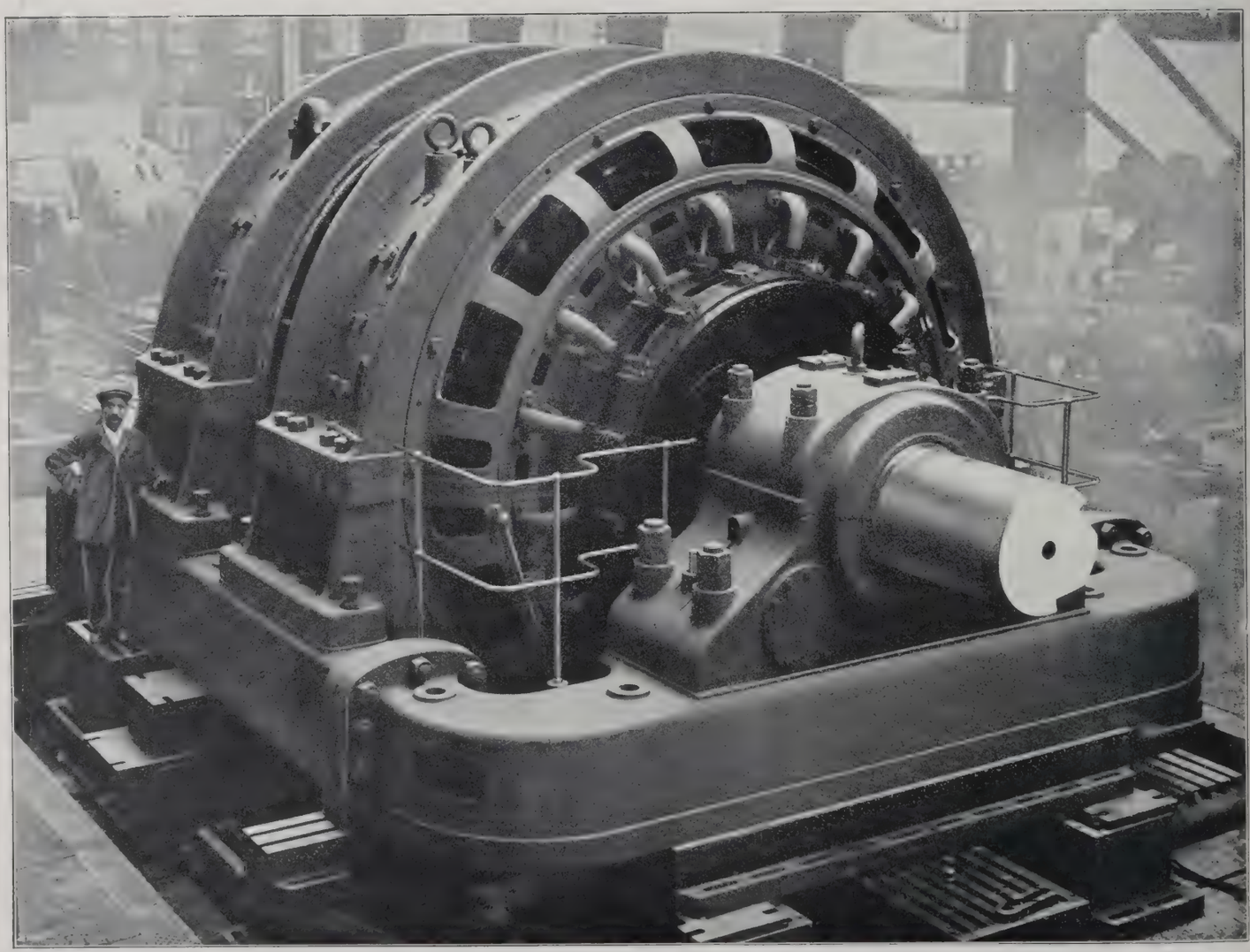


FIG. 6. 12,000-HORSE-POWER REVERSING MOTOR FOR ROLLING-MILL.

ELECTRICAL PLANT FOR DRIVING THE REVERSING ROLLING-MILL AT THE SKINNINGROVE IRON WORKS.

CONSTRUCTED BY SIEMENS BROTHERS DYNAMO WORKS, LIMITED, ENGINEERS, STAFFORD.

(*For Description, see Page* 410.)

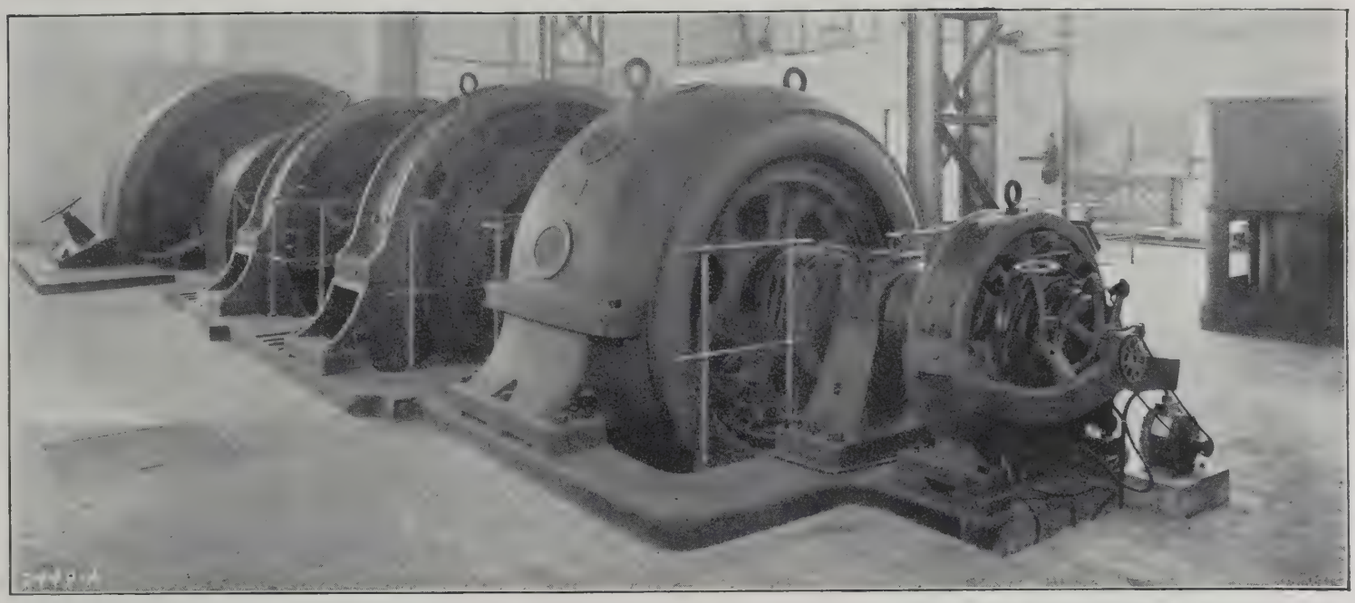


Fig. 7. Fly-Wheel Motor-Generator Set from the Exciter End.

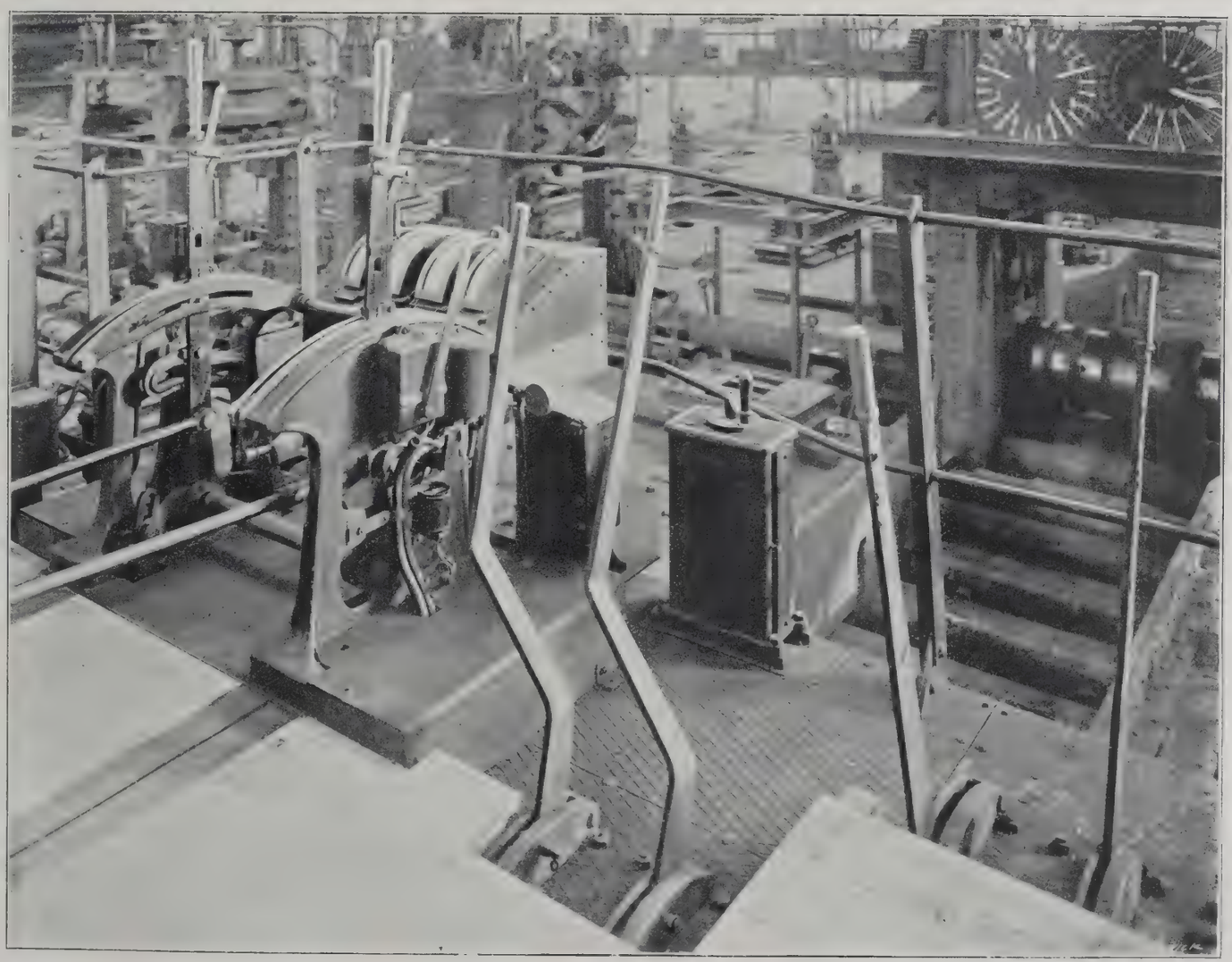


Fig. 8. Driver's Platform and Control Levers.

ELECTRICAL PLANT FOR DRIVING THE REVERSING ROLLING-MILL; SKINNINGROVE IRON WORKS.

CONSTRUCTED BY SIEMENS BROTHERS DYNAMO WORKS, LIMITED, ENGINEERS, STAFFORD.

(*For Description, see Page* 410.)

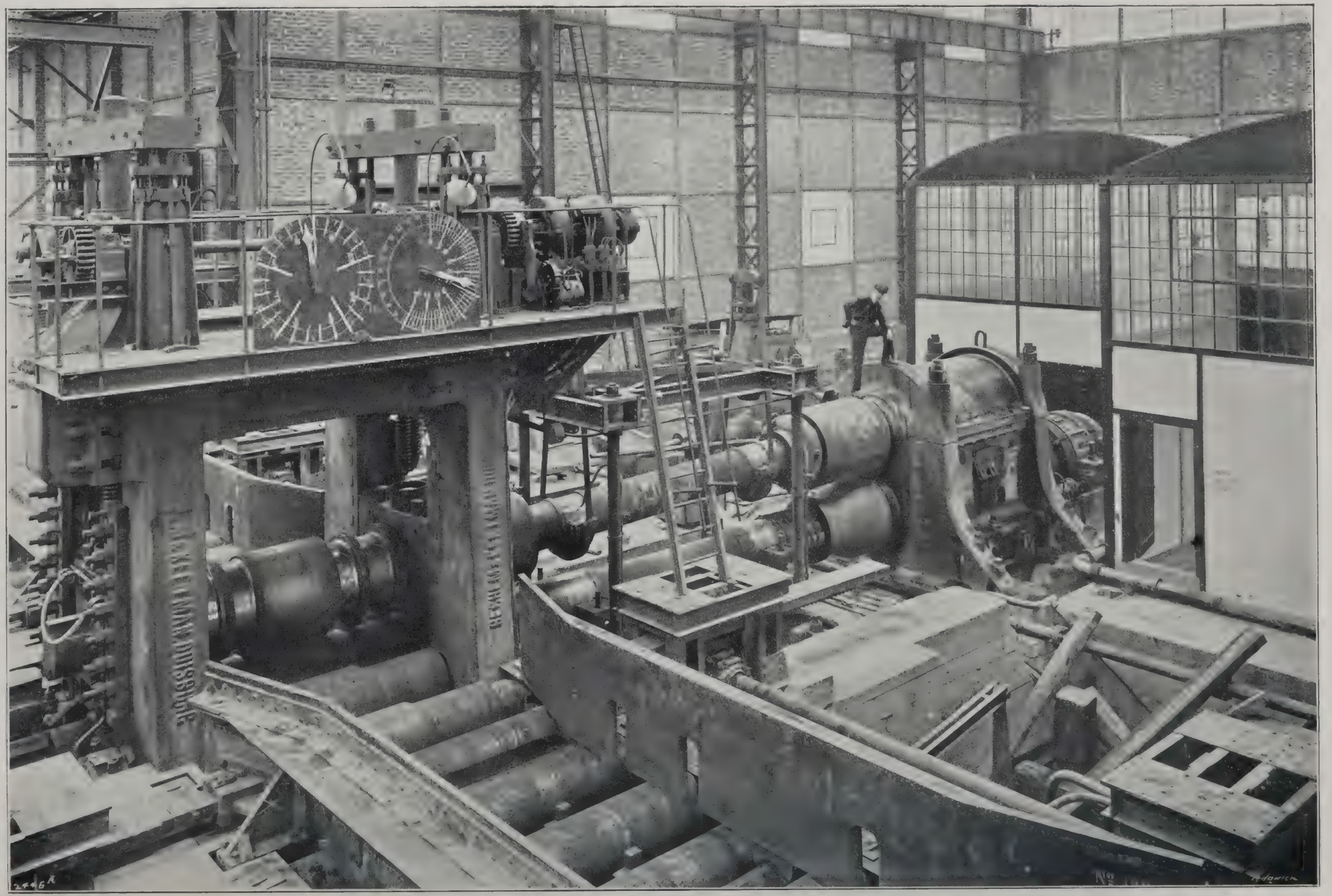


FIG. 9. COGGING-MILL, WITH MOTOR-HOUSE, AS SEEN FROM DRIVER'S PLATFORM.

moved unless the control-lever is in the middle position, and that the control-lever cannot be moved from the middle position unless this handle is thrown over either one way or the other, corresponding either to the series or parallel connection. This prevents the series parallel switch, which may have to carry currents up to 8400 amperes, from being thrown open when it is actually carrying current.

Supposing that the average current were set to a low value corresponding to a small output, and that the mill were suddenly worked on a much larger output without the average current being adjusted to a larger value, then the extra power required to give the large output would have to come from the fly-wheels, which would become exhausted after a few ingots had been rolled. To prevent this there is a magnet-operated stop which is brought into action when the speed of the fly-wheel motor-generator sinks below 380 revolutions per minute. It prevents the lever being moved more than half way from its middle position, so that the driver must either go slower until the fly-wheel motor-generator set has regained its speed, or have the average current set to a higher value corresponding to the required output.

The emergency lever on the left hand affords a ready means of stopping the mill at once: if it is pushed over, it brings the fields of the variable-voltage dynamos to zero instantaneously, and opens the circuit-breaker placed in the circuit between the dynamos and the mill-motor, thus stopping the mill-motor and cutting off the power. If this has been done, the control-lever has to be brought back to the middle position, and the emergency lever replaced before the mill can be started again.

The instrument desk seen between the control-levers in Fig. 8, Plate XLVIII., has two remote-controlled speed-indicators, one of which shows the speed of the mill-motor, while the other shows the speed of the fly-wheel motor-generator set. An ammeter showing the current taken by the mill, and a voltmeter showing the voltage given by the variable-voltage dynamos, are also placed on this desk, so that the driver is always able to see the speed of the mill, and the power which he is taking.

Fig. 15, above, shows the switchboard installed in the mill-motor house. The oil switches, instrument transformers, and other apparatus which are connected to the 2750-volt circuit or the 440-volt three-phase circuit are placed in cells in a cellar below the board, the oil-switches being remote-controlled, so that any wiring, &c., on the back of this switchboard only carries quite low-voltage currents. The first panel on the left-hand side of the switchboard carries the instruments, switch-gear, &c., for controlling the circuits to the fan and oil-pump motors. The next panel is the one controlling the fly-wheel motor-generator set and the mill-motor. The switch-handle operates the main oil-switch in the circuit between the power-house and the three-phase motor driving the motor-generator set. The three instruments on the top of the panel show respectively the amperes, volts, and kilowatts input to this motor driving the fly-wheel converter set. The lower instrument on the left-hand side is the ammeter showing the current in the circuit between the variable-voltage dynamos and the mill-motor; this meter is graduated up to 11,000 amperes. The corresponding instrument on the right-hand side is the voltmeter showing the voltage supplied by the variable-voltage dynamos to the reversing-mill motor.

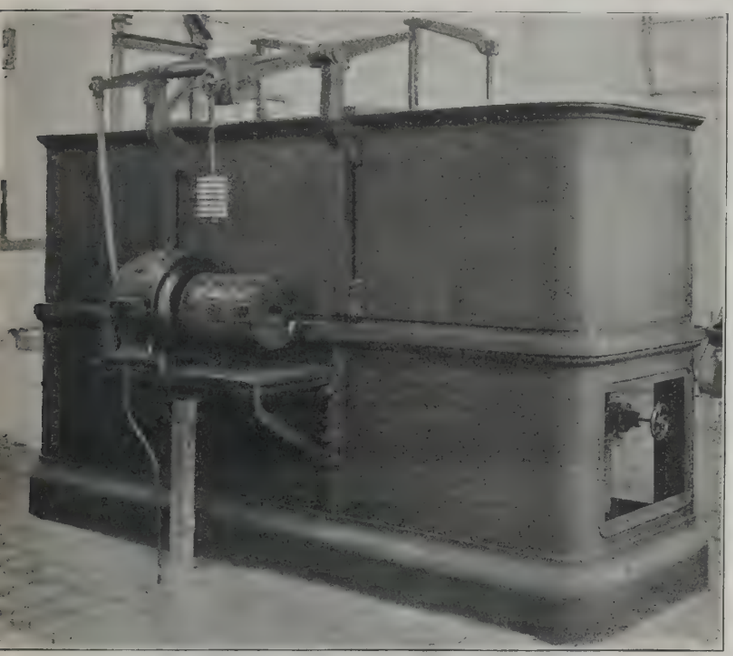


FIG. 13. INTERMITTENT SLIP REGULATOR.

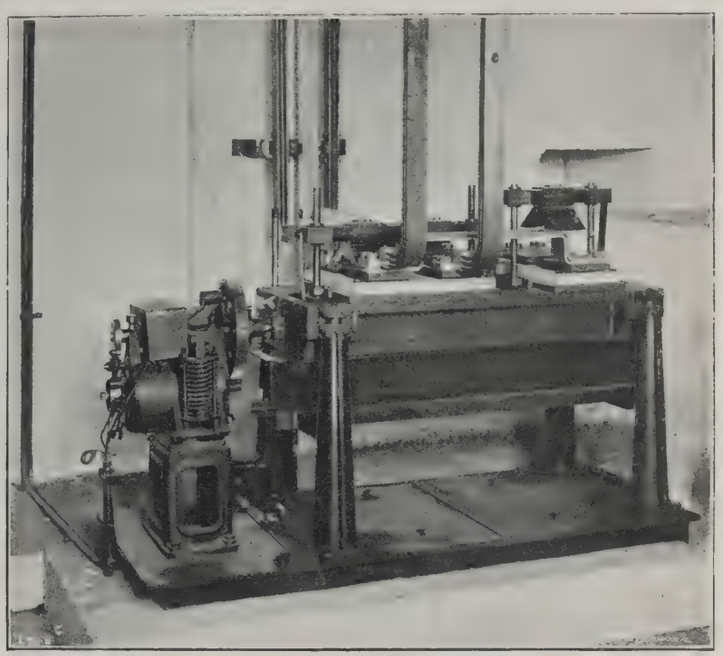


FIG. 14. MOTOR-DRIVEN SERIES-PARALLEL SWITCH.

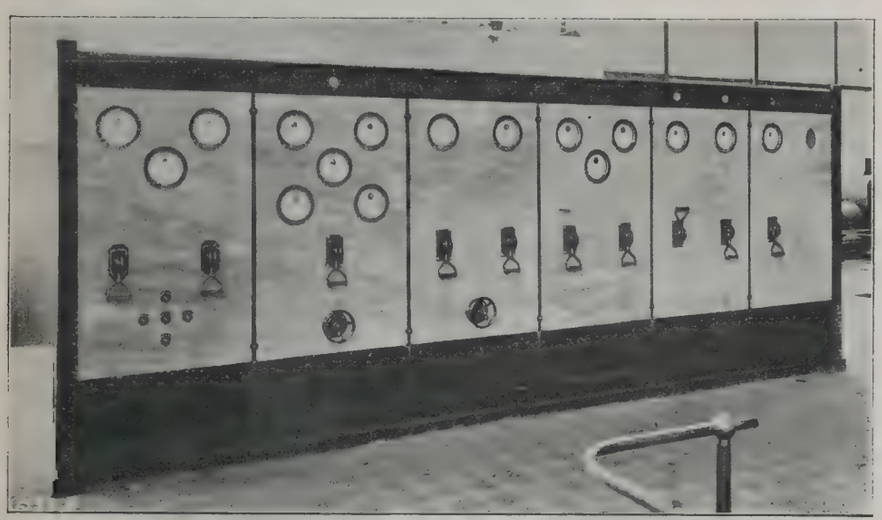


FIG. 15. SWITCHBOARD IN MILL-MOTOR HOUSE.

When the mill is working, it is possible to see how the fly-wheels prevent fluctuations in power being transmitted from the reversing motor to the power-house by comparing the lower instrument on the left-hand side, which shows the current taken by the reversing-mill motor, with the other instrument on the right-hand side, showing the current taken from the power-house. The handle at the bottom of this panel operates the dial-switch connected to the series transformer, which adjusts the motor relay to maintain the particular average current corresponding to the tonnage being rolled.

The next panel is the exciter-panel, the two instruments at the top of the panel showing the exciter voltage and current respectively. The hand-wheel at the bottom of the panel operates the regulator in the exciter main field circuit. The next panel controls the circuits supplying the field excitation of the mill-motor and of the variable-voltage dynamos. The second panel from the right-hand side controls the transformers for transforming the 2750-volt current to 440-volt for supplying the various live-roll motors, &c., about the mill, and a high-voltage feeder leading to other transformers installed near the finishing banks for supplying the small motors on the finishing banks. The last panel controls the circuit to the hydraulic pump-motor driving the hydraulic pump for the bloom shears, and a space is left blank on this panel for an additional feeder should this be required in the future.

Although a motor-generator set is interposed between the reversing motor and the circuit from the power-house, a very high efficiency can be obtained with this electrical plant. With other similar plants, which are in operation, efficiencies of over 70 per cent. have been obtained; that is to say, that 70 per cent. of the power taken from the power-house is beneficially used to drive the reversing mill.

The Siemens companies have constructed twenty-three electrically-driven reversing-mill equipments similar to that installed at Skinningrove, and it is worthy of consideration that while forty or fifty such plants are installed in different parts of the world, only three English steel-makers have

decided to adopt this method of driving up to the present.

The reversing rolling-mill itself was built by the Deutsche Maschinenfabrik A.-G. (Werk Bechem and Keetmann), of Duisburg, while the electrical plant for driving this reversing-mill was built at the Stafford works of Siemens Brothers Dynamo Works Limited.

FOUNDRY PLANT AND MACHINERY.
No. XXXII.

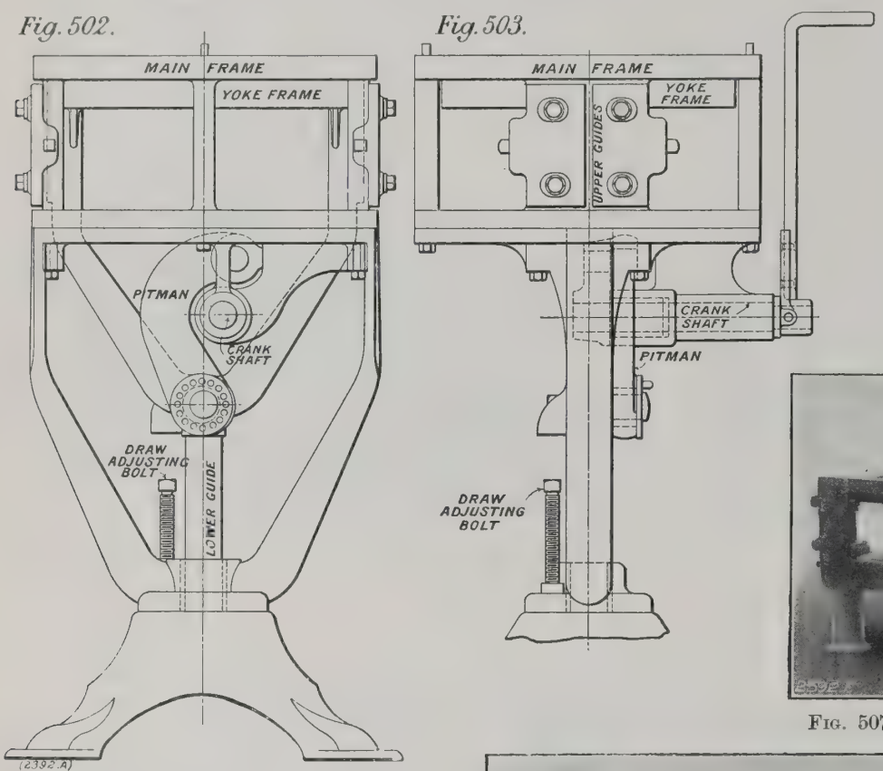
By Joseph Horner.

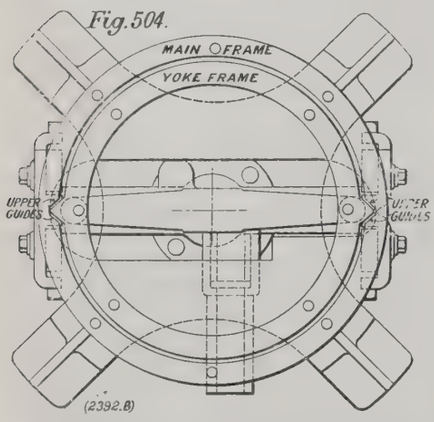
The comprehensive utilities of hand-operated moulding-machines are excellently illustrated in the very extensive series manufactured by Henry E. Pridmore, of Chicago, Illinois, U.S.A., for whom Messrs. J. W. Jackman and Co., Limited, of Caxton House, Westminster, hold the British agency. They were originated over twenty years ago, and developed by Mr. Pridmore in order to render the McCormick Harvesting Machine Company independent of their moulders, who had been causing much trouble by strikes. From this beginning there has grown a big business, manufacturing a large range of machines in different types in many dimensions, between 300 and 400 sizes being now built. In all these, large and small alike, with the exceptions of the rock-over types, which we do not include here, one essential design is embodied. It is that of a main frame supporting a stripper-plate, and a movable frame below carrying the pattern, which is drawn downwards through the stripper-plate. The pattern-table is moved up and down by a lever or levers and a crank-shaft or shafts. Instead of counterweights being employed to balance the heavier tables, coiled springs are adopted, which are of different strengths, and are changed to suit patterns of different weights. The ramming is done by hand, though in a few recent machines mechanical pressure is introduced. Machines are built on these essential principles, small and large, round, square, and oblong, and of various amounts of lift, and with adjustments for variations in amount of lift. The following observations and explanations, with the sketches and photographs selected, will enable a good idea of the utilities of the Pridmore machines to be gathered.

Figs. 502 to 504 illustrate the round type of Pridmore machine in side and front elevations, and plan, prepared from a drawing of the 12-in. size. Essentially it embodies the principles on which all the other machines are constructed, the differences consisting in modifications rendered necessary by differences in dimensions and shapes, with the resulting lever arrangements, &c., already mentioned. These essentials are: the main frame carrying the stripping-plate; the yoke-frame carrying the pattern, moving in guides in vees above, with provision for take-up of wear by means of adjusting-strips and set-screws; and the lower guide. To ensure a steady withdrawal, the slides of the yoke-frame, or pattern-carrying table—the vee'd guides in the upper portion of the main framing—are separated by a considerable distance from the lower guide. The effect is that of a long continuous slide. Provision is also made for securing durability in the lower guide by means of its length, and a brass bushing. There are also eccentric adjustments for wear on the yoke-shaft within $\frac{1}{300}$ in., the take-up consisting of a circle of holes (Fig. 502) and a pin (Fig. 503) inserted in either hole as required, and locking an eccentric bushing. The yoke is held in its highest position, when ramming is being done, by the upper pin in the pitman or crank passing slightly beyond the centre and engaging with a stop. A draw-adjusting bolt, Figs. 502 and 503, on which the yoke rests in its lowest position, is the means by which the depth of draw is adjusted, being included between this and its highest position in which it is held by the crank-pin, as explained above. A single crank-handle effects the vertical movements, its shaft turning in a long brass bushed bearing.

The small type of round machine with a single crank, shown in Figs. 502 to 504, is supported on a claw and stands $28\frac{1}{2}$ in. high, and has a maximum draw of $4\frac{5}{8}$ in. These small round machines range from 10 in. to 20 in. capacity. The small square machines range from 7 in. by 12 in. to 18 in. by 18 in. The views, Figs. 505 and 506, show a pair of square stand machines on which pattern parts for a sewing-machine head are mounted. These and other rectangular machines are sized by the first dimension, indicating the maximum width of pattern capacity, while the second is the length of the yoke or pattern-carrying frame. But as the ends are left open, patterns of several inches greater length than that of the machine can be mounted.

These small stand machines are very useful for dealing with the lighter kinds of patterns. Being all stripping-plate machines, they are able to take gear-wheels, trolley-wheels, grouped patterns with flanges, journals, brake-shoes, &c., provided the depth of draw does not exceed $4\frac{5}{8}$ in. There are besides modifications of these machines made for





Figs. 502 to 504. Round Stand-Type of Moulding-Machine; Henry E. Pridmore, Chicago, U.S.A.

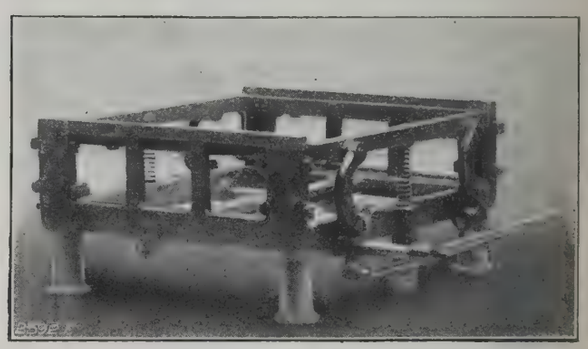


Fig. 507. Oblong Pridmore Machine, Heavy Design.

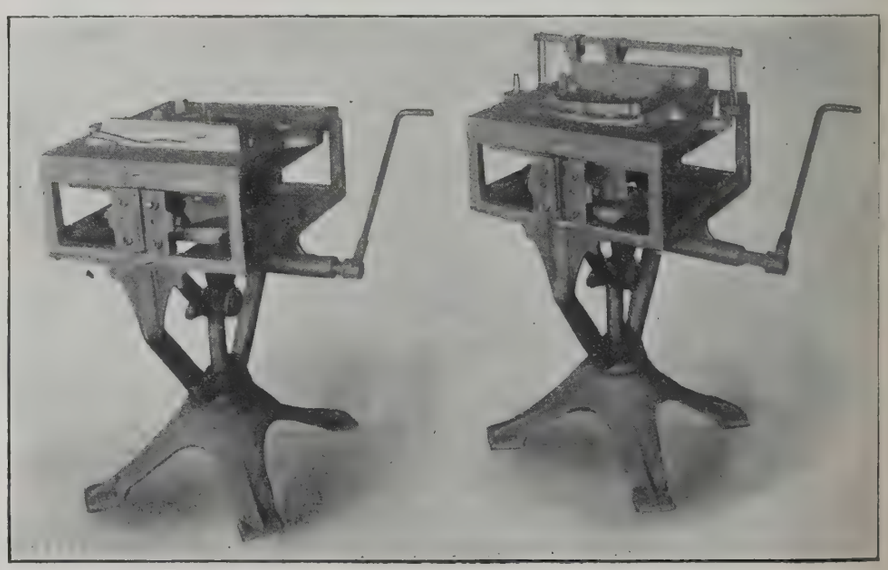


Fig. 505. Fig. 506.

Figs. 505 and 506. Square Stand-Type of Pridmore Moulding Machine.

dealing with special work. Machines built on this general design of rigid stand, non-turnover table, stripping-plate, hand-rammed, down-draw type are also built more powerful in round, square, and oblong stand shapes.

The first leading type is an oblong framed machine with a single crank-shaft, but having two sets of cranks, one at each end. These have a range of dimensions from 9 in. wide by 18 in. long in the smallest to 20 in. wide by 54 in. long in the largest. The cranks are disposed at each end, and each has two vee'd guideways above and one lower cylindrical guideway below, situated centrally in relation to the others. The maximum draw is $4\frac{3}{8}$ in., and the machines stand $25\frac{1}{4}$ in. high. The ends of the frames are open. These again are built in special designs for moulding special articles on.

Following these comes an extensive series of machines in which double shafts are used, still built in the same designs in regard to the guides and provisions for take-up. They are made of square and oblong shapes, being like the previous ones, open-ended, and in light and heavy patterns. The form of the stand, the number of levers, shafts, and cranks, the dimensions, are all matters of extensive detail, which do not alter the essential type. The crank-shafts are each fitted with either two cranks or three, depending on the dimensions. The depth of draw is greater than in the previous series, ranging from 6 in. to 10 in. maximum. Those with a 6-in. draw stand 20 in. high, and each additional draw of 2 in. adds 2 in. to the height of the machine. Fig. 507 shows a heavy pattern double-shaft portable machine, and Fig. 508, page 416, is an oblong machine of light pattern, with a double shaft, also portable. Figs. 509 and 510, on page 416, show a 12-in. by 12-in. square, heavy double-shaft machine, with 7 in. maximum draw.

In these the main frame which supports the stripping-plate is a single heavy casting, and the pattern-carrying yoke is also a single casting. Within the frame are the adjustable guideways. The two crank-shafts have the lower ends of their two sets of cranks, which are disposed at the opposite ends of the machine, keyed at right angles with each other. The lower ends are united with connecting-rods. The upper ends of the cranks carry the pins which are connected to the pattern-carrying frame or yoke. One lever on the end of one shaft operates the series. Compression springs are fitted to counterbalance the weight. Screwed stops or bolts are fitted, two or more in number, for adjusting the depth of draw.

The double-shaft machines in a light and in a heavy series are built up to 52 in. by 54 in., with depths of draw ranging from 6 in. to 12 in., totalling several dozens of different sizes. The light series is mounted on wheels, as shown in Fig. 508, to give them the advantage of portability, saving much walking and carrying of moulds away, since the machine can be moved back as the floor is covered gradually with moulds.

The large output of moulding-machines has its sequel in the portable types, now very extensive, in which the machine is moved along the floor, leaving its accumulated work behind it, as stated, instead of having to carry the moulds along the floor to a constantly increasing distance. The nearest parallel to such an output occurs in some plate-moulded work, notably in railway chairs. When these are moulded on plates by hand, a large area of a shop will be covered with moulds when casting time begins. In some large foundries conveying systems are installed for machine-made moulds. Alternatively the portable machines are employed. They are well adapted to snap-flask work, the output of which is large. They are carried on plain wheels running anywhere on the sand floor, and are suitable only for comparatively light work. In shops where pouring is continuous they are not required. Their place is in the ordinary foundry, in which the moulding is done mostly in the morning, and the pouring begins early in the afternoon.

After the two-shaft machines, a few are built with three shafts, eight cranks, and six guide-ways, while worm-gear is substituted for the lever of the previous machines. These machines are lowered into pits to come flush with the floor, enabling the moulders to ram with the best advantage. In general construction these machines are like those just described. Their capacities range from 54 in. by 84 in. to 58 in. by 90 in., and the maximum depth of draw from 4 in. to 10 in. in different machines.

Round, heavy two-shaft machines are built in about sixty standard sizes, with capacities ranging from 14 in. to 64 in. in diameter, with depths of draw from 5 in. to 10 in. The disposition of the shafts, cranks, and the adjustments, &c., do not differ in any essential from those of the square machines. The photographs reproduced in Figs. 511 to 514, page 416, illustrate one of these machines, portable, arranged for moulding the cope and drag side of a sprocket-wheel. With this example we may commence our remarks relative to the methods of moulding adopted in the Pridmore machines.

When the plate which carries a pattern is not of the turnover type, only one side of it can receive a pattern or pattern part. Then the top and bottom moulding-boxes have both to be rammed on the top face, which involves changing the pattern halves or parts. But this does not hinder the work, because all the tops may be rammed on one machine, and all the bottoms on another adjacent, or both tops and bottoms may be rammed on pattern-plates arranged side by side on one machine of oblong type. As a stripping-plate is always used, except for a few very shallow patterns, and as this is fastened to the top of the outer main framing of the machine, the pattern has to be made deeper than the casting by an amount equal to the thickness of the stripping-plate, or of as much of its thickness as the pattern occupies.

The machine in Fig. 511 is shown fitted with the drag side of a sprocket-wheel, the pattern being at its highest position as set for ramming. In the next figure the mould has been rammed, and the pattern drawn down out of sight, leaving visible the stripping-plate on the outside, and the stool-plates (internal stripping-plates) occupying the arm-spaces. Figs. 513 and 514 show the similar positions corresponding with the cope side of the pattern, Fig. 513 being up, Fig. 514 down.

Figs. 515 to 518, page 417, show the method of moulding a spur gear on a circular Pridmore machine. The pattern is made in two portions—one, Fig. 516, containing the full depth of the rim with its teeth, plus the depth which enters the stripping-plate, and half the thickness of the arms and half the internal depth of the rim portion; Fig. 518 contains the other, the remaining half of the arm and rim, but no portion of the teeth. The pattern portions, attached to the yoke frame through an intermediary pattern-plate, are drawn downwards through the stripping-plates which are supported on the main frame of the machine. The internal edges of the arms are stripped with stool-plates screwed to stools, which by their bases are bolted to the lower portion of the machine-framing. The stool-plates exactly fill the arm-spaces. The stools in this case are of T-shaped outlines, as seen in their plans in Figs. 515 and 517. The lugs and pins which locate the top and bottom boxes also serve for the attachment of the stripping-plates to the machine-framing. Hence the pattern-plates, stripping-plates, and flasks form an interchangeable group, and are all drilled alike from a templet plate supplied with each machine. The illustrations, Figs. 515, 516, and 516*a*, show the fitting of the babbitt lining to the iron stripping-plate. The latter is roughly cast to the outlines of the teeth, with clearances and recesses. The top and bottom faces are tooled. With regard to the making of these plates, the method employed is as follows:—First, the opening gives a plain clearance of about $\frac{1}{8}$ in. around the pattern. Above this a recess is cast of about $\frac{1}{2}$ in. wide and $\frac{3}{8}$ in. deep, to hold the Babbitt metal. Holes are drilled here about $\frac{3}{4}$ in. apart, into which wire nails are driven, with their heads standing out, but below the surface which the babbitt will occupy. The plate is then placed on its machine surrounding the pattern-plate. Asbestos string is laid around the latter, occupying the opening in the lower part of the stripping-plate. A layer of putty is laid round above to form a trough, and into this, previously warmed, the babbitt is poured. When nearly cold the lever of the machine is pulled, drawing the pattern down through the babbitt, and any surplus is cut away, leaving the plate ready for use. One plate is prepared first, and the other is made from that on its own machine, located by the pins, so that the mould parts will match though made on separate machines.

Figs. 519 to 522, page 417, illustrate the method of making a chilled trolley-wheel as done on a Pridmore machine. The shape of the casting can be seen by the mould section, Fig. 522, with which the pattern-parts, Figs. 519 and 521, can be compared. These are made as two distinct portions, one specially for the drag, Fig. 519, the other, Fig. 521, for the cope, so that there is no turning over, and the two mould parts might be made on separate machines, or side by side on an oblong machine. The tread of the wheel does not exist in the pattern, being formed by a heavy chill, Figs. 519 and 522. Only one-half of the flange is formed in sand, and this is made in the cope portion. The illustration, Fig. 522, shows the mould assembled. In this particular case the stripping-plates are not required for stripping, but they are retained in the scheme of interchangeable box-fitting.

Wooden stripping-plates are used largely for wooden patterns mounted on the machine. If they are framed with crossing-strips, or half-lap joints, according to their shapes, and of hard wood saturated with oil, they are very durable. The stuff may range from $\frac{3}{4}$ in. to $1\frac{1}{4}$ in. thick, the extra thickness being, of course, added to the pattern depth. The plates may lie on the machine table simply, surrounding the pattern; or a special cast-iron frame can be made with a recess to receive wooden stripping-plates of various shapes, as is done in some of the Pridmore machines. In combination with these, wooden stools are also used (see Fig. 523).

THE BRITISH ASSOCIATION.

(*Continued from page* 385.)

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

LAST week we noticed the communications on astronomy and cosmical physics brought before Section A. We now turn to general physical papers, beginning with the phenomena of spectrum analysis.

ANOMALOUS DISPERSION AND SOLAR PHENOMENA.

Professor P. V. Bevan, M.A., Sc.D., of Egham, dealt, in a paper on "Anomalous Dispersion and Solar Phenomena," with phenomena, as to which we should refer our readers to our account of Professor R. W. Wood's Royal Institution lectures.* He stated that, in studying the absorption of metallic vapours, he had, when the red potassium ray was considerably deviated and not of uniform brightness, sometimes observed a double reversal of the line. In those cases the image would not exactly fall on the slit, and light of wave-length just smaller than the absorption line might get into the spectroscope. Julius, who had drawn attention to the solar phenomena of this type, had not been able to explain all the peculiarities. Mr. Bevan suggested that clouds of vapour would be floating over the photosphere; though at higher levels these clouds need not be hotter than the photosphere, as had generally been assumed. Light falling obliquely from the photosphere might be deflected in passing through such a cloud, and this light, of nearly the same wave-length as that of the absorption line, would enter together with direct light and produce a double reversal.

In the discussion, Professor Turner considered the novel interpretation of these phenomena as suggestive. Dr. W. J. Humphreys questioned it on the strength of experiments of his own. He had coupled two arcs in series, the arrangement being: arc I., arc II., slit; the two arcs being in series, their temperatures would probably be equal. He had then observed double reversals, and when he replaced the second arc by a Bunsen burner, he had also found reversals, so that he had felt "humbugged." Mr. Rolston was also sceptical; the solar clouds were sometimes observed for three days and more, and it was difficult to assume such constant refraction conditions in the solar atmosphere. Mr. Bevan granted the force of the objections; but there might be many small patches of clouds about, and he merely wished to suggest one of the possible causes of double reversals.

We may notice here a paper on "Absorption and Dispersion in Metallic Vapours," which Professor Bevan communicated to Section B. This paper dealt with the bearing of spectral research on our views concerning the nature of the atom and the vibrating systems which give rise to the spectrum lines. Professor Wood had, from his study of metallic vapours, extended the number of lines of the principal sodium series from 7 to 48. Extending his work to the other alkali metals, Professor Bevan said he had found 41 lithium lines, 24 for potassium, 30 for rubidium, and 31 for cæsium, instead of the 9, 9, 5, 9 emission lines formerly known. He

* See ENGINEERING, vol. xci., page 730, June 2, 1911

FOUNDRY PLANT AND MACHINERY.

(*For Description, see Page* 414.)

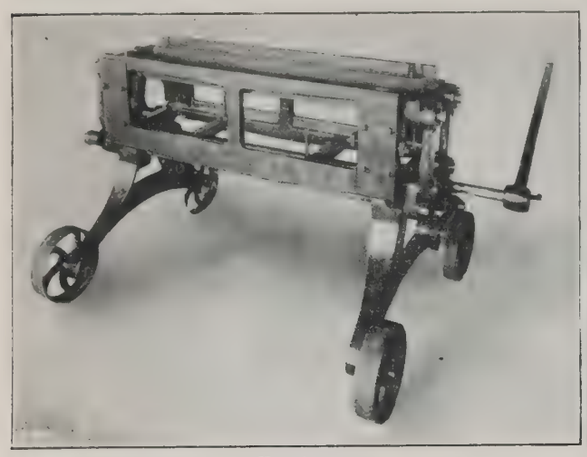


Fig. 508.

Fig. 508. Oblong Pridmore Moulding-Machine, Light Pattern.

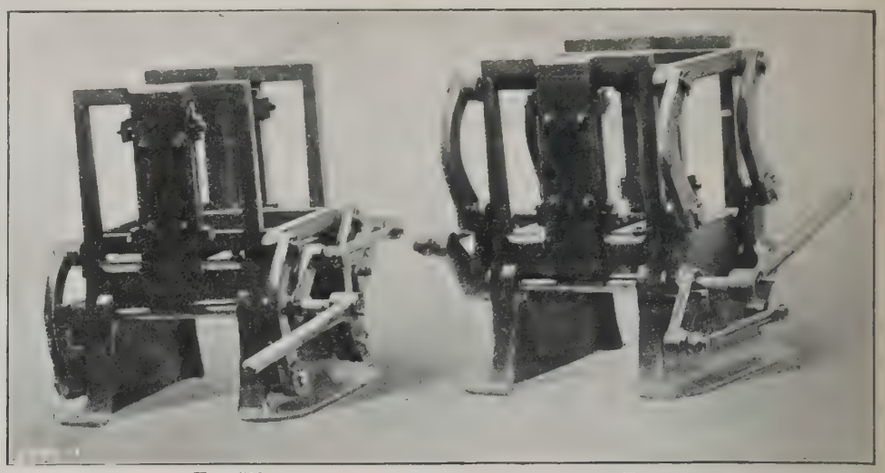


Fig. 509. Fig. 510.

Figs. 509 and 510. Square, Heavy Double-Shaft Pridmore Moulding-Machine.

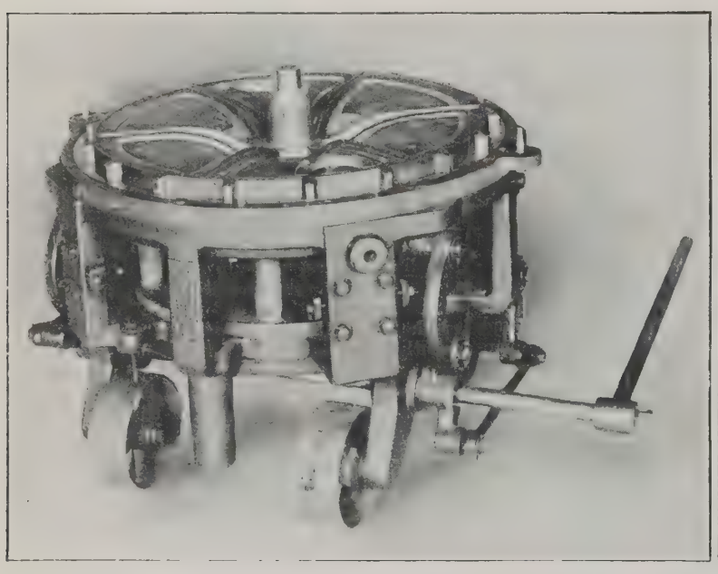


Fig. 511.

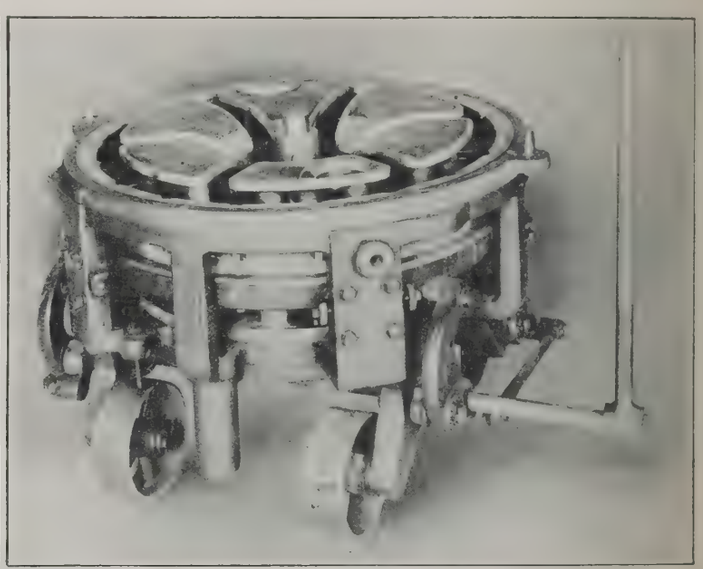


Fig. 512.

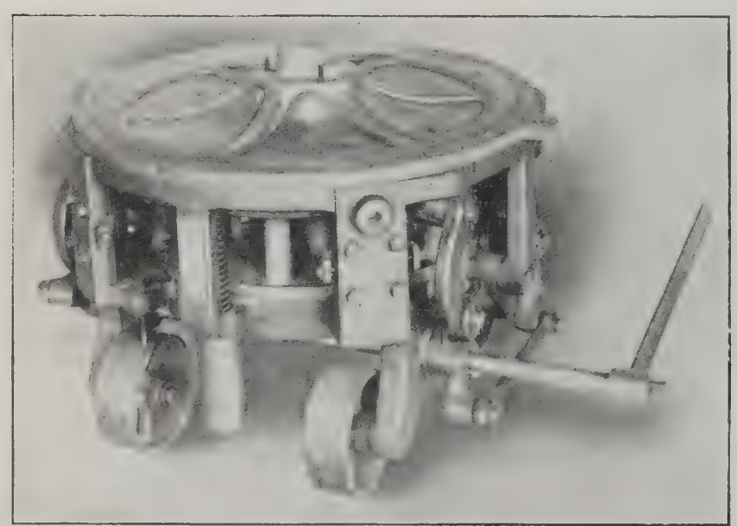


Fig. 513.

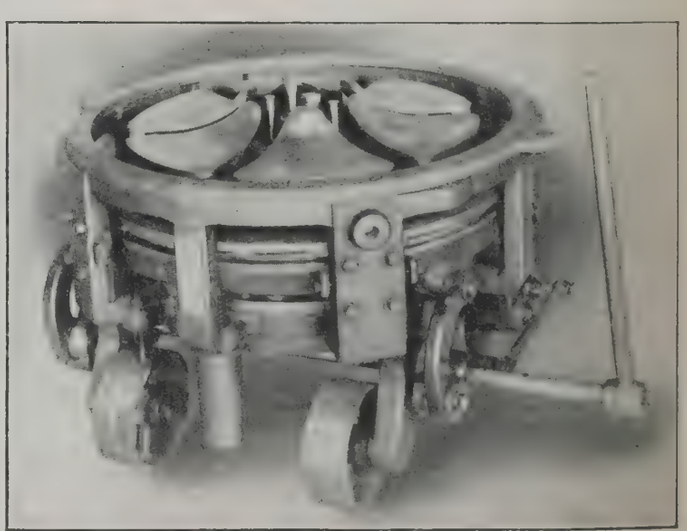


Fig. 514.

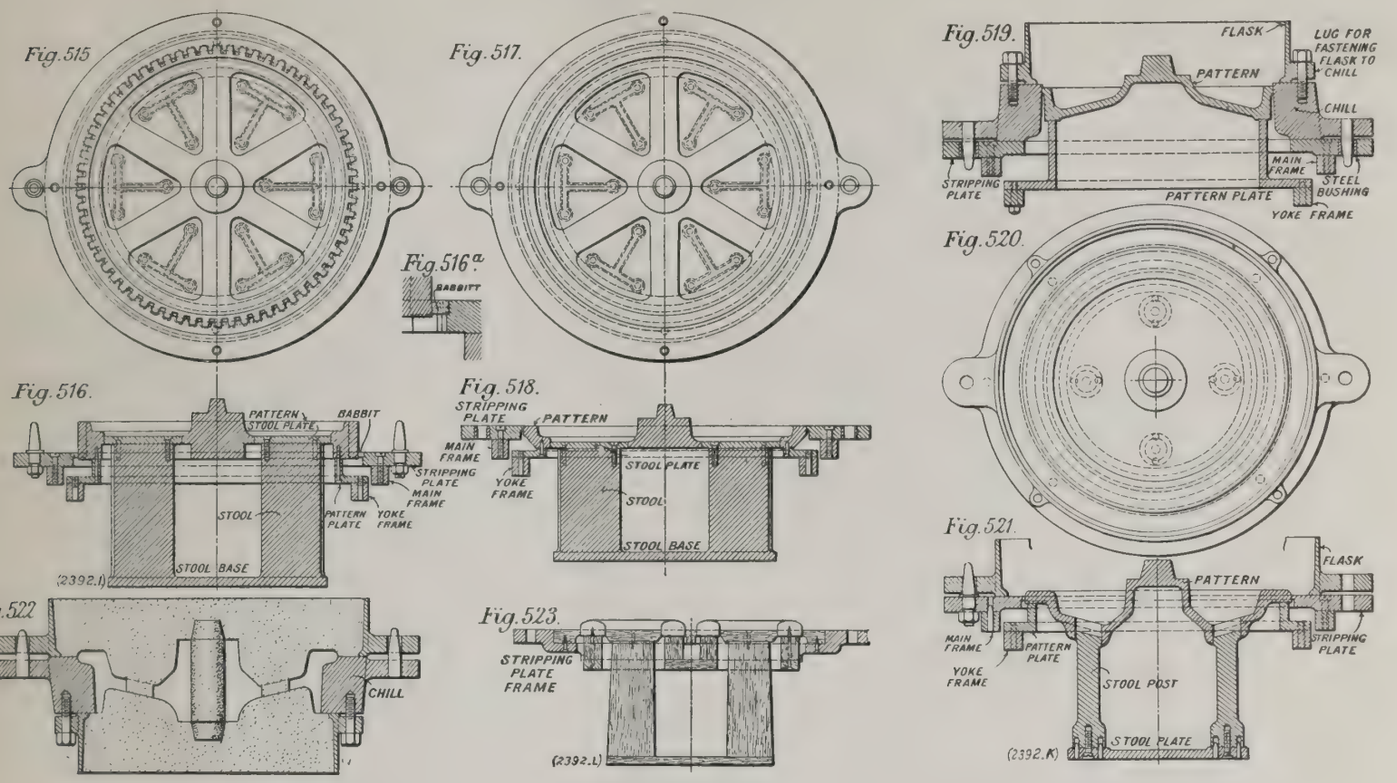
Figs. 511 to 514. Round Type Portable Pridmore Moulding-Machine, Moulding Copes and Drags for Sprocket-Wheels.

added that absolute measurements were difficult with absorption spectra, and anomalous dispersion took place at all of these lines.

Wood and St. Loria (of the Cracow Academy) had made absolute measurements by the interference method, and from these and the (rather uncertain) density of the sodium vapour, the number of electrons taking part in the effect of light could be deduced on Drude's dispersion theory. From his experiments at 380 deg. Cent., Loria had concluded that the ratio of the number of sodium atoms engaged in optical effects to the whole number of

FOUNDRY PLANT AND MACHINERY.

(*For Description, see Page* 414.)



FIGS. 515 TO 518. MOULDING SPUR-GEAR ON A CIRCULAR PRIDMORE MACHINE. FIGS. 519 TO 522. MOULDING CHILLED TROLLEY-WHEEL ON A PRIDMORE MACHINE.

atoms was 400 : 3; experimenting at 644 deg. Cent., Professor Bevan found the ratio 12 : 1. Each line of a series was probably due to a special set of atoms, and the complexity of the spectrum not due to the complexity of each individual atom, but to differences actually existent in the atoms. The Zeeman effect and other evidence pointed to similar conclusions.

THE SPECTRUM OF AN ELEMENT AND ITS ATOMIC WEIGHT.

Professor W. M. Hicks, F.R.S., presented a short communication on "The Dependence of the Spectrum of an Element on its Atomic Weight," a subject he had dealt with last year at Sheffield. He pointed out that, in addition to the well-known series lines of a spectrum, a large number of others were directly related to them in the same way as the second or third set of a doublet or triplet depended upon the first, or as the satellite lines of a D series depended upon the more intense set. He gave formulæ and examples referring to the spectra of magnesium, calcium, strontium, barium, with special regard to the atomic weight term in the formula for the wave-lengths of the lines. The atomic weight could indirectly be deduced from these wave-lengths with the help of certain differences. In the discussion, Dr. J. W. Nicholson asked whether those series would help in determining the spectra of gases in stellar nebulæ. Professor Hicks replied that there were too few lines to put them into a series. Dr. Bevan questioned the feasibility of the computations of atomic weights; Rowland's tables of wave-lengths were not sufficiently reliable; Kayser's were more reliable, yet in dealing with series lines based upon those measurements errors far greater than Professor Hicks's probable errors would creep in. Sir W. Ramsay thought the difficulty was not so great, since most observers referred their measurement to the same standard lines—those of iron. Professor Hicks replied that there was a periodic, though not a constant, difference between the Rowland lines and the true lines.

ARC SPECTRA OF METALS IN THE INFRA-RED.

Major E. H. Hills, F.R.S., of London, presented an essentially tabular memoir on "The Arc Spectra of Certain Metals in the Infra-Red." Abney had shown in 1880, he stated, that a collodion bromide emulsion could be prepared, which was sensitive to infra-red rays as far as λ 10,000, and had published a map of that portion of the solar spectrum a few years later. Little work had, however, been done on metals which were generally studied in the infra-red with the aid of bolometers, of thermopiles, or of photographic plates sensitised with organic dyes; the latter were not sensitive beyond λ 8000, and adequate resolving power was extremely difficult to obtain with thermopiles; the neglect of Abney's method was hence regrettable. The infra-red was important, not because it gave a few additional lines, but because those lines were favourably situated for deducing the laws governing the series, and thus for throwing light on the interior dynamics of the molecule. His own apparatus, Major Hills continued, was a spectroscope of two dense flint prisms; the wave-lengths were determined by comparison with the solar spectrum on Abney's scale, and the results were probably correct within 1 unit. Better results could be obtained with gratings, but they would require very prolonged explosures. The emulsions were prepared essentially after Abney. The tables concerned the metals lithium, sodium, potassium, magnesium, calcium, strontium, barium, and wave-lengths from 7600 to 10,000 λ. In the case of certain Li, Na, Ba lines, the presence in the solar spectrum was doubtful, and Ca gave some strange lines.

ATOMIC STRUCTURE OF THE ELEMENTS.

Mr. J. W. Nicholson, M.A., D.Sc., of Cambridge, read a very long paper on "The Atomic Structure of the Elements, with Theoretical Determinations of the Atomic Weight." He suggested a theory based on a conception of positive electricity as existing in volume distribution of uniform density. The elements would, in his view, be made up of four protyles, or ultimate forms of matter. A protyle would contain two, three, four, or five electrons in rapid rotation, and a single positive nucleus to neutralise the charge, the volume being directly proportional to the charge. He calculated his atomic weight, he explained, from the inertia of the combined positive and negative charges. The four protyles were:—(1) Coronium, probably an enert gas, of atomic weight 0.5131, present in the solar corona; (2) hydrogen, atomic weight 1.008; (3) nebulium, atomic weight 1.63, the basis of the earlier nebulæ; (4) protofluorine, atomic weight 2.36, the cause of the third line of the nebular spectra. Helium, which next appeared in nebulæ, was not one of his protyles, but a compound of one atom of nebulium and one of protofluorine. That combination would readily occur, and the atomic weight would be 3.988, the most probable atomic weight found for helium. Other atomic weights could be built up by simple groupings of two or three of these primary elements. The weight was due chiefly to the positive electricity. On this plan helium would be He = Nu Pf, and argon A = 5 $(He)_2$; and the paper gave a general theory of the periodic table, and particularly of the structure of the inert gases and radio-active emanations in terms of these protyles. These structures were all very similar, and had intimate relations to one another of a kind analogous to those met with in organic chemistry. Some of the formulæ which Dr. Nicholson put on the board were anything but simple, however—*e.g.*,

$$\text{Radium emanation} = 2\{3\,He_4\,(Pf\,H)_3\,2\,Nu_4\,(Pf\,H_3)\}$$

Thorium emanation would, according to Dr. Nicholson, be a radium emanation with a slightly different grouping of the protyles; actinium would also belong to the radium group, and would fall between terbium and erbium; the thorium emanation would liberate particles—not the ordinary *a* particles (helium), however, but HeH_2. The atomic weight of radium would be 226.8, which would accord with the assumption that it ultimately became lead. Many substances, iodine, for instance, were gradually decomposing into inert gases in accordance with the belief that all matter was slightly radioactive. Dr. Nicholson contended that all matter would appear to be electrical in origin, and he pointed out that his calculated atomic weights agreed well with those of the chemist.

The discussion was of a varied character. Professor Turner was much interested in the very striking numerical relationships. Mr. Bateman warmly congratulated the author. Mr. Dyson objected, from the astronomical point of view, that the spectra of hydrogen and helium were comparatively simpler than that of coronium. Professor Bevan inquired whether the spectra revealed the combinations. Dr. F. A. Lindemann, of Berlin,

said, what many no doubt felt with him, that it appeared easy to make up correct numbers with the aid of electrons; the speculations were interesting, but he did not understand how Dr. Nicholson dealt with atomic volumes. Dr. W. F. G. Swann, of Sheffield, said the crux seemed to be to choose the proper ratio between the masses of the positive and negative electrons. Dr. Nicholson replied that he had no coronium spectrum for laboratory comparisons; he assumed a volume distribution of positive electricity, not a surface distribution, as seemed to have been understood.

The Corpuscular Nature of Rays.

Professor W. H. Bragg, F.R.S., of Leeds, expounded his views on "The Corpuscular Nature of Rays" in a charming discourse. A thing was corpuscular, he stated, when the ray carrying the energy did not distribute the energy over a wider and wider area as it advanced. Corpuscular radiation might be defined as consisting of "entities" or "quanta" (the Quanten theory of Planck and Einstein), each moving in a straight line with uniform velocity and unchanging properties, unless impressed forces caused a change. But it was a separate question whether corpuscular radiations were necessarily material. The α and β rays were corpuscular; sound and light waves, as usually conceived, were not. Were X rays and γ rays corpuscular? The X and the γ ray had rather uncertain properties, but the one certain power that they excited a β ray when encountering an atom. The speed of the β ray depended on the quality (soft or hard) of the X ray, not on the nature of the atom, and the direction of the β ray was more (hard rays) or less (soft rays) that of the exciting X ray. Now β rays produced ionisation, phosphorescence, and photographic action, and experiments tended to demonstrate that these effects, when accompanying X ray absorption, were really due to the β rays, while the X rays had no direct effect of this kind, so that the absorption coefficient of a substance was simply a measure of its power of prompting the X rays to produce β rays.

Where did the energy of the β ray come from? It could not come from the atom; for each atom should then have its own speed of ejection, independent of the conditions of the X rays, and there was no evidence of the existence of induced radioactivity implying a release of atomic energy; thus the X ray could not play the part of the trigger of the gun. Nor could the energy of the β ray be the result of an accumulation in the atom of energy extracted from many X rays; for it could hardly be supposed that the accession of the last infinitesimal amount of energy to fill the store of the atom would determine the direction in which the β ray was ejected. Therefore it must be supposed that one X ray provided the energy for one β ray; and similarly, that in the X ray bulb, one β ray excited one X ray. He (Professor Bragg) had pointed out in his presidential address to the Australian Association for the Advancement of Science, Brisbane, 1909, that the near equality in the speed of the β or cathode ray, which produced the X ray in the bulb, to the speed of the β ray, which that X ray finally produced, supported this view, and Whiddington's recent experiments strengthened this argument. Little energy was lost in the interchange from β into X ray and back again, and as the speed of the secondary β ray was independent of the distance which the X ray had travelled, the X ray could not diffuse its energy as it moved: that was to say, the X ray was a corpuscle. Nor could the X ray spend energy on ionisation; its energy was given by the energy of the β ray it produced.

Barkla had shown that many substances emitted homogeneous X rays of characteristic penetrating power when irradiated by X rays of greater penetrating power. Rays of high speed, such as emitted by zinc, would excite rays of lower speed from a metal like iron, but not *vice versa*. In the language of the corpuscular theory, an X corpuscle of definite energy was frequently emitted by a substance which was under bombardment by X corpuscles of greater energy. According to Whiddington, only X rays excited by cathode rays of a certain minimum energy could excite the characteristic rays of any substance, and C. T. R. Wilson's demonstration of the tracks of ionising agents in a gas (tracks rendered visible by the condensation of water vapour upon them) were also illustrations of this theory. The γ rays travelled through space undetected until they met an atom. The corpuscular form of the X (and the γ) ray, and its energy relation to the β ray, which was its origin, and to the β ray, which was its conclusion, were the principal things that theory and models had to account for. For this reason the spreading pulse of Stokes (according to which energy was diffused over a broadening surface) failed, and the kink in the tube of force of J. J. Thomson, which diffused its energy over a lengthening line, also failed.* Certain phenomena, the so-called polarisation of X rays and the photo-electric properties of light, suggested, indeed, links between X rays and light; the nature of these links was not clear yet. The corpuscular theory of X rays was an induction from experiments, and the "neutral-pair" theory (of Professor Bragg) a simple working model. The "ether-pulse" theory was at present little more than an aspiration. If these arguments were true, Professor Bragg concluded, light should be corpuscular.

Sir W. Ramsay, in opening the discussion, said that they had all listened with the greatest interest. It seemed that γ rays only became apparent when there was something present to detect them; was it not the same with the sun's heat? According to the modern theory, the atom consisted of electrons in some sort of motion, and he did not see why energy should not be given off when the γ ray struck the atom. He had kept radium bromide in a glass tube, which he placed in a containing vessel of glass, copper, &c.; the material of the vessel had changed and turned radioactive, and in the case of copper the radioactivity could be precipitated with the copper sulphide after dissolving the copper. How would Professor Bragg explain that? Professor McLennan, of Toronto, and Dr. F. A. Lindemann having also put questions, Professor Bragg replied by further referring to J. J. Thomson's electrons with tails; his reply to Sir W. Ramsay was that he (Professor Bragg) would have to increase his experimental skill, and repeat the experiments, before he could give an answer.

Absolute Measurement of Current.

Dr. N. E. Dorsey presented a paper on "The Absolute Measurement of Current at the Bureau of Standards, Washington." The instrument, he stated, was designed by Professor E. B. Rosa, and the work done—manifestly with exceptional care—under his supervision. A balance of the Rayleigh type was used. The coils, of square cross-section, were wound bifilarly of enamel-insulated wire wound upon brass forms. A novel feature of the fixed coils was the provision in the forms and back of the windings of a channel through which water could be pumped. During the weighing the moving coil was surrounded by a double-walled jacket, maintained at constant temperature. For the final measurements three pairs of fixed coils (two pairs of 50 cm. diameter and 36 of layers, each of 18 double turns; one pair of 40 cm., 28 layers of 14 double turns) and two moving coils (one 25 cm., 12 layers of 6 double turns, one of 20 cm., 14 layers of 7 double turns) were used. After winding, the coils were sealed with paraffined cloth and paraffin, and covered with softer wax; the insulation had been found perfect throughout the work. The distance between the two fixed coils was always such that the sum of the forces which they exerted upon the moving coil was a maximum. Under that condition the maximum force for a given current depended solely upon the ratios of the diameter of the moving coil to those of the fixed coils, and the actual distance between the fixed coils need not be measured. This diameter ratio was determined by a modification of Rayleigh's electric method. The variations in the diameters produced by temperature changes and on the load carried were studied experimentally. An electrical method was devised for detecting and correcting any slight error that might exist in the spacing or in the co-axiality of the fixed coils. The selected values for the electromotive force of the normal Weston cell at 20 deg. Cent. in terms of the international ohm and the Bureau of Standards balances gave the mean 1.018224 volt (the last two figures being respectively 28, 05, 27, and 35). The 1.01822 was by four parts in 100,000 higher than that found in the National Physical Laboratory—where four years ago 1.01818 was obtained, not with exactly similar cells.

A Friction Permeameter.

Mr. W. H. F. Murdoch, B.Sc., M.I.E.E., exhibited a "Friction Permeameter," a modification of an instrument which he brought before the Institution of Electrical Engineers some years ago. He described it as a simple workshop instrument which, with properly adjusted springs, gave measurements correct within 1 or 2 per cent. at ordinary inductions. The magnetic circuit and friction were kept constant during a test. The apparatus was cylindrical, about 9 in. high, and the yoke was split horizontally into an upper and a lower half. The specimen formed the vertical axis of the cylinder, the magnetising coil was pushed over it; the top of the yoke carried a dial, a spring and a torsion head. In making a test the top portion of the yoke was turned about the specimen as axis, the upper and lower surfaces of the split yoke sliding upon one another, and the square root of the angle of torsion was proportional to the induction. The same sliding surface was used for all specimens. As the readings were taken while the pointer and dial were in motion, an acceleration error might come in, if different observers turned the yoke at different rates; but with slow turning this error could be neglected.

Construction of Practical Electric Standards.

The report of the Committee on "Experiments for Improving the Construction of Practical Standards for Electrical Measurements," drawn up by its Secretary, Dr. R. T. Glazebrook, was taken as read. The report regrets to record the death of its distinguished member, Dr. G. Johnstone Stoney, and refers to work done on and with the Lorenz apparatus, resistance standards, and the silver voltameter and standard cells at the National Physical Laboratory, and in the joint experiments of representatives of the national institutions at Washington in the summer of 1910. As the republication of the early reports from 1862 to 1883 was not completed yet, this report was not the last; the Committee will, however, probably not have to ask for re-appointment next year.

The Laws of Solution.

In presenting a paper on "The Laws of Solution," Mr. H. Davies remarked that he had been unaware that the President of Section B would deal with the same subject, a matter to which we shall refer later. Mr. Davies considered the change of the conductivity of electrolytes with dilution and the dilution formulæ of Ostwald, Rudolphi, Van't Hoff, and Kohlrausch. He showed that these formulæ and rules could be brought into harmony if the solvent were taken into consideration, and if water, which, below 15 deg. Cent., he would regard as trihydrol $(H_2O)_3$, dissociated into $(H_2O)_2 + H_2O$ on adding a solute to the water; this dissociation proceeded proportionally to the amount of substance added. He admitted, however, in reply to Dr. H. Borns, that he neglected the changes in volume accompanying these additions.

Adsorption of Salts by Silica.

Professor F. T. Trouton, F.R.S., read a paper on "Peculiarities in the Adsorption of Salts by Silica." Professor Trouton pointed out that when the concentration of the salt was plotted as abscissa against the weight of salt adsorbed per gramme of silica as ordinate, the curve first was concave to the abscissa, then became horizontal for a short distance, and finally took the turn upward usually depicted. The weight of salt corresponding to the critical point, for which the adsorption was independent of the concentration, was, in the case of chlorides, decreased when the temperature was raised, but was independent of the temperature for the sulphates and nitrates examined. With quartz wool the surface per gramme of silica could be estimated, and if the density of the adsorbed salt were assumed to be that of the solid salt, the thickness of the adsorbed layer would be 10 $\mu\mu$ (10^{-6} cm.) for sulphates and nitrates. At higher temperatures the curve turned downward first after the horizontal portion, before finally rising; that showed that the silica actually gave up some salt again as the concentration was raised, and that the adsorbed layer was then unstable, just as certain thicknesses of oil films (Rayleigh) and of soap films (Reinold and Rücker) were unstable. In the case of chlorides the adsorption was zero for considerable concentration values; the curve looked as if it were going to cross over to the negative side, and it would appear that water rather than salt was then adsorbed;

* Compare Sir J. J. Thomson's lectures, ENGINEERING, vol. xci., page 320, &c.

Professor Trouton had not been able to verify this by direct observations, however.

SPECIFIC HEATS AT HIGH TEMPERATURES.

A first communication on "The Specific Heats at High Temperatures and the Latent Heats of Fusion of Metals," by Mr. H. C. Greenwood, M.Sc., was read by Dr. J. A. Harker, F.R.S. The investigation is being carried out in the National Physical Laboratory, and we have described in our accounts of the work of this institution* how Mr. Greenwood has successfully improved and rendered entirely automatic Dr. Harker's clever device of dropping the specimen from a vertically-mounted electric furnace at the right moment, when it is just over the calorimeter, by the fusion of a fine platinum suspension loop. The furnace swings round and returns to its original position; the transfer of heat from the furnace to the calorimeter is hence negligibly small, and any radiation from the furnace remains the same during the initial and final periods. The investigation was undertaken, Dr. Harker explained, in order to provide more reliable data for the specific heat of metals at high temperatures than were at present available, particularly in the region of their melting-points, and also to determine the latent heats of fusion.

The metals aluminium and zinc were first studied on account of their comparatively low melting-points. The previously published data were, in both cases, very unsatisfactory. The metals were sealed up in silica tubes, which were dropped not directly into the calorimeter water, but into a funnel-shaped brass tube filled with calcined precipitated hydrate of magnesia, which formed a very light powder, behaving like a liquid. The cracking of the silica tubes, caused by the expansion and contraction of the metal inside, had first given much trouble. The specific heat of silica, which had a fairly large temperature coefficient, had to be determined in the first instance. The curve for the mean specific heat of zinc was found to be continuous above and below the melting-point, while the latent heat of fusion was about 26 gramme-calories per gramme of zinc. Aluminium had proved difficult. Above 850 deg. Cent. it attacked silica; near its melting-point it could be powdered with the hammer, a method which was applied by the British Aluminium Company. Just before the melting-point the specific-heat curve bent sharply upward, probably owing to premature fusion of the metal. When this heat evolution was included, the latent heat of fusion was 95 gramme-calories. Above the melting-point the specific-heat curve was steeper than immediately below. Professor Trouton and Dr. F. A. Lindemann, who has been doing very remarkable work on specific heats, atomic volumes and cognate problems, at Berlin, in conjunction with Professor Nernst, put some questions to Dr. Harker.

PETROLEUM TESTING.

Dr. J. A. Harker, F.R.S., gave, in a paper by himself and Mr. W. F. Higgins, a brief account of "Methods and Apparatus Used in Petroleum Testing," dealing with their inquiry into the causes of the differences of flash-point readings taken with the Abel, the Abel-Pensky, and similar apparatus. We described these interesting researches in our account of the work of the National Physical Laboratory.†

THE EFFECTS OF AIR CURRENTS ON SOUND-WAVES.

Professor F. R. Watson, of Urbana, Illinois, U.S.A., said, in a paper on "The Effects of Air-Currents on Sound-Waves," that part of his problem had been to cure the echoes and reverberation in the hall of the University of Illinois. If the ventilation were so arranged that a broad sheet of warm air moved over the head of the speaker, to be drawn out at the rear of the auditorium, the warm air should, theoretically, act as a partition, and refract and reflect the speaker's utterances. According to Rayleigh, reflection at the boundary of gaseous media depended on the differences in the velocities of sound in the two media. The velocity of sound $V = \sqrt{\gamma p/\rho}$ would not be affected at constant temperature by changes in the air pressure, as p/ρ remained unchanged, but an increase in moisture or temperature increased ρ, and hence V; while the presence of carbon-dioxide decreased γ and V. Total reflection would occur for very oblique incidence. Refraction also depended on the velocity ratio, and the bent waves might be totally reflected at the upper boundary. Further, air in motion carried sound with it. Thus the effect of an air-current as mentioned would be to turn the sound to the audience, and the total effect was not inconsiderable, though each factor was only small.

THE VERNIER ARC.

Mr. J. W. Gordon, of London, brought a model of "The Vernier Arc, a New Form of Micrometer." The paper was finally taken as read. The model consisted of a scale and divided arc mounted in the focal plane, and a diffraction grating mounted behind the eye-lens. This mounting produced in the field two images, formed by the diffracted light of any image lying in the field; these images flanked the original on both sides. A narrow black line was traced in the centre of the field, the scale being ruled on one side of this line. At the end of the line was a broad black arc, split along its middle by a white line divided into ten arc segments. The grating produced two flanking images of this arc, which intersected one another and the original arc in a point determined by the angular position of the grating. The same angular position caused the image of the scale to be projected on the narrow dark field, and the displacement of the scale could be measured by observing the point of intersection on the vernier arc. The device was inexpensive, the scale lines did not cross the field nor obscure it, and there was no divided screw to be read.

THE PRINCIPLE OF RELATIVITY.

A discussion on "The Principle of Relativity" was opened by Mr. E. Cunningham, M.A., of St. John's College, Cambridge, in a very able memoir, which is to be published in full in the Association Report. The subject concerns the space-time and the energy and inertia relations, and though a clear perception of the fundamental principles is the crux of the matter, the treatment is entirely mathematical, and the discussion does not lend itself to abstracting. We will confine ourselves to a few general remarks. The term "principle of relativity," so often quoted now, was introduced by A. Einstein, then at Bern, now at Zurich, in a paper on "The Electro-Dynamics of Moving Bodies," published in 1905 in the *Annalen der Physik*. Einstein pointed out that the electrodynamics of Maxwell, as usually understood, led to asymmetry. In the case of the mutual electrodynamical reactions between a magnet and a conductor, the observed phenomena merely depended upon the relative movement of the one body with respect to the other, but the explanation had to distinguish between movement of the magnet and movement of the conductor. Similar considerations, and the unsolved problems whether or not there was a movement of the æther relative to the earth, led to the assumption that there were not, either in mechanics or in electrodynamics, any properties of the phenomena corresponding to absolute rest, and that the same electrodynamical and optical laws were valid for all systems of co-ordinates for which the mechanical laws held. This assumption, combined with the assumption of a definite velocity of light *in vacuo*, constituted the principle of relativity. The principle dispensed with the postulates of space absolutely at rest endowed with special properties and of a light æther. Like any other electrodynamic theory, it was based upon the kinematics of rigid bodies (systems of co-ordinates).

One has to read oneself into this language and this principle, which, as such, only says something about rigid bodies, clocks, and light signals. But the principle of relativity implies that a uniformly-driven clock would run more slowly when looked at from a system at rest than when the observer moved with it; and on this consideration Einstein showed that the Doppler effect, which Stark had believed he observed in canal rays, was too large. Before the introduction of the principle the deduction of the laws of movements of the electron on electrodynamic methods required some definite assumption as the distribution of electricity on a rigid frame built up of the forces which keep the electrodynamic forces in equilibrium. The application of the space-time transformation, according to the principle of relativity, permits of deducing the laws of movement of the rapidly travelling electrons from those of the slowly-moving electron, the latter based on observation or supposition. Mr. Cunningham's memoir now dealt chiefly with the electron, entities of energy pulses, velocity of light, and the Michelson-Morley effect. He pointed out that modern science was ready to give up almost anything except the conception of time and space, and came to the conclusion that the term "mass" lost its meaning as a constant of a body.

An animated discussion followed under the ten-minutes' rule. Professor Turner referred to the thesis of H. A. Lorentz (1895), that any moving body would change its shape; whether or not there was movement of the æther relative to the earth could apparently not be decided by experiments, and mathematicians would have to go on irrespective of experiments. Dr. W. Swann, of Sheffield, wished to explain the movement of the electron; Professor G. N. Lewis, of the Massachusetts Technological Institute, argued that mass and energy were the same thing, and suggested a generalisation of Einstein; Professor Zeeman, of Amsterdam, Mr. H. Bateman, Professor A. E. H. Love, and Professor H. M. Macdonald, of Aberdeen, put questions; while Dr. C. V. Burton, of Oxford, referred to cases in which the principle might fail.

MATHEMATICAL PAPERS.

Of the mathematical papers we can only mention the report of the Committee on "The Further Tabulation of Bessel and Other Functions," which includes contributions by Sir George Greenhill on "Elliptic Functions," and by Mr. J. R. Airey on "Neumann Functions," and a paper by Mr. H. Bateman, of Cambridge, on "The Infinitesimal Transformation of an Electro-Magnetic Field into Itself." Mr. Bateman said that Sophus Lie had, in 1895, expressed the belief that the processes which took place in Nature could mathematically be represented by infinitesimal transformations, and these arguments had been applied by Lie to analytical dynamics and wave-motion in various media, and quite recently by Zorawski and Vessiot to the kinematics of a fluid of n dimensions. Mr. Bateman followed the work of Hargreaves on the effect of an infinitesimal transformation on certain integral forms.

(To be continued.)

THE ELECTRICAL EXHIBITION AT OLYMPIA.—No. I.

THE Exhibition which has been promoted by the British Electrical and Allied Manufacturers' Association, and which opened at Olympia on the 23rd inst., is stated to contain the largest collection of electrical apparatus ever brought together in one building. We do not know if this claim be well founded, but certainly there is a notable absence of vacant space at Olympia, the whole of the main floor and the major part of the galleries being taken up with genuine electrical and engineering exhibits. There is a sprinkling of extraneous matter, but it is not present in sufficient quantity to detract from the engineering interest of the show. Compared with the corresponding Exhibition held in Manchester in the autumn of 1908, we are inclined, however, to think that the present one is a little weak in exhibits of the heavier class, and that fittings and domestic appliances come in for a larger share of attention. This fact is probably to be explained, not so much as a direct attempt to popularise the Exhibition, as an indication of a growing appreciation among manufacturers and supply authorities of the importance and possibilities of domestic supply in other than its purely lighting aspects. We do not wish to suggest that machinery, as distinct from appliances, is not well represented in the Exhibition, but, none the less, it hardly occupies the position which it properly should fill.

The stands containing the display of Messrs. Siemens Brothers and Co., Limited, and Siemens Brothers Dynamo Works, Limited, Caxton House, Westminster, illustrate this greater prominence given to the smaller class of electrical goods, and are in this sense an epitome of the Exhibition as a whole. They contain a wonderfully complete collection of cables, jointing materials, telephones, lamps, pyrometers, cells, testing instruments, &c., which it is impossible even to enumerate, but they are notably deficient in what can reasonably be described as machinery. Among the exhibits belonging to this latter class there are, however, some of much interest. One of them is the "Vortex" suction cleaner. This differs from the majority of its kind in that no dust-filter is used to protect the pump and to catch the material drawn in by the nozzle. Messrs. Siemens claim that the periodic cleaning

* See ENGINEERING, vol. xci., page 409.
† *Ibid.*, vol. xci., page 409.

EXHIBITS AT THE ELECTRICAL EXHIBITION, OLYMPIA.

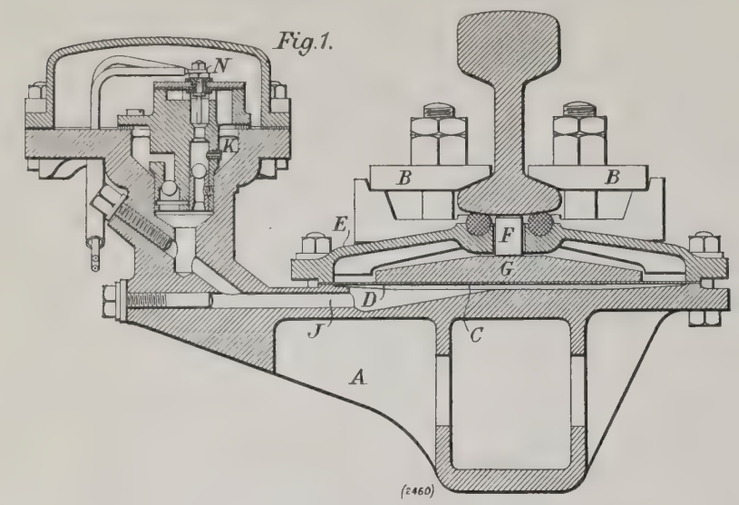


Fig. 1. Mercury Contact Treadle; Messrs. Siemens Brothers, Limited, London.

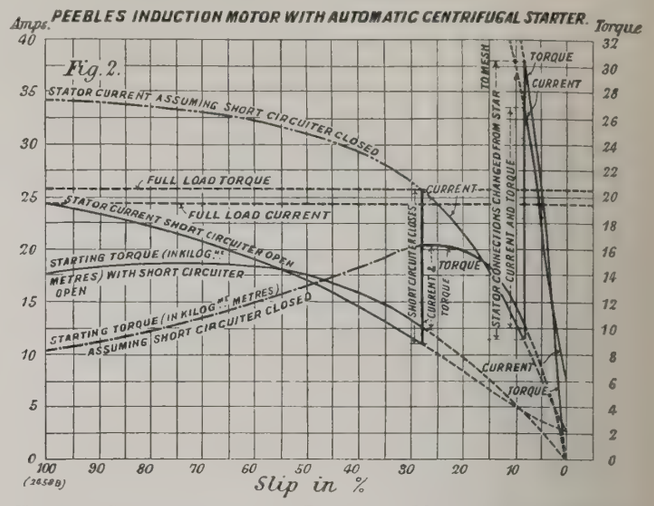


Fig. 2. Characteristics of Induction Motor with Automatic Centrifugal Starter; Messrs. Bruce Peebles and Co., Limited, Edinburgh.

of this filter is a disadvantage of many suction cleaners, and in their arrangement the whole of the dust and dirt lifted by the machine is passed through the pump, and delivered directly to the drain. The device, in essence, consists of a vertical turbine pump, driven by a motor fixed above it, and connected up on its suction side to the cleaning-nozzle through an intercepting-tank fitted with baffle-plates, which arrest any pieces of string or other large articles which may be lifted by the machine. The pump-chamber itself is fitted with a water service, so that the dirt delivered to it is churned up with water and forms a sludge, which easily passes to the drain. The machine is made either for fixed or portable service; but in the latter case it is, of course, usually necessary to combine with it a tank for the service water and a sump-box.

A further exhibit of Messrs Siemens which may be mentioned is the mercury contact treadle for railway signalling. The object of the apparatus is automatically to close or open an electrical circuit by the passage of a train at a given point on a railway line. There are, of course, various examples of this class of device which depend for their action on the magnification of the rail deflection by means of a system of levers, but in Messrs. Siemens apparatus this magnification is obtained owing to the difference in area of two chambers containing mercury. The ratio between the area of the two chambers is 1500 to 1, so that an adequate electrical contact is obtained in the second chamber with an extremely small rail deflection. The treadle is made in various patterns suitable for a variety of train signalling purposes, and can be arranged to give a continuous contact during the passage of a train, or a series of intermittent contacts during the same period. It can also be constructed to maintain a normally closed circuit, which is opened by the passage of a train.

The apparatus is shown in section in Fig. 1, on this page. It consists of a main treadle casting A, secured to the rail, without any drilling, by means of the clamps B B. In the centre of the main casting there is a shallow trough C, above which a steel diaphragm D is held by means of the cover E. On the centre of the diaphragm there lies a flat plate G, which, on the passage of a train, is depressed by the steel plunger F. The space between the cover E and the bottom of the rail is packed with an elastic joint, which is both dust and water-proof. The shallow trough C is filled with mercury, and communicates, by means of the passage J, with the valve-box K in such a way that the depression of the diaphragm forces the mercury up into the box K and makes the necessary contact. The head of mercury in K is sufficient to press the diaphragm upwards against the bottom of the rail with a pressure of 150 lb., so that good mechanical contact is ensured. The electrical contacts N N are carried in, but insulated from, the cover of the contact-box. They are connected up by insulated wires, leaving the apparatus as shown in the figure.

The actual arrangement of the ball-valves and contacts depends upon the type of service which is required, but the figure shows the construction used when a continuous contact during the passage of a train is required. The normal level of the mercury is about $\frac{5}{16}$ in. below the contact pins, but when the diaphragm is depressed it rises *via* the delivery ball-valve and reaches the contacts. The excess mercury passes through the small aperture shown into the box K, and so returns through the suction ball-valve into the passage J. The aperture connecting the delivery valve with the box K is so small that the mercury does not run out quickly enough to break circuit between the intermittent impulses due to the passage of a train, and yet, at the same time, the supply of mercury in K is always available to fill immediately the passage J when the diaphragm rises after the passage of a train, so that the apparatus is capable of dealing with the most continuous traffic. Modifications are made in the valves and contacts for other types of service, but it is not necessary to deal with them in detail, as the principles of action remain the same in all cases.

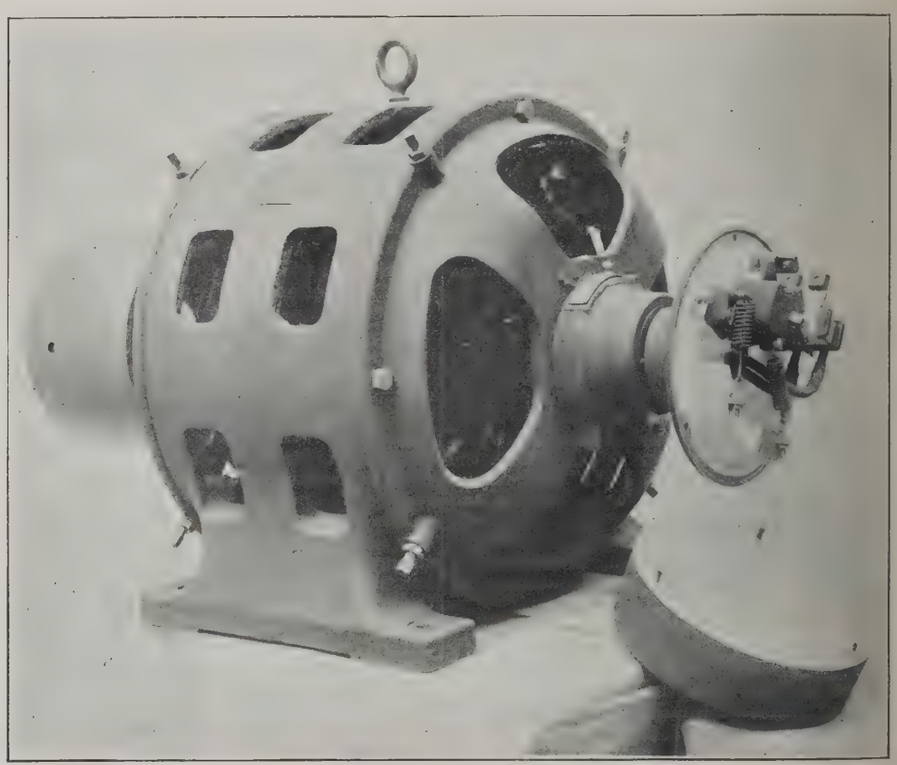


Fig. 3. Induction Motor with Automatic Centrifugal Starter; Messrs. Bruce Peebles and Co., Limited, Edinburgh.

An interesting exhibit is made by Messrs. Bruce Peebles and Co., Limited, of Edinburgh. It consists in the main of electric motors of various types, although the most prominent position is taken by a fine example of a 475-kw. motor converter. It is unnecessary, however, to describe this machine, as its essentials have been so frequently dealt with already. Among the more novel matter there is an induction motor with an automatic centrifugal starter, which is illustrated in Fig. 3, above. It is of 20 horse-power, and runs at 750 revolutions per minute on a three-phase 50-period 500-volt circuit, and has been designed to meet the demand for a motor having a comparatively high starting torque and a relatively small starting current. Its characteristics are shown in the curve given in Fig. 2, on this page. The machine is started like an ordinary squirrel-cage motor with star-delta starter, and at a predetermined speed the rotor is short-circuited by the automatic centrifugal device which is fixed at one end of the shaft, and can be clearly seen in Fig. 2. After short-circuiting, the switch is moved over to the running position, and the motor runs as an ordinary induction motor. In cases where it is desired to start

EXHIBITS AT THE ELECTRICAL EXHIBITION, OLYMPIA.

Fig. 4. Electrically-Driven Pump with Automatic Control; The Phœnix Dynamo Company, Limited, Bradford.

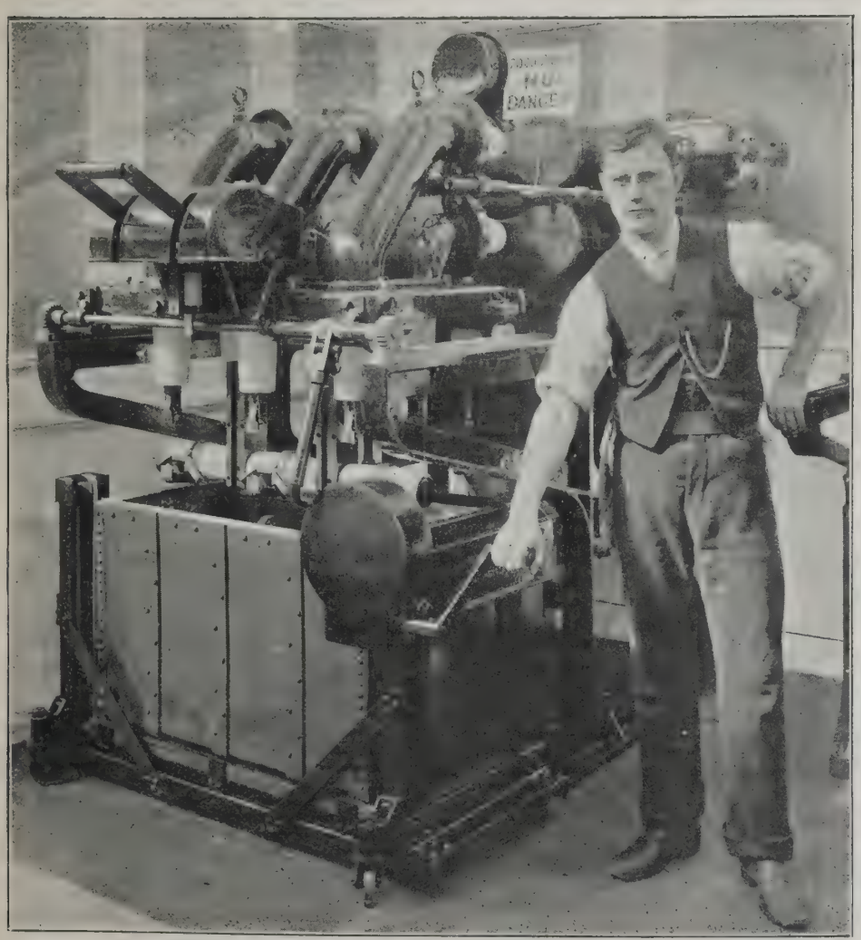


Fig. 6. 20,000-Volt Completely-Enclosed Switch-Gear; Messrs. Reyrolle and Co., Limited, Hebburn-on-Tyne.

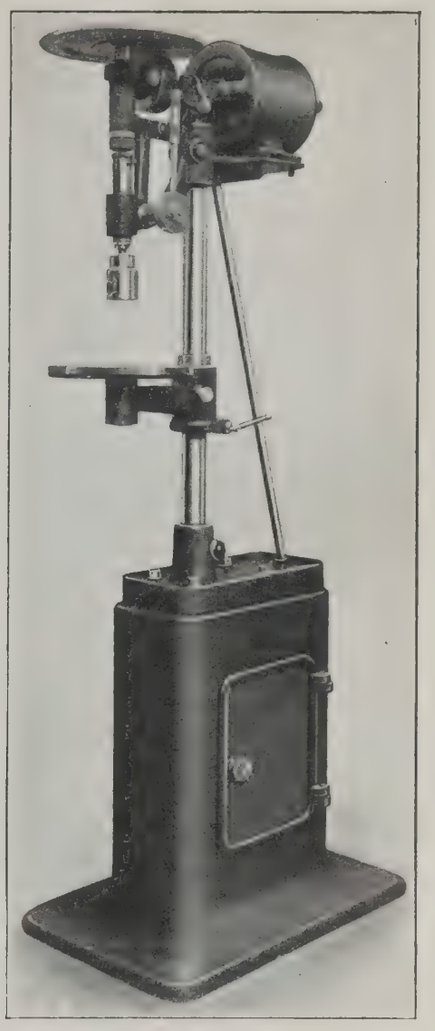


Fig. 5. Sensitive Drill; The Phœnix Dynamo Company, Limited, Bradford.

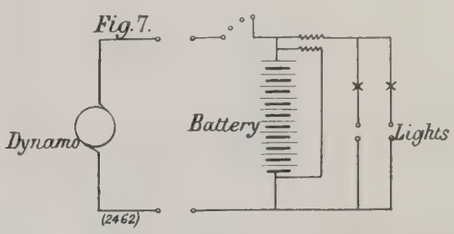


Fig. 7. Lister's Lighting Set; Messrs. R. A. Lister and Co., Limited, Dursley.

the motor from a distance, the star-delta starter can be omitted, but in this case the starting current would, of course, be greater. Messrs. Bruce Peebles also show a direct-current mining-motor, and it is interesting to note that the flame-proof features of the commutator are secured by entirely enclosing it in a gas-tight box with machined joints. This, of course, eliminates ventilation, and necessitates very liberal rating. The firm also exhibit a machine described as a split-pole converter. It is intended in the main for stepping down from a higher to a lower direct-current voltage. The machine has but one commutator, on which there are four brushes connected to two independent armature circuits, but no details of the actual arrangement are available. It is stated to have an efficiency of from 5 to 12 per cent. higher than a motor generator of similar size.

On the stand of the Phœnix Dynamo Manufacturing Company, Limited, Bradford, the main exhibit is a new type of plating dynamo forming

part of a motor-generator set. The arrangement of the machine is of much interest, and we propose to return to it in a later issue. For the moment, however, we will confine our attention to two of the smaller exhibits. These, which are shown in Figs. 4 and 5, on page 421, consist of an electrically driven automatic pump and a sensitive drill. The pump, which is shown in operation at the show, and makes an attractive exhibit, is intended for supplying water to country houses, mills, &c. It is designed to allow of a supply of water being obtained at any time on demand, without the use of a reservoir. The main feature of novelty of the plant lies in the automatic starting-gear, which is operated by means of the pressure reached in a cylindrical vessel attached to the service pipe. The vessel is shown at the right-hand side in Fig. 4. When no water is being used, the pump runs long enough to raise the pressure in this vessel to such a height that, by the operation of an internal diaphragm, the motor-switch, which is fixed on the top of the vessel, is opened. This stops the plant, and the state of affairs continues until the using of more water causes the pressure to fall; this operates the diaphragm, closes the switch, and starts the motor, which runs as long as any demand is made on the supply. This sequence of operations may, of course, be repeated indefinitely.

The electric drill, shown in Fig. 5, will be understood from the illustration, and requires little description. The motor drives a small leather-covered wheel, which lies below and in contact with a horizontal disc, on the drill spindle, the arrangement giving a friction drive, which is amply powerful for the class of work for which the machine is intended, and has the advantage that in case too much pressure is put on the feeding lever, slipping will take place. This renders the breaking of small drills very unlikely. An additional feature of the arrangement is that by moving the leather-covered wheel along its spindle it may be arranged to make contact with the horizontal disc at different radii, so that various drill speeds are obtained in a very simple way. An operating lever, with stops, is fitted for the control of the position of the small wheel. The feeding arrangement and other features of the drill are on the usual modern lines for this class of tool, and are clearly shown in the figure.

Switch-gear is represented at the show by exhibits from most of the important makers, and we will refer to it again in future articles, for the moment confining ourselves to the gear displayed by Messrs. A. Reyrolle and Co., Limited, of Hebburn-on-Tyne. As is well known, Messrs. Reyrolle specialise in this class of work, and have produced many original and excellent designs. Their most striking exhibit at Olympia is a sample of their ironclad completely protected gear designed for use on a 20,000-volt circuit. The sample is one of some hundred units which Messrs. Reyrolle are building for use by the North-East Coast power companies. The general lines of this type of gear have already been fully described in our columns, and it is unnecessary to refer to its features in detail, but the design and construction of completely enclosed gear for a voltage of 20,000 is a development of such interest that we illustrate the unit in Fig. 6 on page 421. We much doubt if any gear for such voltage approaching this in the completeness of its ironclad protection has been constructed by any other firm or in any other country. The gear is, of course, fairly large, as compared with the maker's other apparatus of similar type but for lower voltage, as will be gathered from the illustration. None the less, those conversant with 20,000-volt switch-gear will appreciate at once the very small space taken up by the apparatus when it is compared with gear of the more usual cellular or cubicle type. It must be a matter of satisfaction to Messrs. Reyrolle to find that their boldness in first developing this type of gear has been so well repaid by its success in practice. There are a number of other exhibits on Messrs. Reyrolle's stand, many of them intended for mining work, and it is interesting to note how very completely a flame-proof type of construction, consonant with modern ideas, has been adopted in their design. In all cases a system involving long machined joints has been followed, no reliance being placed on packing. A further exhibit worthy of mention is a series of porcelain-handle fuses, arranged in such a way that no live metal is exposed when the fuses are in position on a board. Messrs. Reyrolle's earlier type of porcelain-handle fuse was very well known, and was very extensively employed. We do not know that there is any evidence to show that its use ever led to an accident, and in its general lines it was, of course, similar to many other makes at present in use; none the less, in obedience to the new Home Office rules, the newer design has been produced. As we said, it has the characteristic that the whole of the live metal forming the contacts is shrouded with porcelain, so that it is impossible for a man either unconsciously or deliberately to get a shock.

One of the most interesting stands at the Exhibition from the point of view of the general public, and by no means the least interesting from the point of view of the engineer, is that occupied by Messrs. R. A. Lister and Co., Limited, of Dursley, who show their automatic electric-generating plant. The apparatus is intended in the main for country house lighting and similar service, and consists of a petrol or gas-engine driven dynamo which is automatically started up or stopped in obedience to the demand on the mains. The whole system is quite a straightforward and simple one, although so novel, and appears to work very well in practice; while the apparatus used is of a well-tried type, and contains nothing of a freak nature. The essentials of the gear are shown in the small diagram given in Fig. 7, on page 421. It contains, as will be seen, in addition to the engine and dynamo, a small battery, a starter and relay, and the usual main switches and fuses. The battery is of small capacity only (about 20 ampere-hours) and is in service for a few minutes only at a time.

The action of the plant is as follows:—When there are no lamps switched on and the battery is fully charged, the engine is standing and its starting-switch is open. On lighting up one or two lamps the current is at first supplied by the battery. When, however, more lamps are switched on, the extra current demanded by the lamps causes the relay instrument, which is shown by its two coils in the diagram, and is in effect an automatic switch, to be put into action. The result of this is that the relay closes circuit through the dynamo-starting switch, which is solenoid-operated. The switch accordingly closes and starts up the dynamo as a motor. In order that the demand on the battery shall not be too great, there is a small tripping device also operated by the solenoid starter, which relieves the engine compression for a few strokes; this trip is then released, and the dynamo begins to generate, taking the load, and at the same time charging up the battery to full voltage. This state of affairs then continues while the load is on, the battery meanwhile floating on the line. When all lamps are switched off, the disappearance of the series current in the two-coil relay causes the shunt current to again make its influence felt, with the result that the starting-switch opens. If, in a comparatively large plant, a very small current is called for, such as that demanded by a single lamp, some time may elapse before the battery voltage falls enough to cause the switching in of the dynamo; but if the load is persistent enough, the series of operations described above will take place, no matter how small the demand. It should be said that the whole apparatus appears to be well made and of a workmanlike character, and that the examples on view at Olympia operate in a very satisfactory way. The engine, together with its dynamo and starting-switch, is mounted on a channel-iron base-plate, so that the whole forms a self-contained and easily portable unit. It is not the practice to bolt the bed-plate to its foundations, the whole arrangement simply being placed on a suitably flat floor without fixing of any kind.

Acoustic Electric Discharge Phenomenon.—In the *Annales de la Soc. Scientif. de Bruxelles*, vol. xxxv., page 129, Canon R. de Muynck describes some discharge phenomena which require elucidation. He stretched a platinum wire, 0.25 mm. in thickness, over insulated supports 55 cm. apart. The end of the wire was brought up to the spark-ball of a battery of four jars, charged from a Holtz machine. The wire could be heated by electric currents from another source. When the spark-gap was too great for a spark to pass, and the wire was hot, the wire gave out a musical note, and was observed to be subjected to oscillations of considerable amplitude—about 1 cm.; the sound was not clear, however, and the pitch would vary with temperature changes in the wire and also for some other reasons not properly understood. The cold wire did not oscillate. Muynck suggests that the wire is attracted by the sphere, moves towards it, and is cooled by the partial discharge and the loss of electricity accompanying it; the wire then recedes, and it is attracted again, and thus oscillations are set up.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was quite idle, but Cleveland warrants were nominally steady with sellers quoting 46s. 7½d. cash, 46s. 10½d. one month, and 47s. 5d. three months. In the afternoon there was again no dealing, and Cleveland warrants were unchanged from the morning, except that cash sellers quoted ½d. less. On Friday morning the market remained idle, and the tone was easier. The closing quotations for Cleveland warrants were 46s. 6½d. cash, 46s. 9½d. one month, and 47s. 4½d. three months sellers. Hematite was quoted at 61s. 9½d. cash sellers. The afternoon session showed little improvement, and business was again at a standstill. Sellers of Cleveland warrants quoted ½d. up at 46s. 7d. cash, 46s. 10d. one month, and 47s. 5d. three months, but hematite was the turn easier, with cash sellers at 61s. 9d. On Monday the market was closed all day, being Glasgow Autumn Holiday. Business was resumed on Tuesday morning, but the tone was dull. The dealing was limited to 2500 tons of Cleveland warrants at 46s. 5d. and 46s. 5½d. cash, and 46s. 9½d. one month, and at the close sellers quoted 46s. 6½d. cash, 46s. 10d. one month, and 47s. 4½d. three months. Weakness prevailed in the afternoon, when a small business of some 3000 tons of Cleveland warrants was put through at from 46s. 9d. to 46s. 8d. one month. The session closed with sellers at 46s. 5½d. cash, 46s. 8d. one month, and 47s. 3½d. three months. When the market opened to-day (Wednesday) the tone was inclined to be easier and the turnover was limited to 2000 tons of Cleveland warrants at from 46s. 8½d. to 46s. 7½d. one month. Closing sellers quoted 46s. 5d. cash, 46s. 8d. one month, and 47s. 2d. three months. In the afternoon no dealings of any kind were recorded, but sellers' quotations for Cleveland warrants were nominally harder at 46s. 5½d. cash, 46s. 8½d. one month, and 47s. 3d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 61s.; Gartsherrie, 61s. 6d.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 63s.; Shotts (at Leith), 62s. 6d.; and Carron (at Grangemouth), 63s. 6d.

Scotch Steel Trade.—Steady employment continues general in the Scotch steel trade this week, although one or two firms report that specifications for ship-plates are just a shade easier. This latter condition is principally on home account, as shipbuilders have recently been taking in large deliveries. The export demand is good, and there is also a satisfactory inquiry for some lots of boiler-plates for export. New business, although not over plentiful, has improved considerably. Structural sections, thin sheets, and light plates are all in excellent demand for shipment, and makers of light material are all actively employed.

Malleable-Iron Trade.—The contracts entered into some time ago by malleable-iron makers are the means of fairly steady employment at present, but most of these were fixed up at the low rate which then prevailed—namely, on the basis price of 6*l.* per ton, less 5 per cent. for crown bars. That price still rules, but several producers will not consider any more business at that figure, and are commanding from 6*l.* 2*s.* 6d. to 6*l.* 5*s.* per ton.

Scotch Pig-Iron Trade.—Heavy deliveries of the ordinary qualities of Scotch pig iron have been general of late, and not only have local consumers been fair buyers, but the inquiries from the South have also been on a large scale. The export trade has been good, and the present outlook points to a continuance of this state, as India, Australia, Canada, and South America are all in the market for supplies. Hematite is in poor demand still, but contracts are running away with a lot of material.

Shipbuilding.—Messrs. Napier and Miller, Limited, Old Kilpatrick, have secured an order for an auxiliary sailing vessel of about 1400 tons displacement. The vessel, which is to be used for surveying, is to be schooner-rigged on four masts. Part of her equipment will include trawling gear, of the type used by the biggest Grimsby trawlers. The auxiliary power will be a gas-engine.—Messrs. Wm. Denny and Brothers, Dumbarton, are reported to have received orders to build two triple-screw steamers for foreign owners.—The Dundee Shipbuilding and Engineering Company, Limited, have contracted to build a mail and passenger steamer of 900 tons for a Newfoundland firm.

Contracts.—The directors of the Great Northern and Great Central Railways West Riding Railway Joint Committee have accepted the tender of Messrs. Robert McAlpine and Sons, of Glasgow and Westminster, for the widening of the line from Nostell Station to Hemsworth South Junction.—The British Humboldt Engineering Company, Limited, have recently received another order for a Wetherill magnetic separating plant from Messrs. Davis and Soper, London, E.C. These separators, for treating weakly magnetic ores, have highly concentrated magnetic fields, and are in universal use in the treatment of tin wolfram ores in the United Kingdom, the colonies, and abroad.—Messrs. Babcock and Wilcox, Limited, Oriel House, Farringdon-street, London, E.C., have, we understand, secured the contract for the complete plant for charging the open-hearth furnaces at the works of the Monmouthshire Steel and Tin-Plate Company, Pontymister. The scheme includes an overhead crane and lifting-magnet for discharging the pig-iron and scrap from the trucks, as well as two of Messrs. Babcock and Wilcox's new ground-type slewing open-hearth charging-machines, together with boxes and all accessories. The whole arrangement was planned under the supervision of Mr. J. H. Louis, manager of the Pontymister Works, with a view to maximum economy.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

A Word of Warning.—With the shadow of a coal strike over all branches of industry there is a particular interest in some remarks made by Lord Aberconway (Sir Charles McLaren) on Monday at the annual meeting in Sheffield of the Sheepbridge Coal and Iron Company, Limited. Discussing the position of the Midland coal trade, and after pointing out how it had suffered through increased outputs on the North-East Coast, he said that there could hardly be a worse time chosen for labour disturbances in colliery districts in the Midlands than the present. If coalowners were not supported by the men in working their coal to the best possible advantage, the colliers would suffer in the long run, because if by arbitrary and unreasonable restrictions the miners prevented the owners from working their collieries to the best advantage, it would be perfectly impossible to maintain wages at their present rate. Several other interesting statements were made at the meeting. The position of the company was shown to be a satisfactory one. The profits had increased by 20,000*l.* in spite of increases in working costs occasioned by the operation of the Eight Hours Act and the Workmen's Compensation Act. Mr. Frederick Fowler, the chairman, was, however, pessimistic about the iron trade. He said it was in a very unsatisfactory condition, and he did not see much prospect of improvement.

Engineering Feat.—A very smart piece of work was done in Sheffield early on Sunday morning last, when the big Midland Railway bridge crossing Princess street, Attercliffe road, was within 24 minutes removed, and replaced by a new one, weighing 200 tons. Heavy traffic on the line at this point had necessitated a new bridge, and the contract for the steelwork was given to the Butterley Iron Company. The new structure, the girders of which measure 75 ft. in length, was erected on huge wooden trestles and rolled into position as the old bridge was pulled out. Mr. Godfrey Wright supervised the work for the Butterley Company. The steelwork had been made to the designs of the Midland Railway Company's engineer.

South Yorkshire Coal Trade.—A good deal of inconvenience is being caused in the export trade and amongst users of steam coal generally by the serious shortage of wagons. Collieries are pressed for deliveries on contract, and are unable to get fuel away with sufficient rapidity. The demand for industrial consumption is still a notable feature, and, apprehensive of a coal strike, manufacturers continue to accumulate stocks. Prices are firm, with an upward tendency. Gas fuel, both for stocking and for current requirements, is meeting with a very ready sale, and shipments have also increased. Slacks are strongly held, and there is a somewhat better appearance about coking smalls. The wagon difficulty is also affecting house-coal pits, which have had a rush of orders, principally from the London merchants, and are many of them only working half-time. Best coals are in the greatest demand, and are not easy to obtain in any considerable quantities Official prices have not been altered, but they have a firmer tendency, and an advance in the near future is very probable. For additional deliveries on contract quantities current prices are being quoted. On the local exchange at the week-end quotations were:—Best branch hand-picked, 14s. to 15s.; best Barnsley Silkstone, 11s. 6d. to 12s. 6d.; Silkstone, 10s. 6d. to 11s. 6d.; Derbyshire, 8s. 6d. to 9s. 6d.; best large nuts, 8s. 6d. to 9s. 6d.; small nuts, 8s. to 9s.; Derbyshire best brights, 11s. to 12s.; Yorkshire hards, 8s. 3d. to 9s. 3d.; Derbyshire hards, 8s. to 9s.; washed nuts, 7s. 6d. to 8s. 6d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. 3d. to 5s. 3d.; smalls, 2s. to 3s.

Iron and Steel.—The position in the pig-iron market appears to be more satisfactory, an improvement attributed in some quarters to low prices of hematites having attracted buyers. On the other hand, the producers of common irons consider that the better business now coming forward in their branch is a justification of their policy of keeping up prices. Consumers, having gained nothing by waiting, have been obliged to come into the market. Both forge and foundry qualities in Lincolnshire and Derbyshire are firm. There is a big consumption of all kinds of iron. Tungsten is in a better position. There is a considerable demand for billets. Prospects in finished iron are rather better. The majority of the city's industries are at present well employed, and there is a particularly good appearance about the heavy trades. The various departments of the armament firms are on full time, with a good weight of both home and foreign orders. An improvement in shipbuilding has brought additional work to the foundries, which are, on the whole, very well occupied, but there is still considerable competition from the Continent in castings. The forges are not satisfactorily employed. An encouraging amount of work in respect both of home and foreign orders continues to come to hand in the railway-steel departments. General engineering is improving, as is manifested in a growing demand for engineers' tools. The hand-tool trade, joiners' tools, &c., has had a good season in the export and in the home trade. Manufacturers report a varying demand for files, but the position is good on the whole.

DONCASTER.—The Hatfield Main Colliery Company has commenced the sinking of a new colliery close to the Great Central Railway and about half a mile to the north-east of Stainforth and Hatfield station. Two shafts are to be sunk, each 22 ft. in diameter, and it is expected that the Barnsley seam will be reached at a depth of about 800 yards, assuming that the dip of the seam is fairly even between Bentley and Thorne.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Extreme quietness still characterises the pig-iron trade. This season of the year usually sees a good deal of briskness, but the present occasion finds buyers very backward, and prospects must be regarded as discouraging. Producers of pig iron have fairly good order-books, but few new contracts are being entered into. That there is at the same time still some confidence in the future is emphasised by the fact that rather higher rates can be obtained on forward account than for early delivery. The most disturbing element is the general feeling of unrest in the labour market. Market quotations for Cleveland pig iron are lower than they have been for the past three months. No. 3 g.m.b. is offered at 46s. 9d. f.o.b., and merchants are rather pressing sales at that figure, while No. 1, which is still anything but plentiful, is 50s. 9d.; No. 4 foundry stands at 46s. 3d.; No. 4 forge, 46s. 1½d.; and mottled and white iron, each 45s. 10½d.—all for early delivery. Any inquiry for delivery ahead elicits quotations of quite 6d. above these rates. East Coast hematite pig keeps quiet, but steady. The general market price for early delivery of Nos. 1, 2, and 3 is 61s., and business has been done over the first half of next year at 61s. 6d. Values of foreign ore are moving upward. Market rates are now based on 19s. 6d. ex-ship Tees for best Rubio, and up to 5s. is named for freights Bilbao-Middlesbrough. Coke has also been advanced. Average blast-furnace kinds are fully 14s. 9d. delivered here, and some sellers now name 15s.

Manufactured Iron and Steel.—The various branches of the manufactured iron and steel industries present no new features of moment. In all departments a lot of work is being turned out, many firms have contracts made which will keep them well occupied for some months to come, and a fair number of inquiries continue to be made. Under these favourable circumstances values tend upward, but no quotable advances have as yet been made. Principal market rates stand:—Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 11*l.* 5s.—sheets less 4 per cent., railway material net, and all other descriptions less 2½ per cent.

Non-Unionist Labour at Cleveland Mines.—The Council of the Cleveland Ironstone Miners and Quarrymen's Association have agreed that, failing satisfactory arrangements being made at Grinkle mines with regard to several non-union men employed there, if the men continue to refuse to join the association, notices will be tendered by members of the association as a protest against the employment of those men. A report was presented in connection with a man at Carlin How, who remained outside the association in spite of the fact that every means possible had been used to persuade him to join. He was at present receiving an advance of 1s. 6d. per week, which the association had obtained for him after arbitration only recently, but the man declared that nothing would induce him to join. It was decided that unless the man joined the association notices of the members employed at the mine in question will be put in.

OIL-PROPELLED VESSEL CROSSES THE ATLANTIC.—The twin-screw vessel Toiler arrived at Halifax, N.S., on Friday morning last, having safely completed her voyage from the Tyne. To Messrs. Swan, Hunter, and Wigham Richardson, Limited, thus belongs the credit of building the first oil-propelled vessel to cross the Atlantic. About eighteen months ago this firm, who, in recent years, have built several vessels for Canadian waters, decided to construct a vessel specially adapted for service on the Canadian canals. They took some little time to consider the various types of machinery, and after careful investigation decided to adopt Diesel engines. Having up to that time not had actual experience in building this type of engine themselves, they arranged with the Aktiebolaget Diesels Motorer, of Stockholm, to provide the engines, which are of the two-cycle, reversible, marine type, using crude oil. The Toiler was then built, and the Diesel engines fitted on board at the firm's Neptune Works. After completing the vessel, trial trips were made in light and loaded conditions, and in order to have actual sea experience the vessel was sent two voyages loaded, one to Calais and the other to Boulogne, returning to the Tyne light. These voyages sufficed to show the reliability of the engines, and the builders had no hesitation in loading the Toiler and sending her across to Canada. There are at present perhaps as many as half-a-dozen vessels being built which are to be fitted with Diesel engines of 1000 horse-power or more. Messrs. Swan, Hunter, and Wigham Richardson, Limited, however, preferred to experiment with the comparatively small power of the Toiler before taking up the building of larger Diesel engines. They are at present building in their Neptune Engine Works a set of 400-horse-power Diesel engines, and expect shortly to be dealing with oil-engines of larger power. With the Diesel oil-engines there are, of course, no boilers, no coals, and no coal-dust and ashes, and, as illustrating the saving in the weight of fuel used, it may be mentioned that the Toiler consumes less than 2 tons of crude oil per day, whilst steam-engines of equal power would require a consumption of about 8 or 9 tons of coal.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has been rather inactive, but prices have shown little change. Colliery owners are taking a somewhat optimistic view of the future course of business, those holding Admiralty contracts being encouraged by the fact that the naval authorities have taken up a larger number of steamers to load for dépôts. The best large steam coal has made 17s. to 17s. 6d. per ton; secondary qualities have ranged between 15s. 3d. and 16s. 9d.; best bunker smalls between 8s. 9d. and 9s.; and cargo smalls between 6s. 9d. and 7s. 3d. per ton. The best ordinary household coal has been quoted at 14s. 6d. to 16s. 6d.; No. 3 Rhondda large between 17s. and 17s. 6d.; and smalls between 10s. 3d. and 10s. 6d. per ton. No. 2 Rhondda large has made 12s. to 12s. 3d.; smalls, 6s. 6d. to 7s. per ton. Foundry coke has realised 18s. to 20s. 6d.; and furnace ditto, 15s. to 17s. per ton. As regards iron ore, Rubio has made 18s. 3d. to 18s. 9d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Weston-super-Mare.—Mr. E. K. North, C.E., an inspector appointed by the Local Government Board, has held an inquiry at Weston-super-Mare with reference to an application made by the local urban district council for power to borrow 3405*l.* for the purchase of 8¼ acres of land situate off Langford-road, and proposed to be acquired for the following purposes:—(1) Public abattoirs; (2) cattle market; (3) a dépôt; (4) refuse-destructor; and (5) workmen's dwellings. A large number of witnesses were called to prove the need of new abattoirs—which was a salient feature of the application, and the only one with which the council intends to proceed at present—and subsequently the inspector heard objections which were advanced to the council's proposals. The inspector intimated that he would present his report at an early date.

Cardiff Corporation Water Works.—The revenue of the Cardiff Corporation Water Works in the last financial year was 73,305*l.* The loan charges of the year were 54,722*l.*, and the working expenses 26,835*l.*, making an aggregate of 81,557*l.* There was, accordingly, a deficiency on the year of 8253*l.* The loan charges, however, included a repayment of 10,686*l.* of capital outlay. The revenue of the Corporation electric light works, after deducting loan charges, showed a surplus of 909*l.*; this total did not make any provision, however, for depreciation. There are now upwards of 2000 consumers on the books. The tramways account, after allowing for loan charges, showed a net profit of 12,034*l.*; of this amount 6947*l.* was appropriated for depreciation, and 5087*l.* was carried to reserve.

The "Amphion."—The Amphion will have only two propeller shafts. The reduction from four shafts to two has been rendered practicable by the introduction of a new type of turbine by the Parsons Company.

THE PANAMA CANAL.—The excavation effected upon the Panama Canal in August amounted to 2,706,223 cubic yards of rock and earth. The corresponding extraction for the previous month was 2,510,982 cubic yards. In the course of August also 149,717 cubic yards of concrete were laid, as compared with 129,717 cubic yards in July.

UNIVERSITY OF LONDON, KING'S COLLEGE.—It is intended by the faculty of engineering of the above College to deliver courses of advanced lectures during the coming session. These lectures will comprise the following:—Civil and mechanical engineering: (*a*) October to December, lectures, Thursday, 6 to 7, commencing October 19. Mr. N. F. Mackenzie, Hon. M.A., M. Inst. C.E. (lately Under-Secretary for Irrigation to the Government of India), "Irrigation." Drawing and design: Thursday, 2 to 5. (*b*) October to April, lectures, Tuesday, 6 to 7, commencing October 10. Mr. D. A. Symons, M. Inst. C.E., M. I. Mech. E., "Water Supply and Sewage." Drawing and design: Tuesday, 2 to 5. (*c*) January to April, lectures, Thursday, 6 to 7, commencing January 11. Mr. G. A. Burls, M. Inst. C.E., "Internal-Combustion Engines," with special reference to the Petrol-Engine. Drawing and design: Thursday, 2 to 5; laboratory, Tuesday, 10 to 5. (*d*) January to April, lectures, Tuesday, 6 to 7, commencing January 16. "Steam-Turbines." Drawing and design: Thursday, 2 to 5; laboratory, Tuesday, 10 to 5. Electrical engineering: (*e*) October to December, lectures, Mondays, 6.30 to 7.30, commencing October 9. Mr. W. H. Patchell, vice-president Inst. E.E., M. Inst. C.E., member of council Inst. Mech. E. "Electric Generating Stations." Drawing, design, and laboratory: Monday, 10 to 5. (*f*) October to December, lectures, Fridays, 6.30 to 7.30, commencing October 13. Mr. F. Lydall, B.Sc., M. Inst. E.E., "Electrical Traction, Direct and Alternating-Current." Drawing, design, and laboratory: Friday, 10 to 5. (*g*) January to April, lectures, Mondays, 6.30 to 7.30, commencing January 15. Mr. W. H. Patchell, "Application of Electric Power to Mines and Heavy Industries." Drawing, design, and laboratory: Monday, 10 to 5. (*h*) January to April, lectures, Fridays, 6.30 to 7.30, commencing January 12, Mr. Wm. Brew, M.I.E.E. (lately chief expert assistant to Dublin Corporation Electric Supply), "Electric Lighting." Drawing, design, and laboratory: Friday, 10 to 5. The fee for each of the above lecture courses is 1*l.* 1s. If practical work in the drawing-office or laboratories is taken, an additional fee of 2*l.* 2s. will be charged for each course. Further particulars may be obtained from the secretary, King's College.

THE ACCIDENT TO THE NAVY AIRSHIP AT BARROW-IN-FURNESS.

(*For Description, see Page* 428.)

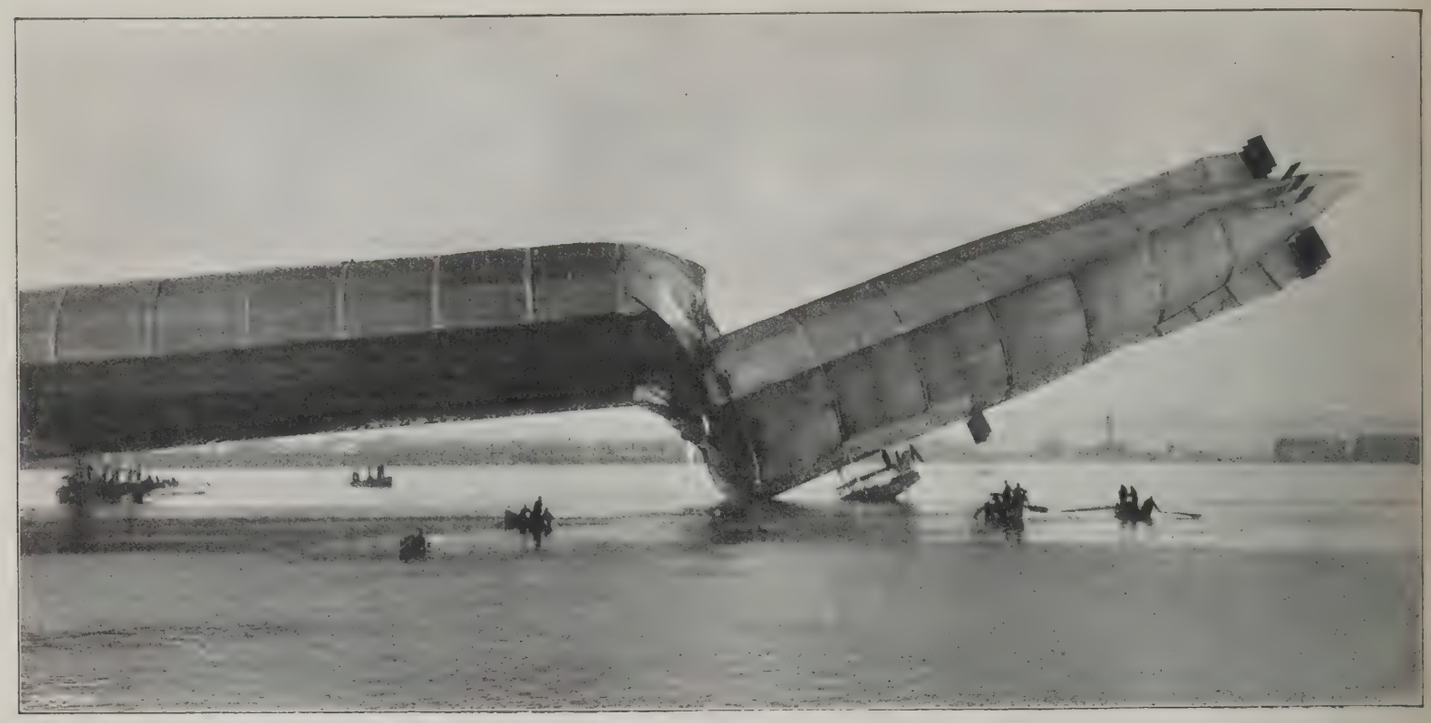


Fig. 1.

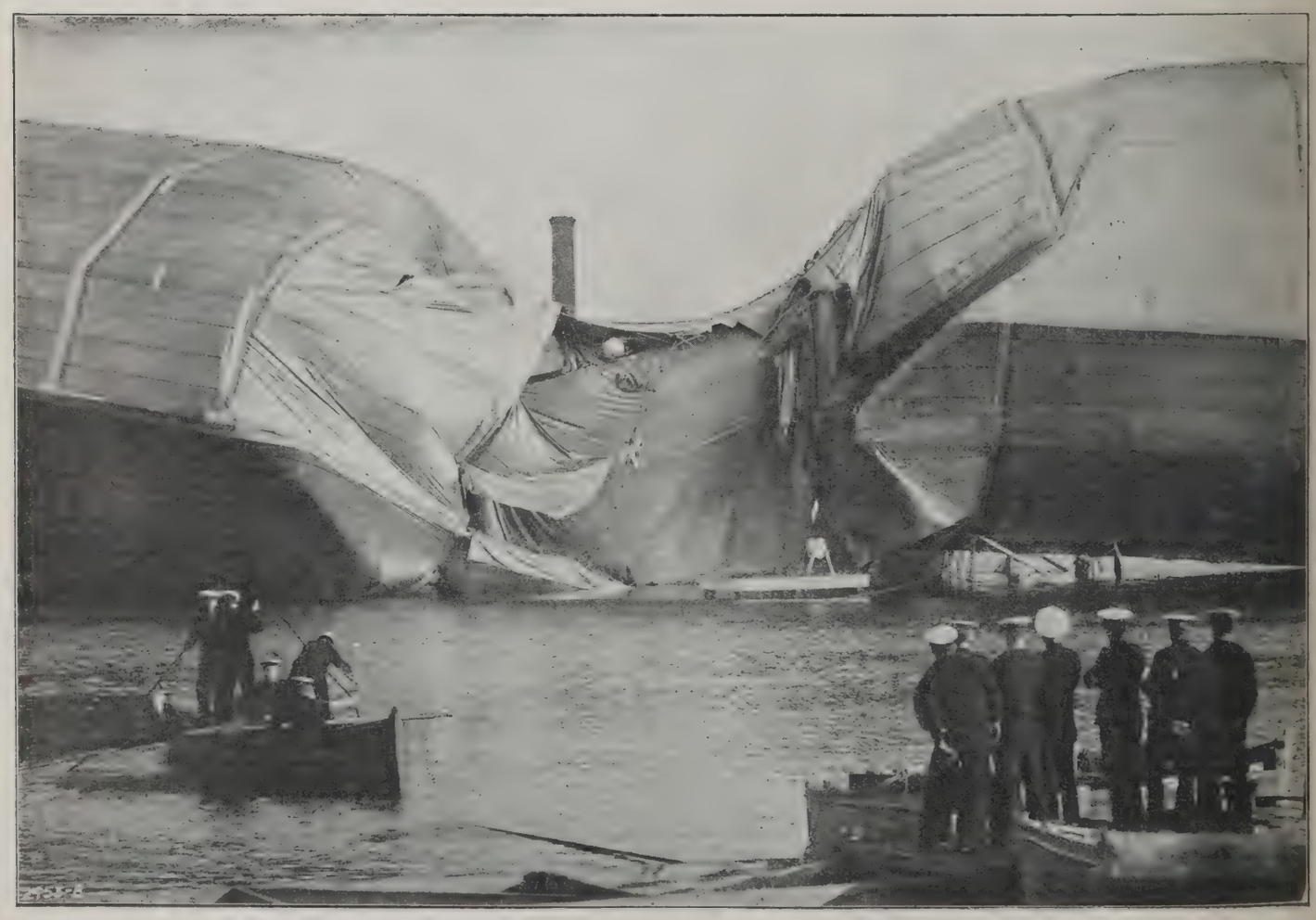


Fig. 2.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Thin paper copies	£1	16	0
Thick ,,	£2	0	6

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NOTICES OF MEETINGS.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, September 30, at 7.15 p.m., at the Institute, Wolverhampton-street, Dudley. The President, Mr. Isaac E. Lester, will deliver his presidential address.

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, October 2, at 7.30 p.m., ordinary meeting, at the Institution of Electrical Engineers, Victoria Embankment, W.C. (south end of Savoy-street, near Waterloo Bridge). A paper will be read on "The Necessity for Safer, Quicker, and Cheaper Railways, with some Proposals Therefor," by Mr. C. Reginald Enock, F.R.G.S.

THE INSTITUTE OF MARINE ENGINEERS.—Monday, October 2, at 8 p.m. Discussion on Mr. F. Shackleton's paper on "Modern Developments in British and Continental Oil-Engine Practice." Paper:—"Notes on Two-Cycle Oil-Engines," by Mr. F. Duncanson, B.Sc.

THE IRON AND STEEL INSTITUTE.—Thursday, October 5, at 10.30 a.m., at the Institution of Civil Engineers, Great George-street, Westminster. Autumn meeting in lieu of the intended meeting at Turin, which has been abandoned. If necessary the meeting will be resumed in the afternoon. The following is the list of papers which have been submitted, a selection of which will be read and discussed:—1. "Reports on the Iron-Ore Resources of Italy." (*a*) "Sardinia," by Ing. L. Testa. (*b*) "Brembana Valley," by Cav. G. Calvi. (*c*) "Central Italy," by Ing. A. Ciampi. (*d*) Southern Italy and the Island Dependencies," by Professor G. la Valle. 2. "On Temperature Influences on Carbon and Iron," by Mr. E. Adamson, Sheffield. 3. "On the Mechanical Influence of Carbon on Alloys of Iron and Manganese," by Professor J. O. Arnold, Sheffield, and Mr. F. K. Knowles, Sheffield. 4. "On the Autogenous Welding of Metals," by Dr. Francesco Carnevali, Turin. 5. "On the Application of Electric Energy to the Manufacture of Iron and Steel in Italy," by Cav. Ing. Remo Catani, Rome. 6. "On the Present State of the Metallurgical Industry of Italy," by Signor Comm. Luigi Dompé and Cav. Francesco Saverio Pucci, Milan. 7. "On the Origin of the Iron Ores of Swedish Lapland," by Mr. L. L. Fermor, Calcutta. 8. "On New Industrial Processes for the Cementation of Steel," by Cav. Professor Dr. Frederico Giolitti, Turin. 9. "On Cementation with Gas under Pressure," by Professor Dr. F. Giolitti and Dr. Francesco Carnevali, Turin. 10. "On the Transformation of Steel within the Limits of Temperature Employed for Heat Treatment," by Mr. L. Grenet, Argenteuil, France. 11. "Researches on the Nature of the Phosphates Contained in Basic Slag Derived from the Thomas-Gilchrist Dephosphorisation Process," by Mr. Victor Adolphe Kroll, Luxembourg.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Saturday, October 7. Visit by the President and members to the Marconi Wireless Telegraph Company's works at Chelmsford, leaving Liverpool-street Station at 1.55 p.m.

ENGINEERING.

FRIDAY, SEPTEMBER 29, 1911.

SCIENCE AND SOCIOLOGY.

FIFTY or sixty years ago, in the enthusiasm generated by the discovery that in every department of science whole classes of phenomena could be reduced to simple arithmetical laws, there arose not a few eloquent advocates of a system of philosophy which looked forward to explaining, in terms of matter and force, not merely the physical aspect of Nature, but also consciousness and thought. Materialism of this thoroughgoing character has long been abandoned, and though the physicist still aims at establishing arithmetical relationships between the multitudinous co-variants offered to his consideration by the cosmos, the laws which apparently govern these inter-connections are now, as Sir J. J. Thomson has well put it, held to be policies rather than creeds. The system of philosophy which seems to-day to be finding much acceptance is one in which natural laws are regarded as mere matters of habit; volition, in the ultimate, being involved, it is held, even in such phenomena as the formation or destruction of chemical compounds, and the varied relationships actually observed are thus regarded as being merely the statistical average of the results of a practically infinite number of elementary wills. Such a conception is interesting, although it is little likely to be of direct use either in laboratory research or in practical engineering, although in both departments of work, when matters persist in going wrong with new apparatus or machinery, there is often every excuse for the development of a belief in the innate malignity of inanimate objects. At such times the distressed and distracted experimenter may well be ready to grant not merely the endowment of matter with mind, but to insist that this has been derived from an exclusively diabolical source.

Incidentally, it may be mentioned, the new philosophy restores to the term "force" much of its former significance. The idea undoubtedly originated in the consciousness of muscular effort, but of late years the word in question has been treated largely as merely a convenient name for one side of an algebraic equation.

Whatever view may be taken of the newest philosophy, many must have been struck with certain curious analogies in the behaviour of aggregates of molecules and of humanity. The study of both is, in the main, a study of statistical averages; but whilst in the case of inanimate nature statistical facts have been scientifically studied before formulating the conclusions which we dub "natural laws," there has been, so far, but little attempt to apply the same process to the statistics of society. Politicians and social reformers, indeed, appear, in general, to start with a ready-made set of opinions, and, instead of imitating the physicist, and using observations and statistics to check their theoretical conclusions, they almost invariably ignore all such facts and figures as tend to invalidate their views, for which their demand is, support, and not criticism. Hence political and social theories are commonly creeds rather than policies. It is thus easy to understand both the tenacity with which such theories are held, and the passions aroused by opposition to them. In physics no theory is accepted as an adequate working hypothesis unless it will account for facts not merely qualitatively, but quantitatively. To quote a recent instance, the pressure of light is sufficient, from the qualitative standpoint, to account for the formation of cometary tails; but a quantitative calculation throws great doubt on its adequacy. Politicians and many sociologists seem, on the other hand, quite content to accept without further investigation theories which appear to them qualitatively sufficient to account for the phenomena with which they are concerned. Ardent temperance advocates, for example, enlarge on drink as a cause of crime, though statistics show that whilst drunkenness is frequently associated with minor breaches of the law, there are large classes of very serious crime in which it is in no way concerned. This is largely true, even in the case of murder.

Again, reasoning on what appears to be the fact that slum-dwellers are commonly somewhat below par, physically and mentally, certain sociologists state that slums render those who live in them defective, whereas the investigations of students of eugenics seem to point to the conclusion that in most cases the people dwell in the slums because they are congenitally either mentally or physically inefficient. Obviously a knowledge as to where the truth lies in this matter is of the utmost importance in considering remedies for the evils of poverty. Again, the statement is frequently made that the half-time system in Lancashire dulls the wits of the children, and teachers are prepared to come forward and testify to this being the case. Actually, however, these witnesses have hardly the data on which to form an inexpugnable opinion. All they know is that certain children, quite smart up to the age of going into the mills, suddenly became incapable, after half a day's labour, of doing decent work at the school. It is quite natural that the half-time system should be held responsible for the change, and it is, indeed, quite possible that it really is at fault. The question is, however, by no means one to be settled off-hand, as there is much independent testimony that at the age of from twelve to fourteen many children appear to develop stupidity quite apart from the conditions of their life. Teachers in secondary schools have assured us that a considerable proportion of the scholarship children proceeding there from the elementary schools prove incapable of making any substantial progress beyond the standard already attained. Again, it has been stated that if negro and white children are educated together, the advantage generally lies with the negro until the age of twelve or thirteen is reached. If, therefore, these latter statements are well founded, it is by no means certain that the apparent loss of brightness of many half-time children is really due to their labours in the mills. Here again is a statistical problem which should be studied with the same care and insight as are corresponding statistics in molecular physics.

Unfortunately this is, however, not the method of the politician or the ordinary run of sociologist. A well-known polemist, for instance, has asserted that the present system of employing boy labour is sapping the mental and physical vigour of the nation. Such an assertion is easily made and as easily supported by quoting the opinions of this and that doctor or school-master, but it can only be proved or disproved by a laborious and scientific study of statistics which have still, for the most part, to be compiled, and for the accurate analysis of which only a very small number of individuals have, as yet, the requisite mathematical knowledge. Investigations of this kind will no doubt be greatly forwarded by Professor Karl Pearson's acceptance of the recently-founded Chair of Eugenics.

The analogy between sociology and molecular physics may, however, be pushed somewhat further than is involved in the circumstance that both are

essentially based on statistics. An equipotential system, for instance, is useless for the production of useful work, and certainly there is much reason for believing that our conquest of Nature advances fastest when there is a considerable concentration of wealth in a few capable hands.

As experience shows, there is much truth in the old Lancashire saw that there are but three generations from clogs to clogs, so that there is a tendency to a dissipation of wealth as there is of available energy. Maxwell pointed out many years ago that by the assistance of his hypothetical demons, able to deal with individual molecules of a gas—that is to say, by the mediation of mind—the dissipation of available energy could be checked, or, indeed, availability could even be created, and mind, having fairly free play in human society, no doubt renders the increase of social entropy less rapid than it otherwise would be; delaying, in some instances for generations, the natural dissipation of wealth.

According to one school of economics, aggregations of wealth are produced solely by certain human atoms robbing others with which they come into contact; just as the more swiftly-moving molecules of a gas have acquired their temporary surplus of energy by abstraction from the bulk. Cases of this no doubt occur, and, if popular report is to be credited, the founders of the great American railway systems did acquire in this way much of the concentration of capital essential to their success But this accumulation was used to render useful to the community at large sources of wealth previously quite inaccessible. In fact, most accumulations of wealth arise not by such abstractions as are referred to above, but by the opening up of new sources of supply, a process which increases the affluence of the community as a whole, and only a fraction of the total increase is ever retained by those immediately responsible for the improvement.

Again, energy which is technically available is not always accessible. Indeed, this condition is the rule rather than the exception. The solar radiation, for example, must be a highly available form of energy considering the temperature of its source, but the only methods yet devised for the practical utilisation of it involve a destruction of the greater part of its original availability. The energy though available is for the present, at any rate, largely inaccessible. Similarly, there are vast stores of potential wealth as yet inaccessible, and which will, if past experience is to be repeated, become so only by the agency of a relatively few able and enterprising individuals controlling more than an average share of wealth already existing. It may be contended that the concentration of capital necessary for such operations might well be provided on a co-operative system by the State, or by the municipality; but experience shows that in such case the return, or the "yield," as the chemists say, is commonly very poor. In the main this arises because the origin of wealth lies neither in labour nor in capital, acting either alone or conjointly. Many tens of thousands of pounds and prodigious labour have from time to time been expended in attempting to produce perpetual motion machines, but the result has been a dissipation and not an increase of wealth. Materialism is, in fact, as unsatisfactory in economics as in philosophy, and the production of wealth requires the intervention of mind as well as of brute force and matter, to which some economists alone appear to make appeal. Of course, the term "labour" may be used with a very wide signification, in which it would include the work of a Charles Dickens or a Cecil Rhodes, as well as that of the highly-useful individual who puts in long hours wheeling pig iron at a blast-furnace. Actually, however, the two have no common denominator, but are different in kind, and should be separately classified. When a street-corner orator tells his audience that their labour is solely responsible for such wealth as they see around them, his statement only fails to appear grotesque to his hearers because certain writers have lumped together in the common term "labour" the operations of both mind and muscle.

The inapplicability of co-operative methods to the development of really noteworthy advances in the mechanical arts is well illustrated by the recent history of aerial navigation. Various governments have expended very large sums for its development, and have done this, moreover, under so-called expert advice, yet the net return for this large wastage of capital has been trivial. All the real advances have, in fact, been made by independent workers, mainly of a type which would never rise to a position of power and responsibility under the conditions which almost of necessity govern promotion in public departments. The reason is not far to seek. The regulations as to advancement in such departments are necessarily laid down to suit the case of the average man, who may be both industrious and intelligent, but who never engineers a new departure or inaugurates a novel idea. According to Professor Ostwald, university education in Germany is now regulated on similar lines, and, as a consequence, he remarks that had Kelvin or Leibnitz had the misfortune to be born in this generation, their early development would have been of no avail, and they would still be sitting on school-benches at an age when, in their lives as they actually lived them, they had already gained prominent positions in science. Men of their class often develop remarkably early. Newton, for example, had invented the calculus, arrived at the theory of gravitation, and analysed light before he was twenty-five years old, and men of exceptional practical ability are commonly equally precocious—Bessemer being a noteworthy example. In public departments it is, however, quite impracticable to promote a genius of twenty-five into a position of responsibility over the heads of fairly able men of forty or fifty, and thus it is that no Government railway, no State telegraph service, or Government factory has ever been responsible for any really notable advance in transportation, telegraphy, or methods of manufacture.

LABOUR IN 1910.

THERE is no doubt that when the history of the present year is written the record will be one which, if it does not surpass previous records in labour troubles, will at any rate stand very high, and will, it is hoped, be unapproached for a long time to come. We, however, anticipate somewhat, its record not yet being complete. The record of 1910, however, is known, and although it will fall short of 1911, yet it stands as one in which labour disputes wasted an enormous amount of time, and left a feeling of unrest that may take years really to pacify. The record of that year has now been published by the Labour Department of the Board of Trade, and can be studied by anyone sufficiently interested in the subject, and from this source figures may be derived and comparisons made with previous years. The publication containing these figures is prefaced by an introductory note by Sir George R. Askwith, who has rendered such good service of late in the settlement of industrial disputes, and who has earned the thanks of the community, and a knighthood, on this account.

As before stated, 1910 was marked by considerable industrial disturbances, and the number of workpeople involved in disputes commencing during the year amounted to 515,165, which was a greater number than in any year since 1893, when it was 634,301. The aggregate number of working days lost appears at first sight almost appalling, amounting as it did to 9,894,831; and, indeed, it has only been exceeded on four occasions during the last eighteen years—in 1908, with 10.834,189 working days lost; in 1898, with 15.289,479 working days lost; in 1897, with 10,345,523 working days lost; and in 1893, with 30,467,765 working days lost. These figures, however, do not convey to the mind what they might do, for their very magnitude is confusing. Put rather differently, the working days lost in 1910 represent the labour of one man toiling nine hours a day for nearly 13,000 years. We all of us have some sort of an idea of the amount of work an average workman employed at any trade—brick-laying, carpentering, moulding, painting, or what not—will perform in a day, and can therefore to some extent understand how much the world is poorer by these labour troubles. The high figures for 1910 were due to great disputes in the coal trade of Northumberland, Durham, and South Wales, in the shipbuilding industry in the North of England and in Scotland, and in the cotton-spinning industry of Lancashire and Cheshire. As many as 265,100 workpeople were affected by these disputes alone, the loss of time caused thereby being over 6½ million working days; and this was not all, for it takes no account of the effect on other industries, which was no doubt considerable.

Of all the workpeople directly affected by disputes in 1910, as many as 30 per cent. were involved in disputes connected with the employment of particular classes of persons, while 24 per cent. were disputes as to hours of labour, both of these percentages being particularly high. What is usually the most frequent cause of disputes—the question of wages—involved, in the year 1910, only 20 per cent. of the workpeople directly affected by disputes. Compromises were arranged for about two-thirds of the total number of workpeople directly affected in all disputes, and a few disputes still remain unsettled. In the remainder, about half the workpeople were successful and half unsuccessful. Methods of conciliation and arbitration, as in other recent years, were extensively used in the settlement and prevention of labour disputes. The number of workpeople directly involved in disputes settled by such means during the year in question was the highest recorded in the decennial period for which statistics are presented in the report. The number of cases annually settled by permanent boards of conciliation, which in previous years had risen to a high figure, showed a further increase in 1910. This, of course, is very satisfactory in the face of much that encourages doubt and despondency, and is one of the hopeful features of the report, particularly when viewed in connection with the present year.

If we study the report more in detail, we find that the lead in the amount of time lost in disputes was, as it has been for the last sixteen years, still maintained by men who labour at mines and quarries, and was followed by the men engaged in the metal, engineering, and shipbuilding trades, who form a good second. The dispute in the shipbuilding industries in the North of England and in Scotland caused a loss of 2,850,800 days, and the iron and steel manufacture accounted for 160,894 working days, as compared with 54,555 days in 1909. A considerable decrease, however, took place in other metal trades when compared with the previous year. The textile trades stood very high in the matter of loss of time during the year; indeed, higher than in any of the other years of the decennial period with the exception of 1908.

Of late years it must have been noticed by all who take any interest in the subject, how frequently disputes have been caused by a refusal of union men to work with non-unionists, and it is a feature that must cause grave anxiety, for it indicates an utterly selfish outlook on the part of the unionists, which, if not checked, can only lead to a form of tyranny that will become unendurable. It is, indeed, one of the grave dangers of modern unionists, this refusal to grant equal rights of freedom to other men that they claim for themselves. If men are allowed the right to strike when they think it is to their advantage to do so, they should also have the right to work if they so wish, and any interference with this right on the part of unionists amounts to gross tyranny, and should be sternly suppressed by law. It is, however, if we judge by the report, undoubtedly certain that this interference with the rights of non-unionists has of late caused more disputes than was at one time the case. In fact, it is not so very long ago that trouble on this account was, if not altogether unknown, at any rate very rare. The number of disputes in 1910 arising from this cause and from other questions of trade-union principle was higher than in the two preceding years, and the number of men involved was also considerably greater than the average of the nine preceding years. In 1910 as many as 32,777 workpeople were involved in these disputes, and of these, 28,950, or 80 per cent., were engaged in the coal-mining industry, 20,726 of them being employed in South Wales and Monmouthshire. That these figures for that part of the country, and for the industry named, are high does not surprise us, because it has for long been evident that the unionists of the mining population have been to the front in the unjust endeavours to coerce all men to see as they do themselves or make them suffer the consequences of their independence. Their shibboleth is membership of the South Wales Miners' Federation, and they would have all who do not believe with them made outcasts.

In cases where demands for increased wages caused disputes it is worthy of note that only 10 per cent. of the workpeople obtained complete success. On the other hand, there were compromises, representing some advances in wages. These compromises were arranged by 74 per cent. of the workpeople, while some 14 per cent. failed to obtain any success. In disputes arising out of resistance to proposed reductions in wages compromises were arranged by 84 per cent. of the workpeople directly involved, while 10 per cent. were successful, and about 5 per cent. were unsuccessful. Where the

hours of labour were concerned, the great majority of the workpeople were involved in disputes in connection with the rearrangement of hours under the Coal Mines Act, 1908, in which amicable settlements were effected between the workpeople at a great number of the collieries involved. In disputes on trade-union principles the great majority of the strikes were successful, but in a number of cases the disputes were between one body of workpeople and another, and not between employers and workpeople. In all other classes of disputes the balance of success was, on the whole, against the workpeople, who were completely successful as regards 32 per cent. of their number, while 49 per cent. were unsuccessful, and 19 per cent. resulted in compromises. Taking all the disputes of the year together, only 16.3 per cent. of the workpeople directly involved were completely successful in attaining their object; and this proportion would be materially reduced if disputes concerning the employment of non-unionists (which do not usually concern the employers to the same extent as other disputes) were excluded. The workpeople who were unsuccessful were 13.6 per cent., and those who effected compromises amounted to 69.5 per cent. Some few workpeople are still involved in disputes yet in progress. Tables given in the report show that the proportion of workpeople effecting compromises was higher than the proportion of those who were completely successful or unsuccessful in four of the eight groups of trades—namely, building, mining and quarrying, metal, engineering and shipbuilding, textile, clothing, transport, miscellaneous trades, and employees of local authorities. In these occupations, with the exception of textiles, transport, miscellaneous, and employees of local authorities, the proportion of workpeople completely successful was higher than of those of unsuccessful. It has, however, to be borne in mind that, in the successful disputes, questions of refusal to work with non-unionists are included, which, as already stated, are more frequently between two bodies of the workpeople than between workpeople and employers. In other occupations the results were in some cases evenly divided between employers and workpeople, whilst in others the balance of success favoured the employers.

Coming now to conciliation and arbitration, those most important elements in labour disputes, which have been particularly to the front of late years, we find that of the 531 disputes which began in 1910, 58 of these, involving 171,773 workpeople, or 44.6 per cent. of the total directly involved in all the disputes of the year, were brought to an end by conciliation, by which is meant the mediation of a third party or board, or by reference to arbitration. In some of these, however, a settlement was not arrived at till 1911. Disputes which began previous to 1910 are not included. The number of workpeople directly involved in such settlements was higher than in any year previously till 1901, which fact was largely due to disputes in the cotton and shipbuilding trades, which involved over 137,000 workpeople. Conciliatory methods of settling disputes have been, during the last ten years, adopted more frequently in the mining and quarrying industries than in any other of the trades we have mentioned, for out of 414 disputes, directly involving 484,960 workpeople, settled by conciliation or arbitration during the period 1901-10, as many as 124, directly involving 143,516 workpeople, occurred in these industries. The number of disputes settled by conciliation in 1910 was only one short of that recorded in each of the two previous years, while the number of workpeople involved was the highest in the period under review.

Arrangements are now in existence between employers and workpeople for the settlement of disputes by conciliatory means which do not quite fall within the description of what is usually understood by conciliation boards. Such arrangements exist in the cotton, engineering, and shipbuilding trades, and there is, of course, the railway conciliation board. In the cotton-spinning industry the means of settling disputes is through the Brooklands Agreement, which provides for the reference of disputes over a large part of Lancashire and the adjoining counties. In the engineering trades it is what is known as the "Terms of Settlement," which provides for local and central conferences to discuss disputed questions, while in the shipbuilding industry an agreement covering all workers, except labourers in the shipyards of the members of the Shipbuilding Employers' Federation, was signed in March, 1909, and revised in 1910.

We have, of course, in the above only been able to give an outline of what is contained in the report, but on the whole, although it may not be regarded as cheerful reading, the report contains much that is encouraging, and points to the fact that conciliation is what must in the future be looked to as the best means we, at present, have of extending industrial peace. If, however, there is to be any real confidence in the efficacy of conciliation and arbitration boards, their decisions must be adhered to on each side with the strictest honour.

GERMANY AND THE IRON ORES OF MOROCCO.

GERMANY'S apprehensions as to her future supply of iron ore have frequently found expression, and have also resulted in the acquirement of iron-ore deposits in foreign lands. In fact, the Morocco affair, which has now for several months engaged the attention of the world, rested, to a great extent, according to some influential German journals, on a question of iron ore, and the Government was vehemently urged not to sacrifice Germany's vital interests. Interesting statistics have been compiled, and the matter is altogether engrossing public attention.

Germany, says the leading paper, *Frankfurter Zeitung*, uses foreign iron to such an extent that no less than one-third of the German iron production is of foreign origin. Still it would be erroneous to conclude from this fact that Germany is dependent upon imported ore. On the contrary, Germany is by far the richest country in iron ore in Europe, and could supply her industry with raw material for many years. Still the import which, from geographical, technical, or purely economic reasons, is taking place cannot be stopped without very serious consequences, and it is therefore necessary to provide that Germany shall not be in a worse position in the future than she is to-day in the international competition.

The Morocco iron-ore deposits, compared with the German, are of but small importance, as far as quantity goes, but the export from these deposits, all the same, plays a very important part as a regulator in the European iron-ore market. For the future we principally have to look to Spain, North Africa, and Sweden as iron-ore exporting countries. As Spain's export of iron ore must decrease, on account of the exhaustion of her ore deposits, and as Sweden's exports are regulated and limited by the large iron-ore companies' compact with the Swedish State, only the African export remains as an uncertain, yet highly important, factor. Morocco alone offers the mutually competing ore-consuming countries—Germany and England—an opportunity of acquiring iron ore, which is certainly insufficient to cover their import requirements of iron ore, but which yet plays an important part in the regulation of prices. The keener the competition between Germany and England becomes in the matter of securing Spanish and Swedish ore, the better the two exporting countries are in a position to make capital out of this situation by raising the prices. But were Germany in possession of Morocco iron-ore deposits, which can compete fully with the Rubio and Gellivara ores, then Germany, by an increased import of Morocco ore, would be able to meet excessive demands, and again bring back the market to a normal position.

England's acquirement of, or control of, Morocco's iron-ore deposits would, of course, have an entirely opposite effect; but worst of all for Germany would be a French control of the Morocco iron-ore deposits. It would be possible then for the Swedish, the Spanish, and the French owners of mines to form a ring for the purpose of forcing up prices, and in a period of great activity a position of much unpleasantness might arise both for Germany and England. Hence Germany's desire to obtain control of the Morocco iron-ore deposits.

Another German journal, specially devoted to the interests of the iron works, voices the same view in a still more decisive manner, giving at the same time some interesting particulars bearing upon the question. The iron-ore deposits of Morocco are described as immense, unlikely to be exhausted for centuries, and a source for the most important raw material of the German industry. The age is more and more becoming an age of iron, and Germany is taking a leading part in the transformation. Germany, which now boasts the second place among the countries of the world which produce iron, the United States occupying the first place and Great Britain the third, has about tripled its production of pig iron during the last twenty years. The consumption of pig iron per inhabitant in Germany is now about 190 kg., against barely 140 kg. ten years ago. In the year 1909 Germany imported iron ore amounting in value to 126,600,000 marks, whilst in 1902 the value of foreign iron ore imported into Germany did not amount to even half that amount—viz., 60,000,000 marks. The figures of 1909, when the reaction after the boom of 1907 had set in, were even considerably surpassed in the year 1910, when foreign iron ore was imported into Germany to the vast amount of 162,000,000 marks. Of the imports of 1909, ore for an aggregate of 89,000,000 marks came from Sweden and Spain, 50,000,000 marks from the former and 39,000,000 marks from the latter country. The imports from France amounted to 8,000,000 marks, those from European Russia to 6,000,000 marks, from Asiatic Russia to 5,000,000 marks, from Algiers to 4,000,000 marks, and the rest from different countries.

The estimates of the world's wealth of iron ore are, as is well-known, of a somewhat problematical nature, but with Europe's present immense consumption, the exhaustion of the existing or presently known deposits of iron ore cannot by any means be looked upon as a mere apprehensive fancy. The following official figures about Germany's production and consumption of iron ore for the years 1900-1908 tell their own tale:—

	Production of Iron Ore. Tons.	Quantity of Iron Ore Smelted Down. Tons.
1900	18,964,300	24,291,800
1901	16,570,200	22,162,900
1902	17,963,600	23,725,700
1903	21,230,700	27,942,400
1904	22.047,400	28,033,500
1905	33,444,100	30,417,000
1906	26,734,600	34,704,900
1907	27,697,100	38,930,400
1908	24,278,200	33,037,400

Under the existing conditions of iron-ore consumption and iron-ore supply there is only one course open for Germany, says the paper in question. The open door in Morocco—that is, free access to the country's iron mines, with every possible political and industrial increase of German influence in Morocco. Various compensations have been suggested, but the journal in question cannot imagine any compensation which could warrant the giving up of Morocco's iron-ore deposits in view of the German iron industry. Germany's present wealth, as well as her political power, rests for the greatest part on her iron industry, and it is urged that this industry must insist upon the German Government and nation showing no weakness in this matter.

Sweden is also watching the development of this question with much interest, but the German views as to the importance of the Morocco iron ore are there considered somewhat exaggerated. Not even if the Morocco mines were owned and exploited by Germans would the Morocco iron ore be able to replace Swedish iron ore, the former being poor in phosphorus and unsuitable for those works which are now based upon Swedish ore rich in phosphorus. On the other hand, the Morocco iron ore can very well be used as a substitute for the Rubio ore, and it would no doubt be a serious matter for England should Germany secure the control of the Morocco mines, which otherwise seem destined to become a substitute for the rapidly decreasing Bilbao ore. It will, however, in any case take some considerable time before the Morocco mines can be worked on a more extensive scale, and before the railway connection with the coast can be established. The exports from Morocco may not go much further than to make up for the shortage in Bilbao ore.

As far as Sweden is concerned, it must also be remembered that she no longer relies upon Europe alone for her market; America is already buying Swedish iron ore on a fairly extensive scale, and will probably become a large consumer.

ACCIDENTS WITH EXPLOSIVES.

THE number and variety of substances, mixtures, and compounds manufactured and classed under the heading of "explosives" is very large. It ranges from toy fireworks to explosives of the most powerful

description. There is always a certain element of danger in handling and using explosives, though with some of the manufactures classed as such the word "danger" may be too strong. It is, however, advisable always to act, in all cases, with the prudence engendered by the belief that a dangerous substance is being dealt with. No liberties should be taken, and familiarity must not be allowed to lessen the care and precautions. This is too often the case, though no accident may result from thus tempting providence.

Prominent among the causes or contributory causes of accidents with explosives, is the ramming or stemming of the charge. This operation is always attended by some risk, and it cannot be too strongly insisted that it should be effected with the least possible exercise of force. Important precautions are the prevention of the use of drills that have become worn, and care to secure that the diameter of the cartridges admits of sufficient clearance in the hole, even if the drills are worn. A suggestion has been made to various manufacturers by the inspecting officers under the Explosives Act that the diameter of cartridges should be standardised, and all made to fixed "over-all" diameters. At present some diversity of practice obtains, some makers taking a 1-in. cartridge to be one which has been put through a 1-in. die, whilst others make an allowance for the paper wrappers. Other essential precautions are to avoid inserting several cartridges at the same time, the use only of wooden rammers, and the thorough softening of all nitro-glycerine explosives before use. The greatest element of danger, however, is the application of undue force.

The majority of accidents with explosives due to "ramming," &c., boring into unexploded charges, and striking unexploded charges into débris, in the case of explosives containing over 10 per cent. of nitro-glycerine, occur in the first three months of the year. Very few indeed occur in the summer, and the number increases again as the weather grows colder. Most of this class of accidents may be attributed to the use of frozen explosive. Therefore it is most desirable that users of these explosives should establish a regular practice of using a warming-pan during winter and spring. This constitutes undoubtedly a very important, and we might say essential, precaution. Explosives which have become hardened, owing to the solidification of the nitro-glycerine, exhibit less tendency to freeze than those which have once been frozen and subsequently thawed.

The report of His Majesty's Inspectors of Explosives for the year ended December 31, 1910, shows that 450 accidents were reported in that period, causing the death of 66 and injury to 442 persons. All mining accidents from explosives are now reported by His Majesty's Inspector of Mines, though prior to 1900 such accidents were not reported except where the circumstances called for investigation by, or were likely to afford useful information to, the inspectors of explosives.

Over 91 per cent. of the accidents reported for the year 1910 resulting in death or personal injury, occurred in the use of explosives under conditions to which the controlling provisions of the Explosives Act, 1875, do not apply.

The Act applies to the manufacture, storage, and conveyance of explosives, and accidents in their use are seldom reported unless causing personal injury. The accidents recorded were 65 in manufacture, 11 in keeping or storage, and 374 in use and miscellaneous causes, the latter category being that to which the controlling provisions of the Explosives Act are not intended to apply, and it is in connection with these accidents that a perusal of the report, and appendix referring thereto, is likely to be especially profitable to those engaged in works where explosives are used. This appendix consists of a table stating the date of each accident, nature of explosive, where the accident occurred, and the circumstances of the accident so far as ascertained, and the number of persons killed or injured. From a study of the notes relating to the circumstances of the accidents, many useful hints as to the precautions to be taken, and the way in which accidents are apt to occur, and consequently of methods to be avoided, may be obtained.

The inspectors make a practice of studying as many accidents as possible arising from the use of explosives, and of drawing the attention of those concerned to measures for their prevention which may suggest themselves, though they have no power to enforce such suggestions. The report is accompanied by tables showing the number and nature of the accidents caused by each description of explosives, and from these the explosives most liable to accident from any given cause may be ascertained.

We have not space to comment on the numerous other causes, or contributory causes, of accidents with explosives, or on the various safeguards and precautions that may be adopted. As instancing the need of rigid routine and extreme caution necessary in all such matters, an accident, reported by Dr. H. E. Miller, of San Francisco, which occurred at Pinole in October, 1910, may, however, be mentioned. It appears that an employee at the powder works lighted a cigar, and an explosion ensued. His finger and thumb were stripped of flesh to the bone, and there seems to be no doubt that the explosion was due to an accumulation of nitro-glycerine under his finger-nails.

NOTES.

The German Navy Programme.

All the warships provided for in the current year's navy programme by the German Government have now been ordered, and in several cases considerable progress has been made in the provision of material. In the case of the British programme, on the other hand, none of the capital ships or cruisers have been arranged for, and only a few of the destroyers have been given out to contract. It is not expected that any material progress will be made with our battleships until the beginning of the year. German shipbuilders have recently shown that they can complete a battleship in about twenty-seven months, and in only exceptional cases are our battleships finished in a less period, so that the German vessels of this year's programme are likely to be ready sooner than the vessels of the British programme. No particulars are available regarding the German battleships, but it is pretty certain that they will be larger, and will carry heavier guns than the 12-in. type. One battleship, "S," to be built at the Imperial Yard at Wilhelmshaven, will be fitted with Parsons turbines built by the Imperial Yard. One battleship, Ersatz Kaiser Friedrich Wilhelm, is to be constructed at the Vulkan Yard, Hamburg, and will have Vulkan A.E.G. turbines built at Hamburg. The third battleship, Ersatz Weissenburg, has been ordered from the Weser Yard, and for her Weser-Bergmann turbines will be made. One battleship cruiser, "K," is to be built by Messrs. Blohm and Voss, and, like her predecessors, will have Parsons turbines also built by them. A second-class cruiser, Ersatz Geier, is to be constructed by the Howaldt Werke at Kiel, and the Parsons turbines in this case will be built by Messrs. Brown Boveri at Mannheim. The second cruiser, Ersatz Seeadler, has been ordered from the Germania Werft, and is to have Germania-Zoelly turbines. Six destroyers are to be built by the Germania Werft, with Parsons turbines built by Messrs. Brown Boveri at Mannheim, and six by the Vulkan Company, with A.E.G.-Curtis turbines. It is particularly notable that the Schichau-Melms and Pfenniger turbines do not appear in the list. There is, indeed, an almost complete disappearance of the multi-wheel type of turbine from the list, which is significant in view of the results claimed for earlier installations in the German ships. It is interesting to note also that one battleship, one battleship cruiser, one scout cruiser, and six of the destroyers will have Parsons turbines, making up about 280,000 horse-power, or 58 per cent. of the total. Of the remaining 42 per cent. of other types nearly all are of the Parsons drum construction, the exception being the six destroyers to be built by the Vulcan Company.

Cause and Effect of the Airship Accident.

It would be a mistake to attach much importance to the accident on Sunday to the naval airship. The airship is still, like the aeroplane, in an experimental stage, and that built for the Admiralty, although its design has been evolved at the Admiralty and War Office, with the assistance of the Government Aeronautical Research Committee, must be regarded as a great practical experiment, in which the results of trial and error, when carefully analysed, must yield important lessons. It may be that too much has been sought for in the matter of carrying capacity, in the praiseworthy aim of excelling in power of attack anything yet achieved by any navy; but that is only in consonance with British military and naval history. We must lead, and to do so we must risk much, and the important point is that our risk has so far been only financial. The airship had been tested during last week as to stability and carrying capacity, according to the terms of the agreement between the Admiralty and the builders, whose responsibilities were limited, as with all navy ships, to those of constructors, and not of designers. On Sunday the atmospheric conditions suggested a trial flight, and the vessel, in the sole charge of the navy officers, was being taken out of its shed when the accident happened. The material used for the outer envelope proved of high resisting quality, only yielding where there was abnormal tension. The duralumin, of which the girder work is built up, proved very ductile and of great tensile strength against the racking stresses set up. The material of which the ballonets are made, as supplied through the War Department, has all along been a source of uncertainty and of little accidents, and the facts point to the cause of the collapse on Sunday being due to the rupture of a gas-bag when the vessel was being drawn out of the shed. The adjacent wires which form the braces between the horizontal and circumferential girders broke, owing to over-strain and lack of support, and the girders next to the ruptured ballonet collapsed. The damage was local. Fig. 1, on page 424, shows the collapse, this view illustrating the airship as it was being dragged back to the shed, while Fig. 2 shows the damaged portion. The forward and after parts stood well the severe strain, and it will be noted that the point of collapse was not coincident with either point of suspension of the load carried—the gondolas containing machinery, &c. Those responsible for the work, and particularly Captain Sueter and Messrs. Vickers, Limited, are to be sympathised with in this set-back to a splendid piece of experimental engineering work; but it is satisfactory to reflect that neither they nor the Admiralty and War Office will be daunted by the untoward event. As with all developments in mechanical science, misfortune is only regarded as temporary, and is but an incentive to further effort.

Government Petrol Motor-Lorry Subsidies.

Particulars have been issued in the course of the last few days of a provisional scheme for subsidising petrol motor-lorries by the War Department. This scheme is to stand until one now pending comes into force, under which it is proposed to subsidise vehicles built to specifications issued by the War Department. The motors covered by the present provisional scheme are of the two classes—viz., for 3-ton and for 30-cwt. loads. Such vehicles will not be enrolled for use at manœuvres, or for hire, but for purchase in case of national emergency, the subsidy taking the form of an initial payment, to which is added an annual sum. The period for which the subsidy will remain in force is two years. The amount of the initial subsidy is dependent on the type of lorry, 12*l.* being paid for live-axle lorries, 10*l.* for chain-driven machines if the chains are encased, 8*l.* if the chains are open. The annual subsidy in all cases is 15*l.* per machine, paid in arrear after satisfactory inspection. Only comparatively new machines will, of course, be accepted, the earliest date of building being placed at January 1, 1910. The engines must be of the internal-combustion type, using petrol, and by preference having four cylinders. In the case of the 3-ton class the cylinders must have a minimum bore of 4½ in., and for the 30-cwt. class, 3½ in. Two-cylinder vehicles may be accepted in the latter class. As regards bodies, some van and box bodies will be accepted, but platform bodies with 1-ft. 8-in. sides and ends appear to be most in requisition, the platforms to be not less than 11 ft. 6 in. by 5 ft. 6 in. for the 3-ton class, and 8 ft. 6 in. by 5 ft. for the 30-cwt. class. Towing-hooks to special design must be fitted. An additional initial subsidy of 10*l.* will be given for a second magneto, preference being given to all lorries having high-tension magneto ignition. There are other regulations with regard to lamps, housing, &c. The 3-ton class of machine is required to make 10 miles per hour fully loaded, and the 30-cwt. machine, 12 miles per hour. Inspection will be carried out by the War Department prior to enrolment, and at six months' intervals subsequently, and the subsidy may be withdrawn if the inspector is not satisfied that the vehicle is

THE COLLISION BETWEEN H.M.S. "HAWKE" AND THE T.-S.S. "OLYMPIC."

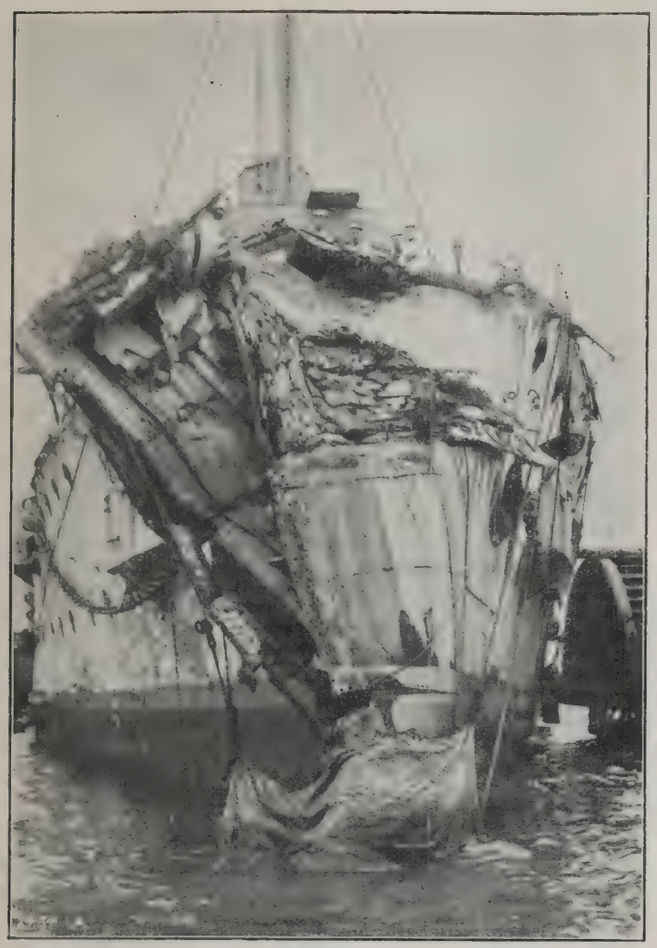


Fig. 1. The Damaged Bow of H.M.S. "Hawke."

Fig. 2. The Starboard Quarter of the "Olympic."

being maintained in a serviceable condition. Purchase will only take place in a case of national emergency, notice being given by telegraph or other means, within three days of the receipt of which the owner must deliver the machine over to the War Department at any specified place, in thorough order and with spares. The price paid will be on a depreciation basis plus a percentage. Depreciation will be calculated at a rate of $7\frac{1}{2}$ per cent. per half year and deducted from first cost, and to the remainder will be added a sum equal to 25 per cent. of the amount thus arrived at. In no case, however, shall the amount paid exceed the first cost of the vehicle. In case of disablement of an enrolled vehicle the owner is to notify the War Department, and if he cannot provide another suitable vehicle within three months, part of the subsidy proportional to the unexpired period will be reclaimed. A similar return of money will be demanded in case of withdrawal before the termination of the agreed period. The sale of a vehicle during the period of subsidy will naturally be accompanied by similar requirements unless the new owner is willing to take over the contract.

International Congress of Applied Chemistry.

The eighth International Congress of Applied Chemistry is to assemble next year on September 4, 1912, at Washington, D.C., under the patronage of the President of the United States, and to hold its scientific and business meetings subsequently at New York from Friday, September 6, to Friday, September 13. Great preparations are being made for this Congress, and pamphlets are issued in the United States to chemical manufacturers, to chambers of commerce, to educational institutions, and, further, to the members of the United States consular service abroad, as well as to members of the foreign consular service in the United States. This is in addition, of course, to circular letters sent to the members of previous congresses, and to the interested scientific and technical societies all over the globe. The Press is particularly invited to provide the committee with copies of any comments on the Congress that should appear in their columns, and contributors of papers are requested to express their opinions on the tentative rules for sectional procedure before December 1, 1911. We are struck by the very large number of sections and sub-sections, of which there will be no fewer than twenty-four, each with its own executive committee and sectional committee, for which separate rooms will have to be found, as well as papers and audiences. Each organising sub-sectional committee has its own address somewhere in the United States. There were only seventeen sections and sub-sections at the London Congress of 1909, and the dreary proceedings and poor attendances not rarely suggested that contributions had been offered, or asked for, which had far better been left to some local society. The first congress was held at Brussels in 1894, and deliberated in four sections. At the Vienna Congress of 1898 the number of sections had risen to twelve. The Berlin Congress of 1903 was attended by 2533 members, 479 papers were presented, and the final reports filled several volumes, aggregating 4044 pages. At Rome, in 1906, the figures were: 2375 members, 658 papers, 5500 pages; at London, in 1909, 4100 members, 985 papers, 4173 pages. The London Congress was decidedly overburdened with papers, and the reports were not of a kind to be much quoted in scientific and technical literature. Excursions and visits to works are not mentioned in the provisional publications for the eighth Congress; such visits will certainly be arranged for, however, and it might be advisable to direct attention to them, though the attendances in the section rooms suffer from excursions. The Honorary President will be Professor E. W. Morley, the President Mr. William H. Nichols, Sc.D., the Secretary is Dr. Bernhard C. Hesse, of 25, Broad-street, New York.

THE COLLISION BETWEEN THE "HAWKE" AND THE "OLYMPIC."

We publish above illustrations showing the damage suffered respectively by the Hawke and the Olympic as the result of the naval vessel ramming the latter as she was passing through Cowes Roads last Wednesday on her journey to New York. The Olympic, which was described very fully in our issue of October 21 last, is the largest ship in service, having a displacement of 62,000 tons at load draught, and is equipped with two engines and an exhaust-steam turbine, developing collectively some 45,000 horse-power. Her over-all length is 882 ft. 9 in., and extreme breadth 92 ft. The Hawke is a second-class cruiser, of 7350 tons displacement and 20 knots speed, and was launched at Chatham in 1891.

The Olympic, it is stated, was steaming at about 15 knots speed, and was overtaken by the other vessel. Through some misjudgment on one side or the other, the two boats came into collision, the Hawke ramming the liner on her starboard quarter at a point about 90 ft. forward of the rudder post. The damage which resulted is well shown in Fig. 2. The triangular gap illustrated is about 10 ft. wide at the top and nearly 20 ft. deep. A smaller hole was also made at the water-line. The Olympic was unable to proceed on her journey, though she had a full passenger-list, and came to anchor, but was taken up to Southampton the next day. The Hawke, in spite of the wholesale destruction of her bows, as shown in Fig. 1, was able to proceed to Portsmouth under her own steam, where an examination in dry dock has, it is stated, shown the damage done to be even more serious than might be anticipated from our illustration. The stem casting, weighing upwards of 20 tons, has entirely disappeared. From the way that the bow-plates are bent over to starboard, it would seem that the blow must have been of a glancing character, and this doubtless diminished the damage done to the Olympic. The latter will be repaired at the works of her builders, Messrs. Harland and Wolff, Belfast.

Personal.—Messrs. Parker and Heagerty advise us that, owing to the termination of their lease, their address is now 6 and 8, Lime-street-square, E.

INDUSTRIAL NOTES.

IN spite of the proclamation of a general railway strike in Ireland, the trains on all the lines, except the Great Western and Southern, were run as usual at the end of last week. The state of affairs on each of the four lines at the time named was reported as follows:—On the Midland Company's line only a small proportion of the men were on strike and the trains ran as usual. On the Dublin and South-Eastern the traffic was worked as usual, as the line was exempted by the men's executive from a strike. The position on the Great Southern and Western was serious and a general stoppage was threatened; and on the Great Northern 60 per cent. of the men at Dublin and Belfast were on strike, but there was not much response in the country districts to the call of the leaders to cease work, and the trains ran as usual. There were grave fears, however, that the strike might extend, although there was evidence of dissatisfaction with their leaders amongst the men. One cause of dissatisfaction was said to be that the strike had not spread to Great Britain, and in another case pique caused friction, the engine-drivers and firemen complaining that their society had not been consulted. On Friday evening last the Lord Mayor of Dublin issued a warning appeal to the men pointing out to them that if the fight continued for a few weeks more it would mean the shattering of the hopes of the country in the progress that is now so promising, and would result in death and privation such as had not been experienced for many years.

In spite of all the efforts of the Amalgamated Society of Railway Servants, in spite of the bombastic threats of the leaders of that society, the general strike on the Irish railways, about which we have heard so much of late, has failed. All the vapouring of the leaders has ended in what is very much like a fiasco; and, naturally, when they see how futile their efforts have been to bring about a complete stoppage of railway work first in Great Britain and then in Ireland, their disappointment has been bitter, and they have abandoned boasting, and have in place of it tried to terrify the men with threats. The general secretary of the General Railway Workers' Union, speaking at Darlington, said: "Although we have had a bit of a flutter, I think you may well prepare for another one. I advise those outside the union to take a tip and come inside before something happens which would cause them inconvenience." Such words as these show clearly enough what we may expect if the management of the railways ever got into the hands of the unions, as there will be a great danger of its doing if they are "recognised" by the companies. At the end of last week only 1000 employees of the Great Northern and Midland lines were on strike, and all the trains on those lines were running as usual. There were also signs that those men who went on strike were inclined to return to work.

On Monday there was everywhere evidence of a collapse of the strike, and these signs increased as public indignation grew, and the men at Belfast, Dublin, Banagher, and Kilkenny returned to their work, or asked that they might do so. As an indication that the leaders have lost their power over the men, a meeting held at Drogheda is an example. At this meeting a member of the executive of the Amalgamated Society of Railway Servants arrived to address the local railway men. He left the town hurriedly, however, as only two men are said to have turned up to listen to him. The conduct of "the irresponsible agitators" was also strongly condemned at a public meeting convened by the Mayor of Clonmel, at which meeting persons of all classes and creeds attended, and pledged themselves to give every possible support to the railway companies in carrying out their statutory obligations; the Government was called upon to give ample protection to the public, to the railway property, and to the railway employees. The combination of merchants and manufacturers was also called for by the Dublin Employers' Federation to secure the free import and export of food and merchandise, for the organisation of convoys of supplies, and for the dismissal of every employee who refuses to work under these conditions. It is really quite a cheering feature among these pitiful performances that the public has been so energetic, and has shown the men that there is a point beyond which it is useless for them to go; the voice of the public, whichever side it takes, must in such cases be final. At the time of going to press it does not appear as though the strike would continue much longer.

About 400 boiler-scalers employed on the Tyne decided on Saturday last to come out on strike because the employers had declined to accede to the demands which they had made for increased wages. These demands are that chargemen shall be paid 6s. 6d. per day instead of 5s. 6d. per day; tube-cutters, 6s. per day instead of 5s. 6d.; chippers, 5s. per day instead of 4s. 6d.; small chippers, 4s. 6d. per day instead of 4s.; and lads a minimum of 4s. The men belong to the Amalgamated Union of Labour. They were told by the masters that owing to the contract prices for the present year being cut down to the very lowest figure, it was impossible to entertain the idea of an advance. The men therefore decided not to resume work until their demands had been agreed to. In the Tyne ship-repairing industry the boiler-scalers occupy a very important place, and it will be interesting to note how things develop.

Trouble occurred at the Dowlais Steel Works last week owing to a strike of rail bankmen; the other workmen followed in sympathy, and the blast-furnaces were damped down. There had been unsettlement among the men for some time previous, the grievances being that the trade unions were not officially recognised, and that all departments had not had their claims attended to. The number of men thrown idle at the steel works amounted to about 2000. The number of men employed at the collieries in connection with the steel works is about 8000, and all the collieries are more or less dependent on the departments of the steel works. The strike, however, was fortunately not of long duration, for it was announced at a mass meeting of the leaders of the men on Friday that an agreement had been come to with the general manager which provided for the recognition of all unions involved, and the raising of the rates of wages of all departments to the standard prevailing in other works. The amount of these advances is to be arranged between the employers and the representatives of the men.

There is again trouble among the Bradford woolcombers, or, rather, among the officials of their union, which has a membership of about 12,000. The causes of the trouble this time appear to be internal differences. Since the strike which took place some months ago there has been dissatisfaction with the officials. The officials have, in consequence, resigned in a body, and a ballot for the election of new ones was arranged. The retiring officials offer themselves for re-election.

On Friday last the employees at the works of Messrs. J. Parkinson and Son, machine-tool makers, Shipley, came out on strike to the number of about one hundred. It appears that trouble has existed for some time among the members of the Amalgamated Society of Engineers employed by the firm on account of the employment of another class of men on certain work. The firm had notice given them that unless the workmen objected to were withdrawn, the members of the Amalgamated Society of Engineers and other allied unions would cease work. On the firm refusing to grant this request the unionists declined to commence work on Friday morning, and pickets were placed at various points leading to the works. The police being in attendance, however, the peace was not broken.

The great strike in Spain ended last week, and it is stated that, on the Thursday, Madrid presented its normal aspect, with the exception that there was a dearth of cabs, and some of the building yards had not commenced work. The country generally appears to be settling down.

According to the *Times* an educational movement is to be started in North Staffordshire during the coming winter. It will consist of a Miners' Higher Education Association, which will be formed to enable lectures to be given in mining districts, not so much on technical subjects as in support of general culture. At the first lecture, on October 7, at Stoke, Mr. Enoch Edwards, M.P., president of the Miners' Federation of Great Britain, will preside, and Professor Turner, of Oxford, will lecture on "Comets."

On Monday last the loyalty of the railway men who stuck to their work on the North-Eastern Railway during the late strike was liberally acknowledged by the company. Ever since the termination of the strike the directors and officials of the company had intended to recognise the services of all those men who remained at work or discharged special duties for the company. The original intention was to pay for all the work done during the strike at the rate of time and a half, but at a meeting of the directors on Friday last (the first since the dispute was settled) a bonus pay-bill on a more liberal basis was sanctioned, with the result that about double pay for all the time worked has been received by the men. The total amount disbursed was just over 20,000*l*.

Under the chairmanship of His Honour Judge O'Connor, a court of arbitration recently sat at Glasgow on the subject of the gas-workers' demand for improved rates of pay. Mr. Upton Clark represented the employers in the Scottish steel-making industry, and Mr. A. Henderson, M.P., represented the workers. The decision of the arbitrators will be announced officially by the Board of Trade, but it is understood that the decision awards time-and-a-half rates for Sunday labour, a decision by which a threatened strike has been averted.

The Swedish lock-out, which has now lasted for more than two months, is nearly over, and has in some directions betrayed a lack of discipline among employers, which was not expected. Not only have a large number of unorganised hands been engaged, but also many organised men, although accurate statistics are not available. Still the Employers' Union states that of late its members have shown all desirable solidarity; although work is progressing in many places, it is only on a reduced scale, with perhaps 25 or 30 per cent. of the number of hands employed at the commencement of the lock-out, and those principally unorganised men. Of renewed negotiations or mediation there seems no question at present.

The problem of finding labour for the unemployed is at present being dealt with in several countries, and the Danish Government, for instance, is preparing a measure dealing with this question. A draft proposal providing for municipal labour bureaux has been submitted to various organisations interested in the matter, and the opinions voiced in their replies are entirely divergent. The Union of Employers and the Joint Industrial Representation hold that the only satisfactory solution can be attained by means of a State institution. The co-operating municipal councils' unions do not consider the time has come for labour bureaux in each parish of the country; they propose to commence with the towns, and otherwise leave to the different municipalities the establishment of labour bureaux. When after a few years it has been ascertained how they work, then it will be time to consider the question of erecting, compulsorily, labour bureaux in each parish. The trade unions, on the other hand, maintain that the labour bureaux must be attached to the unemployed funds in all trades which have such funds, and that any other arrangement, as far as skilled hands are concerned, will be equally detrimental to men and masters alike. For hands outside the unemployed funds they recommend municipal labour bureaux.

RHYMNEY VALLEY SEWERAGE.—We understand that the Rhymney Valley Joint Sewerage Committee has decided to promote a Bill in Parliament for the purpose of forming a joint board, and constructing a trunk sewer for the whole valley, with an outfall into the Bristol Channel. Messrs. Wilcox, Raikes, and Reed, and Mr. J. S. Alford have been retained as engineers, and the scheme is estimated to cost about 250,000*l*.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—We understand that the proposed change of name of the above Institution has now been sanctioned by the Board of Trade, and the Institution will in future be known as "The Institution of Automobile Engineers," the word "Incorporated" being omitted. It is anticipated that the new programme for the session 1911-12, which contains a list of papers on various subjects, will be published at an early date.

UNIVERSITY OF LONDON, BRITISH MUSEUM, AND VICTORIA AND ALBERT MUSEUM LECTURES.—Mr. Banister Fletcher, F.R.I.B.A., will commence a course of twenty-four University Extension Lectures on "Ancient Architecture" at the British Museum (by permission of the Trustees), on Tuesday, October 3, at 4.30 p.m. Also a course of twenty-four lectures on "Renaissance Architecture" at the Victoria and Albert Museum (by permission of the Board of Education), on Monday, October 2, at 5 p.m. These courses are to be fully illustrated by lantern-slides, photographs, diagrams, and models. They will, it is hoped, appeal not only to architects, but to all lovers of art and the public in general, to whom a knowledge of architecture enhances a hundred-fold the pleasures of travel. The museums abound in ancient and Renaissance examples, which will be visited and explained by the lecturer during the class held at the end of each discourse. Full particulars may be obtained from Miss Gaudet, 120, Cheyne-walk, Chelsea, S.W.

WIRELESS TELEGRAPHY AT THE GENERAL POST-OFFICE.—The recent erection of two masts on the roof of the General Post-Office, St. Martin's-le-Grand, has no doubt attracted the attention of the public. The masts, which are 50 ft. high, and stand 240 ft. apart, support a system of bare copper wires forming the antennæ or aerial of a wireless station in connection with the laboratory of the G.P.O. Engineering Department. The main purpose of this installation is experimental. Developments of the theory and practice of wireless communications are proceeding at a very rapid rate, and in the projection of the new stations, as well as in the maintenance of existing stations, much work of an experimental nature has to be carried out. It has often been necessary in the past, when traffic conditions would permit, to convert temporarily a commercial station into a laboratory or test-room for experimental purposes. The wireless equipment referred to will allow experimental work to be undertaken more easily and more economically than heretofore, and will also enable new devices, which inventors submit to the Postmaster-General for trial, to be placed under closer observation than formerly, and to be tested under practical conditions.

A SCHOOL OF FORESTRY.

IN 1904 the Commissioners of Woods and Forests started a school of forestry on a small scale in the Forest of Dean, where a small number of men are trained each year to be foresters or woodmen. Previously to 1904 no school was available where working men could receive a theoretical and practical training in forestry. In the neighbourhood of the Forest of Dean there are about 24,000 acres of forest affording opportunities for the observation of the growth of trees under various conditions.

The admissions to the school at present are limited to twelve a year, and the age limit is from twenty to twenty-five, save in exceptional cases. No entrance examination is in force; the students are selected from the applicants for admission, preference being given to those who have already worked in woods or nurseries and who are well recommended. The students work under the same conditions as Crown workmen under the orders of the woodman of the district in which they are located. As a rule two afternoons a week are spent in the class-room under an instructor. The students are paid at the rate of 15s. a week, or 2s. 6d. a day, but do not draw pay when, owing to bad weather or other reasons, no work is done. No guarantee of employment at the end of the course is given, but the men are assisted when possible to obtain situations. Progress is periodically tested by examinations, theoretical and practical, and all who acquit themselves satisfactorily receive a certificate. The education is given without fee, and includes sylviculture, forest protection and mensuration, the felling of timber, &c., and elementary botany, surveying, arithmetic, and accounts. Attention is also given to fencing, hedging, and draining, and to rough carpentry and gate-making. No difficulty, so far, has been found in finding places for students after the completion of the course, which is of two years' duration. The number who have received full certificates up to June last is forty, all of whom are in situations or employment, and all except three connected with forestry. There are now seventeen men at the school, of whom nine will leave this month. Only two of these had not been provided for on September 1.

The school buildings are at Parkend, and include a dormitory for eight men and a living-room. An institute and miniature rifle-range are also provided, under separate management, for those students who choose to join and pay the subscriptions to these clubs. The first-year students are lodged at the school for 11s. a week, including board, lodging, and washing. Subsequently they live in private lodgings, which can be got in Parkend for about a similar sum. Applications for admission should be made to Mr. V. F. Leese, Deputy Surveyor, Whitemead, Parkend, near Sydney, Glos., from whom full particulars are obtainable.

Such a school as this appears to be has a most useful *rôle* to fill, and its existence and aims ought to be more widely known. Anything in a practical way that is done in the interests of arboriculture and forestry is at the present day not only of great interest, but also of immense importance.

SCHOLARSHIP EXAMINATIONS IN SCIENCE, 1912.—The Science Examinations to be held in 1912, in connection with the Board of Education, for the purpose of the award of scholarships (see the regulations for Scholarships, Exhibitions, &c., in Science for 1912, and the prospectus of the competition in 1912 for Sir Joseph Whitworth's Scholarships, &c.) will be based upon the syllabuses for the subjects and stages concerned which are contained in the 1910-11 volume, except in the case of the Stage 2 examinations in those subjects in which the Board will hold a general examination. The scholarship examinations in Stage 2 of these subjects (a list of which is given in paragraph 1 of the Appendix to Circular 776) will be identical with the lower examinations of the new scheme, and will be based on the revised syllabuses referred to in the paragraph.

SPECIAL TYPE DESTROYER.—H.M.S. Ariel, a torpedo-boat destroyer of the special type included in the 1910-11 programme, and built to the design of Messrs. John I. Thornycroft and Co., Limited, was launched at noon on Tuesday from their Woolston Works, Southampton, the naming ceremony being performed by Miss Christine Noll, daughter of Engineer-Commander Noll, R.N., Engineer Overseer for the Admiralty at the Woolston Works. The vessel is rather over 250 ft. in length, and the propelling machinery consists of a twin set of turbines of the Parsons type, designed to give a speed of 29 knots, steam being supplied by three large water-tube boilers fired by oil fuel. The armament consists of two 4-in. and two 12-pounder guns, and the vessel also carries two torpedo-tubes. The vessel is in an advanced state, the turbines, boilers, and armament being already fitted on board. It will be remembered that a sister-ship to H.M.S. Ariel—namely, H.M.S. Acheron—was launched a short time ago from the Woolston Works, being the first of the six special destroyers ordered in the Admiralty programme of last year to take the water. This vessel has since completed her trials, and is shortly to be handed over to the Admiralty.

LINCOLN WATER WORKS.

IN view of the inauguration of the new water supply for the city of Lincoln and district, which will take place on October 3 and 4, the following brief account of the undertaking may prove interesting. The original Lincoln Water Works Company was formed by Act of Parliament in the year 1846, the undertaking passing into the hands of the Corporation thirty-six years ago. Previous to the formation of the original company the water used by the inhabitants was obtained from wells and from the old conduit fountains, which are still in existence, although the supply from the spring to the fountains has recently been cut off owing to the source being liable to pollution. The original company under the Act of 1846 constructed a reservoir, having a capacity of 40,000,000 gallons, on the Prial Brook at Hartsholme, about 20,000,000 gallons being available for the supply of the city. From Hartsholme Lake to the pumping-station at Boultham an aqueduct 2½ miles long was also constructed, with filter-beds, engine-house, &c. In the year 1871 the undertaking was transferred to the Corporation. Since then additions have from time to time been made as the demand for water increased, and about the year 1881 an additional supply of water was obtained from the ballast-pits and the River Witham. The quality of the water supplied from all sources was, however, only indifferent, and about five years ago works were constructed by means of which the Witham water could, in times of flood, be entirely dispensed with. The filtration works at Boultham were at the same time brought up to date, and the system was made one of the best in the country. A new aerating-tank and clear-water reservoir were also constructed. The designing and construction of these later works has been in the charge of Mr. Neil McKechnie Barron, water engineer to the Corporation of Lincoln.

As the population of the city increased an entirely new supply of water had to be sought, and in the year 1901 a deep-bore well on the water-works ground at Boultham into the new red sandstone was commenced, and was completed in 1906, its depth being 2200 ft., or greater than any other well in the country. Over 1,000,000 gallons per day were available, and as regards quantity this was found satisfactory. Its quality, however, was unsatisfactory, for it contained such a large amount of mineral salts in solution as to be unfit for domestic and trade purposes. A completely new scheme was then undertaken, which consisted of bringing water from Elkesley, in the county of Nottingham. This water is derived from the pebble beds of the new red sandstone, which extend from the city of Nottingham in the South to beyond Bawtry in the North, covering an area of over 200 square miles. The available quantity of water calculated on the three dry years' basis is said to be approximately 30 million gallons per diem.

The collecting works for Lincoln are situated about 22 miles from the city, and at present consist of four boreholes carried to within 30 ft of the base of the pebble-beds, the depth of the boreholes being 570 ft. Their diameter at the surface is 36 in.; at a depth of 300 ft. they are 28 in., from which point to the bottom the diameter is 20 in. They are lined to a depth of 90 ft. with 33-in. lap-welded steel tubes, and grouted, and to a further depth of 80 ft. with 29½-in. lap-welded tubes, and grouted. Pumping trials were carried out, and showed that the pumping-levels for different quantities of water were as follow:—

Quantity of Water, Gallons per 24 Hours.	Natural Rest-Level of Water Below Datum.	Pumping Level of Water Below Datum.	Reduction.
	ft.	ft.	ft.
500,000	28	48	20
1,000,000	28	64	36
1,500,000	28	81	53

The above results were considered satisfactory, particularly as the quality of the water, as is usually the case from this outcrop of pebbles, is excellent, with only from 7 deg. to 8 deg. of hardness. The quantity and quality of the water being satisfactory, the large works for conveying it to Lincoln were commenced.

In addition to the works we have mentioned there have been constructed the pumping-station at Elkesley, an engineer's-house and offices, with workmen's cottages close to the engine-house; the rising main, 21 in. in diameter and 22 miles long; a steel tank at Lincoln, with a capacity of 300,000 gallons, supported on a brick and stone tower 110 ft. high; the city trunk main, and a new reservoir at Bracebridge Heath to the south of Lincoln. The scheme for this new water supply was adopted by the Corporation on the recommendation of Mr. Barron, who, as water-works engineer, was responsible both for the design and carrying out of the undertaking, the estimated cost of which was 248,000*l*. The contractors for the boreholes and test pumping were Messrs. A. C. Potter and Co., Lant-street, Borough, S.E.

UNIVERSITY OF BRISTOL.—A record of the occupations of former engineering students of the University of Bristol has been forwarded to us from the Dean. The faculty of engineering at this University was formed by the amalgamation of the staffs and students of the Merchant Venturers' Technical College, and the late University College, Bristol, so that names of former students at these colleges are included in the record. Former students are invited to send information relating to their present whereabouts and occupations to the Dean, so that the list may be kept as up-to-date as possible. It is intended to republish it at intervals.

"SMOKE ABATEMENT."

TO THE EDITOR OF ENGINEERING.

SIR,—Under the above heading a very interesting paper—read before the British Association—appears in your issue of the 15th inst. The author states:—

"It may be necessary to fire up fresh boilers very rapidly, and there is no known furnace which will admit of the smokeless combustion of bituminous coal."

This statement we are prepared to disprove to you or anyone interested in combustion.

We are manufacturing the Bettington boiler for burning pulverised and other coals smokelessly, and we will be pleased to demonstrate to Dr. Owens or any other interested party, at any time convenient to themselves, the absolute smokelessness of this system.

As you may be aware, in this system of firing the coal is first pulverised in a special mechanical solid-fuel carburettor, where it is intimately mixed with the proper proportion of air, and then burnt at the end of the fuel pipe exactly like a gas flame. One of the special features of this atomised-fuel furnace is that it is quite independent of the hot brickwork of the furnace for ignition, and is therefore smokeless from the commencement of firing.

Yours faithfully,

FRASER AND CHALMERS, LIMITED.

3, London Wall-buildings, London, E.C.,
September 21, 1911.

GROUND AND SLAKED LIME.—An account is given by the West of Scotland Agricultural College bulletin of a method of slaking burnt lime to produce a powder as easily distributable as ground lime, and at less cost. A ton of lime shells was slaked with 20 gallons of water, being immediately covered with a few inches of earth. About twelve hours later it was turned over, and water was poured on all lumps remaining unslaked. The lime was then put through a ½-in. riddle, and the slaked lime thus riddled remained in the form of a very fine powder; if left, however, it becomes sticky. This method is said to produce a much finer powder than is obtainable by grinding. The cost per ton is given as 13s. 8d., compared with 18s. per ton of ground lime.

THE LONDON POLYTECHNIC.—It is intended during the coming winter session to deliver a special course of lectures at the Polytechnic, 309-311, Regent-street, W., on the subject of "Illuminating Engineering." The lectures will be delivered on Tuesday evenings at 7.30, commencing October 31, and on Thursday evenings commencing January 11, 1912. The following is the syllabus:—1. Electric lighting, including the early history of the subject; electric supply; incandescent lamps; use of small transformers on lighting circuits; low-voltage lamps; large candle-power lamps for public lighting, &c. 2. Electric lighting (continued): arc-lamps; flame arc-lamps; colour, efficiency, burning hours, &c.; enclosed flame arc-lamps; vapour lamps, &c. 3. Gas-lighting, including the early history of the industry; luminous-flame burners, flat flame, argand, albo-carbon, and regenerative systems; incandescent lighting. requisites of a good mantle, &c. 4. Gas-lighting (continued), including self-intensified systems of gas-lighting, and the production of high-power units at ordinary district pressures; recent progress; high-pressure systems; calorific power and illuminating power standards, &c. 5. Lighting with oil, petrol-air gas, acetylene, &c. 6. Illumination from the standpoint of the eye. 7. The measurement of light. 8. Illumination and its measurement. 9. Shades and reflectors. 10. Daylight and artificial lighting compared. 11. Colour of artificial illuminants. 12. Practical lighting problems. The lectures will be under the supervision of Mr. L. Gaster, editor of the *Illuminating Engineer*. The fee for the course of twelve lectures will be 12s. 6d., and for any single lecture 2s. 6d. Further particulars may be obtained from the Polytechnic.

CITY AND GUILDS TECHNICAL COLLEGE, FINSBURY.—We have received from this Institute a copy of its programme for the ensuing session, which commences on Monday next, the 2nd prox. The programme, besides giving full particulars of the day and evening classes, contains numerous reproductions of photographs of the laboratories of the Institute, and also includes a complete list of certificated students. The day classes give complete courses of theoretical and practical instruction, extending over two or three years, in mechanical engineering and applied mathematics, electrical engineering and applied physics, and industrial and technical chemistry. Evening classes in similar subjects are also provided for those engaged during the daytime. Apprentices under twenty years of age are admitted to these classes at half the normal fees, which are already very moderate. Full courses have been arranged in the departments of mechanical and electrical engineering, industrial chemistry, and art, and, although students are recommended to follow these courses, they are at liberty to select the classes best suited to their individual requirements. The mechanical engineering course includes lectures and laboratory work in the subjects of practical mechanics, strength of materials, theory of structures, heat-engines, hydraulics, machine drawing, and mathematics. Special evening courses of lectures will also be given in the calorimetry of fuels, and on petrol-engines; these courses commence on October 4 and November 7 respectively. An inaugural lecture on the gyro-compass, by Mr. G. K. B. Elphinstone, of Messrs. Elliott Brothers, has also been arranged to be delivered on October 3. Further particulars can be obtained from the Registrar, City and Guilds Technical College, Leonard-street, Finsbury, London, E.C.

THE EXPLOSION ON THE FRENCH BATTLESHIP "LA LIBERTÉ."

Fig. 1.

Fig. 2.

The explosion on the battleship Liberté, at about 6 a.m. on Monday last, has resulted in a disaster to the French Navy even more serious than that occasioned by the loss of the Jena in 1907. The loss of life is unfortunately much greater, and the loss of the battleship in this instance appears to be almost complete, as is shown by the views reproduced herewith. The number of the killed amounts to 226, and of injured to about 180. Reports differ as to the cause of this catastrophe. At first it was stated that the primary cause was a fire, which got to the magazines before they could be flooded. Subsequently, however, the opinion seems to have gained ground that the accident was due altogether to spontaneous combustion of the so-called "B" powder used in the French Navy. A statement made by Admiral Bellue, of the squadron to which the Liberté belonged, supports this view. The Admiral states that there were two reports, and 19 minutes later the vessel blew up. This lapse of time is stated to agree with what occurred in the case of the Jena, and to conform to what might be expected to happen under certain conditions with this powder. The vessel carried, in common with other ships of the squadron, a certain amount of defective shells which were to be used as soon as possible, and the Admiral has issued instructions that all the rest of this ammunition in the fleet shall be landed at once. A feature of the disaster was the blowing up of the deck of the vessel, which doubled back on the vessel itself. The damage done was widespread, numbers of casualties occurring on neighbouring vessels. The République, lying some distance away, was hit by a mass of armour-plate which has been estimated to weigh 37 tons, and had to be taken into dock for this to be removed.

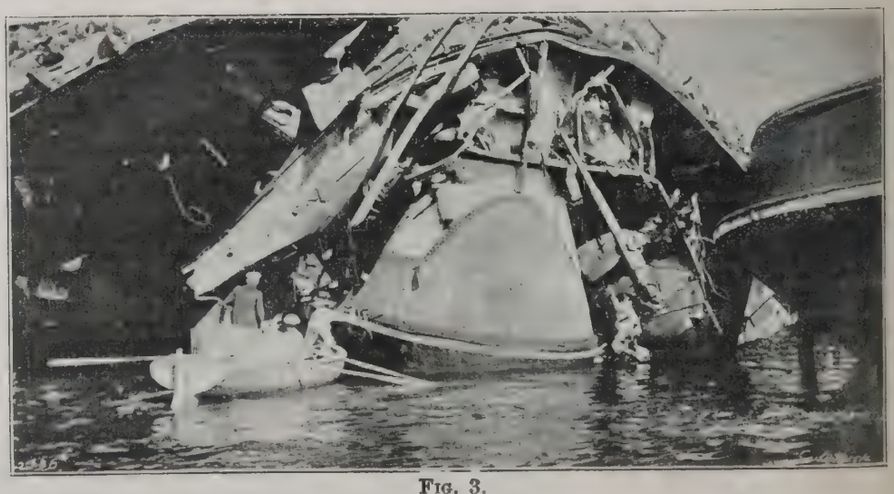


Fig. 3.

NON-FERROUS METALS IN RAILWAY WORK.*

By GEORGE HUGHES, M. Inst. C.E., M.I. Mech. E., Member of Council (Chief Mechanical Engineer, Lancashire and Yorkshire Railway).

(*Concluded from page* 403.)

GUN-METAL.

THIS is made to the well-known Admiralty specification:—

Copper, 88; tin, 10; zinc, 2.

Certain work, such as valve-seatings, bushes, steam-regulator slides, and some slide-valves, are cast in this metal, though other less expensive alloys containing lead are used for bearing brasses.

The alloy casts clean and sound into green sand or skin-dried moulds, and should some of the constituent metals or scrap used be coated with scale entailing a tendency to oxidation, a small piece of phosphor-copper may be added to clarify the whole, with good results.

The casting temperature and the fairly rapid cooling of the casting in the mould are important factors in the production of good castings, otherwise crystallisation becomes pronounced according to the laws of equilibrium, so clearly set forth in preceding issues of this journal.

The following tests have been obtained:—

Tenacity, tons per square inch = 16.01,
Per cent. elongation on 3 in. = 10.1.

This is an average of twenty-eight tests.

INJECTOR METAL AND FITTINGS.

Copper, 84.0; tin, 8.5; zinc, 5.0; lead, 2.5.

This metal has given good results in injectors, ejectors, gauge-cocks, and general details. It results in a clean casting, free from oxidation and scum in the intricate cores of the injector. The metal runs freely, and whilst the lead present may not appear to the mind of everyone as necessary, it assists machining, and the author, feeling that he has no grounds for omitting it, would like to have some comments on this point.

Injectors give no trouble on the score of unsound castings, in machining, and under steam tests and service.

Seatings and clacks require re-grinding from time to time.

Tensile tests are good, averaging 14 tons tenacity with 11 per cent. elongation on 3 in.

A few samples of wear in an injector are on the table for inspection, and the steam action in erosion may be noted.

MOULDING.

In moulding many of the operations are common to all castings. The author does not propose to generalise upon the subject; it would involve too long a dissertation, reiterating facts well known to all workers in non-ferrous metals; but he thinks that to place on record the moulding of an injector in detail, together with the illustrations, Figs. 18 to 27, below, and Fig. 28, page 434, will be useful.

The operation demands a pattern in four parts, numbered 1, 2, 3, and 4 (Fig. 20), and five boxes for the cores, lettered *a*, *b*, *c*, *d*, *e* (Fig. 21). Four parts are also required for the moulding-box, these being lettered A, B, C, D (Figs. 20 to 27), and also a drawback lettered E (Figs. 20 and 23).

The first part of the moulding operation is to place the part pattern No. 1 on to the hollow board marked 5 (Fig. 20), which is large enough to receive the box part A. This box part is fitted with projecting irons or fixed gaggers *g* (Figs. 26 and 27) at each side, to carry the overhanging sand. The sand is rammed round the pattern, the seating for part pattern No. 2 being kept clear. As it is necessary to make a joint at this place, parting sand is put on where required (as shown in Fig. 20). Preparation is made at one end of this box for a pouring gate *h* (Figs. 20 and 22), and when this is done it is ready for box part B to be fixed on. This part is also fitted with projecting irons or fixed gaggers, *k* (Figs. 23, 26, and 27), which carry the thin portion of sand between the body pattern 1 and 2 and the flange marked 3 (Fig. 20). Before putting this box on, however, a layer of sand must be placed on that portion of the pattern which will be covered by the projecting irons, as it will be difficult to get it underneath after the box is in position. The flange 3 (Fig. 20) is now put on, and the sand packed well underneath it. The box is then filled with sand and rammed up, provision being made for a joint round the flange. This joint is required to enable the flange to be withdrawn.

Box part C is next put on, and after being rammed up the whole is turned over, the follow board 5 removed, the mould faced off and made ready to receive part pattern No. 4.

The parting-plate *f*, to carry the drawback E (Figs. 20 and 23), is prepared, and laid over the leg end of the pattern. A layer of sand is put on this plate, and three gaggers *l* (Figs. 22 and 23) are placed on each side to carry the overhanging part of the joint. The part pattern No. 4 is then bedded to make an impression over the plate. It is then removed, and two nails *p* (Fig. 21) are placed across to carry the portion of sand between the overflow and delivery-pipes. The pattern is replaced, and the sand made level to the half of pattern No. 4, and parting-sand sprinkled over, making ready for box part D. When this is placed in position a gating-plug is placed over the gate *h* (Figs. 20 and 22), already provided in box B.

A layer of sand is now placed in the cavity *r* (Figs. 22 and 23) to receive three gaggers *n*, which are to carry the proud portion of the sand at this place. When this box is filled and rammed, the box parts are taken asunder, and the pattern parts withdrawn in the reverse order that they were put in.

On reference to Figs. 20 and 22 it will be seen that the metal is run in down a gate having two branches. After the pouring gate is completed, the mould is dusted with powdered plumbago, then skin-dried, and made ready to receive the cores. Whilst the pattern is being moulded the cores have been made and dried.

In making the cores, red sand, manure, and coal-dust only are used, no special material being required. For the large core *d* (Figs. 21, 22, 25 to 27), owing to the complicated bends in it, one core-iron is bent and fitted to the box, and is then used as a pattern, and cast in brass. This enables a correctly shaped core-iron for each succeeding core to be made, so that no time is wasted in bending core-irons for each injector. For the small cores a special iron is bent each time a core is required. One half the core-box is filled with sand, and before being rammed tight the core-iron is clay-washed and laid in the soft bed of sand. More sand is then put in and rammed lightly, and parted off to the level of the core-box. The other half is also rammed with sand, and cleaned off to the joint. Each half is then clay-washed, and a wax vent *v* (Figs. 21 to 27) is laid right through; the box is then joined together, and hammered with a mallet, after which the ends are rammed with sand to make them level. The core is then taken from the box and placed in the stove. All the cores are dealt with in a similar manner except those that are straight and do not require wax vents, string vents *w* (Figs. 21 to 27) being used instead. When the cores are dried they are taken from the stove, dressed off, subjected to a thick coat of blacking, and again dried, after which they are ready for the moulder. It is essential that the core-boxes for injectors should be made of strong and well-seasoned timber, so that they will retain their proper shape after being in use for a considerable time. The prints on the core-boxes should also be dead lengths to the prints on the patterns, so that the moulder will have no rubbing whatever to do when these cores are being fitted in the mould.

The cores are assembled in the following order:—

Box parts B and C are first fastened together. Core *a* is then placed in position, one stud *s* (Fig. 23) being put under the overhanging portion of the ejector steam passage. Box part A is then put on, and another stud *t* (Fig. 26) is inserted between this and the top of the same core, to keep it from lifting when the metal is being poured.

Core *b* comes next, and this is kept steady by having a long print on the bottom.

The overflow core *c* is then fixed, and over the leg of this is placed the draw-back plate *f* (Figs. 21 and 23).

Owing to the construction of cores *d* and *e*, it is necessary to insert core *e* into core *d*, and lower both together into the mould. When this is done, a piece of string is inserted into the vent holes at the three ends of

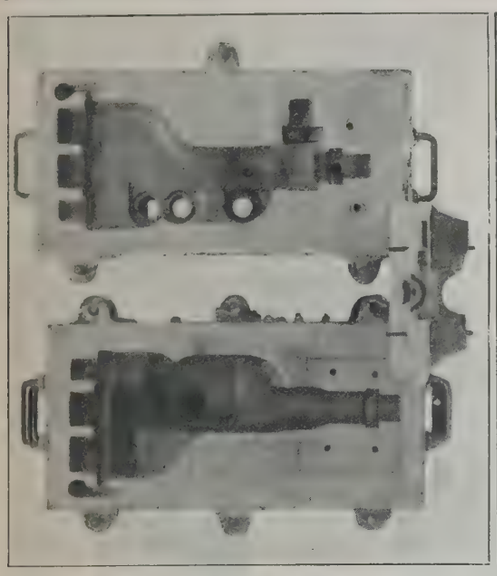


FIG. 18. MOULD FOR INJECTOR.

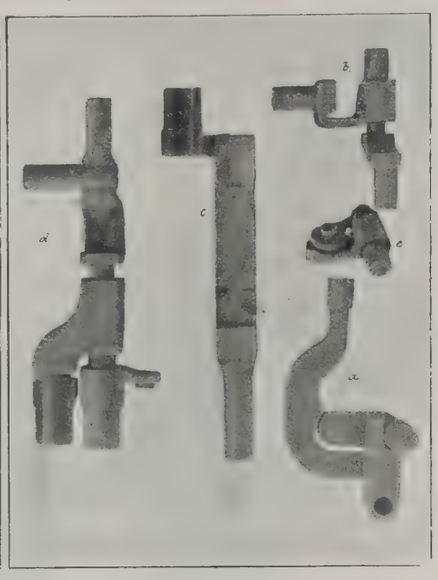


FIG. 19. CORES FOR INJECTORS.

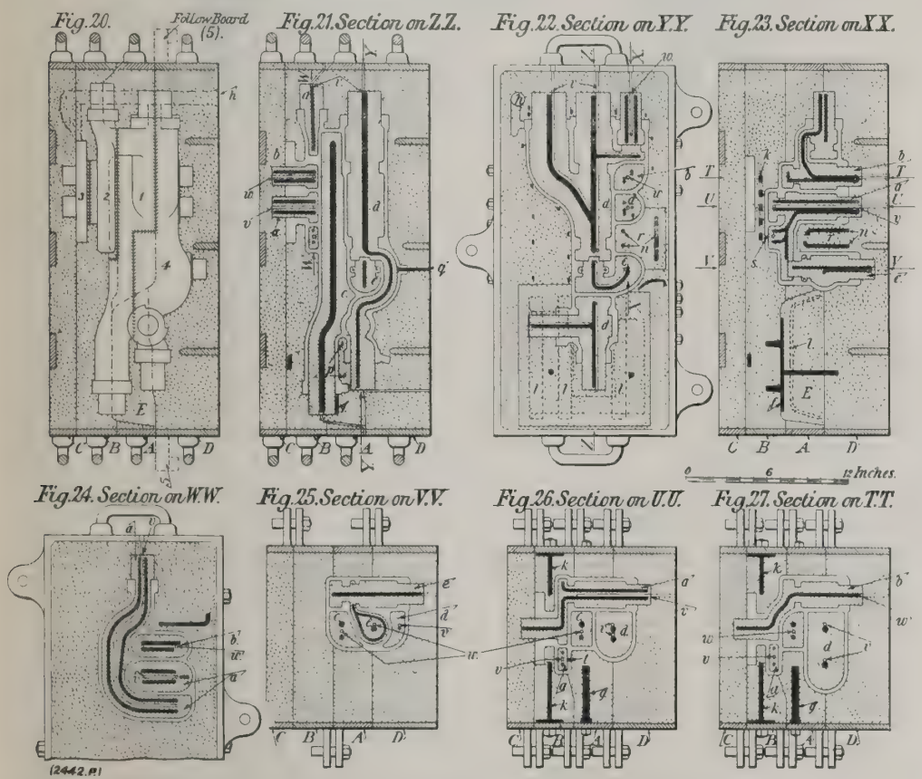


Fig. 20.
Follow Board (5).
Fig. 21. Section on Z.Z.
Fig. 22. Section on Y.Y.
Fig. 23. Section on X.X.
Fig. 24. Section on W.W.
Fig. 25. Section on V.V.
Fig. 26. Section on U.U.
Fig. 27. Section on T.T.
6 Inches.

FIGS. 20 TO 27. INJECTOR-MOULD, CORES, AND CORE-IRONS.

* Paper read before the Institute of Metals at Newcastle, September 20, 1911.

cores *a* and *d*; this string is withdrawn after the box part D has been secured in position, thus allowing free vent through the mould from the cores. A holding-down chaplet *q* (Fig. 21) is placed over the arched portion of core *d*, and fastened into box part D, which is then put on and secured.

A runner box is prepared and placed over the gate, and this completes the moulding process.

It is important to reduce the number of cores to a minimum, and consequently the joints, thereby minimising the risk of flashes, and producing free passages for the flow of water.

Plate-patterns are used in infinite variety, as illustrated by Fig. 29, page 435. They include all sizes of nuts up to 2½ in., spindles, injector and ejector details, wheels, oil siphons, cylinder cocks, and a variety of plugs, &c.

Phosphor Bronze.

Mr. Arnold Philip's paper on phosphor bronze to the Institute of Metals* has now become a standard reference, and the author will not be expected to proceed to lengthy detail here. The composition of the phosphor bronze used by the Lancashire and Yorkshire Railway Company is as follows:—

	Per Cent.			Per Cent.
Copper ..	86.0	To give by analysis	Copper ..	89.5
Tin	10.0		Tin	10.0
15 per cent. phosphor copper ..	4.0		Phosphorus ..	0.5
	100.0			100.0

It is made entirely from clean-picked scrap and new ingot tin, and phosphor copper. It is used for general repairs to heavy machinery, also for mill bearings and wheels and pinions, where great wear takes place.

This mixture has given general satisfaction in gearing at goods yards and docks, working in worm-wheels in conjunction with steel worms. It is chiefly moulded in dry sand, and presents little trouble in casting. It is practically free from slag, which fact is a result of the cleanliness of the materials used. It casts clean, and is readily dressed.

Other Mixtures in Use.

—	Copper.	Zinc.	Lead.	Tin.	—
Yellow brass ..	67	30	3	..	For cab-rings, name-plates, &c.
Brazing metal ..	84	16	..	..	Pipe-flanges, collars, &c.
Telegraph metal	80	7.5	7.5	5	Small castings

—	Aluminium.	Copper.	Zinc.	—	—
Light aluminium alloys	95	5	..	..	For motor dust-caps, grids, and some carriage fittings
	85	..	15	..	

White Metal.

The chief object in mixing a white metal suitable for lining bearings, axle-boxes, and big end-brasses for locomotive connecting-rods, is to avoid overheating of any of the component metals. Thus, in preparing alloy "C" a primary melt is made of equal parts of copper and tin, which is cast into chills and subsequently broken into pieces to be re-melted in the required amount together with the antimony, the remaining tin being added from time to time, with careful stirring. This method is preferable to the simpler one of melting the copper and antimony direct, and is found to result in cleaner metalled surfaces. The product is cast into heavy iron chill moulds for use as required in the metal shop.

White Metals for Bearings.

Three types of white metals are used for lining bearings:—

—	"A" per Cent.	"B" per Cent.	"C" per Cent.	"D" per Cent.	"E" per Cent.
Tin	82.0	11.5	80.0	54.0	85.0
Antimony	14.0	13.5	10.0	11.0	7.0
Copper	4.0	3.0	10.0	1.0	8.0
Lead	..	72.0	..	34.0	..
	100.0	100.0	100.0	100.0	100.0

"A" is used for high-class axle-bearings on the pinion and commutator ends of motors on the electrical rolling-stock running on the Lancashire and Yorkshire Railway, between Liverpool, Southport, and Crossens. The motors have a speed of 780 revolutions per minute at 50 miles per hour, developing 150 horse-power at the pinion. Under trying conditions of service "A" was adopted after careful comparisons with solid gun-metal bearings and other alloys of tin and lead.

Table VIII. is a record of tests made on four types of bearing metals, showing percentage hot bearings, broken collars, days in use, &c., in which the suitability of this metal is clearly seen. The solid brass was the gun-metal mixture shown on page 433.

For locomotive work a harder variety, "C," of this metal, containing 10 per cent. copper and 10 per cent. antimony, is used in big end-brasses, coupling-rod bushes, crossheads, and certain other parts requiring a stiffer alloy than type "B" with a basis of lead—that is to say, "B" withstands pressure well, but not the hammering brought about by the reversal of motion. It has done good service in lining-up main axle-boxes, radial-wheel brasses, reversing-shafts, &c.

The success of a bearing-metal alloy depends more upon structure than absolute composition, the proper distribution of a number of the tin-antimony crystals in a softer matrix of tin or lead being essential. The alloy must run cool without any cutting of the axle-journal, and the wear on this should be reduced to a minimum.

* Journal of the Institute of Metals, No. 1, vol. i., page 164.

TABLE VIII.

Conditions.	Solid Brass.	"D" Metal.	"E" Metal.	"A" White Metal.
Number on test	29	32	35	58
Number taken off due wear ..	10	9	17	16
Number taken off hot	6	..	3	3
Number taken off with broken collars	2	22	12	18
Number still running	11	1	3	21
Average life of warn bearings days	295	193	263	241
Average life of hot bearings days	159	..	141	257
Average life of bearings with broken collars .. days	286	191	281	215
Average life of bearings still running .. .. days	409	447	280	406
Average life of total bearings used .. .. days	318	189	259	299
Per cent. of hot bearings to total	20.7	..	8.5	5.1

White Metalling Axle-Boxes.

As an example of this process, a radial axle-box brass will be dealt with, as shown in Figs. 30 and 31. This consists of a cast-iron box *a* having three sides and a heavy base, and a plate *b* resting on the base of, and secured to, the box, by four links and cotters *d* and *e*, to which is attached the cast-iron chill *c*. The combined plate and chill *b* and *c* having been removed, the brass *f* is placed in the space formed by the three sides of the box; the plate and chill is secured in position as aforementioned, and the white metal poured in from the top, filling the space *g*. The same procedure is adopted when the brasses are metalled in the first instance. The old metal having been melted out of the box, the recesses are well cleaned and rasped with a coarse file. All dirt having been thoroughly removed, the box is placed on a coke fire and slowly heated. By the use of sal ammoniac and tin a very thin coating is produced for uniting with the white metal, which is then cast into the bearing. The metal (type "B") is cast at a temperature of 450 deg. Cent. from the open pan fire.

Other white-metal mixtures are:—

Lead.	Tin.	Antimony.	—
92	..	8	For packing ball-joint water-pipes.
70	17	13	Metallic packings.

NON-FERROUS METALS IN RAILWAY CARRIAGE AND WAGON CONSTRUCTION.

Aluminium.

It is only in quite recent years, after a considerable reduction in price has been made, that the use of aluminium can be shown to be a commercial advantage in many branches of railway engineering and rolling-stock, where it is slowly supplanting the use of other metals.

Car-Panels.

The outside panels of electric cars built for the Liverpool and Southport line of the Lancashire and Yorkshire Railway to work in conjunction with the Liverpool Overhead line are made of aluminium No. 16 S.W.G., the largest panel on the side of the car being 6 ft. 7½ in. long by 2 ft. 8 in. wide. These cars have a turn-under, which, taking a convex shape, adds considerable strength to the panel, and prevents buckling, this being more apparent when the panel is placed vertically flat on the side of the vehicle. Another feature is that if the latter panels assume too large an area, especially if of thin gauge—*i.e.*, 18 or 20 S.W.G.—the varying temperatures will cause the panels to become wavy.

The following comparison between aluminium, baywood mahogany, and steel sheets, used for the outside panelling of a 60-ft. electric car will be of interest:—

	Weight per Car. Lb.	Cost per Car. £
Baywood mahogany ...	340—⅝ in. thick.	9.3
Steel	535—20 S.W.G.	3.4
Aluminium	225—18 S.W.G.	13.9

The cost given for baywood mahogany allows for interest on the storage of timber for seasoning, repairs, depreciation, and insurance of seasoning sheds.

Although the initial cost of the aluminium panels is much greater than for mahogany or steel, a reduction in the cost of haulage of nearly 33 per cent. in favour of aluminium as compared with baywood, and nearly 60 per cent. as compared with steel, is obtained.

The special feature for which aluminium commends itself for use in car construction is the lessening of the dead-weight, which, especially in the case of electric trains subject to frequent stops where rapid acceleration and retardation are essential to gain the desired advantages, is of great commercial importance.

The soldering of aluminium is undoubtedly a difficult problem to be satisfactorily solved. This is not only a question of the composition of the solder, but the fact that the surface of aluminium is always covered with an almost imperceptible, but yet very persistent, film of oxide, and although the surface may be freshly cleaned, the oxide immediately forms. Another point is the conductivity of the metal which removes the heat from the soldering point. Of various compositions of aluminium solders experimented with, zinc appears to alloy with aluminium more readily than any other metal, as the constituent part of the solder.

Mouldings and Fascias and Inside Furniture Fittings for Steel Cars used on the Tube Railways.—The extended use of steel cars for tube and surface railways, and the consequent increase in dead-weight as compared with the older form of timber construction, has led to the adoption of various forms of aluminium mouldings, fascias, &c., to compensate to some extent for the additional weight of the steel girders, angles, channels, &c., used in the designs.

Bearings for Carriage and Wagon Axle-Boxes.—It is reported that the Northern Railway of France is substituting for the bronze bearings hitherto in use on rolling-stock, bearings made of an alloy of 92 per cent. aluminium with 8 per cent. copper, and that certain bearings of this alloy have run 50,000 miles without showing any trace of wear, and, owing to its relative lightness, the cost has been considerably reduced. Experiments on the Lancashire and Yorkshire Railway do not yet confirm this satisfactory result, it being found that the material is hard and brittle, and considerable labour is involved in properly bedding the bearings to the journals, and preventing heating under normal running conditions.

Anti-Friction Alloys.

White Metals, for the lining of rolling-stock bearings, are largely used, although the lining for a pulley-shaft bearing and that used for a railway vehicle will differ, owing to the variation in the load, method of lubrication, and conditions under which they are working.

Of the metals forming anti-friction alloys, it is unusual to find more than three in any particular mixture; a very common alloy used is that for the lining of carriage and wagon bearings, which consists of antimony 15 per cent., lead 70 per cent., and tin 15 per cent. It is common practice for the bearings, after being lined with about ⅛ in. thickness of alloy, to be bored out in a machine and finished off by hand; but successful results have been made by casting a better finished surface from the mould, and bedding it direct on to the journal.

The following types of brass bearings are lined with

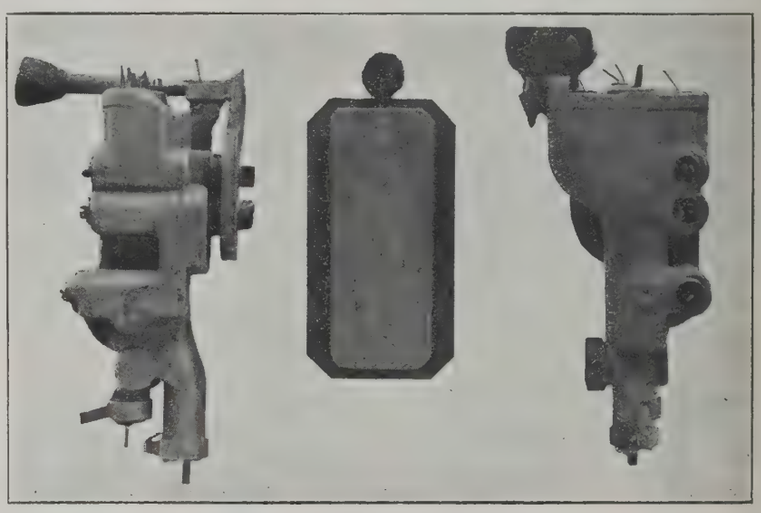


Fig. 28. Injector Casting.

$\frac{7}{8}$-in. white-metal alloy for railway bearings:—10-ton, 12-ton, 15-ton, 20-ton, and 30-ton wagons, and all bearings for carriage stock, and the same applies to private owners' wagons, with the exception of wagons of 8 tons and 10 tons capacity, which are specified in brass; the thickness of the white-metal lining in these vehicles varies from $\frac{3}{16}$ in. to $\frac{7}{16}$ in.

Sheet Tin.—Sheet tin is used in kitchens and pantries of dining-cars, for draining-boards, sinks, &c., and also for various other sundry purposes, such as filter-linings, &c.

Copper.—Copper is used in the construction of the various types of brine-pipes for fish-vans, gas-lamps, water lavatory tanks and heaters, kitchen and pantry sinks and utensils on dining-cars, the latter of which are tinned to prevent any chemical action taking place on the copper.

Lead.—Lead, in its rolled sheet form, is used for the linings of acid tanks, electric-lighting cells and plates, roof coverings, floors of dining-car kitchens, &c.

Brass.—Brass is used in car construction for such purposes as gas and electric fittings, parcel racks, hat and coat hooks, ash-trays, hinges, outside door-handles and commodes, and various other details for which it is particularly suitable.

Zinc.—Zinc is usefully employed in its sheet form for ventilators, roof-coverings, and mouldings.

As a matter of convenience the following table gives in a concise form the composition of these alloys:—

Table of Alloys Mentioned in the Paper.

Used for	Cu.	Sn.	Sb.	Zn.	Pb.	Fe.	P.	15 per Cent. Ph. Cu.	Al.	Ni.
Scrap ingot metal	86.5	7.5	0.08	2.3	3.2	0.2	—	—	—	—
Slide-valves	84.5	10.0	..	..	5.0	..	0.5	—	—	—
Gun-metal	88.0	10.0	..	2.0	—	—	—	—	—	—
Injector metal	84.0	8.5	..	5.0	2.5	—	—	—	—	—
Phosphor bronze	86.0	10.0	..	..	..	..	..	4	—	—
to give	89.5	10.0	..	..	..	..	0.5	—	—	—
Yellow brass for cab rings, name-plates, &c.	67.0	..	..	30.0	3.0	—	—	—	—	—
Aluminium alloys for motor dust-caps	5.0	..	..	..	..	..	..	..	95	—
Brazing metal	84.0	..	..	16.0	—				—	—
Telegraph metal	80.0	5.0	..	7.5	7.5	—	—		—	—
Aluminium alloys for some carriage fittings	15.0	..	..	..	..	—	..	..	85	—
White metal, "A"	4.0	82.0	14.0	—	—	—	..	—	—	—
White metal, "B"	3.0	11.5	13.5	..	72.0					
White metal, "C"	10.0	80.0	10.0	—	—				—	—
White metal for packing ball joints	..	..	8.0	..	92.0	—	—	—	—	—
White metal for metallic packings	..	17.0	13.0	..	70.0	—	—	—	—	—
White metal for carriage and wagon bearings	..	15.0	15.0	..	70.0	—	—	—	—	—
Ordinary axle-box bearings	80.0	5.0	..	..	15.0	—	—	—	—	—
20-ton wagon bearings	64.0	5.0	..	..	30.0	—	—	—	—	1
Argozoil (ornamental fittings)	54.0	2.0	..	28.0	2.0	..	..	..	—	14
Solder (electric fittings)	..	94.5	..	..	5.5	..	—	—	—	—
Solder (plumbers')	..	50.0	..	..	50.0	—	—	—	—	—
Solder (tinsmiths')	..	60.0	..	..	40.0	—	—	—	—	—

Fig. 32 is a general view of the Lancashire and Yorkshire Railway Company's brass foundry at Horwich.

APPENDIX I.

Specification for Copper Plate (Best Quality).

The maker's name, register number, and date of manufacture must be legibly stamped on every plate and sheet $\frac{3}{8}$ in. thick and upwards, within 12 in. from the bottom. All plates and sheets under $\frac{3}{8}$ in. thick to have the information painted upon them. A piece 2 in. wide to be left on each fire-box plate for tensile and bend test purposes, to be sheared within 2 in. of edge of plate as shown on sketch. Wrapper-plates over 15 ft. long to have a similar piece left on both ends of the plate. Plates to be inspected for surface defects. The weight must be painted on each plate. (See Figs. 33 and 34, page 436.)

Bending Test.—Pieces of the plate shall be tested, both cold and at a red heat, by being doubled over on themselves—that is, bent through an angle of 180 deg.—without showing either crack or flaw on the outside of the bend.

Flanging.—Plates must not show any defects in flanging.

Tensile Test.—Ultimate breaking load, 14 tons per square inch; elongation, 35 per cent. in 8 in.

Analytical Test.—To be made at the contractor's expense. The copper upon analysis to give the following results:—Arsenic, not less than 0.35 per cent. nor more than 0.55 per cent.; other foreign elements, exclusive of combined oxygen, not to exceed 0.25 per cent.

Inspection.—The railway company's inspector to have free access to the manufacturer's works at all reasonable times, to be at liberty to inspect the manufacture at any stage, and to reject any material he may consider defective in quality or workmanship. No plate will be accepted which will not stand the specified tests, or which upon analysis is found to exceed the limits stated for the chemical composition.

Testing Facilities.—The manufacturer shall supply the material required for testing free of charge, and shall, at his own cost, furnish and prepare the necessary test-pieces, and supply labour and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.

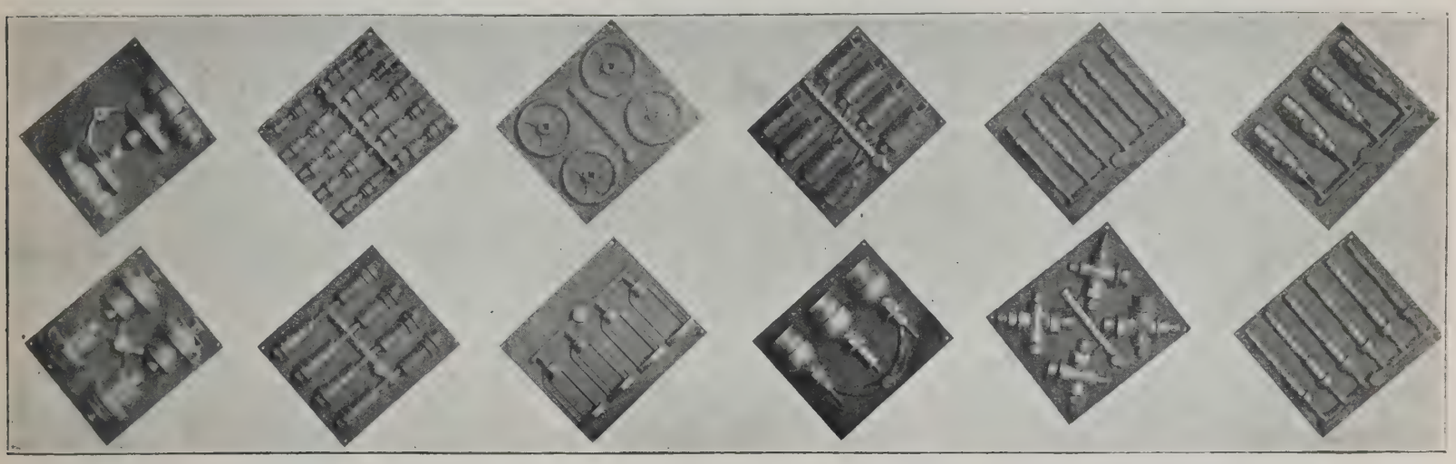
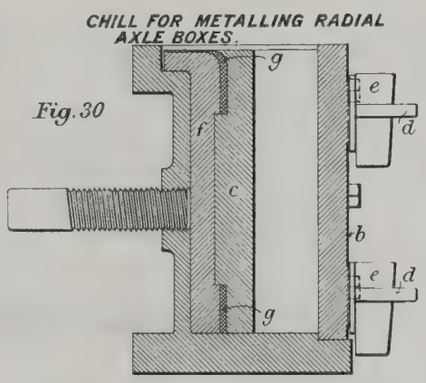
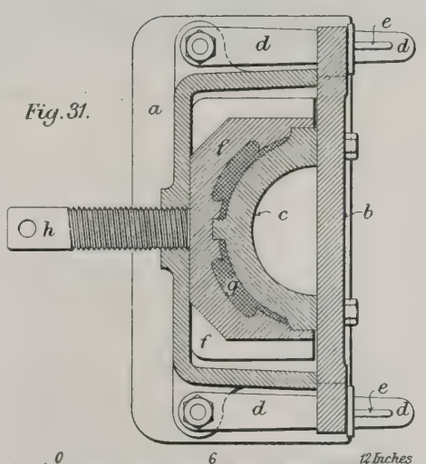


FIG. 29. PLATE PATTERNS.





APPENDIX II.

Specification of Copper Bolt (Best Quality).

To be annealed and sawn off square at the ends.

Must be free from surface defects and parallel. The $\frac{7}{8}$-in., 1-in., and $1\frac{1}{16}$-in. in diameter must also have the following limits of accuracy—viz.: a minimum of $\frac{3}{1000}$ of an inch over size, and the maximum of $\frac{7}{1000}$ of an inch over size.

Bending Test.—Every bar tested to stand bending close, both cold and at a red heat, without any signs of fracture or failure appearing.

Tensile Test.—Ultimate breaking load, 14 tons per sq. in.; elongation, 40 per cent. in 8 in.

Stamping.—The maker's name to be stamped on each bar, not more than 6 in. from the end.

Analytical Test.—To be made at the contractor's expense. To contain not less than 99.25 per cent. of copper and 0.15 per cent. to 0.35 per cent. of arsenic. The manufacturer shall supply an analysis when required to do so.

Inspection.—The railway company's inspector to have free access to the manufacturer's works at all reasonable times, to be at liberty to inspect the manufacture at any stage, and to reject any material he may consider defective in quality or workmanship. No bolt will be accepted which will not stand the specified tests, or which upon analysis is found to exceed the limits stated for chemical composition.

Testing Facilities.—The manufacturer shall supply the material required for testing free of charge, and shall, at his own cost, furnish and prepare the necessary test-pieces, and supply labour and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.

APPENDIX III.

Specification of Copper Tubing (Best Quality).

Freedom from Defects.—The tubing is to be solid-drawn, and left hard, to be clean and smooth, and free from defects or longitudinal grooving, internally and externally, and the ends must be clean and square. It must be straight, cylindrical, and of uniform thickness, and, unless otherwise specified, of uniform diameter throughout.

Analytical Test.—To be made at the contractor's expense. The tubing must contain not less than 99.25 per cent. of copper and 0.25 to 0.45 per cent. of arsenic. The manufacturer must supply an analysis when required to do so.

Mechanical Test.—The manufacturer shall provide, at his own expense, extra tubing at the rate of 1 per cent. of each diameter ordered under contract. The railway company's inspector shall select and test such of the tubing as he shall think proper.

Drifting Test.—The tubing as supplied must stand drifting, without showing either crack or flaw, until the diameter of the drifted end measures at least 25 per cent. greater than the original diameter.

Flattening and Doubling-Over Test.—The tubing must be capable of standing the following test, both cold and at a red heat, without showing either a crack or flaw. A piece of tubing shall be flattened down until the interior surfaces meet, and then be doubled over on itself—that is, bent through an angle of 180 deg., the bend being at right angles to the direction of the length of the tubing.

Hydraulic Test.—All copper tubing shall be tested before delivery by such internal hydraulic pressure as shall be determined by the railway company's inspector.

Inspection.—The railway company's inspector to have free access to the manufacturer's works at all reasonable times, to be at liberty to inspect the manufacture at any stage, to witness the hydraulic test, and to direct tensile and drifting tests of tubing taken from the bulk, rejecting any tubing or materials which, in his opinion, are imperfect in quality and workmanship.

Testing Facilities.—The manufacturer shall supply

material required for testing free of charge, and shall, at his own cost, furnish and prepare the necessary test-pieces, and supply labour and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the test elsewhere.

Branding.—The maker's name and date to be clearly stamped on the outside of each piece of tubing 12 in. from one end.

Tube Ends and Parallel Tubes.

Outside Diameter of Tube.	Weight in Pounds per Foot Run.			
	9 I.W.G.	10 I.W.G.	11 I.W.G.	12 I.W.G.
in.				
1¾	2.80	2.50	2.30	2.10
2	3.25	2.90	2.65	2.40

Flattening and Doubling Over Test.—The tubes must be capable of standing the following tests, both cold and at a red heat, without showing either crack or flaw: A piece of the tube shall be flattened down until the interior surfaces of the tube meet, and then be doubled over on itself—that is, bent through an angle of 180 deg., the bend being at right angles to the direction of the length of the tube.

Hydraulic Test.—Each tube to be capable of standing, without leakage, an internal pressure of 1000 lb. per sq. in.

FIG. 32. GENERAL VIEW OF HORWICH BRASS FOUNDRY.

APPENDIX IV.

Specification of Copper Boiler-Tubes and Copper Tube-Ends for Piecing Purposes (Best Quality).

Freedom from Defects.—The tubes are to be solid drawn, perfectly sound, and well finished, the ends to be clean and square, and the surface free from defects, and to stand the expanding without showing the least sign of splitting or chipping whatever. The tubes are not to be annealed at the ends, but made "half hard" throughout.

Analytical Test.—To be made at the contractor's expense. The tubes must contain not less than 99 per cent. of copper and 0.35 to 0.55 per cent. of arsenic. The manufacturer must supply an analysis when required to do so.

General.—Each tube to be of exact length and outside diameter given on the order, and in thickness within one-half a gauge above or below the specified gauge.

The tubes are to be parallel for a length of 12 in. at the heavy gauge end, then taper in a length of 18 in. to the smaller gauge, and the remainder of the tube to be parallel and of the smaller gauge.

The thin end of every tube to be swelled $\frac{1}{16}$ in. larger or a length of 3 in. to facilitate withdrawal unless otherwise specified on order.

The tubes are to be clean and free from dirt inside and outside, and must be within 5 per cent. above or below the following weights:—

Comp'ete Tubes

Outside Diameter of Tube.	Length.	I.W.G.	Weight of one Tube.
in.	ft. in.		lb.
1¾	11 2½	10 and 12	23.9
1¾	10 11½	10 ,, 12	23.5
2	15 2½	9 ,, 11	41.1
2	14 10½	9 ,, 11	40.2

Fig. 33. HAMMERED PLATES.

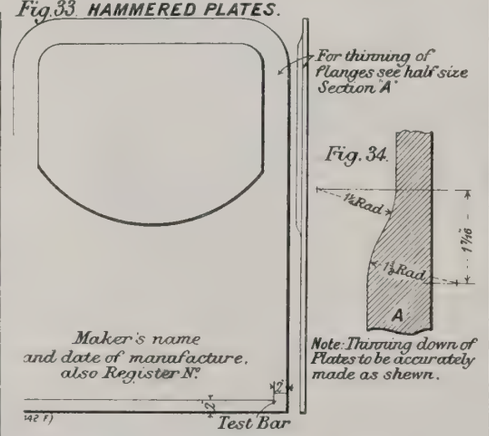


Fig. 34.

Mechanical Tests.—The manufacturer shall provide, at his own expense, extra tubes at the rate of 1 per cent. of each diameter of tubes ordered under contract.

The drifting, tensile, and flattening tests are to be made on the tubes in the half-hard state without annealing, but further annealing tests may be taken at the discretion of the railway company's inspector.

Drifting Test.—The tubes must stand drifting, without showing either crack or flaw, until the diameter of the drifted end measures at least 25 per cent. greater than the original diameter of the tube.

Tensile Test.—Ultimate breaking load 17 tons per sq. in., with an elongation of 25 per cent. on 8 in.

All tubes shall be tested before delivery by such internal hydraulic pressure as shall be determined by the railway company's inspector.

Inspection.—The railway company's inspector to have free access to the manufacturer's works at all reasonable times, to be at liberty to inspect the manufacture at any stage, to witness the hydraulic test, and to direct tensile and drifting tests of tubes taken from the bulk, rejecting any tubes or materials which, in his opinion, are imperfect in quality or workmanship.

Testing Facilities.—The manufacturer shall supply the material required for testing free of charge, and shall, at his own cost, furnish and prepare the necessary test-pieces, and supply labour and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.

Branding.—The maker's name and date to be clearly stamped on the outside of each tube 12 in. from one end.

THE CORROSION OF BRASS, WITH SPECIAL REFERENCE TO CONDENSER-TUBES.*

By PAUL T. BRÜHL, M.Sc. (Bowen Research Scholar, University of Birmingham).

INTRODUCTION.

THE problem of corrosion has been a subject of investigation for many years, and much work has been done in connection with this important subject. Iron and steel practically monopolised attention for a considerable period, with the consequence that the corrosion of copper and brass was somewhat neglected. The enormous industrial importance of the copper-zinc alloys at the

* Paper read before the Institute of Metals at Newcastle, September 21, 1911.

present day, and their frequent failure, have gradually brought home to both manufacturers and users the necessity for fuller investigation. A committee appointed by the Institute of Metals has been collecting data on the subject and inaugurating a systematic and complete series of experiments. There can be little doubt that so active a crusade will sooner or later be productive of much good.

HISTORICAL.

The first work published in connection with corrosion is probably that done by Sir H. Davy in 1824. He, from a consideration of the protective influence exerted by one metal when in contact with another metal more electro-negative, was led to make an important practical application of this principle. It was at that time generally supposed that some impurity of the metal or some defect imparted to it during manufacture was responsible for the occasional marked effect of sea water on copper. Doubtless a considerable element of truth lies in this conception. To protect the copper, therefore, Davy used zinc in juxtaposition to it, the ratio of the area of zinc to copper being from as 1 : 4 down to as low as 1 : 150. Though in this way the life of the copper was considerably prolonged, the method nevertheless had the disadvantage of precipitating the calcium and magnesium carbonates from the sea water in the form of a crust favourable to the development of weeds and of certain marine animals. The speed of the vessel was in consequence much retarded. This trouble could be overcome by diminishing the ratio of zinc to copper; the method, however, was abandoned, as Muntz metal was shortly afterwards introduced for ships' sheathing.

In 1886 Sir W. Tilden published a paper, in which it was suggested that the basic chloride and copper oxide formed during the corrosion of brass were possibly the most harmful of the deposits on a condenser-tube. A proper cleaning out of the condenser at the end of a voyage was recommended.

Milton and Larke, in 1903, came to the conclusion, as a result of their researches, that the presence of more than one phase in the alloy rendered its corrosion the more rapid, and pitting was attributed to segregated impurities. They recommended the avoidance of lead and iron in the brass, and advocated the introduction of tin; they also pointed out the necessity of having smooth surfaces, and referred to the influence of stray electric currents.

Other workers have shown the effect of certain lubricating oils, and experimented on one or another form of protective coating. The literature of the subject being extensive, fuller particulars cannot be given here; but reference may be made to the excellent summary and bibliography prepared by Mr. Bengough for the Corrosion Committee, and presented at the meeting of this Institute held in January, 1911.

THE NATURE OF CORROSION.

It is important to discuss the fundamental principles on which any question depends before the phenomena which arise from them are dealt with in any way; and, therefore, although the electrolytic theory of corrosion has been more than once explained, a brief restatement of it here needs no apology.

According to this theory, when a metal is immersed in an electrolyte or liquid conductor of electricity, it tends to enter into solution from points of maximum solution pressure which are electro-positive to the rest of the metal. The entering metallic ions assume the positive charges of the hydrogen ions, which, as a result of their loss, plate out at cathodic areas as bubbles of gas. If the electrolyte is neutral, the metallic ions acquire their charges from the metal, which, therefore, becomes negatively charged. According to Hittorf, when the positive charge of the solution becomes equivalent to the negative one of the metal surface, further action is rendered impossible by the formation of an "electrolytic double layer." The action may be represented—

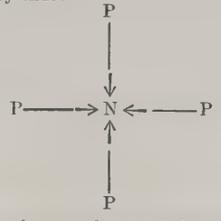
$$\text{Solution pressure} \rightleftarrows \text{electrostatic tension} + \text{osmotic pressure.}$$

In the presence, however, of hydrogen ions the fact that the metal is positive to hydrogen results in the breaking up of the double layer and in a readjustment of equilibrium; the hydrogen ions are forced out of the system, and further solution can again take place.

If now we take the case of a salt, we find it undergoes electrolytic dissociation on solution, the action being a reversible one, as the salt can be recovered by evaporation. There exists between the undissociated salt and its ions a definite quantitative equilibrium, the two bounding limits of which are regulated by the molar concentrations of the solution—by molar concentration being meant the reciprocal of the volume in which a molecule of substance is contained. The one limit is arrived at by an increase of concentration, which tends to the formation of unchanged salt; the other by extreme dilution, which results in the complete ionisation of the salt.

An interesting point in connection with solution pressure is illustrated by what is known as the passive state of metals. Iron, for instance, after immersion in certain strong oxidising agents no longer exhibits its tendency to dissolve in weak electrolytes. Various explanations have been offered. Faraday considered the effect to be due to the production of a thin oxide film, others thought it the result of polarisation following on the retention of oxygen by the metal surface. The same effect can, however, be observed under circumstances where oxygen cannot possibly play a part. The production of a higher valency and an allotropic modification of the metal have also been advanced as probable causes of passivity.

Let us consider now, in the light of the electrolytic theory, what happens when a speck of negative impurity is formed on the surface of brass. It may be represented diagrammatically thus:—



If the impurity be a conductor of electricity, the brass will pass from the atomic to the ionic state by the displacement of the hydrogen ions, and consequently a moat will form round the negative centre. If the impurity happen to be positive, it will itself pass into solution with the production of a pit.

THE CORROSION OF BRASSES.

The brasses we need consider may be classified under two heads—namely, those which contain more than 64 per cent. copper, and those which contain less than that amount down to about 50 per cent. copper. The former class has hitherto been thought to consist of one phase only, but a recent paper published by Professor Carpenter would appear to throw some doubt on this conception. From a consideration of the fact that a thermal change occurs at about 470 deg. Cent. in alloys which need not contain α and γ, but contain some β, the change is attributed to a variation in the β. Reasons are advanced as to why the change cannot be a polymorphic one, but a passage of the β into $\alpha + \gamma$. As this change is observed in the "α brasses," the view is held that α really is "a very intimate mixture of copper and β," and that β tends to pass, even in solid solution, into α and γ. One difficulty at once suggests itself. If the embrittlement of 70/30 brass at 470 deg. Cent. is due to the passage of β into $\alpha + \gamma$, which is the stable form at lower temperatures, why should the metal be malleable in the cold?* It would seem advisable at present to consider the brasses, 100 – 64 per cent. copper, to consist of one phase only, although the necessity for some modification in our views is apparent. The brasses of slightly lower copper content consist of two phases, $\alpha + \beta$. Corrosion in both cases would in the cast metal be accelerated by the lack of homogeneity, due to "coring"—that is to say, to local enrichments due to the prevention of diffusion by quick cooling. But this defect is quite obliterated by work and annealing. 70/30 brass, therefore, which is built up of a mass of α crystals only, will provide no such incentive to corrosion as a 60/40 brass, which consists of a mass of β crystals in a groundwork of α. The β being strongly positive to the α, will set up electrolytic action, and the rate of corrosion will now be correspondingly greater. The copper and zinc do not dissolve out at the same rate, the latter being removed about six times as fast as the former; the ratio, however, varies with circumstances. In one instance the author found that the synthetic sea water, in which 70/30 brass (with a surface of 92 sq. in.) had stood for fourteen days, gave only a trace of copper, but a zinc content of 0.016 gramme per 100 c.c. The corrosion product which formed during the same period, and which was largely non-adherent, assayed at 48.85 per cent. copper and 20.41 per cent. zinc. As a result of this unequal velocity of solution of its constituents, brass plates and tubes very often look "coppery" in places, as a result of corrosion. Mr. Rhodin has found that when electrolytically corroded with Muntz metal, the copper and zinc go into solution at about the same speed. This is due partly to simultaneous removal and partly to "exfoliation of the α crystals, loosened by solution of the inter-crystalline β constituent." The following two diagrams, illustrating this part of the subject, are taken from Dr. Desch's book on "Metallography."

In Fig. 1 is given "the weight of the corrosion product and the weight of copper in it plotted against the original composition of the test-pieces."

In Fig. 2 "the percentage of zinc in the corrosion product is plotted against the percentage in the original specimen."

There is reason to believe that the corrosion of 60/40 brass commences in the β constituent, which is richer in zinc and more electro-positive. After some time the α constituent begins to go into solution, because as zinc is removed more rapidly than copper, the β gradually becomes more and more electro-negative, due to copper enrichment, and its protective influence is, therefore, gradually lost. The various ions which are formed on the dissociation of sea water do not, of course, possess the same mobility—that is to say, the velocity of migration of the anions differs from that of the cations. Concentration accordingly takes place at the one or the other electrode. In the case of sea water, such concentration would occur at the β areas, and the rate of corrosion would consequently be accelerated, were it not for the fact that the microscopic distance apart of the two phases renders this practically impossible, due to the ease with which diffusion can take place. It must be remembered that differences of potential are impossible in the same metal; what we have in the case of Muntz metal is a difference of potential between the liquid near the β and that near the α phase.

Fig. 1.

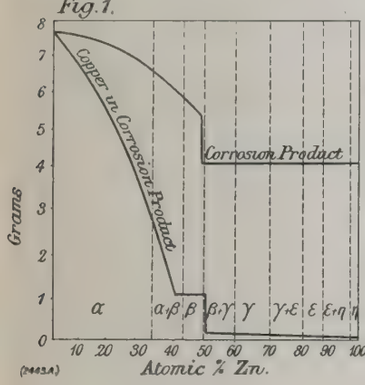


Fig. 2

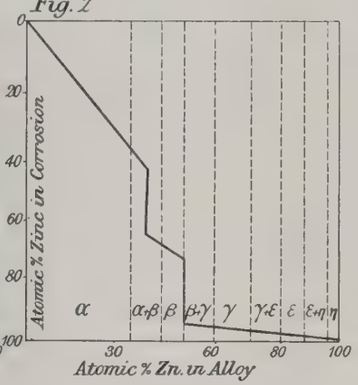
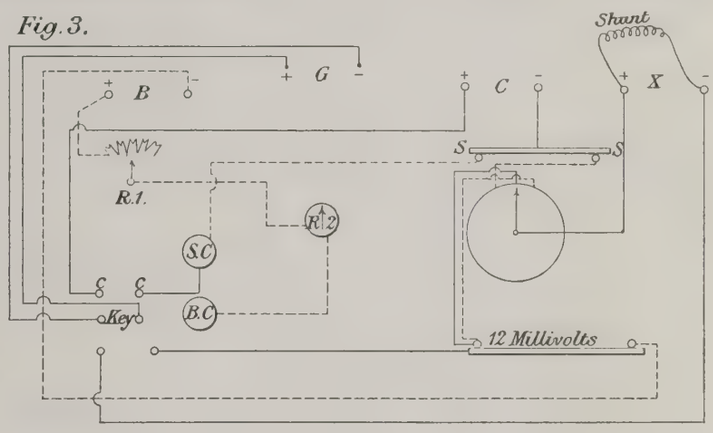


Fig. 3.



B-Battery. G-Galvanometer. C-Standard Cell. X-Unkown Potential
(24438)

The *rationale* of the corrosion of brass in sea water is probably as follows:—A certain amount of oxidation takes place, zinc and cuprous oxides being formed, and both zinc and copper go into solution as chlorides, which, under the action of oxygen and water, are precipitated as the bluish-green oxy-chlorides, the copper salt corresponding to the formula

$$3CuO \cdot CuCl_2 \cdot 4H_2O.$$

Some of the zinc and copper also dissolve out as carbonates, and are later thrown down on the basic salts. According to Charpy, the action of sea water on copper is as follows:—

$$4Cu + 2O_2 = 4CuO$$

$$4CuO + 2NaCl + CO_2 + 3H_2O = Na_2CO_3 + (3CuO, CuCl_2, 3H_2O)$$

$$3CuO, CuCl_2, 3H_2O + 4Cu = Cu_2Cl_2 + 3Cu_2O + 3H_2O$$

$$3Cu_2Cl_2 + 3O + 3H_2O = 3CuO \cdot CuCl_2 \cdot 3H_2O.$$

The insoluble salts formed as indicated above would not, under working conditions, be likely to adhere to the surface of the condenser tubes owing to the velocity of the incoming water. Their presence would constitute the maximum danger when the vessel should have arrived in harbour, and the condenser be no longer in use. When water is once again passed through the tubes most of the precipitated salts would be washed away, but patches would remain here and there along the surface. The oxychlorides being unstable, salts would gradually become converted (commencing nearest the metal) into cuprous oxide and cuprous chloride. The latter is dissolved out, whilst the former is either oxidised to cupric oxide or reduced to metallic copper by nascent hydrogen.

It is suggested that the deposit on the tube may aid corrosion by acting as a nucleus for further precipitation

* [To this objection Professor Carpenter has replied in the Journal of the Institute of Metals, No. 1, 1911, vol. v.—ED.]

by lowering in consequence the concentration of the cupric ions in the solution.

Classification of Corrosion.

The corrosion of brass condenser-tubes may conveniently be classed under four heads :—

1. Corrosion proper; where the metal is uniformly removed over the whole surface.

2. Dezincification; where the zinc being preferentially more rapidly removed than the copper, the surface of the metal becomes copper-rich in places. The action does not usually extend much below the surface, although it may occasionally be so marked as to result in copper "plugs."

3. Pitting. This is by far the most serious form of corrosion, as it considerably curtails the life of the tube. It is due to galvanic action between the deposit on and the metal of the condenser-tube. It may occur in any portion of the tube—that is to say, in the roof and sides as well as along the floor. It most often occurs in the lowest portions of the tube, because of the natural downward gravitation of any extraneous sediment, or of any insoluble product of corrosion.

4. Erosion. Here the mechanical influence of the stream of cooling water comes into play. Its effect is small and, under ordinary circumstances, uniform.

Examination of some Corroded Specimens of Condenser-Tubing.

The following description of five selected cases may serve to illustrate the effects observed in practice. The samples were supplied through the kindness of Engineer Vice-Admiral Sir H. Oram.

Specimen 1.—This tube, four years old, was situated in the eighth row from the top; the water circulated through the tube, and, entering at the bottom of the condenser, discharged at the top. The quality was a 70/29/1. Serious pitting, which in places had pierced the tube, had occurred, the pits being roughly funnel-shaped, with the larger diameter on the water side. Besides the usual corrosion products, both iron hydrate and insoluble matter were present. Specks of spongy copper were common. The pit was not unfrequently filled up by the deposit.

Specimen 2.—The tube (70/29/1) was seven years old, and taken from the bottom row. The circulating water passed through the tube, entering at the top of the condenser. The deposit was principally the green basic chloride. Dezincification was not pronounced, for the lustre of a freshly scratched surface was quite normal; the interior surface of the tube was smooth, and one small hole only had formed along a line of season cracking.*

Specimen 3.—The tube was a 70/29/1, two years old, and taken from the sixth row from the bottom of the condenser. The circulating water was outside the tube, the inlet being at the bottom of the condenser. The deposit was dark brown in colour, the green oxychloride being practically absent. The edges of the pits seemed to be somewhat steeper than in the two preceding instances.

Specimen 4.—The tube (70/29/1) was five years old, and taken from one of the top rows of the auxiliary condenser. The circulating water passed through the tubes, entering at the bottom and discharging at the top. There was very little deposit and no pitting, the tube having been rejected because of incipient season cracking.

Specimen 5.—The tube (70/29/1), four years old, was one of a number removed at random from the condenser for inspection. The circulating water passed through the tubes, entering at the bottom and discharging at the top. The deposit was rich in iron hydrate, and poor in the basic chloride. Dezincification was marked.

The examination of these tubes seemed to show that iron hydrate is by far the most injurious constituent of the deposit, being more electro-negative than cupric oxide and the basic chloride. Specimen 1, which had a deposit assaying 8.6 per cent. ferric oxide and 0.27 per cent. insoluble matter, was much more pitted than specimen 5, which gave the values 1.5 per cent. and 0.41 per cent. for the same impurities. Tube 2, which had been in use for seven years, was hardly affected at all, though well covered with a thin film of the green oxychloride.

Suggested Remedies.

A remedy which suggests itself immediately is the use of some protective coating, which should be electro-negative preferably to iron hydrate. Tinning is certainly useful, though by no means a sovereign remedy, because the layer of tin is not always intact. The application of a coating of iron oxide by the method suggested by Mr. Uthemann is excellent so long as it affords complete protection over the entire surface. But the method appears somewhat risky, as any discontinuity would only aggravate the evil it was intended to counteract.

Another coating is that suggested by B. Müllauer. It is the oxide formed on copper or brass by heating a 5 per cent. sodium hydrate solution to 100 deg. Cent., and adding 1 per cent. potassium persulphate. The article to be coated is immersed in this bath, and kept moving to and fro. The deposit so obtained is said to be strongly adherent, but was found to scale off in sea water after some four weeks. Its protective action, even when the coating was intact, was not very apparent. The plates showed no signs of any action for three or four days, after which the green oxychloride was slowly formed, probably according to the equation :—

$$4CuO + 2NaCl + CO_2 + 3H_2O = Na_2CO_3 + (3CuO \cdot CuCl_2 \cdot 3H_2O).$$

The loss in weight was :—

	Copper.	Brass.
0.1 week . .	0.00094	0.0005 gramme per square inch.

T. B. Allen heats the metal in contact with silicon to a temperature below the melting points of either in a non-oxidising atmosphere. An alloy of silicon and the metal is thereby produced on the surface, which is then said to be more corrosion-proof.

On the whole, however, the question of lessening corrosion by protective coatings does not promise to be of economic usefulness in the case of condenser-tubes. The line along which future investigation ought to be made is the study of the alloys of brass with one or even more other substances, with a view to obtaining a mixture which will give the requisite mechanical properties, and, at the same time, be the least influenced by sea water. Were there no reasons against the circulation of the cooling water along the outside of the tubes, the use of zinc, as has been pointed out by Bengough, might at once put an end to the trouble. The addition of 1 per cent. tin, as in the usual Admiralty specification, does not appreciably affect the E.M.F. Its protective action probably depends on the comparatively inert tin oxide produced. The principal evils to be contended against are iron hydrate and carbonaceous matter. It is admitted that vessels which spend the greater portion of their time at sea beyond the limits where town sewage and river dirt contaminate the water experience fewer troubles from pitting than vessels which ply up and down foul rivers. It follows that the marine engineer should make a point of flushing out his condenser with clean water on arriving in port. The iron hydrate is derived, no doubt, from the cast-iron end-cover and the inlet-pipe, although scale may be drawn in with the cooling water. It would therefore appear advisable for the end-cover and inlet-pipe to be made of brass.* Further, the use of some form of filter for the incoming water would be advantageous. Of these filters many forms are on the market, and some in actual use in electrical installations which obtain their water-supply from dirty canals.

Effect of Strain.

The irregular distribution of strain on any metallic surface gives rise to differences of potential. In order to investigate this point short lengths were procured of condenser-tubing of the following compositions :—

	Per Cent.		Per Cent.
Copper ...	70	Copper ...	70
Zinc	30	Zinc	29
		Tin	1

These lengths were wiped down with cotton waste, and then dipped into potash and clean water to remove any adherent grease. The potential differences of the two ends were next immediately ascertained by comparison with a standard electrode. The electrolyte used was synthetic sea water of the following composition :—

	Per Cent.
Sodium chloride	2.7
Magnesium chloride	0.36
Magnesium sulphate...	0.23
Calcium sulphate	0.14
Potassium chloride	0.07

The first endeavour made was to obtain a standard electrode against which various condenser-tubes could be compared with respect to potential differences. An amalgamated zinc strip immersed in the deci-normal solution of the sulphate was tried, but found unsatisfactory. A calomel electrode was then prepared, with satisfactory results. To prevent any error from the mutual interdiffusion of the electrolyte and the Hg_2Cl_2 – KCl solution of the standard electrode, the solution in the standard was replaced thrice daily, while the electrolyte was still more frequently replaced. As a result of the tests it was found that no tubes showed a difference of potential between the two ends of more than 0.0002 volt. It was noticed that when a comparatively slight strain was put on such a tube, as by gentle polishing with emery paper, the result was an appreciable rise of potential, which tended to reach a maximum with further polishing. The solution pressure of tubes of the 70/29/1 mixture was very similar to that of the 70/30. The above experiments proved a condenser-tube does exhibit differences of potential along its length; but these differences are not sufficiently large and abrupt to explain any corrosion other than a more or less uniform one extending over the whole surface.

The potentiometer used was obtained from the Cambridge Scientific Instrument Company; it was sensitive to the hundredth part of a millivolt, and was constructed as shown in Fig. 3.

An exact balance is first obtained between the standard cell and the battery, when the whole circuit becomes accurately adjusted to a fall of potential of 1 volt per 50 ohms circuit resistance.

(To be continued.)

* Season cracking is attributed to excessive work with insufficient annealing. The resulting strained condition of the crystals leads in time to a split. According to the *Brass World*, it is due in most cases to the contact of the brass tubes either with ammonia water or with substances of which it is a product of decomposition. Hard-drawn seamless tubing (66 per cent. copper, 34 per cent. zinc) was seriously affected by ammonia water, the fracture along the split being strongly crystalline. Professor Carpenter regards the cracking as due to the gradual change of the unstable β into the brittle $\alpha + \gamma$.

Perhaps some rough handling of the tubes when in the neighbourhood of the critical temperature (470 deg. Cent.), as may well occur during annealing, may act as a predisposing cause to season cracking.

* Although the author is aware that the British Admiralty hold strongly to the view that cast iron is best suited for the manufacture of the end-covers,

THE ALLOYS OF ALUMINIUM AND ZINC.*

By Walter Rosenhain, B.A., D.Sc. (Member of Council), and Sydney L. Archbutt, A.I.C. (Both of the National Physical Laboratory.)

In a paper presented to the Royal Society on February 16, 1911,† the present authors have given a detailed account of an investigation of the constitution of the aluminium-zinc alloys. For the purpose of opening the subject for discussion, however, it has been thought desirable to present to this Institute a summary of the principal methods and results of that investigation, leaving it to those particularly interested to refer to the fuller account for any details not dealt with in the present paper.

The alloys of aluminium and zinc have been investigated by Heycock and Neville,‡ Shepherd,§ and Ewen and Turner.‖ The present authors had occasion to study these alloys in connection with an extended research on light alloys of aluminium which they have been engaged upon on behalf of the Alloys Research Committee of the Institution of Mechanical Engineers. At the outset of their research they hoped to be able to depend upon the equilibrium diagram as given by Shepherd, but a few preliminary cooling-curves at once showed that important transformations took place in these alloys which had not been described or explained by Shepherd, and this observation rendered a complete study of the constitution of this binary system imperative.

Materials Employed.—The materials employed were of the highest available purity. The aluminium, presented by the British Aluminium Company, contained 99.63 per cent. of aluminium; while the zinc, presented by Sir John Brunner, contained at least 99.98 per cent. of zinc.

Preparation of the Alloys.—Weighed quantities of the two metals were melted together in salamander crucibles, a previously prepared 50 per cent. alloy being used in some cases. No flux was employed. The furnace used was heated either by gas or electrically. All ingots used for cooling-curve purposes were chemically analysed, and results very close to the values calculated from synthesis were obtained (usually within 0.5 per cent.).

Thermal Study of the Alloys.—Cooling-curves were taken of ingots of the alloys weighing 300 grammes, and it was found necessary to use a very slow rate of cooling—about 1 deg. Cent. in four seconds, decreasing to 1 deg. Cent. in twenty seconds as the temperature falls—in order to obtain indications of all the thermal changes. The temperature measurements were made by means of a platinum-platinum-iridium thermo-couple and a delicate potentiometer, the same thermo-couple being used throughout the research and frequently standardised.

In many cases the cooling-curves of individual ingots were repeated several times in order to eliminate accidental disturbances in the rate of cooling. The "inverse rate" method was used throughout, and the curves were originally plotted on a large scale. Some typical examples are reproduced on a greatly diminished scale in Fig. 1.

The equilibrium diagram, as finally arrived at on the basis of the cooling-curves, together with the data derived from microscopical examination, both of specimens of the alloys as ordinarily cooled and after special treatment, such as annealing and quenching, is given in Fig. 2. On this diagram the observed temperatures of arrests or retardations of cooling are shown as crosses, while the results of quenching experiments are indicated by dots surrounded by small circles or squares. The points plotted include all those observed.

The liquidus (curve of initial freezing) is given in the diagram by the lines A B, B C, C D, which differ from the corresponding curve as given by Shepherd only in respect of the small break at the point C. The insertion of this break in the liquidus is justified by the fact that, in the first place, the accuracy with which points on this curve have been determined precludes an experimental error large enough to allow a smooth curve to be drawn through the plotted points; the observations near C have been repeatedly checked in order to determine this point satisfactorily. There is, further, theoretical ground for the existence of a break in the liquidus at the point C, since it is shown by evidence to be described later that the crystals deposited along the branch B C and the branch C D are two distinct phases.

The solidus of the diagram is given by the lines A E, E B, B F, F G, G H, and H D. This statement rests largely on microscopical evidence, deduced from experiments on specimens of the alloys subjected to prolonged annealing, followed in some cases by quenching.

The eutectic horizontal, E B F, as regards temperature, and also in respect of the position of the eutectic point B, agrees closely with the corresponding line as given by Shepherd, but there is an important divergence between the results of Shepherd and those of the present authors concerning the length of this line. The authors' eutectic line is only drawn as far as a concentration of 78.3 per cent. aluminium (F in the diagram), although in the cooling-curves the eutectic arrest is still noticed down to concentrations of 60 per cent. zinc. The reason for this apparent divergence lies in the fact that the existence of the eutectic beyond the point F is entirely metastable; when alloys lying to the right of that point are heated to 430 deg. Cent. for a considerable time, the eutectic dis-

* Paper read before the Institute of Metals at Newcastle, September 21, 1911.

† Proceedings of the Royal Society and Philosophical Transactions of the Royal Society.

‡ "The Freezing-Points of Alloys Containing Zinc and Another Metal;" Journal of the Chemical Society, vol. lxxi., 1897, page 389.

§ "Aluminium-Zinc Alloys;" Journal of Physical Chemistry, 1905-9, page 504.

‖ "Shrinkage of Antimony;" Journal of the Institute of Metals, No. 2, 1910, vol. iv.

appears entirely both as regards the arrest-point on the cooling-curves and as regards microstructure. Comparative cooling-curves taken at the same rate on ingots cooled slowly direct from fusion, and on others cooled after an exposure of 100 hours to 430 deg. Cent., clearly establish this point.

The estimation of the concentration at which the eutectic disappears was further attempted by the method of measuring the quantities of heat evolved at the eutectic arrests. It must, of course, be borne in mind that even with the special precautions taken in these experiments this method of measuring heat-evolutions is not capable of any great degree of accuracy. By whatever method the quantity of heat is to be estimated, the result depends upon the point which is taken as representing the end of the heat-evolution, and there is no well-defined symptom by which the end of a reaction can be ascertained in taking cooling-curve observations. The authors plotted their observations, taken with special precautions to ensure constancy of cooling rate, &c., in the form of large scale inverse rate curves, and measured the areas of the peaks on these curves. The "end-points" of each of the heat evolutions was inserted by estimation at that part of the curve where the backward sweep which follows the peak proper has nearly reached its full amplitude, the endeavour being made to place these points at corresponding parts of the various curves. The results of these measurements are plotted in Fig. 3 (*a*), and the points thus obtained lie practically on a straight line which cuts the axis of zero heat evolution at a concentration lying close to 78.8 per cent. of aluminium. This result is in close agreement with the concentration at which the most sensitive pyrometer ceases to detect any signs of the eutectic arrest in annealed alloys, and it will appear later than the end of the eutectic line coincides with the concentration of the compound Al_2Zn_3.

Fig. 1.

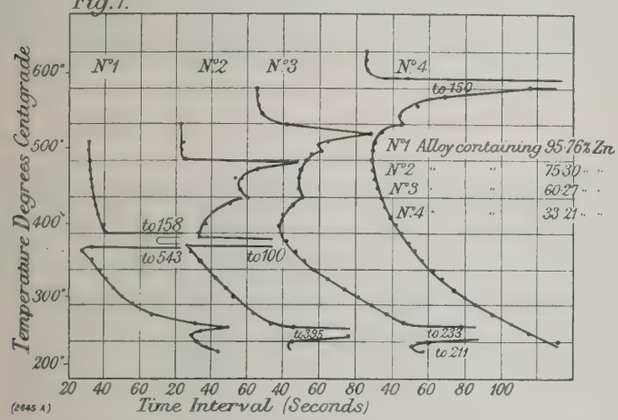
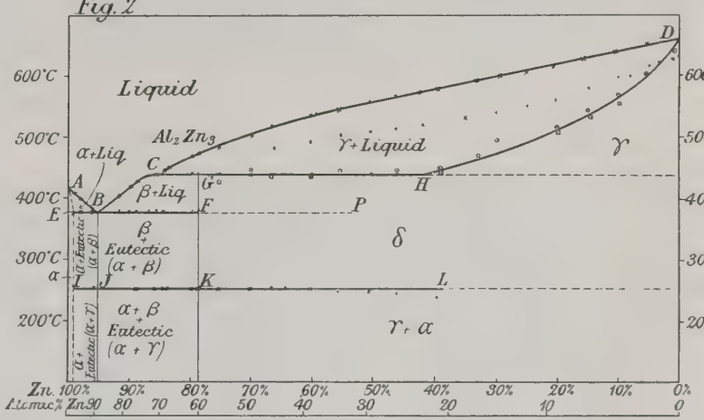


Fig. 2

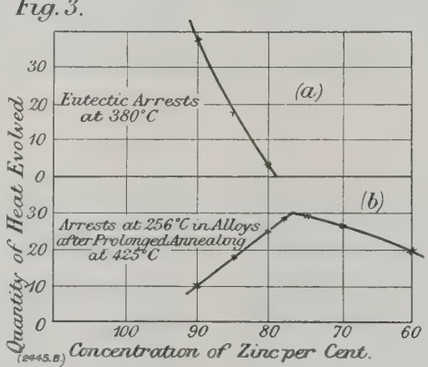


The nature of the heat evolutions along the lines C H and I L of the equilibrium diagram has now to be considered. In view of the fact that some earlier observers have not noticed these heat evolutions at all, it may be remarked that the arrest-points, or rather retardations, along the line C H are decidedly small, and would not be observed except by the aid of delicate apparatus, and, more particularly, would be entirely overlooked if even moderately rapid rates of cooling were adopted. The arrest-points along the lines I L, on the other hand, are decidedly large and well marked, and the only reason why they have not been observed earlier may be sought in the fact that they occur at a comparatively low temperature (256 deg. Cent.), and the cooling-curve observations of earlier workers may not have been pursued down to that region. It is further to be noted that these lower arrest-points, especially beyond the concentration of 85 per cent. zinc, depend upon the extent to which the upper reaction (at 430 deg. Cent.) has been allowed to complete itself, so that with somewhat rapidly cooled alloys these lower arrest-points may also be to some extent suppressed.

The upper line of arrest-points (C H) does not lend itself to detailed thermal study, since the arrest-points themselves are small and lie so close to the arrest of initial freezing that the cooling curve is still in a disturbed condition, rendering heat estimation impracticable. The authors therefore contented themselves with establishing the fact that the heat evolutions along the line C H and those along the line I L were generically connected. This connection was demonstrated by means of a series of comparative cooling curves which showed, for a number of the alloys, that when the rate of cooling through the temperature of the line C H (443 deg. Cent.) was rapid, and the reaction at C H was thereby more or less completely inhibited, then the arrest-point at 256 deg. Cent. was also suppressed, while the same alloy, after annealing at 430 deg. Cent. so as to allow the reaction of the line C H to complete itself, exhibited a very large arrest-point at 256 deg. Cent. This thermal evidence was supplemented by microscopical observations to be described later, the conclusion arrived at being that the line C H represented the formation of a definite compound by a reaction between the solid crystals and the mother-liquid, while the line I L represents the decomposition of this compound. In order to obtain thermal data as to the composition of this compound it was therefore sufficient to study the heat evolutions along the line I L, since the maximum of this line of arrests would coincide with the composition of the compound.

An attempt was first made to study these heat-evolutions by means of observations made on a series of alloys cooled slowly, and at a constant rate, from fusion; this series yielded a curve of heat values giving a well-defined maximum lying at a concentration of about 85 per cent. zinc, thus coinciding with the point C (the break in the liquidus), and not with the end of the eutectic line (F). The reason for this discrepancy becomes evident on considering that to the left of the point C the compound crystallises direct from the molten alloys, while to the right of the point C the compound is only formed by a reaction between solid crystals and a surrounding mother-liquor; now the first stage of such a reaction always results in the formation of sheaths of the compound surrounding the solid crystals, and the completion of the reaction is retarded, since it is dependent upon diffusion through these sheaths. Microscopic evidence has shown these sheaths very clearly, and thus confirms the thermal results. The whole matter, however, serves to illustrate the fact that the method of "thermal analysis" must be applied with considerable caution. In order to avoid the influence of the change in the rate of formation of the compound on the two sides of the point C, a second series of cooling-curves were taken, but on this occasion the ingots of all the alloys were first subjected to a process of annealing at 425 deg. Cent. for a prolonged period (about 100 hours). The resulting curve of quantities of heat evolved is plotted in the curve of Fig. 3 (*b*), which now shows a well-defined maximum lying just above 77 per cent. of zinc. Within the limits of error inseparable from this method, the concentration thus found agrees well with that of the eutectic line and with the composition of the compound Al_2Zn_3 (78.35 per cent. zinc).

Fig. 3.



The demonstration of the fact that the line G H really represents a portion of the solidus curve having been obtained entirely by microscopic evidence will be dealt with in that connection, and the same remark applies to the determination of the position of the solidus curve from H to D. There is, however, another series of small arrest-points which are found on the cooling-curves of the alloys lying between 65 and 0 per cent. of zinc which are plotted in the diagram without being connected with any line, and these require some consideration. It will be seen that they constitute a series of small heat evolutions commencing in the "pure" aluminium at a temperature just below the freezing-point (about 25 deg. Cent.), and ending at a temperature well below 500 deg. Cent. at a concentration of about 65 per cent. of zinc. The "pure" aluminium, however, is far from chemically pure, so that it still remains doubtful whether such a heat evolution would occur in the entire absence of impurities. The difficulty in regarding these points as arising from an allotropic transformation of aluminium lies in the circumstance that they occur at varying temperatures throughout a two-phase region. Now in such a region the solid phase which is, at a given temperature, in equilibrium with the liquid, possesses a constant concentration throughout the region, and even if the transformation of the solid phase in question be depressed in temperature by the addition of zinc, yet this condition of constant concentration also implies a constant temperature of transformation of the solid phase. Now the fact that the transformation occurs in the solid and not in the liquid phase is proved by the definite occurrence of at least two observed heat evolutions of this series in a region where the alloys are already completely solid. The only inference which the authors would suggest is that this series of small heat evolutions is dependent upon the action of a third component, such as one of the impurities (iron or silicon) which are always present in the aluminium, so that this line of arrest-points may be regarded as belonging rather to the outer edge of a ternary diagram than to the binary diagram of aluminium and zinc.

Microstructures of the Alloys.—Reference has already been made to the fact that the equilibrium diagram of Fig. 2 is largely based on microscopic evidence supplementing the thermal data. The description of the microstructures of the alloys will therefore be given from this point of view.

At the zinc end of the diagram (Fig. 2) we have first a narrow area marked α; the α meteral is either pure zinc or a solid solution of zinc containing aluminium—or more probably a compound of zinc and aluminium. The limits of this solid solution have not been exactly determined, but an alloy containing only 1 per cent. of zinc still shows signs of the presence of eutectic after annealing for twenty-four hours at a temperature just below the freezing-point of the eutectic. Unless the rate of solution is extremely slow, therefore, the limit of solid solubility lies within 1 per cent. of aluminium. In the diagram the line representing this limit has only been dotted, and is drawn —for convenience—further from the zinc end than the results indicate.

Immediately below the portion A B of the liquidus we have the usual region of α + liquid, and below this again the usual region of α embedded in a typical eutectic. Above the line I J the constituents of this eutectic are the two phases α and β, but below that line they are shown as α and γ. Under moderate magnifications, the alloys of this region, whether slowly cooled or quenched from a temperature above I J, exhibit the typical appearance of a eutectiferous alloy, but under higher magnifications it is seen that in the case of alloys quenched from a temperature above I J, the dark-etching constituents of the eutectic (β) are quite homogeneous; in alloys slowly cooled through I J, however, the dark-etching constituent of the eutectic has become distinctly duplex. This feature is illustrated in Fig. 4, page 440, where the eutectic is shown under a magnification of 1000 diameters.

The thermal and microscopic data agree in placing the eutectic point at a concentration of almost exactly 5 per cent. of aluminium. The typical structure of this eutectic is shown in Fig. 5, page 440, under a magnification of 2000 diameters. It will be seen that the relative areas of the two constituents of this eutectic are not very different, in spite of the fact that the eutectic point lies so near the zinc end of the series. This fact arises from the presence of a large proportion of zinc in the dark-etching constituent, and points with some degree of probability to the existence of a definite compound in the series.

To the right of the eutectic point (95 per cent. zinc) the diagram shows a region of β + eutectic above the line J K, and of α + γ below that line. The typical structure of the β + eutectic region is shown in Fig. 6, page 440, The six-rayed dendrite of the β meteral there shown is characteristic of the strongly-marked tendency of this body to assume six-rayed forms and to exhibit dendrites having 60 deg. angles, thus differing markedly from most metals, which usually exhibit 90 deg. and 45 deg. angles in their dendrites. This characteristic feature is in itself evidence that the β body is a definite compound. The close relation between the dendrite and the dark-etching constituent of the eutectic is clearly shown in the photograph, where the eutectic crystallisation appears to radiate from the arms of the dendrite.

If an alloy of this group (*i.e.*, lying between 95 and 85 per cent. of zinc) is allowed to cool slowly in the ordinary way, a careful examination of the "β" crystals reveals the fact that this substance exhibits a duplex structure; by prolonged annealing at a temperature just below that of the line J K (256 deg. Cent.) this duplex structure can be rendered very apparent, the "β" body then assuming a structure which, in its laminated appearance, closely resembles an ordinary fine-grained eutectic or the "pearlite" of a slowly-cooled carbon steel. This duplex character of the slowly-cooled or annealed alloys is shown in Fig. 7, page 440, under a magnification of 450 diameters. The same alloy, quenched from a temperature above 256 deg. Cent. shows the β body to be perfectly homogeneous. This microscopic evidence, there-

fore, shows that the reaction along the line I J K represents the decomposition of the β phase into two phases, and phase-rule considerations make it plain that these two phases must be the α and γ phases occurring in other adjacent fields of the diagram.

Along the branch B C of the liquidus, the β meteral crystallises direct from the fusion, but to the right of the point C the crystals first deposited consist of the γ meteral, and according to the diagram the γ body reacts with the residual liquid at the temperature of the line C H to form the β phase, the first result of such an action will be the formation of sheaths of β around the original γ crystals, while these again will be embedded in eutectic, derived from the residual liquid. When the alloy in question lies to the left of the concentration of the pure β body, the residual liquid will remain in a stable condition down to the eutectic line, and will then soldify as stable eutectic, and this condition is found in the alloys lying in the region between the points C and G; to the right of G, however, stable equilibrium would require the complete absorption of the mother-liquor by the reaction:—

$$\gamma + \text{liquid} = \beta;$$

but in ordinary cooling this is not attained, and some residual liquid reaches the eutectic temperature, and remains as metastable eutectic. Prolonged annealing at a temperature just below G H (443 deg. Cent.), however, results in the complete absorption of the residual liquid.

The microscopic evidence entirely confirms these deductions from the diagram, although only a few of the most typical of the resulting structures can be shown here.

The formation of sheaths by the reaction along the line C G H is illustrated in Fig. 8, above, under a magnification of 150 diameters, representing an alloy containing 84 per cent. of aluminium cooled from fusion down to a temperature just above 256 deg. Cent. (I K L) and quenched; this quenching has prevented the decomposition of the sheath of β, which thus remains homogeneous. In Fig. 9 we have the same alloy, after annealing just below 443 deg. Cent. and quenched above 256 deg. Cent. This process has allowed the reaction

$$\gamma + \text{liquid} = \beta$$

to be completed, while the subsequent quenching has prevented the decomposition of the β meteral at 256 deg. Cent. We thus have homogeneous β surrounded by eutectic, but the latter appears white in the photograph in consequence of the segregation which the heat treatment received by the specimen has caused in the eutectic. Finally, in Fig. 10, below, we have the same alloy so treated that first the formation of β was completed, and then again annealed just below 256 deg. Cent., so as to allow of the complete decomposition of the β body. The laminated duplex structure is clearly seen in the photograph.

The next step in the microscopic evidence lies in the determination of the fact that after attainment of equilibrium the alloys to the right of the point G are completely solid immediately below the line G H. This evidence was obtained by a series of experiments in which specimens of the alloys were first annealed for a prolonged period at a temperature just below 443 deg. Cent., and were then quenched and examined under the microscope, duplicate experiments being made at a temperature just above the line G H. The results are indicated in the diagram by means of dots surrounded by small circles and squares respectively. The circles indicate that microscopic examination of the quenched specimens showed the well-known microscopic features due to the presence of minute traces of liquid metal at the moment of quenching, while the squares indicate the complete absence of these features. These results definitely establish the fact that when equilibrium is attained the alloys are entirely solid below the line G H. The same kind of observations were employed to determine the position of the curved portion of the solidus H D.

The evidence just described has been completed by examining a series of the alloys lying near the concentration of the point G in order to ascertain the limit of the presence of eutectic in alloys which have attained equilibrium. In an alloy containing 80 per cent. of aluminium even very prolonged annealing did not entirely remove the microscopic signs of the presence of eutectic, as shown in Fig. 11, below, while in an alloy containing 77 per cent. of aluminium the eutectic disappeared completely after moderately prolonged annealing, as shown in Fig. 12, below. These results taken together form strong confirmation of the thermal evidence to the effect that the β body is the definite compound Al_2Zn_3, whose concentration is given by the line G F K. To the right of the concentration of the pure β meteral we find a region, marked δ in the diagram, in which the alloys, when annealed below the line G H and quenched above the line K L, are completely homogeneous, resembling the photo-micrograph of Fig. 12. This result indicates that the β meteral forms a series of solid solutions with aluminium (or γ), and for a considerable distance to the right of the point K the decomposition of the β body entering into this solid solution can be definitely traced both thermally and by the microscope, but to the right of the point L in the diagram even the most sensitive pyrometer fails to detect any heat evolution, while the microscopic evidence also becomes inconclusive, owing to the difficulty of preparing a polished surface of these very soft alloys sufficiently perfect to make a distinction between slight surface irregularities and slight decomposition clearly evident. For that reason the line K L has been continued tentatively as a dotted line, the same course being adopted with the line representing the formation of the β compound. The question arises down to what concentration such a compound exists in a solid

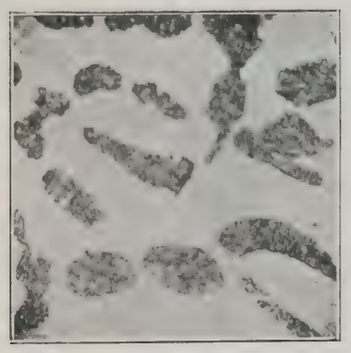


FIG. 4.

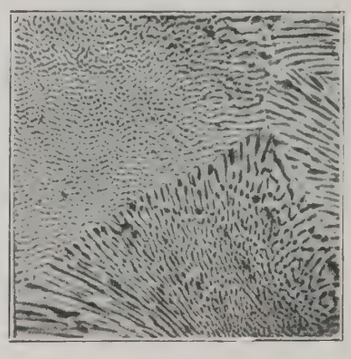


FIG. 5.

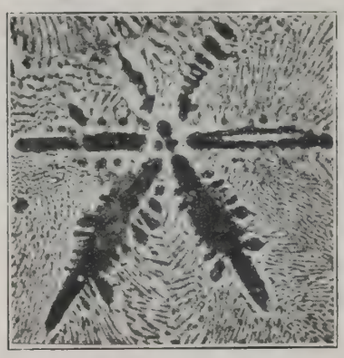


FIG. 6.

FIG. 7.

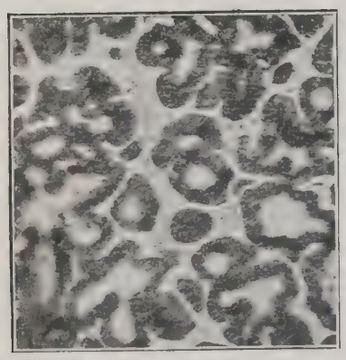


FIG. 8.

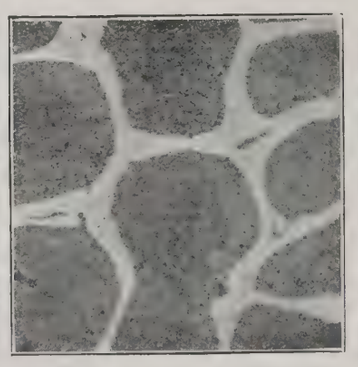


FIG. 9.

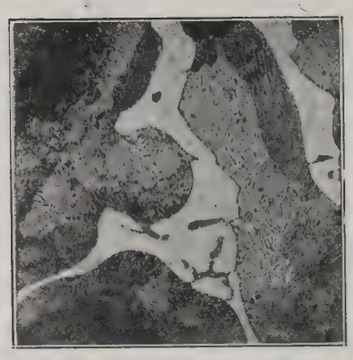


FIG. 10.

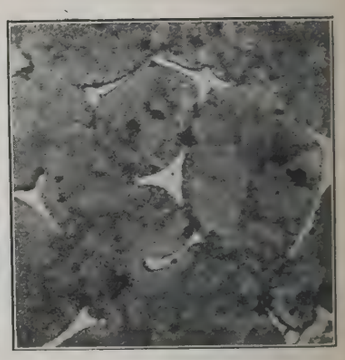


FIG. 11.

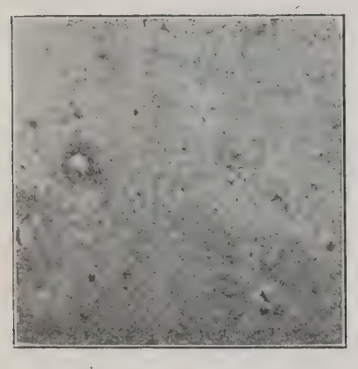


FIG. 12.

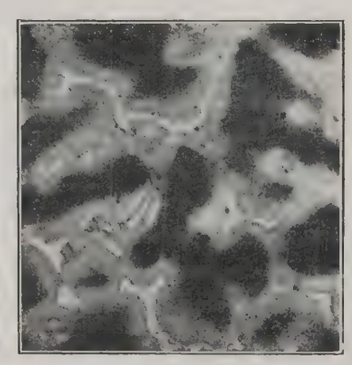


FIG. 13.

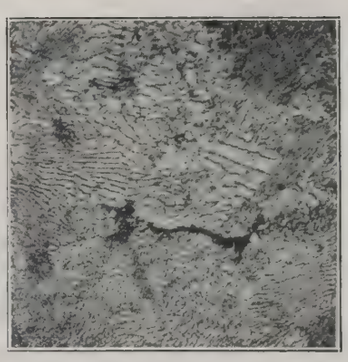


FIG. 14.

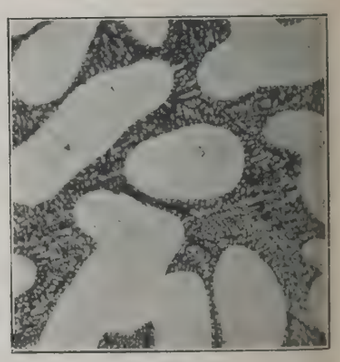


FIG. 15.

solution as a compound—in fact, how dilute such a solid solution must be in order that the compound may be completely dissociated. This is a point which could perhaps be determined by other methods of investigation, but does not lend itself to thermal or microscopic study.

To the left of the points H and L, however, both the formation and decomposition of the β compound can be very clearly traced by the microscope. Thus in the case of an alloy containing 75 per cent. of aluminium, Fig. 13 (150 diameters), page 440, shows the structure resulting from ordinary slow cooling from fusion; the microstructure shows central very dark-etched cores of the original γ body, surrounded by sheaths of β which have become decomposed on further cooling, and the whole embedded in metastable eutectic, appearing white in the photograph. The same alloy, rendered homogeneous by annealing at a temperature just below that of the line G H, and retained in this condition by quenching from a temperature just above 256 deg. Cent. (K L), is illustrated by the photomicrograph of Fig. 12. The decomposition of this homogeneous structure resulting from annealing just below 256 deg. Cent. is shown in Fig. 14, page 440, where the duplex laminated structure is well developed. In Fig. 15 (200 diameters), page 440, is shown the appearance of this alloy after being heated at 473 deg. Cent. for 30 minutes and then quenched.

Summary.

The results of the thermal and microscopic investigation of the alloys of aluminium and zinc are embodied in the equilibrium diagram given in Fig. 2. This diagram differs from that given by Shepherd and others in showing two horizontal lines of heat evolutions, lying at 443 deg. and 256 deg. Cent. respectively, the former cutting the liquidus curve at a concentration close to 85 per cent. of aluminium, where a small break occurs in the liquidus. The eutectic line has been shown to end in alloys which have attained equilibrium, at a concentration near 78 per cent. of aluminium, while the maximum of the heat evolutions at 256 deg. Cent. has also been shown to lie near this concentration. These facts, together with microscopic data, lead to the conclusion that the heat-evolutions at 443 deg. Cent. represent the formation of the definite compound Al_3Zn_3 (called β in the paper), while the heat-evolutions at 256 deg. Cent. represent the decomposition of this substance. The β compound is incapable of dissolving zinc, but forms an unbroken series of solid solutions with aluminium. The exact position of the solidus curves has been determined by quenching experiments, and has been found to accord with the equilibrium diagram as given above.

The researches described in this paper have been carried out in the National Physical Laboratory (metallurgy department), and the authors desire to express their thanks to various members of the staff who have assisted them, and especially to the director, Dr. R. T. Glazebrook, C.B., F.R.S., for his interest in the work.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a list of colonial and foreign engineering projects, for some of which tenders are asked. Further information concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Queensland: The Commercial Intelligence branch of the Board of Trade is in receipt of a copy of the report of the Board of Inquiry which was appointed in March last by the Queensland Government to inquire into and report upon the question of a harbour scheme for the port of Mackay. The Board of Inquiry are of opinion that the construction of an outer harbour at Flat Top Island, with connection with the mainland, will meet the requirements of the case. They therefore recommend the construction of two breakwaters, and of one or more jetties for berthage projecting out from the island between the breakwaters; and also the construction of a viaduct, in reinforced concrete, connecting the island with the mainland.

South Africa: H.M. Trade Commissioner reports that the Works Committee of the Johannesburg Municipal Council recommend the invitation by the Council of tenders from South Africa and abroad for the laying of asphalt or other superior paving material in the roads within the central area of the town, up to a minimum of 100,000 square yards; the material is to be laid on a foundation of cement concrete 7 in. thick. It is also recommended that tenderers should be required to give the following particulars:—The nature of the material proposed to be used, and its thickness; the period over which they are prepared to guarantee the material, and to maintain the roads in a satisfactory condition; the price per square yard for (*a*) laying, and (*b*) maintaining for a period of not less than twenty years; the method of payment required; the time required to complete the work.

Spain: The *Gaceta de Madrid* of September 10 contains a decree to the effect that tenders will be opened on December 12 at the offices of the Dirección General de Obras Públicas, Ministerio de Fomento, Madrid, for a concession for completing the construction of, and working, a railway from Avila to Salamanca, passing by way of Peñaranda de Bracamonte. A deposit of 52,862 pesetas (about 1960*l.*) will be required to qualify any tender. The minimum amount of rolling-stock required for working the railway will consist of three passenger and five goods locomotives, together with eight tenders, 29 passenger coaches, 22 goods wagons, and 12 brakes. Local representation is necessary. The *Gaceta* of September 11 contains a notice, issued by the Ministerio de Fomento, granting to the Sociedad Anónima Tranvía de Orihuela, of Orihuela, a concession for the construction and working of a steam tramway from Orihuela to Crevillente. The *Gaceta* of September 14 contains a notice, issued by the Ministerio de Fomento, granting to the Compañia Norte Central Español Bilbao Vitoria y Extensiones a ninety-nine years' concession for the construction and working of a railway which, starting from Villarreal (Alava), will join the Bilbao-Durango line at Lemona. The rolling-stock required will consist of six locomotives with tenders, four brake-vans, twenty passenger-coaches, and sixty goods wagons. The *Gaceta* of September 16 publishes a notice, issued by the Ministerio de Fomento, granting to the Compañia del Ferrocarril del Tajuña a period of twelve months in which to draw up and present plans for the construction of a secondary railway from Colmenar de Oreja to Villarejo de Salvanés.

Turkey: With reference to the notice on page 416 of the *Board of Trade Journal* of August 31, relative to a call for tenders for the supply of a steam-tug required by the Heraclea Company for use in the Black Sea, the British Acting Consul-General at Constantinople (Mr. A. T. Waugh) reports that the tug in question is required not for the Heraclea Mining Company, but for the Administration des Mines, a Government department. He adds that no final date has been fixed for the receipt of tenders, nor is it clear whether tenders are invited or a private sale contemplated. For further particulars application should be made to the Direction Générale, Administration des Mines, Constantinople. (Local representation is practically indispensable in the case of Turkish Government contracts. A list of British commission agents established in Constantinople may be obtained by British firms on application to the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C.)

Italy: The *Gazzetta Ufficiale* (Rome) of September 9 notifies that tenders will be opened on October 1 by Il Signor Sindaco, Palazzo Municipale, Trinitapoli, for draining the subsoil of Trinitapoli. The upset price is put at 288,000 lire (11,520*l.*), and a deposit of 14,000 lire (560*l.*) will be required to qualify any tender.

Brazil: The *Diario Official* of August 25 publishes a decree (No. 2430) earmarking, in favour of the Ministry of Justice and Home Affairs, an extraordinary credit of 2,363,336 milreis (about 158,000*l.*) for the purpose of completing the building of police cavalry barracks in the Avenida Salvador de Sá, Rio de Janeiro. The same issue of the *Diario* contains a decree (No. 8918) opening, in favour of the Ministry of Communications and Public Works, a credit of 400,000 milreis (about 27,000*l.*) for the purpose of carrying out surveying operations in connection with the proposed extension of the Bahia Railway system. The *Diario* of August 29 notifies that tenders will be received up to November 28, at the offices of the Directoria Geral, Ministerio da Viação e Obras Publicas, Rio de Janeiro, for the carrying out of important harbour works at Jaraguá, in the State of Alagoas, the cost of which is fixed at 11,700,000 milreis (about 780,000*l.*). The form of contract also contains provisions for the working of the harbour on terms stipulated. The works include the construction of wharves, docks, breakwaters, a bridge, railway lines; also dredging; and the provision of 3 locomotives, 30 wagons, 6 movable electric cranes, each of 1½ tons carrying capacity, and of one fixed 30-ton crane, and an electric lighting installation. The work must be commenced within 10 months after the signing of the contract, and be terminated by December 31, 1915. A sum of 40,000 milreis (about 2700*l.*) must be deposited with the National Treasury before tenders are submitted; but, if desired, this amount may be deposited with the Brazilian Treasury authorities in London, when notification thereof will be telegraphed to Rio. The above-mentioned deposit must be increased to 80,000 milreis (about 5300*l.*) by the successful tenderer. Local representation is necessary.

Uruguay: H.M. Vice-Consul at Montevideo (Mr. H. Hall Hall) reports that the municipal authorities of that place are about to invite tenders for the paving of some 80,000 square metres of the streets of the city. The material to be used is to be natural or artificial asphalt. The value of the contract is estimated at about 148,000*l.* A deposit of 5000 pesos (about 1064*l.*) will be required with each tender, to be increased by the successful tenderer to 10 per cent. of the accepted contract price. No date has yet been announced for the receipt of tenders.

Venezuela.—His Majesty's Vice-Consul at Caracas (Mr. G. B. Gilliat-Smith) reports that a contract has been entered into between the Venezuelan Government and General Delgado Chalbaud for the construction of a system of sewers, the laying of new paving, and the extension and purification of the water supply at that town.

Hayti.—The *Bulletin Commercial* (Brussels) of September 16 notifies, on the authority of the Belgian Legation at Port-au-Prince, that concessions have been granted:—(1) For the construction of a railway, 140 miles long, from Leogane to Cayes, including various branch lines; and (2) for the erection of hydro-electric works designed to supply electric power to the railway which runs from Port-au-Prince to Piéton Town, a distance of 5 miles, and to the Port-au-Prince tramways, which have a length of 11 miles.

China: The Acting Commissioner of Customs at Hankow, in his report for 1910, states that great progress has been made by the Yangtze Engineering Works. The prediction that these would become a most important undertaking is being quickly verified, and it is an excellent instance of what efficient Chinese management can do. It has executed a number of big orders for steel tugs and lighters, bridges, and general structural steel work, as well as repairs. It has on the stocks a steel tugboat of 120 ft. and 600 horse-power for the iron-works, and two of 115 ft. and 500 horse-power for the Pingsiang Colliery, and several lighters and pontoons. A new slipway for docking vessels up to 125 ft. has been built, the workshops have been enlarged, and a general extension of the works is being carried out, as orders have frequently had to be declined. A paper mill, capable of turning out 30 tons a day, is being erected by the Government at a cost of 2,000,000 taels (about 268,000*l.*). The machinery came from the United States of America and from the United Kingdom. The paper is to be made from rags, straw, and bamboo, and a considerable amount of resin and china clay will be needed. A large portion of the product will be bank-note paper. It is intended entirely to supply the Government printing establishment at Pekin. In the summer of 1910 the Hupeh cement works put their product on the market. The works are at Tayeh, and are thoroughly up-to-date. The raw material is excellent, and the finished article has been submitted to severe tests. As it can undersell the cheapest imported cement, it has met with strong demand, and should do good work in supplying local needs. The nail and needle factory has been a disappointment, as it has been worked at a loss. Electric light is in such demand that the electric lighting company finds it necessary to erect a second plant. A scheme is on foot for the establishment of water-works in Wuchang.

The Value of Norway's Water-Power.—Norway is estimated to possess an aggregate water-power suitable for exploitation representing, when duly utilised, a total of 4,000,000 constant horse-power all the year round, and in addition 1,500,000 horse-power can be reckoned with during three-fourths of the year. Consequently Norway has 45,000,000,000 horse-power hours per year, representing in coal about 30,000,000 tons. Putting the value of coal at 16s. 8d. per ton, the above aggregate of hydraulic horse-power hours represents a sum of 20,000,000*l.* annually.

The Exhaust Gases from Gas-Engines.—The effect of the exhaust gases on guinea-pigs and mice was observed by Professor Dr. S. Delépine, with the engine working under varying conditions of load and of air and gas supply. With the engine fully loaded, the exhaust was free from poisonous gases, but was dangerous to human beings owing to the large proportion of carbon dioxide and the absence of oxygen. When the air supply was insufficient for complete combustion, the exhaust contained up to 4½ per cent. of carbon monoxide, and was dangerous for inhalation when diluted with less than 50 volumes of air. Insufficiency of air supply may arise from trivial causes, such as partial blocking of the air-pipe. It is recommended to public authorities that the discharge of exhaust gases into sewers should be forbidden, and the discharge into any confined space to which persons have access should be avoided.

Large French Harbour in Iceland.—For some time there has been a question of constructing a harbour in Iceland by French capital, and the plan now appears to be approaching its realisation, the very substantial capital now having been secured. The new harbour is to be at Thorlakshäfn, close to the settlement of Eyrarbakki, in South Iceland. Several French engineers have been spending the summer in Iceland making the necessary surveys. The new harbout is being built for the benefit of the large French trawling fleet, which has hitherto had to go right round to Reykjavik, which means a loss of time amounting to five or six days. This time can now be saved by the new harbour, where there will be large coal and salt dépôts, provision stores, up-to-date appliances for discharging and storing, &c. The French syndicate, which is understood to have a capital of some 4,000,000*l.*, also intends to trade in fish and agricultural produce on a very extensive scale. The scheme, which also comprises the construction of a railway into the country, will, if realised to its full extent, prove a very serious rival to the new harbour at Reykjavik now about to be constructed, to which the Iceland Parliament has recently voted a grant of 400,000 kr.

Shipbuilding in Austria.—On September 9 there was launched from the shipyard of Messrs. Cosulich Brothers, at Monfalcone, Austria, a large twin-screw passenger steamer, the Kaiser Franz Josef I., for Messrs. Cosulich's passenger and emigrant service between the Mediterranean and America. Special interest attaches to the launch of this vessel as being the largest and finest built yet in Austria. The christening and launching ceremony was performed by her Imperial and Royal Highness the Archduchess Maria Gioseffa, there being present H.R.H. the Princess of Saxonia and other representatives of the Austrian Court and State. The vessel, which is expected to attain a speed of about 19 knots, is in length 500 ft.; breadth, 62 ft.; depth to shelter-deck, 42 ft. 9 in.; depth to boat-deck, 69 ft. 9 in.; displacement, 16,500 tons at 26 ft. draught: gross register, 12,500 tons; dead-weight capacity at 26 ft. draught, 7500 tons. The propelling machinery, designed and constructed by Messrs. David Rowan and Co., of Glasgow, consists of twin-screw quadruple-expansion engines, balanced on the Yarrow-Schlick-Tweedy system, capable of indicating 13,000 horse-power, and having six double-ended and one single-ended boilers, all fitted with Howden's forced draught. The auxiliaries include Weir dual air-pumps, automatic feed-pumps, bilge-pumps, sanitary pumps, &c. There are two refrigerating-engines and a complete system of cold-storage rooms for beef, fish, vegetables, wines, &c. Among other work the firm has on hand is the construction of a 9600-ton dead-weight cargo steamer, a steamer of 11,000 tons dead-weight, and two steamers, each of 8000 tons dead-weight, besides six smaller vessels. This busy yard sprang into existence, and built their first vessel, only three years ago; their general manager is Mr. James Stewart.

CATALOGUES.

Arc Lamps.—From the Globe Electric Company, Limited, 11, Farringdon-avenue, E.C., we have received a pamphlet dealing with arc lamps for photographic purposes. The list gives prices and full particulars of lamps suitable for portraiture, copying, process work, blue-printing, and other purposes.

Gear Wheels.—From Greenwoods' Standard Gear-Cutting Company, Limited, of New Bond-street, Halifax, we have received a price-list of machine-cut gear wheels. Prices are quoted for batches of spur wheels with 20 to 120 teeth of 5, 6, 7, 8, 10, and 12 diametrical pitch, and also for sets of change wheels and metric wheels. The teeth of all these wheels are of Brown and Sharpe's involute form.

Second-Hand Rolling-Stock and Machinery.—We have received from Mr. John F. Wake, of Geneva Wagon and Engineering Works, Darlington, a copy of a list of second-hand machinery, plant, and rolling-stock for sale, hire, or exchange. The list, which is arranged alphabetically, gives brief particulars, with prices, of air-compressing plant, cranes and steam-navvies, steam-engines and boilers, gas-engines, electrical machinery, machine-tools, pumps, locomotives, wagons, railway material, and a variety of miscellaneous machinery. Illustrations of several of the items are included.

Sewage Disposal Apparatus.—We have received from Mr. W. E. Horsman, "Rosewyn," Pendle-road, Streatham, S.W., the London representative of Messrs. George Waller and Son, of Stroud, Gloucestershire, a pamphlet relating to "E.F.B." automatic apparatus for use in connection with the bacterial treatment of sewage. The pamphlet deals with a cylindrical revolving screen or strainer, an alternating device for controlling the flow of liquor to and from contact beds, and a sewage distributor operating on the Barker's mill principle. The apparatus is illustrated and fully described, and the special features of each part are pointed out.

Grinding-Wheels, &c.—We have received from Messrs. Buck and Hickman, Limited, 2 and 4, Whitechapel-road, E., a catalogue of "A.E.W." grinding-wheels and specialities. These wheels are made of Canadian corundum by the American Emery Wheel Works. Vitrified, silicate, and elastic wheels are supplied in grades suitable for all purposes. The catalogue gives particulars and states prices of ordinary wheels, cup-wheels, cylinders, and wheels of special shapes for use on grinding-machines, tool and cutter-grinders, &c. Prices are also stated for ring-wheel chucks, wheel-dressing tools, rubbing-bricks, sticks, slip-stones, &c.

Dynamos and Motors.—The Electrical Company, Limited, 122 to 124, Charing Cross-road, W.C., have sent us a copy of their latest list of standard direct-current dynamos and motors. This list deals with machines from the smallest size up to 100 brake horse-power. Many of the sizes listed are kept in stock for immediate delivery, and the particulars of these machines are printed in heavy type in order to distinguish them. Full particulars, including specifications, prices, and dimensions of the machines are given, and instructions for setting them up and running them are also included. Prices are quoted for spare parts, and for accessories, such as shunt regulators, starters, &c. Particulars are also included of motor-generator sets and rotary converters for cinematograph work, &c.

Wireless Telegraphic Apparatus.—Messrs. Siemens Brothers and Co., Limited, Caxton House, Westminster, S.W., having obtained the rights, in the United Kingdom, and some of the colonies, for the "Telefunken" system of wireless telegraphy, have issued a pamphlet dealing with the origin and development of this system. The pamphlet also illustrates and fully describes all the apparatus, and gives particulars of standard installations ranging in size from a small set for use on lightships, trawlers, &c., to one in which the oscillating energy of the antenna is 25 kw., the latter size being suitable for large land stations. Particulars are also given of portable military stations. Numerous installations of widely varying capacities are illustrated, and data relating to the power and range of some of them are included.

Universal Machine-Tool.—A pamphlet containing full particulars of the Drummond-Barreto universal machine for turning, boring, drilling, screw-cutting, milling, and gear-cutting, has reached us from Messrs. Drummond Brothers, Limited, of Guildford, who have designed and built the machine from the sketches and specifications of Baron Barreto for repair-work on his steam-yacht. The firm is now putting this machine on the market for use on steamships or in motor-garages, repair-shops, factories, &c., where there is insufficient work to warrant the installation of separate tools to perform the above-mentioned operations. The pamphlet illustrates the tool, contains a specification, and gives the principal dimensions; prices are also stated. This machine was illustrated and described in ENGINEERING of September 2, 1910, on page 332.

Loud-Speaking Telephones.—A leaflet relating to their water-tight, loud-speaking, marine-type telephones, has come to hand from Messrs. Siemens Brothers and Co., Limited, Caxton House, Westminster, S.W. These instruments are manufactured in two types, known respectively as the ordinary type and the engine-room type. Those of the latter type, being intended for use in very noisy situations, are each provided with two movable car-trumpets, which can be held close up to the ears of the user. The ordinary instruments have only one fixed trumpet or receiver. This type can be supplied mounted in a box supported on a column for use on deck. With both types a bell or indicator, or both, may be used for calling up. The firm states that in these instruments the loud speaking is not obtained by using large currents in the microphone, but by means of the system of connections, and by special construction of the microphone.

Superheated-Steam Engines.—We have received from the firm of Mr. R. Wolf, of Magdeburg-Buckau and Salbke, whose London address is Norfolk House, 7, Laurence Pountney Hill, E.C., a copy of a catalogue illustrating and describing the latest types of their well-know superheated-steam locomobiles. These engines, one of which was illustrated and described in our issue of October 8, 1909, on page 478, are made in a great range of sizes from 12 to 800 horse-power. The catalogue, after fully describing the construction of the engines and boilers, and explaining their special features, gives general particulars of the various types made, which include single-cylinder engines, compound condensing and non-condensing engines, and portable engines. A few types without superheaters are listed for use in cases where fuel economy is of secondary importance. The boilers can, if desired, be fitted with mechanical stokers or arranged for burning oil-fuel. The catalogue also illustrates special furnaces for burning inferior coal, wood-chips, shavings, tan-bark residue, and other waste fuels.

Roller Chains and Sprockets.—From Messrs. Hans Renold, Limited, Progress Works, Brook-street, Manchester, we have received a copy of a sectional catalogue devoted to their bush and roller chains and sprockets for power transmission. These chains are made in four standard series, known as short, medium, and long pitch and extra strong. The three latter classes are derived from the short-pitch chains by increasing or decreasing the pitch of the side plates without altering the dimensions of the studs, bushes, and rollers. Full particulars, with prices, are given of the different sizes made in each series. Prices are also quoted for component parts, joints, and repair parts. The catalogue contains much information intended to serve as a guide to customers in the selection of chains suitable for their requirements, and also includes numerous useful notes on installing, running, and repairing them. Another useful feature included is a diagram, by means of which the working load for a chain under various running conditions can be very easily determined. Prices and particulars are given of sprocket-wheels for use with these chains, and also of milling-cutters for cutting the teeth on customers' own blanks.

Ventilators.—Two circulars, illustrating and stating prices of Morgan's patent mushroom type ventilators for steamers, railway trains, &c., have been received from Messrs. H. D. Morgan and Co., 12, Jordan-street, Liverpool. The ventilator consists of a flanged tube of cast iron or brass, fixed to the roof of the apartment to be ventilated, and containing another casting in the shape of a small tube with four radially projecting plates. The inner casting extends above the top of the outer tube, and is surmounted by a dome, which is held in place by a bolt passing through the small central tube. The dome is somewhat larger in diameter than the outer tube, the whole arrangement of the upper part being such that a current of fresh air is led down into the room from the windward side, while a similar quantity of foul air is extracted from the leeward side. One circular states prices for ventilators from 3 in. to 8 in. in diameter in cast iron or brass, or with brass domes, and mentions that larger sizes are made in wrought iron. The other circular deals with special ventilators for railway carriages. They are of similar construction to those previously described, but are provided with Clayton's patent blizzard-proof and cinder-proof screens.

Gas-Engines and Suction-Gas Plants.—We have received from the Dudbridge Iron Works, Limited, of Stroud, Gloucestershire, a copy of their catalogue of gas-engines and suction-gas producers. The catalogue contains a general description, with illustrations, of single-cylinder engines, which are made in twelve sizes, ranging from 15 to 120 brake horse-power. Two types are made, for ordinary purposes and for electric lighting, respectively. These engines are regulated on the variable-admission principle, the governor controlling the lift of the combined gas and air-valves, so that the quantity of explosive mixture drawn into the cylinder is proportional to the load. A working stroke is thus obtained in every cycle. Ignition is by low-tension magneto, and the sparking plug is provided with a thick glass window, to enable the attendant to observe the spark while the engine is running. Special attention has been given to the matter of lubrication, the arrangements being such that the engines are capable of running continuously for long periods. The catalogue also illustrates and describes the Dudbridge suction-gas producers, for use with anthracite, coke, or charcoal, and gives particulars of fourteen sizes, suitable for engines ranging from 3 to 225 brake horse-power.

Sugar Machinery.—Messrs. George Fletcher and Co., Limited, of Masson and Atlas Works, Derby, are issuing a revised catalogue of their machinery and apparatus for the manufacture of cane sugar, and have sent us a copy of the first section, which deals with machinery for the extraction of the juice. The catalogue first gives general particulars of standard steam-engines for outputs ranging from 8 to 710 horse-power at 100 lb. pressure. These are followed by particulars of single crushing mills, Krajewski crushers, and crushing mills arranged in series with preliminary crushers, the necessary heavy gearing being also dealt with. A large number of small plans are included to show how the mills, engines, and gearing may be arranged. The mills can be fitted with either hydraulic or spring-toggle pressure regulators, particulars of both types being given, as well as of pressure pumps and accumulators for use with the hydraulic type. The catalogue also deals with accessory apparatus such as feed and delivery tables, cane carriers, megass carriers, mechanical juice strainers, juice pumps, &c. For the convenience of foreign clients, the particulars given include weights and shipping dimensions of each piece of machinery; every facility is also given to enable telegraphic inquiries to be made.

Gas-Producer.—From Messrs. Smeeton and Brewer, 56, Victoria-street, Westminster, S.W., we have received a pamphlet illustrating and describing the Rehmann gas-producer, for which they are the sole British licensees and manufacturers. This producer is fitted with a revolving grate and an arrangement for automatically removing the ashes and clinkers. It is claimed to be able to work continuously with low-grade coals of all kinds, with the minimum production of CO_2. The special feature of the grate is the nature and arrangement of the air and steam inlets. These consist of four conical projections provided with annular slots through which the air and steam pass. Downwardly-extending flanges are provided over the slots to prevent them from becoming blocked up. The four cones are situated at the centre and apices of an equilateral triangle, the middle one being a small distance away from the axis of rotation of the grate. Thus all four cones describe circles of different radii, and in doing so thoroughly stir the fuel in the lower part of the producer, thereby preventing it from caking, and effectually removing the ashes and clinkers. These fall into a water-trough surrounding the grate, and are continuously removed from this trough by an automatic device. The pamphlet also illustrates Rehmann's automatic charging apparatus, which has been designed to distribute the coal uniformly over the whole surface of the producer.

Dynamometers.—Messrs. Heenan and Froude, Limited, of 4, Chapel-walks, Manchester, have sent us a copy of a pamphlet issued by them, relating to the Froude water-dynamometer. This dynamometer is of the absorption type, and is largely used for measuring the power developed by engines, turbines, motors, and other prime movers. It consists essentially of a rotor mounted on a shaft, and arranged to rotate inside a stationary casing containing water. The rotor is in the form of a disc, having an annular channel of semi-elliptical section on each end-face, and these channels are divided into numerous compartments by means of oblique vanes. The inner faces of the casing are of similar formation, and only a small space is left between the stationary and moving vanes. When the rotor is driven by the engine under test, the water, being set in motion by the rotating vanes, tends to turn the casing, which is mounted on friction rollers and provided with a balanced lever, so that the turning moment thus exerted can be measured. The power absorbed is expended in heating the water, which is supplied to the casing through flexible pipes at the rate of about two gallons per horse-power hour. The brake is controlled by the water inlet and outlet valves, it being possible to vary the power absorbed at any speed from practically nothing to the maximum capacity. Ten standard sizes are made for speeds up to 4000 revolutions per minute, and horse-powers up to 5560, but the firm states that these dynamometers can be made for any power at any speed. They are claimed to be absolutely accurate, and to maintain a constant resistance for any length of time. It is also mentioned that the design has recently been improved and modified, so that the cost of construction has been greatly reduced.

Railway Signalling Apparatus.—Messrs. Siemens Brothers and Co., Limited, Caxton House, Westminster, S.W., have sent us a copy of a pamphlet illustrating and describing their mercury-contact treadle for use in connection with railway signalling. Its object is to make or break an electrical circuit when a train passes the place where the treadle is fixed. The apparatus consists of a shallow circular cast-iron box, containing a thin steel diaphragm, beneath which is a space filled with mercury. On one side of the diaphragm box, and in communication with it, is a smaller chamber, in which the mercury rises when the diaphragm is depressed, until it reaches two contacts at the top of the chamber, and thus completes a circuit controlling any signalling instruments. This contact-chamber is provided with ball-valves, which may be arranged in three ways to give continuous or intermittent contacts during the passage of a train, or to open a circuit which is normally closed. Adjustments can be made so that the signals are maintained for a period varying from one to eight seconds after the passage of the last wheel. The apparatus is provided with two clamps, by means of which it is attached to the bottom flange of the rail, between two sleepers, the diaphragm being directly connected to the base of the rail by means of a short plunger situated midway between the clamps. When a train passes, the small deflection of the rail is communicated to the diaphragm by the plunger, sufficient mercury being thereby displaced from the diaphragm chamber to produce a considerable rise of level in the contact chamber, since the area of the former is about 1500 times that of the latter. The makers claim for this apparatus, that it can be used with any kind of rolling-stock travelling at high or low speeds, is very sensitive, and unaffected by temperature changes; they also state that it is dust and water-proof, self-contained, and very easily installed. Complete instructions for this operation are included in the pamphlet.

LOCOMOTIVES IN GERMANY.—The central railway office at Berlin is about to commence negotiations with German mechanical construction establishments for the supply of 525 locomotives of various types. Of these engines, 510 are to be put upon Prussian State lines and fifteen upon the German Empire lines. Deliveries are to be made before the close of September, 1912.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

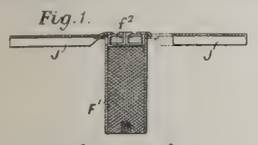
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

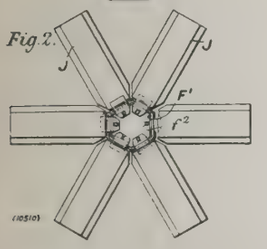
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

GUNS AND EXPLOSIVES.

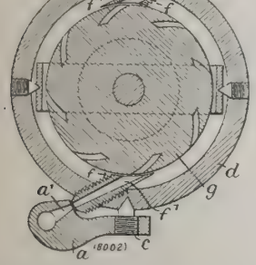
10,510/11. Fried. Krupp Aktiengesellschaft, Essen, Germany. Projectiles. [5 *Figs.*] June 20, 1910.—This invention relates to an illuminating projectile, the illuminating devices being provided with a parachute, and is characterised by the fact that the parachute is formed by wings pivotally arranged on the casing of the illuminating device, and which, when in the position of rest, surround the side walls of the casing. The illuminating projectile is constructed, as regards its general arrangement, similarly to a base chamber shrapnel. The illuminating composition, for the ignition of which a pellet of powder is provided, almost fills the entire casing F^1 of the illuminating device F, which forms a hollow prism of hexagonal section, and is





open at one end. On the end of the casing F^1, which is closed by a transverse wall f^2, are arranged six wings J, which wings form a parachute, and the cross-section of which is suited to the cross-sectional form of the casing F^1. The wings J are hinged to the casing F^1, and are acted upon by helical tension springs attached on the one hand, to the transverse wall f^2 of the casing F^1, and, on the other hand, to tapered lugs on the wings. The springs tend to rotate the wings J into the operative position shown. In this position the helices of the springs lie close together, so that any further rotation of the wings beyond this position, which the resistance of the air would tend to cause during the descent of the illuminating device, is impossible. (*Accepted July* 12, 1911.)

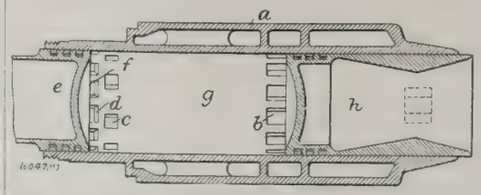
8002/11. Whitehead and Co., Actiengesellschaft, Fiume, Hungary. Automobile Torpedoes. [1 *Fig.*] November 19, 1910.—This invention has for its object controlling means for the fly-wheels of gyroscopes of automobile torpedoes by means of a jet or motor fluid supplied through two diametrically opposite tuyeres, and consists in dividing each of the two diametrically opposite tuyeres into two parts, of which the part *a* is mounted upon the pivot *b* or *c* of the vertical ring *d* of the gyroscope, and connected with the members supplying the motor fluid, while the other part *f* is mounted upon this vertical ring *d*, which is capable of rotation relatively to the fly-wheel *g*. When the fly-wheel is at rest the two passages a^1 and f^1 of each tuyere are arranged opposite each other, and maintained in this position



by the usual locking mechanism until the torpedo is launched. After the fly-wheel has been started the ring *d* and the portion of the tuyere carried by it can be displaced relatively to the fly-wheel *g* without inconvenience. This arrangement presents the advantage of not necessitating any modification in the form of the ring *d*, which merely presents a slight protuberance at the place through which the tuyeres pass, thereby effecting an important reduction of volume as compared with the usual two tuyere devices, in which the ring comprises a very large protuberance with curved slot, permitting of its displacement around the fixed tuyeres. The arrangement also permits of preserving the usual pin formation for the lower pivot *c*. (*Accepted July* 12, 1911.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

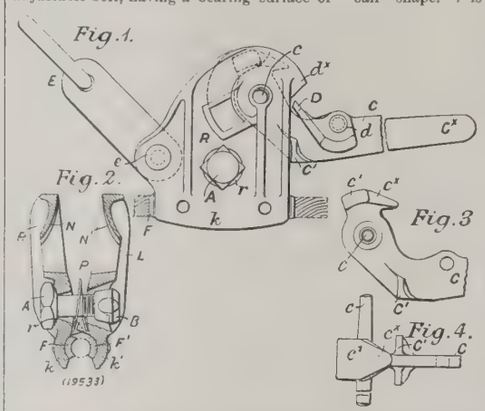
6047/11. W. J. Still, Southall. Internal-Combustion Engines. [1 *Fig.*] March 22, 1910.—This invention relates to a scavenging-engine having scavenging air inlet and exhaust ports disposed at opposite ends of the cylinder, the inlet ports being arranged symmetrically around the cylinder, and consists in a piston with a concave head free from projections or the like and preferably of a radius of curvature equal to the bore of the cylinder. The cylinder casting *a* is provided with three rings of ports opening into the cylinder *g*, which comprise *b* the exhaust ports, *c* the combustible ports, and *d* the scavenging air inlets. The piston *e*, which co-acts with the latter, is provided with a smooth concave face *f*, the radius of curvature of which is equal to the bore of the cylinder *g*. In this case now, as soon as the piston



e uncovers the ring of ports *d*, air will rush in to effect scavenging, but owing to the form of the piston the same will not break up into eddies but will advance as a more or less uniform mass to expel the products of combustion through the exhaust ports *b*. The piston *h* is also shown as having a concave head, but this feature is not essential. It will be understood that it is of importance to have the largest port area possible and also to have a symmetrical port arrangement which features are most easily attained by a port arrangement of the nature above described. (*Accepted July* 5, 1911.)

LIFTING AND HAULING APPLIANCES.

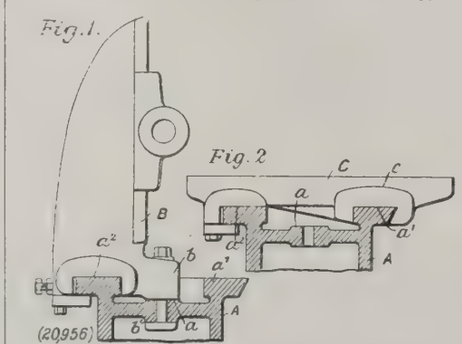
19,533/10. J. W. Smallman, Leamington. Haulage Clip. [7 *Figs.*] August 20, 1910.—The invention relates to haulage clips employed in collieries and mines for attaching the tubs to endless wire-ropes, and comprises two rocking shells, a central adjustable device for loosely connecting the shells, and a lever furnished with a trunnion-peg, the head of the lever working along inclines on the upper part of the shells. The coupling for effecting attachment to the draw-bar of the tub or wagon is secured to the clip by a pin and split-cotter. R is the right-hand shell, L being the left-hand shell. A is a central adjustable bolt, having a bearing surface of "ball" shape. *r* is



a shallow "cup," formed on the boss of the shell R. B is a trunnion-nut, into which the bolt A screws. C is the lever with large lateral stops C^1, C^* being the handle. *c* is the trunnion-peg, upon which the lever C is pivoted. c^1 is the back of the head of the lever, and c^* a wedge-like continuation. The lever C is automatically locked by the catch D that turns on the joint-pin *d*. d^* are front projections. E is the coupling attached to the clip by the pin *e*. F and F^1 are liners riveted in the jaws *k* and k^1. N and N^1 are the inclines (without stops) along which work the back c^1 and continuation c^* of the head of the lever C. P is the hooked spring, *p* and p^1 being the recesses for the hooks. (*Accepted July* 12, 1911.)

MINING, METALLURGY, AND METAL-WORKING.

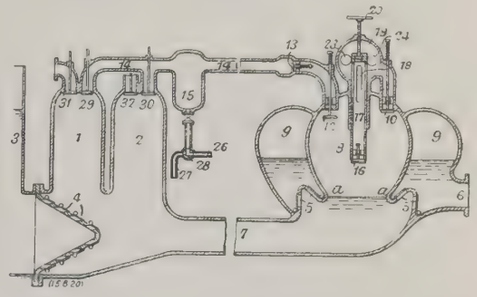
20,956/10. A. Drummond, Guildford. Boring-Machines. [2 *Figs.*] September 8, 1910.—This invention relates to horizontal boring-machines, and the like, in which the table that is adapted to carry the work is mounted upon a saddle that is moved along a bed or gantry during the operation of the tool. This movement of the saddle necessitates a more accurate method of guiding the same than is required in that class of machine in which the saddle is fixed to the bed during the aforesaid operation. A represents the bed or gantry, B the rear support or



sliding-head, and C the saddle. According to this invention, the bed A is formed with a central bearing surface a which extends below the front and back shears a^1, a^2 respectively. The base of the sliding-head B embraces the back shear a^2, and is formed with an extension *b* which rests upon the central bearing surface a, and is capable of being clamped thereto by a bolt b^1. The saddle C rests upon the front and back shears, and is recessed along the front portion to form a narrow guiding surface which embraces the front shear a^1 and is continued in a wing *c* that clears the extension *b* of the rear support or sliding-head when traversed past the same. The arrangement of bed and rear support above described enables the saddle to be formed with a long and accurate guiding surface without sacrificing the bearing surface of the sliding head or rear support in order to prevent the same from fouling the saddle wing. (*Sealed September* 14, 1911.)

PUMPS.

15,820/10. H. A. Humphrey, London. Pumps. [4 *Figs.*] July 1, 1911.—This invention relates to that class of internal-combustion pumps in which a column of liquid is propelled outwardly from a combustion chamber by the energy of expansion of an ignited combustible mixture, and in which a column of liquid flows inwardly towards a combustion chamber to compress a fresh combustible charge. According to the present invention, an outward movement of the liquid is employed to compress an elastic fluid, generally a combustible mixture or a constituent thereof, some of which is supplied under pressure to act upon the combustion chamber end of the column of liquid, and some of which is allowed to act upon the opposite end of the column. Thus a portion of the compressed fluid may be stored and subsequently admitted to the combustion chamber or chambers, while the rest of the compressed fluid is allowed to expand after the outwardly-flowing column has come to rest, and so produce or assist an inward flow. 1 and 2 are the combustion chambers of a pump of the type described in Specification No. 19,341, of 1907, and the supply liquid is taken in from the tank 3, through liquid inlet-valves 4, and discharged through non-return delivery valves 5, leaving the apparatus at outlet 6 against the head or pressure to which the liquid is to be raised or forced. The play-pipe 7 communicates with the air-vessel 8, which, in the present case, is to contain gas and air mixture, and also through valves 5 with a second air-vessel 9. This second vessel should have sufficient capacity to maintain the discharge from 6 as regular as may be desired. Air vessel 8 has an inlet valve 10 normally held closed by a light spring, but opening under suction; also a valve 12, which opens under its own weight, and may close, if the rising liquid reaches it, by the impact of the liquid. In pipe 14, between valve 12 and reservoir 15, is a non-return valve 13. A valve 16, adapted to open under its own weight and to be closed by impact or pressure of liquid, is carried by pipe 17 having slots opening into chamber 19. Pipe 17 projects into vessel 8 to an extent adjustable by wheel 20. Gas and air are delivered to chamber 19 through openings 23 and 24. The reservoir 15 for compressed combustible mixture is preferably connected by three-way cock 28 with a pipe 26 for admission of liquid and a pipe 27 for rejection thereof, so that by admitting liquid or discharging it the capacity of the reservoir for storing combustible mixture may be varied. Suitable pipes convey the combustible mixture from reservoir 15 to the admission valves 29 and 30, fitted respectively to the two combustion chambers 1 and 2 of the pump, which also have the usual exhaust valves 31 and 32 adapted to open under their own weight and to close by impact of liquid. Assuming that reservoir 15 contains a charge of combustible mixture compressed to the pressure at which liquid is to be delivered, that there is a compressed combustible charge in the top of chamber 2, liquid in chamber 1 except for a small elastic

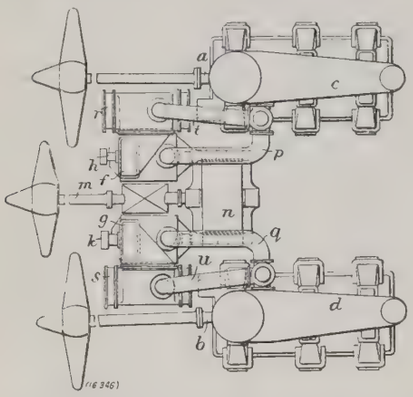


cushion in the top of the chamber, and that valves 29, 30, 31, 32, and 4 are all closed, the cycle commences by ignition of the charge in chamber 2. Combustion and expansion occur, velocity is imparted to the column of liquid, which is forced outwards in pipe 7. As the gases expand in chamber 2, the pressure falls in both chambers, and a moment will arrive when the pressure in chamber 1 is equal to that of the compressed mixture in receiver 15, and this moment may be advantageously chosen to open valve 29 and establish communication between chamber 1 and reservoir 15. As expansion in chamber 2 continues, combustible mixture enters chamber 1 and forces the liquid in this chamber downwards, thus assisting in the outward propulsion of liquid in pipe 7. It is generally desirable to close valve 29 before expansion is complete, and before the pressure in vessel 8 is high enough to open valve 13. Suppose that valve 29 is closed, for example, at two atmospheres gauge pressure, then the last part of expansion occurs after communication with receiver 15 has been cut off and the pressure falls low enough in both chambers 1 and 2 to permit an intake of fresh liquid through valves 4, and to allow exhaust-valve 32 to open under its own weight in the manner explained in Specification No. 19,341 of 1907. Considering what occurs at the other end of pipe 7, and assuming that the level of liquid in vessel 8 was at *a*, *a* when the outward motion of the liquid column started, then, while the level rises to that at which the liquid shuts valve 16, the work done upon the column will have been converted into kinetic energy, for there is practically no resistance offered to the rising liquid while driving combustible mixture past valve 16, through pipe 17, slots 18, and openings 23 and 24 towards the sources of supply of the combustible constituents, which may be gas and air. As soon, however, as valve 16 is shut, further escape is cut off and the pressure rises in vessel 8 sufficiently to open valve 13 and deliver combustible mixture through pipe 14 into the receiver 15, this delivery continuing until the pressure is that at which valves 5 open, whereupon liquid is delivered into air vessel 9. The remaining kinetic energy of the column is thus completely utilised in forcing liquid into vessel 9 until the movement of the column ceases. It is not intended that the liquid should rise high enough in vessel 8 to shut valve 12, and the latter is rather a safety device to ensure a cushion of elastic gases being retained in the top of vessel 8. The cycle has now arrived at that stage when chamber 1 contains combustible mixture, chamber 2 contains burnt products, exhaust valve 32 is open, and the pressure in both chambers is approximately atmospheric. In the upper part of vessel 8 there remains some combustible mixture compressed to the pressure at which liquid is delivered. Thus there is a higher pressure acting upon the liquid in vessel 8 than exists in chambers 1 and 2, and the column of liquid in pipe 7 is forced to return towards the chambers. As the liquid column returns, the pressure falls in vessel 8, but valve 13 prevents any return of mixture from receiver 15, and valves 5 prevent any return of liquid from vessel 9. When the pressure falls to approximately atmospheric pressure, valve 10 opens against its light spring, and gas and air are drawn into vessel 8 as the liquid leaves it. Valve 16 also opens, and when uncovered by the liquid some of the mixture

may enter past this valve. Meanwhile, the liquid in pipe 7, being driven towards chambers 1 and 2, first rises in chamber 2, displacing burnt products therefrom until it reaches the exhaust valve and shuts it, and then rises in chamber 1, compressing the combustible charge therein until the column of liquid has expended its energy, and has come to rest. Everything is then ready to start a fresh cycle by the ignition of the compressed charge in chamber 1, but the functions of chambers 1 and 2 are reversed. (*Sealed September* 14, 1911.)

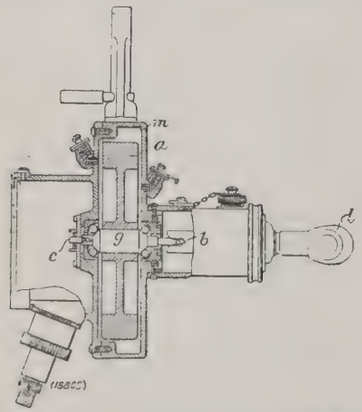
SHIPS AND NAUTICAL APPLIANCES.

16,346/10. C. A. Parsons, Newcastle-on-Tyne, and S. S. Cook, Wallsend-on-Tyne. Marine Propulsion Installations. [1 *Fig.*] July 8, 1910.—The invention consists in a three-shaft installation, having two of the shafts thereof driven by reciprocating engines, which exhaust into low-pressure turbines driving through gearing the third shaft. The reciprocating engines are preferably arranged on the two side shafts, the turbines thus driving the central shaft, while means may be provided to enable the reciprocating engines to exhaust directly into the condenser when going astern or under other circumstances if desired. *a* and *b* are the two side propeller-shafts, each driven by a set of reciprocating engines *c* and *d* respectively, while in the space between the side shafts *a*, *b* two independent low-pressure turbines *f*, *g* are mounted on separate shafts *h*, *k*, and are suitably geared to the central propeller-shaft *m* by gearing *n*. The installation is thus composed of two parts, each comprising a reciprocating engine and a low-pressure turbine. A pipe connection *p* and *q* from the exhaust of each reciprocating engine *c* and *d* carries the working fluid exhausted therefrom to the inlet of the corresponding low-pressure turbine *f* and *g*, and after being exhausted from the latter the fluid passes to the condenser *r* and *s*, one of which is



provided for each part of the installation. In addition to the pipe connection between the reciprocating engine, say, *c* on the side shaft *a*, and the turbine *h*, another pipe connection *t* allows the engine *c* to exhaust directly into the condenser *r*, and thus, if desired, to be run alone, a similar connection *u* being provided between engine *d* and condenser *s*. In operation, the high-pressure working fluid is supplied to each of the reciprocating engines *c* and *d*, from which the fluid thereafter passes by the pipe *p* and *q* to the corresponding low-pressure turbine *f* and *g* and the condenser *r* and *s*, each turbine thus being in series with a reciprocating engine. It will be understood, of course, that the connections between the turbine and the engine are similar on each side of the ship. When the ship is going astern, the reciprocating engine on each side of the ship is directly connected with its respective condenser by the connection *t* and *u* respectively, the turbines *f* and *g* geared to the central shaft *m* being thus idle. The provision of a special reversing-turbine is thus rendered unnecessary by this arrangement. For the purpose of manœuvring the reciprocating engine *c* and *d* respectively on each side shaft can be operating independently either both ahead or both astern, or one ahead and the other astern, as desired. (*Accepted July* 12, 1911.)

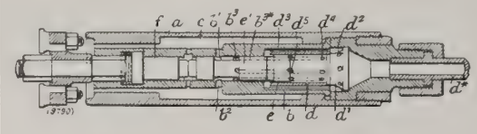
15,809/10. Thomas Walker and Son, Limited, and T. S. Walker, Birmingham. Ships' Log Apparatus. [4 *Figs.*] July 1, 1910.—In ships' log apparatus, of the type in which the revolutions of a rotator in the water are transmitted by means of a rotating tow-line to the registering apparatus, a fly-wheel governor is mounted upon a shaft supported in ball bearings located on both sides of the governor instead of, as hitherto, upon one side only, the whole (with or without an enclosing casing) being supported upon trunnions, either in a sling of substantially usual form suspended overboard, or in ordinary gimbals upon the taffrail. *a* is a fly-wheel governor



located intermediate of, and co-axially with, the primary or first-motion spindle *b* and the second-motion spindle *c* of the log mechanism. At its outer extremity the primary spindle *b* is provided with the usual eye *d* whereby the towing-line may be attached so as to transmit the revolutions of the rotator to the primary spindle *b*, and through the fly-wheel governor *a* to the log mechanism. The governor *a* is supported upon an independent shaft *g*, mounted in ball-bearings situated on both sides of said governor, and said shaft *g* is connected rotatably by clutch connections to the primary spindle *b* and second-motion spindle *c* respectively. Or, alternately, the governor *a* might be mounted directly upon the primary spindle *b* which would, in that case, be prolonged and would be supported in ball-bearings located on both sides of the governor *a*. The governor *a*, primary spindle *b*, and log mechanism may be all contained within a single enclosed casing *m*, closed at the primary spindle end by means of a water-tight cap, and at the opposite or log mechanism end by means of a flanged cover-plate. (*Accepted July* 12, 1911.)

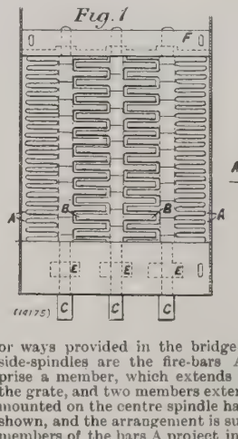
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

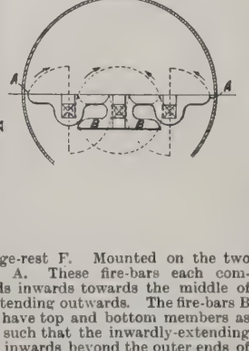
9790/10. W. H. Cheyne, Brentford, and G. R. Mewburn, London. Scaling Boiler-Tubes. [4 *Figs.*] April 22, 1910.—The invention relates to rapid-action steam-hammers more especially intended for use with tools for scaling boiler-tubes. The drawing illustrates a steam-hammer in accordance with this invention. *a* is the outer case, or jacket, and *b* the inner case, or cylinder, which is surrounded by a space *c*, which constitutes a steam-jacket to the cylinder *b*. Within the cylinder *b* is arranged a steam-cylinder *d*, at the head of which is provided a dome d^1, and this dome is, by a pipe d^*, connected with the steam supply, and the dome d^1 is, by ports d^2, connected with channels leading to the outer, or opposite, end of the cylinder *d*. Within the cylinder *d* is arranged a piston *e*, having a rod e^1 of a diameter only slightly smaller than that of the piston *e*, so that the area of the acting surface of the piston *e* on the outer face is very small, whilst on the opposite face the entire area of the piston is available for the steam to act upon. The piston-rod e^1 is prolonged beyond the steam-cylinder *d*. Near to its outer end the piston-rod *e* is of reduced diameter for part of its length, forming an annular chamber b^1 between it and the cylinder *b*, and exhaust ports b^2 are provided, which connect the annular chamber b^1 with the steam jacket *c* and that part of the piston-rod e^1 beyond the reduced part constitutes a valve, which opens and closes the exhaust ports b^2. Near to the head of the cylinder *d* is a set of ports d^4, and assuming the piston *e* to be at the end of its outward stroke, a set of ports d^5 is arranged



in such a position that they are closed to the steam supply by the piston *e*, which acts as its valve, and these two sets of ports are connected by channels. A set of ports b^3 is provided in the chamber b^1, and these ports are always open to the annular chamber, and are connected with the set of ports d^4 and d^5 of the cylinder *d*. Steam is constantly supplied from the steam dome d^1, ports d^2, and the channels d^3 to the inner end of the cylinder *d*, and acts upon the reduced diameter of the piston *e* to effect its return stroke. When the piston *e* is near the termination of its return stroke, the exhaust ports b^2 are closed, and the ports d^5 of the cylinder *d* are opened to the steam supply by the piston *e* passing beyond them, with the result that steam is admitted to the steam cylinder *d* through the ports d^5 and ports d^4, and, acting upon the larger area of the piston *e*, drives it forward, overcoming the lesser resistance of the steam upon the smaller area on the opposite face of the piston *e*, and which steam acts as a cushion and the ports d^5 are again closed. At or near the termination of the outward stroke of the piston *e* the exhaust-ports b^2 from the annular chamber b^1 are opened, and the steam from the cylinder *d* is exhausted through the ports d^4 and b^3 into the jacket *c*. On the return stroke of the piston *e* the exhaust-ports b^2 are closed, and the above-described operations are repeated. Beyond the piston-rod e^1 is, or may be, arranged a reciprocating rod *f*, the extremity of which is provided with a tool-holder. The rod *f* is acted upon percussively by the end of the piston-rod e^1 on the outward stroke of the latter. (*Accepted July* 5, 1911.)

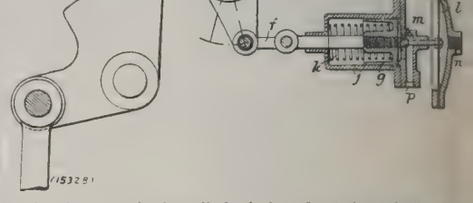
14,175/10. J. W. Thomas and T. A. Thomas, Rhondda, and C. Millard, Pontypridd. Fire-Grates. [11 *Figs.*] June 11, 1910.—This invention relates to grates for steam-generators of the type in which transverse fire-bars, some or all of which are provided with two faces capable of supporting fuel, are mounted on spindles disposed longitudinally of the generator, and adapted to be rotated or rocked. Grates of this type, as hitherto constructed, have been provided with fixed bars next to the side of the furnace; but in grates made in accordance with this invention the side-bars are adapted to be rocked or rotated, and no fixed side-bars or plates are employed. In the tubular furnace illustrated, the fire-bars A are not adapted to be moved through a complete revolution. In wider and in other types and shapes of furnaces the bars A may be arranged to be so turned. The spindles C on which the fire-bars are slung are mounted in bearings E, provided in the front end-plate D. At the other end of the grate the spindles are supported in bearings





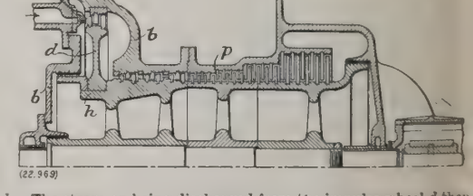
or ways provided in the bridge-rest F. Mounted on the two side-spindles are the fire-bars A. These fire-bars each comprise a member, which extends inwards towards the middle of the grate, and two members extending outwards. The fire-bars B mounted on the centre spindle have top and bottom members as shown, and the arrangement is such that the inwardly-extending members of the bars A project inwards beyond the outer ends of the bars B, as seen more particularly at Fig. 1. The members of the bars on the respective spindles can accordingly pass one another freely when the spindles C are turned. The apertures in the bars A and B through which the spindles C pass are square or rectangular in section, and the bars turn with the spindles. The bars B are reversible, and can be used with either member uppermost. The draught spaces between the bars on the respective spindles are maintained by projections provided at each side of the bars, and abutting against one another. At such times as it is required to clean the grate, the fire is cleared off the fire-bars A at one side of the grate, and together with the fire on the bars B, is moved on to the bars A at the opposite side of the grate. The spindles C carrying the bars B and the bars A at the fire-cleared side are then turned on end and are rocked and shaken. The clinker, ash, dirt, and other refuse having been thus dislodged, the fire is shifted back and the bars A from which the fire is withdrawn are cleared of refuse in like manner. (*Accepted July* 12, 1911.)

15,328/10. J. Davidson, Pendleton, and W. O. Larmuth, Salford. Valve-Gear. [7 *Figs.*] June 27, 1910.—In uniflow steam-engines the exhaust takes place through ports around the middle of the cylinder barrel, which are uncovered by the piston when nearing the end of its stroke. The outlet for the steam is therefore cut off very early on the return stroke, and, consequently, the steam is compressed for the greater part of the return stroke. So long as the engine exhausts to a condenser, the final pressure caused by compression is not excessive, but when the vacuum fails, the compression pressure increases rapidly, and the final pressure would generally exceed the initial pressure of the steam, unless means are provided to prevent it. By means to be described, it is possible to so adjust the apparatus, that when the vacuum fails, the lead of the steam inlet-valves is increased, so that they just commence to open when the compression pressure reaches the pressure of steam in the steam-chest. As the piston then completes the remainder of its



stroke, the steam in the cylinder is forced out through the inlet-valve back into the steam-chest. *g* is a piston in a cylinder *j*, and when working under normal conditions the piston *g* is retained at one end of the cylinder by a spring *k*; at the end of the cylinder is a diaphragm *l* coupled to a valve *m* in the cylinder. One side of the diaphragm closes a suitable chamber which is connected to the exhaust pipe of the engine at *n*, and the other is open to the atmosphere. At one end of the cylinder between the valve and the diaphragm is connected an oil-pressure main, or steam-pipe *p*. When the vacuum is good, the pressure of the atmosphere will keep the valve closed, but immediately it fails, the pressure of oil or steam, or other fluid, will open the said valve and the fluid enters the cylinder, and causes the piston *g* to move to the other end, and by means of the link *f* will cause the valve of the engine that is actuated by a roller *e* and cam to open earlier, the escape of the fluid when the vacuum has again been obtained will be effected by means of a spring-loaded valve. (*Accepted July* 12, 1911.)

22,969/10. C. A. Parsons, Newcastle-on-Tyne. Turbines. [1 *Fig.*] July 15, 1910.—This invention relates to turbines of the type which comprise one or more stages, each having annular or segmental jets formed by a radial restriction of the space between the fixed and rotating parts, and adapted to convey the working fluid in an axial direction while imparting velocity thereto, the fluid being then given angular direction without substantial change of velocity before delivery to the blading of the velocity absorption type, in which part of the energy of the fluid is abstracted, the remaining energy of the low-pressure expansion stages being then abstracted in suitable blading, such as multiple rows of Parsons' fixed and moving blades. The invention consists in a turbine having a high-pressure part comprising one or more impulse stages, from which part of the fluid is delivered to intermediate and low-pressure stages, which are formed as a combined turbine of the type first referred to. The drawing shows one form of turbine of the disc-and-drum type, constructed according to the present invention. Turbines of this type may have any number of high-pressure impulse stages; but in the one shown there is only one impulse stage placed at the high-pressure end of the turbine. This impulse stage comprises one or more nozzles *a*, fixed to part of the turbine casing *b*, the kinetic energy which the working fluid generates in expanding in said nozzles being then abstracted in blades of the velocity-absorption type carried by the disc-wheel *d*, and alternating with guide-blades suitably attached to the casing



b. The steam on being discharged from the impulse-wheel *d* then passes to the intermediate pressure stages, consisting of annular jets or one or more segmental jets formed by radially restricting the space between the drum *h* and the casing *b* by means of projecting parts fixed to the casing *b*. The steam, after having been expanded in such jets, is delivered to a row of crescent-shaped blading fixed to the drum *h*, and then passes to guide-blades of crescent-shaped form fixed to the casing *b*, and causing the fluid to be again delivered to another row of blading carried by the rotor. Preferably only two rows of moving blades are provided in each stage, and it is advisable to form both set of blades with a radial dimension which is gradually increased towards the low-pressure end of the turbine. By this means the increasing volume of the steam is allowed for while at the same time compensating for the loss of velocity due to the friction in the moving and fixed blades. Suitable guide blades are provided in the restrictions or jets, such blades being of such a form that the steam is completely expanded while being given velocity in an axial direction, and on completion of this expansion the direction of this velocity is changed to a circumferential one before the steam is finally delivered to the first row of moving blades. As a rule three such stages comprising jets and fixed and moving blading are sufficient, and after the steam has passed through all these stages, it is delivered into the low-pressure part *p* of the turbine, this part being preferably of the Parsons' annular admission type comprising rows of moving blades alternating with rows of fixed blades. (*Accepted July* 26, 1911.)

FEED-WATER HEATING AND SUPERHEATING ON LOCOMOTIVES.—No. IV.

Combined Feed-Water Heating and Superheating.

The last two articles on this subject* have dealt with the economies which, from such general data as are available, might be logically expected from the application of smoke-tube and waste-gas superheaters to locomotives. In an earlier series of articles,† it will be remembered, the advantages of feed-water heating were set forth. The two-stage system then described embodied a method of first utilising part of the exhaust steam from the cylinders to heat the feed-water, and following this up by further heating the water by the waste gases from the boiler before they pass out of the chimney. It will be evident that the first stage of this system—namely, that of feed-heating by exhaust steam—is applicable to any engine, and can equally well be applied even if the engine be fitted with one or the other form of superheater. It does not interfere in any way with the latter, and these two systems of securing economy may therefore be employed concurrently. It will be also readily recognised that, owing to the high temperature of superheated steam, the use of superheaters, according to either method of application, results in comparatively high final temperatures for the waste gases, and from these, therefore, further heat may appropriately be abstracted, if convenient, by continuing the feed-heating into the second stage named above, after the superheating. Whether it is worth while proceeding with the combination of the two systems to these lengths in practice, depends on certain matters which will be considered later.

At the close of the last article a diagram, Fig. 11 (page 344 *ante*), was given showing the calculated theoretical efficiency of engines using different degrees of superheat on the two systems of waste-gas, and smoke-tube, superheating. This curve can be translated into one giving coal consumptions. This has been done in Fig. 12 herewith, the line *a b c d e* giving pounds of coal per draw-bar horse-power hour for different degrees of superheat. Actually the lines *b c* and *d e* are slightly curved, but, drawn to so small a scale, this can scarcely be made evident. Up to the point *c* the system considered is that on the waste-gas heater principle; beyond, the line represents what might be expected with the smoke-tube system. The consumptions have been figured out on a basis of 14,500 B.Th.U. to the 1 lb. of coal. The line does not suggest quite so large a saving as is well known to be realised in practice, at the higher temperatures. Possible reasons for this are discussed below. The consumptions have been calculated at the various efficiencies necessary for the production of one draw-bar horse-power hour (taken as 2546.6 B.Th.U.). Successful feed-heating diminishes the heat to be produced in the ratio which the heat added in the feed water bears to the total heat in the steam generated. This is clear from the entropy diagram. In Fig. 4, given in Article III.,‡ the area to the left of the line *p q*, for instance, is, when the feed-heating is effected by waste products, removed from the diagram to the temperature corresponding to the point *p*. The heat to be provided, therefore, is reduced to the area *g p l m* in the case of saturated steam; corresponding areas are, of course, obtained for other cases. The expression giving coal consumptions in pounds per draw-bar horse-power hour, starting, as formerly, with feed at 60 deg. Fahr., for which the efficiencies have been worked out, is:—

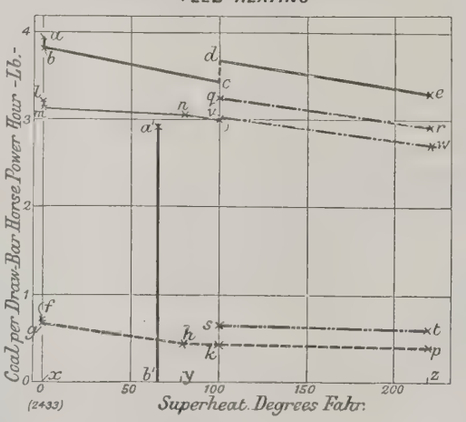
$$\frac{2546.6 \times 100 \times \left(1 - \frac{\text{heat in feed-water} - 28.08}{\text{heat in 1 lb. steam} - 28.08}\right)}{\text{Efficiency} \times 14{,}500}.$$

In this expression, 2546.6 is taken as the heat equivalent of one draw-bar horse-power hour, and 28.08 B.Th.U. as the amount of heat required to raise feed from 32 deg. to 60 deg. Fahr.

It was shown in a former article§ that with the two-stage method of feed-water heating as adopted by Mr. F. H. Trevithick, feed temperatures of 270 and more deg. Fahr. had easily been attained by utilising the heat in waste products only. In a later system, to be described below, temperatures of 284 deg. Fahr. were commonly reached, but in order to avoid anything in the way of exaggeration, the lower figure has been used for the present purpose. It has been amply demonstrated in these columns that such feed temperatures must result in appreciable coal-saving, unless off-set by some handicap arising in connection with the method of application. Experience has proved that there need be no fear of this, if the system be carefully worked out. The figures recorded in previous articles are sufficiently convincing on this point.

If feed-water heating, instead of being employed alone, be combined with moderate superheating or steam-drying by the waste gases, it follows that some apportionment of the total waste heat available must be made between the two. While, on the one hand, both the exhaust steam and waste gases are useful in heating feed-water, since, in each case, the temperature head is considerable, the former is manifestly of no use for superheating. For the latter process, therefore, only the waste gases are available, and the range of possible ordinary combinations thus extends between applying all the waste heat to feed-heating, on the one hand, and, on the other, applying the heat in the exhaust steam to feed-heating, and that in the waste gases to superheating. When combining feed-heating and steam-heating, therefore, the possible feed temperatures decrease while the superheat temperatures increase. The range is from something over 270 deg. Fahr. for feed-heating alone to feed-heating to temperatures of about 206—212 deg. Fahr.

Fig. 12 CALCULATED COAL CONSUMPTIONS WITH DIFFERENT DEGREES OF SUPERHEATING & FEED HEATING



combined with superheating to 90—100 deg. Fahr. Since, however, the ideal is not attainable in practice of transferring all the heat in the waste gases to the steam, owing to the high temperature of the latter, there still remains, after superheating, some heat which, in special combinations to be dealt with later, may be extracted from them. If the further feed-heating stage be introduced, the feed temperatures do not decrease nearly so rapidly, of course. For instance, feed temperatures approaching 270 deg. Fahr. have been secured with superheat of 60 deg. Fahr.

Dealing first with the lower superheat temperatures, the coal consumption line in Fig. 12 commences at *a*, with steam of about 4.5 per cent. moisture, and falls to *b* on the steam being dried. It then slopes down to *c* at about 100 deg. Fahr. superheat, beyond which it is not possible to go in the waste-gas system. If now feed-heating be introduced, ordinate lengths, represented by points on the line *f g h k*, are deducted; that is, for the saturated engine *f x* is deducted from *a x*, leaving *l x*, and so on. If sufficient heat be taken away from feed-heating just to dry the steam, feed-heating would result in the deduction of *g x* instead of *f x*. Deducting this from *b x*, a consumption given by *m x* is obtained by feed-heating and steam-drying. At 80 deg. Fahr. superheat the deduction due to feed-heating has decreased to *h y*, while, with the same feed temperatures, it is still further decreased at 100 deg. Fahr. owing to the smaller proportion the heat in the feed then bears to the total heat of the steam. The coal consumption line for this range of superheat, combined with feed-heating, is therefore represented by *l m n o*. The consumption with higher degrees of superheating alone is represented by *d e*. Feed-heating with the exhaust steam effects deductions corresponding to the length of the ordinates below *k p*, which, for such combinations, brings the coal line down to *q r*. If, in addition, by special arrangements higher feed temperatures are obtained, further deductions, represented by the distance apart of the lines *k p* and *s t*, may be made, and the coal line then falls to *v w*. Special combinations involving additional apparatus are also possible in the lower ranges, the figured coal consumption being given, for instance, by the line *a' b'* for a case of 65 deg. Fahr. superheat and 269 deg. Fahr. feed temperature.

It will be noticed that the coal figures thus arrived at for the highest feed-water temperatures, and also for the combination embodying feed-heating with the highest temperatures attained in waste-gas superheating, are lower than those shown for superheating alone to 220 deg. Fahr. From these lines in fact it appears that superheating, if used alone, must be carried to about 260 deg. Fahr. in order to bring down the coal consumption to that possible with the combination of feed-heating and moderate superheating. It is interesting to note that the amount of the saving shown, according to these calculations, by the combination arrangement giving feed temperatures of about 210 deg. Fahr., with superheating to 80 deg. Fahr., amounts to 22.7 per cent. of the consumption of the saturated engine with no feed-heating. Further, of this saving just about half is due to the feed-heating and half to superheating.

These conclusions make no allowance for possible modification for the better or the reverse, arising out of the manner of practical application of the systems, so that they are not advanced as by any means decisive. Nevertheless, they afford very good ground for the contention that both systems, unless practically heavily handicapped, must result in economy. Not only so, but, on account of a factor which cannot be properly introduced into these calculations, the probability is that the position in favour of feed-heating, and of the combination system, as well as that of the high degree system, is in reality better than these figures would suggest. A study of the St. Louis and of other tests will conclusively prove that the over-all efficiency of a locomotive boiler falls as the rate of firing increases. As typical of this tendency, it may be noted that one test showed a boiler efficiency of 55 per cent. when firing was at the rate of 70 lb. per square foot of grate area per hour, rising to 65 per cent. when the rate of firing fell to 50 lb. per square foot.

The consumption shown in Fig. 12 for the saturated engine (*a x*) corresponds in the Purdue tests to a rate of firing of about 70 lb. per square foot of grate per hour. The reduced consumptions represented by *l x*, *n y*, and *e z* have, therefore, in all probability, a reflex influence on the boiler efficiencies, with the result that the latter are in all likelihood greater than those directly accompanying the introduction of the superheaters, as worked out in Article II.* As bearing on this point it must not be forgotten that the use of part of the exhaust steam for feed-heating purposes most probably accounts indirectly, according to circumstantial evidence, for some of the saving realised. This was fully gone into on a previous occasion,† and will not be enlarged upon again. The conclusions then arrived at apply similarly to the combination arrangement now under consideration, the hot feed relieving the boiler, with the result that a much larger blast-pipe top, and lower smoke-box vacuum, may be employed, not only without loss of effect, but with a considerable reduction in the loss in unburnt coal. For these reasons, among others, the actual economies might well be expected to exceed those shown, always on the understanding, of course, that the manner of application is an effective one. In corroboration of this suggestion it may be pointed out that, while calculations show feed-heating to 210 deg. Fahr. to result in some 11 or 12 per cent. economy, or half the total economy when feed-heating to that temperature and superheating to 80 deg. Fahr., it was found in the evaporative tests, of which an account was given in Engineering, vol. xci., page 834, that feed-heating to 215 deg. Fahr. resulted in an increased boiler output of 14.1 per cent., which, with equal outputs, would mean an economy of about that amount. So far

* See pages 271 and 341 *ante*.
† See Engineering, vol. xci., pages 143, 211, 271, and 342.
‡ Page 341 *ante*.
§ See Engineering, vol. xci., page 343.

* See page 275 *ante*.
† See Engineering, vol. xci., page 344.

FEED-WATER HEATING AND SUPERHEATING ON THE EGYPTIAN STATE RAILWAYS.

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Fig. 13.

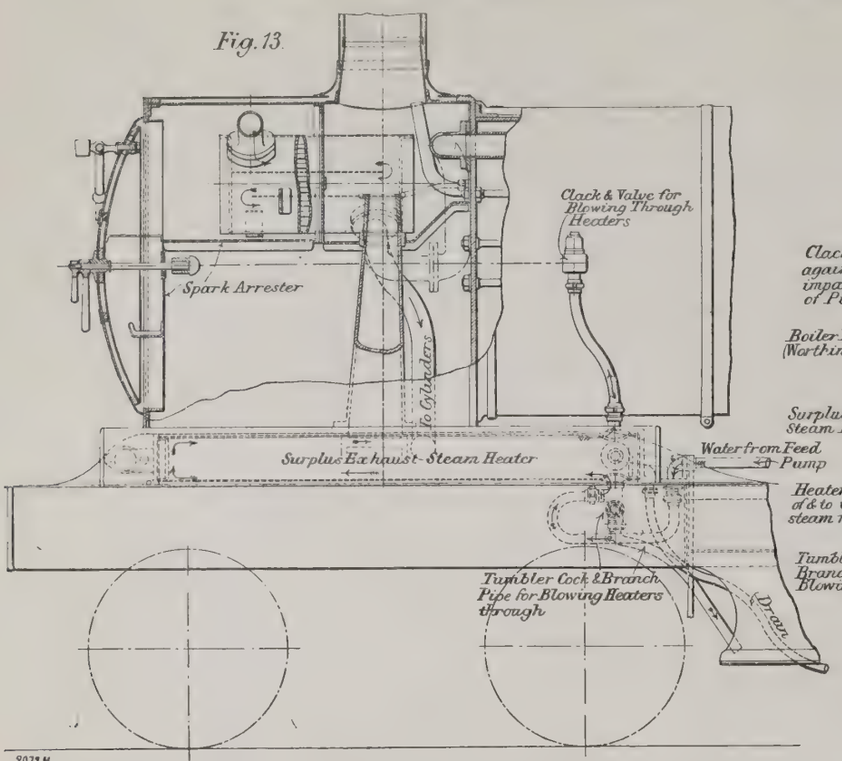


Fig. 14.

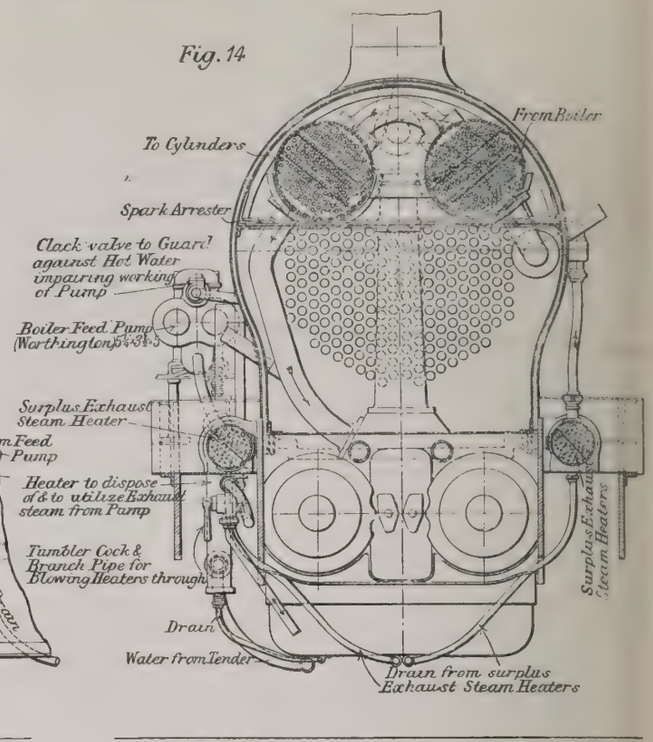
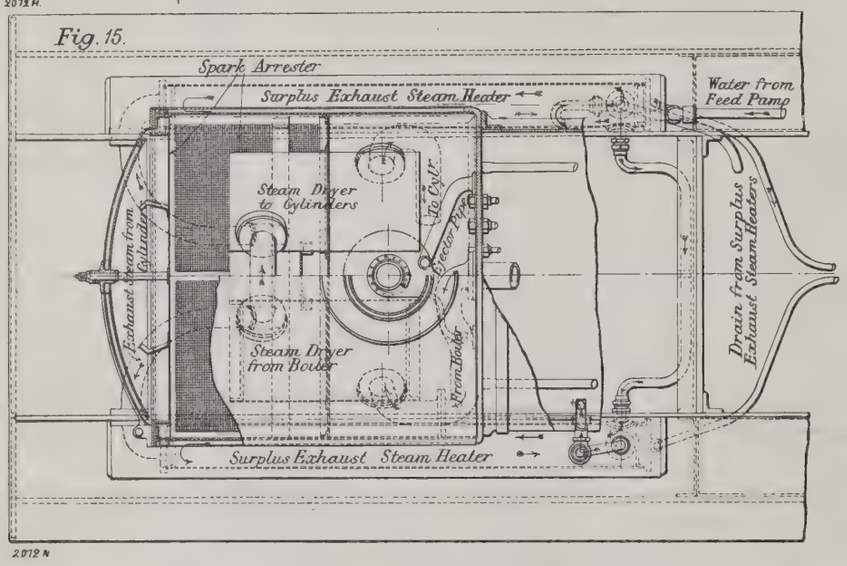

From Boiler
To Cylinders
Spark Arrester
Clack valve to Guard against Hot Water impairing working of Pump
Boiler Feed Pump (Worthington 5×3×5)
Surplus Exhaust Steam Heater
Heater to dispose of & to utilize Exhaust steam from Pump
Tumbler Cock & Branch Pipe for Blowing Heaters through
Drain
Water from Tender
Drain from surplus Exhaust Steam Heaters
Surplus Exhaust Steam Heaters

Fig. 15.



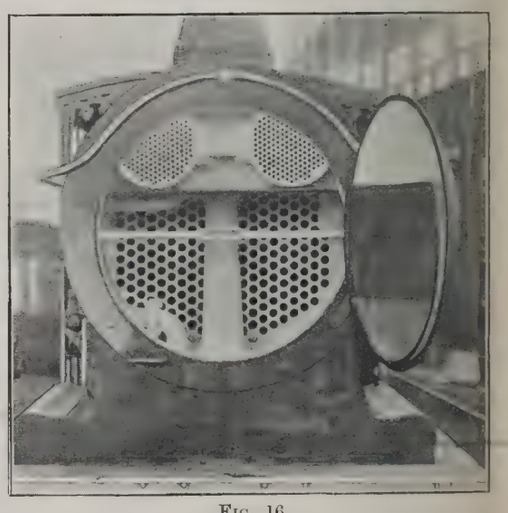


Fig. 16.

as this is concerned, therefore, the calculations appear to be in fair agreement with practical results.

The Practical Application of the Combination of Feed-Heating and Moderate Superheating.

The apparatus introduced on the Egyptian State Railways for feed-water heating, of the form described and illustrated in Engineering, vol. xci., page 211, was soon found to be susceptible of considerable improvement, and though resulting, as we have shown, in very great economy, it was not largely applied for these reasons. It was bulky, and consequently weighty, besides being inconvenient to handle in case of repairs, &c. It was also found that the lower part of the outer shell plating deteriorated rapidly. This apparatus was therefore replaced by a type of heater which overcame all these drawbacks, weighing only one-third as much, being out of the way, and removed from all danger of deterioration.

The new apparatus consisted of two small barrel or tubular heaters placed in the upper part of the smoke-box. It is shown in Figs. 13 to 16, on the present page. Each heater consisted of a drum made of $\frac{7}{32}$-in. steel plate, lap-welded, and 35 in. long by $17\frac{1}{2}$ in. internal diameter. Flanged tube-plates were set 30 in. apart, and between these ran 253 tubes of $\frac{3}{4}$ in. external and $\frac{21}{32}$ in. internal diameter. Internal longitudinal copper diaphragms, 27 in. long, butted against the tube-plates at alternate ends, thus ensuring circulation along a definite path. The heating surface provided in the two heaters together amounted to 228 sq. ft., and the aggregate flue area to 157 sq. in. Supported at the front ends by cross-bars and brackets, at the back the drums protruded through a vertical plate running across the upper part of the smoke-box. On the boiler side of this plate an enclosed space was formed, the equivalent of the outer chamber of the earlier design. Into this enclosed space the blast was ejected, the gases from the boiler being drawn, as before, through the return flues in the heater, by its action. This blast-chamber took various forms during the experiments, according to the arrangement of heaters in use. In one modification the heaters were placed as far forward as possible, so that the ends scarcely projected through the vertical plate above referred to. In another, as illustrated in Figs. 13 to 16, they were pushed far back, in order to see what the effect on their performance, of introducing them into a short smoke-box, would be. The heaters were also tried close together, and also as widely separated as possible.

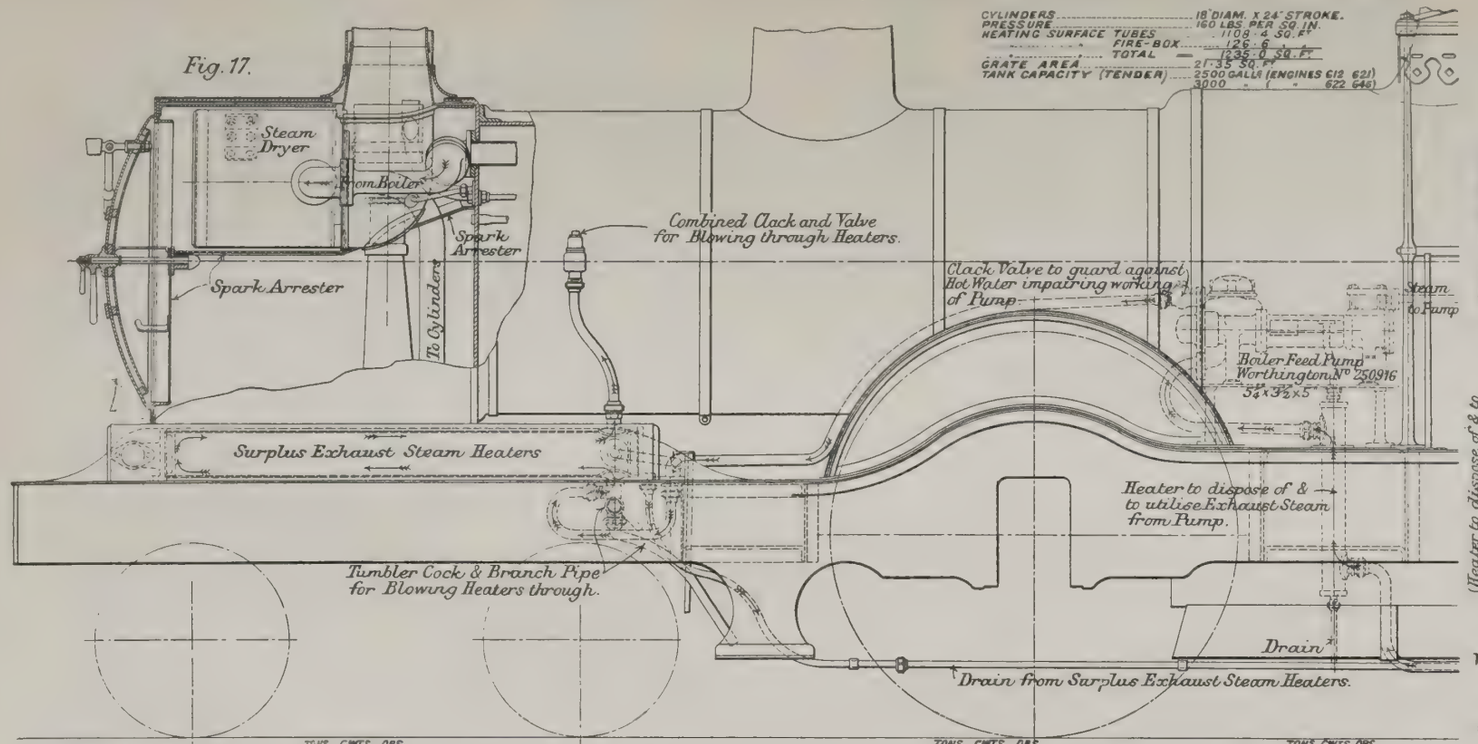
With this radical departure in the type of heater the spark-arrester underwent a change of form. As fitted with the drum heaters it at first consisted partly of a vertical wire screen attached to the door, and swung out on opening the same, and of horizontal wire netting placed across the smoke-box below the heaters and extending from the screen attached to the door, in front, to the vertical plate running across the upper part of the smoke-box. All the gases had thus to pass through the wire screen before entering the heaters, and as the arrangement of the latter drew the gases well forward, the cinders carried through from the boiler tubes were distributed evenly over the bottom of the box. There was no tendency for them to bank up in any particular place, as in the earlier design, or to block the netting; and as the quantity of ash brought through was small, for reasons already pointed out in a previous article dealing with feed-water heating, and referred to briefly above, the use of the ash-hopper, described in connection with a former development, was discontinued.

With the comparatively trifling alterations of connections, this apparatus could be used equally conveniently either for feed-water heating or for steam superheating, or, again, part for feed-heating and part for superheating. In Figs. 13 to 16 it is shown as used for superheating, and it was with

FEED-WATER HEATING AND SUPERHEATING ON THE EGYPTIAN STATE RAILWAYS.

MR. F. H. TREVITHICK, M. INST. C. E., CHIEF MECHANICAL ENGINEER.

Fig. 17.


CYLINDERS ..... 18 DIAM. X 24" STROKE.
PRESSURE ..... 160 LBS. PER SQ. IN.
HEATING SURFACE TUBES ..... 1108·4 SQ. FT.
FIRE-BOX ..... 126·6 "
TOTAL ..... 1235·0 SQ. FT.
GRATE AREA ..... 21·35 SQ. FT.
TANK CAPACITY (TENDER) ..... 2500 GALLS (ENGINES 612 621)
3000 " " 622 646
Steam Dryer
From Boiler
Spark Arrester
Spark Arrester
To Cylinders
Combined Clack and Valve for Blowing through Heaters.
Clack Valve to guard against Hot Water impairing working of Pump
Steam to Pump
Boiler Feed Pump Worthington's No. 250916 5¼ x 3½ x 5
Surplus Exhaust Steam Heaters
Heater to dispose of & to utilise Exhaust Steam from Pump.
Tumbler Cock & Branch Pipe for Blowing Heaters through.
Drain
Drain from Surplus Exhaust Steam Heaters.

	TONS. CWTS. QRS.		TONS. CWTS. QRS.		TONS. CWTS QRS
Without Heaters	15 – 12 – 1	on Bogie	76 – 1 – 2	on Drivers.	13 – 16 – 3 on Trailer
			45 – 12 – 2	Total.	
With Heaters and Slab	TONS. CWTS. QRS. 16 – 13 – 0	on Bogie	16 – 3 – 0	on Drivers.	15 – 17 – 2 "
			48 – 13 – 2	Total.	

Fig. 19.

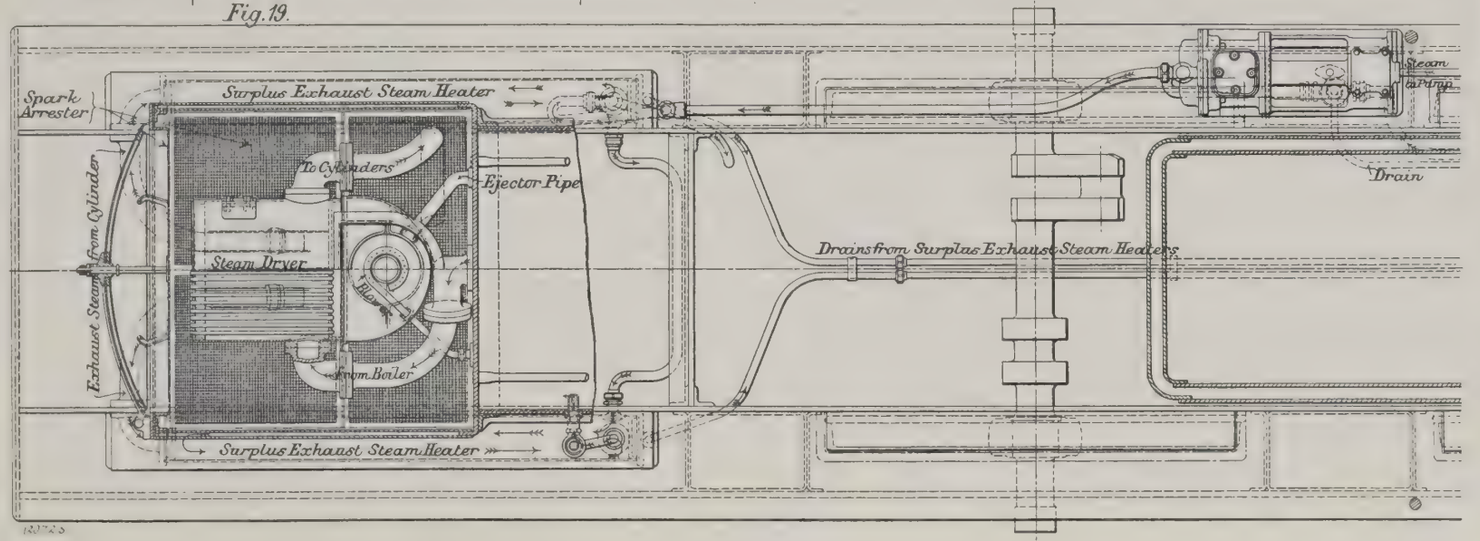
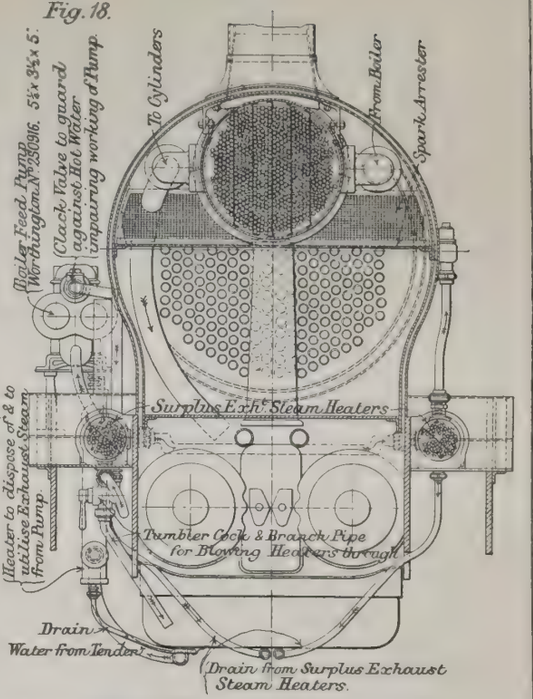
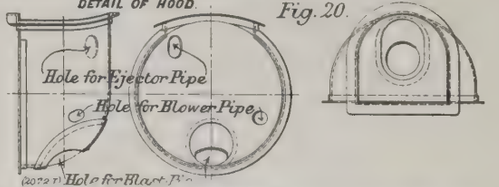


Fig. 18.


To Cylinders
From Boiler
Spark Arrester
Boiler Feed Pump Worthington's No. 250916 5¼ x 3½ x 5"
(Clack Valve to guard against Hot Water impairing working of Pump.
Heater to dispose of & to utilise Exhaust Steam from Pump
Surplus Exh.t Steam Heaters
Tumbler Cock & Branch Pipe for Blowing Heaters through
Drain
Water from Tender
Drain from Surplus Exhaust Steam Heaters.

DETAIL OF HOOD.

Fig. 20.



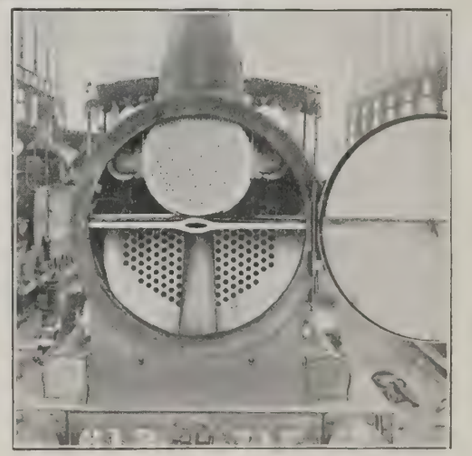


Fig. 21.

this form of apparatus that the first trials in this direction were made on the Egyptian State Railways, feed-heating by means of part of the cylinder exhaust being simultaneously utilised. This was the first stage in the combination system of feed-heating and superheating by waste products developed by Mr. F. H. Trevithick. The smoke-box heater here illustrated will be seen to conform in essential principles with that illustrated in Fig. 2 of Article II., which was there shown to be of an efficient design. The results obtained with the twin-heater arrangement were satisfactory. The great advance in type is evident when it is stated that the smoke-box heater last illustrated in connection with feed-heating* furnished only 5.8 sq. ft. of heating surface per 1 cwt. In the new design no less than 24 sq. ft. were obtained per 1 cwt.

Fitted in the same engine with which so much of the later experimental work had been performed—viz., No. 694—fully described when dealing with the large feed-water smoke-box heater, the new arrangement gave feed temperatures of between 200 and 210 deg. Fahr., the steam being superheated to about 76 deg. Fahr. Under these conditions records show the engine to have taken, as the average for a large number of runs, express trains of 350 tons tare behind tender at a coal consumption of 0.0959 lb. per ton mile. Of a class normally intended for trains of 270 tons weight behind tender, this engine could take with ease loads of 400 tons tare at an economical coal consumption, and could handle to time, though naturally at slightly greater cost, trains of 433 tons behind tender. It may be as well to mention here that the figure of 76 deg. Fahr. superheat has been well surpassed in later types.

The photograph reproduced in Fig. 16 shows the twin-heater arrangement applied to one of a class of goods engines having cylinders 19 in. by 26 in., a working pressure of 180 lb., the boiler having a heating surface of 1961 sq. ft. The weight of the engine is 54 tons. The exhaust-steam heaters, though of slightly altered dimensions, provided the same heating surface as those previously described. The smoke-box heaters, however, had a larger aggregate flue area to suit the larger grate of this class of engine. It was enlarged to 184.8 sq. in., while the total heating surface provided by the smoke-box heaters was 231 sq. ft. The two heaters together weighed, empty, 8 cwt. This apparatus was accommodated in the original 4-ft. 6-in. smoke-box, without enlargement of the latter. It gave very good results, though, unfortunately, the manner in which the records for goods working are kept on the Egyptian State Railways precludes anything beyond approximate conclusions in this instance. No records of tonnage hauled, or of the class of train worked, are available, and the statistics refer only to the figure of coal per mile, which, though employed on home railways to such an extent, is, after all, without additional data, of limited value. Engine No. 464 showed the highest consumption of her class before being fitted, and afterwards by much the lowest. Compared with sister engines, this one fitted with heaters showed an economy of 13.5 per cent. in coal per mile. Gauged by the performance of the whole class up till the time No. 464 was fitted, it showed an economy of 17.7 per cent. after application of the heaters, while compared with its own performance, before and after fitting with the additional apparatus, an economy was shown of 25.3 per cent. under the latter conditions. In view of the none too favourable conditions of goods working, these must be considered as very favourable indications. It is to be regretted, however, that figures are not available allowing of rather more definite conclusions.

Still another modification was subsequently tried with a view to further simplifying the apparatus. The twin smoke-box heaters were replaced by a single heater, with the result that a still greater reduction in weight was effected. This heater was first tried with the blast-chamber constructed, as in Figs. 13 to 16, by means of vertical and horizontal plates running across the upper part of the smoke-box. The effect of this was rather curious. The blast drew the gases only through the centre tubes of the heater, the others becoming choked with the fine dust passing through the netting. On consideration of this phenomenon, it was concluded that the air within the chamber itself must have continually expanded and contracted to such a degree, in response to the pulsations of the blast, that conditions were satisfied if gases were drawn at high velocity through the heater-tubes just in the area of greatest suction. The size of the blast-chamber was therefore reduced to the minimum, and with satisfactory results. All the tubes proved then to be self-clearing, and capable, therefore, of performing useful work for continuous periods. The smoke-box arrangement had thus been brought down to the form shown diagrammatically in Fig. 2 (page 275 *ante*), and illustrated more completely on page 447, herewith, by Figs. 17 to 21.

The experimental work continued for the most part to be carried out with engine No. 694, the single-barrel heater fitted to her being 28 in. long and $23\frac{3}{16}$ in. in internal diameter, made of $\frac{5}{16}$-in. plate. It contained 798 tubes, $24\frac{3}{4}$ in. long between tube-plates, $\frac{1}{2}$ in. internal diameter. Weighing only 7 cwt., it provided 253 sq. ft. of heating surface and a flue area of 156 sq. in. The gradual advance in the design of the smoke-box heaters is shown in the following table, the weight per unit of heating surface having been reduced in the course of the evolution to about one-tenth of what it was originally :—

TABLE V.—*Particulars Showing Development of Waste-Gas Smoke-Box Heaters on Egyptian State Railways.*

Engine No.	Type of Heater.	Weight, Full.	Heating Surface, Sq. Ft.	Sq. Ft. of Heating Surface per 1 Cwt.
620	Annular shell heater* ..	2.25 tons	159	3.53
694	Annular tubular heater† ..	1.5 ,,	175	5.8
694	Twin-barrel tubular heater .	9.5 cwt.	228	24
694	Single-barrel tubular heater	7.0 ,,	253	36

* Described in ENGINEERING, vol. xci., page 146.
† *Ibid.*, page 211.

The single heater has, as a rule, been used for steam, but it has also been used for feed-heating, for which simple changes in connections are all that is required. With it steam temperatures equivalent to 76 deg. Fahr. were obtained on engine No. 694, or water temperatures (in conjunction with preliminary heating by exhaust steam) of 283 deg. Fahr. and more. Between these two methods of utilising the apparatus there is very little choice, as regards the effect on coal consumption, though it is considered that the latter gives rather the better engine at maximum loads. Superheating has, however, certain practical advantages which have resulted in its adoption in preference to feed-heating.

On the satisfactory development of this single heater it was decided to equip a number of passenger locomotives on the Upper Egypt section of the Egyptian State Railways, on which the need had arisen for engines of greater power. Since the existing stock very nearly reached the permissible loads on this part of the system, and for certain reasons it was not desirable then to purchase new stock, existing engines were taken into the shops, and heaters added. These engines have already been described in ENGINEERING.* They were locomotives of the 4-4-0 type, with 18-in. by 24-in. cylinders, 6-ft. 3-in. driving-wheels and 160 lb. working pressure. The boiler-heating surface was 1235 sq. ft., and the grate area 21.33 sq. ft. The feed and steam-heating apparatus fitted to them is shown in Figs. 17 to 21. The system included the use of a Worthington pump, a small heater making use of the pump exhaust, two large feed-heaters and the smoke-box waste-gas superheater.

The small exhaust-steam heater, giving 9 sq. ft. of heating surface, was placed on the suction side of the pump, the feed, in being drawn through it, being raised about 30 deg. Fahr. It was a tubular heater, similar to that described in a former article. From the pump the feed was forced past a clack and then through two large tubular heaters, one on either side of the smoke-box, on the running-board. These each provided 75 sq. ft. of heating surface, and were supplied by part of the exhaust steam from the cylinders. A diaphragm in each compelled the water to flow to the far end and back again before leaving. It passed in succession through both heaters and then to the boiler by way of a clack, likewise described in the article above referred to.

The superheater fitted consisted of a drum of $\frac{3}{8}$-in. plate, $25\frac{5}{8}$ in. internal diameter, and provided with $\frac{5}{8}$-in. tube-plates $24\frac{3}{4}$ in. apart. It contained 792 tubes $\frac{1}{2}$ in. in diameter, the whole giving 270 sq. ft. of heating surface and 155 sq. in. of flue area. To the back of the heater-drum was fitted an inverted cowl, depending from, and forming a continuation of, the chimney. Into the space so formed the blast-pipe top projected, as shown in Fig. 17. This cowl, or hood, forming the blast-chamber, is shown in Fig. 20. With this heater and hood it was possible to increase still further the area of the spark-arrester netting, which now ran across the whole of the smoke-box for its full length (Fig. 19), and connected at the front with a vertical screen fixed to the door. With this ample area all danger of clogging, found to be present in former cases in which the area of netting had been restricted, was obviated. In order to bring the engine to proper trim, a cast-iron slab was placed on the foot-plate in the cab, the total additional weight on the engine being thus brought up to about 3 tons, distributed over four axles.

In view of the illustrations (Figs. 17 to 21) and the notes thereon, further description is scarcely needed. Fig. 21 is a view of the smoke-box of one of the engines, No. 613, as it took part in a comprehensive test, which will be dealt with in our next article.

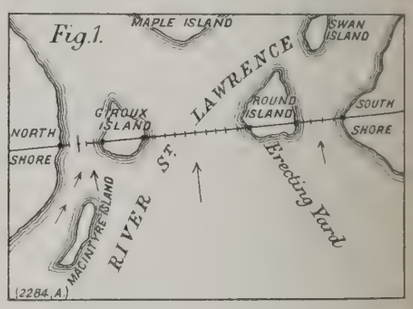
* See ENGINEERING, vol. xci., Plates XIV. and XV., page 212.

* See description of engine No. 620 in ENGINEERING, vol. xci., page 146.

THE COTEAU RAILROAD BRIDGE ACROSS THE ST. LAWRENCE RIVER.

By FRANK W. SKINNER, M. Am. Soc. C.E.

THE original crossing of the Grand Trunk Railway over the St. Lawrence River, about 37 miles west of Montreal, and one mile above the swift Coteau Rapids, was by a car ferry, which, in 1888, was replaced by a single-track through bridge, about 4025 ft. long and 25 ft. clear above the water. This, as shown in the plan, Fig. 1, subjoined, was built over two islands and three channels. Here the water was 23 ft. in maximum depth, with a current which at times attained $8\frac{1}{2}$ miles per hour, moving over a bottom of smooth hard rock overlaid with 3 ft. to 6 ft. of cemented gravel and boulders. The river is not, however, subject to freshets, and for about seven months in the year is navigable at this point for large boats going down stream. In the spring the channel is filled with enormous quantities of heavy ice.



There were four 223-ft. spans over the south channel, ten 217-ft. spans over the middle channel, two 175-ft. and one 139-ft. fixed spans, and one 355-ft. swing span over the steam-boat channel, which, as the plan shows, is adjacent to the north shore. The superstructure, weighing about 2750 tons, had double intersection trusses with riveted connections, and was supported on 8-ft. by 24-ft. masonry piers on concrete footings, built in open wooden cofferdams, and located by measurements made on the ice.

The cofferdams for the fifteen fixed river piers were 20 ft. wide and 67 ft. long, with pointed ends and braced walls of 12-in. by 12-in. timber. They were built about a mile up-stream from the bridge site, and floated to position suspended from a pair of 24-in. by 24-in. oak beams on 20-ft. towers on the decks of a pair of barges towed by from two to five tugs. When within 800 ft. of the site, they were secured by five heavy anchors, the tugs released, and the anchor cables slacked off until the cofferdam was about 25 ft. up-stream of the required position, when it was heavily loaded with steel rails and lowered nearly to the bottom by the four nine-part tackles previously used to lift it while passing through shoal water. Both anchor and suspension tackles were then simultaneously slacked to land it in exact position. The cofferdams were sunk in pits excavated to rock in about 15 days each by two dipper dredges. The swift current frequently broke the 18-in. by 20-in. oak anchor spuds of the

REPLACEMENT OF THE COTEAU RAILROAD

MR. HOWARD G. KELLEY, ENGINEER; TH

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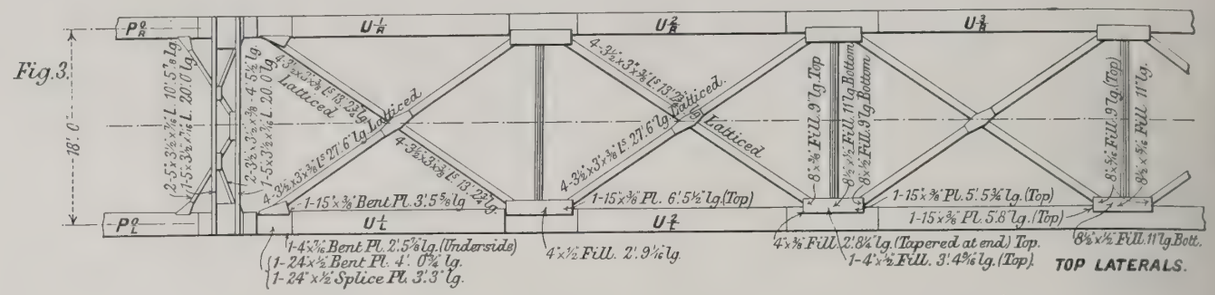
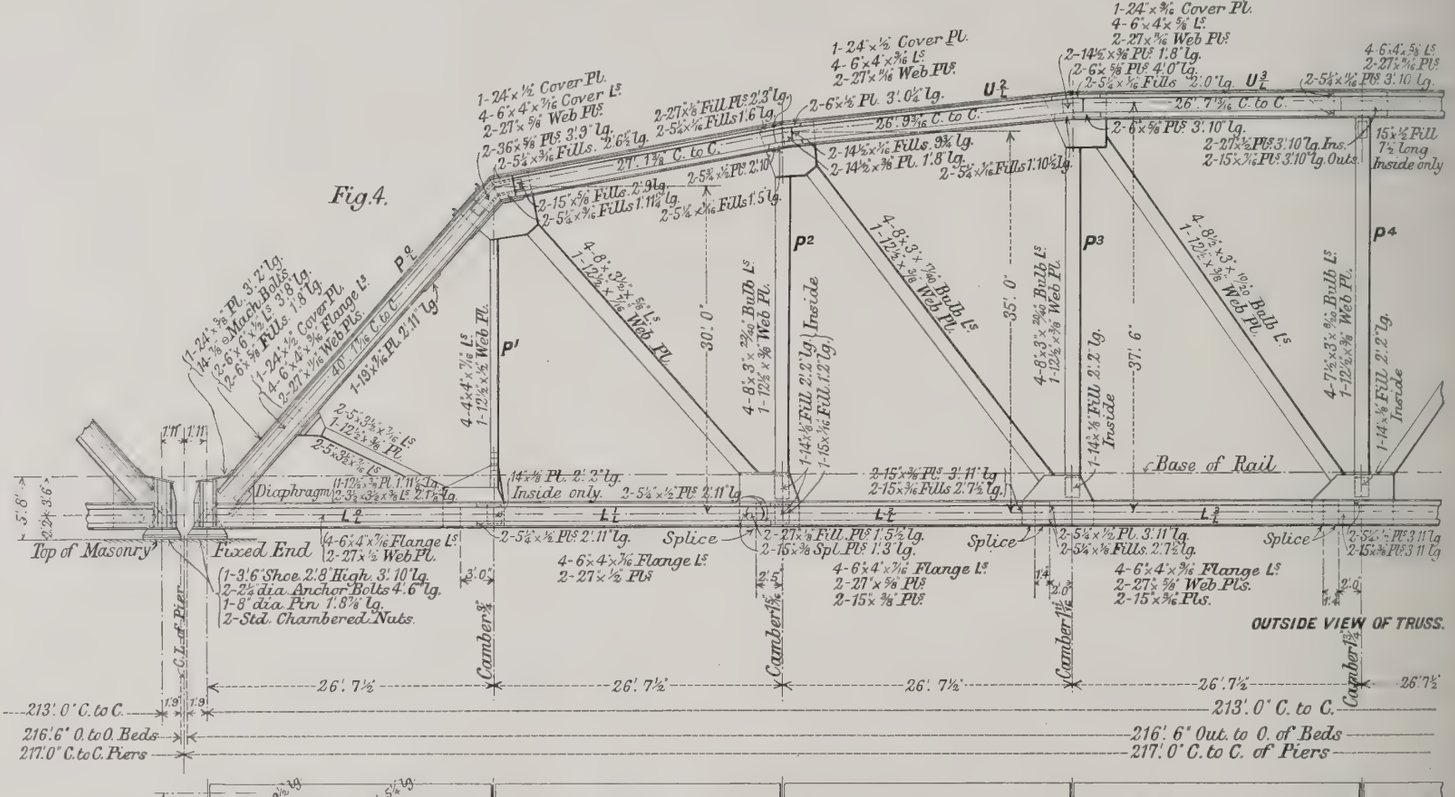
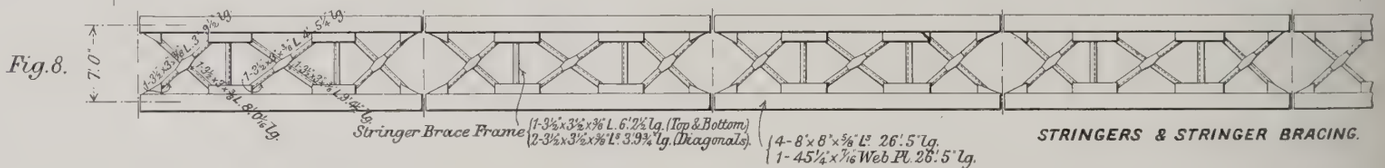
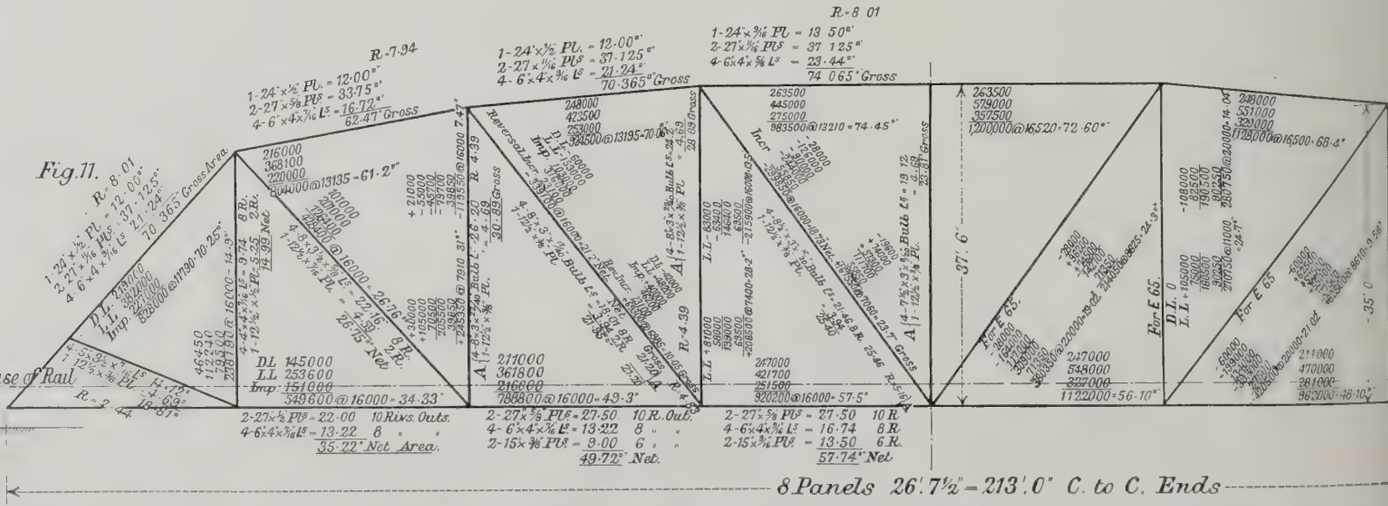
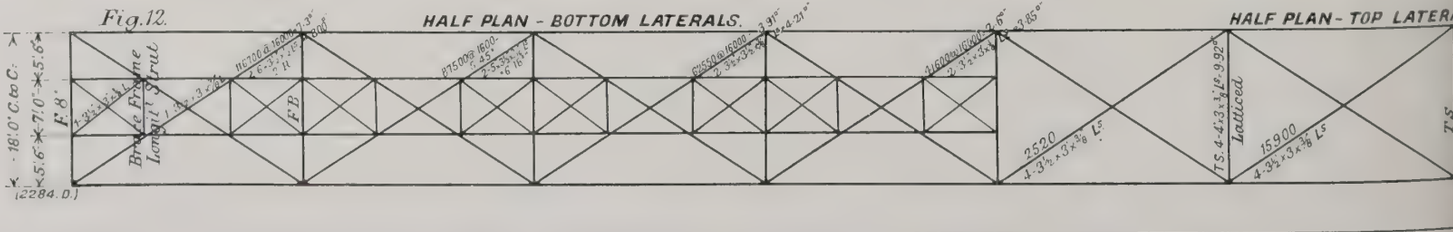






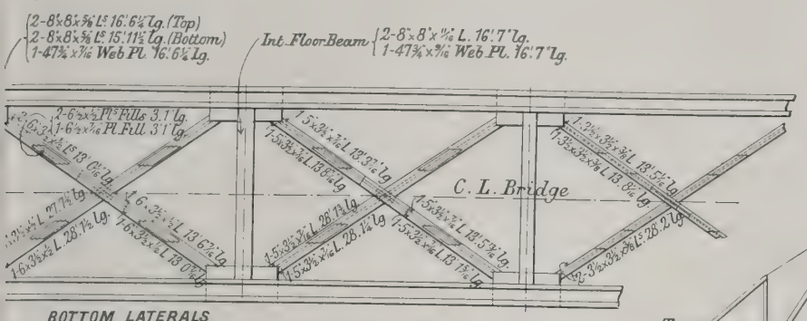




ACROSS THE ST. LAWRENCE RIVER, CANADA.

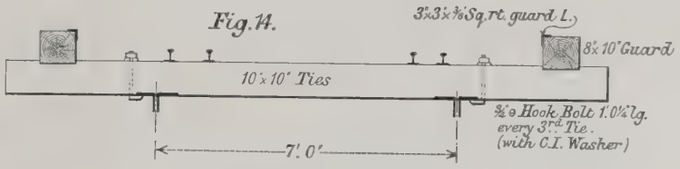
DGE COMPANY, MONTREAL, CONTRACTORS.

48.)



BOTTOM LATERALS

Fig.14.



SECTION OF FLOOR.

Fig.15. SECTION Z.Z.

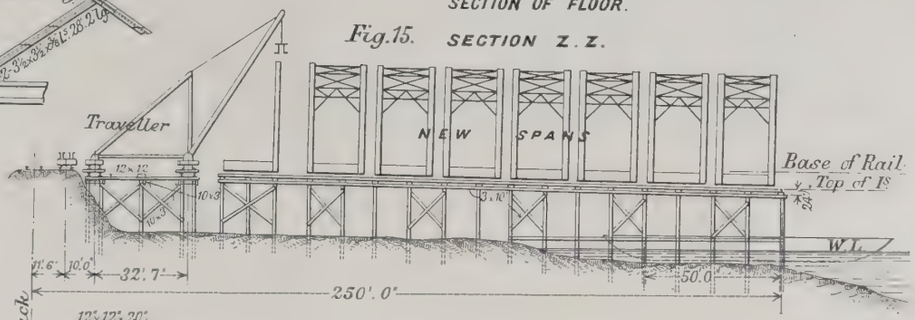
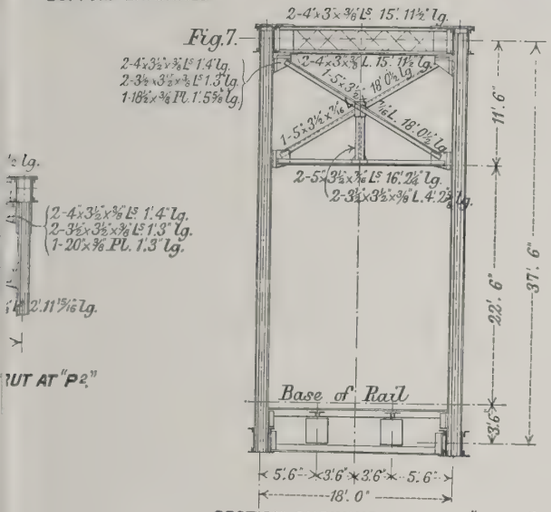
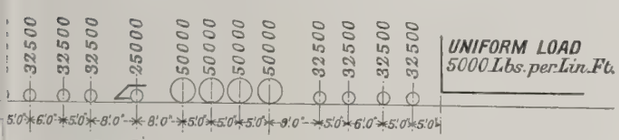


Fig.7.

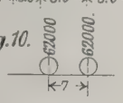


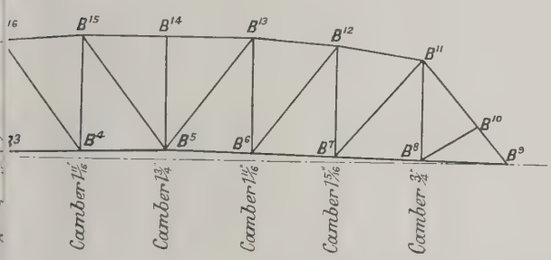
SECTION SHEWING STRUT AT "P3 & P4"

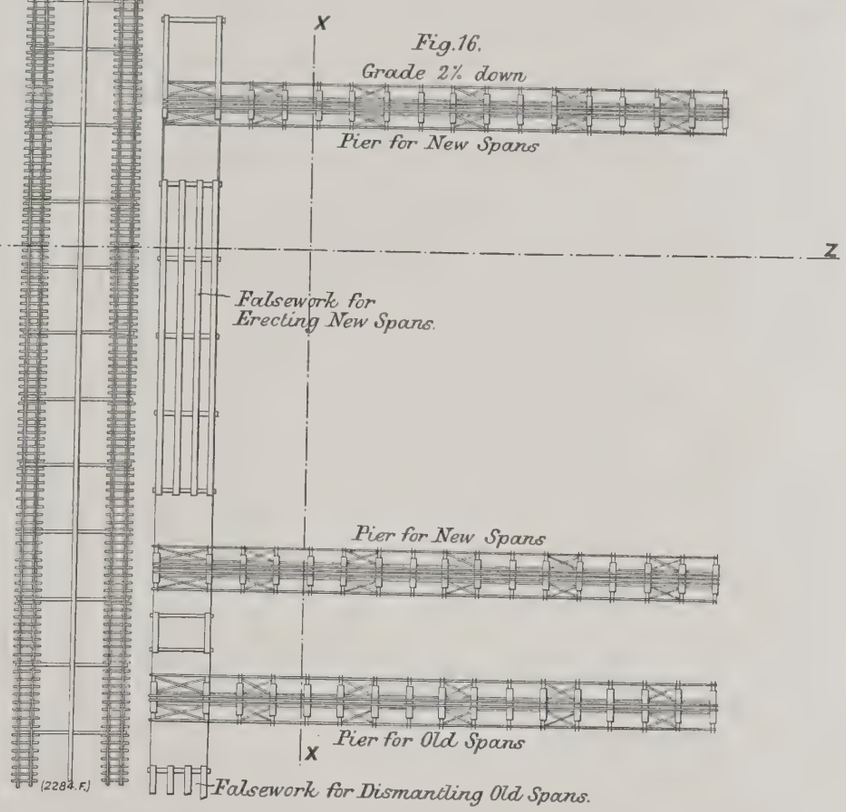


UNIFORM LOAD
5000 Lbs. per Lin. Ft.

Fig.10.







SECTION X.X.

Fig.17.

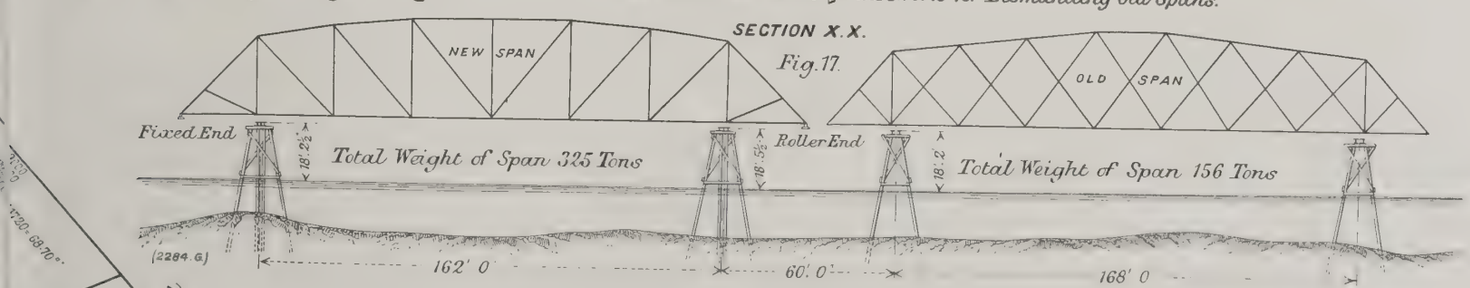
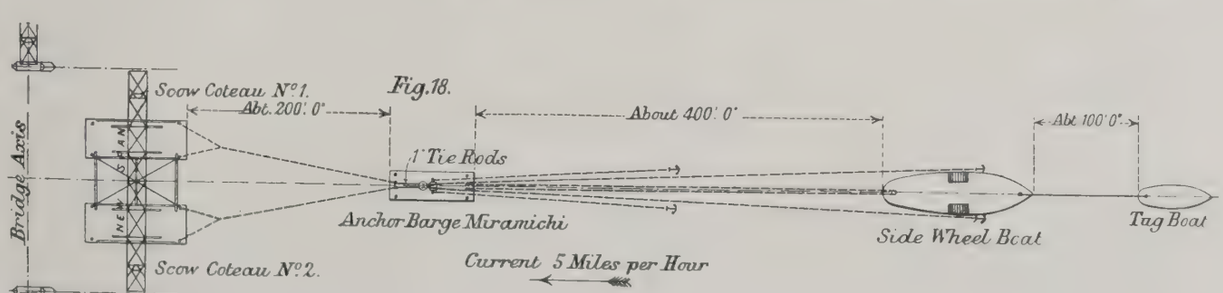


Fig.18.



THE COTEAU RAILWAY BRIDGE ACROSS THE ST. LAWRENCE RIVER, CANADA.

MR. HOWARD G. KELLEY, ENGINEER; THE DOMINION BRIDGE COMPANY, MONTREAL, CONTRACTORS.

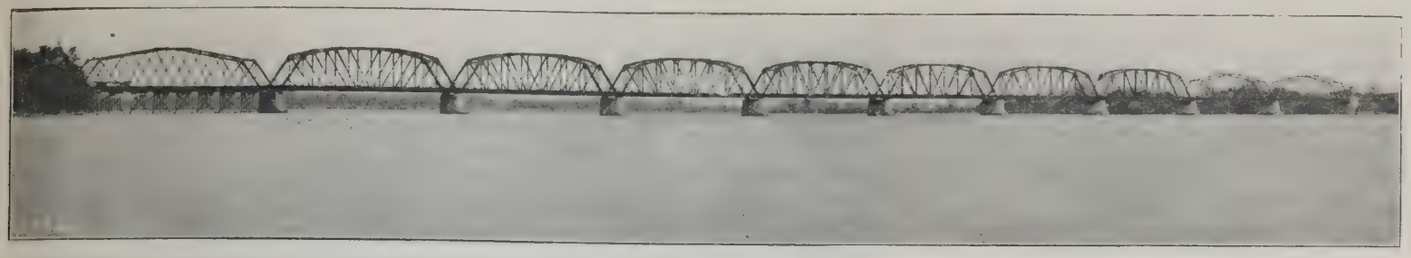
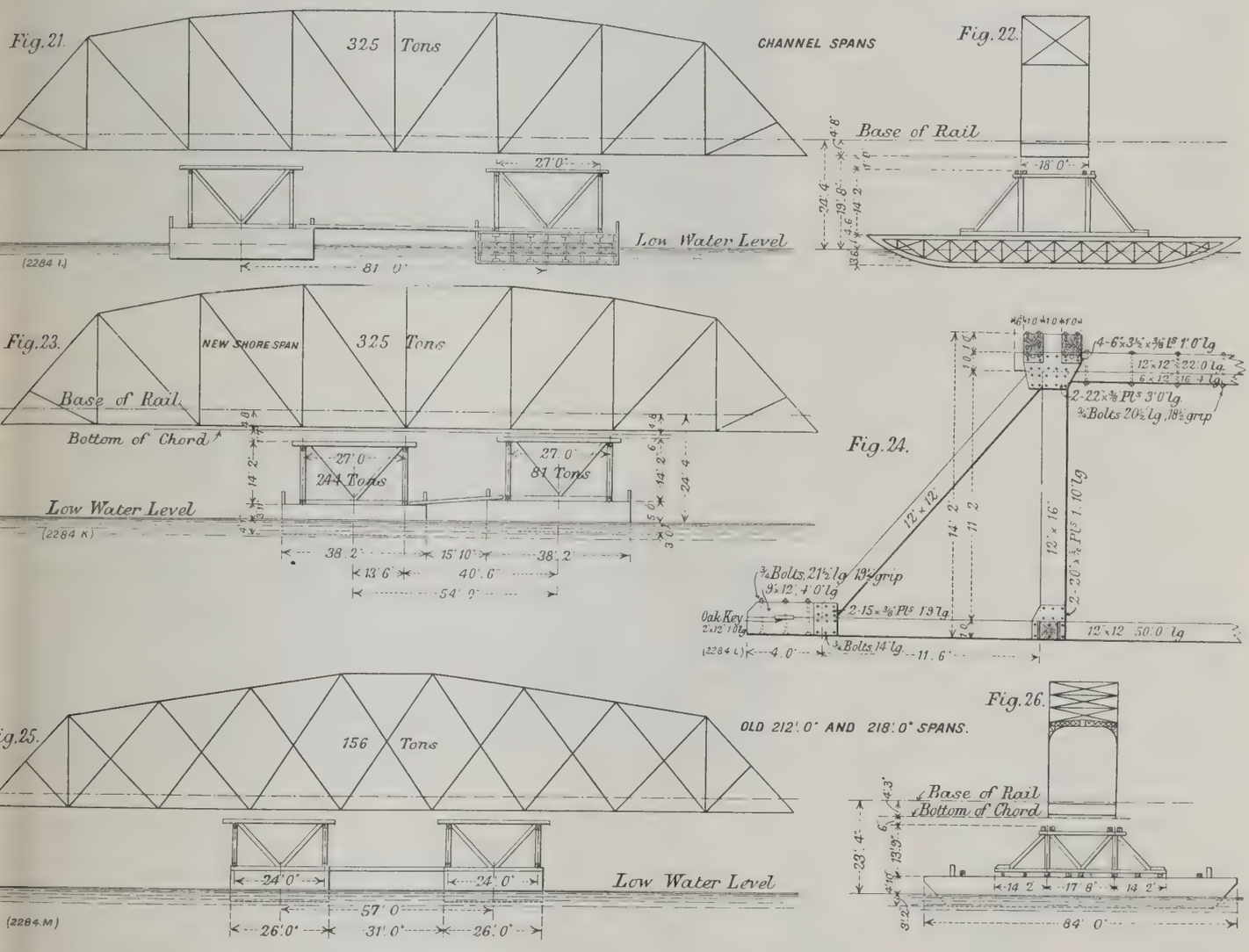


FIG. 2.



edges, and on one occasion overturned a cofferdam 30 ft. of water, depositing its rail ballast in the

After landing, the cofferdams were additionally ded, and canvas curtains, previously nailed to the ier walls 2 ft. above the bottom, were unrolled d spread over the bottom by divers, who piled gs of concrete on them. Concrete was then con- uously deposited by one and two-yard bottom mp-buckets and levelled 12 ft. below water-level. er it had set 48 hours, the water was pumped out 30 minutes by an 8-in. centrifugal pump, and the sonry was built in the dry.

The fixed spans, weighing about 156 tons each, re erected on falsework on an island a mile above bridge site, skidded on to barges, towed be- en the piers, and deposited on them by admis- n of water ballast to the barges The bridge s put in service 10 months and 20 days after k on the substructure was commenced.

n order to provide for increased traffic and vier loads the old superstructure was replaced in 1910 by a much heavier new one, on the same substructure, without seriously interrupting traffic, and the methods adopted in executing this work are illustrated on Plate L., which also shows details of the new bridge, and on the present page and page 450. Fig. 2, above, shows the work of replacement at an advanced stage. As will be seen, seven of the channel spans are new, the three remaining ones being old trusses still in place. The new spans, like the old ones, were made and erected by the Dominion Bridge Company, Montreal, under the direction of Mr. Phelps Johnson, manager. As shown by Figs. 3 to 8, Plate L., the structure is riveted throughout. Its details were proportioned to take a load of two ten-wheel engines and tenders, followed by a uniform load of 5000 lb. per foot run, as shown in Fig. 9, but the floor-beams and stringers were also made strong enough to carry two concentrated loads of 62,000 lb. each, spaced at 7-ft. centres, as shown in Fig. 10. The strain-sheet, which gives also the amount of metal provided in each member, is reproduced in Fig. 11, whilst similar data as to the top and bottom lateral systems are given in Fig. 12. Fig. 13 shows the amount of camber allowed on erection at each panel point. The floor is of wooden ties. Guard-timbers, measuring 8 in. by 10 in., are provided, as indicated in Fig. 14. The most interesting feature of the bridge is, however, the method used to erect it and transfer it to place. A low pile falsework, 550 ft. long and 20 ft. high, was built on the shore of one of the islands crossed by the bridge (see Figs. 15, 16, and 17), and the steel, delivered from the shops alongside, was unloaded from the cars and erected on it by a travelling stiff-leg derrick moving from end to end of the falsework on a 32½-ft. gauge track on an independent falsework trestle.

The assembled spans, weighing 325 tons each, were supported at the second panel points from the ends on rollers moving on pile trestle piers about 200 ft. long, perpendicular to the erection falsework. The piers, 162 ft. apart, carried roller-tracks made of three lines of 15-in. I-beams graded down 2 per

cent. towards the river end. The field-rivets were driven while the next span was being erected in the same manner, after which it was moved out and riveted, and so on until seven spans were on the piers and an eighth on the erection falsework. A group of the spans thus finished and ready for transfer is shown in Fig. 19, annexed.

To effect the transfer two 38-ft. by 100-ft. steel-frame barges, Figs. 21 and 22, page 449, braced together, 81 ft. apart on centres in the case of the main span, and less in that of the shore, were partly filled with water ballast, and placed under the outermost span on the piers. The water ballast was pumped out, allowing the barges to rise until the span took bearing, at the second and third panel points from each end of each truss, on wooden towers, 14 ft. high, on the decks of the barges (see Fig. 24), and were lifted clear of the piers.

The barges, with a draught of $3\frac{1}{2}$ ft. and a free-board of $4\frac{1}{2}$ ft., were then towed to a point a little up-stream of the piers, and secured to an anchored scow, as shown in Fig. 18, Plate L., and Fig. 20, annexed. Their tackles were then slacked, and they were carefully eased down-stream, and water ballast was readmitted to sink them until they deposited the spans on the piers, after which they were towed back to the erecting-yard for another span, and so on for eleven of the fixed spans, the remaining six being erected in the usual manner, on ordinary falsework in shallow water at the bridge site.

While each new span was being lifted from the erection piers, floated down-stream and placed in permanent position on the piers, the corresponding old span was conversely lifted from the same piers by a pair of smaller wooden barges, Figs. 25 and 26, page 449, operated by water ballast, towed up-stream, and deposited on the erection piers at the opposite end of the island falsework. It was then rolled down a 2 per cent. grade, to the shore ends of the falsework piers, and there taken apart by a wrecking-car, and the next span brought in, and so on. The movement of the spans was so arranged as to occur during the longest intervals between regular trains, and as it occupied but a few hours for each exchange of an old for a new span, little interference with the train service was occasioned.

Solid-steel live rollers, $2\frac{1}{2}$ in. in diameter, were put under the spans on the falsework piers, and the spans were moved by two four-part tackles operated by the hoisting engine on the erecting traveller. The new-span barges were stiffened by five longitudinal steel trusses (see Fig. 22); they drew 19 in. light, and were equipped with one 8-in. centrifugal pump on each, to handle the water ballast in and out. The old span barges had a draught of 15 in. light and 21 in. loaded, and were each provided with a 6-in. gate and a 6-in. centrifugal pump supplied with steam from a boiler on deck.

The new bridge was designed and erected under the direction of the engineering department of the Grand Trunk Railway system, Mr. Howard G. Kelley being the chief engineer.

THE COTEAU RAILWAY BRIDGE, CANADA.

THE DOMINION BRIDGE COMPANY, MONTREAL, CONTRACTORS.

Fig. 19.

Fig. 20.

THE BRITISH ASSOCIATION.

(*Concluded from page* 419.)

SECTION B.—CHEMISTRY.

The Chemical Section came out with a well-arranged, compact, and instructive provisional programme on Thursday, August 31, discussed the twenty-seven papers and reports in the order arranged, with praiseworthy punctuality, and disposed of the programme in four mornings, as intended. The Section and its officers may thus be congratulated upon a successful meeting. The chief questions discussed concerned physical chemistry, colloids, indicators and colour, and the part played by enzymes in the economy of plants and animals. There were hardly any strictly chemical contributions, and the chief interest of a communication on optically-active substances not containing any asymmetric atom in the molecule, whose details only the chemist could appreciate, was again physical. The reports were more of a chemical character; but it has become the custom to distribute reports and to take them as read, though they often represent the best work brought before the Section. In the interest of facilitating intercommunication between the different sections, it was fortunate that Section B, which had originally been quartered in the Secondary School near Fratton Station, was able to move over to the Portsmouth Municipal College, in which Sections A, C, and G were meeting.

The officers of the Section were:—President: Professor James Walker, D.Sc., F.R.S., of Edinburgh. Vice-Presidents: Dr. J. E. Stead, F.R.S.; Professors A. Béhal and Albin Haller, of Paris; Professor W. J. Pope, F.R.S., of Cambridge; and Professor A. Senier, M.D., Ph.D., of Galway. Secretaries: Messrs. E. Frankland Armstrong, D.Sc., of Reading (Recorder); C. H. Desch, D.Sc., of Glasgow; T. M. Lowry, D.Sc., of London; and F. Beddow, D.Sc., of Portsmouth.

Theories of Solution.

In introducing his presidential address, Professor Walker said that the nature of solutions had been discussed at Leeds in 1890, the first meeting that he had attended. Van't Hoff had then been present, and he had hoped to be present again. But they had to mourn the departure of Van't Hoff, the founder of the modern theory of solution, whose name would remain one of the greatest in theoretical chemistry; in time to come, Professor Walker thought, it would be considered almost the greatest. A general theory of solutions must be binding to all solutions, to mere intermixture between solvent and solute as well as to those in which solute and solvent were bound together to what could not sharply be distinguished from chemical union, and to all grades of intermediate binding.

Where no affinity existed between solute and solvent, the solution was practically of the type of the mixture of two gases which did not chemically act on each other. Saturated hydrocarbons, like pentane and hexane, formed such mixtures. There was no evidence of union, the heat of solution was practically nil, the volume of the mixture was practically the sum of the volumes of the components, and the vapour pressure of each component was reduced as if by dilution with the other. Yet there was some interaction, but rather of a physical kind, as in the case of compressed inert gases, whilst liquid argon and nitrogen seemed really devoid of affinity. At the other extreme end stood solutions like that of sulphuric acid and water. There was every physical evidence of chemical union; the amount of heat evolved in mixing was very great, the resulting volume was by no means equal to the sum of the component volumes, the mixture conducted the electric current whilst the component were insulators. The influence of the solvent on the solute was chemical in character. Any such influence would be reciprocal; hence there could be no chemical action in mixtures if one constituent were an inert substance like argon or the hydrocarbons, which were inert, as their name (paraffins) indicated. The effect of solvents on solutes could conveniently be illustrated by the behaviour of a coloured substance in a series of colourless solvents; if the substance were un-

affected by the solvent, the colour of the solution might be expected to be the same as that of the vapour of the substance. Iodine gave a violet vapour; its solutions in carbon disulphide, in chloroform and hydrocarbons, had the same colour; the solutions in water and alcohols were brown; the solution in a glacial acetic acid was brown in the cold, and pink at boiling, suggesting that compounds formed were decomposed by heat.

Van't Hoff's osmotic pressure theory now applied equally to mixtures of gases, of inert liquids, and of sulphuric acid and water, and as long as the solutions were diluted, simple relations were found to connect osmotic pressure and other easily measurable properties of solutions. It had, unfortunately, been the custom to oppose the osmotic theory to the hydrate, or more generally the solvate, theory, in which combination between solute and solvent was assumed. But the solvate theory was not a general theory, and was, moreover, perfectly compatible with the osmotic pressure theory. The great practical advantages bequeathed to chemists by the genius of Van't Hoff was the assimilation of substances in dilute solution to substances in the gaseous state—very diluted solutions, of course, only, as Van't Hoff himself emphasised, for even simple gases diverged widely from the gas laws when compressed. There had been a tendency in thermodynamical quarters to belittle the importance of the conception of osmotic pressure. It was true that, from the mathematical point, it might be relegated to a second place, or dispensed with, for it was thermodynamically related to other magnitudes; but without it the cultivators of thermodynamic methods would hardly have arrived at their results. The investigator might choose one of several equivalent methods according to his personal idiosyncracy. The teacher had no open choice, he had to take the most intelligible method, least likely to be misunderstood. The student could grasp the osmotic pressure conception, but Professor Walker would be sorry to have to teach the theory of solution by means of thermodynamic functions. The latter method was mathematically more elegant, and even simpler; but it did not give the student an opportunity to submit his method to a practical check or test, and it would often lead to error and confusion.

The outstanding practical problem in the domain of electrolytic solutions, Professor Walker continued, was to show why strong electyolytes* were not subservient to the same laws as govern weak electrolytes. According to the general law of mass-action, the activity of a substance was proportional to its concentration. If we applied that law to the ions and to the un-ionised (or non-dissociated) molecules, a certain formula, known as Ostwald's dilution law, connected concentration and ionisation, the latter being deduced from the electrolytic conductivity, according to Arrhenius. But Ostwald's law was only applicable to feeble electrolytes, not to strong electrolytes. In order to explain this peculiarity, it had been suggested that the rule of Arrhenius failed in the case of strong electrolytes; that suggestion was now abandoned. The other explanation suggested that the law of mass-action failed, because complexes were formed, such as Na_2Cl+ and $NaCl_2-$ from Na_2Cl_2; the simple formation of hydrate, NaCl. $2H_2O$ would not create any difficulty. Professor Walker now proposed that it was not, as had often been thought, the ions of strong electrolytes which behaved abnormally, but the undissociated molecules, and he explained his views with reference to acetic acid and its salts and derivatives, and to other compounds, and with regard to the modifications of Ostwald's laws by Van't Hoff, and also to the constant ionic solubility product of Nernst. There was closed equilibrium between ions, non-ionised salt, and solid salt, and when the abnormality was attributed to the non-ionised portion, theory and experiment agreed. Why some molecules should behave abnormally was not known. Nor had the laws of dissociation been worked out yet for other solvents than water; it was rather peculiar that Professor Walker said so little about his part of the problem, which has assiduously been investigated of late.

Concluding, he stated that it was time that all the irrelevant and intemperate things that had been said and written by the supporters of the osmotic pressure and electrolytic dissociation theory, on the one hand, and by those of the hydrate theory, on the other, should be forgotten.

* Solutions of strongly dissociated salts and acids. The degree of dissociation depends upon the substance, and some molecules always remain non-dissociated.

The Diffusion of Gases through Water.

Professor Carl Barus, of Providence, Rhode Island, described experiments on "The Diffusion of Gases through Water," which, he explained, permitted of a remarkable accuracy. The apparatus was a Cartesian diver. The diver itself was an oval vessel of glass, open below, partly filled with water so as to keep some gas imprisoned; the diver floated in a large container of water, in which it rose or descended, according to its weight, and the weight and the pressure on the gas bubble could exactly be determined. The diver came to rest on a wire grating; it was not allowed to touch the bottom of the container. The gas would, in the course of hours and weeks, slowly diffuse through the water into the gas above the water of the container; the inner and the outer gas were the same or different; air, oxygen, and hydrogen had, so far, been experimented with. The curious fact resulted that gases would sometimes diffuse against the apparent pressure gradient; that could be explained in terms of the partial pressure of the mixed gases within the diver as compared to the simple gas without. Thus there would sometimes be an initial rise of the diver followed by a fall. The temperature of the water was kept constant; but in some cases the regular curves showed ripples due to temperature fluctuations. If the coefficient of diffusion were known, the density of the gas could be calculated, and by the aid of Stokes's formula the virtual viscosity of the medium, through which a single molecule of gas transpired between the molecular forces of the liquid, could be deduced. It is especially from this point of view that a continuation, by so distinguished an investigator as Professor Barus, of these experiments with many gases and liquids appears desirable.

Molecular Volumes and Constitution.

Mr. Gervaise Le Bas, B.Sc., of Jersey, read a very suggestive paper on "The Influence of Constitution on the Molecular Volumes of Compounds at the Boiling Point." The communication concerns a subject which he has been studying for some years, starting originally with the molecular volumes of solids at their melting-points. He now stated that if an examination of the molecular volumes M V and atomic volumes A V proved the relation $M V = \Sigma A V$ to be nearly true for related compounds, it would probably be true for the individual compounds. The molecular volumes at boiling-points might be regarded as proportional to the molecular volumes at absolute zero, and thus to the real molecular volume. It would follow that the molecule was a compact arrangement of spheres of atomic influence, such that the intramolecular interstices should be negligible [which points to "close packing"].

The atomic volume would depend upon the nature of the atom, the pressure and temperature, and the environment at the boiling-point, and, as the latter would be very different for an element and its compounds, the atomic play-spaces should differ as they did. But the volume ratio appeared to remain constant throughout the liquid and solid states, in spite of complexity of constitution. Thus, taking the volume of the hydrogen atom H as unit, carbon gave the relative volume 4H, oxygen 2H or 3H, trivalent nitrogen 3H, chlorine 6H, &c. In many cases the molecular volumes of compounds could be calculated with very fair accuracy. The relation being mutual, it would then appear that an atom entering a compound had a certain volume impressed upon itself, and impressed a corresponding volume upon the other hydrogen equivalents in the molecule. The constitution had some influence, however, because the resulting volumes were frequently smaller (sometimes even larger) than those calculated from the constituents. The total volume was hence contracted (or enlarged), and the contraction was ascribed to a residual affinity. The contraction was marked in certain types of compounds, quantitative particulars of which were given, and it might induce a curved configuration, which would change a straight-chain arrangement into a partial ring. It was interesting that the polyterpenes formed bridged-ring compounds, leading over to compounds resembling india-rubber.

Influence of Substituents on Reaction Velocities.

Professor Rudolf Wegscheider, of Vienna, communicated a paper on "Influences of Substituents on Reaction Velocities," a subject on which he has presented many memoirs to the Vienna Academy of Sciences. He pointed out that the changes of free energy connected with the chemical transformations doubtless determined the direction of possible transformations. But the velocity of the transformation of organic compounds, with which the paper dealt, was generally small, and was not alone, and not even chiefly sometimes, determined by the changes of free energy. When the two components were brought into reaction, the saponification, esterification, or other reaction, would result with a certain velocity; that velocity would be altered by introducing various elements into the compounds, and the influence of these substituents would depend upon the electrolytic dissociation (the negatifying or positifying effect) of the substituent and upon other properties as well, some of which Professor Wegscheider would, for the present, comprise under the term "steric hindering."

Absorption Spectra of Vapours and Solutions.

Professor J. E. Purvis, of Tokio, Japan, contributed a paper on "The Ultra-Violet Absorption Spectra of Vapours of Various Organic Substances Compared with the Absorption of these Substances in Solutions and in Thin Films," a subject on which he has been engaged for some years. In the present paper he dealt with pyridines, nicotine, quinoline, coniine, anilines, and chloro- and bromobenzenes, &c., and he considered the general results and the influences which the nature, weight, type, and orientation of the atoms would have on their movements. The extent of free path, the impact of symmetrically and asymmetrically oriented molecules, and radiant energy would also have to be studied. The vapour molecules, he concluded, had considerable freedom of movement, and many bands would be produced, unless (pyridines and anilines) the asymmetrical orientation destroyed the rhythmical oscillation. The solvent of a solution restrained the vibrations and the number of encounters, and also absorbed radiant energy, so that the narrow bands of vapours would become broader and more diffused. In thin films the closer packing would further restrict the molecular movements; but the selective absorption would probably be as in solutions, with the bands of the thin films shifted towards the less refrangible regions. Professor P. V. Bevan's paper on "Absorption Spectra and Refractive Power of Vapours" has already been noticed in connection with his Section A paper.

Optically Active Systems.

Professors W. H. Perkin, F.R.S., of Manchester, and W. J. Pope, F.R.S., of Cambridge, presented a paper of high theoretical interest on "Optically Active Substances which contain no Asymmetric Atom in the Molecule." In explaining their researches Professor Pope stated that Van't Hoff, when examining the relation between molecular configuration and optical activity, had clearly indicated that it was not only solutions of compounds containing an asymmetric atom in the molecule [an atom, carbon atom in the first instance, asymmetrically linked with others] that should be optically active, but also compounds of enantiomorphous configuration [in which the two groups linked to an atom would be the mirror images of one another, or like the right and left hand]. Whilst now optically active compounds in the amorphous or dissolved condition containing quinquavalent phosphorus or nitrogen, or tetravalent silicon, sulphur, selenium, and tin had been discovered, optically active compounds of the enantiomorphous or centro-asymmetry type, without asymmetric atom, had not been prepared until quite recently. After years of experimenting they had decided that the 1-methyl-cyclo-hexylidene-4-acetic acid should be of this type, and had synthetically prepared it. Curiously enough, Marckwald and Meth had simultaneously carried out a similar investigation. The compound mentioned, Professor Pope explained with the aid of models, gave optically active and inactive derivatives, as anticipated, and his exposition was a beautiful demonstration of the fidelity with which the constitutional formulæ of the chemist can depict molecular configuration.

Reports on Organic and Analytical Chemistry.

We mention committee reports presented, with the names of the secretaries in brackets: On "Dynamic Isomerism" (Dr. T. M. Lowry), dealing with the general and specific absorption in the

ultra-violet in its relation to constitution, a very valuable contribution to these problems; on "The Study of Hydroaromatic Substances" (Professor A. W. Crossley); on "The Transformation of Aromatic Nitroamines and Allied Substances and its Relation to Substitution in Benzene Derivatives" (Professor K. J. P. Orton), embodying papers by Mr. Harold King, M.Sc., and Miss M. G. Edwards; and on "Electro-Analysis" (Dr. H. J. S. Sand), embodying a contribution by Dr. F. Mollwo Perkin on the electrolysis of alkali salts with a mercury cathode, so as to determine both the metal and the acid, after the method of J. F. Hildebrand and Edgar F. Smith.

We may also mention a paper by Dr. J. F. Thorpe, F.R.S., of Sheffield, on "The Chemistry of Glutaconic Acid."

The Compressibility of Mercury.

Dr. W. C. McC. Lewis, of University College, London, gave an account of an inquiry into the "Compressibility of Mercury." For the majority of normal liquids, he stated, the formula $L = Ta/\rho\beta$ was found to hold, in which L was the latent heat of vaporisation of the liquid, T the absolute temperature, a the expansion coefficient of the liquid, β its compressibility, and ρ its density. In the case of mercury the discrepancy between the observed and the calculated L was great, and he suggested that the discrepancy was due to errors in the accepted value of β, the compressibility of mercury. From the L of Knudsen, Callendar and Moss had calculated $\beta = 1.3 \cdot 10^{-6}$ per kilogramme per square centimetre, while P. Bridgman had recently found $\beta = 3.7 \cdot 10^{-6}$. Experimental errors, all leading to too high β values, Dr. Lewis suggested, might arise from an absorbed layer of air or moisture between the mercury and the walls of the vessel, from the unavoidable slip of the mercury past the piston, and from the incomplete removal of the mixture into which the piston was dipped before insertion in the mercury. Dr. Lewis did not speak of any experiments of his own.

Colloids.

The discussion on "Colloids" was opened by Professor H. Freundlich, of Leipzig, in a lucid summary of the "Theory of Colloids." The ultra-microscope of Zsigmondy, he pointed out, had shown colloids to be two-phase systems, containing suspended particles, and the quantitative experiments of Perrin and Svedberg on Brownian movements proved the colloids to form a connecting-link between coarse suspensions and true solutions. In true solutions combination between the dissolved substance and the solvent undoubtedly occurred. Coarse suspensions consisted of sparingly soluble substances, which had little tendency to react with the solvent. Colloidal solutions stood between the two extremes; they might be classified as suspension-colloids or lyophobic sols, comprising colloidal metals, sulphides, many hydroxides, and distinguished from coarse suspensions by the ultra-microscopic dimensions of their particles, and emulsion colloids or lyophilic sols, comprising albumin, gelatin, starch, &c., substances approaching true solutions, but more irregular in their behaviour, and comparatively little studied so far. The particles were, in many cases, certainly amorphous, but might possibly retain crystalline properties. Adsorption was chiefly manifested by amorphous substances, and the adsorbed substances were frequently of high molecular weight. Adsorption was probably an effect of surface condensation, but solid solution and chemical combination might be concerned. Owing to the high adsorbing power of amorphous substances, it was almost impossible to obtain pure colloidal solutions, and as the presence of impurity lessened the tendency to crystallise, the maintenance of the colloidal state was favoured.

Among the factors affecting the stability of colloids were internal friction, and the electric charge of the particles. The addition of an electrolyte discharged the particles and facilitated coagulation. The order of this influence was for positively charged sols (metallic hydroxides), the reverse of that for negatively charged sols (colloidal metals and sulphides). Experiments by Elisejeff and Freundlich on the influence of electrolytes in diminishing the electro-endosmosis of a solvent showed that a complete parallelism existed between this effect and the discharging effect of the same electrolytes of a hydrosol. These electric conditions were of little importance in the case of emulsion colloids. In conclusion, Professor Freundlich emphasised the, now acknowledged, importance of colloidal and, in a wider sense, of capillary chemistry in its bearing on physiological and also technical problems.

After a general discussion by Professor C. J. Martin, of the Lister Institute, Sir William Ramsay, Professor Trouton, and others, Dr. G. Barger, of London, followed with papers on "Colloids in Pharmacy" and on "The Adsorption of Iodine by the Glucocide Saponarin," a pure substance of definite composition and molecular weight, 468, preferable to starch (molecular weight unknown) for such studies.

Colloidal Copper.

Mr. H. H. Paine, M.A., B.Sc., of Newport, Mon., described "The Rate of Coagulation of Colloidal Copper," prepared after Bredig's method by passing the electric current through electrodes of the metal dipping into water or some other liquid. The solution was, he said, gradually—not at once—precipitated by salts (sodium sulphate, &c.); the precipitated gel would settle, and could be separated from the clear liquid; the copper could be determined in both these portions, and the rate of coagulation thus be studied. The results suggested a distinction between salts containing a divalent anion (sodium sulphate) and those containing a monovalent anion (potassium nitrate or chloride).

The Colloid Theory of Cements.

In a paper on "The Colloid Theory of Cement," Dr. Cecil H. Desch, of Glasgow, said that the old explanation of the setting of calcareous cements, as caused by the crystallisation of the products of hydrolysis from a super-saturated solution, failed to account for the great mechanical strength of cements. The colloid theory of Michaelis, whose death we reported in our issue of June 16 last,* attributed the setting to the formation of a gel of calcium silicate, which subsequently hardened by loss of water and adsorption of the free lime in the cement, and this view was confirmed by microscopical examination. The complex substances contained in the so-called alite of the cement were alone hydrolised; calcium aluminate crystallised first (the initial setting); the insoluble calcium monosilicate separated afterwards more slowly as a colloidal gel. This gel adsorbed some lime, while another portion of the lime could be detected as plate crystals of calcium hydroxide. Dr. Desch stains the colloids with dyes such as methylene blue, patent blue and safranin in these microscopical studies, and as the cement is too brittle to permit of the preparation of very thin sections, he grinds and polishes the surface and examines them, as in metallography, under vertical illumination after etching or staining.

Indicators and Colours.

The discussion on "Indicators and Colours" was opened by Dr. V. H. Veley, F.R.S., of London, by a paper on "The Application of Methyl Orange for the Determination of the Affinity Constants of Weak Acids and Bases, with a Discussion of the Errors." By indicators the chemist understands substances which are added in small quantities to compounds under reaction, not to take part in the reaction, but to indicate, mostly by colour changes, whether there is still an excess of the one or the other reagent present. The most common indicator is litmus, whose neutral violet colour changes into red when there is a slight excess of acidity (any acid), and into blue when the base predominates. The chemist applies a variety of indicators, and Mr. Veley gave an account of their use, and especially of methyl orange, of the advantages and limitations of their application in determining affinity values, and of the concentration of the hydrogen ion, which is characteristic for all acids.

The Sensitiveness of Indicators.

Mr. H. T. Tizard, of Oxford, contributed an important memoir, on "The Sensitiveness of Indicators," which is to be printed *in extenso*. He pointed out that indicators were now regarded as pseudo-acids or pseudo-bases. They consisted of two or more tautomeric forms in equilibrium capable of undergoing almost instantaneous tautomeric changes. This view did not affect Ostwald's method of treatment. The ions might still be regarded as coloured differently from the "undissociated molecule," if that expression were understood to mean not one particular molecular species, but the equilibrium mixture of the various forms which the indicator could assume in its undissociated form. Applying Ostwald's dilution law, it was easy to show that, when the colour of an indicator was exactly midway between the extreme colours of its dissociated and its undissociated form, then the concentration of the hydrogen ions (C_H) in the solution should numerically be equal to the dissociation constant of the indicator K_a, and that the colour changes should take place mainly between the concentrations $10\ K_a$ and $0.1\ K_a$. The most useful indicators would hence be those of a dissociation constant of about 10^{-7}; that is to say, that the concentration of the hydrogen ions should, at the time of "neutral point," lie between 10^{-5} and 10^{-9}. Indicators which were very weak or very strong acids or bases would hence be of little use. Mr. Tizard proceeded to demonstrate with the aid of curves, showing the concentration of the H ions in a salt on addition of small quantities of bases or acids, how the accuracy of a titration depended upon the choice of the indicator.

Enzymes in the Economy of Plants and Animals.

"The Part Played by Enzymes in the Economy of Plants and Animals" was discussed in a joint meeting of Section B and the Agricultural Sub-Section of Section K—Botany. The Recorder of Section B, Dr. E. Frankland Armstrong, opened the discussion. It concerns a branch of physiological chemistry which appeals to everyone. We should refer our readers to our remarks on the exhibits of Professor H. E. Armstrong and Dr. E. F. Armstrong, which excited so much interest at the recent *soirées* of the Royal Society.*

By enzymes Dr. Armstrong understands the agents which bring about the changes in the plant and animal that are commonly regarded as vital. The enzymes act as catalysts, obey the physical laws of catalysts, and are distinguished by the specific character of their action. Each enzyme promotes a particular interaction, and no other; most of them bring about hydrolysis, some oxidation, some act synthetically. They are not proteins, and nothing definite is known as to their chemical character; our readers will remember the old definition of enzymes—unorganised ferments.

One function of enzymes, Dr. Armstrong pointed out, was to break down complexes in the cell; there was a necessity for some restriction of this action, otherwise the cell would be killed, and Dr. Armstrong described the safeguards of Nature. He showed how the leaves of the cherry laurel, which gave off prussic acid, or those of the Japanese laurel, which were blackened, could be used to indicate that changes were taking place in the plant cell, and how the resting leaf could be stimulated into activity by certain substances, such as toluene and chloroform, which had little affinity for water, and were as a class chemically inert. It was suggested that such substances, to which the general name of "hormones" was applied, were able to penetrate the cell and to bring about hydrolytic changes within it. A large number of substances, which acted as very weak hormones, were found in plants combined with glucose in the so-called glucosides. Each glucoside required an appropriate enzyme to hydrolyse it before its products would be effective as hormones, and the speaker alluded to the wide distribution of glucosides in plants and gave an account of the work done in studying and localising their appropriate enzyme. Whereas the leaves of a plant contained, as a rule, an enzyme adapted only for the glucoside contained in the leaves, the seeds of the same plant contained an enzyme or a mixture of enzymes able to attack a variety of glucosides. Dr. Armstrong illustrated the application of these investigations to various problems of animal and vegetable physiology and agriculture.

The discussion mainly turned on controversial points in Dr. Armstrong's chain of reasoning, and it was generally agreed that the theory, whether it could be upheld in the future or not, marked a material advance in the chemical conception of metabolism.

Treatment of Wheaten Flour.

We mention a paper by Mr. A. E. Humphries, on "Some Points in the Treatment of Wheaten Flour;" the bread problem was, of course, dis-

* See Engineering, vol. xci., page 791.

* See Engineering, vol. xci., pages 626 and 797.

cussed in different Sections at Portsmouth. What Mr. Humphries advocated was the addition of water —and, if necessary, of salts—to the flour some time before making the dough, with the object of increasing the strength of the flour, an important question for storage and transport.

Electric Steel-Melting.

We have left two reports on iron and steel last, not because they are unimportant, but because they stand apart. The report by Professor Andrew McWilliam, M.Met., of Sheffield, on "The Present Position of Steel-Melting," is indeed to be printed *in extenso*. Professor McWilliam pointed out that electric steel-melting had passed the experimental stage, but had not emerged from it in the sense that most steel processes were continually being experimented with. The product of the arc furnace from slightly impure materials just about took its place near Swedish open-hearth and Bessemer steels, and the induction-furnace products from pure materials equalled anything but the very highest qualities of crucible steel. But it should not be forgotten that the electric furnace, of whatever design, could not make good steel automatically; the metallurgical skill of the old processes had to be expended on the proper finishing and killing. Having critically reviewed the chief features of different electric furnaces, Professor McWilliam gave statistics. In June, 1910, the number of furnaces installed of all types amounted to 118, of which 70 had been working, 38 were being built, and 10 not working. Of the 77 arc furnaces, 29 were accredited to Héroult, 17 to Girod, 13 to Stassano, and 6 to Keller; the pig-iron furnaces in Norway and Trotthättan were each to produce 7500 tons annually. The total capacity of the Héroult furnaces was 80 tons per charge (those being built had an aggregate capacity of 50 tons); the corresponding figures for Girod were 38 (26) tons, Keller 13 (5) tons, and 20 (13) tons for the others. Of induction furnaces, there were 14 Kjellin furnaces with a total capacity of 35 tons, 15 Röchling-Rodenhauser furnaces with a capacity of 30 tons in work and 18 tons, being built; the capacity of the other induction furnaces was 18 tons. That gave a total capacity of 250 tons for arc, and 100 tons for induction furnaces, 350 tons per charge for all electric steel melting.

Professor McWilliam added special lists for the Kjellin and Röchling-Rodenhauser furnaces (mostly single-phase), and for the Héroult furnaces; in both lists Germany leads. The most powerful Héroult furnaces mentioned are those of the Deutscher Kaiser Stahlwerke, Bruckhausen (25 tons), the two 15-ton furnaces of the United States Steel Corporation (at Chicago and Worcester), and the 15-ton furnace of the Skinningrove Iron Company Yorkshire (being built). The output of electric steel in Germany, Austria-Hungary, and the United States amounted to 112,000 tons in 1910 (63,000 tons in 1909). In 1911 England would for the first time appear as regular producer, with about 13,000 tons probably; in 1910 the Héroult furnace of Messrs. Edgar Allen, in Sheffield, was the only one in steady operation. Since January last three Héroult furnaces had been commenced at Vickers, Thomas Firth and Sons, and at Lake and Elliott's, Braintree; Kjellin furnaces had been working at Vickers, at Jessop's, and in the University of Sheffield, and a Grönwall furnace had also been started at Sheffield in January. Electric furnaces were being employed to replace crucibles, as cheaper; for foundries, to replace Swedish Bessemer steel, for steel of axle and tyre quality; for weldless tubes (Mannesmann Company, Héroult furnaces); in combination with Talbot furnaces, to increase their output and life (at Skinningrove for making rail steel); for melting high-speed turnings and for making culinary vessels of pure nickel (Kjellin furnace).

The Corrosion of Steel.

A committee, of which Professor J. O. Arnold is chairman, and Dr. W. E. S. Turner is secretary, reported upon "The Influence of Carbon and other Elements on the Corrosion of Steels." Pure iron-carbon alloys had been prepared in Sheffield University from Swedish iron and charcoal, ranging from 0.1 to 0.96 per cent. of carbon; they were free from manganese sulphide, which favours electrolytic corrosion. Polished cylinders, 4½ in. long, ⅝ in. in diameter, of these alloys were separately kept in sea-water for thirteen weeks. In the rolled, normalised, and annealed specimens (in which, it was pointed out, the carbide existed either as the diffused, normal variety, or as the laminated variety of pearlite) the corrodibility increased to a maximum at saturation point, 0.89 per cent. of carbon, and then decreased upon the appearance of cementite. In the hardened or tempered specimens (in which the carbide had been converted into hardenite or the emulsified variety of pearlite) the corrodibility rose continuously without reaching any maximum. The deposit was light brown and easily removable on the top, and bluish black underneath; the latter adhesive deposit was found especially at the lower end of the bar.

In the tests of the solubility in acids, in which 1 per cent. sulphuric and hydrochloric acid gave substantially the same results, bars of ⅝ in., 1½ in. long, were separately immersed for forty-eight hours. The results differed from those of Heyn and Bauer, inasmuch as they showed a maximum corrodibility at 0.22 per cent of carbon, which Heyn failed to observe, probably because he had no steel between 0.14 and 0.30 per cent. of carbon; Heyn put the maximum solubility at 0.4 or 0.5 per cent. These figures concerned normalised, annealed, and rolled specimens; in the tempered steels the solubility rose up to 0.3 per cent., and again up to 0.55 per cent. of carbon; the tempering temperature (500 or 400 deg. Cent.) had an influence. The report states that smooth curves were drawn through the experimental points, instead of joining the points by straight lines. Those curves look smooth enough. There is, for instance, a fine S curve, traced through five points which do not mark the maxima and minima. If there were really not more than five determinations, the smoothness of those and other curves does not appear convincing. Solution pressures (potential differences) were also determined. The chief point, again brought out by these tests, is that different irons behave differently in sea-water, acid, and in galvanic couples, so that no single method of testing can be regarded as a reliable criterion.

We cannot report the proceedings of the other sections, but reserve special subjects for future consideration.

The Evening Discourses.

The first evening discourse was delivered by Dr. Leonard Hill, F.R.S., on "The Physiology of Submarine Work." Dr. Hill had made great preparations for his discourse That increased air pressure did not prevent the regular beating of the heart, he showed with the aid of a frog's heart. The danger came with decompression, as Paul Bert had demonstrated in 1879, because nitrogen was dissolved by the blood and afterwards released in bubbles which blocked the capillaries; when the pressure exceeded 8 atmospheres, the oxygen might act as a poison, but divers seldom went down to more than 60 ft. or 70 ft. Old, fat, intemperate men, especially when fatigued, suffered most. Men working in short periods of compression and decompression were hardly affected; the humidity and heat of the air-lock probably caused more discomfort than the carbon dioxide. The Admiralty had adopted the stage-decompression of Dr. Haldane, which Dr. Hill thought valuable for men not working very long and very hard. His own ideal method of decompression was:—1. Oxygen breathing for five minutes, rapid decompression to 2 atmospheres; 2. pause for taking exercise and breathing oxygen; 3. rapid decompression to one atmosphere, breathing and exercise being continued. In this way men working in the East River Tunnel at New York had truly been raised from the dead. He had designed a double-chambered diving-bell, with a manhole connecting the two chambers. The divers entered the inner chamber after completing their work and were raised in safety and decompressed by the stage method, without exposure to cold and the roughness of the waves.

Professor A. C. Seward, F.R.S., delivered the second discourse on "Links with the Past in the Plant World." The crowd which the lecture to operative classes by Dr. H. R. Mill on "Rain" attracted testified to the general interest now taken in meteorological observations.

Concluding Remarks.

Portsmouth, with its 1241 members and associates, will not rank with the great meetings. It was a good meeting scientifically, however. The small attendance was chiefly due to the absence of the local element. The old members had remained faithful, and the number of foreign visitors was large. The official list counted thirty-one especially invited foreigners; but many more foreign scientists had come privately. It was almost hopeless, however, to find a name in the original list of members, in which names were arranged in batches, apparently as the members had registered. That the second list was incomplete was probably the fault of members who had neglected to enter their names. We have praised the guide-book for its historical notes; it did not deserve praise in other respects.

The excursions—all on the Saturday—to the New Forest, Isle of Wight, Arundel, Chichester, and Goodwood, were not particularly noteworthy. Among works thrown open to members were the Portsmouth Water Works and Pumping Stations, the Municipal Electricity and Destructor Works and Sewage Pumping-Stations, the Portsea Island Gas Works at Hilsea, the Locomotive Works at Eastleigh, and also the Southampton Docks and Messrs. Thornycroft's works at Southampton—quite a sufficient number, especially in view of a special visit to Portsmouth Dockyard, and a Naval Display for all members. For the latter the gunnery ship Revenge took the large party down Spithead into the open sea, where ten torpedo-boats and three submarines made torpedo attacks on the Revenge. Under the circumstances, Admiral Sir Arthur W. Moore naturally was singled out for a special vote of thanks at the concluding meeting.

The grants made at Portsmouth amount to 1050*l.*, which is the average sum; but several demands had been cut down considerably. They include a grant of 30*l.* to the International Commission on Annual Tables of Physical, Chemical, and Technological Constants, for which Dr. N. T. M. Wilsmore, of University College, the British member of the executive committee, enlisted new friends. When the Association assembles next year at Dundee, there will be twelve sections, instead of eleven, Agriculture, for several years a sub-section, having been raised to the rank of an independent Section M. It is hoped that farmers will be attracted to this new section in their own interest; they may not have felt comfortable as visitors among biologists, botanists, or chemists. The accretion of new members is desirable. But there is danger in splitting off sections, quite apart from the fact that twelve sections—not reckoning the separate sub-sections—means twelve section rooms and committee rooms, and that all the sections should deliberate close to one another. Up till 1883 there were eight sections; D, Biology, then comprised zoology, botany, physiology, and anthropology. Anthropology split off first, and has certainly become one of the most instructive and attractive sections. Physiology, I, and Botany, K, followed. Then L, Education, was created, which has undoubtedly justified its right of existence. But the very essence of the Association lies in common discussions, and a member cannot be in more than one of the twelve or sixteen section rooms at the time. We are sorry, therefore, to notice a strong current in Section A in favour of division; the simultaneously-meeting departments are sufficiently awkward. Some reform seems to be needed, and the question is receiving the earnest attention of the Council of the Association.

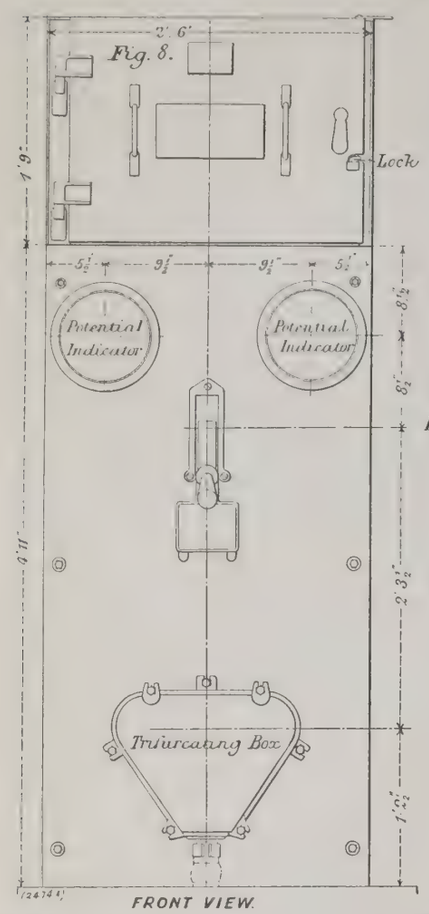
The British Association will meet at Dundee, on September 4, 1912, under the presidency of Dr. E. A. Schäfer, F.R.S., Professor of Physiology at Edinburgh.

THE ELECTRICAL EXHIBITION AT OLYMPIA.—No. II.

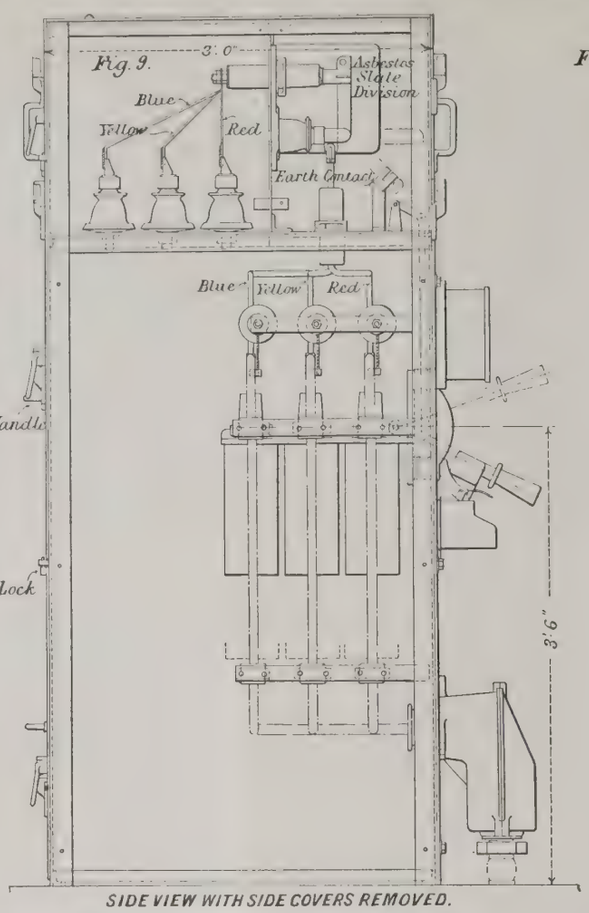
The tendency of the exhibitors at Olympia to display small apparatus rather than large, referred to in our article of last week, is perhaps less illustrated on the stands devoted to switch-gear than on those dealing with some other types of plant, and, in as far as it is possible to display switch-gear at an exhibition at all, the matter shown is of much interest. We have already dealt with the exhibit of Messrs. Reyrolle, and now illustrate part of the large display made by Messrs. Ferranti, Limited, of Hollinwood. Apart from the gear shown on their stand, Messrs. Ferranti have contributed a three-panel switchboard controlling the 300-kw. rotary converter, by Messrs. Vickers, Limited, which converts current for use in the Exhibition. This board, being alive and enclosed, is not readily accessible for inspection, and as, in addition, it is of a standard type, we will not attempt to describe

SEMI-PORTABLE SHEET-IRON-TYPE SWITCHBOARD FOR 5000 VOLTS AT OLYMPIA.

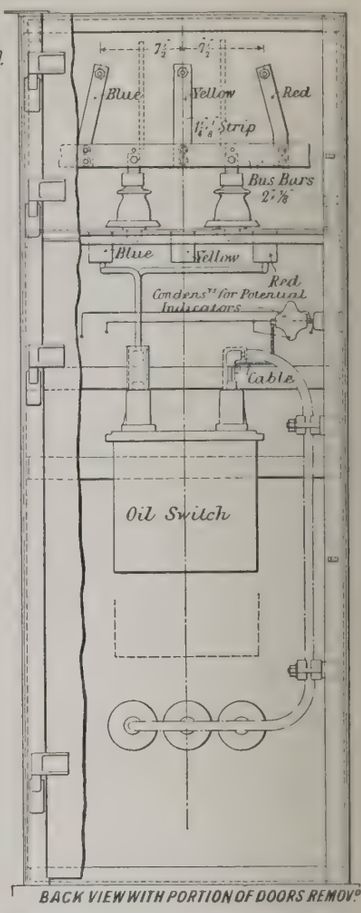
CONSTRUCTED BY MESSRS. FERRANTI, LIMITED, ENGINEERS, HOLLINWOOD, MANCHESTER.



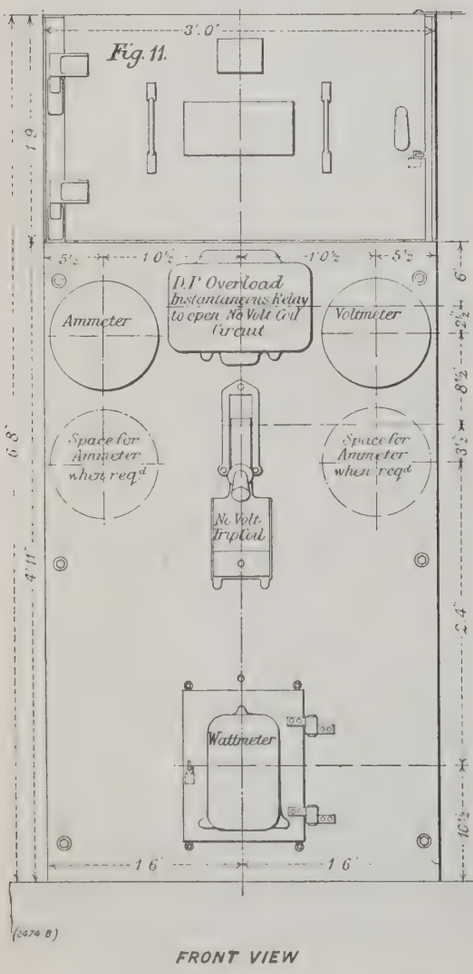
FRONT VIEW.



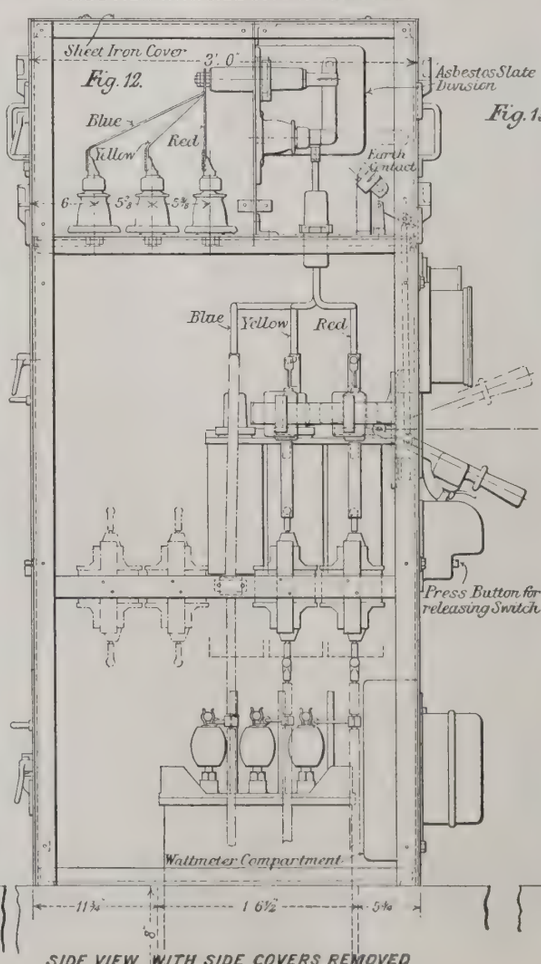
SIDE VIEW WITH SIDE COVERS REMOVED.



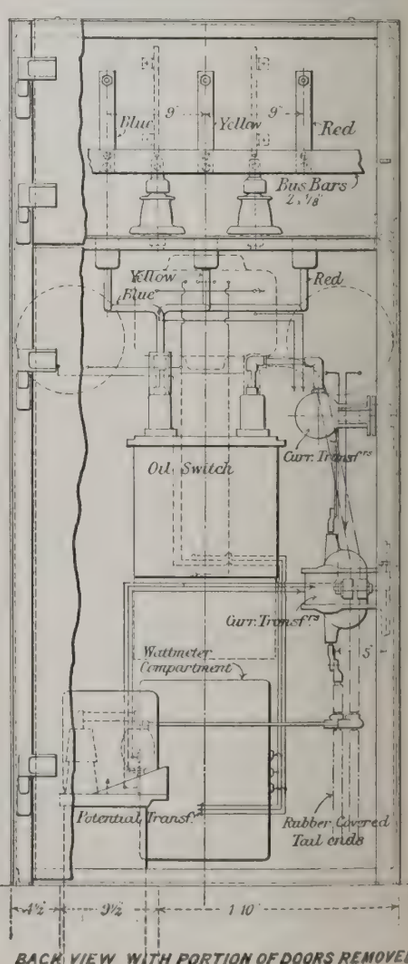
BACK VIEW WITH PORTION OF DOORS REMOV^D



FRONT VIEW



SIDE VIEW WITH SIDE COVERS REMOVED



BACK VIEW WITH PORTION OF DOORS REMOVED

SWITCH-GEAR EXHIBITS AT OLYMPIA.

CONSTRUCTED BY MESSRS. FERRANTI, LIMITED, ENGINEERS, HOLLINWOOD, MANCHESTER.

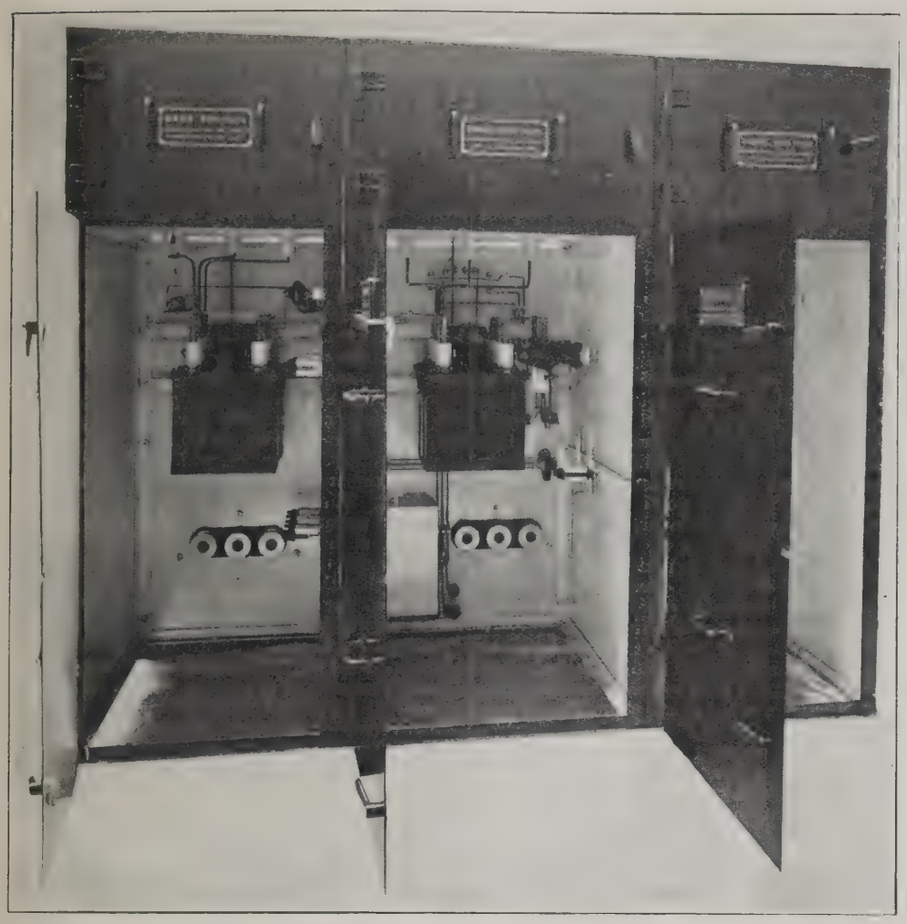


Fig. 14. Rear View of Semi-Portable 5000-Volt Switchboard.

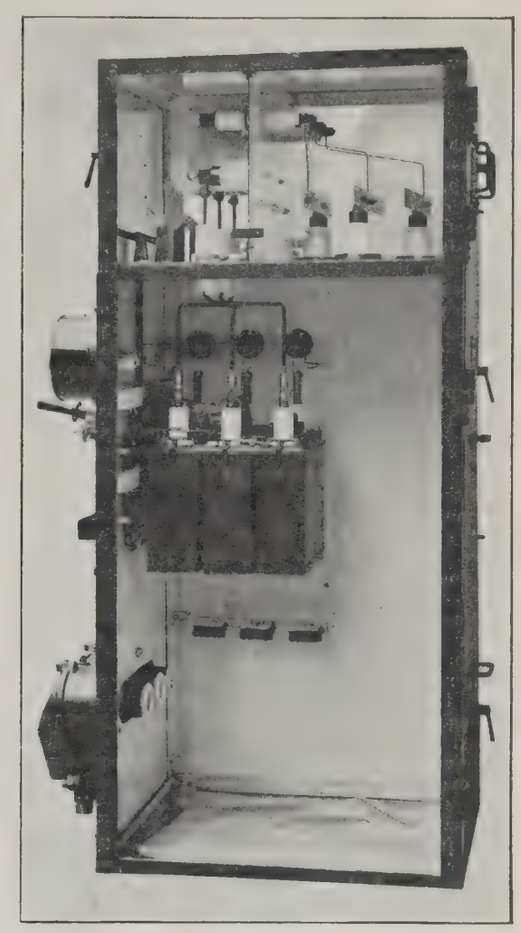


Fig. 15. Side View of Feeder Panel for 5000-Volt Switchboard.

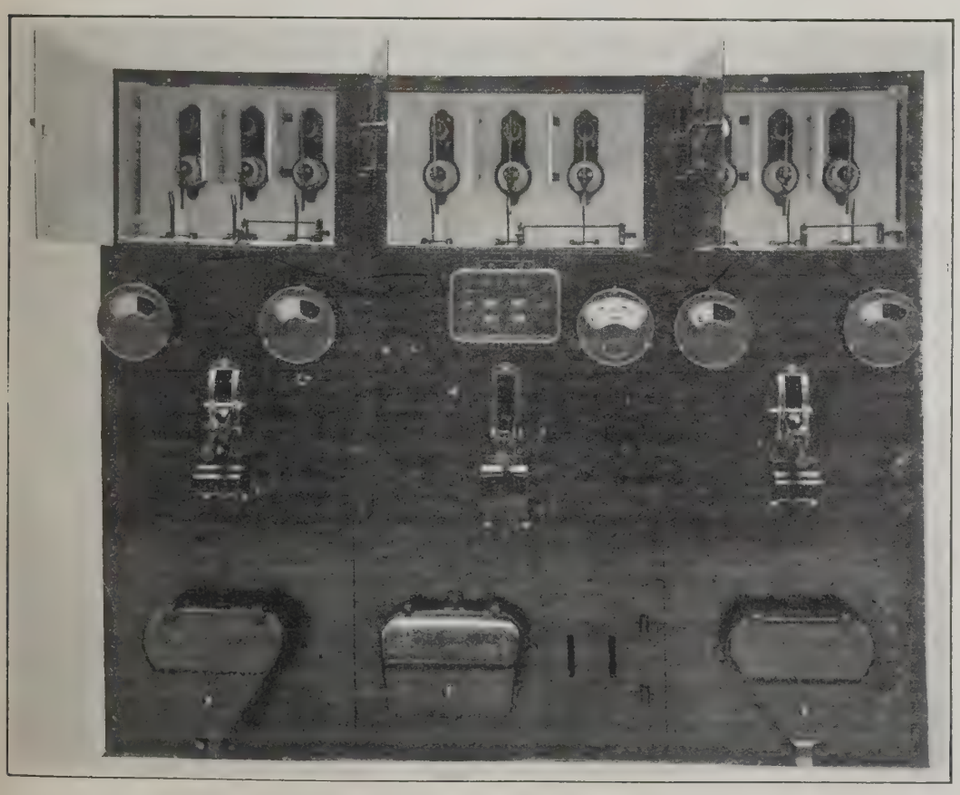


Fig. 16. Front View of 5000-Volt Switchboard with Isolating Switch Chambers Open.

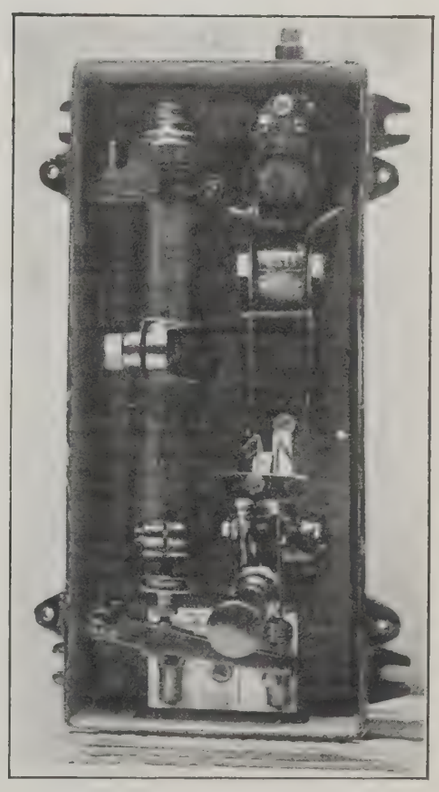


Fig. 17. Compression Type Starter.

it in detail, contenting ourselves with a reference to some of the apparatus shown on Messrs. Ferranti's stand.

An enclosed sheet-steel switchboard of the semi-portable type occupies the most prominent position, and forms the most striking object in Messrs. Ferranti's display. It illustrates a form of gear of which the firm have supplied some eighty panels to the Birmingham Corporation for use in large consumers' sub-stations. Each panel is made up as an independent unit, the only connection between them being made by the bus-bars, and as the whole of the live gear is carried inside the steel boxes forming the various panels, the arrangement is both safe and very readily installed in a works or factory. No foundation is necessary beyond an adequately strong flat floor, and as the cable-boxes form an integral part of the gear, installation involves little more than putting the gear in place and connecting up. Further, the panels may, of course, easily be taken apart, and re-erected in a new order, or in a different place. The board is illustrated very clearly in Figs. 8 to 16, on pages 454 and 455, and requires little further description. It consists of two incoming feeder-panels for a ring or duplicate main, and a consumer's panel. The oil-switch chambers are quite separate from the isolating-switch and bus-bars, and the isolating-switches chamber doors are interlocked with the oil-switches.

Among the large selection of apparatus making up the remainder of Messrs. Ferranti's exhibit there are a number of interesting regulating and starting resistances of unusual type. In these the usual contacts, with resistance connections between them, are done away with, and their place is taken by a column, or series of columns, of thin carbon disks assembled inside steel tubes lined with refractory material. The columns of disks form the resistances, the current being carried through them from end to end. The resistance is varied by mechanical end-compression on the columns, such compression, of course, decreasing the over-all resistance. It will be realised that the system is not a new one, such variable carbon resistances having been used for laboratory purposes for many years, but Messrs. Ferranti would appear to have made a new and highly practical application of the principle. An example of a simple starting resistance made on this method is illustrated in Fig. 17, on page 455.

Messrs. Ferranti also show a new range of fuses with fibre handles, designed to comply with the new Home Office regulations, and arranged so that when the holder is in place there is no live metal exposed. They also exhibit a new type of electric radiator of novel and very pleasing design. In it the resistance unit consists of a flat spiral of nickel-steel ribbon insulated with mica, and mounted behind a flat circular plate of thin quartz. This plate is in turn mounted in the centre of a polished copper bowl. When the current is on, the spiral glows to a dull red, which is reflected in the inside of the bowl, a very warm and satisfactory effect being produced. The collection of Ferranti meters, dating back to the earliest, of 1884, should also be mentioned as one of the points of interest of the stand.

A number of firms exhibit control gear, one of the most complete displays being made by the Adams Manufacturing Company, Limited, of Bedford. It is difficult to select among the wealth of material shown on the stand of this company, but mention may be made of the theatre dimmers, which are displayed. These are of the "Igranic" type, in which the resistance consists of wire wound radially on soap-stone slabs. The arrangement results in a design which, in its over-all dimensions, compares very favourably with the more usual liquid type. It should be of particular value for places in which space is limited. The firm exhibit various hand-operated and automatic starters, among the most interesting being the series relay device, in which the succeeding steps of a resistance are cut in by relays which are themselves operated by the motor-starting current, so that the rate of cutting out resistance varies directly in terms of the load. Control gear is also exhibited by the Electrical Apparatus Company, Limited, of Vauxhall Works, South Lambeth-road, London, S.W., one of their most striking exhibits being a slow-motion motor-starter, in which a spring-controlled pawl carried at the end of the handle alternately fouls and springs clear of a number of ratchet-teeth carried by a segmental casting bolted to the starter base. When the handle is moved slowly, the pawl has sufficient time to clear the teeth, but any attempt to move it too quickly at once results in jamming. The device, which is, of course, purely mechanical, is a very pretty one, and should work well in practice.

An interesting display of electro-magnetic separators is made by the Rapid Magnetting Machine Company, Limited, of 10, The Crescent, Birmingham. The first machine shown is of the firm's "Standard" type, and is intended for removing iron from metal turnings and similar material, particularly when it is present in large percentage. It consists of a rotating drum fitted with fins or baffles on the outside and parallel to the axis, which lies horizontally. The material to be sorted is fed on to the top of the drum from a hopper situated above it and furnished with a jigging delivery spout. On reaching the drum the iron in the material is attracted and held by electro-magnets situated inside it. The magnets are fixed and independent of the drum, which revolves outside them. They are arranged with alternate poles running the full length of the drum, the effect of the arrangement being that as the mixed material is carried forward by the moving fins the iron in it is carried from the field of one magnet into that of the next. The travel of the iron particles is not, however, a uniform and steady one, since, although the drum revolves uniformly, the effect of the different magnetic fields is to make the iron jump forward into the strongest part of the leading field as soon as the moving fins have carried it into a weaker part of the field it is leaving. The effect of this jumping is that the mixed material is thoroughly stirred up, so that any brass or other non-magnetic substance it contains has every opportunity of being separated from the iron. The mixture is carried round to the underside of the drum, from field to field, the brass, &c., dropping off into a bin below, while the iron is carried to the back of the machinery, where no magnets are fixed, so that it too finally falls off into a second bin. The arrangement appears a very effective one, and it is stated mixtures containing 99 per cent. of iron can be sorted by it.

The second machine shown is illustrated in Fig. 18, on page 458. It is intended for use with mixtures containing a very small percentage of iron, and may be used for a final treatment of material which has already been passed through the machine described above. It is also adapted for treating cotton-seed, fire-clay, ground bones, and similar materials. The arrangement of the machine will be followed from the figure. It consists of a jigging-shoot, with electromagnets of alternate polarity running from side to side, like the rungs of a ladder. The mixed material is slowly passed down the shoot, the iron being gradually picked out by the magnets; any escaping the first few is caught lower down. The series arrangement of the magnets makes the machine very searching and thorough. The collected iron is cleared from the shoot by simply switching off the current, when the jigging motion shakes the particles down. A special receptacle is, of course, placed below during this process. A third machine, illustrated in Fig. 19, on page 458, is intended for removing iron from large material, such as destructor-furnace clinker and packing-room refuse. The machine is similar to the standard type in that no cut-off is used, the iron being carried by the drum out of the range of the magnetic field. Its difference lies in the fact that the collecting magnet poles are arranged circumferentially along the drum, and that the drum itself is made up with iron pole-pieces instead of being entirely non-magnetic, as in the case of the standard machine. The drum pole-pieces are magnetised by induction, and their object is to give the strong field which is necessary to gather iron particles from a heavy material like destructor clinker. The collected iron is finally dropped off the back of the machine when it has passed the magnets. The feeding-shoot has a reciprocating motion, in order to distribute the incoming material.

The Sunderland Forge and Engineering Company, Limited, of Pallion, Sunderland, have a good exhibit of their products. This includes open-type vertical steam-engines coupled to electric generators for ship-lighting and similar work, continuous and alternating-current motors, and electric winches. Most of this gear is of well-known type, but the winches represent a class of apparatus whose manufacture has as yet been taken up by but few firms. We illustrate one of the winches in Fig. 20, on page 458. It is of 2 tons capacity, and is intended for installation on shipboard for handling boats or passengers' baggage. The drum is worm-driven, the gearing running in an oil-bath, and the end thrust being taken by a ball-thrust block. The winch is fitted with a foot-brake and an electrically-operated brake, which is always on except when the motor is running, the driving current being used to release the brake. An interlock is fitted between the foot-brake lever and the controllor, so that when the latter is depressed to put on the brakes, the controller is first thrown into the off position. The controller is of the reversing type, and, together with the motor and starting resistances, is completely enclosed, so that it is unaffected by the worst weather. The motor is of the series type, and is specially designed for severe service.

On the stand of the Lancashire Dynamo and Motor Company, Limited, of Trafford Park, Manchester, there are shown a number of both alternating and continuous-current motors, but the most important exhibit is a 4-ft. by 4-ft. by 10-ft. Buckton planing-machine driven by the Lancashire patent reversing motor-drive. The system of operation involves the use of a motor generator supplying the driving motor with direct current. The reversing of the table is obtained by reversing the field of the generator, while the speed of the table is similarly controlled by the adjustment of this field. The gear for operating the switch and regulator connected to the field is operated by a tappet from the table. A feature of the system is that only this small field current is handled by the gear, so that there is no trouble with the arcing of heavy brushes. There is an additional attachment of much interest, which the makers term the "accelerating device." It is operated by adjustable tappets from the table, and its function is to accelerate the table when the tool is passing over a portion of a job where no machining is required. When the space has been passed, a second tappet, acting on gear controlling the field, causes the speed to be reduced again to that proper for cutting. The arrangement should prove of much value, and should lead to increased output on some classes of work. In addition, it should be said that the latter part of the stroke of the table may be retarded by the same gear, so that, if a heavy cut is being taken, the end of the work is not broken. In the machine shown the cutting speed may be varied from 25 ft. to 75 ft. per minute, and the return speed from 120 ft. to 220 ft. per minute.

The only two prime movers of other than small size in the Exhibition are displayed on the stands of Messrs. Mirrlees, Bickerton, and Day, of Hazel Grove, Stockport, and the Brush Electrical Engineering Company, Limited, of Falcon Works, Loughborough. The first of these is a 160-brake-horse-power four-cylinder four-cycle Diesel oil-engine, which is illustrated in Figs. 21 to 24, on page 459. The engine is coupled to a dynamo, and is shown in operation on oils of varying quality, an arrangement of four fuel oil-tanks being fitted for the purpose. The general lines of the engine do not differ greatly from those of Diesel engines by other makers, although, as is well known, Messrs. Mirrlees have put in much original work during the development of their engine, their practice having to some extent resulted in modification of the designs of some other makers. The example shown is of the completely-enclosed type, with forced lubrication, and is a duplicate of many that the firm have built for the British Navy. The details of the engine will be seen from the illustration, Fig. 24 being a cross-section to an enlarged scale through one of the cylinder-heads. It is interesting to note that the cylinders, with the whole of their gears, are made up as standard units, and carried in stock by the firm, so that an engine of any number of cylinders may be built up at short notice.

The prime mover on the stand of the Brush Company is a fine example of a 400-kw. Brush-Parsons combined action and reaction mixed-pressure steam-turbine coupled to a 220-volt direct-current dynamo. The set makes an excellent exhibit, but it is not necessary to describe it, as we have frequently dealt with the Brush Company's machine. In addition to this the firm exhibit a 22.5-kw. steam-dynamo, various electric motors, and two samples of electric pulley-blocks. These latter are, we believe, a new line of manufacture for the company. The motors driving them are operated from reversible controllers manipulated by wire-

cords from below, the handles on the ends of the cords being sufficiently heavy to pull the controller into the off position, in case they are loosened by the man operating the blocks.

INDUSTRIAL NOTES.

At the end of last week the railway strike in Ireland was practically at an end on all the lines except the Great Southern and Western, all the strikers on the other lines having approached their companies in order to obtain reinstatement. The companies, however, stipulated that the men should send in written applications for employment in order that their names might be considered for any vacancies that might exist. Even on the Great Southern line things even then appeared to be slowly improving. It was among the men of this company that the baneful influence of the executive of the Amalgamated Society of Railway Servants lingered longest. It is thought by the public that the companies fought for a great principle, and that they took up an impregnable position. There were some few people who appeared to have had the idea that the companies ought to have reinstated the strikers as soon as they applied to be taken back, but this view is not entertained by the great majority of the people. Such an act would have been fraught with the gravest danger of injustice to loyal men and to those who filled the places of the strikers. Members of trade unions are becoming far too ready to rush into a strike without fully counting the cost. Men who have recently been promoted to fill the places of the strikers ought not to be reduced simply to give place to the strikers, who do not appear ever to give a thought to the intolerable inconvenience to which the public are put only to satisfy some silly whim of the union leaders. Why should men who have been willing to work all through the trouble be treated in the unjust way recommended by some people?

At the beginning of this week the only change in the situation caused by the Irish railway strike was an offer by the chairman of the Great Southern Railway Company to reinstate to their old positions all old locomotive men now on strike, and the majority of the other men, if they applied on Monday. This offer was conveyed in these words:—"My board, being of opinion that the majority of the men who have left work did so under the most severe compulsion, are prepared to let every man returning to duty have the benefit of his past service if application is made by 12 o'clock on Monday. After this hour all men taken on will be regarded as new hands."

On Monday a fair number of the Great Southern and Western Railway Company's strikers offered themselves for work at provincial stations, in spite of the unfortunate intervention of the Nationalist Parliamentary Party. At Waterford the whole staffs of the locomotive and traffic departments had gone back to work, and it is understood that the majority of them have been reinstated in their old positions.

On Tuesday afternoon a deputation representing the employees in the locomotive and traffic departments of the Great Southern and Western Railway were received by the directors, and, although the proceedings were private, it was understood that the directors offered to reinstate 90 per cent. of the traffic men and the whole of the locomotive men without penalty. They declined, however, to reduce any of the men who had been promoted, or to dismiss men recently engaged. The men were given to 12 o'clock on Wednesday to decide what they would do. Afterwards Sir William Goulding gave the following letter to the Press:—

"I beg to inform you that the strike on this line has to-day been definitely settled, a deputation from all departments having accepted the directors' offer of yesterday—viz.:—The Board undertake to take back at once all the locomotive and permanent-way and 90 per cent. of the traffic men. The company must have an absolute withdrawal of the manifesto put forward in Checker O'Meara's letter of September 15, with an expression of regret for leaving work without notice, and an undertaking to handle all traffic offered and to obey all the commands of the officers. All promotions made to stand, and men taken on to be retained in the service.

"This undertaking was signed on behalf of the traffic and permanent-way men by Checker Joseph O'Meara, and on behalf of the locomotive men by Driver John Byrne. Work on the line and at the various works will be resumed as quickly as possible. The Board will grant the men taken back credit for their past services."

It was understood that the Great Northern and Midland Railways had offered similar terms to their men.

In connection with the strike Mr. Burt, M.P., in his monthly circular to the Northumberland Miners' Association says:—"It would seem that the strikers and those who have advocated the strike have acted in a most high-handed and arbitrary way. Such action would certainly be highly resented and bitterly denounced if it proceeded from employers. At any time such methods would be open to criticism, but, when a strong case is being presented for recognition of the unions, the action described is not only peculiarly ill-timed, but it is in every respect deplorable. Those who thus act render a very ill-service to the trade-union movement, which they discredit, and they inevitably weaken, if they do not tend to shatter, the principle of collective bargaining."

On Friday, last week, a conference was held between the coal-owners and the miners' representatives with a view to coming to an agreement which would settle the unrest that now exists, and remove the risk of any further strikes. It ended, however, without any settlement being effected. The conference was the result of the miners' meeting held last July, when it was agreed that before resorting to extreme measures the executive should endeavour to meet the masters. The great difficulty appears to be with the miners of South Wales, where the owners, in framing their Conciliation Act, inserted a condition that for a period of five years, ending in 1913, the abnormal places question should not be touched. The owners in other districts, however, last week over-ruled the South Wales owners, and agreed to confer with the Federation officials. At the Conference on Friday last the coalowners made the following suggestions:—1. The owners recognise the right of workmen who are engaged in places which are abnormal to receive wages commensurate with work performed. 2. The customs and circumstances of the different districts vary so much that it is, in the opinion of the coalowners, impossible to deal with the question collectively as applying to the whole of the United Kingdom, and therefore the methods of dealing with it can only be satisfactorily settled locally in the different districts. 3. This collective meeting of coal-owners, therefore, recommends the coalowners in the various districts to meet the representatives of the miners in their respective districts when requested to do so. 4. It must be understood that, in coming to the foregoing resolution, the meeting must not be assumed to have done anything to abrogate existing agreements. From the men the following proposal was made:—"That this joint conference of coalowners' and miners' representatives recognises the right of miners working at the coal face at fixed tonnage rates to receive full wages when employed in an abnormal place, the rate to be the average rate of wages previously earned by the workmen under normal conditions, which shall not be less than the recognised minimum or average rate paid in each district. Further, machinery should be set up in the different districts for the purpose of deciding on the question as to whether the place in dispute is abnormal. Pending the settlement of a dispute as to whether the place is abnormal or not, the men to be paid the district rate." It was arranged last week to consider the application of the Northumberland miners for a national strike on the following Thursday, which was yesterday, but up to the time of going to press the result has not been received.

The failure of the conference of Friday last rendered critical the situation in Durham and Northumberland, because it is thought that the men there want a strike on some pretext or another, and the pretext of abnormal places is as good as any, although that question is not an acute one in the north. In Derbyshire also the situation is viewed with alarm as tending to increase the possibility of a national coal strike. In Lanarkshire and Fifeshire the coalowners have intimated an advance in the price of house coal of 1s. per ton, to take effect at once.

The court of arbitration in the Norwegian mining district, to which several points in the recent dispute were referred, and which consists of the two arbitrators, has now given its verdict. It is to the effect that the present minimum rates of pay for the eight mining concerns affected by the dispute continue until December 31, 1913, after which date the minimum pay is to be increased by 1 öre (0.135d.) per hour. The decision, and the arguments upon which it rests, are equally objectionable to the men, both the arbitrators having accepted and admitted the justice of the masters' statements as to conditions of labour and the conditions of the market. The men first held out for an increase of 5 öre (0.675d.) per hour, and afterwards 2 öre (0.27d.) per hour from 1913. Had they been willing to accept the 1 öre which has now been awarded, both strike and lock-out would probably have been avoided.

At a conference under the chairmanship of Sir Charles Macara, held in Manchester on Friday last, between the Emergency Committee of the Federated Cotton-Spinners' Associations and the Executive Committee of the Card-Room Workers' Amalgamation, the Operative Spinners' Amalgamation and the Northern Counties Weavers' Association, a proposal to amend the Brooklands agreement, with a view of securing the continuance of negotiations whenever a dispute occurs in the cotton trade, was adopted. It was proposed that the agreement should be extended to provide that when a dispute has passed all the stages of negotiation already provided by the agreement, and has resulted in a stoppage of work, there shall be periodical meetings afterwards between the representatives of the employers and the operatives, in order to take advantage of any changes of the situation calculated to lead towards a settlement. It was decided that a new clause be added to the agreement, providing that, when a strike or lock-out has been begun, the parties to the dispute shall meet within two weeks, and, if no settlement is then reached, they shall meet regularly afterwards at monthly intervals till the dispute is ended. After the meeting there was a feeling that the cotton trade had again led the way in the direction of settling labour disputes by peaceful measures, and set an example to other industries.

It is stated that the scheme which is on foot for the establishment of a daily paper devoted to labour interests is receiving considerable support from the trade unions, and it is announced that the British Steel Smelters and the Boiler-Makers' Society are each to invest 1000*l.*, and the Amalgamated Society of Railway Servants propose to subscribe 2500*l.* The new paper is, it is said, to be called the *Daily Citizen*.

The grievances at the workshops of the Lancashire and Yorkshire Railway Company at Horwich have been satisfactorily arranged, as the result of the intervention of Mr. Cummings, of the Board of Trade. A workshop management committee is to be formed, on which the men are to be represented, and it was arranged that the question of the labourers' minimum wage should be dealt with on the resumption of work last Tuesday.

On Monday last the Amalgamated Society of Railway Servants began their annual meeting at Carlisle, a civic reception being given by the Mayor, Sir Benjamin Scott, After the formal opening of the Congress the retiring President, Mr. Bellamy, was re-elected. The main trend of his remarks, when returning thanks, was a plaint against what he termed the flouting of their society, and a rejoicing over the dislocation of the railway industry (which, by the way, put the public to so much inconvenience). He said he had come to the conclusion that the constitution of one trade union for all railway workers was more than ever the end to which all their efforts should be directed.

The proceedings continued on Tuesday, the nationalisation of railways coming in for a large share of attention, and a motion was carried declaring that no satisfactory solution of the present position of affairs could be found outside the national ownership and control of the railways. Another resolution unanimously carried was in favour of Mr. Hudson's Eight Hours Bill for railway workers. The Congress also expressed regret that Labour Exchanges had been used in some instances in a way detrimental to trade-unionism. On Wednesday the National Insurance Bill was discussed, and drastic alterations in it were advocated before it could be acceptable to the trade-unionists. A resolution was passed to that effect. The subject of employing Royal Engineers on the Irish railways in the place of strikers was also condemned, while Mr. Gore, of Kentish Town, used threatening language against Mr. Asquith, which language he, however, afterwards withdrew.

The Russian Naval Development.—The first stone has been laid of a great basin at Cronstadt, which is to be named after the heir to the Russian throne, Prince Alexia Nicolaievitch. The basin will be 836 ft. 8 in. long, and 35 ft. 8 in. deep below the ordinary water-level. The Russian Minister of Marine has proposed an extension of the Russian Admiralty yards in the Gabeeren Isles. The land proposed to be acquired, and the buildings to be built, will involve an estimated outlay of 1,080,000*l.*

Northampton Polytechnic Institute.—At this polytechnic, the address of which is St. John-street, Clerkenwell, E.C., day and evening classes and courses of study are conducted in technological and trade subjects, particular attention being paid to the requirements of the district in which the institute is situated. Full particulars of the work, which commenced in the evening classes on the 25th ult., and in the day classes on the 2nd inst., are set out in the prospectus, a copy of which has recently been received. The subjects dealt with include mechanical and electrical engineering, automobile engineering, technical optics, horology, technical chemistry, and artistic crafts. Theoretical and practical instruction is given in these and in other subjects, the institute being furnished with numerous laboratories and workshops for the practical part of the work. The Northampton Institute is recognised by the London University, so that students preparing for the degree in engineering may be registered as internal students of the University. We note that the evening courses in aeronautical engineering, commenced two sessions ago, are being continued, and that this session it is proposed to establish complete day courses of instruction in this subject. Also a course of ten evening lectures on the distribution of light, intended to serve as an introduction to the subject of illumination, will be commenced on January 16, 1912, provided a sufficiently large number of applications for admission is received by November 1.

ELECTRICAL EXHIBITS AT OLYMPIA.

(*For Description, see Page* 453.)

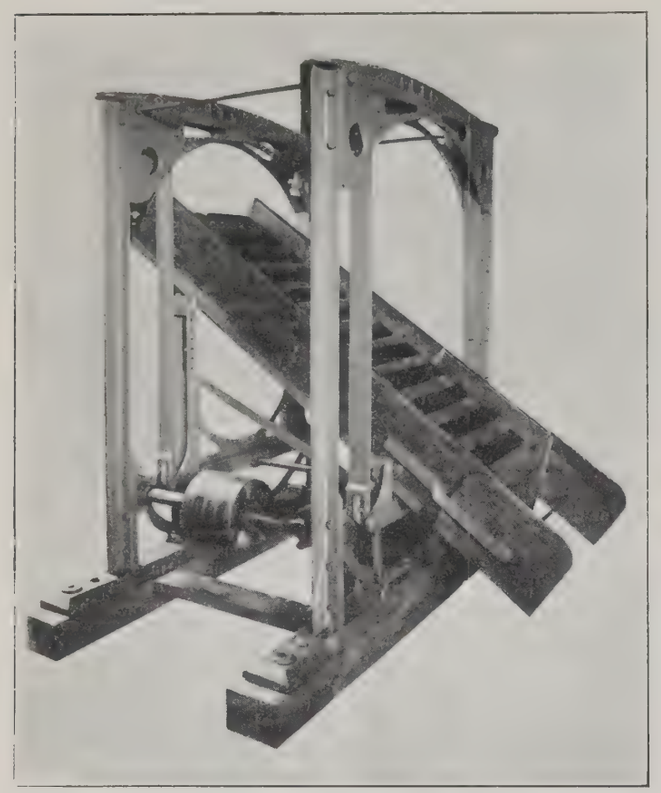


Fig. 18. Ladder-Type Electro-Magnetic Separator; The Rapid Magnetting Machine Co., Ltd., Birmingham.

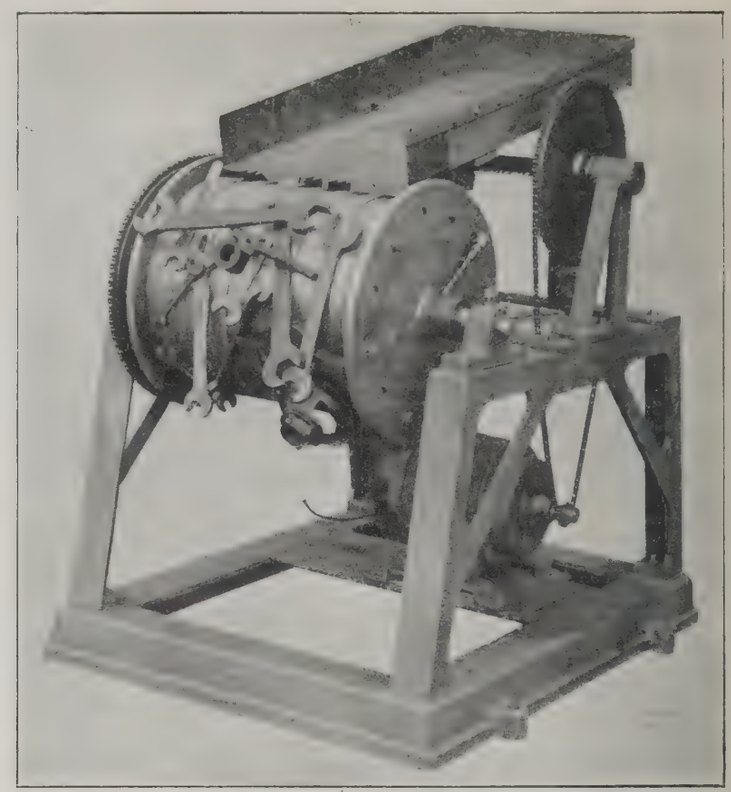


Fig. 19. Rotary Type of Magnetic Separator for Destructor Clinker; The Rapid Magnetting Machine Co., Ltd., Birmingham.

NOTES FROM THE UNITED STATES.

Philadelphia, September 27.

A number of railway systems have just presented inquiries for steel cars and for wooden cars with steel underframes. The orders will run into many thousands. Among the large railroad buyers is the Pennsylvania Railroad, which, in addition to its recent order for 730 freight cars for its western system, is now about to arrange for 1000 cars for its eastern system. The 'Frisco refrigerating line that handles enormous quantities of Californian fruit for shipment across the continent has contracted for 2500 refrigerator cars for immediate construction. The Grand Trunk Pacific Railroad has ordered 25 engines from the Canadian Locomotive Works. The Norfolk and Western Railroad will probably close an order this week or next for 30,000 tons of rails to be delivered next year. The downward tendency in prices noted recently still continues. There is not exactly a demoralisation in the trade, but there is great unrest. Hundreds of holders of stock in the United States Steel Corporation have sold out over the apprehension that the Federal Government may attack this corporation with a view of bringing about its dissolution. The positive course of action by the Government against so many corporations is the cause of a great deal of unrest in stock-jobbing circles as well as in general trade conditions. There has been a further curtailment in tin-plate mill operations, which is quite at variance with the statements recently made as to continued activity. Very few tin-plate manufacturers have opened their books for 1912 business. The tone of the market is weaker and the cutting of prices is causing much apprehension. The cut rates have not yet resulted in a very large volume of business. The wire trade is an exception to the rule, and prices are high and strong.

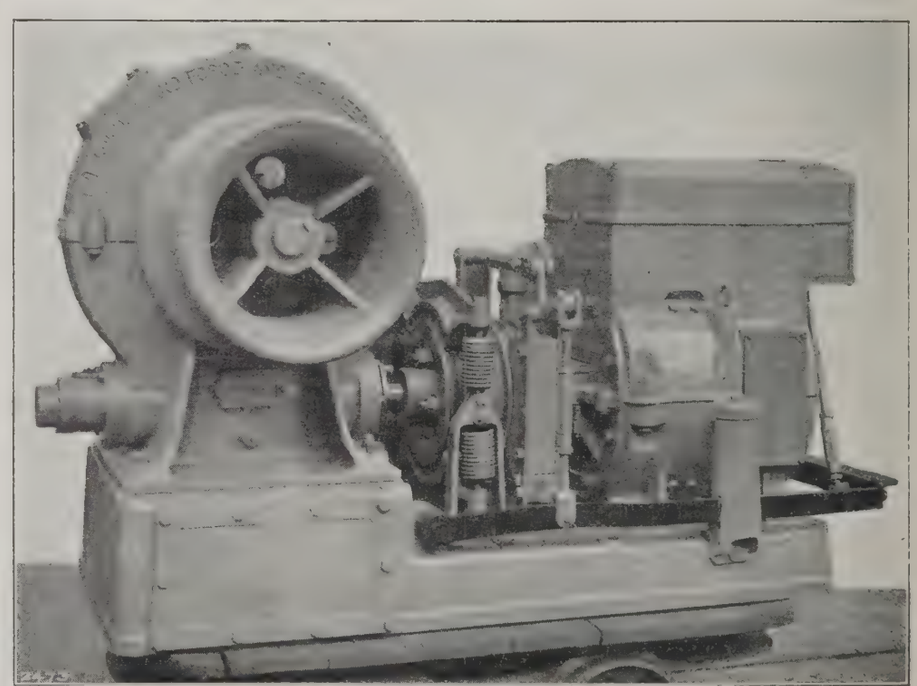


Fig. 20. Two-Ton Electric Baggage-Hoist; The Sunderland Forge and Engineering Company, Ltd., Pallion, Sunderland.

The Road Board.—During the months of July, August, and September, 1911, the Road Board, with the approval of the Treasury, have made advances amounting to 131,764*l.* from the Road Improvement Fund to county councils and other highway authorities, mostly for improvements to road crusts. The work of putting down trial lengths of twenty-three different kinds of road material on a section of the London-Folkestone road between New Eltham and Sidcup has now been completed. Five trial lengths have also been put down on the Portsmouth road in the Borough of Wandsworth, between Wimbledon Common and Robin Hood Gate.

The British Association: Erratum.—Two figures should be corrected in our report of Mr. Greenwood's paper on "Specific Heats at High Temperatures," published on page 419 of last week's issue. Aluminium attacks silica above 750 deg. Cent. (not 850), and its latent heat of fusion is 93 (not 95) gramme-calories per gramme of aluminium.

Borough Polytechnic Institute.—A copy of the prospectus for the session, which commenced on the 25th ult., giving detailed particulars of the varied work carried on in this and other affiliated institutes, has recently come to hand. Besides the technical day school, this polytechnic conducts evening classes and courses of theoretical and practical instruction in mechanical and electrical engineering, metal-working, building work, printing, bookbinding, and other trades, as well as in commercial and scientific subjects, languages, and arts. Particular attention is given to practical work in the trade classes, the institute being provided with well-equipped laboratories and workshops for this purpose. The social and recreation side of the work is also well developed at this polytechnic, the address of which is 103, Borough-road, S.E.

160-H.-P. FOUR-CYLINDER FOUR-CYCLE DIESEL ENGINE AT OLYMPIA.

CONSTRUCTED BY MESSRS. MIRRLEES, BICKERTON, AND DAY, LIMITED, HAZEL GROVE, NEAR STOCKPORT.

(*For Description, see Page* 453.)

Fig 21.

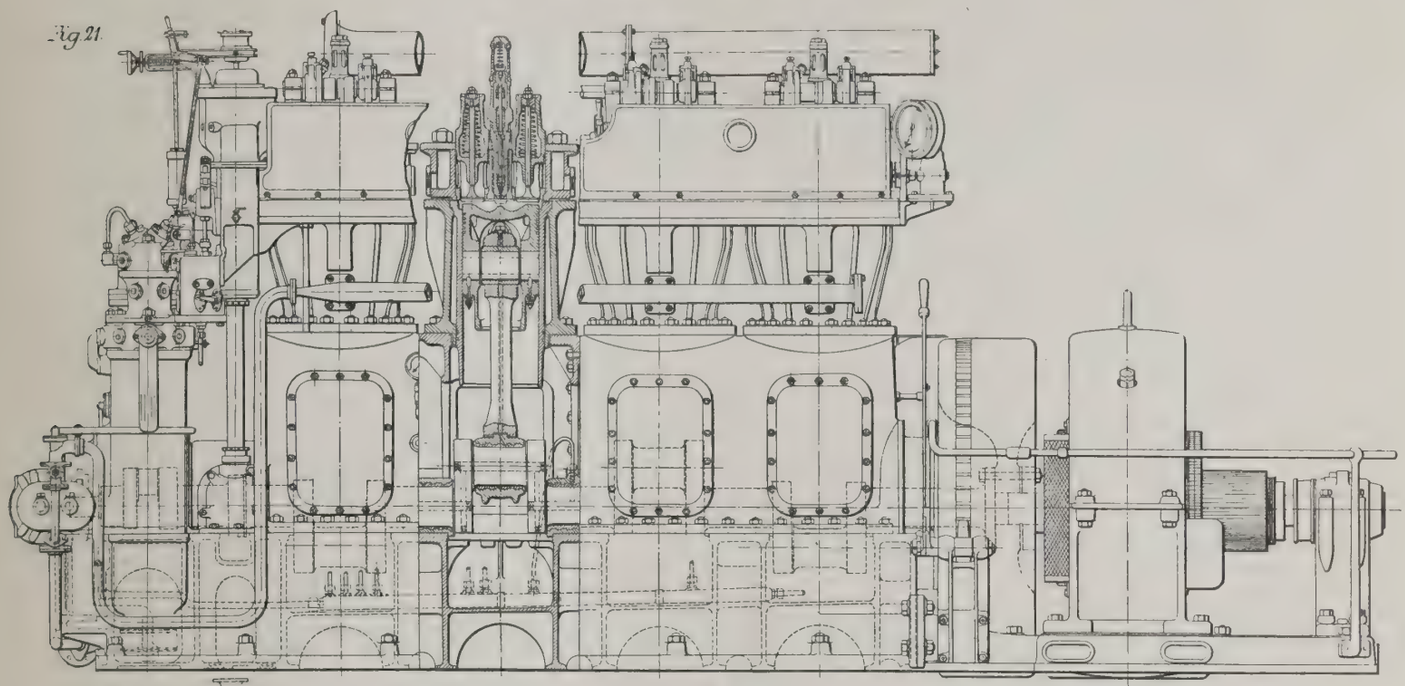


Fig 22.

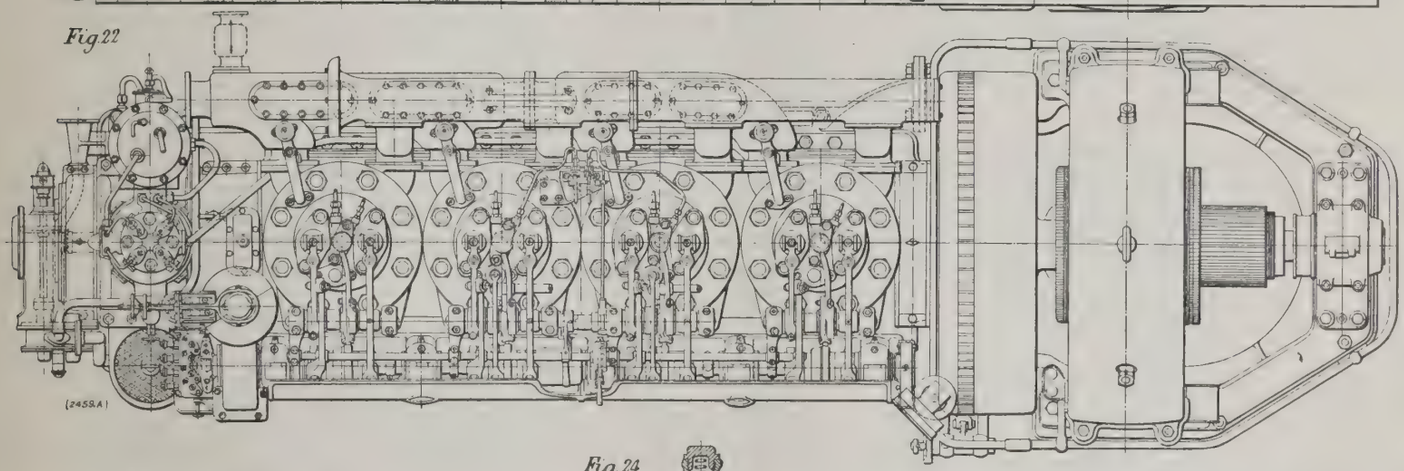


Fig 23.

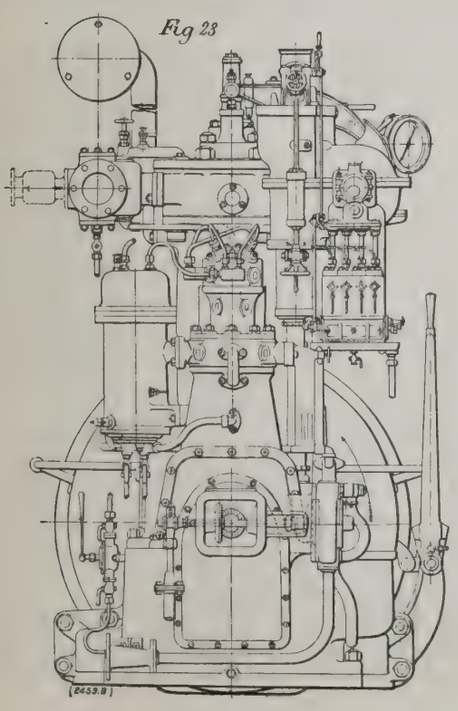
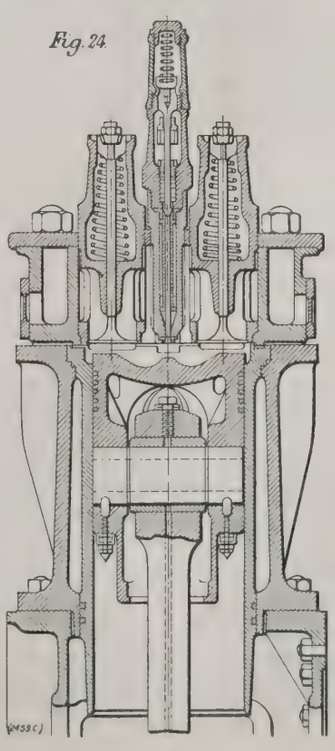


Fig 24.



PERSONAL.—We have been asked to announce that Mr. William Scott Taggart has taken an office in Manchester, at 22, Bridge-street, as consulting engineer in general engineering and textile work.—We are informed that the Westinghouse Companies' Publishing Department, Trafford Park, Manchester, has opened an office for direct representation at 35, Lime-street, London, E.C.—The Cargo Fleet Iron Company, Limited, have opened offices at 35, Lime-street, London, E.C., for the direct sale of all materials manufactured at their works.—Messrs. Roe and Harrison, Limited, Iron-Founders, of Derby, have appointed Mr. T. S. Smith, of 5, Idol-lane, Eastcheap, London, E.C., as sole agent for the sale of their castings in London and district.—The Baldwin Locomotive Works having terminated the contract by which Messrs. Sanders and Co. acted as their general agents, have appointed Mr. Lawford H. Fry, M.I. Mech. E., as their European representative. Mr. Fry has transferred his office from Paris to 34, Victoria-street, London, S.W.

THE COPPER MARKET.—According to the monthly report of Messrs. James Lewis and Sons, the copper market has withstood the many depressing events of the past month with but slight depreciation—1*l.* 3s. 9d. per ton—standard falling from 56*l.* 3s. 9d. for cash on the 1st ult. to 54*l.* 17s. 6d. on the 14th, recovering to 55*l.* 12s. 6d. on the 18th, declining to 54*l.* 5s. on the 25th, and closing at 55*l.* Several circumstances have tended to unsettle the market, among them being the great depreciation in the value of securities on the New York, London, Paris, and Berlin Stock Exchanges, the advance rates on the Bank of England and other countries, and the trouble over Morocco. The firmness of the copper market in the face of these unfavourable factors is due to the fact that consumption continues to exceed production and stocks steadily decrease. High conductivity wire-bars have been sold down to 57*l.* 5s. per ton net c.i.f. American shipments for the month are advised at 25,745 tons.

THE IRON AND STEEL INSTITUTE.

The autumn meeting of the Iron and Steel Institute was held in London yesterday at the Institution of Civil Engineers. The President, His Grace the Duke of Devonshire, was in the chair. The meeting was, unfortunately, not very well attended, owing, doubtless, to the unavoidable change in plans, the first arrangements having been to hold this meeting in Italy. A large number of papers had been presented for reading and discussion, many of them by members of the Italian Association, with which the meeting had been planned. These papers were taken as read at the meeting, which, after the formal business, passed on to the consideration of three papers. A full report of the proceedings will appear in next week's issue. In the meantime, it may be stated that a resolution was passed regretting the unavoidable abandonment of the Italian meeting, and acknowledging the arrangements which had been made for the Institute's entertainment. The meeting desired to place on record an expression of its most sincere regret that circumstances had arisen to deprive the Institute of the honour and privilege of holding the autumn meeting at Turin under the auspices of its kindred organisation, the Association of the Italian Metallurgical Industry. At the same time it desired to convey its sense of the great obligation under which the Institute had been placed towards that Association, and particularly towards its distinguished president, Mr. G. E. Falck, and to others, who had made extensive arrangements for the Institute's private and official reception and entertainment, the abandonment of which, on the eve of realisation, had undoubtedly caused serious disappointment. The papers discussed at the meeting were—(1) "The Transformations of Steel Within the Limits of the Temperatures Employed in Heat Treatment," by M. L. Grenet; (2) "The Mechanical Influence of Carbon on Alloys of Iron and Manganese," by Professor J. O. Arnold and Mr. F. K. Knowles; and (3) "Temperature Influences on Carbon and Iron," by Mr. E. Adamson. A paper by Mr. L. L. Fermor, "On the Origin of the Iron Ores of Swedish Lapland," was also read, but no discussion followed thereon. We print Professor Arnold's paper in this issue.

University of London, University College.—A copy of the college calendar for the 1911-12 session, which commenced on the 2nd inst., has just reached us in the form of a cloth-bound book containing over 700 pages. The contents include a brief history of the college; lists of staff, officers, and students; particulars of scholarships and prizes; regulations; a list of original papers and publications emanating from the college; and the examination papers set during last session. Full particulars are also given of courses of study in the faculties of arts, science, laws, economics, medicine, and engineering. In the latter faculty a new lectureship in ventilation and heating has been instituted, and Mr. Arthur Barker, B.A., B.Sc., has been appointed thereto. We have also received a leaflet giving some particulars of special afternoon and evening lectures, with drawing-office and laboratory work, suitable for engineers in practice and graduates in science and engineering, to be delivered during the session. The subjects to be dealt with include, among others, heating and ventilation, electrical design, steam-turbines, structural design, photo-micrographic study of metals, aeroplane design, railway engineering, waterways, harbours, docks, and municipal engineering. Application for admission to these lectures, some of which commence next week, should be addressed to Mr. Walter W. Seton, M.A., Secretary, University College, London. The number admitted to each course will be limited, so as to secure individual attention.

Armstrong College, Newcastle-on-Tyne.—We have recently received a copy of the calendar for the session 1911-12 of the Armstrong College of the University of Durham. The first term of this session commenced on the 25th ult. The book, which contains nearly 500 pages, gives a list of officers, graduates, students, and others connected with the college, and includes particulars of scholarships, prizes, &c., together with full information as to courses of study for degrees in arts, science, agriculture, engineering, naval architecture, mining, and metallurgy. College diplomas are granted to students unable to take a complete course for a degree, provided they follow a specified course, and attain a sufficiently high standard in the examinations. The college has secured the co-operation of several important engineering and shipbuilding firms, who have agreed to permit their pupils to sandwich two or three sessions of college training in between periods spent in the shops or drawing-office. Parents are free to make their own arrangements with the firms, but the course recommended takes five-and-a-half years, the time being divided up as follows:—One session at college, fifteen months in works; two sessions at college, and eighteen months in works. It is considered that this system enables students to derive the greatest possible benefit from their college training. The college also holds evening classes in engineering, naval architecture, and other subjects. All communications and inquiries should be addressed to the secretary, Armstrong College, Newcastle-on-Tyne.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was quiet, and the tone was rather flat. The dealing in Cleveland warrants consisted of 2000 tons at 46s. 6½d., 46s. 7d., and 46s. 6½d. one month, and closing sellers quoted 46s. 3½d. cash, 46s. 7d. one month, and 47s. 1½d. three months. One lot of hematite changed hands at 61s. 9d. one month, with sellers over. The afternoon session was also quiet, and only one Cleveland warrant was done at 47s. three months, with sellers over. For the other positions sellers' prices were down to 46s. 2½d. cash, and 46s. 6d. one month. On Friday morning the market was again quiet, and Cleveland warrants were easier. The turnover amounted to 2000 tons at 46s. cash, and 46s. 2½d. one month, and closing sellers quoted 45s. 11½d. cash, 46s. 3d. one month, and 46s. 10d. three months. A better tone prevailed in the afternoon, but the business was limited to 500 tons of Cleveland warrants at 46s. 1d. cash. At the close there were sellers at 46s. 1½d. cash, 46s. 5½d. one month, and 47s. three months. On Monday morning the market was quite idle, but sellers of Cleveland warrants quoted firmer at 46s. 2½d. cash, 46s. 6d. one month, and 47s. three months. In the afternoon the tone remained firm, but no dealings were recorded. Closing quotations for Cleveland warrants were called at 46s. 3d. cash, 46s. 6d. one month, and 47s. three months sellers. On Tuesday morning a hardening tendency prevailed, but business was quiet, and only one lot of Cleveland warrants was dealt in at 46s. 6d. one month. Closing quotations were all up, and sellers named 46s. 4½d. cash, 46s. 8d. one month, and 47s. 3d. three months. The tone continued good in the afternoon, but the turnover was again small, and consisted of 1500 tons of Cleveland warrants at 46s. 4½d. and 46s. 5d. cash. The market closed strong, with sellers quoting 46s. 5½d. cash, 46s. 9½d. one month, and 47s. 4½d. three months. When the market opened to-day (Wednesday) Cleveland warrants were again firm, and 2000 tons were done at 46s. 5½d. cash and 47s. 4d. three months, with buyers over in each case, and sellers at 46s. 6d. cash, 46s. 9½d. one month, and 47s. 5d. three months. There was little change in the afternoon, when 1500 tons of Cleveland warrants changed hands at 46s. 5½d. cash and 46s. 9d. one month. At the close sellers quoted 46s. 6d. cash, 46s. 10d. one month, and 47s. 4½d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 61s.; Gartsherrie, 61s. 6d.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 63s.; Shotts (at Leith), 62s. 6d.; and Carron (at Grangemouth), 63s. 6d.

Sulphate of Ammonia.—A little better demand is reported for sulphate of ammonia this week, and the general inquiry for forward parcels also shows signs of increasing. The price has advanced slightly, and the current figure is now called 14*l.* 5s. per ton for prompt delivery, Glasgow or Leith. Last week the amount shipped from Leith Harbour was 350 tons.

Scotch Steel Trade.—Fairly active conditions continue to rule in the Scotch steel trade, and rolling-mills are all running steadily. Specifications for ship and boiler-plates are more plentiful and the demand for heavy material generally is exceedingly good, but new contracts are still rather slow. Angles are in better demand and prices have a firmer tendency. There is no falling-off in the trade in black and galvanised sheets, and makers are busy, while in the case of thin plates the demand for lots for shipment is very good. Export business is quite satisfactory and large lots of general material are being put through; Canada and New Zealand are this week reported to have fixed up fairly large lots of light steel for constructional purposes.

Malleable-Iron Trade.—The West of Scotland malleable-iron makers are well employed at present, and are supplied with sufficient specifications to ensure steady working for the next week or two. Prices, however, exhibit little sign of improvement.

Scottish Shipbuilding.—Considerable activity is general in the various shipyards in Scotland at present, and the output for the year to date is highly satisfactory. The figures for the month of September are above the average month of the year, and the following are the totals:—

	Vessels.	Tons.
The Clyde	21	50,628
The Forth	3	500
The Tay	3	2,599
The Dee	4	700
Total	31	54,427

The Clyde output is interesting from the fact that it is nine years since the tonnage of over 50,000 was recorded during the month of September. In that year—1902—the total amounted to 53,045 tons, which is still the record figure for a September output. For the nine months of this year the Clyde total now stands at 433,218 tons, representing 195 vessels; but, good as that total is, it is a bit behind the years 1906 and 1907. The output from all the shipyards in Scotland for the past nine months is:—

	Vessels.	Tons.
The Clyde	195	433,218
The Forth	20	10,256
The Tay	14	14,106
The Dee	53	8,177
Total	282	465,757

With regard to new contracts, it cannot be denied that booking has been rather quieter during the past month, although some good orders have been fixed up. In addition to those already reported, several others have recently been booked. Messrs. Napier and Miller, Old Kilpatrick, have contracted to build a small steamer for a firm of owners in New South Wales.—Messrs. Scotts' Shipbuilding and Engineering Company, Limited, Greenock, have secured an order to build a cargo and passenger steamer, of about 12,000 tons, for the Australian trade of Messrs. Alfred Holt and Co., Liverpool. The same firm have also received the contract to repair the popular Clyde turbine passenger steamer Queen Alexandra, which was recently much damaged by fire. The cost of this job is estimated to reach nearly 9000*l.*—Messrs. Murdoch and Murray, Port Glasgow, have booked an order for a new saloon paddle passenger-steamer for the Clyde. This vessel, which is for Mr. John Williamson's fleet, will be supplied with compound surface-condensing engines by Messrs. Rankin and Blackmore, Greenock, and will be ready for service by next summer.

Wages in the Iron Trade.—Messrs. James C. Bishop and James Gavin, joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board, have received the following intimation from Mr. John M. MacLeod, C.A., Glasgow:—"In terms of the remit, I have examined the employers' books for July and August, 1911, and I certify the average realised net selling price at works brought out is 6*l.* 0s. 11.13d. per ton." This means no change in the wages of the workmen.

Scotch Pig-Iron Trade.—There has been little change in the Scotch pig-iron industry during the past week, but inquiries from the South are a shade easier. Good deliveries are being made both on home and foreign account, and in the latter connection a fair volume of business has lately gone through for India, Australia, Japan, and South America. The hematite position is still unchanged, and although deliveries against contracts are fairly large, new bookings are practically nil. Prices are poor and mostly a matter of arrangement.

Contracts.—We are informed by the British Westinghouse Electric and Manufacturing Company, Limited, that they have recently received some important orders, among which are the following:—One 150-kw. alternator, with exciter and rheostat, for Messrs. Montague Higginson and Co.; one 1200-kw. rotary converter, transformer, and switch-gear for the Metropolitan District Railway; one 1200-kw. rotary converter, with transformer and switch-gear; forty T.I.F. controllers for Noyes Brothers, Melbourne, for the Adelaide tramways; and one 200-kw. rotary converter, transformer, and switch-gear.

The Commercial Motor-Users' Association.—We understand that the committee of the Commercial Motor-Users' Association has now completed its careful consideration of the conditions requisite to govern the sixth Annual Parade of Commercial Motor Vehicles. A parade, which has for its object the encouragement, by means of money prizes and other awards, of drivers of commercial motor vehicles and tractors to take a personal interest in the driving and condition of their machines, will be held during the morning of Whit Monday, June 10, 1912, in London. Certain modifications have been made in the conditions of entry and award of prizes, and these are set out in detail in the circular issued. The vehicles will not be examined on parade, but an inspection of the store-sheds, the drivers, and the vehicles will be previously carried out by an engineer appointed by the association. Members' vehicles will be allowed entrance free, and those of non-members on payment of a fee of 10s. per vehicle. Entries will close on January 1, 1912, but late entries will be allowed up to March 31 on payment of a fine of 1 guinea per vehicle, and from March 31 to May 9 on payment of a fine of 2 guineas per vehicle. Further particulars may be obtained from the secretary, 89, Pall Mall, London, S.W.

Moving Stairway at Earl's Court Station.—On Tuesday last there was a demonstration of a very interesting addition to the means of communication between the District Railway and the Piccadilly Tube at Earl's Court Station. This addition consists of a moving stairway, which is similar to a number that have for some time been in use in the United States, where they are said to have given every satisfaction, and it is the first that has been fixed in a tubular tunnel. The stairway is to replace lifts, and it begins as a level platform, which moves forwards until it forms into steps, which then rise slowly as a complete staircase, the motion being very quiet and steady. There is also a hand-rail of flexible material which travels with the staircase. Two of these stairways are placed side by side, one of them rising while the other descends. The passengers step on the platform of the staircase, either at the top or bottom, without any inconvenience, and on arrival at the top or bottom there is no danger of injury if they forget to step from the platform, for they are gently pushed, with a sliding motion, from it; also anything dropped on the stairs is treated in the same way. Passengers are raised and lowered without any exertion to themselves, as in a lift, but they can, if they choose, walk up or down the stairs, and so save time. There are 3600 steps rise and fall per hour, each step being 4 ft. 6 in. wide, 8 in. rise, and 18 in. tread, and each capable of holding three people comfortably. The stairway is capable of carrying 10,800 people per hour from the Tube to the District Railway, and the same number in the opposite direction. The advantages claimed for the appliance are that there is no waiting, as in the case of lifts, for the stairway is always running; passengers are carried practically to the point of their destination; and there are no long connecting passage-ways. In case of breakdown, passengers can walk up or down the stairs, and the stairway will deliver the same number of people for a short or long rise.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

The Master Cutler.—In the new Master Cutler, Mr. Arthur Balfour, managing director of the well-known steel firm of Messrs. Seebohm and Dieckstahl, Dannemora Works, Sheffield has honoured one of her citizens, who, in the ranks of industry, takes a prominent place. Mr. Balfour's career has been a triumph of youth. At the age of thirty-eight he is the youngest member of the Cutlers' Company, with two exceptions, to be appointed to the mastership. He commenced his career with Messrs. Seebohm and Dieckstahl at the age of fourteen, went to America in his nineteenth year, became works manager for the New York Car-Wheel Company, Buffalo, before he was twenty-one, was promoted general manager, returned to England, and was then appointed works manager at the Dannemora Works. A few years later he became managing director. The success of the firm under Mr. Balfour's leadership has been largely due to his wide knowledge of foreign markets, obtained by extensive travel, his personal grip of the essentials of the business, and his belief in the value of science applied to industry. The firm were one of the first to produce high-speed steel, and have always been in the front rank of modern developments. They possess one of the best-equipped laboratories in the city for chemical research in relation to steel. Mr. Balfour is likely to prove a popular choice as Master Cutler. His business experience will be of inestimable value, and he has a personality which will make for success in the fulfilment of the large number of social duties which the Master Cutler is called upon to perform. Mr. Balfour is the Vice-Consul for Denmark in Sheffield.

South Yorkshire Coal Trade.—Although there is wide-spread anxiety as to the possibility of a winter coal strike, it is urged in local colliery circles that this catastrophe is considerably discounted by the fact that the vexed question of abnormal working places only affects a very small number of men, and in South Yorkshire, where there are so many new collieries, scarcely exists. It was reported on the local Exchange last week-end that the steam-coal trade had received a setback, exports having fallen off considerably. There is still, however, a big demand on industrial account, and many manufacturers continue to lay in stocks. The difficulty occasioned by the shortage of wagons has become acute and is curtailing working hours at collieries. At the same time pits have a good many orders on hand, and consequently they are placed in the position of being considerably in arrears on contracts. Gas fuel is going away well, and extra quantities of these sorts are being put into stock. Slacks and coking smalls are in a stronger position. Good business is being done at house-coal dépôts, though most of the orders for cheap coals have been got through. It is in the best grades that the biggest demand is experienced. These, however, are difficult to obtain. Collieries are strongly pressed for supplies, and prices have been further advanced from 6d. to a 1s. since the previous week. Exchange prices at the week-end were:—Best branch hand-picked, 14s. to 15s.; best Barnsley Silkstone, 12s. to 13s.; Silkstone, 11s. to 12s.; Derbyshire, 8s. 6d. to 9s. 6d.; best large nuts, 8s. 6d. to 9s. 6d.; small nuts, 8s. to 9s.; Derbyshire best brights, 11s. to 12s.; Yorkshire hards, 8s. 3d. to 9s. 3d.; Derbyshire hards, 8s. to 9s.; washed nuts, 7s. 6d. to 8s. 6d.; rough slacks, 5s. 3d. to 7s.; seconds, 4s. 3d. to 5s. 3d.; smalls, 2s. to 3s.

Iron and Steel.—Without having changed much during the week, the pig-iron market may be said to be in a somewhat stronger position. A good deal of hematite has changed hands, indicative of growing consumption. The common irons have been selling more freely, and both Lincolnshire and Derbyshire sorts are firm. In finished iron an interesting announcement was made last week. After a very long period of unchanged prices, the South Yorkshire Bar-Iron Association decided to make a 5s. increase upon bars, bringing the present quotation up to 7*l.* The increase synchronises with a trade revival; most of the makers are fully occupied, and there is a good outlook. This improvement in finished iron may be expected to influence favourably the condition of pig iron. The iron foundries are busier. Reports from the general trades of the city show that these continue to be actively engaged, though manufacturers are not free from anxiety as to possible trouble in the coal world. Trade is also being hampered to a certain extent by railway delays, a difficulty occasioned by the fact that the companies, in spite of recent ordering, are short of rolling-stock. Railway steel manufacturers have had a good deal of work in hand lately, but have not been able to work under the best conditions, because of the irregularity with which orders have come forward, causing alternating periods of pressure and slackness. This is neither good for the employers nor the workmen. Industries relying upon the condition of shipbuilding are doing well just now, and the activity on the North-East Coast is having a very beneficial effect upon the metal trades. Forgings and castings and engineers' and machine-tools are being turned out in large quantities. The condition both of the heavy and light branches of the general trades is very good, and the home trade is beginning to show some of the satisfactory activity which has for a considerable time characterised exports.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Some little improvement can be reported in the pig-iron trade, but buyers still act with great caution, and, as a rule, continue to confine their operation to purchases of small lots for early delivery. It is gratifying, however, to be able to report a better feeling, notwithstanding war troubles abroad and a continued under-current of unrest in the labour market at home. There are undoubted indications of returning confidence, and several traders now express the belief that a large business will be done over the remainder of the autumn. More satisfactory reports from the United States, and the more favourable condition of the stock market, are the principal causes of the better tone of the iron market. No. 3 g.m.b. Cleveland pig is firm at 46s. 9d. f.o.b., at which price several sales have been made, and considerably above that figure has been realised for certain named brands; whilst No. 1 is fully 50s. 3d.; No. 4 foundry and No. 4 forge each 46s. 3d.; and mottled and white iron each 46s.—all for early delivery. There is little business passing in hematite pig iron. Makers adhere to 61s. for early delivery of Nos. 1, 2, and 3, but second hands are prepared to sell at a little below that figure. There is a persistent report that a well-known hematite pig-iron-making establishment will change hands very shortly. The likelihood of this happening was foreshadowed by the chairman of the company at the annual meeting of shareholders a month or two ago. It is stated that negotiations for the transfer are now complete, and particulars will be made public very shortly. Business in foreign ore is at a standstill, but dealers are very firm, and market quotations are still based on 19s. 6d. ex-ship Tees for Rubio of 50 per cent. quality. Coke is steady and in good request for local consumption. Average blast-furnace kinds stand at 14s. 9d. delivered here.

Manufactured Iron and Steel.—The various branches of the manufactured iron and steel industries present few new features of moment. Not only is production heavy, but manufacturers have large contracts made, and there are substantial inquiries still in the market. Under these favourable conditions values show an upward tendency, but, as yet, no quotable advances have been announced. Principal market rates stand:—Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron girder sheets, 6*l.* 17s. 6d.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 7s. 6d. to 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 11*l.* 5s.—sheets less the usual 4 per cent. f.o.b., railway material net at works, and all other descriptions less the customary 2½ per cent.

Shipments of Iron and Steel.—Shipments of iron and steel during September realised expectations. Those of pig iron reached 106,693 tons, and as substantial deliveries to foreign customers have yet to be made, shipments to buyers abroad promise to be maintained, at all events for a while. Of the pig iron despatched last month, 92,538 tons went from Middlesbrough, and 14,155 tons from the neighbouring little port of Skinningrove. For the previous month the total clearances of pig were officially given at 101,336 tons, and the loadings for September of last year were returned at 107,536 tons. Of the pig shipped at Skinningrove last month, 541 tons went to the Continent and 13,614 tons to Scotland. Of the pig loaded at Middlesbrough last month, 56,457 tons went to customers abroad and 36,071 tons to coastwise buyers, Scotland once more being the largest customer, receiving 27,245 tons, whilst Italy imported 12,056 tons; France, 8016 tons; Japan, 6811 tons; Belgium, 4765 tons; Wales, 4154 tons; and Russia, Sweden, Germany, and Canada, each over 3000 tons. Of the 20,740 tons of manufactured iron despatched last month, 12,876 tons went to foreign ports, and 7864 tons coastwise; and of the 48,506 tons of steel shipped, no less than 41,186 tons went abroad, and only 7320 tons coastwise. India was the largest customer for both manufactured iron and steel, importing 4795 tons of the former and 15,567 tons of the latter. Other principal customers for manufactured iron were the Argentine, 4436 tons, and China, 2331 tons; whilst the other chief importers of steel were the Argentine, 8147 tons, and Japan, 5180 tons.

THE INSTITUTE OF MARINE ENGINEERS.—On Monday evening, October 2, the adjourned discussion on Mr. E. Shackleton's paper on "Modern Developments in British and Continental Oil-Engine Practice" took place. The chairman remarked at the commencement of the meeting that he considered it highly necessary, in the face of the fact that Diesel engines were now so much to the front, and were taking the place of steam-engines in sea-going ships, that marine engineers should have not only a general knowledge of them, but also an intimate knowledge. The author of the paper stated that it appeared desirable to lose a little in propeller efficiency and have a higher revolution engine, as the lower speeds involved to some extent a tarry deposit on the piston. Mr. F. M. Simpson thought that most of the discredit attached to the motor industry was due to the fact that makers of land engines for land work had constructed marine engines without a knowledge of marine conditions, and he did not consider that horizontal engines would find a place in marine work. Mr. J. T. Milton did not agree with the author that engineers of large experience in the making of marine engines should have no voice in determining the different sizes of internal-combustion engines. The matter should not be left entirely in the hands of gas-engine makers. He also considered the vertical type of engine superior to the horizontal for marine work. The discussion was adjourned until Monday, October 9, when the paper, "Notes on Two-Cycle Oil-Engines," by Mr. F. Duncanson will be read.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has been rather irregular and uncertain, but colliery owners anticipate favourable results from the activity of Italian Government agents in arranging for prompt supplies. The best large steam coal has made 16s 9d. to 17s. 3d. per ton; secondary qualities have ranged between 15s. 3d. and 16s. 6d. per ton; best bunker smalls between 8s. 3d. and 8s. 9d. per ton; and cargo smalls between 6s. 6d. and 7s. per ton. The best ordinary household coal has made 14s. 6d. to 16s. 6d. per ton; No. 3 Rhondda large, 17s. to 17s. 6d. per ton; and smalls, 10s. 3d. to 10s. 6d. per ton. No. 2 Rhondda large has been quoted at 12s. to 12s. 3d. per ton; and smalls, at 6s. 3d. to 7s. per ton. Foundry coke has brought 18s. to 20s. 6d. per ton; and furnace ditto, 16s. to 17s. per ton. As regards iron ore, Rubio has realised 18s. 6d. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Welsh Coal for Italy.—There was much activity on Friday among the Italian Government officials at Cardiff who buy coal for the Italian Navy and the Italian State Railways. Instructions were given diverting the vessels loading on their account to Syracuse and other Sicilian ports instead of to the destinations originally arranged, while several additional steamers were chartered at high freights to load immediately.

More Welsh Coal.—The officials of the Wernos Colliery, Pontyffynon, have struck the Stanllyd vein. The sinkings started from the Pumpquart vein, and passed through two other veins before the Stanllyd was reached. The coal obtained appears to be of good quality. The first sod of a new pit at Ynyscorrwg Farm, Glyncourwg, was cut on Wednesday by Mr. T. F. Thomas, director of the Ynyscourwg Colliery Company. Mr. M. Evans, the manager, and other officials, were also present. The new pit will be a house-coal shaft, and the estimated depth is 250 yards.

Lundy Island.—Telegraphic communication between Lundy Island and the neighbouring mainland was interrupted on Friday. The service is to be re-established without delay.

Abertillery.—Mr. G. Jones presided at the last meeting of the Abertillery and District Water Board at Newport on Wednesday. The engineer (Mr. Baldwin Latham) reported that he and the solicitor (Mr. T. S. Edwards) had come to a satisfactory agreement with the London and North-Western Railway Company and the Great Western Railway Company for the Board's mains crossing the lines of those companies. The Great Western Company demanded that a depth of 5 ft. of water should be provided for after the mains had been laid under their Monmouthshire canal. This would increase the cost of the works.

The Eddystone.—The Trinity House proposes to establish a bell-buoy, which will be fitted with a submarine bell, in a position 3 cables S. 17 W. from the Eddystone Lighthouse. The bell will be worked by the movement of the buoy, so that the number of strokes per minute will not be uniform.

Dowlais.—Labour difficulties having been adjusted, operations have been resumed in all departments. The Goat Mill was the first to return to work, some urgent orders for light rails requiring attention.

Bristol Docks.—Mr. Ross Johnson has been appointed general traffic manager of the Bristol Docks by the Bristol City Council, at a salary of 1000*l.* per annum rising to 1200*l.* He is at present secretary of the Indian Railway Conference Association, but he will return at once to Bristol.

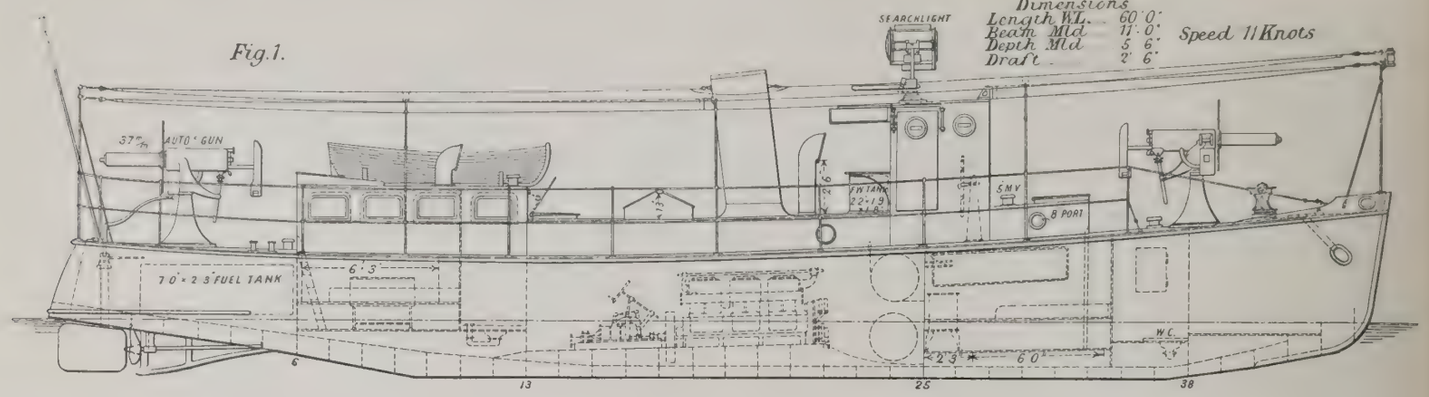
MARINE GAS-ENGINES.—Since the trials of the Holtzapfel I. (the first sea-going cargo vessel fitted with gas-engines), the public has not heard a great deal about the ship's performances and movements. There were several reasons for this. When the vessel first started off she met with a collision; there were also other delays arising from the newness of the machinery and from the lack of familiarity of the certified engineers with the type of machinery. Before the vessel could do regular and satisfactory work various adjustments had to be made, and the owners naturally preferred to say nothing until they had some substantial facts on which to base their opinions. The required experience has now been gained, and we are able to state what the vessel is able to do. She has already carried the following cargoes:—Tyne to London, 242 tons of coke; London to Llanelly, 330 tons of scrap iron; Llanelly to London, 330 tons of lime; London to Cork, 330 tons of hardwood and cement; Cork to Newhaven, 251 tons of granite; London to Tyne, 340 tons of chalk. These voyages were, we understand, all performed in a satisfactory manner, the consumption of fuel varying from 25 cwt. to 33 cwt. of coal per 24 hours, which is regarded as moderate, other vessels of the same size driven by steam engines consuming more than double that quantity. Since the vessel started some improvements have been made in her machinery, and she is now undergoing a general overhaul at South Shields. The owners appear quite satisfied with her performance, and see no difficulty in fitting larger vessels with gas-engines. We understand that plans have been completed in conjunction with the Power-Gas Corporation of Stockton-on-Tees for installing on board cargo vessels of considerable size gas plant able to consume practically any class of coal, and fitted with tar-extractors. The Holtzapfel Marine Gas-Power Syndicate, 57, Fenchurch-street, London, E.C., inform us that they will be pleased to supply information to shipbuilders, ship-owners, and engineers concerning these gas plants.

ARMOURED MOTOR-LAUNCHES FOR TURKEY.

CONSTRUCTED BY MESSRS. JOHN I. THORNYCROFT AND CO., LIMITED, ENGINEERS, SOUTHAMPTON.

(*For Description, see Page* 470.)

Fig.1.



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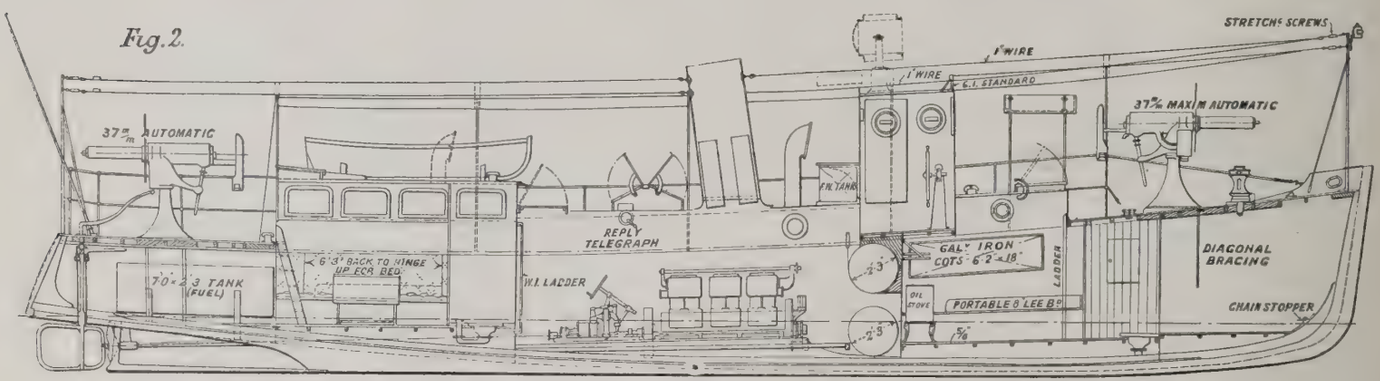

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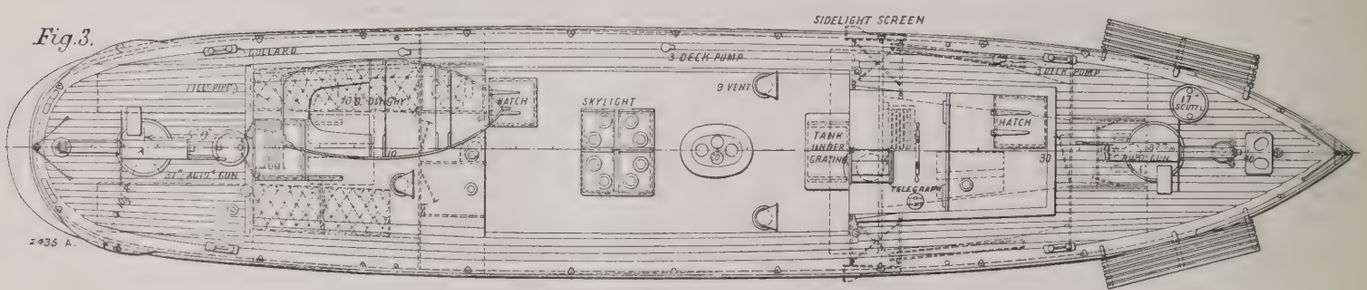

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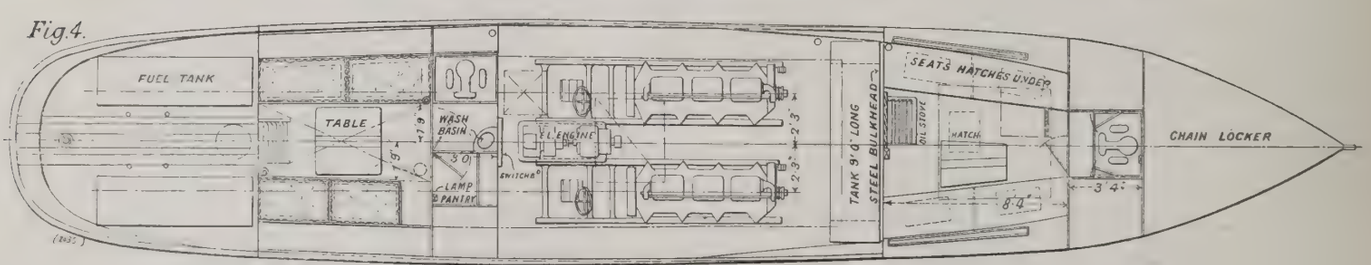

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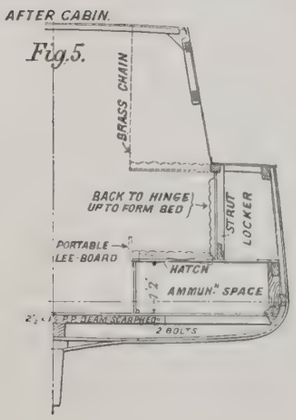

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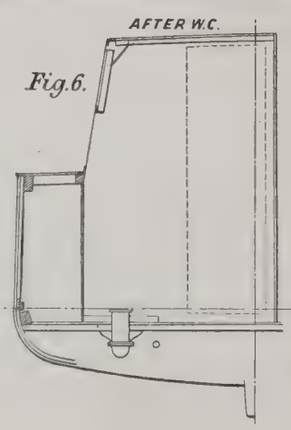

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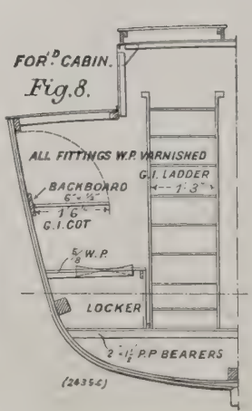

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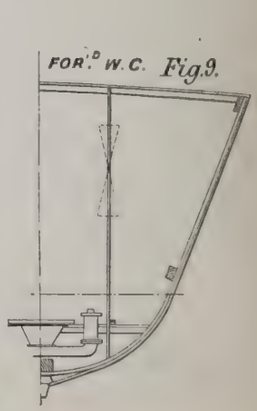

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

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Thick ,,	£1	16	0 ($8.75)
For all other places abroad—			
Thin paper copies	£1	16	0
Thick ,,	£2	0	6

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We desire to call the attention of our readers to the fact that the above is our SOLE Address, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With a Two-Page Plate of the REPLACEMENT OF THE COTEAU RAILROAD BRIDGE ACROSS THE ST. LAWRENCE RIVER, CANADA.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—Monday, October 9, at 8 p.m. A paper entitled "The Advantages of the Steam-Turbine as Compared with the Reciprocating Engine," will be read by Mr. W. A. Hatch, graduate, of Newcastle-upon-Tyne. Chairman: Mr. Mark Robinson, Member of Council.

THE INSTITUTE OF SANITARY ENGINEERS.—Monday, October 9, at 7.30 p.m., at Caxton Hall, Westminster. The President, Mr. A. J. Martin, M. Inst. C.E., will give an address on the programme for the session.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 13, at 6.30 p.m. Visit to *The Model Engineer* Small-Power Engineering and Scientific Exhibition at the Royal Horticultural Hall, Vincent-square, Westminster.

ENGINEERING.

FRIDAY, OCTOBER 6, 1911.

THE "LIBERTÉ" DISASTER AND PROPELLANT POWDERS.

WHILE it would be, to say the least, premature definitely to ascribe the disaster to the French battleship Liberté to the spontaneous combustion of the propellant powder on board, there is sufficient justification for some examination of the subject, in view, firstly, of the tendency of naval opinion in France in favour of this theory, and, secondly, of the question which has been raised in this country, owing to inadequate information, as to the immunity, or otherwise, of our own ships from similar catastrophe. As a court of inquiry is to be held into the cause of the Liberté disaster, we shall refrain from attempting any investigation of the subject. But consideration can profitably be given to the main points of comparison between the two classes of propellant powder used in the respective navies in order to set at rest any misgivings which may exist in this country as to the likelihood of similar accidents in our own ships. This, too, can be done without injuring the susceptibilities of our friends in the French service, with whom all sympathise. They themselves, in large numbers, are disposed to attribute the accident to the spontaneous combustion of the powder, as the events immediately preceding the actual principal explosion are reported from reliable sources to have resembled greatly those which occurred in the case of the Jena explosion, which was officially ascribed to the spontaneous combustion of the propellant powder on board. Moreover, it is of much significance that an order has been issued withdrawing from service all the propellant powders of a certain age still in the French ships. If the reports as to the newspaper interview with Admiral Bellue, commanding the Second Squadron, are correct, it would also appear that that officer has no doubts whatever in his own mind that the accident was due to spontaneous decomposition of the propellant powder, in the same way as occurred on the Jena.

In speaking of this powder, it will be noticed that we emphasise the word "propellant," and we do so advisedly, inasmuch as many writers in the daily journals confuse this class of powder with high explosives or shell powders used for destructive purposes. Briefly, a propellant powder is the powder used in the gun for projecting the shot therefrom. Being generally of a colloidal type, the speed of combustion is entirely under the control of the manufacturer, in that it burns from the surface only, and therefore can be manufactured to burn slowly or quickly according to the size of the gun for which it is intended. High explosives, however, being designed for use in shells and to do the greatest amount of damage by disruption of the shells containing them, it is essential that their combustion should be as rapid as possible, and if they can be detonated, so much the better; detonation has been defined as "instantaneous decomposition throughout the mass." It is evident, therefore, that a propellant powder would be unsuitable for a shell, whilst a high explosive powder used for filling shells would shatter a gun to pieces if detonated therein. The modern types of high explosives, such as picric acid, trinitrotoluol, &c., are very stable bodies, so no fear need be entertained that they are to blame. Propellant powders, on the other hand, are far more complex, and susceptible to various influences and consequent changes in their characteristics and behaviour, which constitute at all times a certain element of anxiety. It is only by the utmost care in the choice of a propellant and in the manufacture thereof, combined with a most thorough system of periodical inspection, testing, and proper conditions of storage at moderate temperatures, that disasters similar to those which have, unfortunately, occurred elsewhere have been avoided in our Navy.

There is a broad distinction between the types of propellant powders used by Great Britain and France, the one being what is known as the nitroglycerine type, the other the nitrocellulose type. Besides Great Britain the following countries use the nitroglycerine type for their navies:—Germany, Italy, Japan, Brazil, Argentina, whilst those which use the nitrocellulose type are France, the United States, and Russia. It is a somewhat striking fact that, with the exception of Russia, it is the navies that use a nitrocellulose propellant powder which have had most trouble and accidents. Russia, however, has not had a very severe trial, as her ships mostly lie in cold climates, and not being so often at sea, and consequently, with steam up, the magazines are seldom warmed to high temperatures, or, even if so, are not kept at high temperatures for long periods. In all navies magazine cooling has done a great deal towards minimising risks with either class of powder; but magazine cooling alone is insufficient for safety unless accompanied by a proper system of inspection and testing.

A nitroglycerine propellant powder consists of an intimate mixture of nitrocotton, and nitroglycerine to which is generally added a small percentage of non-volatile matter, the most usual being "mineral-jelly," popularly known as vaseline. The nitrocotton, of which gun-cotton is a high grade, is mixed with the nitroglycerine by hand in suitable proportions, generally about two or three parts of nitrocotton to one of nitroglycerine, and is then machine-mixed with acetone and mineral jelly, passed through suitable dies, &c., and finally dried in hot-air stoves. The acetone breaks down the structure of the nitrocotton, and is said to gelatinise it—*i.e.*, change it more or less into a colloid, and, as the nitroglycerine and mineral jelly are already colloids, it follows that the resultant mass when squeezed into cords or tubes through suitable dies, or rolled out into strips, is also colloidal; in other words, the physical state of the finished article is such that combustion takes place only on the surface instead of penetrating the mass. The mineral jelly also has, so to say, a "waterproofing" effect which preserves the propellant against the deleterious influence of changes in atmospheric conditions, and prevents alterations in the percentage of the residual moisture which it is impossible completely to extract or dry out. This is a most important point, as will be shown presently.

A nitrocellulose powder consists almost entirely of nitrocellulose, another grade of nitrocotton containing less nitrogen than the gun-cotton used in a nitroglycerine powder. The solvent or gelatinising agent employed with nitrocellulose propellants is a mixture of ether and alcohol; acetone will not do, as it makes the finished article too brittle, and, further, would gelatinise it to too great an extent, rendering the powder difficult to burn. Consequently, as nitrocellulose powders are not of such a colloidal nature as nitroglycerine powders, and as it is impossible to incorporate mineral jelly with them, they are thus considerably influenced by differences of temperature, moisture, &c., necessitating their storage in hermetically sealed cases. This is a necessity, from a ballistic point of view, for the reason that even very small fluctuations in the percentage of residual moisture have a very large influence upon the behaviour of the powder in the gun, with consequent loss of accuracy in the shooting. On the other hand, hermetically to seal up a case of powder is distinctly deleterious in the long run to the chemical stability of that powder, more particularly in hot climates or in hot magazines; for if the gaseous products of decomposition are not allowed to escape, they have a cumulative effect upon the rest of the powder. It may here be remarked that all modern propellant smokeless powders of the nitro type, being, as it were, in a state of strain, commence a slow, though gradual, decomposition from the moment they are made; consequently, any influence which tends to hasten such decomposition, or which causes a cumulative effect in such decomposition, is to be carefully avoided. In addition, therefore, to keeping modern propellants cool, it is necessary that they should be aerated, and not bottled up in hermetically closed cases, otherwise a time will come when the decomposition will become so accentuated and rapid that the accumu-

lation of the gaseous products of decomposition in the sealed cases will engender sufficient heat to burst into flame. Then, in an enclosed space, such as a ship's magazine, the gases of the burning powder, not being able to escape sufficiently rapidly, will set up such a pressure as to reach the critical point, when the burning will change to explosion of a violent character and the ship will be destroyed.

In comparing the nitroglycerine and nitrocellulose types of propellant powders we have two entirely different sets of factors. With the nitroglycerine type we have a powder which, from the nature of its composition, is more stable, which can be safely left in non-air-tight cases and allowed to aerate freely, and which is not so subject to the great influence of fluctuations in moisture content, and which, consequently, gives very even shooting results.

On the other hand, a nitrocellulose powder is inherently less stable, is greatly influenced by fluctuations in percentage of moisture content, with consequent loss of accuracy in shooting, necessitating its enclosure in hermetically sealed cases, which not only prevent its aeration, but also render its systematic inspection and testing much more difficult. From the above considerations it is evident that, at any rate for naval purposes, a nitrocellulose propellant powder cannot compare as regards stability with a nitroglycerine propellant powder. The only point in its favour is the claim that it gives less erosion, but this has, in recent years, been found to be based on a wrong premise—viz., that the temperature of combustion of a nitrocellulose powder being lower than that of a nitroglycerine powder, the erosion with the former is less. Experiments have shown, however, that erosion is not only a function of the temperature of explosion, but also of other factors which tend to counterbalance the advantage of the lower explosion temperature.

It is somewhat surprising, therefore, to see the French Navy adhering to a powder which offers, apparently, no advantages, and, indeed, would appear to be distinctiy inferior, from every point of view, to a nitroglycerine powder, if we are to judge from the experience of those navies which, presumably having tried both classes of powder, decided, for naval purposes, to adopt the nitroglycerine type. It is interesting to note that Germany, Japan, Brazil, and Argentina, though using a nitrocellulose powder for their armies, use, so far, only nitroglycerine powders for their navies. Great Britain uses the latter for both Navy and Army. In any case, even with the more stable nitroglycerine powder, a rigid and thorough system of inspection and testing must be carried out, not only during manufacture and on proof, but also during subsequent storage and use in the Service. It is satisfactory to know that in no country in the world is such scrupulous care taken in these respects as in this country. We make no apology for referring to two articles on the subject of "Nitrocellulose Powder for Naval Purposes," which appeared in Engineering of August 18, 1911, and May 20, 1910. The latter, written a short time after the Jena disaster, quotes from the "Memorial des Poudres et Saltpetres," a French Government publication, and also from official United States instructions, all of which fully bear out the arguments put forward above in support of our contention that for naval purposes a nitrocellulose powder is unsuitable, and will possibly be found to be the cause of the terrible accident to the Liberté, which we, as a nation, deplore as deeply as our friends in France.

PAPERS FOR DISCUSSION.

Within a brief space now programmes of the technical and scientific societies will be issued, and the activities accompanying the winter sessions will be renewed. For the majority of such bodies the winter meetings constitute the chief means of attaining their end, which is, of course, the dissemination and advancement of knowledge. Probably there are few societies of this class but make some reference to this line of work, either in their by-laws, regulations, or charter; for this, for most of them, is one of their chief reasons for existence. In the ideal, what could better assist progress, in fact, than the consideration and healthy criticism, by a body of specialists, of the views advanced by an expert in close touch in daily life with the subject he brings forward? With liberal handling an opportunity of this kind must almost certainly result in some good. It may even be fruitful of valuable conclusions, or, if finality be not possible, it should at least be conducive to progress along sound lines.

Whatever opinions the cynics may hold to be the object, the desire to contribute to the general knowledge still prompts many a communication, although perhaps this incentive may not be the prime mover so frequently as it was in early days, when the membership lists were smaller, and friends and acquaintances formed a larger proportion of the audiences than they do now. The lengthy lists of medals, prizes, and premiums often suggest to the less charitable that now-a-days an author is probably, in the first place, a seeker of reward, notoriety, or what is collectively known as *kudos*, and only in the second place a dispenser of information which he has had unique opportunities of acquiring, but which ordinary members find difficult to come by.

It does not follow that the sole criterion as to the value of a paper for discussion at a meeting rests in the uniqueness of its information. The councils responsible for the selection are naturally placed in a difficult position here, in knowing just what will lead to instructive debate. A contribution may, for instance, be so erudite and specialised as to render oral discussion impossible, or, at any rate, completely lacking in interest to the assembled members. Such a paper should not be brought before a meeting, but placed before the members, if possible, in some other way, in which facilities for discussion by correspondence would be provided. On the other hand, one of the most satisfactory forms of contribution appears to be that which, though dealing with simpler subjects, gives the results of experience in usage. There are, then, almost certain to be some other engineers working along similar lines, or at least pushing in a similar direction, who may be willing to give details of their experience, when often an interesting debate will result.

It may be taken that pure descriptions of works are apt to engender speechifying, full of platitudes and compliments, of little value to anybody, and most annoying to the members present, and such a paper is often serviceable only as a record of a large undertaking, which has probably been adequately dealt with months previously in the technical Press. It is the unwritten rule of many of the technical bodies that subjects dealt with at meetings shall be restricted to work actually done. This does not apply, of course, to presidential addresses; but the practice is undoubtedly a safeguard against abuse by individuals having pet hobbies to advance. In certain directions some speculation is not only allowable but welcome, but to be so it must be limited to those whose standing in the profession makes their views of interest and of value in further work. Technical societies are not intended to be vehicles for the conveyance of the lucubrations of fertile imaginations. For this purpose the Patent Office has been provided.

The ideal of a paper would be one to which, in all sincerity and not merely as a complimentary formality, resolutions might apply such as those recorded for our entertainment as having been passed on the historic occasion of the reading of Mr. Pickwick's "Speculations on the Source of the Hampstead Ponds, with some Observations on the Theory of Tittlebats." The reading of a valuable paper should undoubtedly produce "feelings of unmingled satisfaction," and should have made the assembled members "deeply sensible of the advantages which must accrue to the cause of science from the production to which they have just adverted, no less than from the unwearied researches of" the author. Well received though Mr. Pickwick's paper was, and therefore to be emulated in this respect, that gentleman's subsequent style of oration is not to be encouraged, or meetings may be lacking in the dignity to which our modern institutions aspire.

Perhaps we may dwell for a moment upon one of the more coherent portions of that famous speech, which has a peculiar application in our present argument. "Travelling," said Mr. Pickwick, "was in a troubled state, and the minds of coachmen were unsettled. Let them look abroad and contemplate the scenes which were enacting around them. Stage-coaches were upsetting in all directions, horses were bolting, boats were overturning, and boilers were bursting." We have got beyond stage-coaches, but it will not be denied that travelling is in a troubled state. The air is full of strikes and rumours of strikes, and if some people had their way they would also have us believe that we are suffering from an altogether inordinate number of railway accidents. This may seem to be an altogether irrelevant digression, but our purpose is now to point a moral.

Before a certain society, which need not be named, a few days since a paper was read, which proved to be in many ways the reverse of what we would wish to see down for discussion. In this paper the author set out to prove the need of safer, quicker, and cheaper railways. In it in the first place, in the endeavour to show that the railways of the United Kingdom were unsafe, it was stated that 27,186 people were killed or injured on them in 1907. Referring, however, to the Board of Trade returns, we find that actually only 9928 casualties of all kinds occurred in that year through the movement of rolling-stock, and only 817 in accidents to trains. Railway travel proper is only responsible for a very small proportion of these. For instance, 980 casualties to passengers occurred in entering and alighting from trains; 630 from the closing of carriage-doors; trespassers and suicides account for 580 casualties. Among the employees, 570 casualties were due to moving vehicles with capstans; 438 to crossing the line while on duty, while 2899 occurred in the loading and unloading of wagons at rest; 2363 while attending to engines at rest; 1495 from falling off engines at rest; and 1049 were due to stumbling while walking on the line—all of which facts show how grossly exaggerated was the case made against the railways by this author, who was ostensibly considering accidents due, to borrow words from his paper, to "hurtling through space with a living freight at a mile a minute." The author seems to have been inspired with a love for the sensational, quite out of place in the proceedings of a technical society, for though, after pointing to the largest figures he can procure, he goes into the investigation a little more closely, his detailed treatment of the subject is altogether inadequate, and calculated to convey a wrong impression. Proceeding to the question of the proportion of casualties to travellers, again an erroneous presentation of facts is made. The vast body of season-ticket holders is ignored, so that, though the journeys of a business-man travelling 13 or 20 miles or more twice a day, six days a week, are not taken into account, a market-woman travelling on a Saturday, 5 or 7 miles perhaps, would be credited with two journeys. Again, "turning from effect to cause," the author tacitly implies that the large number of casualties he cited arose, at least in part, from 4890 accidents recorded. Actually nothing of the kind occurs. Many of the accidents reported are trivial, and result neither in loss of life nor in injury.

We no not propose to criticise this paper in detail. Our object is to show why a paper of the style we are alluding to should not be read at a meeting, and offered for discussion. The facts, as we have shown (we might produce other examples by the score), have not been fairly presented. Their proper appreciation only renders the more ridiculous much of the remainder of the paper. With extraordinary inconsistency, the author, for instance, first proposes the use of a weird armour-plated buffer carriage, necessarily of great weight, which, he plaintively remarks, six of the leading railways of the country have shown no disposition to adopt, while he subsequently suggests that weight should be cut down in all directions. That he must not be taken too seriously in his suggestions will be evident when it is remarked that a proposal is made by the author that a specially trained observer should sit in a specially constructed vantage point in the front of express engines, this man to be provided with binoculars to see if the road is clear! We could improve upon that even. We might put the man on an extension in front of the engine, and thus place him a few feet still further ahead, and we could provide him with extension mirrors long enough for him to see round all curves on the road! Like all reformers, the author thinks railways will be cheapened by scrapping the whole existing system, which it has cost some 1300 million sterling, in round numbers, to produce, replacing it with a new-fangled construction of his own, embodying single-unit trains fitted with aeroplanes. The effect of the planes would be to lift the cars, and driving would be on to side and overhead rails. The author, unfortunately, overlooks the fact that by this ingeniously roundabout method he would get increased head resistance and reduced driving effort.

We need not take further pains to show that this

was not a paper for serious consideration at a technical meeting. It was demolished after the reading by a gentleman who, though not an engineer, had a sound knowledge of facts. The facts as presented we have shown to be inaccurate; the paper dealt in an altogether superficial manner with actualities, and it indulged largely in fantastic speculation. In language it was extravagant. Tittlebats have, we doubt not, pursued the even tenour of their ways since 1827, quite indifferent to the theories advanced by Mr. Pickwick. Our railways and the public will similarly be unmoved, except perhaps in the direction of merriment, by the paper we have regretfully felt compelled to criticise somewhat severely. The point that we would lay stress upon is this, that it is in the general interest of the profession that only rational papers should be brought forward for discussion, by the council of any technical society. Within the society itself papers of the impossible type may afford an evening's amusement, but it is a dangerous experiment to lay before the members the ridiculous merely to arouse criticism and artificially to foster debate. The experiment would be rash enough in the case of an old society permeated with the spirit of goodfellowship, but in the case of one only just reconstructed, and attempting to qualify for a standing among the leading professional societies, it may not improbably result in lowering its reputation to such an extent that it is likely to find its work hampered for years subsequently.

BRITISH BATTLESHIP BUILDING PROGRAMME.

The only lesson which the unfortunate outbreak of war between Italy and Turkey has, so far, taught, or appears likely to teach, is the need of complete preparedness for war at all times, since once more it has been demonstrated that the "bolt from the blue" is not the mere imagery of the poet. As with Japan, so with Italy, the issue of the ultimatum, or declaration of war, was instantly followed by military operations. Although such action may not of itself ensure in all cases ultimate success, it confers a considerable advantage in the initial stage, which may influence greatly the final issue. It is therefore gratifying to note the unequivocal pronouncement of the First Lord of the Admiralty in reference to our building programme, which is an important item in any scheme of preparedness for war. Like every other citizen, he is anxious for the minimising of naval expenditure as far as prudence permits, but he has once more laid down the dictum that our programme must be determined with full conception of the effect in war strength, at any future date, of the building operations of possible combatants. Thus he naturally awaits the issue of the estimates of foreign Powers before completing the preparation of his financial and shipbuilding proposals for next year.

In the meantime it is agreeable to record simultaneously the satisfactory completion of the searching trials of the first of our ships fitted with the 13.5-in. gun, the prospective launch within the next three months of four of our new battleships, the issue of orders to Portsmouth and Devonport Dockyards each to prepare for the building of a battleship, and the sending of invitations to private firms to tender for the building of two battleships included in the current year's programme. In addition to these four battleships, closely resembling the four ships of the King George V. class, soon to be launched, there will be a fifth armoured ship. This will be a cruiser of the Lion type, and will also be built by contract. This vessel will complete a cruiser fleet unit of four such ships of 28 knots speed, with practically the fighting power of battleships. The differences in the new battleships, as compared with the King George V. class, are unimportant, although it is probable that an advance will be made in connection with the torpedo-repelling guns. There will be a slight increase in displacement to over 24,000 tons, and the horse-power will be increased to 29,000 shaft horse-power, in order that the same speed of 21 knots may be easily realised. More it might not be patriotic to divulge at the present moment, and we depart from this part of the subject with the remark that the Admiralty obviously intend to place the orders for the three contract armoured ships, and for the machinery for the two ships to be built in the dockyards, before the end of the year, since the tenders for the battleship work are to be at the Admiralty by the 31st of the present month.

The King George V. is to be launched on Monday from the Portsmouth Dockyard, the Centurion from the Devonport Dockyard a month later, and in December the Scotts' Shipbuilding and Engineering Company will launch the Ajax, and Messrs. Cammell Laird and Co. the Audacious. All four ships are in a satisfactorily advanced stage, so that, notwithstanding the labour troubles, they are likely to be completed in two years from the date of laying the keel; but it is probable that they will not be ready for commission before the beginning of 1913. These ships are a development of the Orion class. It seems almost inevitable that the demands of the strategist and tactician should, in the case of each successive ship, involve increased displacement. Thus the original Dreadnought was 490 ft. long, the St. Vincent was 500 ft., the Neptune 510 ft., and the Orion 545 ft., while the King George V. is 555 ft. in length. The increase in tonnage is from 16,350 to 22,680 tons in the case of the Orion, and just over 23,000 tons in the case of the King George V. A still more important increase, however, has been made in the beam, the 82 ft. of the Dreadnought being increased to 89 ft. in the case of the King George V., which is 6 in. more than in the Orion. This has been done to minimise the draught, notwithstanding the greater displacement consequent upon the fitting of larger guns, and thus the advance in draught has only been 6 in., the King George V. having a mean load draught of 27 ft. 6 in. The ships have therefore very fine ends, the block co-efficient being less than 0.6. So far as form is concerned, the result has been an increase of propulsive efficiency, because the earlier Dreadnoughts required from 1.27 to 1.3 horse-power per ton of displacement to attain 21 knots, whereas the provision made in the later ships is for about 1.17. The speed trials of the Orion are therefore of interest, and it must at once be said that the results got were most satisfactory.

The machinery, as in all of the later battleships, is of the Parsons type, and the constructors were the Wallsend Slipway and Engineering Company. The two low-pressure turbines are in one centre engine-room, and the low-pressure astern turbines are incorporated in the same casing as the ahead turbines. Each wing-shaft has a separate high-pressure ahead and astern turbine, the ahead turbines being arranged with cruising blading, to be cut out when the vessel is running at high speed; a by-pass valve is fitted for this purpose. The boilers are of the Babcock and Wilcox type, fitted to burn coal and oil, and, as in the usual Admiralty practice, quite 2 sq. ft. of heating surface is allowed for each horse-power to be developed, the ratio of heating to grate surface being about 35 to 1. The condensers are of Weir's "Uniflux" type, with Weir's dual-type pumps. On the trials, which were attended by Mr. Andrew Laing, the managing director of the contracting company, and by Engineer-Captain Onyon, on behalf of the Engineer-in-Chief, the results were in excess of those anticipated in the designs. Trials were run at progressive speeds, in order to determine the radius of action at given speeds. The principal trial was that of 30 hours' duration at two-thirds power (18,500). On this trial the mean revolutions of the turbines were 298, and the horse-power developed 18,960, the fuel consumption being 1.8 lb. per shaft horse-power per hour. During this trial six runs were made over the measured distance at Polperro, when the speed was found to be 19.5 knots with the engines developing 18,900 shaft horse-power. On the eight hours' full-power trial the mean revolutions were 346, and the shaft horse-power 27,600, the four runs giving a mean speed of 21.02 knots, with the engines developing 27,400 shaft horse-power. At full power the fuel consumption was equal to 1.62 lb. of coal per shaft horse-power per hour. On a subsequent trial, with the engines more fully opened up, 29,700 shaft horse-power was maintained. It will thus be seen that the 21 knots anticipated in the design were realised, and that, in emergency, even a greater speed can be got out of the machinery.

The new battleships, like the Orion, will be fitted with ten 13.5-in. guns, a weapon which has proved most satisfactory from every point of view. In designing the gun the main idea was not so much to increase the ballistics as to gain a higher bursting charge, because it was realised that, with moderate velocity, which tends to prolong the life of the gun, sufficient penetration was possible at long ranges, while the increased calibre ensured greater destruction as soon as the shot penetrated the armour. The trials of the 13.5-in. gun on the proving-ground fully realised the aim of the Admiralty in this respect, and the interesting point about the gun performance of the Orion had reference to the efficiency of the mountings and to the structural strength of the ship. The mountings are of the Vickers hydraulic type for loading at any angle of elevation, as well as at any arc of training. Many improvements have been introduced in the details of the mechanism and in the material used, in order to minimise the area required within the barbette and the weight. The gun-mountings stood the severe test imposed on them during the trials on the Orion with complete efficiency, both guns in several of the barbettes being fired simultaneously with repeated rounds. Good results, too, were got in respect of rapidity of fire, although no effort was made to test the guns in this regard; this will be undertaken during battle practice, when the Orion goes into commission. All of the ten guns were fired on a broadside simultaneously, and with full charge. Here again the result was wholly satisfactory, no damage of any consequence whatever resulting from the terrific stress set up by the volley; only some of the internal fittings broke loose from their fastenings, a condition which may arise even with the discharge of one gun. This is not the first occasion of such volley-firing on trial, as has been stated in some of the daily papers, nor was there any doubt as to the constructional strength of the ship to withstand the stress. It may be remembered that we illustrated in our issue of January 21, 1910, the Brazilian battleship Minas Geraes, built by Sir W. G. Armstrong, Whitworth, and Co., Limited, firing ten 12-in. 50-calibre guns simultaneously, and, later, the sister-ship São Paulo, built by Messrs. Vickers, Limited, fired ten 12-in. 50-calibre and eleven 4.7-in. guns simultaneously, as recorded in our issue of June 3, 1910.

The King George V. and the new ships will have practically the same arrangement of guns as the Orion, four being grouped forward and four aft, while amidships are two guns in a barbette on the centre line between the after funnel and the engine casing and after bridge. Thus, four guns may fire ahead and four astern, while all ten can be fired on either broadside. The disposition of the quick-firing guns for repelling torpedo attack, however, has been considerably improved. These are located within 4-in. armour casemates on the upper deck and on the superstructure adjacent to the bridge. Forward there are six guns on each broadside, and aft two on each broadside.

As regards the main armour of the ship, which appears from a view of the ship on the slip to extend for quite 60 per cent. of the length, there are two strakes, one under and one above the water-line, of 12 in. thickness, one above this of 9 in., and one extending to the upper deck of 8-in. thickness. Forward and abaft this the armour is continued for nearly the whole length of the ship, but is of reduced thickness, varying from 6 in. downwards. In addition there are two protective decks, the lower being of 2 in. thickness. It will thus be recognised that the increased power of attack has not involved any forfeiture in effectiveness of protection.

Another interesting feature of the King George V. is that the officers' quarters are placed in the stern of the ship. In the Dreadnought the practice was introduced of arranging the officers forward, adjacent to the bridge, in order that they might be close to their work. This proved quite feasible with the former arrangement of guns, but when it was found desirable to have all the barbettes in the centre line, and consequently to concentrate the uptakes from the boiler, difficulties arose in providing satisfactory quarters for the admiral and for the officers. Moreover, it was felt that the crew, when located in the stern, were placed too far away from their work. In the case of cruisers, again, the difficulty was increased owing to the extremely fine "entry" limiting the width available for quarters, and thus some of the rooms were placed right up in the bow, involving excessive discomfort when the vessel was driving through heavy seas. In the case of the King George V. the old practice has been reverted to of placing the admiral's rooms, the cabins for the officers, and the ward-room in the after part of the ship. The

admiral's stern walk has been replaced, so that the King George V. aft differs materially in appearance from her predecessors; but in one respect we may be sure that she will be like them, and that is in the general efficiency of the design of ship and machinery as evolved by Sir Philip Watts and Sir Henry Oram respectively.

THE LIGHTING EFFICIENCY OF METAL-FILAMENT ELECTRIC LAMPS.

By A. W. E. Harris, B.Sc., Assoc. M. Inst. C.E.

Owing to a lack of sufficient data relating to the variation in illuminating effect produced by the different forms of shades used with incandescent electric lamps, and further to obtain some definite figures as to the relative costs of using metallic and carbon-filament lamps, the authorities concerned with the management of a large building, comprising offices, reading-rooms, &c., instituted the tests which we detail below.

The lighting of the building was originally effected entirely by carbon-filament lamps, about 320 being used; of these, some sixty or seventy were of 25 candle-power, and the remainder of 16 candle-power. The lighting consumption amounted to rather over 20,000 units per annum at a cost of approximately 300*l*. On instituting the experiments with metal-filament lamps, the Osram type was selected as being most suitable, and the substitution of these in place of the carbon lamps has proceeded tentatively up to the present. There are now about fifty of these lamps in circuit, replacing some eighty of the carbon type, but it has not been thought advisable to substitute many more, since the saving in current resulting from the employment of a 25-candle-power metal lamp—the lowest candle-power obtainable for 200 volts—in place of a 16-candle-power carbon lamp, does not appear to warrant the greater capital cost involved. Many of the lamps are only in use some 200 hours during the year; others burn much longer.

Whilst the light produced by an electric incandescent lamp in the horizontal plane is generally known, or can be readily ascertained, the actual illumination, expressed in candle-feet, given at various angles, is not so universally known, especially when combined with a globe or shade. Tests were therefore made to determine the illumination given at "table height" with a lamp at a distance of 7 ft. from the floor, under the following conditions:—Two sets of tests were carried out with both kinds of lamp, one set having a white ceiling, 2 ft. above the centre of the lamp, and the other with a black ceiling. In each case a series of three curves was obtained; the first corresponding to the unshaded lamp and the other two respectively to the lamp combined with a shade and with a globe.

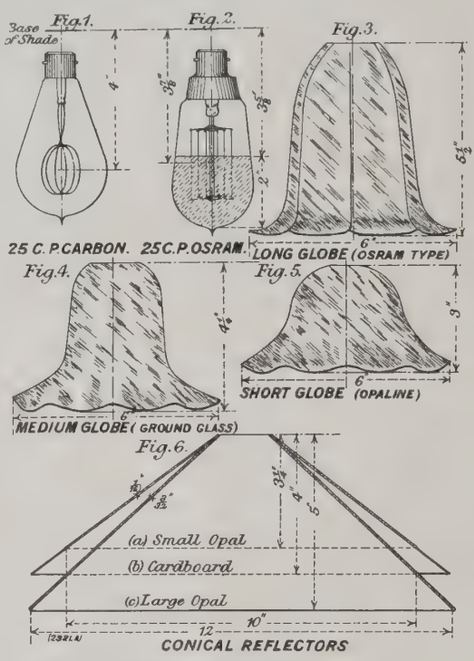
When the new metal-filament lamps came into use it was recognised that electric lighting would be rendered still more brilliant, the intrinsic brilliancy of the metal filament being nearly three times that of the carbon. In May, 1908, during the discussion of a paper* on the use of metallic lamps, Dr. Louis Bell stated that in America they were seldom used unless in such a position as to be well out of the field of vision, or else with the bulb half-frosted and provided with a diffusing shade coming down nearly to the tip. He further stated that the effect of the unshaded filament on the eye-sight was "terrific," and that the new illuminant must be treated thus cautiously, or one's eye-sight would suffer.

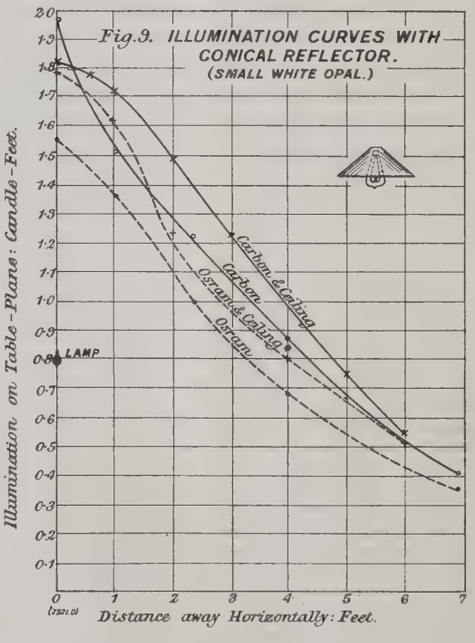
These views being considered reasonable, it was decided to make comparison between a clear globe carbon lamp (Fig. 1) and a semi-obscured metallic lamp (Fig. 2). Tests have shown that totally obscuring the lamp considerably shortens its life, but that partial frosting has not this effect. Partial frosting, however, reduces the candle-power about 2½ per cent., and a form of reflector is necessary above the lamp, to prevent loss of light upwards due to the reflecting agency of the frosted bowl of the lamp.

The globes and shades used in the building are shown in Figs. 3 to 6, those in most general use being Figs. 4 globe and 6*a* shade. These might be used in accordance with Dr. Bell's suggestion, the former for lamps placed fairly low, and the latter for those well up out of the line of sight.

The experiments with a blackened ceiling were taken on a "grease spot" photometer with an arrangement for revolving the lamp and shade, and those with a white ceiling in an ordinary room by means of a portable photometer, the "ceiling" being of closely-woven white canvas. The lamps were hung vertically, cap upwards, 2 ft. from the ceiling, and the illumination was taken on or calculated for a table-plane 4 ft. below the lamp—*i.e.*, 3 ft. from the floor, this corresponding with a room 9 ft. high.

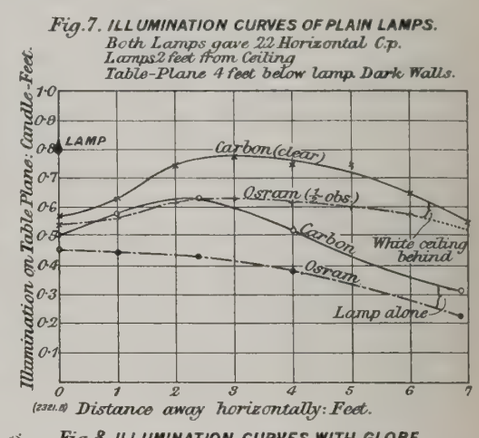
The 25-candle-power metal-filament lamp was new, and gave 22 candle-power horizontally on test. The carbon lamp, originally of about 25 candle-power, was therefore run until its light was reduced to a similar figure.

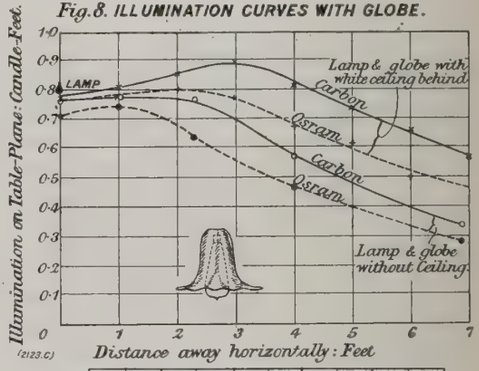




The curves given in Figs. 7, 8, and 9 show the illumination in candle-feet produced by the various combinations of ceiling and globe or shade, as indicated, the illumination being measured on a plane at right angles to the light rays at each point, or reduced to the corresponding value. It will be seen from these curves that at angles below the horizontal the metal lamp consistently gave less light than the carbon lamp, partly due to the effect of frosting, already mentioned, and partly owing to its lower ratio of mean spherical to mean horizontal candle-power, which, as may be calculated from the polar diagram in Fig. 11, is about 6 per cent. less than for the carbon lamp. The lower illuminating effect below the metal lamp is also to be seen from the curves in Figs. 7, 8, and 9; and taking an average value, omitting only the figures relating to the lamp with a black ceiling behind it, it was found that the metal lamp was 14 per cent. less efficient than the carbon lamp:—

	Less Illumination. Per cent.
Vertically under the lamp ...	9.5
1 ft. away horizontally	7.2
2 ft. away horizontally	14.5
3 ft. away horizontally	18.8
4 ft. away horizontally	18.4
5 ft. away horizontally	16.7
6 ft. away horizontally	15.2
Average	14.3





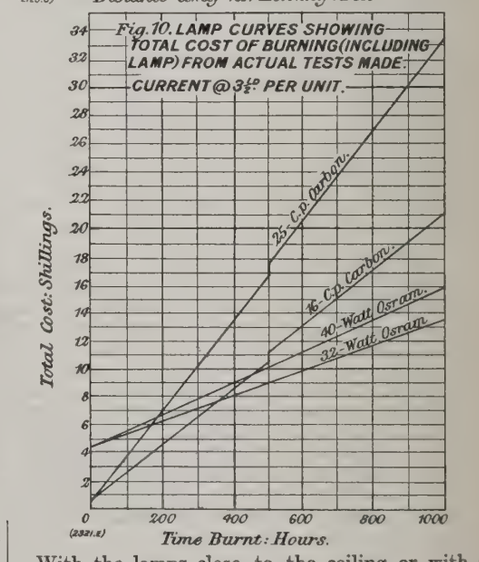


Fig.10. LAMP CURVES SHOWING TOTAL COST OF BURNING (INCLUDING LAMP) FROM ACTUAL TESTS MADE: CURRENT @ 3½d. PER UNIT.
Total Cost: Shillings.
25 C.P. Carbon.
16 C.P. Carbon.
40-Watt Osram.
32-Watt Osram.
(2321.E)
Time Burnt: Hours.

With the lamps close to the ceiling or with a more perfect reflector, the two illuminations would not differ by much more than the 6 per cent. previously mentioned; but such conditions being seldom realised, the figure of 14 per cent. may be taken in order to give a fairly accurate comparison as follows:—

	Carbon Lamp.		Osram Lamp.	
	25-Candle-Power.	16-Candle-Power.	32-Candle-Power.	25-Candle-Power.
Actual British candle-power	23.5	16.1	28.5	22.5
Equivalent illuminating power below the lamp, deducting 14 per cent. for metal lamps ...	23.5	16.1	24.0	19.3
Consumption watts	110	68	40	32

* Journal of the Institution of Electrical Engineers, vol. xli., page 665.

These figures are the average results of a number of tests on lamps, so that, in making a substitution, it would appear that a 32-candle-power metal lamp should be used in place of a 25-candle-power carbon lamp to produce the same illuminating effect ; and a 25-candle-power metal in place of a 16-candle-power carbon, giving about 20 per cent. more light. The economy effected on this basis will be seen from the curves in Fig. 10, the total costs for current and lamps for 1000 hours being :—

	s.	d.
25-candle-power carbon	33	4
2 ,, Osram	16	0
Difference ...	17	4
16-candle-power carbon	21	0
25 ,, Osram	13	6
Difference ...	7	6

Thus it will be seen that, on the basis of 7½d. for carbon, and 4s. 3d. for Osram lamps, the difference of cost of the lamps is balanced by the saving in current (at 3½d. per unit) after a run of about 180 hours for the 32-candle-power lamp, and of 350 hours in the case of the 25-candle-power lamp. After 1000 hours the proportionate saving

Fig. 11. POLAR LIGHT CURVES OF PLAIN LAMPS.

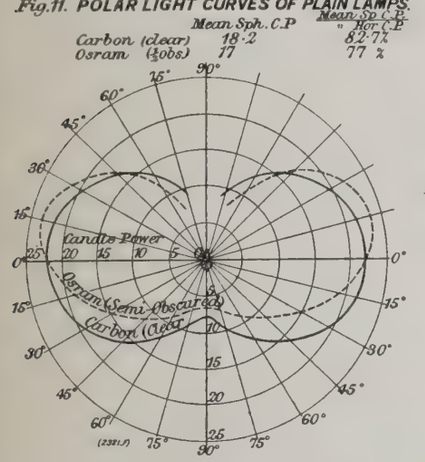


Fig. 12. ILLUMINATION CURVES WITH VARIOUS GLOBES.

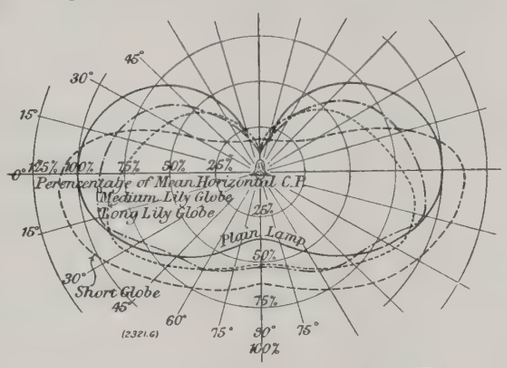
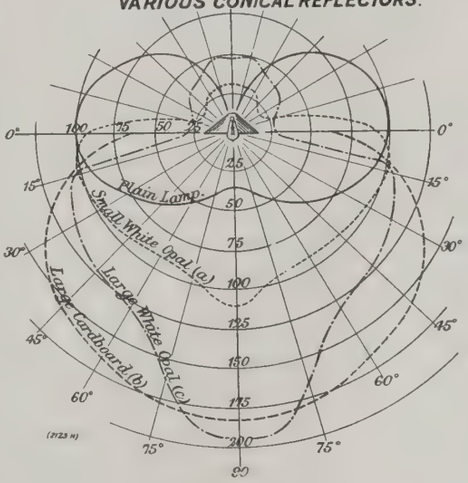


Fig. 13. ILLUMINATION CURVES WITH VARIOUS CONICAL REFLECTORS.



would be rather greater, as the life of the Osram lamps has been found to average about 2000 hours, as against 500 hours for the carbon lamp.

For ordinary reading and writing work it has been found that an illumination of rather over one candle-foot is required, and that for long continued work this figure should be increased to 1.5 candle-feet. A 25-candle-power metal lamp, therefore, giving 22 candle-power, though sufficient for a small room, would give scarcely enough light for working by when combined with a globe, whilst in the offices a 16-candle-power carbon lamp is commonly used, combined with a conical reflector. Taking the average of the two curves for the 22-candle-power carbon lamp in Fig. 9, with and without a ceiling for the lamp 4 ft. above vertically and 1 ft. away horizontally—*i.e.*, 1.62—we should obtain an illumination of 1.18 candle-feet for the 16-candle-power lamp. A better light for working by could be obtained by hanging the lamp lower, since the illumination varies as the square of the distance.

Whilst the globe produces even a better general distribution than the unscreened lamp, the conical shade gives a very uneven distribution, and the effect of one-half of the paper or book being more brilliantly lit than the other is apt to be very tiring. It was realised that shades, either larger or of different material and form, might produce better effects, and to obtain information on this point a further series of tests was carried out. For these tests a semi-obscured metal lamp of rather larger size and greater candle-power was used throughout, and the actual curves obtained are given in Figs. 12 and 13. These curves show the actual candle-power given out in any direction expressed as a percentage of the mean horizontal candle-power, the directions being indicated by the angle made with the horizontal, and being in the form of polar diagrams, indicate graphically the effects produced by the various shades and globes. The actual illumination in candle-feet at any point can be calculated from these curves, but the effect of ceilings and walls is, of course, neglected ; still, in a high room this effect is usually very small.

Similar curves for the plain 16-candle-power carbon and 25-candle-power Osram lamps, without shades, have been given in Fig. 11, and the extent to which the light is thrown upwards by the frosted bowl of the metal lamp is plainly indicated. In Fig. 12 the light distribution from the plain lamp is compared with that obtained when combined with the three types of globe illustrated in Figs. 3 to 5. The general illuminating effect produced by a long lily-shaped globe, Fig. 3, was not quite so good as that of the medium (standard) globe, Fig. 4, except for angles up to 30 deg. from the vertical ; this result might have been expected, as in producing diffusion some light is bound to be lost.

The best distribution for general lighting was obtained with the short saucer-shaped globe, Fig. 5, of white opaline (the former globes being of fine ground-glass). At all angles below the horizontal, it will be seen from Fig. 12 a better illumination is produced—at 45 deg. some 15 per cent. better than the standard globe ; but, of course, the screening effect is not so good. In large open spaces, where a good general illumination is required, this type of globe seems to possess advantages, as it gives a large amount of light at angles near the horizontal.

Where general illumination is not required, and the light is only wanted at angles between the vertical and 45 deg., there is nothing to equal the conical reflector, which will increase the light in these directions as much as two or three times, as shown by the curve in Fig. 13. A larger and deeper shade (Fig. 6c) gave even better light immediately beneath, though the distribution was not good. The bad effect seems to be due to the glazed nature of the reflecting surface, for on trying a shade of white drawing-paper a much more even curve was obtained, although the shade was of the same size and about the same degree of opacity. This led to one of the makes of green cardboard shades, which are white inside, being tried (Fig. 6*b*), and it was found to give a very similar distribution to that of the drawing-paper. Its superiority to the glazed surface opaline shade is apparent from Fig. 13, and, in fact, it gave the best result in these experiments. There are now on the market opaline shades with a roughened interior, which, as these experiments indicate, should give a much better light distribution than those having a bright surface, and should also do away with the glitter that these produce.

As shown by the earlier experiments quoted, the illumination may be considerably improved by "ceiling effect," especially at angles just below the horizontal (30 deg. and 45 deg.). In the case of shades, however, less light being allowed to pass upwards, the ceiling effect is not so apparent, but with globes it is necessary sometimes to make an allowance, as also for the effect of light-coloured walls.

As an example of the improvement that may be effected by an alteration of the shades, an actual case may be quoted. In one of the offices complaint was made that the light was not good enough for continuous work. The lamp in this case was of 22 candle-power, and was fitted with a 10-in. conical shade (similar to Fig. 6*a*), and gave an illumination as tested on the desk of slightly under 1 candle-foot. A deeper 12-in. conical shade was fitted, and by this means the light was increased to 1.75 candle-feet at the desk, as measured by the portable photometer. This result coincides with the figure obtained from the curves in Fig. 13.

Referring to the curve relating to the 12-in. opal shade it will be seen that an increase of 80 per cent. over the horizontal candle-power occurs at an angle of 80 deg., corresponding with the position of the desk in the above example. The distance of the lamp from the desk was 4.75 ft., and the metal lamp was of 22 candle-power. Thus the illumination at the desk would be $22 \times 1.8 \div (4.75)^2 = 1.75$ candle-feet.

The general method of determining the number of lamps for incandescent lighting has apparently been to allow so much illumination (expressed as horizontal candle-power) per square foot of room, but this method, though useful for obtaining a given general illumination, does not enable a specified illumination to be arranged for a given portion of the room. With data obtained from these tests, however, a predetermined degree of lighting can readily be arranged with the forms of shades, &c., employed in the experiments.

It will be realised that these experiments are to a certain extent limited, and no tests have been carried out with the various types of prismatic globes now made. They will serve to indicate, however, the lines on which improvement should proceed, and the principles which should generally be borne in mind when designing a lighting scheme.

NOTES.

The Census of Production Act, 1906, and the Building Trades.

The ninth of a series of tables summarising the returns received under the Census of Production Act, 1906, relating mainly to the building and contracting trades, quarries, and works of public utility, has been issued. The publication summarises the preliminary results obtained from the information received under the Act, and concludes the series of preliminary tables and reports. It is prefaced by a short report to the Secretary of the Board of Trade over the signature of Sir G. R. Askwith, K.C., and includes a report by the Director of the Census, followed by a large number of tables showing the value of work turned out in the various departments of industry considered, cost of materials, wages, &c. The report deals with the year 1907. The average number of persons employed in 1907 in work covered by the tables was about a million, and the total output for the year represented an increase of about 101¼ million pounds over the value of the materials purchased. The average number employed on work covered by the census was about 7 millions, and the total output resulted in an increase of about 712 million pounds over the value of materials purchased. It is pointed out that the totals are subject to revision, but that the alterations will be of comparatively minor importance. The census was taken under the Act of 1906, and shows the relative and absolute magnitude of all industries within its scope. The results of subsequent censuses will afford the means of gauging the development of manufacturing and extractive industries of the United Kingdom. The Act required information to be obtained as to the output, cost of materials used, amount paid to other firms for work given out to them, and the number of persons employed. For the purposes of the Act "the exercise and performance of a local or other public authority of the powers and duties of that authority shall be treated as the trade or business of that authority." Manufacturers can only be required under the Act to state the quan-

tities of goods made by them in the case of commodities entered by quantity in the official export and import lists. In those trades where the manufactures cannot be classified in the manner adopted in the lists, or where the work does not consist in the production of goods for sale, the output was required to be stated in value only. By deducting the cost of materials from the value of the gross output for any one industry or group of factories the "net output" of the industry or group is obtained. This gives the value added to the raw materials in the course of industrial processes. Out of this resulting figure for any industry the charges for wages, salaries, rents, rates and taxes, advertisement, depreciation, &c., are met. It will be remembered that the year 1907 fell between two years of falling wages. The tables require close study; but if this be given, they afford a fund of information to those interested in commercial and trade statistics.

The Admiralty Library.

The principles of naval strategy are unalterable, and, although improvements in the munitions of war, due to scientific developments, involve certain changes in tactics, the lessons of the past must have great influence on all sea operations. The Admiralty have therefore done well to reorganise the wealth of naval literature possessed by the department, and to render it more available for the student of strategy and tactics and of naval history generally. Indeed, it is surprising that no attempt was made to classify and catalogue the works possessed by the Admiralty until about fifty years ago, and still more remarkable that it is only now that many works have been rescued from the attics and store-rooms. All are housed in rooms where naval officers and lay students will be welcomed and encouraged in the pursuit of knowledge of our sea story. The explanation was hinted at in the speech of the First Lord of the Admiralty in opening the new library. "For many years," he said, "there was a certain jealousy in the mind of a sailor of everything pertaining to book-learning; the simple sailor was supposed to be content with his experience at sea." As in all professions, the study of science is considered an essential concomitant of practical experience, so in the Royal and merchant navies acquaintance with theory, as well as practice, is indispensable, and in the discriminate blending of these depends in great measure the efficiency of the application of knowledge. Unfortunately, as we have had occasion to point out, there is difficulty in ensuring the correct proportion of time devoted to books and to bridge or engine platform; the swing of the pendulum, operated by the mainspring of fashion, tends to excesses, and we note with satisfaction Mr. McKenna's pronouncement that "experience gained at sea is overwhelmingly of the first importance." Correspondingly accurate is his view that "the individual who has acquired it (sea experience) should also study." This has been the burden of our argument for years in connection with the training of the naval engineer; but for the present we content ourselves with this passing reference to a special significance of the First Lord's view, and pass to the general application of his words. The naval officer in command of strategical or tactical operations will succeed in direct proportion to his knowledge of the lessons of the past, their significance, and their relation to the altered conditions consequent on changes in *matériel*, as much as to his courage, and the efficiency of his staff, his men, and the munitions at his command. The extension of the Admiralty buildings, the solicitation of the secretary, Sir Inigo Thomas, G.C.B., and the energy and enthusiasm of Mr. W. G. Perrin, recently appointed librarian, and of Mr. J. F. Phillips, the deputy librarian, have combined to form an important addition to the organisation of the department which will be most conducive to the efficiency of the Service. Mr. Perrin has shown great skill and judgment in the classification of the books on biography, gunnery, history, machinery, strategy, tactics, and other subjects—many of the books and MS. having been recovered by him from bundles which have laid unopened for years. These works are accommodated in rooms about 100 ft. in length on two floors above the arch from Trafalgar Square into the Mall, and there the naval officer, on presentation of his card, or any member of the general public on written application, will be able to consult any of the works. Sir Inigo Thomas, in his speech at the opening, gave us hope that the advantages of the library will be fully utilised; he said that the marked increase in the number of inquiries on naval historical matters received from officers afloat and ashore, indicated the need for some centre of information. Mr. Perrin's obliging disposition will assist greatly towards the fulfilment of this need.

The "Paragon" Electric Steel Furnace.

The new electric steel furnace of the Gröndal-Kjellin Company, which Mr. J. Härdén described in the Faraday Society on Tuesday last, is fitted with the auxiliary electrodes of the second class, which Röchling and Rodenhauser introduced some years ago, but is not in other respects of the Röchling-Rodenhauser or Kjellin induction type. The new furnace combines arc heating with resistance heating, and the furnace may be thus likened to an open-hearth furnace, which is also heated from below and from the sides. The arcs heat, in the first instance, the slags on the top of the metal and the surface of the bath; the current entering the special electrodes at the sides and in the bottom heat the metal directly as a resistance. The electrodes are of the so-called second class; that is to say, they consist, like the Nernst glowers, of materials which are at ordinary temperature insulators, and become conductors only when they are hot. These electrodes consist of iron cooled at the back, and covered in front with mixtures which will conduct, when hot, without being corroded by the molten iron; various compounds have been proposed by the Gröndal-Kjellin Company; for instance, a mixture of dolomite or magnesia and tar, and they will at any rate resist for a reasonable time. When Kjellin first constructed his induction furnace, Mr. Härdén pointed out, he merely aimed at melting high-class crucible steel which did not require any further purification. For removing sulphur and phosphorus a large slag surface was required, and the hotter this surface became the better. For this purpose arcs were useful; at the same time, however, the roof of the furnace suffered from the intense radiated heat of the arc. For other purposes, moreover, a direct heating of the metal from below was desirable—namely, for expelling the gases and for uniformly heating the metal all through its mass. This could be secured with the aid of the special electrodes embedded in the walls and bottom of the furnace. If part of the current were sent through these electrodes, the roof was spared to a certain extent. It was, moreover, difficult to obtain carbon electrodes for the powerful electric steel furnaces now in use. This is certainly a serious difficulty in the case of furnaces of the Héroult and similar types. The special electrodes had to be of considerable area so as to introduce currents of large intensity; for 30-ton furnaces Mr. Härdén proposed electrodes of 10 in. square; for 50-ton furnaces, electrodes of 24 in. square. Only half of the total energy would in these furnaces pass through the arc carbons, and in such large furnaces the arc heating could hence be kept to a reasonable limit. The new furnaces could also partly be heated by gas (gas firing replacing the arcs), and partly with the aid of the special electrodes, which would help to expel the gases. The question which will occur to the reader is whether any profitable heating can be secured by means of these electrodes of the second class, since the resistance of the hot iron is not large; we referred to this point in a recent note. Mr. Härdén uses, of course, large surfaces. But the point was not discussed, the discussion on Mr. Härdén's paper and two others read the same evening being adjourned. Trial furnaces of the new type are being constructed at the Röchling-Rodenhauser Works at Völklingen, in Rhenish Prussia.

Condition of the Shipbuilding Trade.

According to Lloyd's returns for the quarter ending September 30 last, there was, exclusive of war vessels, a slight decrease in both the gross number of vessels under construction, as well as in the total tonnage, when compared with the state of trade on June 30, 1911, but there was a considerable increase over the figures given in the returns made in September, 1910. There were under construction in the United Kingdom at the end of September, 1911, as many as 493 merchant vessels, with a gross tonnage of 1,446,317, compared with 368 vessels, of a total tonnage of 1,154,197, at the end of the corresponding quarter last year. Of the 493 vessels now being built, 470 are steamers, 458 of which are of steel, and all represent a tonnage of 1,438,088. There are 23 sailing vessels, of the gross tonnage of 7779, of which 16 are of steel and the remainder are wood and composite. The Glasgow district is responsible for 109 of the vessels now under construction, of a gross tonnage of 352,463, of which 97, with a tonnage of 348,575, are steamers. The Newcastle district comes next, both in point of numbers and in tonnage, with 68 vessels, of a gross tonnage of 255,247, all of which are steamers. Belfast has on hand 24 steamers, with a gross tonnage of 253,808; no sailing ships are being constructed there. In Greenock 52 vessels are being built, of 215,750 tons, 49 of them being steamers, with a tonnage of 214,250. The United Kingdom takes the largest proportion of all the vessels that are on hand—namely, 339, of 1,189,109 tons—while the Colonies will receive 27 vessels, of 53,365 tons. In point of tonnage Norway stands next on the list, though in numbers some other countries are ahead of her. She takes 10 vessels, of a tonnage of 31,113; Holland takes 19,310 tons; Spain, 12,640 tons; Russia, 12,000 tons; Brazil, 11,046 tons; Germany, 10,720 tons; and Sweden, 10,280 tons. With regard to the size of the vessels building, the greatest number come within the 100-ton to 500-ton class, there being in all 127 vessels of this class, 115 of them being steamers and 12 sailing ships. Vessels of between 4000 and 6000 tons come next, these numbering 103, all being steamers; of vessels over 10,000 tons each, there are 19, of which 11 are between 10,000 and 12,000 tons, three between 12,000 and 15,000 tons, three between 15,000 and 20,000 tons, and two over 20,000 tons. There are now 10 warships building at the Royal Dockyards, while at private yards there are 59 on hand. The tonnage of those at the Royal Dockyards is 87,440, and of those in private yards, 331,110. Of those now in hand in private yards, all but six are for the British Government, and include five battleships, four armoured cruisers, seven protected cruisers, twenty-eight torpedo-boats, and nine submarine-boats. Of those building for foreign governments, one is a battleship of 27,000 tons displacement, one is an armoured cruiser, two are scouts, and two are torpedo-boat destroyers. The total of all the war vessels building in Government and private yards is 69, with a total displacement of 418,550 tons. According to the returns, the total number of vessels now being constructed abroad, exclusive of warships, is 344, of 713,774 tons. Of these, 307 are steamers and 37 sailing vessels. As many as 88 of these vessels, with a tonnage of 273,185, are being built in Germany, and 54, with a gross tonnage of 88,549, are on hand in the United States. Norway is building 37 vessels, with a gross tonnage of 18,145; Japan, 35 vessels, with a tonnage of 22,038; Holland, 32, with a tonnage of 74,256; and France, 29, with a tonnage of 125,160.

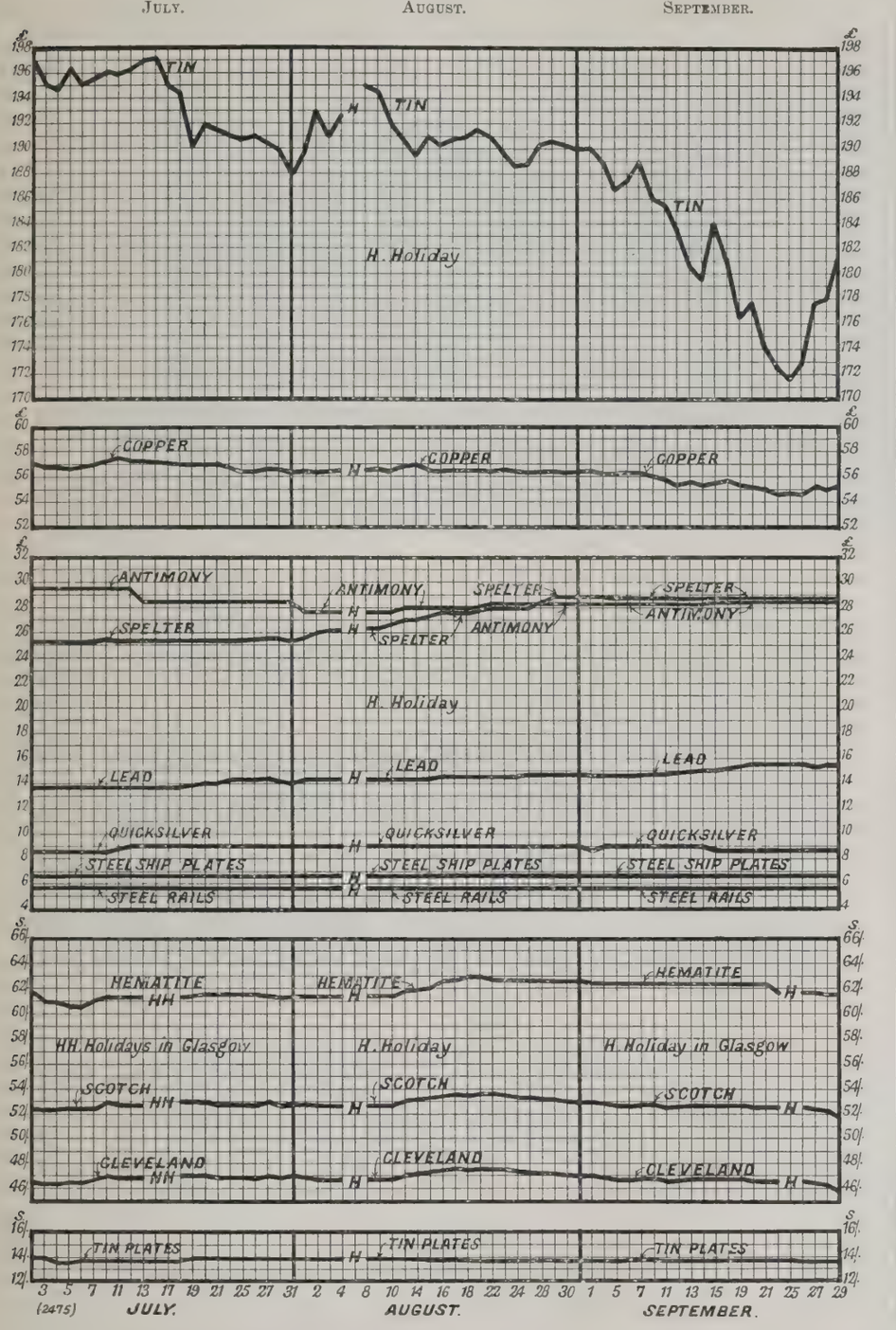
THE TRADE OF JAPAN.

The report on the trade of Japan for the year 1910 by the Acting Commercial Attaché to His Majesty's Embassy, Tokio, contains a great deal of information which will be useful to those who are engaged in commercial transactions with Japan, as well as to those who study the course of the industrial evolution which is going on in the Far East, and which is certain to have very important results on the economic conditions of this and other countries in the West. A few of the more important points may therefore be noted.

The total volume of trade for the year was of the value of 94,188,494*l.*, of which 47,390,534*l.* was imports, and 46,797,960*l.* was exports, being within a small amount of the total in 1907, which was a record one in the commerce of Japan. The boom of that year was followed by two years of depression, but last year was one of recovery from the reaction which was the direct result of the unfortunate period of over-trading witnessed in 1907. Viewed from this standpoint, the recovery made in 1910 must be considered satisfactory, as it shows evidence of a healthier tone and promise of continued expansion, provided the natural laws of supply and demand are respected. No doubt, the alteration in the tariff, which came into operation at midnight on July 16, 1911, had considerable influence on the trade of the year, as merchants would stock the goods which they thought would be in demand. It will be interesting to note the effects of the tariff on the operations of the current year. Speaking generally, the new tariff may be described as an attempt to draw up a schedule which shall be sufficiently high to exclude those imported goods which compete with domestic manufactures, while at the same time imposing heavy duties on many commodities which cannot

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



In the accompanying diagrams each vertical line represents a market day, and each horizontal line represents 1s. in the case of tin-plates, hematite, Scotch and Cleveland iron, and 1*l.* in all other cases. The price of quicksilver is per bottle, the contents of which vary in weight from 70 lb. to 80 lb. The metal prices are per ton. Heavy steel rails are to Middlesbrough quotations. Tin-plates are per box of I.C. cokes.

be produced in Japan, especially those which may be regarded as luxuries. The writer of the report says that it is unfortunate that when trade was beginning to revive from the depression of 1908-9 such a disturbing event as an alteration of the import duties should occur to unsettle commercial conditions, but that is a matter which the Japanese have taken into their own hands, and those in authority evidently believe in what is called a scientific tariff.

The most striking increase in the imports was in the value of raw cotton, which amounted to 16,111,200*l.*, as compared with 10,900,800*l.* the previous year, being an increase of 5,210,400*l.* The development of the cotton industry in Japan has been of a very remarkable nature, and not only are the Japanese producing a large amount of the cotton yarn required in their country, but they also export considerable quantities to China and other countries. In 1910 the value of cotton yarn imported into Japan was only 35,000*l.*—a decrease of 53,000*l.* as compared with the previous year, which seems to show that this part of the trade will soon disappear. The value of cotton tissues imported in 1910 was 1,377,200*l.*, as compared with 1,421,900*l.* for the previous year; but the Japanese are rapidly extending their weaving establishments, and the decrease would have been much greater had it been possible to work the new cotton-printing factory of the Nippon Seifu Company, near Kyoto; but the financial troubles of this company have not yet proved capable of adjustment. The factory is beyond comparison with anything of its kind in Japan. It was designed, erected, and fitted by a first-class firm of British manufacturers of cotton-printing machinery, and finally completed in September, 1909. Its position is an excellent one, combining a plentiful supply of good water with easy communication with both Osaka and Kyoto by rail and water. The annual capacity of this factory is estimated at 1,000,000 pieces of 24 yards each—a figure which should, however, be accepted with considerable reservations. The import of woollen and worsted yarns for weaving increased from 2,970,890*l.* in 1909 to 3,381,700*l.* in 1910, and it ought to be noted that a great part of this trade is in the hands of the Germans and the French, the share of the United Kingdom being only about one-sixth of the whole. Drugs, chemicals, and medicines increased from 1,159,100*l.* in 1909 to 2,249,200*l.* in 1911, showing the development in those industries requiring the use of chemicals. The value of the artificial manures imported was 3,717,900*l.*, being an increase of 119,900*l.* over the previous year. The Japanese are applying all the latest developments of science to agriculture, and while devoting great attention to new industries, they are not overlooking the oldest industry of all. They are also producing a large quantity of fertilisers, the latest returns showing a value of 3,023,400*l.* in one year, as compared with the total import mentioned above. When the value of the other manures used, such as home manufactured vegetable cakes (chiefly rape seed cake), soy refuse, saké lees, rice, bran, hay, &c., is included, the total annual consumption probably amounts to about 17,000,000*l.*, a point which British farmers ought to note.

The value of the machinery imported in 1910 was about 22 per cent. less than that of the preceding year. It amounted to 1,606,700*l.*, which was less than one-half that imported in 1908. The most important items in the list are spinning and weaving machinery, which the Japanese cannot yet make themselves. It includes almost every kind of machine, The shares in this line of business which fell to the principal countries were as follows:—United Kingdom, 954,500*l.*; United States, 370,500*l.*; Germany, 237,800*l.*; France, 9800*l.*; other countries, 34,100*l.* The imports of iron and steel, with the exception of pigs and ingots, show increases as compared with 1909, but the total for the year is still below the totals for 1907-8. It is interesting to note that there was an astonishing increase in the number of motor-cars during the year, and that a large proportion of them are of British make. With a view to encouraging the import of automobiles, those intended for the private use of the importer, and not for sale, are allowed to enter duty-free. The prospects of the motor-car being largely used in Japan are very favourable. There is a large opening for inexpensive cars in, more especially, Tokio, Yokohama, Osaka, Kyoto, and Kobe. So far they have been little used for the transport of goods and public conveyances, but there is a wide scope for their employment in these directions. The two most serious obstacles to the greater use of automobiles are the bad roads and the lack of efficient chauffeurs and mechanicians. An automobile club has been formed in Tokio, and numbers some influential Japanese among its members. This association will probably be able to render considerable assistance in obtaining improved roads and in training mechanicians.

The Japanese are turning their attention to the utilisation of the water-power in their country, and a Government Commission was appointed for the purpose of examining and making a record of the available water-power resources. By this means the Government hope to assist the development of the use of water-power, and at the same time to guard against the granting of water-power concessions to persons seeking to obtain them for speculative purposes. In recent years there has been steady progress in the direction of extending the use of hydro-electric power for lighting and industrial purposes, and, besides the power-stations already erected, a large number are in contemplation or in course of erection.

The extension work on the Japanese Government railways in 1910 does not call for any detailed description, as it was chiefly of the nature of details. Considerable interest was aroused by the announcement of the intention of the Government to bring before the Diet a proposal for the conversion of the main line between Tokio and Shimonoseki to the standard gauge. The cost was estimated at 230,000,000 yen (23,479,000*l.*), which would be spread over a period of thirteen years. The scheme was rejected by the Diet in 1911, but will probably be brought up again in 1912. The chief harbours are being improved and developed so that they may accommodate the largest vessels which come to Japan. The shipping—steam and sailing—entered at Japanese ports in 1910 shows rather a large decrease in numbers, but a slight increase in tonnage. The figures for the last three years are as follow:—

	Vessels.	Tonnage.
1908	13,029	20,215,577
1909	12,330	19,794,451
1910	11,168	20,173,787

A glance at the tables given at the end of the report shows that the Japanese and the German flags have not done so well during the past year. British shipping shows an increase in both vessels and tonnage, while Russian shipping has more than doubled.

ARMOURED MOTOR-LAUNCHES FOR TURKEY.

CONSTRUCTED BY MESSRS. JOHN I. THORNYCROFT AND CO., LIMITED, ENGINEERS, SOUTHAMPTON.

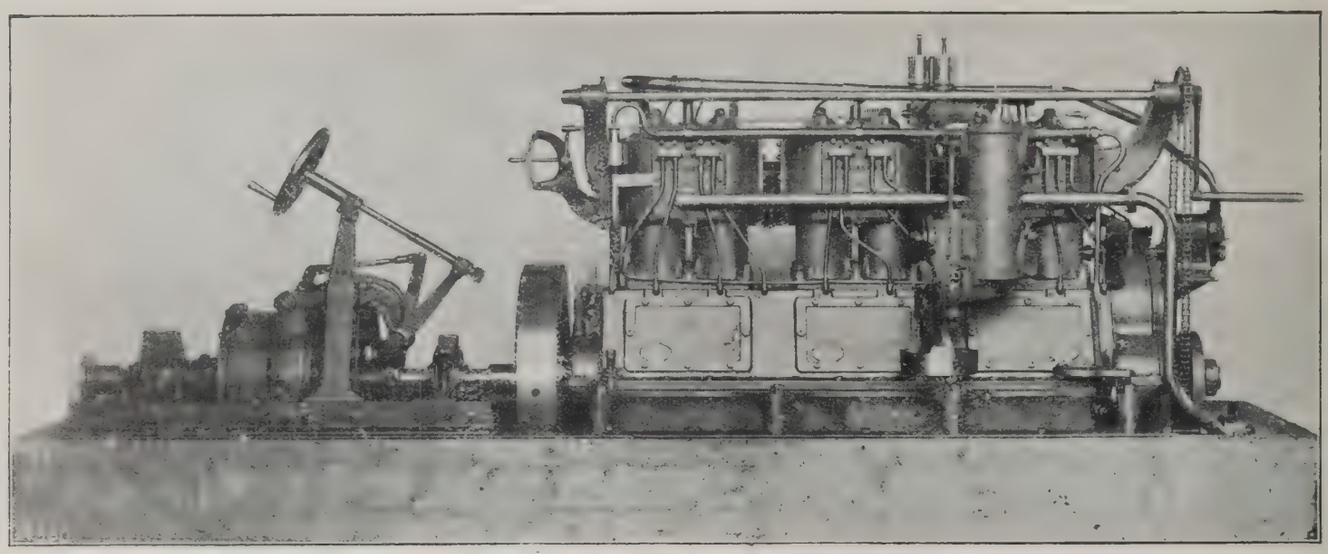


Fig. 10.

Some months ago an order was placed by the Imperial Ottoman Government with Messrs. John I. Thornycroft and Co., Limited, of the Woolston Works, Southampton, for twenty-two armoured motor patrol launches, for the prevention of smuggling and for kindred purposes along the coast of the Red Sea, Persian Gulf, and Mediterranean. Several of these vessels have been delivered and two have been captured on their way out by the Italians, while others are being held up here by the Customs until the conclusion of the present hostilities.

The general arrangement of the boats is clearly shown in our illustrations, Figs. 1 to 9, page 462, and on this page we give an illustration of the engines and of one of the boats at sea.

The principal dimensions of these craft are:—Length, 60 ft.; breadth, 11 ft.; depth, 5 ft. 6 in. The draught of water has been kept down to a minimum, being only 2 ft. 6 in., thus making the launches capable of shallow-river work. The lines of the hull have been designed to secure the best results possible on the shallow draught. The flat stern gives an easy run, and prevents the stern from "pulling down" when the launch is going at full speed. The speed guaranteed as a mean of six runs on a recognised measured mile was 11 knots, and this speed had to be maintained for a further period of two hours. On official trials a speed of over 11.9 knots has been attained with engines not fully extended. In fact, all the boats yet tried have been capable of about a mile over the contract speed. The boats have been proved to be very handy, and can turn a complete circle of about a length and a half in diameter when running at full speed. Steering is effected by means of a hand steering-gear fitted in the wheel-house (see Fig. 2), and connected to the tiller on the rudder head by wire-rope leads. Protection has been afforded to the steersman by constructing the wheel-house of bullet-proof nickel steel. Circular brass-framed lights, having armoured deadlight plugs with sight-holes, are fitted to the wheel-house for light and air. The hulls are protected against rifle bullets by means of nickel-steel bullet-proof plates. These extend from the aft end of the after cabin to the forward end of the motor-room, and from the water-line to the deck. The casing sides also have been protected for the same length up to the height of the motor casing. The top of the motor casing is also covered with bullet-proof nickel steel inclined at 60 deg.

The arrangement of the boats is compact (Fig. 4). The machinery is placed in a separate water-tight compartment amidships, and is separated from the rest of the hull by steel water-tight bulkheads. The main fuel supply is carried at the forward end of the motor space in two circular brass tanks, the upper of which is used as a service tank, and supplies the motors under gravity. There are, in addition, two reserve tanks of brass placed in the stern compartment, and connected to the forward tanks by means of a semi-rotary pump. The total fuel capacity is about 740 gallons of paraffin, which gives a range of over 600 sea-miles at full speed. Abaft the machinery space a cabin for officers has been arranged, with a sofa-seat berth, having cushion backs, on each side of the cabin, and the seat-backs are arranged to hinge up to form top berths. At the fore end of the cabin are located a w.c. and a pantry for

Fig. 11.

officers' use. The underside of the casing top has been lined with Vanesta wood in panels, with air-spaces to keep the cabin cool. Forward of the machinery room a cabin has been provided for the crew, with locker-seats on each side to form lower berths, and folding pipe-berths with canvas bottom above. A small oil cooking-range has been provided and fitted in the crew space, and at the forward end of the crew-space a w.c. is arranged for the use of the crew.

The boats are fitted with double-canvas awnings all fore and aft (see Fig. 11), carried on ridge wires, and supported on wrought-iron stanchions. Two guns have been fitted, one forward and one aft, of the Vickers-Maxim patent 37-mm. quick-firing type, having water-cooled barrels. One thousand rounds of ammunition per boat are carried and stowed in lockers in the crew and officers' spaces. The construction is practically similar to that adopted by the British Admiralty for their 50-ft. and 56-ft. pinnaces. The shell consists of two thicknesses of teak, the inner thickness laid diagonally, and the outer fore and aft. The hull, from the keel to a distance of about 4 in. above the water-line, is covered with 12-oz. copper sheathing. The keel is of oak, with a 1½-in. rubbing strip to take the wear. The boats have been built under the supervision of Lloyd's Surveyors, and are equal to Class A in their Yacht Register for river service. The mild-steel armour has been tested under British Admiralty supervision.

The main engines (Fig. 10, above) consist of two of the Thornycroft C/6 type, having six cylinders, 6 in. bore, with an 8-in. stroke. At 750 revolutions per minute each engine will develop 70 horse-power; but in these boats the speed is limited to 670 revolutions per minute by means of a spring-controlled governor. The fuel used is commercial paraffin, which is vaporised in a Thornycroft vaporiser heated by the exhaust. Starting is effected on paraffin by heating the vaporiser with a blow-lamp, or, if petrol is available, by running on petrol for a few minutes. The ignition is by high-tension magneto. Lubrication is effected by means of the drip method, a pump forcing oil into a pipe over the cylinders, from which it runs through nipples to each main bearing and connecting-rod. The pipe is provided with an overflow into the crank-case. This method of lubrication is at once sure, fool-proof, and extremely economical in practice. Reversing is effected by means of an epicyclic reversing gear. There is also an electric lighting set, consisting of a Thornycroft M I. paraffin-engine, having cylinders 4½ in. by 6 in., connected to a Crompton four-pole direct-current dynamo, giving an output of 60 volts and 41 amperes at 800 revolutions per minute. This dynamo, which can also be driven by a belt off the main engines, is used to light the ship (ten electric lamps being provided), run three electric fans, and work the searchlight. The latter is of the Crompton type, with automatic and hand control, and has a projector 16 in. in diameter.

Four of the boats have been built in steel, and three others of the same power and of similar general arrangement, but of a still shallower draught—viz., 22 in.—are about to be put in hand, also of steel. The hulls are being built complete at Messrs. Thornycroft's Woolston Works, and as they are put in the water receive their motors, which are made at the company's motor works, Basingstoke.

The Institution of Electrical Engineers: Students' Section.—The attention of those members of the Students' Section who desire to read papers is called to the fact that it is necessary that notice of such intention be sent immediately to the hon. sec., Mr. D. Betts, 3, Fordwych-road, London, N.W., in order that the announcement may be embodied in the programme of the session.

International Machinery and Engineering Exhibition, Olympia.—We understand that at the above exhibition, which has been organised by the Machine-Tool and Engineering Association, Limited, and which will be open at Olympia from October 4 to 28, next year, a large amount of space has been applied for, and it is expected that the Hall will be well filled,

CRUDE-OIL MARINE ENGINES.*

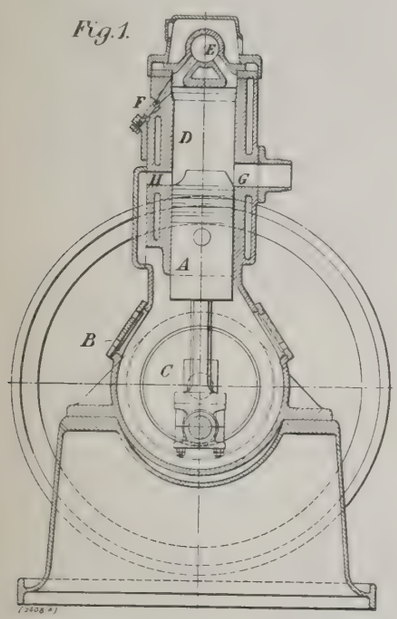
By James H. Rosenthal, M.I.N.A., M.I.M.E., &c.

The problem of converting fuel into power as directly as possible is one with which, for many years, engineers have been occupied. No doubt the achievements in the construction of gas-engines using gas produced from coal or coke, as well as in engines using the light distillates of oil or spirit, by the dissemination of knowledge of essential details connected with their construction, have materially assisted in the development of the crude-oil engine, which is dealt with in this paper, and great credit is due to the designers and constructors of such engines.

Engines using the light distillates of oil or spirit may be properly called "explosion engines," and although these are used for launches and small pleasure craft to an enormous extent, and are now made so simply that they can be worked by persons who are not skilled in mechanics, the nature of the fuel used being of a low flash-point, and necessarily dangerous and high-priced, precludes their use and development for large powers.

The aim which designers of crude-oil marine engines have had before them is to get as near as possible to the simplicity of the ordinary marine engine, and this aim has been achieved to the extent of producing a type of crude-oil marine engine which is reversible, and in which energy is imparted to each stroke of the piston.

How far such engines will displace steam for marine propulsion no one at the present time can foretell, but



the general opinion is to the effect that, whilst their substitution for the reciprocating engine up to what are considered in marine practice moderate sizes may be looked for in the near future, as yet they cannot be looked upon, even assuming the present conditions of the oil supply would admit of it, as a substitute for the steam-turbine for marine propulsion.

The advance so far made with these engines, and the energy with which eminent engineers are pursuing the subject, leads to the expectation that mechanical difficulties will not stand in the way of the aforesaid application.

The advantage of these engines, even for small craft, is in the greater safety of the fuel, as compared with petrol or paraffin, and as compared with steam, in a saving in weight and space, and they admit of a larger radius of action of a vessel, owing to the fact that the same weight of fuel gives more power.

The use of such engines on submarines is already well established in some of the principal navies of the world. For cargo vessels and yachts, and vessels of a commercial type, trials have already been made, and a good many such engines are running and under construction. For naval vessels, such as torpedo craft, designs are under consideration and large engines are being constructed.

The question of the oil supply is a very important factor; whilst a ship can readily carry enough crude oil for three times the distance of travel that it can on the same displacement if coal and steam-boilers are provided, yet difficulties of replenishing the oil supply are bound to cause serious consideration to a shipowner before deciding to equip his vessel with oil-engines. Moreover, the present price of the crude oil being more than double that of Welsh coal, and three times that of other classes of coal, does not admit of much saving in the cost of fuel in running a vessel, but, even under the present conditions, a saving is established in weight and in crew.

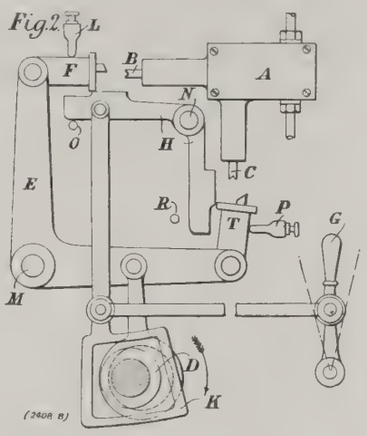
It goes without saying that this relative cost of coal and crude oil does not apply to places in the world which are reasonably close to oil-fields, or in which crude oil is stored in such quantities that the possibility of obtaining it is assured.

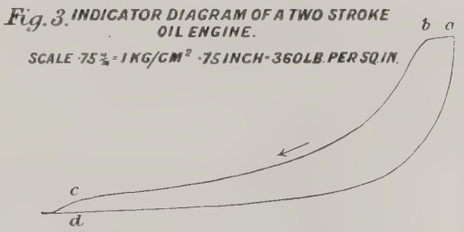
It is not considered necessary in this paper to go into the question of places where crude oil can be obtained, and the price of it in such places, as these are points with which shipowners are well acquainted.

Definite results of the total saving in the working of a ship are not generally available, although within a year or two, undoubtedly, they will be; but Messrs. Swan, Hunter, and Wigham Richardson, the eminent shipbuilders, state, as the result of the working of a ship, the Toiler, of 2700 tons, that the comparison of oil at 45s. per ton and coal at 12s. 6d. per ton resulted in a saving in money of 3*l.* 18s. 8d. per day.

Of the ship Vulcanus, of 1900 tons, which is fitted with Diesel engines of 450 brake horse-power, in service between Rotterdam and Hamburg, the English agents write:—"The average consumption corresponds to 1 ton of fuel oil per 100 knots."

The two types of engines which are particularly dealt with in this paper are the Bolinder engine, as an example of a crude-oil reversible marine engine, which is not on the Diesel principle, but in which the ignition of the fuel takes place in a heated chamber at the top of the cylinder, by some termed a "hot pot," and the Diesel engine proper. The former type is one which is essentially suitable for small craft, and it has been largely fitted on fishing vessels and barges. Considerable numbers of them have been made for sea-work. Messrs. James Pollock, Sons, and Co., the representatives for this engine in England, have fitted them in twenty-four barges and cargo-boats, three fishing-boats, and eight launches; and Messrs. Babcock and Wilcox, Limited, of Sydney, have





a-b Combustion, b-c Expansion, c-d Exhaust and Scavenge d-a Compression.

fitted them likewise in several fishing-boats running in Australian waters. It is found that there is very little difficulty in training one of the crew of a fishing vessel to work the engine. The sizes generally used run from 10 to 30 horse-power, although sizes up to 150 horse-power have been made and are running. A drifter on the East Coast has such an engine of 120 horse-power. The construction is explained by Fig. 1, and the reversing gear by the diagram, Fig. 2, above.

Messrs. Bolinders have sent Captain Neilson's report regarding the barge Travers, belonging to Val de Travers Asphalte Paving Company, running between Havana and the Port of Spain, as follows:—

Trinidad, January 15, 1911.

During the voyage of twenty-three days, and a distance of about 1850 miles, through gales of wind and high seas, the engine has at all times been kept running and at a regular speed, not the same as a steam-engine, running at a gallop when the vessel is pitching, and nearly stopping when the stern gear goes down.

Fig. 1, above, shows this engine, which is of the two-cycle type, compressing its scavenging air in the crank-chamber. When starting the engine to work, a blow-lamp is inserted through the cover of the ignition chamber E. When this ignition chamber is heated to a dull red (which takes about 10 minutes in the smaller sizes), the engine is turned either by hand, in the smaller sizes, or by compressed air in the larger sizes, and a charge of fuel is admitted through the fuel-valve F. It is ignited by contact with the heated chamber E which forms the cylinder head. The air for combustion, which, by the previous uncovering of the passage H, passed from the crank-case into the cylinder, is compressed by the up-stroke of the piston. The port G is the exhaust port; this commences to be uncovered before the air-admission port H, and the gases commence to exhaust as soon as it is uncovered, and their expulsion is completed by air entering through the port H being slightly compressed through previous downward stroke of the piston in the crank-case.

The cylinder is water-cooled, and if sea-water is used, although this gets hot, it is kept in continual circulation through a pump attached to the engine, and, consequently, does not get concentrated enough to deposit salts. After the engine is started, the blow-lamp can be extinguished, as the combustion of the fuel in the cylinder keeps the chamber E at a sufficient heat.

The reversing operation is illustrated by Fig. 2. In the diagram A is the fuel-pump case, and B and C are the fuel-pump plungers. These are operated by a toggle F at one end of a bell-crank E, and by toggle T at the other end, this bell-crank E being operated by an eccentric on the engine crank-shaft. Normally the toggle F is in operation, but when the engine is reversed the reversing lever pulls link K on to the friction disc D, and alters the position of the bell-crank H. This pushes the toggle F out of action, and allows the toggle T to go into action on the fuel-pump C, so that the reversing is effected by temporarily throwing out of action the fuel-pump which, in normal running, injects the fuel at the top of the stroke, and substituting for it another pump, timed so as to inject a charge before the piston reaches the top of the stroke; this checks its up-stroke, and drives it down in the reverse direction. Owing to the previous putting out of action of the fuel-pump, the engine is slowed down, so that the shock of reversing is minimised. When the engine has reversed, the bell-crank E resumes its former position, and fuel is again injected at the top of the stroke for normal running.

As stated, the larger engines are started by compressed air. This is stored in an air-vessel conveniently placed in the engine-room. In the first instance this vessel must be charged from some independent source, such as a hand-pump, but afterwards the engine itself is used for this purpose, in the following manner:—

When the engine is finished with for propelling purposes, the fuel is cut off one cylinder, the other one continuing to drive the engine, the propeller being declutched. The cylinder from which fuel is cut off continues, in other respects, its normal cycle, and as it compresses the air on its up-stroke, this compressed air is passed through a valve into the reservoir. The starting is effected by putting the engine just over the top centre, and opening the air-valve sharply by hand, thereafter the fuel-valve is opened, and the ignition of the fuel takes place in the hot cylinder-head chamber E, as before described.

The type of engine for larger powers is that on the Diesel principle, on what is called the "Diesel cycle of combustion." This cycle of combustion is based upon the fact that when air is compressed to 450 lb. per sq. in. it attains a temperature of about 1000 deg. Fahr., and this ignites the atomised crude oil with which it is brought into contact.

The Maschinenfabrik Augsburg Nürnberg A.-G., Germany; Messrs. Carels Frères, of Ghent; Messrs. Sulzer, of Winterthur; Messrs. Schneider, of Creusot; Messrs. Nederlandsche Fabriek van Werktuigen en Spoorweg Materiel, Amsterdam, and Messrs. Burmeister and Wain, Copenhagen, are the firms principally working at this development at present. Messrs. Schneider work with Messrs. Carels Frères, as do also Messrs. Vickers Sons and Maxim.

The firm, however, which so far has done most work in developing the two-cycle reversible marine crude-oil engine on the Diesel principle is the Maschinenfabrik Augsburg Nürnberg. This firm has an enormous experience in large gas-engines and in building Diesel engines for stationary purposes, and now has several eminent marine engineering firms abroad as licensees, and in Great Britain the licenses are in the hands of:—

Messrs. Harland and Wolff; the Fairfield Shipbuilding and Engineering Company, Limited; Sir W. G. Armstrong, Whitworth, and Co., Limited; Messrs. Cammell Laird and Co., Limited; Messrs. J. S. White and Co., Limited; Messrs. Yarrow and Co., Limited; Messrs. Babcock and Wilcox, Limited, and the extensiveness of this organisation, and the author's connection with it, in addition to the fact that these engines are, up to the present, the most largely adopted, has led to its being put forward as an example of the latest development of the reversible two-cycle crude-oil marine engine. It is constructed single-acting and double-acting.

The crude-oil marine engine on the Diesel cycle of combustion made by the Maschinenfabrik Augsburg Nürnberg, hereinafter referred to briefly as the Nürnberg engine, found its first introduction for propulsion of submarines. The before-mentioned advantage of engines working with crude oil which is difficult to ignite applies most forcibly to such craft, and the advantage of such engines being reversible without requiring clutches or gearing is a recognised one.

Submarines are now coming into use which have in them as much power as two engines of 900 horse-power each, and even larger powers are contemplated, and these reversible engines have been adopted in the German, French, Danish, Dutch, Italian, and American navies.

From the records which have so far reached the author, this engine appears to be the most economical in weight for the power produced. In the type used for submarines the average weight of fairly large sizes is 35 lb. to 37 lb. per effective horse-power.

This engine for use in submarines, pinnaces, and any case where great lightness is required, is run at comparatively high speeds, varying from 550 revolutions per minute for a 200-horse-power engine to 420 for an engine of 900 horse-power. For lightness the framing and bed-plates are made of manganese bronze, and gear-covers, &c., of aluminium

The Nürnberg Works have already made twenty-two or twenty-four of these engines, and have others in hand. Fifteen have been made for submarines. The American licensees, the Holland Submarine Boat Company, have in hand fourteen such engines, and the French licensees

* Paper (slightly abbreviated) read before the British Association at Portsmouth.

four. In this country, Messrs. J. Samuel White and Co. are building two engines of 150 brake horse-power for pinnaces for the Argentine navy, two 150-horse-power engines for a yacht, and one for a pinnace for their own use, and Messrs. Yarrow and Co. are building an engine of 300 brake horse-power. At Nürnberg two such engines of 2400 horse-power each are under construction at the present time.

The same principle of engine has been used, but built with less regard for saving in weight and at less cost per horse-power, for slower running commercial installations. These engines run at speeds of from 360 to 160 revolutions per minute. Of this type the Nürnberg Company have already built sixteen engines for tugs, yachts, cargo, and passenger boats. All the before-mentioned engines are single-acting.

The reversible double-acting two-cycle engine is on the eve of being tried commercially for long distances on a vessel of the Woermann Line, and on a vessel of the Hamburg-Amerika Line, both vessels being built by Messrs. Blohm and Voss. In the case of one vessel there are two engines of 1000 horse-power, and in the other two engines of 1500 horse-power. In all these engines there are only three cylinders. The former engines have gone through shop tests, both in the works of the Nürnberg Company at Nürnberg and in the works of Messrs. Blohm and Voss (one of the engines having been built by each firm), and these shop tests have shown them to run most satisfactorily. The following are the particulars of one of the 1000 horse-power engines :—

Number of cylinders	3
Diameter	18.9 in.
Stroke	25.6 ,,
Revolutions of the engines	125
Diameter of crank-shaft	12 in.
Weight of engine	75 tons

Limits of speed from 40 to 125 revolutions normally.*

The double-acting engine most closely resembles the reciprocating marine steam-engine, everything below the cylinders being practically identical and open for inspection.

Description of Single-Acting Engine.—The single-acting engines are made with from four to eight cylinders, depending upon the power, six cylinders being the most usual arrangement, and ranging from 150 to 900 horse-power; eight cylinders are adopted where the same power is to be obtained as on a six-cylinder, but with a lesser number of revolutions.

For all engines on the Diesel principle, an air-compressor and a means of storing compressed air are essential. The air-compressor may be attached to the main engine, or it may be separate and independently driven.

The single-acting engines are made entirely enclosed. The cylinders are jacketed and cooled with sea or fresh water. The connecting-rods are of the usual gudgeon-pin type used in single-acting engines. The piston is of two diameters, the upper part being the working piston above which the combustion takes place. The lower and larger diameter works in a liner and forms the guide as well as the compressor for the scavenge air. This air is drawn in on the down stroke, and on the up stroke is discharged at a pressure of about 5 lb. into a reservoir formed in the upper part of the crank-case, and from this is led to the scavenge valves.

A cam-shaft, running along the tops of the cylinders, carries for each cylinder one cam to operate the fuel valve, and one for the scavenge valve, as well as the ahead and astern manœuvring cams. This shaft is driven from the crank-shaft by a vertical spindle, fitted with helical wheels at each end.

The vertical spindle is not solid all the way up, but is fitted with a coupling or clutch, which allows the lower part to revolve through 30 deg. before driving the upper part and the cam-shaft. Thus, if the engine is reversed, the crank-shaft and lower part of the vertical spindle will revolve through 30 deg. before the upper part and cam-shaft move, and this will bring the cams into a fresh position relative to the crank-shaft. In this new position they will give the fuel and scavenge valves the same point of opening and closing relative to the piston travel as they previously had in the ahead position. The cam-shaft, at the forward end, drives a tachometer for showing the speed of the engine, and an emergency governor for cutting off the fuel supply, should the engine race.

From this vertical shaft are driven, by worm gear, the pumps for supplying lubricating oil to the cylinders. There is a visible feed, and the oil is positively delivered by a force-pump to each cylinder. All the bearings are lubricated by oil under pressure, which is forced round by a pump working at the forward end of the engine. This oil is collected in the crank-pit and passes through a filter and cooler, and is then pumped round the bearings again. The thrust-block is made either as part of, or attached to, the main bed-plate, and thrust-collars are turned on the after end of the crank-shaft. The bearing is adjustable, so that there should be no chance of the crank-shaft getting out of line fore and aft with the guide position. In the larger sizes of engine this oil, passing through the cross-head and the piston-rod, is pumped round the hollow top of the working piston also to keep it cool.

Forward of, and in line with, the cylinders is fitted a two-stage air-compressor, driven from an extra crank. This delivers air at about 800 lb. pressure into the injection air vessel, which stands alongside the engine. From this vessel a pipe leads to the fuel valve on each cylinder, the pressure of air for injecting the fuel being regulated by a valve. The surplus air is led from this vessel to the starting air-reservoirs fitted on the side of the engine-room, so as to keep up the reserve of air necessary for manœuvring.

At the extreme forward end of the crank-shaft is an eccentric from which motion is given to the lubricating-oil pump, the cooling-water pump and the fuel-oil pumps. Of these latter there is one for each cylinder, forcing the fuel oil into the fuel-valve casing. When the needle-valve lifts the charge of oil in the casing is driven into the cylinder by the injection air.

The speed of the engine is varied by regulating the quantity of this charge of fuel oil, the position of the manœuvring lever controlling the lift of the suction valves of the fuel-oil force-pumps. When reversing, the fuel oil is cut off automatically by this lever, until the engine starts by air in the new direction, when it is again supplied to the fuel valves.

In addition to the fuel and scavenge valves each cylinder is fitted with an air starting-valve. This is operated by compressed air from the reservoirs which, acting on top of a piston, presses the valve open.

The reversing of the engine is accomplished by the operation of either a lever or a hand-wheel on bell-crank tappets, which operate air-valves. The head of each cylinder is provided with a fuel-valve, with its injection-air attachment, and a scavenger valve, and these are operated by two of the cams on the cam-shaft, and, in addition, there is a starting air-admission valve arrangement operated by the other two cams. These cams are set for going ahead or going astern, and admit air to the piston of the air-valve in the cylinder-head.

As before stated, there is always one of the pistons in a position to go ahead or astern on receiving an impulse of compressed air, and as the engine starts to go ahead or astern in this manner, the movement of the lever also operates the fuel-admission valve, so that before the air is entirely shut off the cylinders are firing; the same takes place in whichever direction the engine is started. The first movement of the lever from the centre point also operates an air-pipe for opening simultaneously the air-valves on all the cylinders for an instant, to enable any gases in the cylinders to be blown out.

The capabilities of these engines for manœuvring were demonstrated on the tug Nürnberg at Rotterdam. Repeatedly on trials and in ordinary work the times taken to effect changes have been observed to be :—

	Seconds.
Full speed ahead to full speed astern ...	3
Full speed ahead to stop	2½
Stopped to full speed ahead	2½

The engine having started on fuel, now pursues its normal cycle, which is as follows, and is shown by Fig. 3, on page 471.

Just before the piston reaches the top of its stroke, the fuel valve opens and a charge of fuel is injected by means of the injection air, the pressure of which is higher than that of the air compressed on the up stroke of the piston.

The fuel oil is atomised in the fuel valve, and entering in a spray mixed with the injection air, it ignites, the ignition being due to the temperature of the compressed air in the cylinder. This combustion continues for about one-twelfth of the stroke, when the fuel valve again shuts, and the gases expand, driving the piston down, until the top of the piston uncovers the exhaust ports.

The gases are then free to escape to the atmosphere through the silencer. Their expulsion is made certain by the admission of scavenging air which has been compressed to about 5 lb. pressure, and which, entering by the scavenge valve, sweeps out the burnt gases and leaves the cylinder full of fresh air, which is compressed to about 450 lb. per sq. in. by the up-stroke of the piston. The scavenging air is compressed in the case of double-acting engines by pumps driven from the main engines.

The consumption of fuel oil varies from 0.52 lb. in small engines to 0.45 lb. in large engines. This is assuming that the oil fuel has a calorific value of about 18,000 B.Th.U., which is the average for these oils.

Description of Double-Acting Engine.—The double-acting engine is built with three working cylinders and the scavenge-air cylinders arranged on either one of two plans to suit the exigencies of the ship design. In one arrangement these scavenge cylinders are in line with the working cylinders, and their pistons worked from a continuation of the main crank-shaft. In the second arrangement they are placed on the side of the engine and worked by rocking levers from the main crossheads. This arrangement saves length, and enables the compressing cylinders to be put on the main frame and worked by a continuation of the main shaft.

The framing below the cylinders is very massive, and the crosshead, guides, and connecting-rods are made just as in a steam-engine. The pistons not being stepped to form scavenging pumps, separate scavenging pumps are essential. The cylinders are provided at the bottom end with stuffing-boxes, the form of stuffing-box being that which has been used successfully for a number of years in the large gas-engines made by the Nürnberg Company with most satisfactory results.

The cycle of operation is precisely the same as in the single-acting engine, except that it takes place at each end of the cylinder alternately, and for this reason there are cam-shafts both top and bottom of the cylinders.

In order to get a better distribution of fuel oil and more even burning, the valves at the bottom are in duplicate. The reversing and starting gear is similar to that on the single-acting engines, but actuates starting air-valves at each end of the cylinders. There is also an arrangement whereby in starting or running slowly the fuel may be cut off one end of the cylinders, leaving the other end firing only, and so running as a single-acting engine.

The bearings, as in the single-acting engines, are lubricated by oil under pressure, and this same oil is used to cool the working pistons, being pumped through the cross-heads and piston-rods. The advantage of using oil is that, should any leakage occur, no harm is done, whereas if water be used and leaks down into the crank-pit, it seriously affects the lubricating quality of the oil circulating round the bearings.

For auxiliary purposes, on a ship, non-reversible engines are used, driving dynamos to enable the auxiliaries to be worked by electricity, or a separate small steam installation may be used. On the single-acting engines hitherto the compressor has always been driven off the main engine, and is in line with the other cylinders. In the double-acting engines, which have so far been constructed for the vessel for the Woermann Line, there are separate compressor engines. This appears to have advantages in manœuvring. Designs, however, have been got up in which the compressors are driven from a continuation of the crank-shaft, the scavenging pumps being driven by rocking levers. In all these installations a small auxiliary compressor is usually fitted for manœuvring.

* The engine has been run quite satisfactorily up to 220 revolutions per minute.

THE CORROSION OF BRASS, WITH SPECIAL REFERENCE TO CONDENSER-TUBES.*

By Paul T. Brühl, M.Sc. (Bowen Research Scholar, University of Birmingham).

(*Concluded from page* 438.)

The Effect of Crystal Size.

To test the influence of crystal size on the rate of corrosion, six 70/30 plates were taken in the hard rolled condition, three of them being annealed at 700 deg. Cent. for 10 minutes, the other three at the same temperature for 3 hours. By this means two sets of plates were obtained, one with small crystals, the other with crystals very much larger; and as both sets were cut from the same strip, they were, of course, of identical composition. After thorough cleaning with dilute sulphuric acid and emery paper, the plates were weighed and immersed in synthetic sea-water, which was kept stirred, on an average, for 10 hours a day. No precautions were taken to maintain a constant temperature. The plates were removed from time to time, washed in a stream of water, dried with alcohol, and re-weighed, with the following results :—

Large and Small Crystal Structures.

Loss in Grammes per 46 Sq. In. of Surface.

	Time in Weeks.					
	1-0	0-3	0-6	0-9	0-12	0-15
S 1	0.0493	0.0751	0.1711	0.2893	0.4893	0.5839
S 2	0.0512	0.0800	0.1714	0.2918	0.4905	0.5600
S 3	0.0520	0.0795	0.1776	0.3186	0.4991	0.5653
L 1	0.0518	0.0853	0.1710	0.3168	0.5203	0.6253
L 2	0.0456	0.0542	0.1663	0.2996	0.53 7	0.6518
L 3	0.0445	0.0694	0.1622	0.2873	0.4996	0.5994

The loss in weight during the first six weeks shows on the whole that a small crystalline structure is conducive to more rapid corrosion. If we suppose that the electromotive force remains unchanged with prolonged annealing, it might happen that corrosion will be greater with small crystals than with large ones, owing to the greater surface exposed.

As a matter of fact, however, the electromotive force is raised by annealing—that is to say, the brass, which is now built up of large crystals, tends to dissolve faster. Therefore, unless the annealing has been very prolonged, so as to ensure a sufficient difference in superficial area, a coarsely crystalline condition, which is the usual case, will mean an increased rate of corrosion. This increase is obviously not due to crystal size, but to a rise in the electromotive force. The method of manufacture of condenser-tubes does not permit of serious variations in the crystalline structure, and therefore crystal size plays a very insignificant part in the problem of corrosion. The figures given indicate that after some twelve weeks the small crystalline plates, which had hitherto corroded faster, now commence to lose weight more slowly than the large crystalline plates. It would be interesting to ascertain the reason for such a change.

Effect of Different Annealing Temperatures.

In order to obtain information on this point, three specimens of 70/30 brass were annealed in an electric furnace and slowly cooled. The figures show that corrosion increases with the temperature of annealing. It is not good, therefore, for the final annealing in the manufacture of condenser-tubes to be unduly long.

Specimen 1, annealed half an hour at 330 deg. Cent.
Specimen 2, annealed half an hour at 470 deg. Cent.
Specimen 3, annealed half an hour at 600 deg. Cent.

The microstructure is finest with No. 2 and largest with No. 3.

Loss in Grammes.

Time in Weeks.	I.	II.	III.
0-1	0.0270	0.0315	0.0341
0-2	0.0528	0.0602	0.0663
0-5	0.0732	0.0772	0.0935
0-9	0.0968	0.1014	0.1306

Q_1 (quenched from red-heat) = 0.0479
Q_2 (quenched from red-heat) = 0.0445
No. 1 (slowly cooled) = 0.0203
No. 2 (slowly cooled) = 0.0207

* Paper read before the Institute of Metals at Newcastle, September 21, 1911.

The effect of quenching is to increase the rate of corrosion.

Effect of Rolling.

Brass, on rolling, becomes more electro-positive, or, in other words, more liable to corrosion than the soft metal. The energy imparted is partly evolved as heat and partly stored up in the metal as a kind of potential chemical energy; the rolling results in the production of an amorphous modification which is electro-positive to the crystalline metal, and the resultant voltaic effect causes more rapid solution. To test the effect of rolling, three plates of 70/30 brass were hard rolled to different extents and then immersed in sea-water.

Plate H_1 was 0.1 in. thick.
,, H_2 ,, 0.0875 ,,
,, H_3 ,, 0.075 ,,

The loss in grammes per square inch surface was as follows:—

Time in Weeks.	H_1.	H_2.	H_3.
0-2	0.0049	0.0053	0.0058
0-3	0.0053	0.0057	0.0062
0-6	0.0083	0.0085	0.0092
0-9	0.0098	0.1010	0.1070

The figures show clearly how the rate of corrosion increases with the amount of work.

If we take a strip of brass bent over in the shape of a U, with one limb hard rolled and the other well annealed, and immerse it in dilute H Cl, bubbles of hydrogen will be disengaged at the cathode—*i.e.*, on the annealed limb. After some hours the hard-rolled limb will be practically dissolved away, whilst the other will have been markedly less attacked. At the junction of metal and liquid corrosion will be very pronounced, the brass being eaten through in a succession of perforations similar to the edges of a postage stamp. Any convex bands in the metal are harmful, as the limbs tend to peel at such localities of strain, and the gases evolved from below, becoming entangled in the projecting scales, help them to break away. On rolling, there is a slight increase in density, which must result in a fall of electromotive force owing to the now closer agglomeration of the molecules; the imparted energy, however, more than counterbalances this fall. The depth below the surface to which the effect of rolling will be felt will depend upon the amount of rolling. It follows, therefore, that a slight degree of work will influence the polarity of the brass to only a limited extent. The electromotive force cannot be raised by work beyond a certain definite value. Beilby's work on the surface effect of rolling well repays the trouble of reference; it is from his paper on the subject that the following extract has been taken: "Extremely slight mechanical treatment will suffice to cause molecular movement and flow on the surface of a highly crystalline substance. A freedom of movement has been conferred on the molecules which enables them to behave like liquid molecules. This freedom lasts only so long as the molecules are moving over each other. When the movement ceases we must assume that the freedom also ceases, but not before the molecular attraction has drawn the surface into a continuous covering skin comparable in smoothness with the surface of a liquid."

In view of the more rapid corrosion of hard rolled metal, it would appear advisable, considering the thinness of the tube wall, that the last pinch in the drawing of condenser-tubes (after the final annealing has been performed) should be as small as possible.

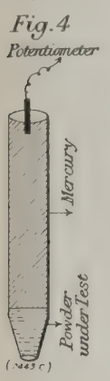


Fig. 4.

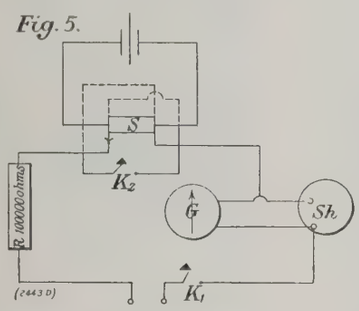


Fig. 5.

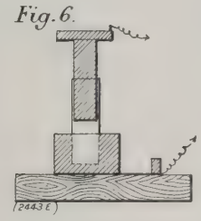


Fig. 6.

Experiments on the Corrosion of Annealed 70/30 Brass under Different Conditions.

A series of experiments were undertaken to test the rate of corrosion under varying conditions, such as are met with in practice, and the results are given below in tabular form:—

1. *In Stagnant Sea-Water at the Ordinary Temperature.*
Loss in Grammes per Square Inch Surface.

Period in Weeks.	Plate I.	Plate II.	Average.
0-1	0.0023	0.0019	0.00207
0-3	0 0041	0.0038	0.00384
0-6	0.0065	0.0063	0.00643
0-9	0.0081	0.0077	0.00771

2. *In Stagnant Sea-Water at 40 Deg. Cent.*
Loss in Grammes per Square Inch Surface.

Period in Weeks.	Plate I.	Plate II.	Average.
0-1	0.00181	0.00181	0.00181
0-3	0.0044	0.00435	0.00438
0-6	0.0073	0.0076	0.00737
0-9	0.0106	0.0111	0.01087

Air was bubbled through the sea-water for seven hours a day, when the following results were obtained:—

3. *Effect of Air on Corrosion.*
Loss in Grammes per Square Inch.

Period in Weeks.	Plate I.	Plate II.	Average.
0-1	0.0014	0.00205	0.00172
0-3	0.00713	0.00593	0.00653
0-6	0.00957	0.00760	0.00886
0-9	0.0107	0.00811	0.0093

4. *Effect of ½ per Cent. NH_3 in Salt Water.*

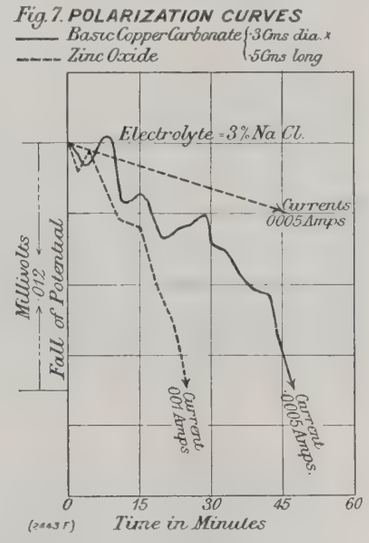
Period in Weeks.	Loss in Grammes per Square Inch.
0-1	0.0054
0-3	0.0062
0-6	0.0087
0-9	0.0086

5. *Effect of ½ per Cent. HCl in Salt Water.*

0-1	0.0237
0-3	0 0556
0-6	0.1263
0-9	0.1501

6. *Effect of ½ per Cent. KOH in Salt Water.*

0-2	0.00083
0-6	0.00063



Effect of Bilge-Water.

Bilge-water was always found in the wooden ships of former years, and was formed by the contact of sea-water with decaying wood. Its effect on copper and brass is, as may naturally be expected, much more rapid than that of ordinary sea-water, and ships anchored off jetties near which sewage is discharged have frequently been seriously affected. The action seems to depend on the formation of corrosive sulphur compounds, the presence of hydrogen sulphide being readily disclosed by its characteristic odour; hydrochloric acid may also be formed. Wood kept immersed in sea-water is immune from decay, rot only setting in on exposure to atmospheric agencies. Interesting cases are cited by B. F. Isherwood. One ship, stationed off West Africa, in the vicinity of a swampy coast, had its copper sheathing attacked with amazing rapidity. In the other, the water obtained from a river fed partly from swampy areas was so corrosive that the boilers in which it was used never gave any trouble from scaling.

Some lengths of condenser-tubing, containing plugs of seaweed, were immersed in sea-water for two months. They were then cut in half in the direction of their length and examined. The outer surface was darkened by a film of sulphide, and showed occasional patches of oxychloride. The inner surface was similarly affected. Dezincification had only taken place to a slight extent; and corrosion, though more marked than in the other experiments, showed no immediate tendency to become dangerous.

Effect of Oil.

The oil used in the lubrication of the piston and slide-valves should be composed of hydrocarbons only—that is to say, it ought always to be of mineral origin. It is not advisable to employ organic oils for the purpose, as they possess more body at high temperatures than do the previous class. They are subject, on the other hand, to partial decomposition in the presence of steam, giving rise to glycerine and free acid, which latter becomes a serious danger when in contact with the wall of the condenser-tube. Any oil which may find its way into the condenser does so in the form of vapour, owing to the temperature in the cylinder and the continuous rush of steam from it. In the condenser the oil condenses on the tubes in the form of minute globules, which give rise to irregular corrosion.

The figures given leave no doubt that a rise of temperature up to a certain extent is favourable to corrosion, as it increases the reaction velocity between the brass and the sea-water. An increase in the quantity of dissolved air also promotes chemical activity. The very imperfect agreement between the losses in weight of Plates I. and II. is due to the fact that the nozzle of the air-duct was for the greater portion of the time placed closer to I. than to II.

The supply of sea-water was changed every third week; corrosion during this period was most marked just after such renewals, the reaction velocity being proportional to the concentrations of the salts dissolved in the sea-water. As the concentrations must diminish with time, the rate of corrosion, other conditions being constant, must gradally diminish.

Relative Rates of Corrosion of Muntz Metal and Copper in Salt Water.

Time in Weeks.	Muntz Metal. Grammes per Sq. In.	Copper. Grammes per Sq. In.
0–1	0.00223	0.00102
0–3	0.00305	0.00347
0–7	0.0076	0.0078
0–10	0.00843	0.0107

If predictions based on the constitutions and electromotive forces of the two metals were to be made, one would certainly think that Muntz metal, by virtue of its dual structure and higher electromotive force, would be more liable to corrosion than copper. As a matter of fact, such predictions would not be entirely correct. Muntz metal corrodes somewhat more than twice as fast as copper during the first week of immersion in sea-water. This may naturally be expected. Why, then, does copper corrode more rapidly with further lapse of time? The most apparent cause is found by an examination of the specimens. Copper exhibits a tendency to peel, thereby incurring a mechanical loss in the first place and a chemical one in the second by the continual exposure of fresh surfaces. Muntz metal, on the other hand, shows no such tendency, although the surface becomes roughened by the unequal rate of attack of the α and β constituents. The peeling is certainly not due to any strained condition of the surface, as the copper was annealed before use. Another explanation of the greater durability of Muntz metal is that the oxide film which forms on it is a mixture of the oxides of copper and zinc, whilst the film that appears on copper is cuprous oxide. Zinc oxide is very much less harmful electrochemically than cuprous oxide, because of its smaller difference of potential and higher specific resistance. Further, as the oxide film forms the cathode, hydrogen will be evolved at such negative areas; cuprous oxide is in all probability reduced by nascent hydrogen at the temperature of the condenser-tube—*i.e.*, 40 deg. Cent.; that it is comparatively easily reduced is seen by the fact that ordinary hydrogen reduces it at 155 deg. Cent. The reduction of the cuprous oxide may explain the peeling referred to above.

Effect of Stray Electric Currents.

There can be no doubt that stray currents of electricity escaping from imperfect fittings increase the rate of corrosion of condenser-tubes by increasing the velocity of removal from the solution of the charged ions. Troubles from this source not infrequently arise both on ships using continuous current to a great extent, and in tramway generating stations, where the negative pole is earthed. On this subject Mr. Milton, writing on the decay of metals, says:—

"If, for instance, there is a leakage from the positive cable in such a position that part of it proceeds to the sea (earths) through the water flowing through the condenser-tubes, which are, of course, clean metal, instead of through the hull of the vessel, which is kept painted in order to prevent any actual contact between the iron and the sea-water, some electrolytic action must take place in the tubes themselves."

The prevention of corrosion from this source can be effected by providing a good path for the stray currents outside the condenser.

"This may be done by making a connection between the condenser-tube plates, the cooling-water inlet, the outlet piping, and the air-pump suction piping, by means of a large cable, which need not be insulated, so that the condenser is, so to speak, short-circuited. As a rule, the locality of the stray currents can usually be accurately determined by careful voltage measurements, and the most suitable points for the connection of the short-circuiting cable chosen accordingly."

The importance of stray electric currents on corrosion is further emphasised by the instance cited by another writer, who states that two water-pipes, each close to an electric lead, were eaten right through in small holes, apparently punched out of the metal.

Certain Substances Arranged in the Electro-Chemical Scale.—By means of the potentiometer certain corrosion products were arranged in the electro-chemical scale. The products were placed in glass tubes, and by testing one against the other their respective positions were ascertained. Sea-water was employed as electrolyte.

1. Brass.
2. Zinc oxide.
3. Oxychloride.
4. Iron oxide.
5. Cuprous oxide.
6. Cupric oxide.
7. Iron hydrate.
8. Basic zinc carbonate.
9. Coke.
10. Basic copper carbonate.
11. Tin oxide.

as the passage of an electric current between any two

of the above substances demonstrates that electro-chemical action between the corrosion products themselves must take place to some extent.

The specific resistances were next measured to see whether any one of them would be so high as to be unable to function as one pole of a galvanic couple. The apparatus employed is represented in Fig. 5.

The zero point having been noted, the deflection D_s, with the megohm resistance in circuit, was next obtained, after which the deflection $D_{s\,x}$, with the standard resistance + the resistance of the corrosion product in circuit, was taken. These values were found by the alternate use of the keys K_1 and K_2, whence

$$\frac{\text{zero deflection} - D_{sx}}{\text{zero deflection} - D_s} = \frac{1}{1+x}$$

from which x can be valuated, and from this the specific resistance is calculated from the formula

$$\text{Specific resistance} = \frac{x \times (\text{diameter})^2 \times 0.785}{\text{length}}$$

the length and diameter referring to the dimensions of the cylinder of corrosion product, which was contained in the apparatus represented in Fig. 6.

It consists simply of a glass tube containing a known length of well-rammed corrosion product, and fitting into a brass socket. To ensure a good contact between the brass rod and the powder, a weight of 50 grammes was placed on the seats. The following table gives certain substances in the moist state in increasing order of resistance per cubic centimetre:—

	Ohms.
1. Coke	<1,000
2. Cuprous oxide	<1,500
3. Iron oxide	2,800
4. Basic zinc carbonate	4,000
5. Basic copper carbonate	6,500
6. Zinc oxide	7,000
7. Oxychloride	7,500
8. Cupric oxide	10,000

These figures are only approximations, as it is difficult to ensure the various powders being of the same degree of moistness, although every effort was made to lessen errors from this source.

The values for the dry state were:—

	Megohms.
Zinc oxide...	0.5
Ferric oxide	1.4
Cuprous oxide	0.13
Cupric oxide	10.25

The thickness of the deposits on a condenser-tube is small, and as the specific resistances are not of a high order, little opposition will be offered to the passage of an electric current; hence we may suppose that all the products of corrosion, when wet, set up electro-chemical action with the brass. From a consideration of the above results, we see that the most dangerous substances are carbon, cuprous oxide, and iron oxide. Iron hydrate and the oxychloride promote chemical action by the absorption of oxygen.

Polarisation and Depolarisers.

By the passage of an electric current from brass to any of the corrosion products resting on it, hydrogen is evolved at the cathode, and, being a high insulator, it will tend, unless removed, to stop any further action. The cathode is said to be polarised by the hydrogen, but as there is always a certain amount of oxygen dissolved in sea-water, the hydrogen will be oxidised and removed to some extent. In the case of a condenser-tube, polarisation is very unlikely, as the bubbles of hydrogen are mechanically removed by the swirl of water. Some experiments were carried out to study the rate of polarisation in still water, and a couple of typical curves are given. They show that the substances considered act as depolarisers in a small way by absorbing the hydrogen, but the current which can pass would eventually be very slight.

Schoch, investigating the passivity of a nickel anode in sulphate and chloride solutions, attributed the phenomenon to the formation of an oxide film of extreme thinness, and not to polarisation by oxygen. Recovery from the passive state is quick in acid and slow in neutral electrolytes. An anode therefore is either dissolved or oxidised according to the character of the anions present, the tendency to oxidise being represented by the following order:—

1. Halogens. 4. Perchlorates.
2. Sulphates. 5. Nitrates.
3. Acetates. 6. Chromates and hydroxides.

Some reaction must therefore take place either between the anions and the anode, or between the anions and the entering metallic ions. "Alkaline acetate solutions are able to convey currents of greater density than sulphates, on account of anodic depolarisation, resulting from the oxidation of the acetion to methyl alcohol." The paper is suggestive of the causes which govern the behaviour of certain anodic segregations in brass, such as, for example, the behaviour of free lead and tin. C. Russo, working on the same point, attributed the passivity of the nickel anode to the formation of a solid solution of oxygen with the metal surface. The fact that this passivity was observed only within the range of certain current densities, 0.1 to 0.4 ampere, would seem to show that in a ternary brass, where the third constituent has partially separated out, the ill or beneficial effect of this third constituent will depend upon its potential difference as compared with the rest of the metal. Free lead, for instance, being easily oxidised, retards corrosion.

Influence of Surface Impurities.—The influence of impurities on the surface of 70/30 brass is given below, but as the difficulties due to polarisation could not be overcome under the conditions of the experiment, the potential differences cannot be returned in definite terms. As far as was possible, equal contact areas of the several impurities were added. It was observed that for a given area of brass there was in the case of each impurity a certain contact area beyond which the effect became very marked. Therefore, for a given area of protecting metal only a definite extent of the other metal can be rendered corrosion proof.

	Effect.
1. Lead increases + in liquid	Great
2. Iron increases + in liquid	,,
3. Machine-oil decreases + in liquid ...	Slight
4. Fireclay	,,
5. Carbon	Small
6. Zinc oxide...	Slight
7. Copper scale	Small
8. Brass scale	,,

The Localities of Pits.—A point of interest and importance is the consideration of the circumstances which go to determine the localities where pitting will take place. In the case of 70/30 brass these localities cannot be supposed to depend upon the distribution of any segregated impurity. In fact, as has been pointed out, the presence in brass of free lead or tin, or, in fact, of any phase besides the α phase, would not, *ipso facto*, lead to an increased rate of corrosion, sea-water being the electrolyte. The use of acid completely alters the conditions under which the metal is being destroyed. Here no film can form on it, owing to the solvent action of the acid, and the effect of the products of corrosion on the metal—which is of very considerable importance—is altogether lost. Therefore it follows that in corrosion experiments it would be better not to use an accelerator.

The positions of the more serious pits are probably governed by two factors—the presence of mechanical defects such as "spills" and of certain deposits. Even a comparatively small spill in the tube wall will result, when the cooling water ceases to be pumped through, in the formation of a little reservoir, to which air has complete access. It is precisely under these conditions that corrosion becomes very marked. A brass plate which had been immersed in sea-water for several weeks, and which had corroded perfectly uniformly, was then so placed that $\frac{1}{4}$ in. of the plate stood above the surface of the

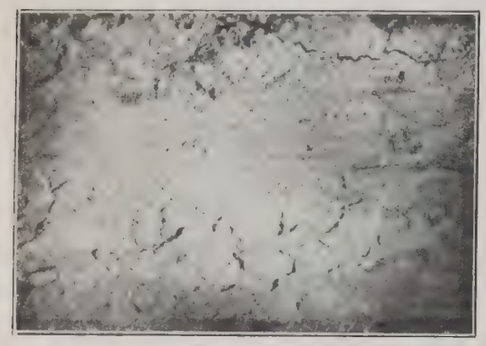


Fig. 8. Stage 1 in Corrosion; Incipient Pitting.

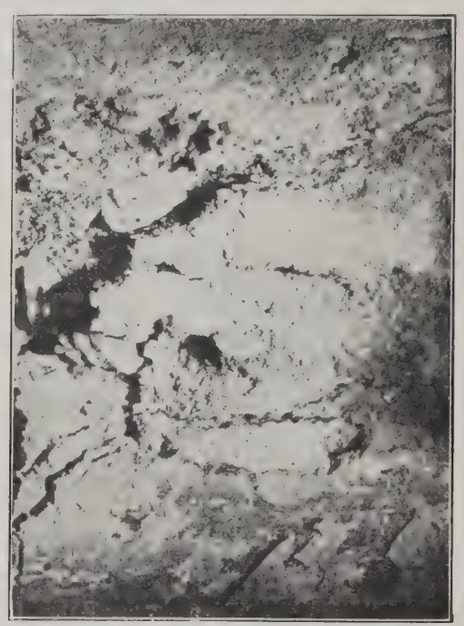


Fig. 9. Stage 2 in Corrosion; Pitting Much More Pronounced.

Fig. 10. Stage 3 in Corrosion; Holes in Tube.

Fig. 11. Condenser-Tube showing Season Cracking and Strong Pitting.

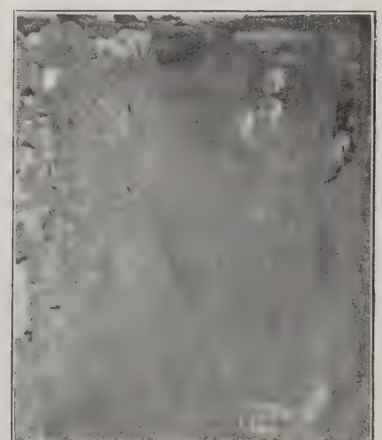


Fig. 12. From a Photograph illustrating the Peeling of Copper.

liquid. In a few days the result was very noticeable; along and just above the junction of liquid and air pitting had occurred, and the metal became quite bright and crystalline in appearance. The direct effect of the reservoir would therefore be an increased rate of corrosion along a contour, which would narrow as evaporation progressed.

The second cause for pitting is the strong electrochemical action set up by certain substances. Of these, ferric hydrate and carbon are probably the worst; and of the corrosion products of brass, the oxychloride appears to be the most injurious. On two or three of the plates small pits were found under the patches of green deposit after the lapse of four months. The location of these patches depends on the roughness of the surface. The causes of abnormally rapid corrosion must be due to the presence of stray currents of some magnitude. Corrosion may be accelerated by the interaction of the various products of corrosion, but it is not rapid and local enough to give rise to pitting.

The Effect of Impurities in Brass.

To study the influence of lead, tin, aluminium, and nickel on brass, some alloys were prepared from the purest metals available.

The proportion of copper to zinc aimed at was approximately 75 : 25, so as to prevent variations in the electromotive forces so far as the copper-zinc content was concerned. Lawrie has shown that the electromotive forces of the brasses from 100 to 75 per cent. copper remain constant, and therefore any fluctuation in the electromotive forces of the special alloy can be ascribed to the addition of the third metal. The copper was first melted under charcoal in a coke-fired wind furnace, the zinc was then added, and finally the desired addition. After thorough mixing the alloy was cast in iron moulds in the form of plates. The nickel was added as cupro-nickel containing 15 per cent. nitrate. The alloys were rolled with a final annealing at 600 deg. Cent. for 10 minutes. After pickling and cleaning they were weighed and immersed in seawater, the loss of weight from time to time being compared with a standard alloy consisting of copper and zinc only.

Composition of the Alloys.

Standard : Copper, 74.5 per cent.; zinc, 25.5 per cent.

Alloy No. 2.	Alloy No. 3.	Alloy No. 4.	Alloy No. 5.
Per Cent.	Per Cent.	Per Cent.	Per Cent.
Cu 74.97	75.20	74.12	75.34
Zn 24.09	23.82	24.90	23.78
Pb 0.94	Sn 0.98	Ni 0.98	Al 0.91
Alloy No. 6.	**Alloy No. 7.**	**Alloy No. 8.**	**Alloy No. 9.**
Per Cent.	Per Cent.	Per Cent.	Per Cent.
Cu 74.35	74.85	75.21	73.95
Zn 23.95	23.28	23.87	24.13
Pb 1.70	Sn 1.87	Ni 1.92	Al 1.92

Loss of Weight in Grammes per Square Inch Surface.

Time in Weeks.	Standard.	Alloy No. 2.	Alloy No. 6.
0-1	0.0018	0.0016	0.0014
0-3	0.0058	0.0056	0.0045
0-6	0.0126	0.0119	0.0053
	Alloy No. 3.	**Alloy No. 7.**	**Alloy No. 4.**
0-1	0.0014	0.0028	0.0032
0-3	0.0061	0.0035	0.0079
0-6	0.0113	0.0034	0.0129
	Alloy No. 8.	**Alloy No. 5.**	**Alloy No. 9.**
0-1	0.0036	0.0019	0.0005
0-3	0.0077	0.0070	+ 0.0017
0-6	0.0133	0.0112	+ 0.0012

Every alloy may be considered to corrode in two stages—the first holding good when the metal is freshly immersed in the corroding liquid, and therefore before secondary reactions occur to any appreciable extent; the second when corrosion or oxidation products have been deposited or formed on the metal. We may accordingly consider that the loss during the first few weeks gives the true effect of the added impurity, although the ultimate effect may be quite different. This is seen in the relative rate of corrosion of Muntz metal and copper. The figures show that the initial effect of 1 and 2 per cent. lead, 1 and 2 per cent. tin, and 1 and 2 per cent. aluminium, is to increase the resistance to corrosion, whilst that of the nickel alloys is to diminish it.

Unfortunately, the time was not available for a more thorough research along these lines. Such a research is of importance, as it seems to offer at present the only solution to the problem of lessening corrosion. The effects of bismuth, arsenic, antimony, and lead, which are present only to small extents in copper, should be studied. Small percentages of lead, for instance, increase the rate of corrosion, whilst additions which result in the separation of free lead retard it markedly. As a sort of general summary, the avoidance of nickel and small amounts of lead, and the introduction of 1 per cent. of tin or 2 per cent. of aluminium are recommended. The effect of iron was not tried, but is in all likelihood an adverse one.

Some Aluminium Brasses.

As the aluminium brasses gave such promising results from the corrosion point of view, a few alloys of the following compositions were prepared :—

Alloy No. 1.	Per Cent.	Alloy No. 2.	Per Cent.
Cu	74.32	Cu	73.00
Zn	25.21	Zn	25.93
Al	0.47	Al	1.07
Alloy No 3.	**Per Cent.**	**Alloy No. 4.**	**Per Cent.**
Cu	73.38	Cu	72.85
Zn	25.01	Zn	25.12
Al	1.61	Al	2.03

Alloy No. 5.	Per Cent.
Cu	74.35
Zn	22.60
Al	3.05

These alloys were immersed in an aqueous solution of hydrochloric acid, with the following results :—

Rate of Corrosion in 600 Cubic Centimetres of 5 per Cent. HCl (Three Weeks).

	Loss in Grammes.
Alloy No. 1	5.8775
,, No. 2	5.0709
,, No. 3	4.8457
,, No. 4	4.8237
,, No. 5	0.8193

The Necessity of CO_2 and Oxygen for Corrosion.—In connection with the necessity of both CO_2 and O_2 for corrosion, a necessity which has been insisted upon by Professor Cohen and others, some experiments were carried out. 70/30 brass placed in a sealed flask of seawater, from which the dissolved gases had been removed by boiling, showed no signs whatever of corrosion after the lapse of several months. In the presence of oxygen only the surface of the metal became oxidised, and there was a slight loss of weight after four weeks, although the solution did not answer the ammonia colour test for copper. The loss in weight may have been due to the removal of some non-adherent oxide when the specimen was being washed prior to weighing. The experiment is, unfortunately, inconclusive, but it seems difficult to understand why the presence of CO_2 should be essential. V. Andström working on the rusting of iron came to the conclusion that the proportion of O_2, and not that of CO_2, was the determining factor in the rate of corrosion.

Conclusion.

It is again urged that so important a subject as the corrosion of brass by sea-water, the neglect of which must mean no slight expenditure, should induce steamship companies to keep records bearing on the subject. It has been this lack of data that has hitherto retarded the solution of the corrosion problem. All the companies with whom correspondence was opened possessed "no definite information."

The conclusions to be drawn from the paper are :—

1. That the presence of air or an increase of temperature up to a certain point accelerate corrosion.
2. That iron, nickel, and small amounts of lead are injurious; tin up to about 1 per cent., large amounts of lead, and aluminium are useful in diminishing corrosion.
3. That the inlet pipe and the condenser plates should preferably be made of brass.
4. That the condenser should be protected against stray currents.
5. Protective coatings are not recommended.
6. The importance of "spills" cannot be exaggerated.
7. That the tubes should be flushed with clean water after use.

Finally, the author very cordially thanks Professor Turner, under whom the research was conducted, for his direction of, and assistance in, the work, and expresses his indebtedness to Messrs. O. F. Hudson and D. M. Levy for their kindly criticism and help in several ways.

SUCTION-GAS ENGINES AND PRODUCERS.

*A Comparison of Test Performances, with Results obtained in Daily Operation, and Notes upon Working Costs for Fuel, Oil, and Labour, &c.**

By W. A. Tookey.

Notwithstanding that during the last ten years or so a very large number of suction-gas engines and producers have been installed in all quarters of the globe, with satisfaction to purchasers, as is evidenced by the increasing demand for these simple and economical prime movers, it is a fact that reliable figures recording the actual performances with regard to fuel consumption, cost of maintenance, cost of repair, &c., are difficult to obtain.

Yet in order properly to appreciate the claims advanced by the makers of gas-engines and gas-producers, it is very necessary that such records should be available, so that comparisons may be made with competing types of motive-power generators, and more particularly with those which, according to results published of test-bed performances, would appear to compete very closely, if not, indeed, to surpass, gas-power plants in reliable and economical working.

It is the object of the present paper to record in a useful form a series of figures representing the actual performances of suction-gas power plants of various types and different powers, not only when tested by some form of brake dynamometer, but also when the output over the period of test can be measured by the generation of electric current or by the raising of water, so taking into account the combined efficiencies of the electric or pumping machinery and that of the gas-power plant.

However, inasmuch as "test" figures are usually obtained under what must be admitted to be abnormal conditions—no account being taken of stand-by losses, wastage of coal in charging and in removal of ashes, while the engine and producer are usually at such times worked at a constant and regular output for but a limited number of hours—further figures are presented which enable the average performances of suction-gas engines and producers of moderate power to be noted. These figures have been compiled from the statements of users themselves both in Great Britain and in other parts of the world. They take into account the variations of consumption due to the different grades of fuel used. They reflect the influence of variations of output, of load fluctuations, of length of stand-by periods. They also show the effect of variation in the human element in maintaining more or less successfully those conditions which make for the best gas production and for the lowest consumption of fuel per unit of power delivered.

Mention is made of the recorded performances of suction-gas engines and plants with regard to non-stop runs, and the experiences of users in connection with the cost of maintenance and repairs. It is from information of this character that it is possible to realise how reliable these installations are, and what little attention is really needed, provided the man in charge efficiently discharges his duties, that the engine is properly correlated to the producer, and the latter to the quality of the fuel and the rate of its combustion.

The question of capital outlay is next considered for engines and producers fixed complete upon foundations, with piping and all accessories. No figures are indicated for buildings or space occupied, as, after all, though these items are of importance, they vary so much in value according to local circumstances that, in the author's opinion, no useful purpose would be served by any general assumption. In many instances buildings have already been erected within which some space can be set apart for the power plant, and the comparison from an accountancy point of view would then be concerned with the value of the space occupied in relation to the capital cost of the whole building.

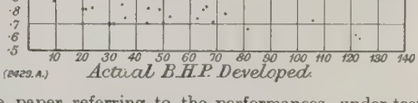
Having thus dealt with the more important considerations that come under survey in connection with the application of suction-gas power, some attention is given to the comparative costs of operation between liquid-fuel engines of the Diesel type, which, although more efficient as regards utilisation of the heat units available in the fuel for conversion into power, yet require the fulfilment of several conditions before the higher efficiency becomes apparent in the pocket of the power-user.

Similarly, some points are suggested with regard to the relative performances of steam-engines of the high-pressure superheated, compound condensing, semi-stationary type, to direct attention to the fact that although, according to test results, it would appear that suction-gas engines and producers are threatened by a competitor which offers nearly equal cost of operation, there are claims of a negative kind which must incline the balance of advantages in the favour of the gas-power plant, at all events for moderate powers, for surging loads, and for duties which many years of experience have shown cannot be performed by compound condensing steam-engines with highest efficiency.

Brake-Horse-Power Tests.—It has so long been customary to state that the consumption of coal—anthracite—by suction-gas engines and producers is about 1 lb. per brake horse-power per hour, that it is rarely borne in mind that such a statement is made by makers merely for the purpose of stipulating a safe figure in contract guarantees, well knowing that this leaves a margin for contingencies which enables them to comply with specified duties without the risk of incurring penalties which are sometimes insisted upon by the purchasers, or by consulting engineers on their behalf.

It will come as a surprise to many, therefore, that in the majority of the tests mentioned in the accompanying table the actual consumption of a combined set of engine and producer working with anthracite, irrespective of size, but, naturally, dependent somewhat upon design and the date of manufacture, is between 0.7 lb. and 0.85 lb. per brake-horse-power hour. It will be observed that the uniformity of coal consumption ranges from about 10 to over 220 brake horse-power. A chart has been plotted which enables the lesson taught by the table to be the more readily appreciated. (See Fig. 1.) That this is so is confirmed by another table given later

Fig. 1. CHART SHEWING FUEL CONSUMPTION IN B.H.P. TESTS.



in the paper referring to the performances, under test conditions, of combined suction-gas engine and dynamo sets, wherein the average figure for fuel consumption is less than 1.4 lb. per kilowatt hour, including, as this does, the efficiencies of the dynamo, and of the method of power transmission employed between the engine and the dynamo.

For the majority of the figures given in Table I., the author is indebted to M. Mathot, who, in his book "The Construction and Working of Internal-Combustion Engines," gives a lengthy table of test results.

When allowances are made for the different conditions under which the respective tests were conducted, the varying qualities of fuel, and the diversities in rate of fuel consumption in producers of different designs, the figures given for the coal consumption on the brake-horse-power-hour basis are remarkably uniform for engines loaded more or less up to the full outputs for which they are severally capable. It cannot then be doubted that suction-gas engines and producers of moderate power and modern construction do, in fact, give far better results as regards thermal efficiency than any other apparatus using solid fuel for the purposes of power generation.

As a matter of interest to designers of suction-gas engines, columns have been included in the table to indicate the relative cylinder dimensions and piston speeds of the various engines. Similarly, when the information has been available, note has been made as to the number of explosions taken per minute as a percentage of the maximum number possible at the running speed of the respective engines. In some cases the engines are not governed upon the "hit-and-miss" principle, and therefore the

* Abstract of a paper read before Section G of the British Association at Portsmouth, September 5.

degree of load in relation to maximum output cannot so clearly be seen.

With a view to comparison of all the engines mentioned upon a similar basis, two columns have been furnished, in which are noted the total specific piston displacement of the various engines, expressed in cubic feet per cycle per minute, and also the ratio between the brake horse-power developed during the test and the figure obtained in the manner just mentioned. In order to make the matter quite clear, the columns are headed in a manner which shows how the figures have been calculated.

From column 7 and column 2 a second chart (Fig. 2) has been plotted to indicate graphically the relation between the actual piston displacement per cycle per minute per brake horse-power developed, and the coal consumption in pounds per brake-horse-power hour. It will be seen that the limits are closely defined. With best fuel and most skilled attention, 1 brake horse-

Fig. 2. CHART SHEWING RELATION BETWEEN CONSUMPTION OF FUEL PER B.H.P. HOUR & SPECIFIC PISTON DISPLACEMENT PER B.H.P. MINUTE.

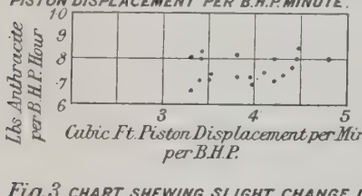
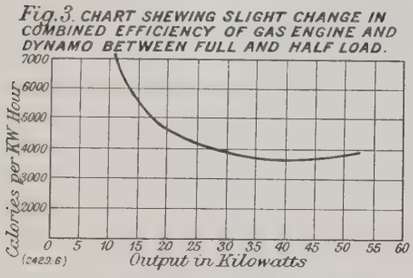


Fig. 3. CHART SHEWING SLIGHT CHANGE IN COMBINED EFFICIENCY OF GAS ENGINE AND DYNAMO BETWEEN FULL AND HALF LOAD.



power can be developed with a piston displacement of 3.5 cub. ft. per minute, while with conditions less favourable a displacement of 4.5 cub. ft. per minute per brake horse-power is required. There seems to be no diversity in the consumption figures as a consequence of variation in the size of the unit.

At the end of Table I. there are a few figures, given in a similar manner, which refer to the consumption of fuel of gas-engines and producers when working at about half load. From these it would appear that the brake-horse-power hour can still be obtained from less than 1 lb. of anthracite under the average conditions of tests. It is usually stated that the efficiency of gas-power plants falls off very considerably when the output is low, but this does not seem to be borne out by facts.

In this connection it is interesting to reproduce a chart (Fig. 3) which represents a consumption curve of a Winterthur engine tested by Professor Aimé Witz in March, 1906. This engine was served with town gas, and the amount of heat admitted to the engine cylinder in the form of gas is plotted against the output of the engine in terms of kilowatts. This therefore represents the combined efficiency curve of the engine and its dynamo, and it will be seen that the consumption in calories per kilowatt does not rise appreciably until the load is below one-half the maximum capacity of the engine. Thus the figures noted in Table I. for half-load consumptions are confirmed.

In order to show the relation of rated horse-power to hourly consumption of fuel, the accompanying chart has been prepared (Fig. 4). It will be observed that, notwithstanding the great divergence that must exist in the different conditions that apply in individual installations,

Fig. 4. ACTUAL HOURLY CONSUMPTION OF FUEL INCLUDING VARIATIONS DUE TO: DIFFERENT GRADES OF FUEL, LOAD FLUCTUATIONS, DIFFERENT LOAD FACTORS, LENGTH OF STAND-BY PERIODS, ABILITY OF ATTENDANTS, RATE OF COMBUSTION IN PRODUCER, ETC.

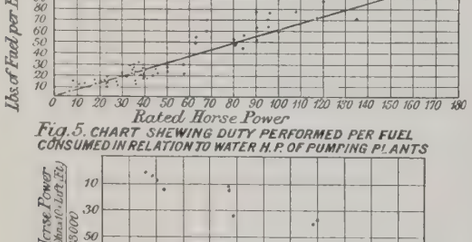
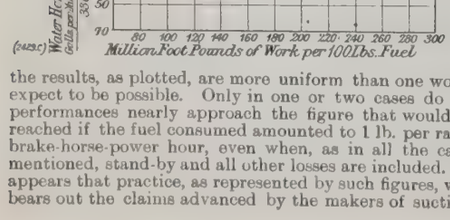


Fig. 5. CHART SHEWING DUTY PERFORMED PER FUEL CONSUMED IN RELATION TO WATER H.P. OF PUMPING PLANTS


Water Horse Power (Units per hour 10 Lbs. 1 ft.) 33,000
10
30
50
70
80 100 120 140 160 180 200 220 240 260 280 300
(2432c)
Million Foot Pounds of Work per 100 Lbs. Fuel

the results, as plotted, are more uniform than one would expect to be possible. Only in one or two cases do the performances nearly approach the figure that would be reached if the fuel consumed amounted to 1 lb. per rated brake-horse-power hour, even when, as in all the cases mentioned, stand-by and all other losses are included. It appears that practice, as represented by such figures, well bears out the claims advanced by the makers of suction-gas engines and plants. Speaking generally, it would appear that the average consumption of fuel of suction-gas plants is at the rate of 0.6 lb. of fuel per rated brake horse-power per hour, inclusive of all losses.

That such low hourly consumptions can be so universally obtained with suction-gas plants proves that the attendant is powerless to affect the economy to any appreciable extent, and, conversely, that the necessary manipulation is so readily learned that the factory owner can safely rely upon uniformly economical working.

To those who know how coal can be wasted by neglect to control the combustion during stand-by hours, the figures of consumption will be surprising. In one case in the author's experience, owing to the attendant being improperly instructed, more coal was burnt through the fourteen stand-by hours than during the ten working hours of a 90 horse-power producer. In many cases, owing to carelessness or neglect, the stand-by losses are permitted to approach 10 lb. per stand-by hour instead of from 4 lb. to 5 lb., as is the usual figure in practical working. The lowest stand-by consumption known to the author is one of 1 lb. per hour, but this is rarely obtained, it being necessary, in order to ensure the fire being in a fairly active state for ready quickening in the morning to the gas-making temperature, to allow rather more air to pass through the furnace than is there implied. A change in the direction or intensity of the wind may result in letting the fire die out if combustion is too slow, and it is therefore deemed to be more prudent to ensure a prompt start in the morning than to cut down the stand-by losses (which are already low) to the uttermost.

Generation of Electricity.—In Table II. particulars are given of the test performances of a few combined sets of gas-engines, suction-gas plants, and dynamos. The sizes vary from 30 to 250 rated horse-power, and the fuel is in two cases gas-works coke, and in the others anthracite. There is little difference to be noted in the relative performance upon the basis of pounds of fuel per kilowatt-hour.

In order to compare the test figures with those obtained per kilowatt-hour in actual practice, with varying load factors and different conditions of working, Table III. is also presented. From this it is evident that the average consumption, including stand-by losses and other wastage of fuel—the latter being burnt at different rates of combustion and being of different grades of quality—amounts to about 2 lb. of anthracite per kilowatt-hour. In cases where this figure is exceeded it will be observed that the fuel is coke, while in one instance the load is on the engine for only four hours out of the twenty-four when anthracite is used.

Pumping Plants.—Table IV. records the performances of combined suction-gas engines, producers, and pumping plants during tests lasting from five to twenty-seven hours, with varying types of pumps, dealing with quantities of water and heights of lift which indicate that the actual water horse-power exerted ranges from less than two to sixty-four. In order that these widely different duties should be brought to a comparable basis the author has computed the number of foot-pounds of work performed by each set per 100 lb. of fuel consumed (see column 5).

The results obtained differ greatly, as shown in the chart, Fig. 5; but in view of the undoubtedly uniform results given by the engines and producers, as evidenced by the previous tables, it can be stated with confidence that the divergences are due more to the varying efficiencies of the pumping machinery than to the gas-power plant.

Table V. supplements Table IV. and shows the performances of the combined pumping sets under ordinary conditions of working. It will be seen that the information furnished with regard to some of the plants is somewhat incomplete, but in three instances it is possible to compare the test figures contained in Table IV. with those in Table V. These variations amount to about from 72 to 82 per cent. of the test figures. This means that, taking into account fuel wastage from all causes, the hourly consumption of coal in every-day work is increased from 18 to 28 per cent., as compared with the "test" result. It is worthy of remark in this connection that in the Welwyn plant, which appears the least favourable, not only is the unit a very small one, but the fire has to be raked out each day and the generator allowed to cool during the night in order that no accumulation of clinker or ash in the small furnace should make it necessary for the attendant to pay more than a few visits of inspection during the eleven hours of working.

In Table IV. the figures relating to the Tendring Hundred plant, as in those for the high-lift pumps of the Sutton District Water Works, are somewhat abnormal when compared with the average results, from which it would appear that some mistake has crept in. These figures are based upon those given in the paper read a year or so ago by Mr. D. H. Irwin before the Association of Water Engineers. In his paper it was mentioned that they were furnished by the engineers responsible for the carrying out of the tests, to his firm (Messrs. Crossley Brothers, Limited).

General Reliability.—From the point of view of the power-user no saving, even though it might be a large one as regards fuel consumption, would be of practical service if the working of a suction-gas engine were to be unreliable or constantly subject to sudden interruptions from derangements of a temporary character. Much has been stated at various times with respect to the lack of strength or "sensitiveness" of some portions of the mechanism of a gas-engine which makes it unreliable. But, after all, the question of reliability is largely dependent upon the ability of the attendant. If the driver fails to detect the development of a defect, and omits the "stitch in time," it is indisputable that a gas-power plant is more liable to sudden interruptions than steam. This does not infer that it is necessary for the attendant to stand by the engine during the whole period of working. Occasional inspection only is called for; but this should be given carefully, thoughtfully, and systematically. Experience soon shows the parts most likely to give trouble, and once these are kept under watchful care, long-continued operation is secured.

TABLE I.—*Results Recorded in Brake-Horse-Power Full-Load and Half-Load Tests.*

1. Brake Horse-Power.	2. Consumption. Pounds per B.H.P. Hour. Fuel.	Maker.	4. I.H.P. Constant. A.L / 396,000	5. Percentage of Load to Maximum Impulses ÷ ½ Revolutions.	6. Piston Displacement. Cubic Feet. A L revs. per min. / 1728 × 2	7. Ratio. Column 6 / Column 1
9.0	0.855	Tangye ..	0.001554	0.958	40.1	4.45
20.1	0.80	Tangye ..	0.00377	0.849	85.0	4.23
21.6	0.80	Körting ..	0.00474	..	104.0	4.8
23.32	0.82	Stockport ..	0.00357	0.870	90.0	3.86
29.9	0.70	Tangye ..	0.0048	..	102.0	3.42
31.2	0.70	Winterthur	0.00522	0.82	132.0	4.24
35.6	0.735	Guldner* ..	0.00302	throttle	76.5	4.30
35.43	0.834	Bollinckx ..	0.00572	..	120.9	3.42
43.53	0.694	Winterthur	0.00704	..	172.0	3.95
44.63	0.81	Onghena ..	0.00656	..	151.0	3.38
49.85	0.716	Otto Deutz	0.00812	..	174.5	3.5
48.4	0.805	Winterthur	0.00992	..	216.0	4.46
52.72	0.765	Baechtold ..	0.0116	..	232.0	4.4
62.5	0.744	Schmitz ..	0.01216	..	255.0	4.08
65.1	0.825	Deutz .	0.01022	..	220.6	3.40
65.0	0.79	Otto Deutz	0.01025	..	221.5	3.40
68.6	0.72	Tangye ..	0.0124	throttle	271.0	3.95
72.9	0.786	Guldner ..	No details	—	—	—
81.12	0.665	Tangye ..	0.0124	throttle	271.0	3.35
106.0	0.735	Otto Deutz	0.018752	..	386.0	3.54
122.0	0.622	Guldner ..	No details	—	—	—
123.0	0.594	Guldner ..	No details	—	—	—
222.8	0.715	Otto Deutz	0.0247	..	850.0	3.82
		Half-Loads.				
5.0	0.945	Tangye ..	0.001554	0.656	40.3	8.06
10.9	0.920	Tangye ..	0.00377	0.545	85.5	7.84
28.28	1.0	Otto Deutz	0.00812	..	176.5	6.24
68.2	0.718	Guldner ..	No details	—	—	—
94.6	0.681	Guldner ..	No details	—	—	—

* Two-cylinder.

TABLE II.—*Test Performances of Combined Gas-Engine, Suction-Gas Plant, and Dynamo Sets.*

Horse-Power.	Maker.	User.	Period, Hours.	Output, Kw. per Hour.	Lb. per Hour per Kw.
		Anthracite.			
65	Gardner engine Mersey producer	Walton-on-Naze Electric Works	12	42.67	1.57
33	Benz engine Piat producer	Verreries de Montlucon	7	21.0	1.38
39	Tangye	Sterling Telephone & Electric Co., Ltd.	8	24.5	1.43
68	Ditto	Ditto	8	33.3	1.38
45	Campbell (one cylinder of 90 h.-p. twin engine)	Morris-Hawkins, Ltd.	6	24.3	1.24
		Coke.			
68	Tangye	Cie. Anon. Continentale	10	26.6	1.675
250	Guldner	Julius Pintsch, Berlin	10	160.2	1.3

Elasticity of Output.—Recent improvements in design have done much to increase the elasticity of the gas-engine. The old comparatively slow-speed engine with "hit-and-miss" governing is still looked upon by many engineers as being the most economical type; but at the present time most British makers are offering engines of both types of speed regulation; but there can be little doubt that if no question of price came into consideration, and if no choice were to be submitted, users generally would accept the throttle-governed engine and admit its great advantages.

But there is another improvement that has synchronised with the development of the throttle-governed engine and which has been somewhat overlooked, or, at all events, not properly appreciated, and that is, the increased rotative speed of the later types of gas-engines. It has frequently been contended that a quick-running engine must of necessity be inferior to one that makes but a comparatively few revolutions per minute. It is unnecessary for the author to discuss this question—facts speak louder than words. In the author's opinion, the increase in the rate of power generation per unit of time, and consequent greater ability to deal with sudden increases of load, without the slowing of the engine, is a very decided improvement.

Consumption of Lubricating Oil.—Another considerable improvement that has recently been effected is in connection with methods of lubrication.

In the most modern engines, the lubrication of the cylinder and the gudgeon-pin are separately provided for. Forced lubrication is fitted to the cylinder and piston, the quantity of oil pumped per stroke being adjustable to meet varying grades of oil and varying temperatures, which affect viscosity. The main bearings are provided with oiling-rings which, constantly dipping during their rotation on the shaft into an oil-well formed below the bearings, enable the same oil to be used over and over again without waste. As may be imagined, the consumption of lubricating oil has now been brought down to ex-

TABLE III.—ACTUAL WORKING RESULTS OBTAINED FROM COMBINED GAS-ENGINE, SUCTION-GAS PLANTS, AND DYNAMO SETS.

Horse-Power.	Maker.	User.	—	Kilowatts per Hour.	Fuel.	Per Annum.	Pounds per Kw.-Hour.	Pence per Kw.-Hour.
12	Gillieron	Société Suisse Electrique Accumulateurs	45 hours per week	..	Anthracite	..	2.125	—
Two 20	Campbell	Great Eastern Railway	46 hours per week	13.8	Anthracite, at 31s. 6d., and waste carbon ends	45*l.*	1.935	0.3265
Two 60	Guldner	New Berlin Beleuchtungswerke	..	157,795 kilowatt-hours per annum, including stand-by	Anthracite	..	1.40	—
68	Tangye	Compagnie Anonyme Continentale, Paris	Over 29 months	27.26	Coke and anthracite	..	2.5	—
One 68 / One 39	Tangye	Sterling Telephone & Electric Co., Limited	Over 12 months	34.4	Anthracite	146*l.* 10s.	2.0	0.364
65	Gardner engine, Mersey producer	Walton-on-Naze Electric Works	10 per cent. load-factor	..	Anthracite	..	2.9	0.632
70	Campbell	Robb Brothers, Birkenhead	1000 hours per annum	25.0	Anthracite at 30s., foundry coke at 17s. 6d. (mixed)	38*l.*	..	0.306
96	Campbell	Broxburn Electricity Station	9 hours per day, 15 hours stand-by	46.5	Anthracite at 16s. 9d.	..	1.48	0.133
96	Campbell	Broxburn Electricity Station	4 hours per day, 20 hours stand-by	28.8	Anthracite at 16s. 9d.	..	2.43	0.22
115	Hornsby-Stockport	Ascot District Gas and Electric Company	..	..	Coke at 16s. 6d.	..	..	0.197
120	Campbell	Workington Bridge and Boiler Company	53 hours per week	37.9	Coke screenings at 8s. per ton	52*l.*	2.9	0.1243
125	Guldner	State Railway, Bettenburg	32 hours ½ to full, 30 hours stand-by	..	Belgian anthracite	..	1.475	—
Two 132	Tangye	Wanganui Electric Tramways	17½ hours per day, 364 days	31.7	Coke	374*l.*	2.97	0.443
Two 250	Westinghouse (Campbell producer)	Davis and Timmins	273,583 units per year of 2712½ hours	109	Anthracite at 30s.	..	2.15	0.246

TABLE IV.—TEST PERFORMANCES OF GAS-ENGINES, SUCTION-GAS PLANT, AND PUMP SETS.

1. Gallons per Hour.	2. Height of Lift.	3. Water Horse-Power.	4. Fuel. Pounds per Hour.	5. Million ft.-lbs. per 100 Lb. of Fuel.	6. Fuel.*	7. Period, Hours.	8. Horse-Power.	9. Maker.	10. User.	11. Pumps.
3,128	120.0	1.896	4.1	91.6	A at 20s.	10	6	Tangye	Welwyn Water Works	Three-throw deep-well pumps
6,000	145.0	4.4	12.5	69.6	A at 30s.	6	Two 8	Crossley	Spilsby Water Works, Lincs	Three-throw deep-well pumps, each 3000 gallons per hour
6,000	235.0	7.12	14.0	100.5	A at 30s.	6	Two 8	,,	Alford Water Works, Lincs	Ditto
7,777	330.0	12.96	16.66	154.0	A at 27s. 6d.	9	29	Tangye	East Kent District Water Works, Snodland	Ram pump
10,597	255.0	13.6	17.77	154.0	A at 27s. 6d.	9	29	,,	Ditto	Three-throw deep-well pump
19,500	137.6	13.6	25.6	104.6	C at 20s.	5	39	,,	Paris-Plage Water Works, Etaples	Ditto
40,000	167.6	33.8	42.5	157.5	A at 30s.	12	63	,,	Basingstoke Water Works	
29,600	230.0	34.4	65.0	104.9	A at 30s.	27	117	Ruston Proctor	Newport Water Works	Ditto
52,162	150.0	39.5	36.0	218 0	A at 30s.	18	100	Crossley	Sutton District Water Works, Woodmansterne	Low lift
50,886	250.0	64.0	52.0	240.0	A at 30s.	18	100	,,	Ditto	High Lift
20,000	472.0	47.4	45.8	210.0	A	10	70	Guldner	Aschaffenburg Water Works, Germany	Two-throw high pressure, at 75 revs. per min.
40,000	269.0	54.4	89.8	124.0	Lignite	8	70	,,	Ditto	Single-throw low pressure, at 75 revs. per min.
30,183	402.0	62.0	51.0	236.0	A	24	Two 90	Crossley	Tendring Hundred Water Works, Essex	

* A = anthracite. C = coke.

TABLE V.—ACTUAL WORKING RESULTS OBTAINED FROM COMBINED GAS-ENGINE, SUCTION-GAS PLANT, AND PUMP SETS.

Gallons per Hour.	Height of Lift.	Water Horse-Power.	Fuel. Pounds per Hour.	Million Foot-Pounds per 100 Lb. of Fuel.	Fuel.*	Period.	Horse-Power.	Maker.	User.	Pumps.
3,120	120	1.89	5.275	71.0	A.	1 week	Two 6	Tangye	Welwyn Water Works	3-throw well pumps, at 25 r.p.m.
13,240	250	16.75	—	..	A.	12 months	Two 28	Campbell	Chippenham Water Works	High lift.
10,530	150	8.0					One 16			Low lift
..	..	..	21.5	..	A.	..	35	Campbell	Bath Water Works	
57,500	64.0	18.6	24.65	149.61	A. at 29s.	18½ hours	Three 48	Hornsby-Stockport	Esher and Ditton Sewage Works	Ram pump.
							Two 24			Air-compressor for sewage
28,000 to 30,000	..	..	30.0	..	A. at 32s. 6d.	..	58	Campbell	Chertsey Sewage Works	Air-compressor for sewage
31,292	..	..	66.1	..	C at 20s.	6 months	63	Tangye	North-Eastern Railway, York	
40,000	50.0 / 79.0 / 195.0	32.0	49.0	129.15	A.	1 year	63	Tangye	Basingstoke Water Works	Well pump. Low-lift pump. High-lift pump.
27,500	400	55.6	66.0	168.0	A. at 34s.	3 months average	90	Crossley	Tendring Hundred Water Works	
13,800	81	7.0			Coke breeze at 16s. 6d.	173½ hours	..	..	Bolsover Water Works	3-throw ram-pumps
11,900	385	20.2	84.0	52.5						
29,600	230	34.4	72.0	94.65	A.	27 hours out of 47 hours	117	Ruston Proctor	Newport Water Works	3-throw double-acting, at 23.5 r.p.m.

* A = anthracite. C = coke.

tremely low figures, while, after filtration, most of the oil can be used again upon the line shafting and general machinery of the factory.

Cost of Attendance.—Depending upon the situation of the engine-room with regard to the factory as a whole, and also upon the class of work undertaken, so does the cost of attendance vary. For example, in water-works the cost of attendance is higher than in the case of ordinary factories, where it is possible for the driver to fill up time not required for the operation of the plant by doing useful work elsewhere. But even in such cases it should be remembered that the attendant is required to keep the pumping machinery, as well as the engines, in good order, and no allowances have been made for this.

Combined Costs of Fuel, Oil, and Labour.—Table VI. has been compiled to show the actual working costs per hour of engines of various sizes, using fuel of different qualities and at varying prices, as regards the three chief items of fuel, oil (including waste, rags, and other stores, in some cases), and attendance.

From Table VI. it can be claimed, without fear of contradiction, that suction-gas engines and producers enable users of power to obtain the means of driving their factories at extremely low cost, and in these days of keen commercial competition it suggests that they may well consider whether it would not be economical to instal gas power in preference to existing methods of power generation, which, although probably adequate as regards power, and reliable in everyday work, are inferior to the gas-power installation in respect to the whole of the working expenses attached to them.

Repairs and Renewals.—Low cost of operation, however, would not in itself be a sufficient basis for comparison. Consideration must also be given to the amount of repairs necessary and the expense attached to renewals. The information collected shows that for periods varying from one to seven years the expense for upkeep of the gas-power plant is practically negligible. The author's experience in this matter extends over many years of working of individual installations, and with but one or two exceptions he can confirm this statement. Naturally, much depends upon the attendant, and if compensation for wear and tear be neglected, and if the "stitch in time" is not given, the engine will continue to operate until "something happens." Then either a big bill has to be faced for an expensive overhaul, or a smaller amount is spent in making as good a job as possible for the money.

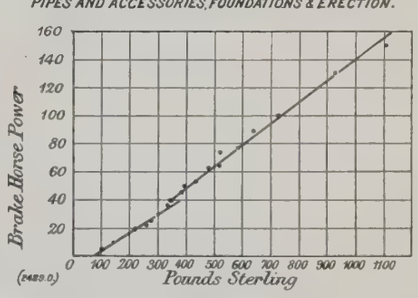
The chief items of expense occur in the renewal of piston rings, refacing and, perhaps, renewal of exhaust valve, reboring or renewal of cylinder liner. The bearings require occasional refitting, but rarely need relining. As far as the piston rings are concerned, the usual rate of renewal is at the rate of one a year. The exhaust valve may need to be replaced about every four or five years, while the life of a liner and piston can be taken as an average at about seven years. Of course, these periods vary according to the actual number of hours worked during the periods referred to, and according to the attention given to minor matters, such as rebushing of levers, replacement of worn pins and spindles, which, if neglected, may cause excessive deterioration of other working parts.

As far as the producer is concerned, the firebricks lining the generator require to be renewed about every two years, for which the material costs little; but the time occupied in dismantling and re-erecting runs into about three days. Generators made with sheet-steel casing will usually require patching around the portion exposed to the action of the heated moist gases within the ashpit after about five years of work, and perhaps renewal of this portion about every seven years. Cast iron is preferable for this portion of the apparatus, but is only used for the smaller powers on account of first cost. Firebars will be wanted about every two years, or at longer periods, unless the fire is worked at a high temperature, arising from an insufficiency of steam, which causes burning out.

The cost of these renewals and repairs, which from their recital would appear to be somewhat high, are not actually more than would be required to cover the cost of similar work in connection with steam plants, including the cost of cleaning, scaling, and preparing boilers for inspection, repairs to feed-pumps, and other auxiliary apparatus.

Capital Outlay.—For the purpose of computing the average cost of installing gas-engines and suction-gas producers, the author has decided not to take into account any approximate figure for the cost of space occupied, or for any special buildings erected for their special housing, owing to the very few instances that occur in practice when it becomes necessary to do otherwise than fit them up in some corner of a factory already in existence. The prices indicated in the accompanying chart (Fig. 6) includes the cost of the engine, producer, pulley, water-circulating tanks, piping (to what gas-engine makers call "standard arrangement"—that is, when the component parts are disposed within about 20 ft. from one central point), foundation and builders' work, and labour in erection.

Fig. 6. CAPITAL OUTLAY, INCLUDING ENGINE, PRODUCER, PIPES AND ACCESSORIES, FOUNDATIONS & ERECTION.



As a basis, the ruling prices listed by two different makers have been plotted, additions being made for the builders' work and for labour, according to the author's experience of what may be considered average "fixings." These prices are probably on the high side, but will be quite sufficiently correct for rough estimating purposes.

It will be seen that, from 150 to 50 brake horse-power, the total cost is at the rate of about 7.5*l.* to 8*l.* per brake horse-power. From 40 brake horse-power downwards the

TABLE VI.—Combined Costs for Fuel, Oil, and Attendance.

Horse-Power.	Maker.	User.	Remarks.	Fuel. Pence Per Hour.	Labour. Pence per Hour.	Oil and Stores. Pence per Hour.	Total Pence per Hour.
96	Campbell ..	Martin and Co., Hull	Coke breeze	5.67	6.9	0.41	13
90	,,	Butler and Co., Bristol	,, at 15s.; 75 tons	6	8.5	1.28	15.78
120	,,	Workington Br. and Boiler Company ..	At 8s., coke-screenings	4.7	9.05	0.965	14.65
Two 132	,,	Glaholm and Robson, Sunderland ..	Anthracite, 10½ tons; coke, 52 tons; and town gas to eke out power	17.0	9.25	3.74	30
70	,,	Robb Brothers, Birkenhead	Anthracite, at 30s.; coke, at 17s. 6d.; mixed.	9.12	3.84	1.1	14.06
Two 29	,,	Great Eastern Railway, Hunstanton ..	Anthracite, at 31s. 6d.; carbon ends, at 31s. 6d.	4.5	8.75	0.81 and water	14.06
136	,,	Dereenalomane Barytes Mines, Limited	Anthracite, at 26s...	14.5	7.78*	2.54	24.8
30	,, ..	V. Rawson, Glasnevin	Anthracite, 25 tons, at 20s. 6d., 25l. 12s. 6d.	2.4	4.8	..	7.2
46	,, ..	J. A. Grant and Co., Glasgow ..	Anthracite, at 13s. 6d.; 25 tons	1.51	4.0	0.178	5.68
108	,, ..	Watkins Brothers, Hereford	,, at 25s.; average 115 tons..	10.3	4.9	0.86	16.0
40	,, ..	Martyn and Co., Wadebridge ..	Labour, portion of 8.2d. per hour ..	5.3	4.1	0.6	10.6
120	,, ..	Stevenson and Son, Dundonald	Anthracite, at 32s.; 1?0 tons	14.8	3.2	1.86	19.86
28	,, ..	Smith and Son, Barnard Castle	,, at 24s. 6d.; 17 tons ..	2.07	1.74	0.174	4.0
50	,, ..	Jno. G. Cooling, Gainsborough	,, at 15s. 8d.; 25 tons 13 cwt.	3.6	2.45	—	—
One 140 & one 40	Crossley ..	Arrol-Johnstone Car Company	Anthracite, at 15s. 6d.	10.75	5.35	0.642	16.75
58	Campbell ..	Chertsey Sewage Works	,, at 32s. 6d.	5.17	11.0	1.235	17.45
Two 28 & one 16	Campbell ..	Chippenham Water Works	.. ..	4.8	4.9	1.39	11.1
Three 63	Tangye ..	North-Eastern Railway, York	.. ..	7.0	6.0	0.965	14.0
35	Campbell ..	Bath Corporation	Anthracite, at 30s. 6d.; 27 tons.. ..	3.55	6.9	1.36	11.8
6	Tangye ..	Welwyn Water Works	,, at 24s.	0.68	2.0	0.153	2.83
63	,, ..	Basingstoke Water Works	,, at average 30s. per ton; 95 tons 6 cwt.	7.84	10.05	3.88	21.77
Three 40 & 2 other	Hornsby ..	Esher and Ditton Sewage Works ..	.. ..	3.8	9.0	0.575	13.4
68	Tangye ..	Cie. Anonyme Continentale	Anthracite, at 20s...	7.35	12.5*	—	19.85
Two 150	Westinghouse	Davis and Timmins, Limited	,, at 30s..	35.0	14.6	5.34	55.0
96	Campbell ..	Broxburn Electric Station	,, at 16s. 9d.	7.7	4.95	1.18	13.83
50	Hornsby ..	F. B. Grant and Co., Teddington ..	82 weeks, 4?87 hours	4.4	2.22	0.602	7.2
70	,, ..	Holliday and Greenwood, Brixton ..	No details	..	..	..	8.5
35	,, ..	C. Horsell, Weybridge	.. ..	1.31	—	—	—
40	,, ..	David Rees and Sons, Swansea Valley ..	.. ..	2.4	—	—	—
100	,, ..	Crystal Ice Co., Cheetham, Manchester..	No details	..	..	.	12.0
90	,, ..	Withington Sewage Works	Coal, 28s. 6d.; oil, water, and labour..	..	..	..	33.0
39	Tangye ..	Alex. Gray, Buckie, N.B.	Anthracite, at 16s.	1.67	—	—	—
39	,, ..	Jno. Bryce, Kirkcaldy	,, at 12s.; water, at 1s. per 1000 gals.; oil, at 2s. per gal.	1.4	—	1.2	2.6
115	,, ..	Hutchison, Main, and Co., Glasgow ..	Anthracite, 15s. per week of 66 hours..	2.72	—	—	—
44	,, ..	O. Smith and Co., Wolverhampton ..	,, 15s. per week of 54 hours..	3 33	—	—	—
44	,, ..	Wm. McPherson, Stirling	20 months, at 9 hours per day	1.33	—	—	—
59	,, ..	Jas. Thorburn and Co., Stranraer ..	8s. 6d. per week of 57 hours	1.78	—	—	—
25	,, ..	P. J. Woodruff and Co., Newport, Mon.	Anthracite, at 20s.; 1 cwt. in 7 hours..	1.71	—	—	4.5
17½	,, ..	Thomson Craik and Co., Ltd., Perth ..	,, at 11s. 6d.	0.968	—	—	—
17½	,, ..	Jas. Allen and Co., Coatbridge	,, at 10s.; 60 hours = ½ ton..	1.0	—	—	—
17½	,, .	Methil Engineering Works, Fife.. ..	,, at 11s. 7d.; 1176 lb. for 87 hours	0.833	—	—	—
39	,, ..	Robt. M. Stirling, Glasgow .. .	Anthracite, at 11s. 6d.	1.18	1.0	..	2.18
44	,, ..	Fraser and Young, Dalbeattie	,, at 17s. 6d.	1.76	—	—	—
17	Hornsby ..	Milne and Robb, Peterhead	.. ..	1.4	—	—	—
94	,, ..	Petty and Sons, Limited, Reading ..	.. ..	8.7	—	—	—
81	,, ..	Jas. Thomas and Co., Limited, Newport, I.W.	Anthracite, at 32s.; 2½ tons 125 hours	8.2	—	—	—
37	,, ..	W. Hooker and Son, Canterbury ..	,, at 31s.; 25 cwt. 90 hours..	5.16	—	—	—
36	,, ..	Wakely Bros., Rainham	,, at 31s.	2.07	—	—	—
135	,, ..	Wm. Conolly, Ltd., Goulbourne, N.S.W.	,, at 20s.	7.5	—	—	—
40	,, ..	B. Horton and Son, Westerham	,, at 30s.	2.57	—	—	—

* These include repairs.

rate per brake horse-power increases, ranging from about 9*l.* to 11.5*l.* in the smallest sizes.

Comparison with Diesel Engines.—One of the most successful engines that have been brought to a high degree of efficiency and reliability of late years is the internal-combustion engine using heavy liquid fuel, and operating upon the Diesel principle. Now that the early patents have expired, quite a number of engineering firms, both in this country and on the Continent, are taking up the construction, and the future seems to promise some keen competition between the two types in the industrial world.

There is no doubt that the Diesel engine, as made by firms possessing wide experience in their design and operation, permits a nearer approach to the ideal efficiency with regard to the conversion of heat units available into work than any other motor yet produced. Repeated tests have shown that as much as 42 per cent. of the total heat value of the fuel is represented by the work performed upon the piston of the engine as recorded by the indicator, whereas the equivalent of a consumption of 0.7 lb. of anthracite per brake horse-power with a combination of gas-engine and suction-gas producer would represent a thermal efficiency, on the indicated horse-power basis, of but 31 per cent.

The consumption of liquid fuel per brake horse-power with a Diesel engine is usually at the rate of 0.45 lb. per hour. The price of the oil fluctuates according to the ruling market prices, and for the present purposes can be fixed at 50s. per ton. At this rate, the cost per brake-horse-power hour is about 0.12d.

Upon the basis of 0.7 lb. of anthracite per brake-horse-power hour at 30s. per ton, the cost of fuel for the suction-gas plant is 0.1125d. It will be seen, therefore, that as far as fuel-cost alone is concerned there is not very much to choose between the Diesel and suction-gas engines, and the decision to instal the one or the other must rest upon other considerations. One very serious consideration, to the disadvantage of the Diesel engine, is the matter of capital outlay, involving, as this does, not only increased annual standing charges for interest on the sums expended beyond the relative cost of a suction-gas installation of equal power, but also the allowance for depreciation must be increased in proportion. In some instances, when the engines are of considerable capacity and are working long hours with sufficient load to enable full advantage to be taken of the low consumption, and where local conditions are least favourable to the gas-power plant, the balance inclines to the use of the Diesel engine. But, even then the gas-power plant, calling, as it does, for attention of a less skilled nature, can frequently be run at a lower rate for attendance, while the consumption of lubricating oil is usually lower.

It will be recognised from these remarks that there is no warrant for a general assumption of superiority, as far as total costs of running are concerned, in favour of either one or the other motor; but for factories in which a skilled engineer is not required by the type of industrial machinery, it will not be seriously challenged that in that factory there is no room for a Diesel engine. Even in factories where the daily supervision can be given by an engineer, and not an engine-driver, it must be admitted that whether the superior thermal efficiency of the Diesel engine is likely to be actually shown on the balance-sheet or not is a matter that cannot be settled merely by reading a magazine article and by giving a nod or a shake of the head to the arguments for and against there incompletely stated.

Comparison with Semi-Stationary Steam-Engines.—Semi-stationary steam-engines combined with a high-pressure boiler with superheater, jet condenser, with two-stage or compound expansion, have come to the front during recent years. From test results, it has been found that under full loads the consumption of fuel per brake-horse-power hour has been brought to the low figure of approximately one pound of coal, and this being so, the steam-engine has been able to show to much better advantage than ever before in competition with the suction-gas engine.

From the circumstances inseparable from steam generation, however, this remarkably low consumption cannot be maintained in actual operation with the same continuity as, from the tables presented in this paper, has been proved to be existent with the gas-power plant.

When it is remembered that, for the best results to be maintained, it is advisable to adopt some system of water-softening and purification, and that the cost of the whole equipment is thereby increased far beyond the cost of the gas-power plant, it will be recognised that the advantages of the latter are still further emphasised. Especially is this so when the engine is required to deal with a load much above or below the rated power of the plant, or for unsteady and widely-varying outputs. In the one case the economical limits of condensing steam-engines are sharply defined, while the liability of sudden fluctuation of load must involve some waste of fuel from the blowing off of excess steam from the safety-valves, due to the natural anxiety of the stoker to have his plant ready for any emergency.

Conclusion.—The author is strongly of the opinion that, in the near future as in the years that have just passed, there is bound to be a great demand for the suction-gas engine and producer. He has dealt only, in the present paper, with those installations in which the fuel has to be purchased from outside sources, and has not referred to the recent developments in the utilisation of material that is a waste product of industrial processes, such as wood chips and sawdust, &c., from sawmills and joinery works, from cotton seeds, and similar refuse. Neither has he referred to the suction-gas plants that are now available for the utilisation of bituminous coal in place of anthracite. Sufficient has been said, it is hoped, to enable the actual working results obtained in practice to be appreciated at their true value.

The author's thanks are tendered to those firms mentioned in the various tables who have been kind enough to provide him with such useful data, and who have accorded him their permission to use it in this public manner.

THE MECHANICAL INFLUENCE OF CARBON ON ALLOYS OF IRON AND MANGANESE.*

By J. O. Arnold, D.Met., and F. K. Knowles, B.Met., Respectively Professor and Lecturer of Metallurgy in the University of Sheffield.

In the *Journal of the Iron and Steel Institute*, 1910, No. 1, page 172, in their paper on "The Chemical and Mechanical Relations of Iron Manganese and Carbon,"† Arnold and Read stated that "the influence of the carbon is very considerable, but is by no means the dominating factor, which without doubt is the manganese.

The present paper may be regarded as being written mainly to prove the truth of the foregoing enunciation. The authors have already described the methods adopted for the preparation of the steels employed, in the *Journal of the Iron and Steel Institute*, 1906, No. 1, page 108 *et seq.*‡

Chemical Compositions.—With reference to elements other than carbon and manganese, the sulphur contents ranged from 0.02 to 0.04 per cent., the phosphorus from 0.02 to 0.07 per cent., and the silicon range was from 0.06 to 0.21 per cent.

Two series of steels were made, in both of which the manganese ranged from about 1 to 20 per cent.

In one series, however, the carbon was about 0.85 per cent., whilst in the other it was kept under 0.1 per cent.

Heat Treatment of the Alloys.—What may be regarded almost as the extremes of physical condition were secured in both series of alloys by a rapid and by a very slow cooling of the 1-in. round bars, which were respectively quenched in a tank of cold water from 860 deg. Cent. (quenched or Q series), and cooled from a similar temperature to milk-warm over a period of about three days (annealed or A series).

Turning Properties.—The authors' laboratory engineer, Mr. J. Harrison, reports his observations at the lathe during the preparation of the test-pieces as follows:

TABLE I.—*Annealed Series.*

Steel No.	Carbon.	Manganese.	Physical Properties.
	per cent.	per cent.	
952 A ..	Under 0.1	1.10	Soft.
977 A ..	,,	3.13	Soft.
961 A ..	,,	4.10	Slightly tough.
957 A ..	,,	5.50	Slightly hard.
951 A ..	,,	10 50	Very hard and very tough.
956 A ..	,,	12.90	Hard and very tough.
967 A ..	,,	15.70	Moderately tough.
955 A ..	,,	19.85	Tough.

The word "tough" refers to the capacity of the material to curl off in spirals from the nose of the turning tool.

TABLE II.—*Quenched Series.*

Steel No.	Carbon.	Manganese.	Physical Properties.
	per cent.	per cent	
952 Q ..	Under 0.1	1.10	Slightly tough.
977 Q ..	,,	3.13	Slightly hard and slightly tough.
961 Q ..	,,	4.10	Moderately hard. Slightly tough.
957 Q ..	,,	5.50	Hard and slightly tough.
951 Q ..	,,	10.50	Would not machine.
956 Q ..	,,	12.90	Ditto
967 Q ..	,,	15.70	Slightly hard. Moderately tough.
955 Q ..	,,	19.85	Slightly hard. Very tough.

The behaviour in the lathe of the carburised series in their annealed condition was as follows in Table III.:—

TABLE III.—*Carburised Annealed Series.*

Steel No.	Carbon.	Manganese.	Physical Properties.
	per cent.	per cent.	
990 A ..	0.85	1.16	Slightly tough
996 A ..	0.88	3.10	Moderately tough
999 A ..	0.87	4.98	Tough
1085 A ..	0.95	10.07	Very hard and very tough
1065 A ..	0.82	15.11	Hard and very tough
1084 A ..	0.93	19.59	Slightly hard and very tough

The above carburised series in a quenched condition

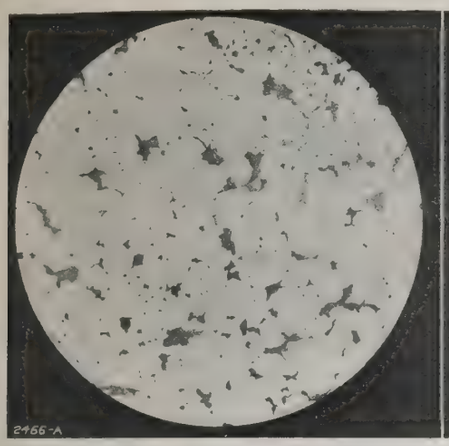
* Paper read before the Iron and Steel Institute in London on October 5, 1911.

† See Engineering, vol. lxxxix., page 626.

‡ *Ibid.*, vol. lxxxi., page 670.

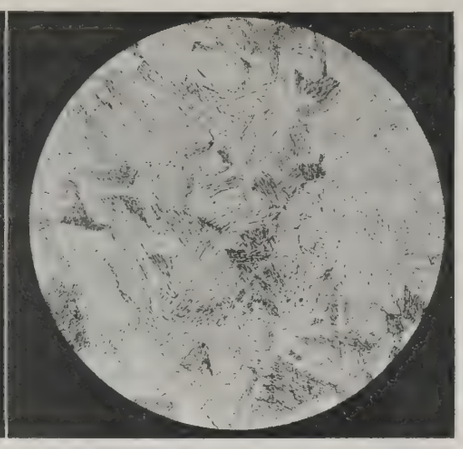
are reported as "non-machinable" by the highest quality of Sheffield high-speed turning tool steel.

Static Mechanical Tests.—The comparative tensile tests of carburised and nearly carbonless alloys of iron and manganese are embodied in Table IV., the steels being in their highly annealed state.



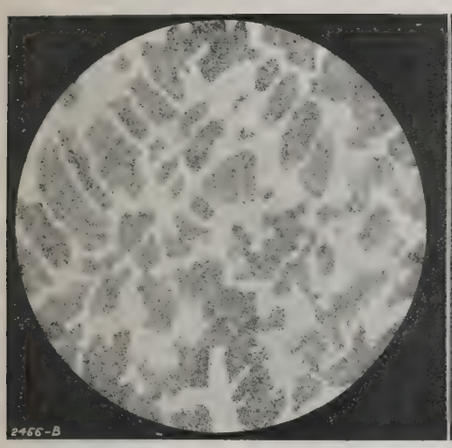
MICROGRAPH No. 1.

Steel No. 952A Carbon, under 0.1 per cent.; manganese, 1.10 per cent. Magnified 185 diameters. Direct light.



MICROGRAPH No. 2.

Steel No. 961A. Carbon, under 0.1 per cent.; manganese, 4.1 per cent. Magnified 185 diameters. Direct light.



MICROGRAPH No. 3.

Steel No. 956A. Carbon under 0.1 per cent.; manganese, 12.9 per cent. Magnified 185 diameters. Direct light.

MICROGRAPH No. 4.

Steel No. 955A. Carbon, under 0.1 per cent.; manganese, 19.85 per cent. Magnified 185 diameters. Direct light.

TABLE IV.

All test-pieces 2 in. parallel by 0.564 in. in diameter.

Steel No.	Carbon.	Manganese.	Yield-Point.	Maximum Stress.	Elongation per Cent. on 2 In.	Reduction of Area.
	per cent.	per cent	tons per sq. in.	tons per sq. in.		per cent
990 A	0.85	1.16	25.76	52.76	10.5	11.7
952 A	Under 0.1	1.10	19 04	24.48	43.5	79.7
996 A	0.88	3.10	39.48	59.64	5.0	5.2
977 A	Under 0.1	3.13	34.56	41.42	25.0	63.2
961 A	Under 0 1	4.10	20.56	53.48	25.5	42.4
999 A	0.87	4.98	33.96	54.64	2.0	2.0
957 A	Under 0.1	5.50	38 68	65.96	28.5	38.1
1085 A	0.95	10.07	30.12	42.22	1.0	1.4
951 A	Under 0.1	10.50	30.80	57.88	1.0	0
956 A	Under 0.1	12.90	19.80	56.12	6.5	4.6
1065 A	0.82	15.11	28.00	49.88	9.5	9.7
697 A	Under 0.1	15.70	57.80	63.72	17.5	20.6
1084 A	0.93	19.59	24.68	52.16	23.5	19.5
*955 A	Under 0.1	19.85	22.32	55.05	30.0	33.5

* The mechanical properties of a 30 per cent. manganese alloy may be found in Arnold's paper on "The Uniform Nomenclature of Steel," Journal of the Iron and Steel Institute, 1910, No. I., page 190.

Dynamic Stress-Strain Tests.—The alternating tests carried out under standard conditions on the Arnold machine registered the results recorded in Table V.

The figures registered in alternation by a quenched nearly carbonless series are embodied in Table VI. The corresponding carburised series were not capable of being turned.

MICROGRAPHIC FEATURES OF FOUR TYPICAL NEARLY CARBONLESS ALLOYS.*

Micrograph No. 1.—Manganese, 1.1 per cent. This consists of allotrimorphic crystals of manganiferous ferrite with dark etching troostitic areas containing the double carbide of iron and manganese in an emulsified condition. The segregation of this first variety of manganiferous pearlite is obviously incomplete.

Micrograph No. 2.—Manganese, 4.1 per cent. This section exhibits a martensitic structure often well defined.

Micrograph No. 3.—Manganese, 12.9 per cent. This section exhibits a martensitic structure often well defined.

Micrograph No. 4.—Manganese, 19.85 per cent. This section exhibits the apparently non-crystalline and soft alloy, having the colour of pale brass, which is typical of iron containing, say, from 15 to 35 per cent. of manganese. The softness of this type of alloy increases with the manganese within the limits named.

The authors, in conclusion, tender their thanks to their colleague, Mr. J. Wreaks, B.Met., for his beautiful and exact reproductions of the four micro-sections chosen to illustrate the paper, and also to their melter, Mr. Stacey, for his skill in carrying out the difficult practical operations necessary to produce almost carbonless alloys of iron and manganese

* A similar set of carburised alloys are figured by Arnold and Read in the Journal of the Iron and Steel Institute, 1910, No. 1, page 184. See also ENGINEERING, vol. lxxxix., page 627.

TABLE V.—*Behaviour in Alternation of the Annealed Series.*

Steel No.	Carbon.	Manganese.	Alternations Endured.		
			First Test.	Second Test.	Mean.
	per cent.	per cent.			
990 A ..	0.85	1.16	160	162	161
952 A ..	Under 0.1	1.10	344	356	350
996 A ..	0.88	3.10	72	106	89
977 A ..	Under 0.1	3.13	186	182	184
961 A ..	Under 0.1	4.10	210	240	225
999 A ..	0.87	4.98	28	28	28
957 A ..	Under 0.1	5.50	192	222	207
1085 A ..	0.95	10.07	8	8	8
951 A ..	Under 0.1	10.50	6	6	6
956 A ..	Under 0.1	12.90	52	36	44
1065 A ..	0.82	15.11	244	238	241
967 A ..	Under 0.1	15.70	274	306	290
1084 A ..	0.93	19.59	226	272	249
955 A ..	Under 0.1	19.85	216	214	212

TABLE VI.—*Alternating Stress Tests on Quenched Alloys.*

NOTE.—The 10 to 13 per cent. manganese alloys would not machine.

Steel No.	Carbon.	Manganese.	Alternations Endured.		
			1st Test	2nd Test	Mean.
	per cent.	per cent.			
952 Q	Under 0.1	1.10	248	276	262
961 Q	,, 0.1	4.10	140	136	138
957 Q	,, 0.1	5.50	30	22	26
967 Q	,, 0.1	15.70	232	188	210
955 Q	,, 0.1	19.85	208	206	207

FOREIGN ENGINEERING PROJECTS.

WE give below a list of foreign engineering projects, for some of which tenders are asked. Further information concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Egypt: The British Acting Consul-General at Alexandria (Mr. E. H. Mulock) reports that tenders are invited by the municipal authorities at that place for the construction of the Mahmudieh main rain-water sewer and its waste-pipe, being part of the Alexandria Main Drainage Works (see page 112 *ante*). Sealed tenders, enclosed in two envelopes, the inner marked "Offre pour la construction du Collecteur Mahmoudieh et de son Déversoir," and the outer addressed to M. le Président de la Commission Municipale, Alexandria, will be received by him up to noon on January 9 next. A deposit of E1000*l.* is required with each tender. Proof of technical capability is required from tenderers. A copy (in French) of the *Cahier des charges* may be seen by British contractors at the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C.

Turkey: The following information is from the report by the British Vice-Consul at Cavalla (Dr. S. Pecchioli) on the trade of that district in 1910, which will shortly be issued:—A plan of the town has been made with a view to the elaboration of a main drainage system, very favourable proposals for the execution of which have been made by a German company; no practical result, however, has yet been arrived at. The question of the water works—which is, if anything, even more important for the town than that of the drains—stands to-day in a slightly more hopeful position. A good and abundant supply of water has been found at a distance of about 4 miles from the town, the necessary plans and estimates have been drawn up, and it is hoped that work will really be commenced within the space of a few months.

Austria-Hungary: The *Reichsgesetzblatt* (Vienna) of September 23 publishes a notice granting to Messrs. Bruno Pammer and Ernst Porak, of Kienberg, a concession for the construction and working of a standard-gauge railway from Zartlesdorf to Lippner Schwebe *via* Hohenfurth.

Belgium: The *Bulletin Commercial* (Brussels) of September 23 notifies, on the authority of the Belgian Consul at Batavia, that a company, domiciled in Europe, is on the point of obtaining from the Government of the Netherlands East Indies a concession for the construction of a direct railway from Kamal to Kwanjar (Island of Madura). The line will be 10 miles long, and will cost 200,000 gulden (about 17,000*l.*) to construct.

Spain: The *Gaceta de Madrid* of September 20 contains a notice, issued by the Ministry of Fomento, to the effect that the contract for the construction of the Tosas Tunnel, in connection with the building of the Ripoll-Puigcerdá Railway, has been awarded to the Sociedad Corsini Retuerta y Bruned, of Saragossa. The cost of the work is estimated at 6,207,000 pesetas (about 230,000*l.*).

Brazil: The *Diario Official* of September 1 publishes decrees as follow:—(1) Decree No. 8926, opening, in favour of the Ministerio da Viação e Obras Publicas, a credit of 700,000 milreis (about 47,000*l.*) to defray the cost of extending the Central Railway of Brazil main line in the direction of Montes Claros; (2) Decree No. 8927, similarly providing a credit of 500,000 milreis (about 33,000*l.*) for extending the Itacurussá section of the Central Railway of Brazil as far as the town of Angra; and (3) Decree No. 8928, providing a credit of 100,000 milreis (about 7000*l.*) for dredging and clearing the Paruguassú River, in Bahia. The *Diario* of September 3 contains a decree, No. 8931, authorising Manoel José da Costa Lisboa to construct 12½ miles of railway from the iron works which he is arranging to erect at Antonina to the Paraná Railway.

Norway: The Commercial Intelligence Branch of the Board of Trade is informed by H.M. Consul at Christiania (Mr. E. F. Gray) that tenders are invited by the Norwegian State Railway authorities for the supply of various tools and materials. Tenders, marked "Anbud redskaper og materialier," and accompanied by drawings, models, or samples, should be addressed by the resident agents of British manufacturers to "Bygningschefens kontor," Trondhjem, where they will be received up to 7 p.m. on October 14. It should be noted that in all Norwegian Government contracts a preference (apart from Customs duties) is given to Norwegian manufacturers, and that it is obligatory that a resident agent (not necessarily a Norwegian firm) should act for tenderers not residing in Norway.

A NEW INDUSTRY FOR SOUTH AFRICA.—Messrs. Cartwright and Eaton, Limited, of Johannesburg, S.A., have commenced the erection of an iron and steel works near Benoni for the purpose of working up iron and steel scrap into products to meet the local requirements. Rolling-mills and other machinery are being shipped by Messrs. Thos. Perry and Sons, Messrs. Francis Berry and Son, and others, through Messrs. Mitchell, Cotts, and Co., of No. 4, London Wall-buildings. Skilled men are being engaged in England to run the plant.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

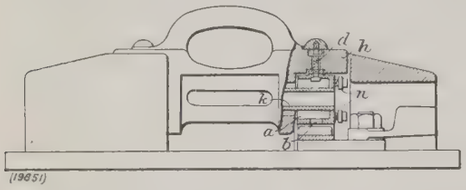
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

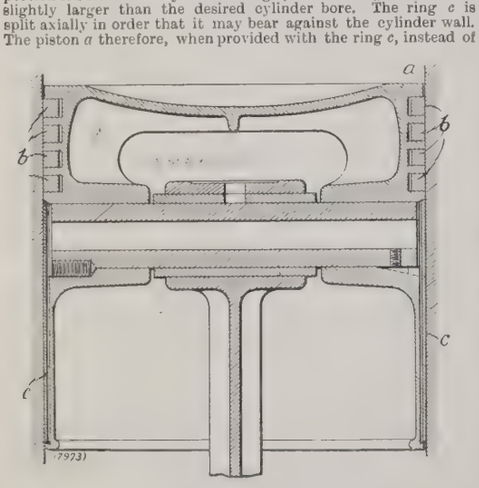
19,851/10. A. C. Reyrolle and A. Reyrolle and Co., Limited, Hebburn-on-Tyne. Cut-Outs. [4 *Figs.*] August 25, 1910.—This invention relates to cut-outs comprising a fuse extending between a pair of rigid contacts carried by a holder of insulating material, and each adapted to be inserted between the jaws of a corresponding stationary clip so as to be readily removed therefrom, and so that whilst in use its opposite faces make contact with both of the said jaws. According to this invention, for the purpose of securing efficient contact between the opposing faces of each rigid fuse contact and the jaws of the corresponding stationary clip, such rigid contact is pivotally secured to its holder. In the example illustrated, each self-adjusting contact is in the form of a hollow brass casting *a* having a flat surface, which is adapted to be pressed by a tool introduced through a hole *b*, so as to produce an externally protruding seating that is partially spherical in form, with a more or less corresponding internal surface. A screw *d* having



a head with a convex surface adapted to engage the concavity of the said seating, is passed through a hole of larger diameter than the screw formed in the seating, so that, with the aid of a nut having a concave surface complementary to the convex surface of the seating, the contact block *a* can be clamped in a yielding manner to a movable porcelain support *h*. The screw *d* may extend completely through the porcelain support *h* and be secured by an ordinary nut, any suitable cap of insulating material being screwed on to the screw *d* to prevent contact being accidentally made with the latter. The movement of the contact blocks *a* is limited partly by an asbestos tube *k*, through which the fuse-wires pass, and partly by the shape of the porcelain support *h*, the whole arrangement being such that the contacts are permitted to yield to suit any inclination which may exist between a pair of stationary clips, and so secure good electrical contact. *n* represents bars for clamping the fuse-wires to the contact-blocks. (*Accepted August* 2, 1911.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

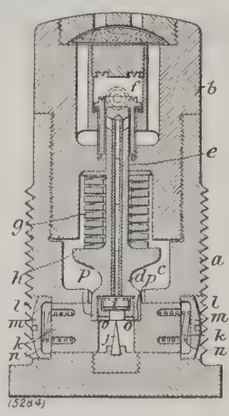
17,973/10. C. Y. Knight, Coventry. Pistons. [1 *Fig.*] July 28, 1910.—This invention relates to trunk pistons of the form commonly employed in internal-combustion engines, and consists in surrounding a piston substantially throughout its available length with a spring sleeve member. The invention further consists in surrounding that portion of the cylindrical surface of a piston unoccupied by the usual pressure-retaining spring-rings with a spring member. The piston *a* is of the usual shape, and the portion below the usual pressure-retaining rings *b* is reduced in diameter, a small flange being left at the bottom edge. This portion is surrounded by a broad ring *c*, which is originally turned slightly larger than the desired cylinder bore. The ring *c* is split axially in order that it may bear against the cylinder wall. The piston *a* therefore, when provided with the ring *c*, instead of



having the necessary clearance between the walls of the piston itself and the cylinder, has a clearance between it and the surrounding ring *c*, and as the ring has an outward spring action a film of oil is readily formed between the ring *c* and the piston *a*. According to a modification, the top edge of the broad ring may be formed with a flange adapted to engage in the lowest of the grooves of the pressure-retaining rings, and is thus held from shifting longitudinally of the piston; and in this case the formation of an oil film between the wide ring and the piston may be aided by tapering the bottom edge of the surrounding ring in an outward and downward direction, so that the spring ring has a more or less sharp bottom edge, which tends to force the oil between the piston and the ring on every down stroke. (*Accepted August* 2, 1911.)

GUNS AND EXPLOSIVES.

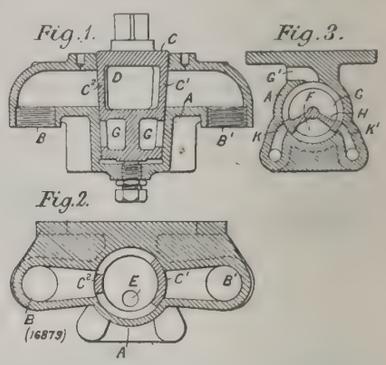
5284/11. R. H. S. Bacon and R. Redpath, Coventry. Percussion Fuses. [3 *Figs.*] March 2, 1911.—This invention consists in a percussion fuse for projectiles wherein an axially sliding plunger carrying a percussion cap is designed to move under the action of a spring against a fixed firing-pin to effect the firing of the fuse, in a reverse direction to that in which the projectile travels when fired from the gun, the said spring being under compression and capable of being slightly further compressed under the weight of the plunger when the velocity of the projectile is suddenly retarded, and wherein there are weights normally restraining the plunger from movement towards the firing-pin, which weights, when the plunger moves slightly forward in compressing the spring, will move under centrifugal action and free the plunger to operate under the action of the spring to fire the percussion-cap. The body of the fuse consists of two parts *a* and *b*, the part *a* being a hollow and externally screw-threaded portion, designed to be screwed axially into the end of the projectile, and the part *b* a plug which is screwed into the hollow portion *a*. In the interior of this body is formed a chamber *c*, in which the plunger *d* is arranged, the plunger being capable of longitudinal movement in the direction of the axis of the projectile, and sliding in a hole *e* formed between the chamber *c* and a second chamber *f* in the body part *b*, a spring *g* being arranged around the plunger between the body part *b* and a shoulder *h* on the plunger. This spring is strong enough to overcome the tendency which the plunger *d* always has to move forward relatively to the fuse, owing to the constant retardation of the velocity of the projectile due to the resistance of the atmosphere, but not strong enough to withstand slight compression under the momentum of the plunger when the projectile strikes an object. The rear end of the plunger *d* is constructed to carry the percussion-cap, and



is arranged adjacent to the firing-pin *j* secured to the body part *a* of the fuse. *k*, *k* are the blocks or weights which normally prevent the plunger from moving rearwardly under the action of the spring *g*, these weights being inserted through radial apertures *l* in the body part *a* of the fuse, and the apertures being subsequently closed by caps *m*, *m*, whilst springs *n*, *n* are provided between the said caps and the weights *k*, *k* for pressing the latter inwards towards the plunger. These weights *k*, *k* are provided with lips or projections *o*, *o* which engage with corresponding projections *p*, *p* upon the plunger *d* in such a manner that, during the flight of the projectile, the weights will be prevented from moving outwards under the centrifugal action due to the rotation of the projectile. From the above-described construction it will be seen that, when the projectile is fired from the gun, the central plunger *d* is restrained from movement under the action of the spring *g* by the weights *k*, *k*, whilst the weights are at the same time restrained by the plunger from radial movement due to the centrifugal force arising from the rotation of the projectile. When the motion of the projectile, however, is retarded, due to its striking any object which suddenly reduces its velocity, the central plunger, which is not subject to such retardation, moves forward under its momentum and compresses the spring *g* sufficiently to release the weights *k*, *k* from the restraint of the interlocking projections *o*, *p*, so that they are free to move out radially under centrifugal action owing to the rotation of the shell, thus freeing the plunger *d* for longitudinal movement. The forward movement of the plunger relative to the shell, due to the sudden retardation of the latter, soon ceases, and the plunger is then forced rapidly to the rear by the action of the spring *g*, thus causing the percussion cap to strike against the firing-pin and be ignited, but, owing to the above-described movement of the plunger, at some small interval of time after the first impact of the projectile against an object. (*Accepted July* 26, 1911.)

PUMPS.

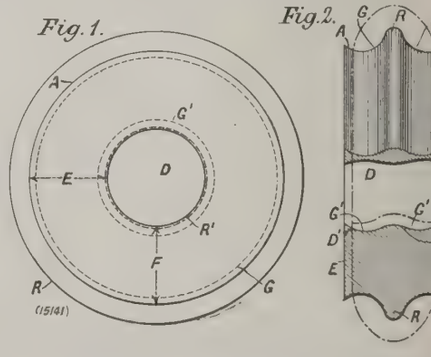
16,879/10. Mayor and Coulson, Limited, and J. M. Copland, Glasgow. Air-Compressors. [4 *Figs.*] July 15, 1910.—This invention relates to mechanism for controlling the operation of air-compressors of a type in which the compressor is provided with valve-gear adapted to be set for the purpose of distributing the air to the compressor to produce either forward or backward rotation, as may be required, by means of which mechanism a connection with a supply of compressed air may be made with and cut off from the engine, and, in the operation of making the connection, the distribution of compressed air to valve-gear mechanism governed for effecting the required setting of the valve-gear. Controlling mechanism consists, according to this invention, in a rotary valve by which compressed air from a source of supply may be delivered direct to, or cut off from, an engine to be controlled, and in the rotation of the valve, for the delivery of air to the engine, a connection made by the valve governing the distribution of air from the source of supply to valve-gear mechanism for effecting the required setting of the valve gear. The controlling device illustrated, which is appropriate for use in conjunction with a valve-gear having no tendency to assume any definite position, or one having a tendency to normally assume a neutral position midway between that for forward or backward rotation, comprises a shell A having a conical bore from which an in-branch B, for connection with a main air-supply pipe, and an out-branch B^1, for connection with the valve-chest of the engine, extend, the two branches B, B^1 presenting ports adapted to be controlled by a conical plug-valve C formed with a central chamber D, to which communication is established with the in-branch B and out-branch B^1 by a through way, the closure of the out-branch being effected by a covering portion C^1. As shown, the valve is formed with a portion C^2, which is not sufficiently wide to cover the port of the in-branch B. From the central chamber D a way E extends and forms a permanent connection between the chamber D and a chest F (see Fig. 3) formed below the central chamber D. The chest F may conveniently be of segmental form, the complementary part of the circle constituting with the surrounding portion of the shell A an exhaust chamber G, having an exhaust port G^1, the chest and exhaust-chamber being separated by a wall H, the two peripheral face portions of which are adapted to act as closure portions to pass over two gear ports K, K^1 formed in the casing and arranged so that by turning the valve C in one direction one of the gear ports is put into connection with the main air-supply, while the other is put into connection with exhaust. The peripheral face portions of the wall H are so disposed that when the valve is set in what may be termed a neutral position they cover both the gear ports K, K^1. In order that the connection with either of the gear ports may be established before the through connection has been established for the engine, the covering portion C^1 which controls the out branch B^1 is made longer than the covering portion C^2 which controls the in-branch B, so that in either direction of rotation a connection is first made with the central chamber D and with one of the gear ports K or K^1, and at a later stage in the continued turning of the plug valve C the connection between the air-supply from the in-branch B with the out-branch



B^1, and the engine is established. The covering portion C^2 controlling the in-branch B, as shown, is of less width than its corresponding port, or it may be entirely dispensed with, so that a connection between the central chamber D and the in-branch B is always maintained. It will be understood that in the turning of the valve when one of the gear ports K or K^1 is put into connection with the exhaust, the other is put into connection with the air main. For operation, the valve C may be fitted with a hand-lever, adapted to be turned into a neutral or central position, and into a backward valve-gear setting and backward working position, or into a forward valve-gear setting and forward working position. In either of the valve-gear setting positions, the connection necessary for moving the valve-gear is first made, the connection of the air-supply with the valve-chest of the engine only being completed after passing the gear-setting position when the working position is approached. To indicate the respective positions, stops may be provided for the extreme positions of the controlling lever, and for indicating when any of the intermediate positions are reached the lever may be furnished with a spring detent associated with appropriate depressions, of which one corresponds to the neutral or central position, the others with, say, the backward and the forward valve. (*Accepted July* 26, 1911.)

RAILWAYS AND TRAMWAYS.

15,141/10. C. H. Gray, Silvertown. Buffers. [10 *Figs.*] June 23, 1910.—This invention relates to annular buffers of india-rubber, and of the type exemplified by the rings employed to encircle the stem of a metallic buffer-head in railway rolling-stock. According to this invention, there is provided a rubber buffer which has approximately parallel ends, is annular, has a central rib, and has gutters or depressions whose edges provide a set-back portion. If desired, both the inner and outer circumferences of the annulus may be provided with a central rib, gutters, and set-back portions. The contour of the outer circumference of the buffer is set back at A, so that the interior angle between it and the adjacent end is necessarily less than 90 deg. Fig. 2 shows the buffer uncompressed and having a cylindrical central bore D, the circumference of which is also set back at each end, so that the interior angle between it and the adjacent end is again necessarily less than 90 deg. The annuli at E and



F are each reduced in width, as compared with the width of corresponding annuli in old types of rubber buffers, to such an extent as to obviate the cracking of the material intermediate of the width of each of the said annuli, which cracking has heretofore been common. An external central rib R is provided on the buffer, which, co-operating with the set-back portions A and gutters G formed thereby, prevents the portions of the buffer set-back at A from curling away from the rib towards the compression-plate. Similarly, a central internal rib R^1, co-operating with the gutters G^1 formed by the set-back portions D^1, prevents these latter from curling towards the compression-plates from the said rib. It will be seen, therefore, that in a buffer thus constructed, with ribs, gutters, and set-back portions, the compression will not be able to bring into contact with the compression surfaces applied at its ends any portion of the buffer not originally in contact with them—that is to say, it is not able to bring into contact with them any portion either of the central bore or of the outer circumference. (*Accepted August* 2, 1911.)

THE STEAM-TURBINE.

(*Continued from page* 374.)

It was stated on page 307 *ante* that when there is no tip leakage the work, W, done by a group of blades, per pound of steam passed, is given by the relation

$$W = \frac{s}{32.2} \cdot \left[r_0 \left(N + \tfrac{1}{2} \log_\epsilon \rho \right) b \cos \alpha - \frac{N s}{2} \right].$$

If there is tip leakage, the work done, in the case of standard blades, will be reduced in the ratio $\frac{h - c}{h + 2.15\, c}$, where h denotes the blade height, and c the tip clearance. The coefficient b is equal to

$$\frac{\gamma + 1}{\gamma} \cdot \frac{1 - \frac{x_N}{\rho_N x_N}}{1 - \frac{1}{\rho_N x_N}},$$

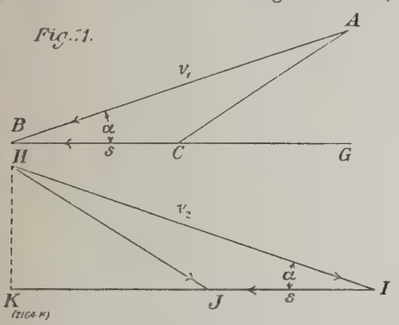
where γ is the index in the expression $P V^\gamma$ = constant.

These formulæ may be established as follows:—

Consider a group consisting of n stages, half of which are constituted by the fixed rows and half by the moving rows. Let $v_1\ v_2\ v_3 \ldots v_n$ be the velocities of outflow of the steam from the corresponding stages.

Referring to Fig. 11, let A B $= v_1$ denote the direction and magnitude of the velocity of the steam as it issues from the first row of guide-blades, and

Fig. 11.



let C B $= s$ denote the speed of rotation of the wheel. The momentum of each pound of steam as it issues is equal to $\frac{v_1}{g}$, and the component of this momentum in the direction of rotation is G B $\div\ g$, or

$$\frac{v_1 \cos \alpha}{g}.$$

Taking now stage No. 2, which is a row of moving blades, the steam issues from this with a velocity which, measured relatively to the moving blades, is given by the line H I $= v_2$. This, as stated, is a relative velocity, and the absolute velocity, in space, of the steam as it issues, is obtained by setting off I J $= s$ and joining H J. The absolute momentum of 1 lb. of the steam as it issues is, therefore, equal to H J $\div\ g$. The momentum of this in the direction of motion is $-$ K J $\div\ g$, which, it will be seen, is equal to

$$-\frac{v_2 \cos \alpha - s}{g}.$$

This component is directed in the opposite direction to G B, and hence the total change of momentum parallel to the direction of its own motion which the moving wheel has effected on the pound of steam is

$$\frac{\text{G B} + \text{K J}}{g} = \frac{v_1 \cos \alpha + v_2 \cos \alpha - s}{g}.$$

Now, by an elementary principle in mechanics, the force acting on a body is equal to the change of momentum effected per second in the same direction. Hence, if w pounds of steam pass through stage No. 2 per second, the force exerted on this mass in the plane of rotation is equal to

$$\frac{w}{g} \left\{ (v_1 + v_2) \cos \alpha - s \right\}.$$

Since action and reaction are equal and opposite, this is also the force tending to rotate the wheel.

The total rotating force exerted on a group is therefore the sum of a similar quantity to the above for every row of moving blades. This may be called the impulse on the group, and this impulse is therefore equal to

$$\frac{w}{g} \cdot \left\{ \cos \alpha \sum_1^N v - \frac{N s}{2} \right\},$$

where N denotes the total number of stages, which is, of course, twice the number of moving rows in the group.

In passing through the various stages of a group the steam expands, and its specific volume V increases. If Ω be the area of the passage-way, the velocity v is given by the relation $V w = v \Omega$, so that the expression just given may be written

$$\frac{w}{g} \left\{ \frac{w}{\Omega} \cos \alpha \sum_1^N V - \frac{N s}{2} \right\}$$

where $\sum_1^N V$ denotes the sum of the specific volumes of the steam measured at each successive stage.

In general, V_0, the initial volume of the steam, is known, as are also p_0 and p_N, where p_N denotes the pressure on discharge from the group.

If the law by which V increases stage by stage from V_0 to V_N were known, the value of $\sum_1^N V$ could be readily found. The simplest assumption, no doubt, is that the value of V plotted against n gives a straight line, but this overestimates the work done, since the true curve is convex towards the axis of n.

A more accurate assumption is that

$$V_n = V_0 \mu^n,$$

where μ can be obtained from the relation that $V_N = V_0 \mu^N$, or $N \log \mu = \log \rho_N$

This makes

$$\sum_1^N V = V_0 \frac{\rho_N - 1}{1 - \left(\frac{1}{\rho_N} \right)^{\frac{1}{N}}},$$

whence the impulse on the group is

$$\frac{w_0}{g} \left\{ r_0 \cos \alpha \cdot \frac{\rho_N - 1}{1 - \left(\frac{1}{\rho_N} \right)^{\frac{1}{N}}} - \frac{N s}{2} \right\}$$

This, though a better approximation to the truth than the assumption that the relation between V and n is expressed by a straight-line law, is still not satisfactory, and again overestimates the work done; because the assumed law $V = V_0 \mu^n$ makes the ratio of expansion the same for each successive stage. Since the volume increases, however, more work is necessarily expended at each successive stage in forcing a given weight of steam through it, and thus actually the ratio of expansion must increase from stage to stage, so as to provide for the additional energy required.

An approximation to the true law of increase of volume can be established as follows:—It appears to be a reasonable assumption that the kinetic energy generated at each stage shall be approximately proportional to the expansion energy* expended in the stage.

The drop of pressure at each stage is small, and calling it ΔP, the expansion energy accounted for in the stage, per pound of steam passed, may be taken as equal to $V \Delta P$.

The kinetic energy per pound of steam leaving the stage is, of course, equal to $\frac{v^2}{2g}$.

Thus, on the assumption above made we may write

$$V \Delta P = \lambda \cdot v^2,$$

where λ is some constant. But v^2 is proportional to V^2; hence we may write

$$V \Delta P = \beta V^2,$$

or

$$\Delta P = \beta V,$$

where β is another constant.

Assuming the relation between P and V to be $P V^\gamma$ = constant, we thus get $\Delta P = l P^{-\frac{1}{\gamma}}$, where l is some constant to be determined later on.

Now, ΔP is the decrease in pressure for a unit increase in the number of stages, and the solution of the above equation is accordingly a problem in the calculus of finite differences.

An approximate solution can be obtained as follows:—

Obviously, if P_0 be the initial pressure, and P the pressure behind some stage N, we must have

$$P_0 - P = \sum_1^N \Delta P \quad . \quad . \quad (3)$$

the total pressure difference being the sum of the pressure differences at each intervening stage.

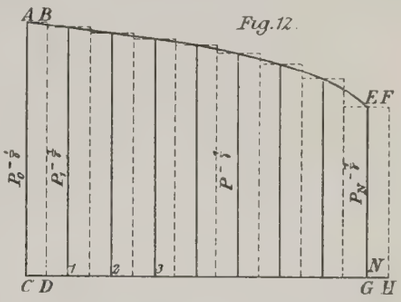
* This may also be called the "available heat" expended in the stage.

We may write, therefore,

$$P_0 - P = \sum_1^N \Delta P = l \sum_1^N P^{-\frac{1}{\gamma}}.$$

Suppose the ordinates in Fig. 12 represent successive values of $P^{-\frac{1}{\gamma}}$, then $\sum_1^N P^{-\frac{1}{\gamma}}$ is equal to the area of the dotted rectangles shown. This area is, in its turn, practically equal to that of the

Fig. 12.



curve A E G C, less the rectangle A B C D, plus the rectangle E F G H.

Since

$$\text{A C} = P_0^{-\frac{1}{\gamma}}, \text{ and E G} = P^{-\frac{1}{\gamma}},$$

the rectangle A D is numerically equal to $\frac{1}{2} P_0^{-\frac{1}{\gamma}}$, and the rectangle E H to $\frac{1}{2} P^{-\frac{1}{\gamma}}$.

Hence from (3) we get

$$P_0 - P = l \left(\text{area A E G C} + \tfrac{1}{2} P^{-\frac{1}{\gamma}} - \tfrac{1}{2} P_0^{-\frac{1}{\gamma}} \right).$$

$$= l \int P^{-\frac{1}{\gamma}} d n + \frac{l}{2} P^{-\frac{1}{\gamma}} - \frac{l}{2} P_0^{-\frac{1}{\gamma}}.$$

Differentiating with regard to n we get (since P_0 is constant)

$$-\frac{d P}{d n} = l P^{-\frac{1}{\gamma}} - \frac{l}{2\gamma} \cdot P^{-\frac{1}{\gamma} - 1} \cdot \frac{d P}{d n}.$$

Multiplying by $P^{\frac{1}{\gamma}}$ this equation may be written

$$-P^{\frac{1}{\gamma}} \frac{d P}{d n} = l - \frac{l}{2\gamma} \cdot P^{-1} \cdot \frac{d P}{d n}.$$

On integration this gives

$$-\frac{\gamma}{\gamma + 1} \cdot P^{\frac{\gamma + 1}{\gamma}} = l n - \frac{l}{2\gamma} \cdot \log_\epsilon P + A, \quad . \quad (4$$

where A is the constant of integration.

To determine l and A, we note that when $n = 0$, $P = P_0$, and when $n = N$, $P = P_N$, P_0 and P_N being respectively the initial and final pressures of the steam.

We thus have

$$-\frac{\gamma}{\gamma + 1} \cdot P_0^{\frac{\gamma + 1}{\gamma}} = -\frac{l}{2\gamma} \cdot \log_\epsilon P_0 + A \quad . \quad (5)$$

and

$$-\frac{\gamma}{\gamma + 1} \cdot P_N^{\frac{\gamma + 1}{\gamma}} = l N - \frac{l}{2\gamma} \cdot \log_\epsilon P_N + A$$

Subtracting we get

$$l \left[\left(N + \frac{1}{2\gamma} \right) \cdot \left(\log_\epsilon P_0 - \log_\epsilon P_N \right) \right] = \frac{\gamma}{\gamma + 1} \cdot \left\{ P_0^{\frac{\gamma + 1}{\gamma}} - P_N^{\frac{\gamma + 1}{\gamma}} \right\},$$

which if $\frac{P_0}{P_N} = x_N$ may be written

$$l \left(N + \frac{1}{2\gamma} \log_\epsilon x \right) = \frac{\gamma}{\gamma + 1} \cdot P_0^{\frac{\gamma + 1}{\gamma}} \left\{ 1 - \left(\frac{1}{x_N} \right)^{\frac{\gamma + 1}{\gamma}} \right\}$$

But if ρ_N be the ratio of the volumes at the beginning and end of the expansion, we have

$$\rho_N = x_N^{\frac{1}{\gamma}},$$

and thus we get

$$l = \frac{\gamma}{\gamma + 1} \cdot P_0^{\frac{\gamma + 1}{\gamma}} \left(1 - \frac{1}{\rho_N x_N} \right) \div \left\{ N + \tfrac{1}{2} \log_\epsilon \rho_N \right\}.$$

Substituting this value for l in equation (5) we get

$$A = \frac{\gamma}{\gamma+1} \cdot P_0 \cdot \frac{\gamma-1}{\gamma} \left[\left(1 - \frac{1}{\rho_N x_N} \right) \frac{\log_\epsilon P_0}{N + \frac{1}{2}\log_\epsilon \rho_N} \cdot \frac{\gamma}{2\gamma} - 1 \right].$$

Hence, substituting in equation (4) the values found for A and l, and letting P denote the pressure after any stage n, and if also $\frac{P}{P_0} = x$, whilst $\frac{V}{V_0} = \rho$, the following relation subsists between n, x, and ρ.

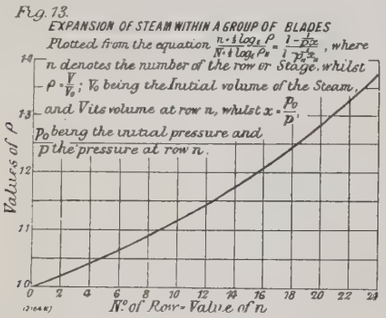
$$\frac{n + \frac{1}{2}\log_\epsilon \rho}{N + \frac{1}{2}\log_\epsilon \rho_N} = \frac{1 - \frac{1}{x\rho}}{1 - \frac{1}{x_N \rho_N}},$$

which, since $\rho = x^{\frac{1}{\gamma}}$, may also be written

$$\frac{n - \frac{1}{2}\log_\epsilon \rho}{N + \frac{1}{2}\log_\epsilon \rho_N} = \frac{1 - \left(\frac{1}{\rho}\right)^{1+\gamma}}{1 - \frac{1}{x_N \rho_N}} \quad . \quad . \quad (6)$$

The way the volume increases from stage to stage within the group is well shown in Fig. 13, where

Fig. 13.


EXPANSION OF STEAM WITHIN A GROUP OF BLADES
Plotted from the equation $\frac{n-\frac{1}{2}\log_\epsilon \rho}{N+\frac{1}{2}\log_\epsilon \rho_N} = \frac{1-\frac{1}{\rho x}}{1-\frac{1}{\rho_N x_N}}$, where
n denotes the number of the row or stage, whilst
$\rho = \frac{V}{V_0}$; V_0 being the initial volume of the Steam,
and V its volume at row n, whilst $x = \frac{P_0}{P}$,
P_0 being the initial pressure and
P the pressure at row n.
Values of ρ
10
11
12
13
14
0 2 4 6 8 10 12 14 16 18 20 22 24
No. of Row - Value of n

the ratio of expansion has been plotted against the number of the row.

For many purposes the logarithmic terms on the left may be omitted, and we may write simply

$$\frac{n}{N} = \frac{1 - \left(\frac{1}{\rho}\right)^{1+\gamma}}{1 - \frac{1}{x_N \rho_N}}.$$

The object at issue in deducing equation (6) has been to evaluate

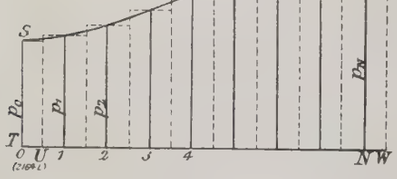
$$\Sigma_1^N V.$$

Since $V = \rho V_0$, we may write

$$\Sigma_1^N V = V_0 \Sigma_1^N \rho.$$

Suppose the successive values of ρ are plotted down against n, as in Fig. 14, then the value of $\Sigma_1^N \rho$ is equal to the area of all the dotted rectangles, which, it will be seen, is practically equivalent to the area of the curve S T V N, minus the rect-

Fig. 14.



angle S U, and plus the rectangle V W. Hence we may write

$$\Sigma_1^N \rho = \int_0^N \rho \, d\, n + \tfrac{1}{2}(\rho_N - \rho_0).$$

To find $\int \rho \, d\, n$, differentiate equation (6) *supra* with respect to n.

This gives

$$d\, n + \frac{1}{2\rho} \cdot d\,\rho = \frac{N + \frac{1}{2}\log_\epsilon \rho_N}{1 - \frac{1}{\rho_N x_N}} \cdot (\gamma+1)\,\rho^{-\gamma-2} \cdot d\,\rho.$$

Whence

$$\rho \, d\, n = \frac{N + \frac{1}{2}\log_\epsilon \rho_N}{1 - \frac{1}{\rho_N x_N}} \cdot (\gamma+1)\,\rho^{-\gamma-1} d\,\rho - \frac{d\,\rho}{2}.$$

Hence

$$\int_0^N \rho \, d\, n = \left[\frac{N + \frac{1}{2}\log_\epsilon \rho_N}{1 - \frac{1}{\rho_N x_N}} \cdot \frac{\gamma+1}{\gamma} \cdot \rho^{-\gamma} \right]_0^N - \left[\frac{1}{2}\rho \right]_0^N$$

$$= \frac{N + \frac{1}{2}\log_\epsilon \rho_N}{1 - \frac{1}{\rho_N x_N}} \cdot \frac{\gamma+1}{\gamma} \cdot \left\{ 1 - \rho_N^{\gamma} \right\} - \tfrac{1}{2}\rho_N + \tfrac{1}{2}\rho_0.$$

Since $\rho^\gamma = x$, we get finally

$$\Sigma_1^N \rho = \int_0^N \rho \, d\, n + \tfrac{1}{2}\rho_N - \tfrac{1}{2}\rho_0$$

$$= \frac{N + \frac{1}{2}\log_\epsilon \rho_N}{1 - \frac{1}{\rho_N x_N}} \cdot \frac{\gamma+1}{\gamma}\left(1 - \frac{1}{x_N}\right).$$

Values of

$$\frac{\gamma+1}{\gamma} \cdot \frac{1 - \frac{1}{x}}{1 - \frac{1}{\rho x}}$$

for different values of x are plotted in Fig. 4, page 307 *ante*, both for wet and superheated steam, and this expression we may conveniently denote by b. Up to values of $x = 3$, the value of b is, with such ranges of turbine efficiency as are usual in practice, nearly independent of variations in the efficiency η of the turbines.

Thus, taking the case of wet steam, comparative values of b for values of γ, equal respectively to 1.108 and 1.0675, are as follow :—

Pressure ratio, x, =	1.25	1.50	2.0	2.5
b ($\gamma = 1.108$)	1.1000	1.1796	1.2986	1.3836
b ($\gamma = 1.0675$)	1.1039	1.1868	1.3108	1.3993

From Fig. 9, page 374, it will be seen that $\gamma = 1.108$ corresponds to an efficiency of about 77 per cent., and $\gamma = 1.065$ to one of about 29 per cent. The difference between the corresponding values of b is, it will be seen, very small, even for pressure ratios as high as 2.5, whilst in practice this pressure ratio is commonly not much more than $\sqrt{2}$.

As already proved, the impulse on the blading of a group having no tip leakage is equal to

$$\frac{w}{g} \cdot \left\{ \frac{w}{\Omega} \cdot \cos\alpha \, \Sigma_1^N V - \frac{N\,s}{2} \right\}$$

and $\Sigma_1^N V = V_0 \Sigma_1^N \rho$, which, from the foregoing, is equal to $V_0 (N + \frac{1}{2}\log_\epsilon \rho)\, b \cos\alpha$.

Hence the impulse may be written in the form

$$\frac{w}{g}\left\{ \frac{w V_0}{\Omega} \cdot (N + \tfrac{1}{2}\log_\epsilon \rho)\, b \cos\alpha - \frac{N\,s}{2} \right\}$$

But $\frac{w V_0}{\Omega} = v_0$, the velocity at entrance, so that finally the impulse on the group is

$$\frac{w}{g}\left\{ v_0 (N + \tfrac{1}{2}\log_\epsilon \rho)\, b \cos\alpha - \frac{N\,s}{2} \right\}$$

The work done per second is equal to this impulse multiplied by s, the blade speed. Whence W, the work done per pound of steam passed per second, is given by the relation

$$W = \frac{s}{g}\left\{ v_0 (N + \tfrac{1}{2}\log_\epsilon \rho)\, b \cos\alpha - \frac{N\,s}{2} \right\}$$

Q.E.D.

It now remains to find an expression for the value of v_0, the velocity of the steam at entrance.

The energy tending to produce flow through any row of blades of the group is equal to the energy developed by the expansion of the steam as it flows through a row, plus the kinetic energy carried over from the preceding row.

Let q_n denote the expansion energy, at any row n, expressed in foot-pounds per pound of steam passed, and

$$\frac{v_{n-1}^2}{2g}$$

the kinetic energy "carried in" to the same row.

The kinetic energy of the steam as it leaves the row is equal to

$$\frac{v_n^2}{2g}$$

and we have then the relation

$$\frac{v_n^2}{2g} = m\, q_n + M \cdot \frac{v_{n-1}^2}{2g}$$

where M and m are coefficients to be determined from experiment.

Then if v_{n-1} be the velocity of outflow from row $(n-1)$, and s be the blade speed, we have from Fig. 11

$$v_{n-1}^2 = v_{n-1}^2 + s^2 - 2\,s\,v_{n-1}\cos\alpha.$$

We thus get

$$\frac{v_n^2}{2g} = m\, q_n + \frac{M}{2g} \cdot \left[v_{n-1}^2 + s^2 - 2\,s\,v_{n-1}\cos\alpha \right]$$

Putting

$$v_n = \rho_n \, v_0$$

we get

$$\frac{v_n^2}{2g} = \frac{v_0^2 \rho_n^2}{2g} = m\, q_n + \frac{M}{2g} \cdot \left[v_0^2 \rho_{n-1}^2 + s^2 - 2\,s\,v_0 \rho_{n-1} \cos\alpha \right]$$

Now, since experiment has shown that former ideas as to hydraulic shock are erroneous, we may take M as practically constant for every stage.

It is convenient to assume that there is a "carry in" of energy even in the case of stage No. 1, and to put this as equal to

$$\frac{M}{2g}(v_0^2 + s^2 - 2\,s\,v_0\cos\alpha).$$

The error involved is very small at the most, and the assumption simplifies the mathematics of the problem.

Adding up the values of $\frac{v_0^2 \rho_n^2}{2g}$ for every row, we get

$$\frac{v_0^2}{2g} \cdot \Sigma_1^N \rho_n^2 = m \Sigma_1^N q_n + \frac{M}{2g} \cdot \left[v_0^2 \Sigma_0^{N-1} \rho_n^2 + N s^2 - 2\,s\,v_0 \cos\alpha \, \Sigma_0^{N-1} \rho_n \right]$$

We have already shown that

$$\Sigma_1^N \rho = \int_0^N \rho \, d\, n + \tfrac{1}{2}(\rho_N - 1),$$

and, similarly, by reference to Fig. 12 or Fig. 14, it will be obvious that

$$\Sigma_1^N \rho^2 = \int_0^N \rho^2 d\, n + \tfrac{1}{2}(\rho_N^2 - \rho_0^2);$$

and ρ_0 is, of course, equal to 1.

Again, the figures in question show that

$$\Sigma_0^{N-1} \rho^2 \text{ is equal to } \int_0^N \rho^2 d\, n - \tfrac{1}{2}(\rho_N^2 - 1)$$

and, similarly,

$$\Sigma_0^{N-1} \rho = \int_0^N \rho \, d\, n - \tfrac{1}{2}(\rho_N - 1).$$

The value of $\int_0^N \rho \, d\, n$ has already been found, and is equal to

$$b (N + \tfrac{1}{2}\log_\epsilon \rho_N) - \frac{\rho_N - 1}{2}.$$

Hence

$$\Sigma_0^{N-1} \rho = b (N + \tfrac{1}{2}\log_\epsilon \rho) - (\rho_N - 1).$$

To obtain the value of $\int_0^N \rho^2 d\, n$ we get from (6), above

$$d\, n + \frac{d\,\rho}{2\rho} = \frac{N + \frac{1}{2}\log_\epsilon \rho_N}{1 - \frac{1}{\rho_N x_N}} \cdot (\gamma+1) \cdot \rho^{-\gamma-2} d\,\rho.$$

Whence

$$\rho^2 d\, n + \tfrac{1}{2}\rho \, d\,\rho = \frac{N + \frac{1}{2}\log_\epsilon \rho_N}{1 - \frac{1}{\rho_N x_N}} \cdot (\gamma+1) \cdot \rho^{-\gamma} d\,\rho.$$

Therefore

$$\int_0^N \rho^2 d\, n = \left[\frac{N + \frac{1}{2}\log_\epsilon \rho_N}{1 - \frac{1}{\rho_N x_N}} \cdot \frac{\gamma+1}{1-\gamma} \cdot \rho^{1-\gamma} \right]_0^N - \left[\tfrac{1}{3}\rho^3 \right]_0^N$$

$$= \frac{N + \frac{1}{2}\log_\epsilon \rho_N}{1 - \frac{1}{\rho_N x_N}} \cdot \frac{\gamma+1}{\gamma-1} \cdot \left(1 - \frac{\rho_N}{x_N}\right) - \tfrac{1}{3} \cdot \left(\rho_N^3 - 1\right)$$

Substituting this value in our equation for $\frac{v_0^2}{2g}$ we get

$$\frac{v_0^2}{2g}\left[(N + \tfrac{1}{2}\log_\epsilon \rho) \cdot \frac{\gamma+1}{\gamma-1} \cdot \frac{1 - \frac{\rho_N}{x_N}}{1 - \frac{1}{\rho_N x_N}} + \tfrac{1}{4}(\rho_N^3 - 1) \right]$$

$$= m \Sigma_0^N q_N + \frac{M}{2g} v_0^2 \cdot \left\{ \begin{array}{l} (N + \frac{1}{2}\log_\epsilon \rho) \frac{\gamma+1}{\gamma-1} \cdot \frac{1 - \frac{\rho_N}{x_N}}{1 - \frac{1}{\rho_N x_N}} \\ - \frac{3}{4}(\rho^2 - 1) + N s^2 \\ - 2 s r_0 \cos\alpha \left\{ b (N + \frac{1}{2}\log_\epsilon \rho) \right. \\ \left. - \rho_N + \rho_0 \right\} \end{array} \right\} \quad (7)$$

Now $\Sigma_0^N q_n$ is the total work done in expansion

$$i.e., \Sigma q_N = \frac{\gamma}{\gamma - 1} \cdot P_0 V_0 \left(1 - \frac{\rho_N}{x_N}\right).$$

We have thus obtained a rational expression connecting together the steam-speed at entrance to a group, with ρ the total ratio of expansion in the group, s the blade-speed, and N the number of rows in the group.

(To be continued.)

THE IRON AND STEEL INSTITUTE.

As briefly reported last week, the autumn meeting of the Iron and Steel Institute was held at the Institution of Civil Engineers on Thursday, October 5, the President, his Grace the Duke of Devonshire, being in the chair. At the commencement of the meeting the President explained that the Council had regretfully concluded that it was advisable to postpone the Italian meeting. When the time approached the numbers who would have been able to go to Turin were greatly reduced, chiefly on account of the present labour troubles, and it was thought that it was not worth while going in only a small body. They had, therefore, had to send their apologies to the Italian Society, and he hoped that he would shortly be able to see the Italian Ambassador and express personally to him the regret they felt at the unavoidable change in their plans, and, with their apologies, to thank through him all who had made arrangements on their behalf. The resolution, of which we gave the gist last week, was then read and passed, the President proposing, and Sir Hugh Bell seconding it. Before proceeding to the papers a proposal was made by the President that, as the new Master Cutler was to be elected that day, they should send a message of congratulation to Mr. A. Balfour in connection with that event. This was duly approved by the members present.

Transformations of Steel.

After some formal business the President announced that the first paper to be taken would be that by M. L. Grenet, on the "Transformations of Steel within the Limits of the Temperatures Employed in Heat Treatment." This paper we commence to reprint *in extenso* elsewhere in this issue of Engineering, and we will therefore proceed at once to the discussion, which was opened by Sir Robert A. Hadfield, who thought that the Institute was greatly indebted to M. Grenet for the paper, although all members would possibly not agree with his conclusions. The paper put before the Institute the French view of this subject, and it was important to them as influencing the French steel-makers. In one part of the paper M. Grenet used the words "such rapid cooling does not occasion variations in the hardness," while in his conclusions he remarked that cases were known of quenched material being softer than unquenched. The statements did not appear quite to agree. Sir Robert Hadfield stated that he had himself known cases, notably of manganese steel forgings, which did not increase in hardness when quenched, but rather showed slightly softer.

Professor J. O. Arnold, who spoke next, said that it was a source of great congratulation to him to notice from the paper how closely the two rival schools of thought on this subject were approaching one another. With regard to the statement in the paper that martensite might be regarded as a very fine aggregate of two, or sometimes three, constituents, that, of course, was the view that metallurgists of the Sheffield school had taken from the first. Martensite was not a distinct constituent, but a structure. It was a generic structure. M. Grenet's conclusion that "iron-carbon alloys partake of the general category of alloys, and no complications due to allotropic transformation of the element iron need be taken into consideration," was most important. The carbonist school had held that view for some twenty years, and it was a pleasure to find that the Paris school was now coming into line with them.

The next speaker was Dr. J. E. Stead, who said the paper was worthy of careful consideration. He agreed with Sir R. A. Hadfield in thinking that opinions would differ as to the conclusions, but the ideas advanced should be discussed in the fullest possible manner. He regretted the introduction of so many terms into the subject. The "hot stable state" of the paper was, of course, known by others under the name of "austenite," and the cold stable state as the "α condition." All said and done, the paper gave no definition of what transformation really was, and the author, towards the end, came to the conclusion that "so far as the real cause of hardening is concerned, it cannot be said to be known." All that they knew was that when quenched from above some critical point, hardening did occur. Before trying to draw dogmatic conclusions, he thought it would be wise to go into the matter more fully. When the cause of hardening became known, it would be possible to make some further progress. Until that occurred, comparatively speaking, we knew nothing.

On the subject of alloys he disagreed with the author's mode of expression. An alloy was commonly supposed to consist of two or more metals melted together, but M. Grenet applied the term to pure metals, in which he claimed one of the constituents was in the proportion of nil, instancing pure, or nearly pure, iron. This was, Dr. Stead held, a misapplication of terms. There could not be an alloy of one constituent any more than there could be a marriage solemnised in the absence of one of the two parties. In the case of slightly impure metals the impurity would form the second constituent of an alloy. The author further made a peculiar statement with reference to solid solutions, to the effect that when pure iron passed through the critical temperature the iron itself passed into solid solution. This could scarcely be correct, as the iron was already in the form of a solid solution before the change. Apparently the author considered that iron-carbon alloys below 900 deg. Cent. were α iron, and all above, γ iron. This, of course, was not the general view by any means.

Dr. W. Rosenhain was the last speaker on this paper. He said that from the author's conclusions as stated in the paper, he apparently differed both from the majority of the French workers, and also from investigators here. M. Grenet seemed to think that hardening was due to transformation under difficult conditions. He was willing to explain or to discuss hardening without reference to allotropic modifications. Dr. Rosenhain considered that in this the author was mistaken, as those facts were intimately connected with the hardening, as the equilibrium diagram clearly explained. The author further ignored the heat evolutions which occurred in changes from γ to β iron. It was clear that there were changes in the mechanical properties and in the constitution when the temperature was raised. These the author did not take account of. Perfect quenching might be regarded as the perfect permanent retention of the metal in the form it took when heated. Some of the changes to which names had been given, such as martensite, troostite, &c., found no place in the equilibrium diagram. These should not be named in this way, as it led to confusion.

The Mechanical Influence of Carbon on Alloys of Iron and Manganese.

The next paper taken was one by Professor J. O. Arnold and Mr. F. K. Knowles. This we reprinted in full in our last week's issue.* It was entitled "The Mechanical Influence of Carbon on Alloys of Iron and Manganese." The paper was summarised by Professor Arnold, and the first speaker in the discussion was Sir R. A. Hadfield, who said that he thought the series of alloys with which the paper dealt was a most remarkable one. He considered that, in all probability, the laboratory of the Sheffield University was the only place where the production of such an excellent series of alloys was possible. He referred especially to those low in carbon. Twenty-five years ago, when he was experimenting with manganese alloys, there was no pure manganese. Manganese steel owed its properties jointly to the manganese and the carbon. Without the carbon it would be useless. Professor Arnold had supplied him with samples of the alloys referred to in the paper, and these he had taken the liberty of testing by the Brinell method, after having heated them to 1000 deg. Cent., and then quenched them. The following figures for the low-carbon series were obtained, the specimen numbers and percentages being as given in Professor Arnold's paper:—

Specimen Number.	Manganese. Per Cent.	Brinell Hardness Number.
952 A	1.10	143
977 A	3.13	430
961 A	4.10	418
957 A	5.50	418
951 A	10.50	444
956 A	12.90	302
967 A	15.70	192
955 A	19.85	235

* See page 478 *ante*.

It would be noticed that at and after the 13 per cent. of manganese the hardness test showed a considerable drop, which corresponded with the facts brought out in Professor Arnold's paper. He would say that the Brinell figure for pure iron was about 90, and for the hardest steel known between 700 and 800. The low-carbon series showed a gradual increase to about 12 per cent., but the figures for the high-carbon series were rather different, as would be seen in the following table:—

Specimen Number.	Manganese Per Cent.	Brinell Hardness Number.
990 A	1.16	650
996 A	3.10	600
999 A	4.98	286
1085 A	10.07	179
1065 A	15.11	196
1084 A	19.59	192

This series showed a gradual falling off from high figures at the commencement of the series down to about 12 per cent, and then an increase. He had also carried out bending tests on these alloys, and these he would add in his contribution to the Proceedings. Briefly, in the low-carbon series the low per cent. manganese alloys bent easily, but as the percentage increased the alloys became brittle and would not bend. After a certain amount, however, the bending improved again. The bending tests, in fact, corresponded with the result of the hardness tests. In the high-carbon series there was the same agreement. The first alloy bent very little, while that containing 10 per cent. Mn bent to 82 deg., and the alloy of the highest manganese content bent double and remained unbroken. The micro-photographs in the paper were very interesting, and the author was to be congratulated on the fact that he had not attempted an explanation when he had no sure ground to go upon. He thought that many mistakes had arisen solely through attempts being made at explanation. The fact that a man of Professor Arnold's experience admitted that explanation was still lacking showed how far we still had to go in such matters.

Dr. J. E Stead said that a great deal more of the kind of work recorded in this paper was wanted before conditions accompanying annealing, &c., were considered. He was sorry, however, that the author left so much out of his paper, as, for instance, matters relating to recalescence, &c. Had Professor Arnold obtained information on such points? What was the final state of the alloys? Was there twinning in the case of the alloys with the higher percentages of manganese? He had found that with austenite steels (as, for instance, 1.5 per cent. carbon steels) twinning appeared throughout the series. On reporting this matter to Professor Osmond that gentleman had informed him that this was only to be expected. He would like to know whether austenite conditions could be obtained with low carbon with rapid quenching. With reference to the use of the term "martensitic structure," he wished members for a moment to consider how this could be defined. One definition would evidently be that it was a structure sometimes taken by a substance called "martensite." A sorbitic steel would be one containing sorbite. Troostite, sorbite, and martensite had no place in the equilibrium diagram. Was there any justification for the retention of terms which denoted a form instead of a substance? For instance, martensite might sometimes have a large structure. It was only obtained when the heating was carried sufficiently high. A name for the form taken was essential, but it would equally well be described as a triangular structure, and the name martensite could be abolished.

Professor J. O. Arnold, in reply, said that with regard to the remarks of Dr. Stead, that speaker asked for information outside the ground covered by the paper. With regard to recalescence points none had been obtained, so that it was not possible to speak of them, neither had twinning been observed. He might add that martensitic structure existed in all sorts of material, and was not found only in connection with hardenite; it might occur in other steels.

Temperature Influences on Carbon and Iron.

The next paper taken was one by Mr. E. Adamson, entitled "Temperature Influences on Carbon and Iron." This paper is reproduced verbatim on page 507 of this issue. The discussion, which followed upon the summary of it given by the author, was brief. It was opened by Dr. J. E. Stead, who was of the opinion that the paper constituted an attack upon the analyst. He considered analysts' work most

valuable. The determination of the silicon was most important. One might have a No. 1 pig with only 0.5 per cent. silicon, but if that were remelted it was impossible to reproduce from it pig with 0.5 per cent. silicon. Analysis helped the founder. If there were 2 per cent. of silicon in pig giving a close-grain fracture, the analysts' work led one to believe that sulphur must be present also. Fractures alone were misleading. No. 1 pig run to a ½-in. plate or slab gave a No. 4 fracture. Analysis would then be more valuable than the fracture. No. 4 pig, with close fracture, cooled very slowly, would give a fracture of a grade below No. 1, and so on, so that fracture alone was no indication. The analyst considered the total carbon. If there were too much carbon, the iron was weak, and analysis showed that it should be reduced. All elements should be taken into account. Again, the analysts' work was important in that it indicated in what way bad irons could be utilised to give good results. This knowledge was now put to service, and results obtained which had been impossible before. He thought it just as well that this subject of grading of pig should be brought up from time to time, so that they might know where they stood.

Sir R. A. Hadfield said he thought the paper needed some amendment in its title, to which the words "in Pig Iron" should be added, as it was wholly concerned with that material. In his own experience, it might be interesting to relate, he had obtained exactly similar results to those obtained with silicon, by employing aluminium instead of silicon. In the paper reference was made to pig containing 8 per cent. of carbon. This was a remarkable percentage, and he thought an effort should be made to obtain a sample of it to add to the collection gradually forming at the Institute's rooms.

Mr. Adamson, in reply, stated that Dr. Stead had slightly misunderstood him. He was not attacking the chemist, who, they would all admit, rendered valuable service in pointing out how unsatisfactory irons could be utilised. What he did attack, however, was the system of grading pig by analysis. That meant grading by silicon merely. The tables given in his paper did not agree altogether with Dr. Stead's statement as to sulphur present with 2 per cent. or so silicon, in conjunction with a close-grain fracture. He had found many similar results for pigs containing 1 per cent. and 3 per cent. silicon.

As time permitted, a short paper by Mr. L. L. Fermor was next read. This was entitled "On the Origin of the Iron Ores of Swedish Lapland." At the close of this paper, on which there was no discussion, the President proposed a vote of thanks to the Institution of Civil Engineers for allowing the Institute the use of their building for the meeting. This was duly seconded and adopted. It was followed by a vote of thanks to his Grace the Duke of Devonshire for presiding, proposed by Sir R. A. Hadfield. This was carried unanimously, and, after a few words of acknowledgment by the President, the meeting terminated.

LITERATURE.

Nitrocellulose Industry: A Compendium of the History, Chemistry, Manufacture, Commercial Application, and Analyses of Nitrates, Acetates, and Xanthates of Cellulose as Applied to the Peaceful Arts, with a Chapter on Gun-Cotton, Smokeless Powder, and Explosive Cellulose Nitrates. By Edward Chauncey Worden, Ph.C., M.A. In two volumes. London: Constable and Co., Limited, [Price 42s. net.]

To many it may be a surprise that two ponderous volumes should be required in order to set forth the part played by cellulose nitrate in industry and the arts. For to few can it be possible to apprehend adequately the magnitude of the ramifications outside their own experience. The manufacturer of explosives takes little interest in the formation of lacquers, the preparer of collodion films is indifferent to the question of turpentine substitutes. Cellulose, however, connects many apparently independent processes. There are, too, others, such as those engaged in producing silk filaments, or patent leather, who are willing perhaps that their ingenuity should not be too fully recognised, and are content to find their reward in the consciousness of having benefited their fellow-citizens by supplementing a deficient natural supply. A very cursory consideration, therefore, of the many departments of technical manufacture into which it is possible for nitrocelluose to enter will convince us that if completeness is to be achieved, one must have not one book, but many, a special Encyclopædia, whose object must be to offer a classified account of original investigations. That there must be necessarily much compilation goes without saying, but this, conducted with intelligence, enhances, rather than detracts from, the value of the book. An exhaustive bibliographic record at the hands of an expert, who carefully examines the statements and sifts endless patent specifications, has a value of its own, and in this case the value is increased by the preservation of an accurate perspective, extending throughout the many branches into which this subject is divided. Having in view the number of workers in the field, the ingenuity displayed, and the many directions in which it has been illustrated, the wonder is rather that sufficient industry should be manifested by one authority to examine and digest so many varied applications. The index alone runs to 75 pages, and we are afraid to say to how many journals and thousands of patents reference is made. For if we are to have a comprehensive survey of the growth of a varied and fascinating industry, there are allied subjects which must not be overlooked.

Such is the history of the discovery and manufacture of the solvents that have so enormously increased the usefulness and extent of cellulose application. The author is justified in saying that a main factor in the development of the industrial uses of cellulose nitrate has been due mainly to the discoveries and extensions of the solvents. Viewed in the perspective of present knowledge, the failure in the early days to advance can be traced to the lack of appreciation of the fundamental importance attaching to the solvent as distinguished from the pyroxylin. Early scientists were not able to discern the essential importance of appropriate dissolving liquids, or of converting solids. Many a solvent once rejected as unsuitable or uneconomical for a particular object, may yet find valuable application in an entirely different combination, so limitless is the range into which nitrocellulose enters.

The general scheme of the author can be indicated in a few words, the industry exhibited in carrying it to a successful issue can be best appreciated by those who have attempted similar analyses, and the degree of success can only be judged by the technical expert. The raw material destined to figure in so many protean forms is cellulose, and the author is perhaps indifferent whether this vague substance, whose chemical structure eludes exact analysis, is to be regarded as a colloidal aggregate, or as a highly complex molecule. He is concerned in its behaviour under technical treatment, not in its constitution, but he tells enough of its composition and manufacture to explain the process of nitration. By the end of the third chapter we are in possession of the cellulose nitrate, but inasmuch as in the dry state this preparation, save in the single case of explosives and propellants, has little commercial value, the author, true to his scheme of insisting on the equal importance of the solvents, devotes three chapters to the consideration of their manufacture and convenient manipulation. Here we can follow the exciting tale of the chemistry of fusel oil, the amyl alcohols, and of amyl acetate, that made pyroxylin lacquers possible. The interest is continued to the latent solvent, camphor, that has made celluloid a commodity of daily use, revealing both the magnitude and the possibilities of a wide extending industry.

Passing over the preparation of turpentine substitutes and paint-removers, which may find a wider application in the future, the author next traces in detail the preparation of lacquers and enamels, artificial and real leather coatings, and the production of silk filaments—a rapidly-expanding industry, which, if it has not yet had a detrimental effect upon the world's production of natural silk, may explain the comparative stationary condition of the French trade in the product of the silkworm.

These chapters conclude the first volume, and the second opens with the account of the formation of pyroxylin plastics, typified by celluloid, in which chemical ingenuity has been able to imitate so much that is beautiful in Nature and Art, and supply many of the necessities and luxuries of civilised life. Here doubtless the unscrupulous have enjoyed opportunities for deceiving the unwary amateur, and it is not impossible that many a valued *cloisonné* vase owes its origin to pyroxylin plastics, just as the amber mouthpiece of many a costly pipe has little in common with the fossil resin it so ingeniously imitates. The author may and does tell us much, but we imagine still more is unknown, for in many of these plastic processes there is room for the exercise of manipulative ingenuity and the display of artistic individuality. The laboratory and the machine-room still guard many secrets. Collodions as applied in pharmacy and photography conclude the application of what the author calls the peaceful arts. A chapter is added on gun-cotton, smokeless powder, and explosives. Cellulose acetates and xanthates are also considered, and remembering the all-important part played by denatured ethyl alcohol in most of the preparations, a final chapter is added on this indispensable adjunct.

This collection of chapter headings, to which we have been obliged to limit ourselves, indicates an ambitious programme, but is one that the author has treated ably. He knows and admits that it is not infrequent in industrial works for the text to leave off just at the point where specific information is most needed. He hopes that he has avoided that pitfall. This is a point that can be decided only by those who approach the book with a view of acquiring precise information on a particular difficulty. But it is a book that is addressed to the technical expert, and Dr. Worden is no doubt sincere when he says that there has been no mental reservation whatever in the development of the subject. The general plan in the treatment of each section is to describe the history of each process, to trace the treatment to which the raw materials are submitted in order to attain certain results, to describe the formation of allied compounds with their intermediate and subsidiary products, followed by an enumeration of the technical uses to which these products have been put, and the future possibilities in expanding the art. This seems to be a natural course, and it is one that the author has followed with success.

La Géologie et les Richesses Minérales de l'Asie: Historique, Industrie, Production, Avenir, and Métallogenie. Par L. de Launay, Ingénieur en Chef des Mines. Paris: Libraire Polytechnique Ch. Béranger. [Price 35 francs.]

M. de Launay has entered upon a hard task, but one of which his previous researches on the mineral wealth of Africa enabled him to gauge the difficulties. To appreciate the scheme upon which continents are built, destroyed, reconstituted, and reshaped, requires a vivid scientific imagination, great mastery of detail, and subtle insight into the behaviour of materials submitted to chemical, thermal, or physical forces. In a continent such as Asia, wide regions of which have not been geographically examined, the task is still more onerous, since it is necessary to fill up lacunæ as best possible, and to run the risk of minute correction as facts collect. But at times such risks must be accepted if we would cultivate the study of structural geology on a broad scale, and escape the narrowing influences that are apt to accompany the contemplation of small areas. The author invites us here to consider systems, and systems are not decided by small variations or increments due to local movements, but by changes that are world wide in scope. It is not necessary to suppose that sudden and unnatural catastrophes have occurred in the earth's history, or to depart from the accepted dogma that geological changes are the consequences of processes still in operation; but it is desirable to keep in mind that the rate of progress need not be uniform. Long periods of slow change have prepared the way for sudden movements and the exhibition of unusual energy. The machinery of earthquakes affords a familiar example.

M. de Launay takes us away from the study of the minute changes, with which we are too apt to content ourselves, to the broader issues for which the slow changes are a preparation, but, as the title of his book indicates, he keeps in view the economic side of geology, and although the petrographer and geologist may be more attracted by the inquiry how the minerals came into the position they occupy, their genesis and mode of aggregation, the author recognises that the capitalist, the prospector, or the practical miner is more concerned in estimating the value of the mineral wealth, and the methods of its extraction. He therefore caters for these classes, and for a still larger section of the public, who watch the gradual development of the country, the effect the mining industry will have upon the social forces of a district, and the extent to which it will

compete with older sources of exploitation. But, above all, the author is interested in developing his theory of "métallogénie" and of "gîtes métallifères," and we have here but a collection of facts, minute and valuable from an industrial, statistical, and economical outlook, which we understand will be used subsequently to show that the knowledge of the tectonic formation of a region will indicate what ore bodies will be encountered, as certainly as our knowledge of the stratigraphy of a district determines the possibility of finding coal or petrol. In a country so little explored as Asia, we admit the extreme importance of an accurate criterion for prospecting, and are glad to know that in every case in which the author has put his theory to a test he has met with ample confirmation. Nevertheless, of the three sections into which he has divided his treatise —1. Industrie; 2. Géologie; and 3. Métallogénie Régionale—it is the two earlier sections which have given us the greater satisfaction.

In the first part details are given of the gradual evolution of the industry from ancient times, with statistics regarding its present position, the influence of the extension of railways in effecting the economic development, and the more special conditions prevailing in the principal mines. We are invited to consider the future, in which all countries having reached an economic equilibrium, all will utilise their mineral wealth to the most effect. In those days English coal will be driven from the Far East by the Japanese supplies, and from the Indian Ocean by the stores dormant in Hindostan; while the petroleum supply of the Dutch Indies and of Japan will monopolise the markets of the East to the detriment of the American wells. In the meantime the remarks on gold-mining, with special reference to the Lena Goldfields, are not reassuring. M. de Launay does not look with a favourable eye on the permanence of the Siberian source of supply. An auriferous country can count on continuous mining only when the exploitation can be sunk to a considerable depth, as in the conglomerates of the Transvaal. The Siberian "placers" are not in this condition, and, with few exceptions, the primitive beds encountered in Siberia are of small value. Theory seems to point to the possibility of auriferous conglomerates, like those of the Transvaal, in the folded strata on the borders of the Chinese Empire, but no trace has yet been announced.

In the second part on the Geology of Asia, a uniform plan is pursued of presenting first a comprehensive glance at the main stratigraphical and tectonic features, and then describing the geology of the natural divisions in detail. It is on this study of the existing conditions combined with a general homotaxis, that all ulterior deductions must rest. How far the author's maps, which he has given, correctly represent the paleographical history of the continent at contemporaneous epochs, must be left to experts; and it may be safely said that in the absence of more exact data than are at present forthcoming, scarcely two authorities would agree even in the principal features. The author is perfectly aware of the uncertainties of contour, and the reason for them, but he maintains that there is sufficient evidence to prove that from the Cambrian period down to our own times certain prominent features can be recognised with more or less distinctness. This persistence is the more remarkable as constant change is the main characteristic. This persistence is manifested "(1) pour un long sillon marin Est-Ouest, destiné à être remplacé à l'époque tertiare par la plus haute des chaînes montagneuses actuelles, sillon qui va de l'Arménie à l'Himalaya et aux chaînes birmanes; (2) d'une façon plus hypothétique pour la bordure de la mer pacifique, dont l'existence paraît avoir été marquée, sur le rivage de l'Asie, dès ce début lointain et s'être constamment perpétuée dans la suite; (3) pour la mer arctique qui, a bien des époques vient faire des incursions dans le Nord du continent Sibérien, comme si elle était toujours là, très proche de lui, prête à y lancer ses marées."

The stratigraphic history is pursued with some minuteness through successive systems, and the facts or deductions are used to determine the course of other movements from which resulted the foldings and flexures of strata, injected rocks, and metalliferous "emanations." The tectonic zones, upon whose importance the author insists, are well worthy of study, particularly as an attempt is made to determine the epoch at which they were produced; but the conclusions are suggestive rather than decisive. The exhibition of the data, and the attempt to draw a conclusion from all the material available, is a bold and praiseworthy effort, for one can easily be lost in the mass of detail, and fail to grasp the bearing of any set of facts correctly.

In the third section, that of "Métallogénie Régionale," the author shows, by the examination of different regions, that the aggregation and genesis of metals are associated with the age and type, with the folds and dislocations to which orogenic masses have submitted. Unfortunately, the theory or scheme by which the origin and deposition of metals are explained is too long to be reproduced here. Down at a depth of 10 to 30 kilometres below the surface, among the crystalline rocks, the origin is placed, and successive operations are traced upwards to the earth's surface, where the mechanical effects of mountain foldings make themselves felt in determining the character and position of metalliferous beds. It is contended that it is possible to trace analogies in virtue of which a little known metalliferous field can be compared with a type that has long been explored. Practically it is evident that there is a great advantage in being able to determine beforehand the direction research should take, and its probable result. How far the suggestive theory has been put to decisive test does not appear very clearly.

BOOKS RECEIVED.

The Design of Static Transformers. By H. M. Hobart, M. Inst. C.E. London: Constable and Co., Limited. [Price 6s. net.]

The Eleventh Financial and Economic Annual of Japan, 1911. The Department of Finance. Tokyo: Government Printing Office.

Illumination; its Distribution and Measurement. By Alexander Pelham Trotter. London: Macmillan and Co., Limited. [Price 8s. 6d. net.]

Nitrocellulose Industry. A Compendium of the History, Chemistry, Manufacture, Commercial Application, and Analysis of Nitrates, Acetates and Xanthates of Cellulose as Applied to the Peaceful Arts, with a Chapter on Gun-Cotton, Smokeless Powder, and Explosive Cellulose Nitrates. Two Volumes. By Edward Chauncey Worden, Ph.C., &c. Member of the Society of Chemical Industry, &c. London: Constable and Co. Ltd. [Price 42s. net.]

Quaternions as the Result of Algebraic Operations. By Arthur Latham Baker, Ph.D., Head of Department of Mathematics, Manual Training High School, Brooklyn, N.Y. London: Constable and Co., Limited. [Price 6s. net.]

Cold Storage, Heating, and Ventilating on Board Ship. By Sydney F. Walker, R.N. London: Constable and Co., Limited. [Price 8s. 6d. net]

Marine Engine Design, including the Design of Turning and Reversing Engines. By Edward M. Bragg, S.B., Assistant Professor of Marine Engineering, University of Michigan. London: Constable and Co., Limited. [Price 8s. net.]

History of Bridge Engineering. By Henry Grattan Tyrrell, C.E., Graduate of Toronto University, Bridge and Structural Engineer. Evanston, Illinois, U.S.A.: H. G. Tyrrell, 540, Judson-avenue. [Price 4 dols. net, post paid.]

Highway Bridge over the Miami River at Elizabethtown, Ohio. The Longest Simple-Truss Span. By H. G. Tyrrell. Evanston, Illinois, U.S.A.: H. G. Tyrrell, 540, Judson-avenue. [Price 1 dol.]

Engines and Boilers Practically Considered: A Hand-Book for Young Engineers on the Construction and Working of Steam, Gas, Oil, and Petrol-Engines and Steam Boilers. By W. McQuade, Instructor in the Engineering Department, University College, Exeter. London: G. Bell and Sons, Limited. [Price 3s. 6d. net.]

Lubricating Oils, Fats, and Greases; Their Origin, Preparation, Properties, Uses, and Analysis. By George H. Hurst, F.C.S. Third edition, revised and enlarged. By Henry Leask, F.C.S. London: Scott, Greenwood, and Son, 8, Broadway, Ludgate-hill, E.C. [Price 10s. 6d. net.]

The Practical Design of Reinforced Beams and Columns. With Labour-Saving Diagrams. By W. Noble Twelvetrees. London and New York (Fifth-avenue): Whittaker and Co. [Price 6s. net.]

Recherche Pratique et Exploitation des Mines d'Or. Par Georges Proust. Paris: Gauthier-Villars, Quai des Grands-Augustins 55. [Price 2.75 fr.]

Hommes et Choses du P.L.M. Paris: La Cie. des Chemins de Fer de Paris à Lyon et à la Méditerranée.

Das Automobil. Eine Einführung in Bau und Betrieb des Modernen Kraftwagens. Von Ingenieur Karl Blau. Second edition. Leipzig: B. G. Teubner. [Price 1.25 marks.]

Handbuch der Mineralchemie, unter Mitwirkung von mehr als 50 Fachgenossen des in- und Auslandes. Von Prof. Dr. C. Doelter, Vorstand der Mineralogischen Instituts an der Universität Wien. Band I.: Erste Abtheilung. Dresden: Verlag von Theodor Steinkopff. [Price 6.50 marks.]

Bulletin of the Imperial Earthquake Investigation Committee. Vol. IV., No. 2. *The Usu-San Eruption and Earthquake and Elevation Phenomena.* Vol. V., No. 1. *Application of Seismographs to the Measurement of the Vibrations of Railway Bridge Piers.* By F. Omori. Tokyo: Seismological Institute.

Professional Paper of the Department of the Interior, United States Geological Survey. No. 72. *Denudation and Erosion in the Southern Appalachian Region and the Monongahela Basin.* By Leonidas Chalmers Glenn. Washington: Government Printing Office.

Water Supply Papers of the Department of the Interior, United States Geological Survey. No. 257. *Well-Drilling Methods.* By Isaiah Bowman. No. 258. *Underground Water Papers, 1910.* By M. L. Fuller, F. G. Clapp, G. C. Matson, Samuel Sanford, and H. C. Wolff. No. 270. *Surface Water Supply of the United States.* Part X. *The Great Basin.* Prepared, under the direction of M. O. Leighton, by E. C. La Rue and F. F. Henshaw. Washington: Government Printing Office.

Bulletins of the Department of the Interior, United States Geological Survey. No. 436. *The Fauna of the Phosphate Beds of the Park City Formation in Idaho, Wyoming, and Utah.* By George H. Girty. No. 438. *Geology and Mineral Resources of the St. Louis Quadrangle Missouri-Illinois.* By N. M. Fenneman. No. 439. *The Fauna of the Moorefield Shale of Arkansas.* By George H. Girty. No. 441. *Results of Spirit Levelling in Alabama, Georgia, North Carolina, South Carolina, and Tennessee, 1896 to 1909 inclusive.* By R. B. Marshall, Chief Geographer. No. 443. *Reconnaissance of the Geology and Mineral Resources of Prince William Sound, Alaska.* By U. S. Grant and D. F. Higgins. No. 445. *Geology of the Pegmatites and Associated Rocks of Maine, including Feldspar, Quartz, Mica, and Gem Deposits.* By Edson S. Bastin. No. 446. *Geology of the Berners Bay Region, Alaska.* By Adolph Knopf. No. 447. *Mineral Resources of Johnstown, Pennsylvania and vicinity.* By W. C. Phalen and Lawrence Martin. No. 453. *Results of Spirit Levelling in Minnesota, 1897 to 1910 inclusive.* By R. B. Marshall, Chief Geographer. No. 465. *The State Geological Surveys of the United States.* Compiled under the direction of C. W. Hayes. Washington: Government Printing Office.

Building in London: A Treatise on the Law and Practice Affecting the Erection and Maintenance of Buildings in the Metropolis. By Horace Cubitt, A.R.I., B.A., P.A.S.I. With special chapters dealing respectively with *The Cost of Building Work in and around London*, by H. J. Leaning, F.S.I., and *The Valuation, Development, and Rating of London Property*, by Sidney A. Smith, F.S.I. London: Constable and Co., Limited. [Price 31s. 6d. net.]

Shop Management. By Frederick Winslow Taylor, M.E., Sc.D. With an Introduction by Henry R. Towne, President of the Yale and Towne Manufacturing Co. New York and London: Harper Brothers. [Price 5s. net.]

The Chemistry of the Coal-Tar Dyes. By Irving W. Fay, Ph.D. (Berlin), Professor of Chemistry, Polytechnic Institute, New York. London: Constable and Co., Limited. [Price 16s. net.]

Wood Pulp and Its Uses. By C. F. Cross, E. J. Bevan, and R. W. Sindall, with the collaboration of W. N. Bacon. London: Constable and Co., Limited. [Price 6s. net.]

Speed and Consumption of Steamships, with Algebraical Formula for Economical Speed and Rules for Calculating the Alterations in Draught and Trim corresponding to Changes in Displacement, and for Using the Hydrometer to Estimate those due to Differences in the Specific Gravity of the Water, to which has been added a Chapter on Stability with Practical Rules. By J. F. Ruthven, Master Mariner, late Lieut. R.N.R., &c. London: J. D. Potter, 145, Minories, E.C. [Price 4s.]

Contemporary Chemistry. A Survey of the Present State, Methods, and Tendencies of Chemical Science. By E. E. Fournier D'Albe, B.Sc., A.R.C.S., M.R.I.A. London: Constable and Co. [Price 4s. net.]

Elastizität und Festigkeit. Die für die Technik wichtigsten Sätze und deren erfahrungsmässige Grundlage. Von Dr.-Ing. C. Bach. Sixth enlarged edition. Berlin: Verlag Julius Springer. [Price 20 marks.]

Department of Commerce and Labour. Statistical Abstract of the United States. 1910. Thirty-third number. Prepared by the Bureau of Statistics under the direction of the Secretary of Commerce and Labour. Washington: Government Printing Office.

A New Method of Coast Surveying. By John Ball, Ph.D., D.Sc., M. Inst. C.E. Egyptian Survey Department Paper, No. 21. Cairo: Geological Museum, Ministry of Public Works. [Price 100 milliemes.]

THE WORKS OF THE BRITISH WELDING COMPANY.

The ever-increasing demand for welded-steel pipe-lines for the distribution of water and gas, and for the disposal of sewage, &c., is sufficient evidence that the advantages of this type over the older cast-iron pipe are becoming more generally appreciated. The steel pipes are naturally much lighter than cast iron for a given set of conditions, resulting in a considerable reduction in the cost of carriage and handling. The lesser weight of the pipe, too, enables correspondingly longer pieces to be handled, with a like reduction in the number of joints necessary; this latter point being especially noticeable in the case of the larger sizes of pipe. The smoothness of the bore also is an item of considerable importance, resulting in the diminution of friction losses and liability to fouling-up, &c., and a further advantage is gained in the greater strength of the steel pipe, and its practical immunity from

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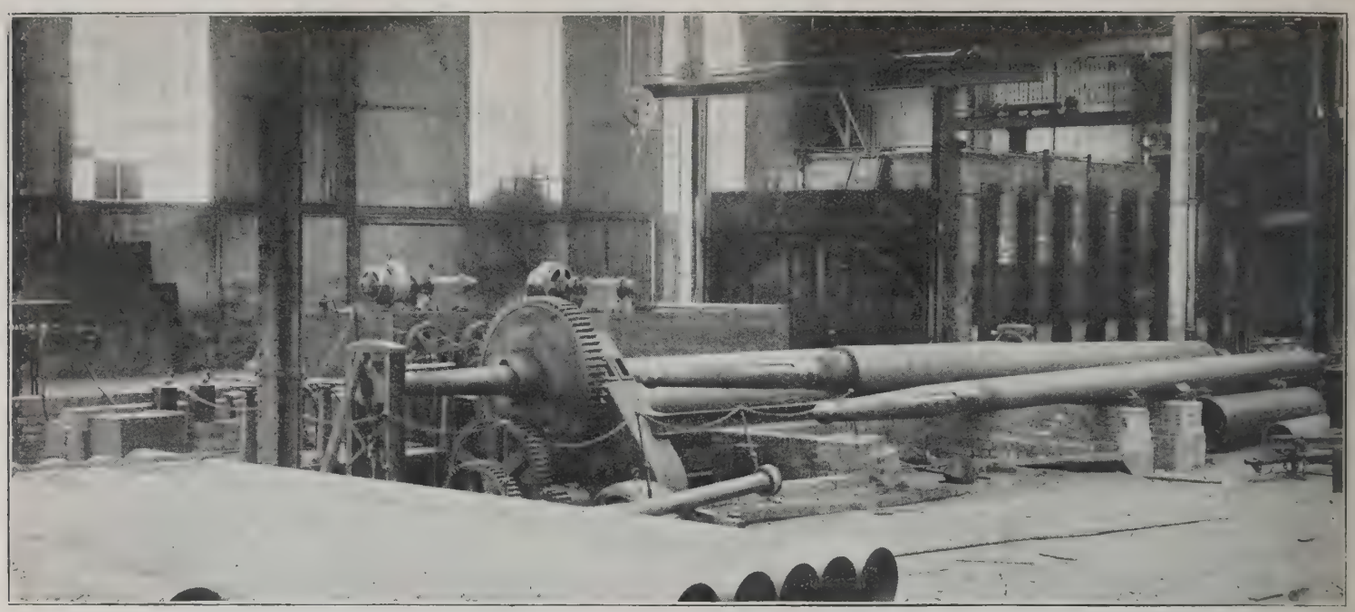

Fig. 2. General View of Bending Rolls.

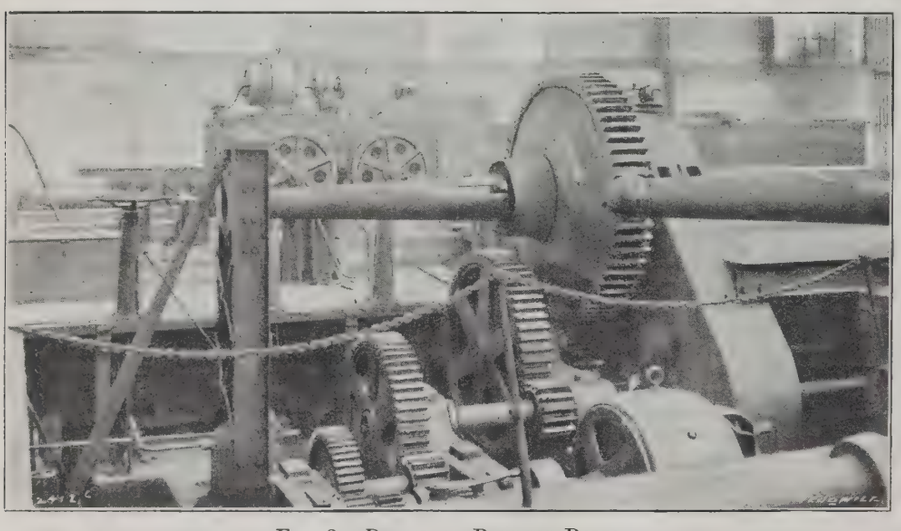

Fig. 3. Detail of Bending Rolls.

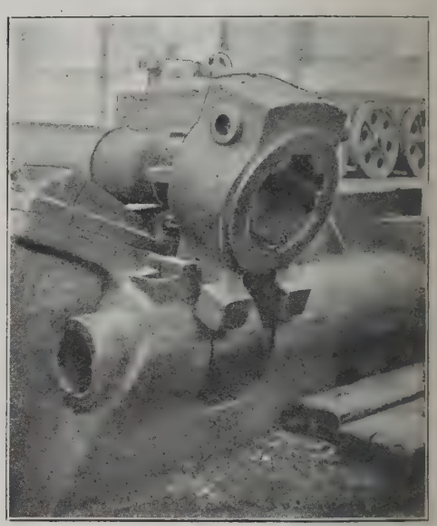

Fig. 4. Hinged Bearing of Bending Roll.

fracture, making it specially suitable for use in places liable to local subsidences.

In order to meet the demand for welded-steel pipes on a competitive basis, the British Welding Company, some two years ago, equipped their works at Motherwell with a full complement of modern plant, comprising a number of special machines. Being situated in the steel-making district, with a siding connecting to the Caledonian Railway, they are conveniently placed for obtaining the necessary steel plates, &c. The works at present equipped comprise a main machine-shop about 300 ft. long, in three bays of 50 ft. each, containing the pipe-making plant, with power-house, stores, &c., attached; whilst adjacently situated are the gas-producing plants, tarring-shed, &c. All the machines are either electrically driven or hydraulically operated, the plant in the power-house consisting of a 200-kw. Willans-General Electric Company continuous-current set and two 200-kw. Parsons turbo-generators, a steam-driven air-compressor, and an hydraulic pump with accumulator, &c. The necessary steam is supplied by three Stirling boilers, which are fitted with stokers for burning low-grade coal.

For welding purposes water-gas is employed, two Delwick-Fleischer plants by Messrs. R. and J. Dempster, Manchester, being installed in a separate building, together capable of generating 50,000 cub. ft. per hour. The gas from these plants is delivered to a gas-holder, from which it is distributed by mains at a pressure of about 3 lb. per sq. in., to the various welding-machines and blow-pipes.

Fig. 6. General View of Tube-Welding Machines.

On account of the great importance of obtaining a pure gas for welding purposes special scrubbers are employed. A separate producer is installed adjacent to the annealing and plate-heating furnace—which is in the main building—to supply gas for heating this furnace, the plant in this case

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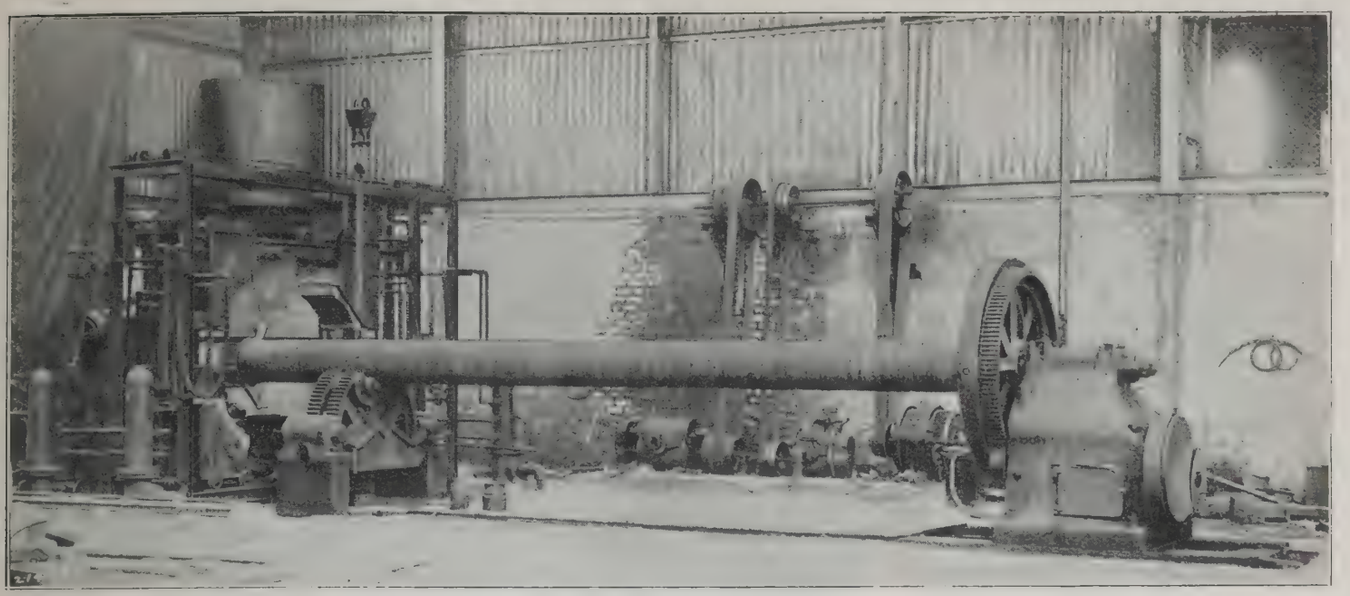


Fig. 11. General View of Pipe-Socketing Machine.

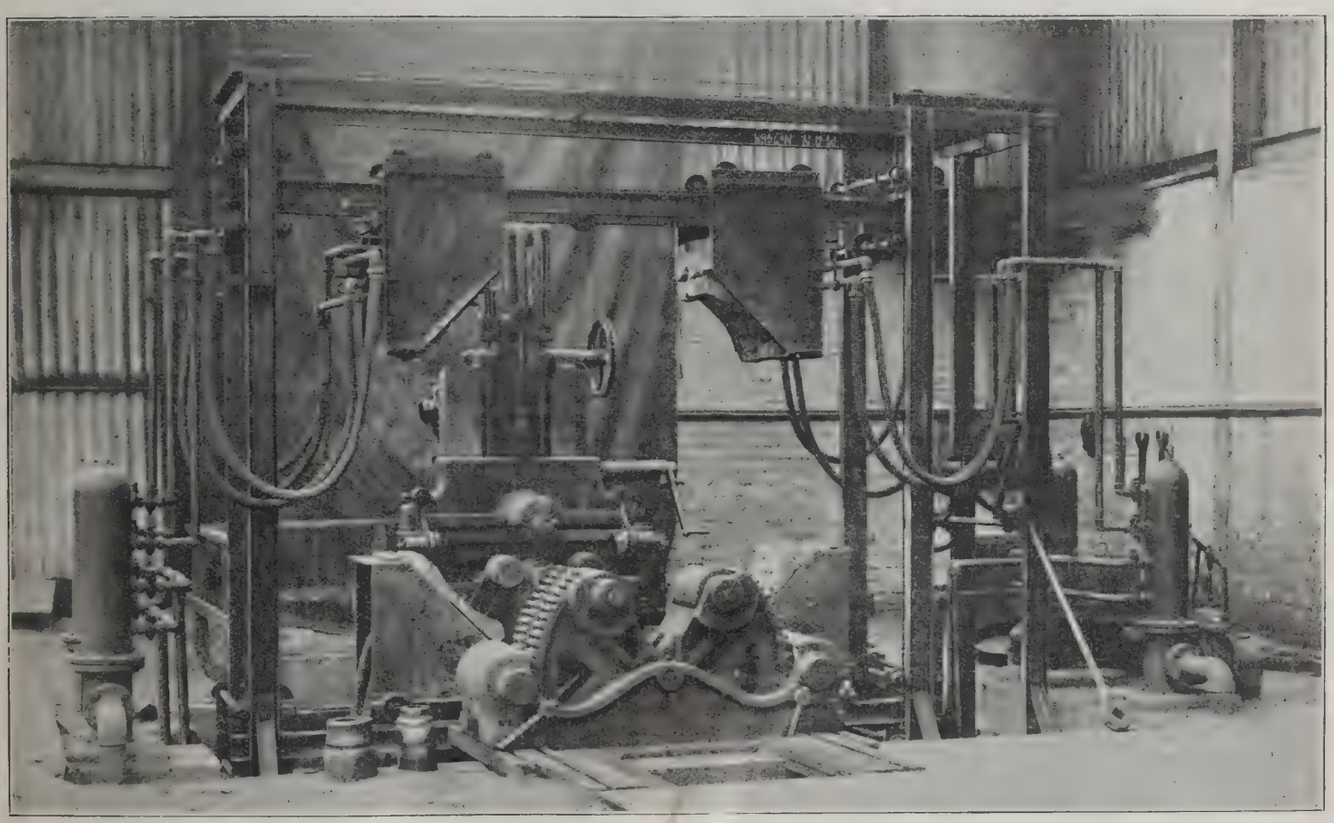
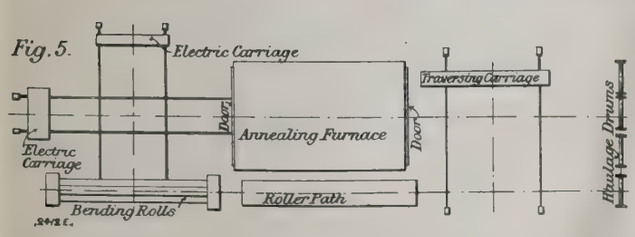


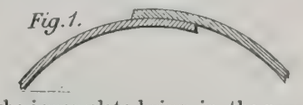
Fig. 12. Detail View of Pipe-Socketing Machine.



being a Duff generator, by Messrs. Mason's Gas Power Company, Limited, of Manchester, and using low-grade coal.

The manufacture of the pipes, the plant for which at present installed can deal with sizes from 14 in. up to 6 ft. in diameter and 26 ft. long, without circumferential welds, proceeds as follows:—The plates are first machined on the edges to give the required scarf for welding, and are then transferred to the bending-rolls. Plates up to about ½ in. thick are dealt with cold, but above this thickness they are heated in the gas-fired furnace previous to bending. The seam is then welded and, after passing a preliminary test and inspection, the tube is annealed and trued up on the rolls. The ends are next turned up in a special lathe, and passed on for socketing, or flanging, as the case may be. An hydraulic test is then applied, and after passing inspection the pipes are coated with anti-corrosive composition on the Angus Smith system, and a final serving of tarred hessian given when specially called for. Having given a general outline of the manufacture, we will now refer in detail to the special machines, &c., employed.

In preparing the plates for welding the edges are bevelled as indicated in Fig. 1, the bevel at the



edge of the inner plate being in the reverse direction to that of the outer. This method, it is stated,

results in a long scarf being obtained when the plates are welded, and consequently in a more satisfactory job being effected. The machine used for bending the plates, and also employed for truing up the tubes after welding, is shown in Fig. 2, page 486, whilst details are given in Figs. 3 and 4. This machine has four rolls, and is direct driven by electric motor, whilst the adjustment of the pressure on the rolls is effected by hydraulic power. The top roll is arranged to lift up at one end to facilitate the removal and placing in position of the tubes, the bearing at this "lifting" end of the roll being carried in a hinged housing, shown in detail in Fig. 4, page 486. This housing is operated by hydraulic gear, and is so constructed as to swing downwards, thus permitting the free end of the roll to lift up, and leave a clear path for placing a tube in position on the rolls. The opposite end of the roll with the elevating gear is shown in Fig. 3. From this illustration it will be seen that the roll is provided with an extended spindle, the outer end of which is engaged by an hydraulic gear; this gear, by pulling downwards, elevates the further end of the roll, the housing and bearing at this end of the machine being made of spherical form to allow for the canting of the roll. The bottom roll of the machine is raised and lowered by hydraulic rams, and the two side-rolls also are adjusted by hydraulic gear.

The control of the machine is carried out by a set of levers placed at the back, and all the various motions being operated by power, the work can be rapidly dealt with. As already mentioned, the heavier plates are heated previously to bending, and in order to get these heated plates rapidly into the machine from the furnace, two electrically-operated traversing carriages are provided. The traversers are to be seen in Fig. 2, and the method of their use will be readily understood by reference to the plan given in Fig. 5, page 487, which indicates the relative positions of the bending-rolls, furnace, and plate-handling plant. As will be seen, the two carriages run on tracks at right angles to one another; the first, which runs in a direction parallel to the rolls, is used for drawing the plate from the furnace and placing it in position for the other carriage to pass it into the rolls. The controllers for these carriages are fixed adjacent to the operating gear of the rolls—the current being taken to the carriages by flexible cables—thus enabling the man in charge of operations to get the plate from the furnace into the bending-machine without loss of time. On completion of the bending process the tube is drawn off the rolls on to the "roller-path," shown alongside the furnace, whence it is transferred to the welding-machine. The roller-path mentioned consists of a series of inclined rollers so placed as to form a V-shaped trough along which tubes can be readily passed. This device is also used in connection with the annealing and truing up of the tubes after welding. The welded tube is placed by a crane upon the traversing carriage, shown at the back of the furnace, the top of which is provided with a set of rollers similar to the roller-path already described. This carriage is then brought to the desired position, and the tube passed into the furnace. When the annealing is complete, the tube is drawn out on to this traverser, a set of hauling-drums being provided for use in the case of large tubes. The carriage is then hauled along the track until it is in line with the fixed path, and the tube transferred along the rollers directly on to the bending-machine, where it is trued up. The arrangements just described enable a tube to be taken from the furnace and placed in position on the rolls with a minimum loss of heat.

In Fig. 6, on page 486, is given a general view of the welding-machines, of which three are installed, while in Fig. 7, on page 498, a more detail view is given of one of these machines. From these illustrations it will be seen that the tube to be welded is mounted upon rollers on a movable carriage, which is travelled along by a hand-wheel as the work proceeds. The height of the carriage is adjustable for different sizes of tubes, so that the weld is brought level with the anvil, which is mounted on a balanced arm. This arm also carries one of the blow-pipes, and passes inside the tube operated upon. A second blow-pipe, which is carried by its gas and air-pipes, as will be seen in Fig. 7, and which can be raised and lowered as required by means of a winch, is provided for heating the weld from above. Both sets of blow-pipes are employed in making the weld, and as soon as the welding heat is reached, the blow-pipes are shut off and the outside one raised out of the way; the tube is then moved back, so that the heated portion comes beneath the welding hammer. As will be seen from the illustrations, this hammer is mounted on a frame spanning the pit in which the tube carriage travels, and is of the power pneumatic type, belt-driven from the countershaft at the back of the machine.

The machines, which are belt-driven, have all the various operations controlled by a set of levers at the side, immediately in front of the welding position, so that the man in charge is able readily to manipulate the processes. The movement of the carriage and the axial motion of the tube, however, are effected by hand. Each machine is provided with a separate blower, which supplies air to the blow-pipes at a pressure of about 4 lb. per sq. in. After the welding is completed, the joints are carefully inspected and tested with oil in the usual manner. The tubes are then annealed and rolled true, as already described, after which they are taken to the lathe, shown in Fig. 8, page 498, in which the ends are machined up.

This machine, which was supplied by Messrs. J. Holroyd and Co., Milnrow, has two hollow spindle headstocks, mounted on a solid bed-plate, capable of taking tubes up to 38 in. in diameter. These heads are fitted with traversing motion, and in their limiting position allow of a 26-ft. tube being lowered directly on to the adjustable rests from the overhead crane. The rests are so regulated that the tube comes slightly below the centre of the lathe; thus when held in the chucks the tube runs clear of the rests. After lowering the tube into position the heads are moved along the bed until the ends of the tube project through the chucks, and the jaws are then closed; both these motions are power operated. The tool-rests, which are mounted on the bases of the headstocks, are provided with cross-feed and screw-cutting gear, the latter having about 10-in. travel.

The tube having been dealt with in this machine, is ready for the formation of the socket, or the fitting of the flanges, as the case may be. The standard form of the socket employed by the company is shown in Fig. 9, on this page, a special feature being the short parallel portion at A, having for its object the centering of the pipe in the socket when erected. This parallel portion practically fits the end of the adjoining pipe, and thus prevents the yarn used in making the joint from being forced into the pipe when the lead is being caulked in place. Further, the pipe being held centrally in the socket ensures a uniform and sound joint being made, whilst the form of the joint allows for expansion and contraction due to any variations of temperature. An additional advantage is secured in that the lengths of pipe being concentric, a full bore is maintained throughout the line.

In the case of flanged pipes the work is carried out by hand, the method of preparing the tube and flange being indicated in Fig. 10, below, which shows the work before welding. The tube-ends are first heated and slightly opened out, so that the pressed-out portion of the steel flange can be driven into the tube. The flange is then hand-

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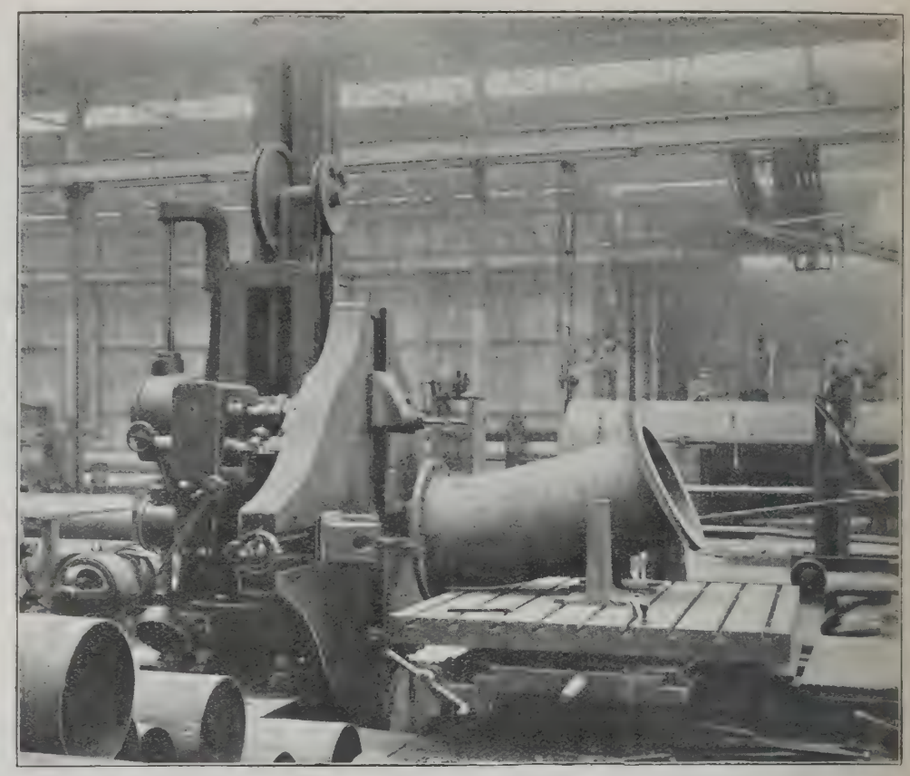
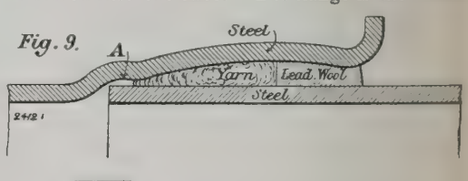
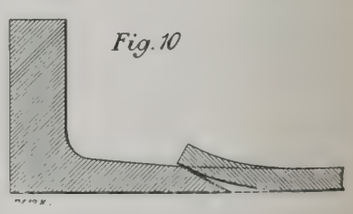


Fig. 13. Flange Facing and Drilling Machine.





welded on to the tube, the heating being done by portable gas blow-pipes in a similar manner to that employed on the welding-machines. T-pieces and bends, &c., are also built up by hand-welding by means of gas blow-pipes.

Returning to the formation of sockets on the pipes, we give in Figs. 11 and 12, page 487, two views of the machine employed, the former being a general view of the machine with a tube in place, and the latter a view of the socket-forming gear. As will be seen from Fig. 11, the tube is held in the chuck of the driving headstock at one end, the opposite end running on the adjustable rollers; the position of the headstock is, of course, varied according to the length of tube to be dealt with, the traverse being operated by power. Four blow-pipes are arranged on a framework, shown to the left of the general view—and more clearly seen in Fig. 12—for heating the end of the pipe, and, being

provided with vertical and lateral adjustments, they can be put in position for different sizes of pipes as necessary. During the heating process the pipe is rotated so as to obtain a uniform heating effect. The headstock is travelled forward as soon as the pipe is sufficiently heated, and thus brings the end of the pipe into a set of rolls (shown more clearly in Fig. 12, page 487), so formed as to give the socket the required shape.

The machine shown in Fig. 13, page 488, is designed for facing and drilling the flanges of T-pieces, bends, &c. The table on which the pipe is clamped is provided with traversing and cross-feed; it also has a swivelling top, with a stop for setting accurately to right angles when dealing with T-pieces and right-angle bends. The headstock works on a vertical guide and carries a face-plate having two tool-boxes and two drilling-heads. The tool-rests have radial and axial feeds, and are used for facing and turning the edges of flanges, the machine being capable of dealing with flanges up to 7 ft. in diameter. On completion of the facing process the two drill-heads are brought into gear, and the bolt-holes drilled in the flange without altering the setting of the pipe. During this operation the face-plate is locked in position, and a dividing arrangement ensures the accurate spacing of the holes circumferentially; the radial adjustments of the drill-heads are geared together, so that the holes are accurately drilled on the required pitch circle concentrically with the flange.

As already mentioned, the completed pipes, after passing the hydraulic tests and inspection, are taken to the tarring-shed, where they are heated and coated with a preservative compound on the Angus Smith system. An extra protection is also, as previously stated, given in some cases by serving the pipe with layers of tarred hessian wound on spirally in a special machine.

In addition to the special machines described above, the works are equipped with a number of modern machines for dealing with the preparation and testing of the various welded work turned out by the company. Although welded steel pipe-work, the manufacture of which has been dealt with above, may be taken as the chief work of the company, such articles as cylindrical tanks and receivers, gas-chambers for buoys, and so on, form a by no means unimportant item of their output.

LONDON AND SOUTH-WESTERN AND METROPOLITAN DISTRICT RAILWAY IMPROVEMENTS.

In recent years important improvements have been made on the lines approaching London, not only for the convenience of main traffic, but to enable the ever-increasing suburban passenger service to be accelerated. In many such instances flying-bridges have been substituted for cross-over roads, with immense advantage to the public. A notable instance of such improvement is found on the line between Ravenscourt Park and Chiswick Park, jointly used by the London and South-Western and Metropolitan District Railway companies. The line belongs to the former, and the Metropolitan District Company have running powers, and conduct a heavy traffic to Uxbridge, Ealing, Hounslow, and Richmond, sharing this length of line, which has only a pair of roads, with the South-Western traffic connecting the Northern and Western suburban systems and the City, through them, with Richmond.

The widening of this important length in order to double its capacity, and the reconstruction of the two stations upon the island platform principle, have become imperative necessities, owing to the rapid increase of the number of the trains. But more than this was required in the interests of secure and rapid working. The lines of the two companies intersect each other at Ravenscourt Park and Turnham Green junctions, with the exception of the District Railway down line to Richmond. The proposals therefore also included (see Fig. 1, on this page, and Fig. 2, overleaf), the raising and lowering of the lines west of Turnham Green, with the necessary bridge-work to enable each line's traffic to be worked independently. This will, of course, save much signal work, and add considerably to the fluidity of the traffic. The small-scale map (Fig. 1) shows the relation of these alterations, which are now in progress, to the suburban railway system generally of the west of the Metropolis. To carry into effect the alteration, the Metropolitan District Railway Company obtained the necessary powers from Parliament, and the Royal Assent having been given in August, 1910, work was started in the following month, according to plans prepared by Mr. A. R. Cooper, Assoc. M. Inst. C.E., engineer to the Metropolitan District line. Conformably with the carrying out of many railway reconstructions elsewhere, in which non-interference with existing traffic is a compelling feature, the elimination of the contractor was found desirable. The work is thus being carried out departmentally by the London and South-Western Railway Company's engineer, Mr. J. W. Jacomb-Hood, M. Inst. C.E., under the immediate supervision of Mr. H. H. Dalrymple Hay, M. Inst. C.E., Mr. E. A. Ogilvie acting as resident engineer.

The widening proper, except for the splayed approaches to the reconstructed island platforms, is entirely on the north side of the existing railway, and is to be devoted to the London and South-Western Railway traffic. It begins at Galina-road, the junction near which will be abolished, the low-level District Railway line here attaining the London and South-Western Railway high-level, which is maintained westward to beyond Turnham Green Station. The widening for 50 chains—viz., to the crossing over of the North and South-Western Junction Railway—conforms to the present line, being on a brickwork viaduct, 40-ft. elliptic arches included in it being constructed over Ravenscourt-avenue and Prebend-gardens. All other roadways on the widening are crossed by through plate girders. On this viaduct length a new station will be provided, called Stamford Brook, between Goldhawk-road and Prebend-gardens. As this station will only be used by the District Railway trains, an island platform only is provided on the southern side between the up and down metals of that line. Beyond the railway crossing, and up to Turnham Green, just beyond which the widening proper ends, the latter is in embankment. The island reconstruction of this station necessitates the addition of a single-line plate-girder bridge at each side of the present one over Turnham Green-terrace, which adjoins the station on the west side. Opportunity has, at the same time, been taken of widening the span of this bridge, which will greatly improve the approach between Chiswick High Road and Bedford Park, to which the terrace leads. The local council shares the extra expense of this street improvement.

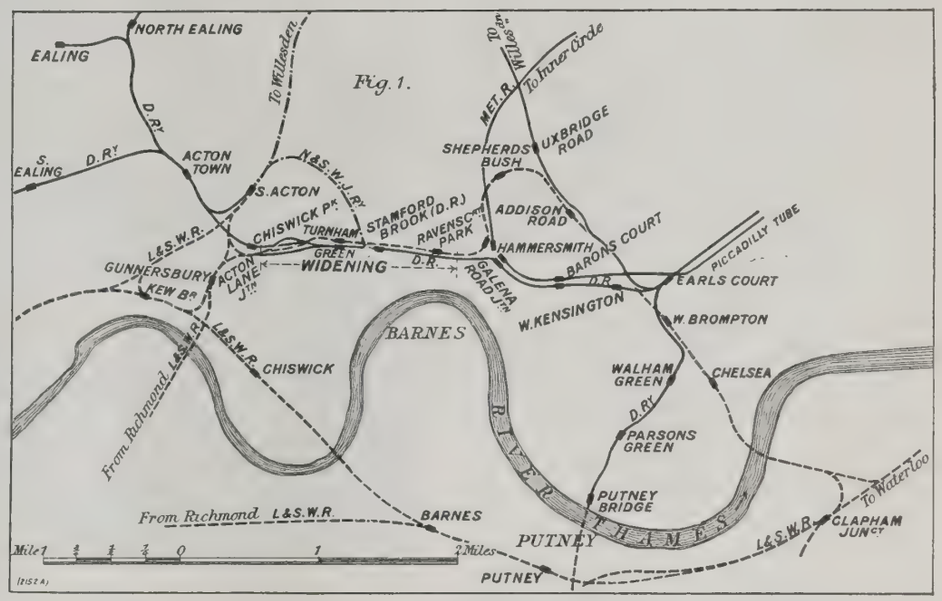


Fig. 1.

In removing the old bridge at this point use was made of the oxygen-jet cutting process with considerable success. The structure consisted of main plate girders with cross joists and steel decking, and is shown in course of demolition in Fig. 3, page 490. It was important in this instance to maintain the roadway clear for traffic, and the method employed enabled this to be done. The decking was first removed, being cut away in sections by the oxygen jet; the cross joists were then cut through close up to the main girders, as shown in the illustration. This enabled them to be lowered directly on to lorries in the road below. The whole of the cutting away in connection with this work was carried out by the Sirius Autogenous Works Company, Stratford, E., who supplied the necessary plant and labour.

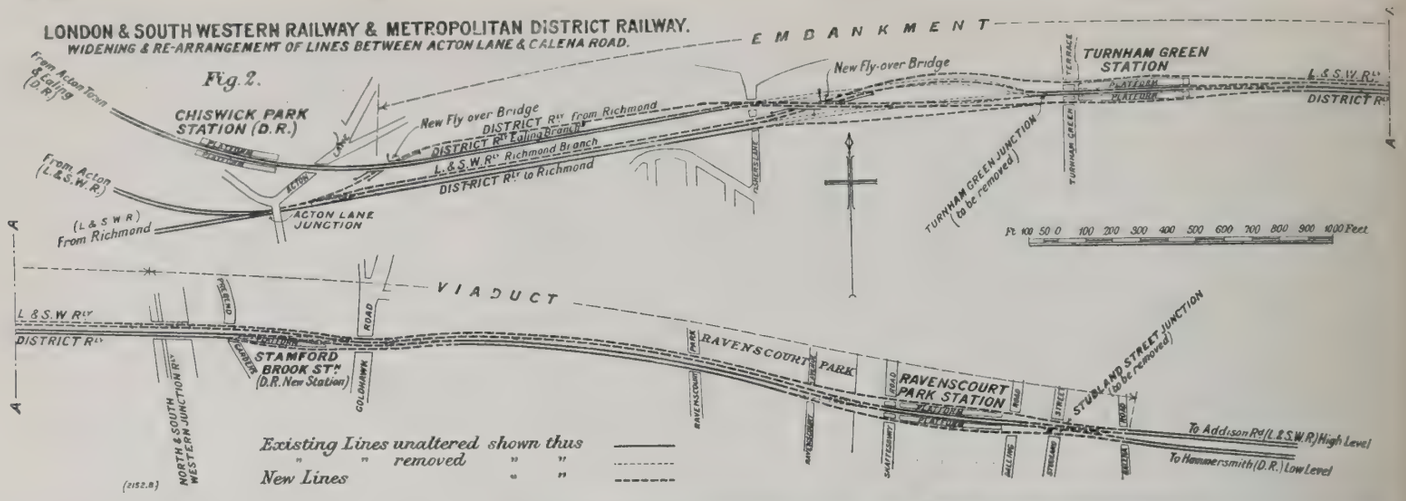
At Turnham Green Station begins the works necessary to enable the lines to cross each other at different levels; both of them hitherto crossed at the same high level, at about 20 ft. over surface. This work was facilitated by the fact that there was a falling grade from this point of the Richmond branch down towards the Thames. Taking the metals north to south in order, the arrangement made was as follows:—The London and South-Western tracks are carried by a falling grade extending to about 1000 ft. to westward of Turnham Green, where they pass under, through a girder bridge, the whole traffic, except the down Richmond, of the District line; thence, using the present up track as a down one, and having a new up track, they rejoin their original alignment at Acton-lane. Turning to the two District Railway tracks at Turnham Green, after being diverted and raised to pass over the London and South-Western Railway, as mentioned, they develop into three tracks at Fisher's-lane, the northernmost one becoming the Richmond up line, which by a falling grade passes, through an arch, under the two others at about 2600 ft. beyond Turnham Green, rejoining there the present Richmond line at Acton-lane. The two other tracks forming the branch to Ealing, &c., rejoin the present tracks just after throwing off the above-mentioned Richmond up line. There remains the District Railway Richmond down line. This is a new falling road from Turnham Green Station to Fisher's-lane, whence, westward, the trains pass over the present London and South-Western Railway down line, which, as has been said, is diverted here to its former up line.

The rearrangement just described is in embankment reinforced on the south side for the greater part of the distance between Turnham Green-terrace and Fisher's-lane, by a concrete retaining-wall, so as to avoid encroachment on Acton Green Common. The steepest grade on the reconstructed works is 1 in 50.

Considering that the improvements are upon a portion of a line, which, as far as railways are concerned, carries practically the whole of the western suburbs' travelling population to and from the heart of London by trains following each other every three or four minutes each way—making over 500 trains per day—there is evidently much difficulty in the construction of works while leaving such a traffic absolutely unimpeded. Perhaps the most interesting of the provisional works for this purpose is that for the construction of the skew arch near Acton-lane for the Metropolitan District Richmond up line. This has to be built in tunnel under the present Ealing branch of that railway. Two sets of heavy timbering are to be used for the temporary support of the line above, during the excavation and the construction of the arch.

In order to expedite the construction of new works west of Turnham Green Station, the junction

WIDENING OF THE L. AND S.-W. AND M. D. RYS. NEAR TURNHAM GREEN STATION.


LONDON & SOUTH WESTERN RAILWAY & METROPOLITAN DISTRICT RAILWAY.
WIDENING & RE-ARRANGEMENT OF LINES BETWEEN ACTON LANE & CALENA ROAD.
Fig. 2.
EMBANKMENT
CHISWICK PARK STATION (D.R.)
New Fly-over Bridge
DISTRICT Rly from Richmond
DISTRICT Rly Ealing Branch
L. & S.W. Rly Richmond Branch
DISTRICT Rly to Richmond
From Acton Town & Ealing (D.R.)
From Acton (L. & S.W.R.)
(L. & S.W.R.) From Richmond
ACTON LANE JUNCTION
TURNHAM GREEN STATION
TERRACE
L. & S.W. Rly
DISTRICT Rly
TURNHAM GREEN JUNCTION (to be removed)
Ft. 100 50 0 100 200 300 400 500 600 700 800 900 1000 Feet
VIADUCT
L. & S.W. Rly
DISTRICT Rly
FULHAM ROAD
STAMFORD BROOK STn (D.R. New Station)
NORTH & SOUTH WESTERN Rly JUNCTION
GOLDHAWK ROAD
RAVENSCOURT PARK
RAVENSCOURT PARK STATION
STUBLAND STREET JUNCTION (to be removed)
To Addison Rd (L. & S.W.R.) High Level
To Hammersmith (D.R.) Low Level
Existing Lines unaltered shown thus
" " removed " "
New Lines " "
(2152.B)

at that point has been temporarily removed to other positions, and temporary inclines formed on the existing District line embankment.

Even greater difficulties, and much expense, are being incurred in the provision of the temporary arrangements at the two stations for the disposal of the flow of passengers and their requirements while the extensive re-modelling is being carried out. Needless to say, large alterations are involved in connection with the high-tension electric cables, upon which the whole motive power for the District trains depends.

The Cleveland Bridge and Engineering Company of Darlington are supplying and erecting the steel-work for the bridge over Ravenscourt Park, and Messrs. E. C. and J. Keay, Limited, Birmingham, that at Turnham Green-terrace.

DEMOLITION OF BRIDLINGTON RAILWAY BRIDGE, NORTH-EASTERN RAILWAY.

The Ammonal Explosives, Limited, of London, has recently carried out an important operation in blasting by demolishing a five-span bridge at the railway station at Bridlington, Yorkshire, belonging to the North-Eastern Railway Company. The bridge in question originally supported a road leading from the high road to the railway yard, and, in order to facilitate the operation, the surface of the bridge had been stripped, leaving simply the crowns of the arches and the buttresses to be blown down.

Bridge demolition by means of explosives, although by no means a novelty, is an operation which, nevertheless, has always to be carried out with the greatest of caution, and unless the technical experts have experience in this particular class of work, it would be an easy matter to cause trouble to adjacent property, and even danger to life and limb. The bridge in question is composed of five arches, each arch having a span of about 18 ft., with a width of 37½ ft., these five arches being built of four courses of hard ringing bricks set in cement, thus forming a hard, tenacious mass of masonry requiring to be pulverised completely and instantaneously.

The difficulties of this blast were increased owing to the near proximity of the main station platform and buildings, portions of which were only about 8 ft. or 10 ft. from the crowns of the bridge which had to be blown down, and were parallel to the bridge. Owing to this fact it was found inadvisable to blast at the first operation more than the crowns of the arches leaving the buttresses and retaining walls to be taken down at a later period for fear of shaking the foundations of the main station buildings.

The experts of the Ammonal Explosives Company determined to effect this by boring in the five arches some 139 holes, 10 in. deep, in parallel lines, into each of which was inserted a 4-oz. cartridge in the sides of the crowns, and a 6-oz. cartridge in the centres of the crowns, the total quantity of explosive used being 39½ lb. of ammonal No. 5.

The actual quantity of explosive used was therefore not very great for the amount of work to be accomplished, but the careful distribution of the charges effectively accomplished the purpose, and the whole operation was concluded with the greatest success, and to the satisfaction of the officials and engineers of the North-Eastern Railway.

Another feature of this operation, which rendered it more than usually interesting, and, to a certain extent, hazardous, was the employment, for the first time in England, of an entirely new kind of patent detonating-fuse, introduced by Messrs. Bickford, Smith, and Co., of Cornwall, and called Bickford's toluene fuse, or "Cordeau" detonant.

Fig. 3.

Hitherto the firing of a large number of small charges has been accomplished by the insertion of a detonator into each cartridge forming the various charges, thus necessitating the employment of a number of detonators, and considerably increasing the risk and danger of the operation. One of the peculiarities and advantages claimed for this new detonating fuse is that the use of detonators in each charge is dispensed with, for the fuse may either be laid alongside or simply inserted into each cartridge, and after the main cables and subsidiary lines attached thereto have been properly connected, one detonator attached to the firing end of the fuse is only really necessary to cause the instantaneous detonation of the whole mined structure. As is well known, the presence of one unexploded cartridge left in a mass of débris constitutes a serious danger, and is one of the greatest objections to the demolition of masonry by blasting. This danger is always present when a large number of shots have to be fired simultaneously by electricity, for even with the greatest of skill and care misfires occur owing to unequal conductivity of the electric wires, the possibilities of faulty connections, short-circuits, and other factors of incertitude, which one would fain see eliminated from such operations.

On reference to the plan of the bridge on the next page, it will be observed that the method of coupling up the shots for simultaneous firing by the toluene fuse was as follows:—Into each separate hole a charge consisting of one cartridge was inserted alongside a short length of the fuse, about 15 in. long, which after stemming would leave about 5 in. of the fuse free. This fuse end was then slit with a pen-knife into two equal halves, forming a junction similar to the letter Y, into the angle of which was laid at right angles, embedded in the detonating mixture laid bare, a length of subsidiary fuse, running parallel with the bore-holes, three on each arch, the slit end of the short lengths being transversely wound round the parallel fuse, the ends of which were likewise slit, and coupled up in a similar manner to the two main lengths of fuse running at right angles at the outside of the arches for their whole length, the whole forming a ladder-like connection of fuses. (See Fig. 1.)

In order to make assurance doubly sure an electric detonator was inserted into each fuse at each end of the main cable, and the wire of these electric detonators coupled in series, the two final wires being then connected with the main electric cable and battery for firing purposes. The plan on the next page shows exactly the position of the four electric detonators and their connections.

It would have been possible to fire the whole series of charges by one single detonator, but the inexperience of the efficiency of the toluene fuse rendered it inadvisable to make such an experiment, although the experts of the Ammonal Company have now no doubt that in any future operation of the same nature there should not be the slightest difficulty of firing the whole 139 holes, or even ten times that number, by one single detonator properly placed.

After the couplings had been carefully made, and the joints where the subsidiary and main fuses were connected had been covered with waterproofing tape as a precaution against rain, the charge was eventually fired from the battery, causing an immense explosion, in which the whole débris seemed to be shattered and pulverised, raised about 10 ft. into the air, and then precipitated with immense force to the ground below.

THE DEMOLITION OF THE BRIDLINGTON BRIDGE; NORTH-EASTERN RAILWAY.

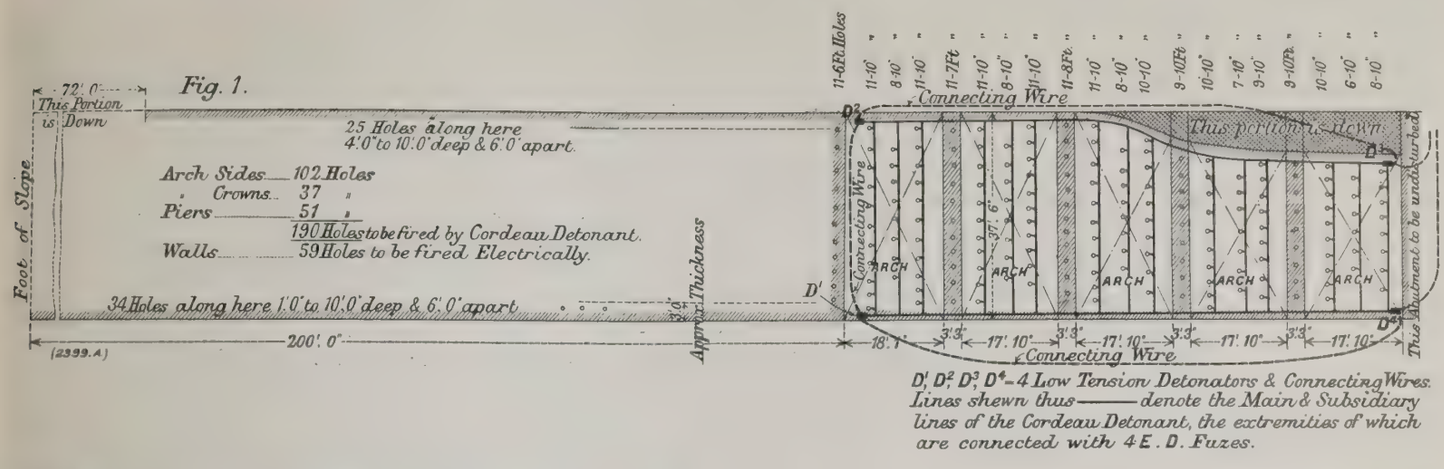
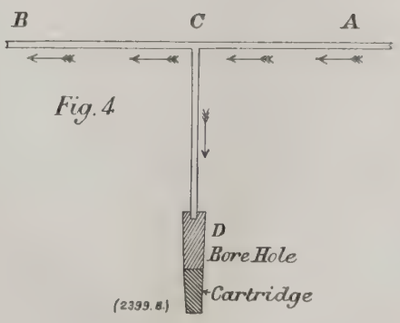


Fig. 1.
72' 0" This Portion is Down
Foot of Slope
25 Holes along here 4'0" to 10'0" deep & 6'0" apart.
Arch Sides 102 Holes
Crowns 37 "
Piers 51 "
190 Holes to be fired by Cordeau Detonant.
Walls 59 Holes to be fired Electrically.
34 Holes along here 1'0" to 10'0" deep & 6'0" apart
Approx. Thickness of Arch
200' 0"
(2399.A)
11-6Ft. Holes
Connecting Wire
Thus portion is shewn
This Abutment to be undisturbed
ARCH
3'3"
17' 10"
18' 1"
D' D² D³ D⁴ - 4 Low Tension Detonators & Connecting Wires.
Lines shewn thus ——— denote the Main & Subsidiary lines of the Cordeau Detonant, the extremities of which are connected with 4 E. D. Fuzes.

Fig. 2.

Fig. 3.

Fig. 5.



The report of the explosion was terrific, and was accompanied with dense clouds of blue-black smoke, which soon passed away, and showed the whole of the operation to have been successfully completed.

As an indication of the enormous rapidity of the detonating wave exerted by the "Cordeau" detonant, it may be stated that experiments have shown this rate to be no less than 6560 yards per second, which is practically equivalent for all general purposes to that of electricity. Given an explosive, therefore, of the type of ammonal, which is eminently suitable for such work, being probably the safest explosive known, and one of the strongest, the only danger of the whole operation was that from flying débris, and this contingency had been well provided against by placing over the crowns of the arches heavy ship chain cables, and between the arches as many railway sleepers as could be obtained, thus preventing flying of the masonry, and causing the brickwork, by the weight of the chains, to fall on to the ground beneath.

The whole operation was carried out in the most workmanlike and successful manner, and demonstrated the care and efficiency with which the Ammonal Explosive Company's officials had carried out their part of the work. The greatest credit is also due to the careful work done by the representatives of Messrs. Bickford, Smith, and Co., Limited, and their technical expert, in the laying of the fuse, whose valuable assistance contributed in no small measure to the success of the undertaking.

As an indication of the very great improvements which have taken place in later years in the method of demolition of masonry by blasting, it may be mentioned as an interesting fact that in the year 1886 a retaining wall at Galleons Wharf, Victoria Dock, London, estimated to weigh 8500 tons, was blown down, and that it was found necessary to use 2900 lb. of blasting gelatine, or in the proportion of 1 lb. blasting gelatine to 3 tons masonry. In comparison with this only 39½ lb. ammonal was used in the operation under review.

A few words as to the "Cordeau" detonant or Bickford's toluene fuse may be interesting. This fuse is a blasting medium hitherto unknown in practical use in England, but known on the Continent since a short time. It is a fuse of lead supplied in various diameters, and contains throughout its whole length a homogeneous core of trinitrotoluol, in itself an explosive of power, and possessing equally the safety characteristics of the explosive ammonal it was used with. Not having been used before, its action is not thoroughly well understood in this country yet, and for that reason it requires to be somewhat carefully handled and adjusted, for it has some remarkable peculiarities which might, in the hands of inexperienced persons, cause disappointment and misfires. One peculiarity is that the detonating wave travels in one direction only, so that the explosive force is only exerted in certain fixed directions, and, strange as it would appear, the detonating wave is ineffective at any junctions of the fuses forming a right angle, unless first passing along the main portion of the cable.

This can be best explained by the accompanying sketch (Fig. 4), where the direction of the wave is shown by the arrows:—

Should the detonating wave follow the lines D to C, the cable A B would simply be split in two at C and remain undetonated; whereas, if exerted in the direction of A to B, shown by the arrows, the detonating wave is communicated effectively at the point C along to D, thus firing the charges at the extremity D.

After the limited experience in the above-detailed operation, it would be somewhat premature to determine precisely the advantages, disadvantages, and weak features of this new detonating-fuse, but it is safe to anticipate that for certain kinds of blasting it should have a great future before it, more especially for deep holes in different places, for submarine mines, and certainly for detonating simultaneously a large number of charges which could not be fired by electricity.

Trinitrotoluol, being a very violent explosive under certain conditions, is most suitable for detonating explosives of the nitrate of ammonium class, such as ammonal, which are, comparatively speaking, more insensitive to shock than those of the nitro-glycerine class, which require detonators of less strength to cause complete detonation. Given, therefore, a powerful explosive insensitive to fire, shock, or con-

cussion, but which can be detonated by a fuse of the nature already described, there is no doubt that an almost perfect and safe, and, at the same time, efficient medium of blasting is now at the disposal of railway contractors and all those who are interested in large blasting operations connected with public works.

INDUSTRIAL NOTES.

The ill-advised Irish railway strike has yielded to the admirable firmness of the railway companies; yielded as it was bound to do, for it was started on the most ridiculous and flimsy pretext, and never had during any part of the time it existed any public sympathy. Whether its failure will be a check on similar foolishness in the future remains to be seen. We can hardly believe that it ever really had the sympathy of the majority of the men themselves. The dispute in the timber trade in Dublin, which was the cause of the trouble, was settled last Friday. It lasted six weeks, and indirectly caused great hardship in the city. It commenced by a demand for an increase of wages and a recognition of the Irish Transport and Workers' Union. All the men who struck belonged to this society, but they met with no success, for the masters, though willing to discuss the wages question, firmly declined to recognise the union or their leader, Mr. James Larkin, although it is understood that pressure was put upon them from Dublin Castle to do so. After being put to great trouble, inconvenience, and loss by the action of the men who picketed the works, the employers finally decided to import a full staff of workmen, the fear of which appears to have brought the strikers to their senses, and negotiations were opened with the employers. These resulted in the latter agreeing to take back all men on the pay-sheet of August 13, with the exception of those who misconducted themselves during the strike, the conditions being that; (*a*) the men were to resume work on Saturday; (*b*) the carters were to deliver goods wherever instructed, and, with the labourers, to work amicably with all the other hands; (*c*) the rate of wages and conditions of employment to be similar to those existing when the strike commenced; and (*d*) the question of wages to be considered later on.

An application by the miners for an advance in wages was made at a meeting held on Saturday last at Newcastle-on-Tyne between the representatives of the Northumberland Coalowners' Association and the Northumberland Miners' Association. According to the *Times*, the rate of miners' wages in Northumberland has for some years past been regulated by the Conciliation Board, composed of fifteen representatives of the coalowners and fifteen representatives of the miners, with an independent chairman, who met quarterly in Newcastle, and decided upon the rate of wages for the ensuing three months. The changes in wages this year were, so far, a fall of 1¼ per cent. in January, a second fall of 3⅜ per cent. in April, and an advance of 1¼ per cent. in July, when the men's wages were 27½ per cent. above the standard of 1879. The men asked to be paid a minimum wage of 30 per cent. above the 1879 basis, but this was refused, and the miners thereupon gave notice to terminate the Conciliation Board, the last meeting of which was held on July 1. A system of negotiations then followed, and the men are now continuing their agitation for a minimum wage. There is another trouble in the Northumberland coal trade over the alleged victimisation of ex-Ruskin College students. One of these students at Blackburn, who returned three months ago, has not yet been reinstated, and the workmen consider that the owners are making a dead set against the college, and they consequently want to strike. On the other hand, the owners state that they have no feeling against the college, but that they are under no obligation to re-employ a man after leaving colliery employment for a prolonged period.

The question of a national coal strike was brought into the sphere of industrial politics at the closing sitting of the Miners' Federation of Great Britain, held at Southport last Friday, for the demand for a minimum wage, which hitherto was confined to miners working in abnormal places, was discarded, and in spite of a moderate policy advocated by the more temperate men, a minimum wage for all coal-cutters was demanded, and a time limit was fixed for negotiations in different districts in order to secure this end. This subject is discussed in our leading article on page 499.

The death of Mr. Henry Broadhurst, ex-M.P., at the age of seventy-one, took place on Wednesday last at Cromer, where he had lived since 1906, when he retired from Parliament. Mr. Broadhurst, who did invaluable work in winning universal approval for the old, and now discarded, system of trade-unionism, was the first working-man to have a seat on the Treasury Bench. He made the friendship of the late King when they were both members of the Royal Commission on the Housing Question, the King being then Prince of Wales.

The Free Labour Association intend to hold their nineteenth annual congress at the Memorial Hall, London, E.C., during the week commencing October 30. Among other resolutions the following will be brought forward:—"That this congress of delegates representing 800,000 free-labour workmen, having been eye-witnesses of many acts of violence, intimidation, and molestation during recent labour conflicts, most earnestly places on record the firm conviction that the time has arrived, in the interests of freedom and the maintenance of our national trade, for a repeal of the Trades Disputes Act, 1906, which allows so-called peaceful persuasion during trade disputes, and is taken by trade-union pickets as an excuse openly to resort to intimidation and terrorism." "That no solution of the labour question of a permanent character can be arrived at until fair and equitable boards of conciliation and arbitration are established throughout the country, mutually satisfactory to employers and workmen, and upon which desirable boards the free labour and independent workmen are fully represented." "That this Congress of Free Labour protests against the dangerous precedent made by the present Government in creating official positions for trade-union agitators, as exemplified in their recent appointments to the Labour Department of the Board of Trade, Labour Exchanges, Industrial Conciliation and Arbitration Boards, and so-called labour advisers to the Home Office, who have been appointed without competitive examination, and urgently urges that a just and adequate share under the State Insurance scheme should be allotted to free labour representation, so that the widespread distrust prevailing amongst the millions of non-union workmen throughout the country with regard to the Government's trade-union bias, as shown by these appointments, may be allayed, and a perfect equality of industrial rights secured to trade unionists and non-unionists alike." "That the Congress views with the greatest alarm the growing tendency of the Employers' Association to enter into 'closed-shop' agreements with trade unions by which the trade unions seek to make it impossible for any free and independent workman to sell his labour, and calls upon employers of labour throughout the country to stand up for their right to engage men according to their ability, and irrespective of membership of any trade union or other society, as well as their undoubted right to manage the businesses which they create, for which they provide capital, and for which they are responsible."

Last Friday saw the end of the annual Congress of the Amalgamated Society of Railway Servants at Carlisle. It was announced that the Congress had considered the Irish strike in private, and had passed the following resolutions:—(1) That this Congress, having carefully considered all the facts incidental to the recent strike in Ireland, expresses regret that the railway men on the Great North of Ireland and the Midland Great Western Railways failed to respond to the call of the executive committee which was given after many urgent requests on the part of those already on strike, and desires to point out that such inaction on their part was not only responsible for the failure of the men to obtain just terms of settlement, but has resulted in numbers of loyal members being victimised. This Congress pledges the financial support of the organisation in accordance with rule, and also assures those victimised that any and every effort will be made by this society to take such steps as will ensure their reinstatement. (2) That this Congress, having given careful consideration to the many and varied circumstances in which railway men are involved in trade disputes, and the enormous danger that follows sectional and local outbursts, hereby instructs the general secretary to ask the Parliamentary Committee of the Trade Union Congress to consider this question with the view of a uniform policy and concerted action being taken. We also instruct the executive committee and the general secretary that no support can be given to men who leave work without the authority of our executive committee.

It is pointed out in the *Journal of the Royal Society of Arts* how easy it is for workmen to injure themselves even when their demands have been granted, as is shown by the recent strike of seamen at Cardiff. The number of unemployed sailors in Cardiff is at the present time extraordinarily large, and it is a direct result of the strike in which they were the apparent victors. The exceptional number of the unemployed is due to the action of the seamen's leaders in demanding, under the recent agreement, a minimum wage of 5*l.* per month, whereas the prevailing wage in most ports is 4*l.* 10*s.* In order to avoid being penalised 10*s.* per month per man, the Cardiff shipowners are signing on crews elsewhere. On the other hand, many seamen have flocked to Cardiff from other ports in the belief that by so doing they would be able to secure higher wages. It is now said that the leaders of the men are inclined to accept the view that the wage secured by the agreement is too high, but unfortunately it provides that there shall be no alteration in the port wage rate until three months' notice has been given by either side.

A serious condition of things arose last week in North and North-East Lancashire because of the refusal of trade-unionists at the Yatefield Mill, Burnley, to work with non-unionists. A ballot of the spinners was taken, which showed that twenty-eight union men were prepared to cease work unless four non-unionists could be persuaded to join the society, and on Thursday last week they gave a week's notice. As a means of retaliation the employers decided on a lock-out of all the spinners and weavers in North and North-East Lancashire should the strike take place. It seems that the trouble became centred on the decision of one man, for three of the non-unionists expressed their willingness to join the union if the fourth man would. The man finally gave way and joined the union. This terminated the difficulty.

According to the monthly report of the United Pattern-Makers' Association for September it appears that the general condition of the trade improved during that month, and there were rather fewer members signing the vacant-books from involuntary causes than has been the case during the past two months. The total number of men idle was 239, brought up by 58 members who are on strike at Horwich and Oldham, leaving 181 members unemployed owing to slackness of work, or 2.4 per cent. of the total membership. It appears that trade is still good on the North-East Coast, and there is a very good demand for men on the middle reaches of the Tyne. Throughout the Clyde district also trade is busy. The worst condition of trade seem to be at Belfast, at any rate among the marine centres. On the Mersey trade is fair, although any demand for men can at once be satisfied from local sources. Good reports come from the Midland districts, but Manchester and district show a slight falling off from the very favourable conditions they have experienced during the greater part of the present year. In the London district trade is somewhat dull. On the whole, the general condition of trade appears to be good, with every prospect of a continuance of the present favourable conditions for a considerable time to come.

It does not appear as though syndicalism is approved of by all unions, for the executive committee of the Associated Society of Locomotive Engineers and Firemen issued a manifesto last week to the effect that they wished to dissociate themselves from sympathetic strikes, on the ground that they considered that continuous, spasmodic, and unauthorised strikes undermine and destroy the best results of trade-unionism and collective bargaining. The withdrawal of labour cannot, they consider, be sanctioned except upon constitutional lines.

On the examination by the Liverpool City Council of the special expenses incurred during the recent strikes, it has been found that the claims for extra police and soldiers, special constables, and overtime for the regular police, rewards for injuries and special services, and for damage by riot, amounted to 21,000*l.* After some opposition by one or two members of the Council, a resolution to pass the bill for payment was carried, and an extra week's pay was granted to the police force and to the loyal tramway men.

According to the circular for October issued by the Emigrants' Information Office, it is now too late in the year for emigrants other than female servants to go to Canada, unless they are prepared to keep themselves during the winter months. For farmers having a little capital, and farm labourers, especially dairymen, there are openings in New South Wales; mechanics also may now find work there. In Victoria the building trades are very prosperous, and work of all kinds is plentiful in South Australia. Large sums of money are being spent by the Government in the construction of railways and other public works, and there is employment for most classes of labour. Carpenters, coachbuilders, trained mechanics for the construction of rolling-stock, and plumbers, will find good openings in Western Australia. Farmers, farm labourers, shepherds, and female domestic servants have reduced passages offered them to New Zealand, and women workers are wanted in that colony for the woollen mills. Female servants are the only class of workers now wanted in South Africa.

Death of Sir William Crossley, Bart.—We regret to learn of the death of Sir William Crossley, one of the founders of the firm of Messrs. Crossley Brothers, Limited, the well-known engineering firm of Manchester, which has been so closely identified with the development of the internal-combustion engine. The death took place on Thursday morning, and we reserve until next week's issue a record of the career of Sir William, who was sixty-seven years of age.

THE BURNLEY CORPORATION GAS-WORKS EXTENSION.

In the pages of ENGINEERING references have been made, during the past few years (vol. lxxxviii., October, 1909, pages 506, 535, 573, and vol. xci., page 181) to the changes taking place in the mode of gasifying coal. These may be summarised as follows:—(*a*) Modification of the weight and duration of charge to horizontal retorts, with a variety of mechanical means for operating the same (see ENGINEERING, vol. lxxx., page 444, vol. lxxxviii., page 573, vol. xci., page 181); (*b*) the use of inclined retorts; (*c*) the use of vertical retorts.

This order represents broadly the growth of ideas in town-gas manufacture, except that (*a*) includes within itself a quite modern procedure, to some extent suggested by the experience gained by means of (*b*) and (*c*). But all increase of this knowledge is not confined to the type (*a*), for there are many indications that the type (*c*) is meeting with considerable approval in schemes of modernisation of gas-works. It is to be remembered, in any comparison of these types, that each one is capable of being aided very substantially by means of a good arrangement of coal and coke-handling plant. The latter must, of course, be designed to suit the kind of retorts adopted, as well as the topographical conditions prevailing in the works and site, and as an example of such a combined scheme the extension of the Burnley Gas-Works is herein described.

The area available was very restricted, the existing works being hemmed in by dwellings, by a tannery, and a cotton-mill, the only remaining vacant land being at the foot of the embankment sustaining the Leeds and Liverpool Canal, and bounded also by the River Calder. These hydraulic boundaries, whilst adding to the cost of construction, are, however, valuable in providing facilities for receiving coal by barges direct from the adjacent collieries, and by the availability of river-water for various cooling purposes. The level of the canal is 40 ft. above that of the gas-works site.

The contiguity of the gas works to the usual source of coal supply—viz., the Burnley Collieries—does not do away with the necessity for storing coal, as the variations due to stoppage of mines, or to the range of consumption of coal from mid-winter to mid-summer, apply here with undiminished force. And whilst the disorganisation of railway traffic is here ordinarily eliminated, there yet remains the fact that at times railway-borne coal must be used, and also that a canal may be frozen over at the time when most coal is required for gas-making purposes. The coal-store arrangements have therefore been made as ample and as convenient for working as possible. The retort-house has been designed for future, as well as present, needs, so that only one-half is at present equipped with retorts. It was designed also so that either inclined or vertical retorts could be adopted; and until that fundamental question was settled, the provision of coke-handling plant was deferred.

Encouraged by the trials made in London of the Woodall-Duckham system of continuously operated vertical retorts (see ENGINEERING, vol. lxxxviii., page 535 *et seq.*), the gas engineer, Mr. J. P. Leather, advised his committee to adopt (under satisfactory guarantees from the contractors) that method. As frequently happens with a new departure in technical practice, various difficulties have presented themselves, but these have been surmounted, and the Corporation of Burnley have taken over the vertical retorts, and are working them by their own staff.

The space available for coal-stores was that remaining of the site after the rectilinear areas devoted to the retort-house and coke-yard had been determined. The irregular quadrilateral resulting is shown in plan in Fig. 2 on our two-page plate. The coal from the adjacent canal is brought (by hand at present) along a short tramway in trucks holding 4 cwt., and these are emptied by means of a rotary "tippler" at the end of the overhead girders carrying the tram-rails. This place is over the part marked "receiving hopper" in Fig. 1, and there it is dropped about 30 ft. into a large hopper (Figs. 1, 2, 6, and 7), falling gradually from thence on to a short shaking-screen (Figs. 6 and 7), which removes the smalls and the remainder from thence into a breaker (Figs. 6 and 7). From the screen and breaker proceed shoots delivering the coal into a filler, shown in Fig. 6, and more in detail in Figs. 10 and 11. By means of this filler the buckets of a gravity bucket-conveyor are supplied with the requisite quantum without spilling. This conveyor travels outward horizontally from the breaker through a subway shown in Fig. 1 (longitudinal section), Fig. 2 (plan), and Fig. 3 (cross-section).

At the gable end of the coal-store a space is reserved by a walled partition for the vertical rise of the gravity bucket-conveyor, and in the roof the direction is changed, passing through the roof trusses. Alongside is provided a platform with hand-rail, and at various points the buckets may be tipped by an automatic device placed where desired along the house. The empty buckets pass onward, past the electric motor (Figs. 1 and 2, and in detail in Figs. 8 and 9), downwards through a walled-off compartment, to the tension gear (Figs. 1 and 6), and forward to the coal-breaker.

Should coal be received from the collieries, not by barge, but by railway and road, then the carts would discharge into the coal-receiving hopper, gaining access thereto by the inclined roadway shown in Figs. 2 and 3. By these means the coal is received, screened, broken, and stored. When it is desired to use the coal at once, delivery takes place from the conveyor, down the "shoot to elevator boot," shown in Figs. 1, 2, and 3. The boot referred to is that of the ordinary bucket-elevator, shown in Figs. 2 and 17, delivering coal on to a band-conveyor placed in the retort-house roof (Figs. 18 and 19).

When coal is not coming in, the daily supply is taken out of the store by way of the receiving hoppers for the travelling filler, shown in the floor of the coal-store (Figs. 1, 2, and 3). These are fitted with duplex lever valves, shown in side elevation (Fig. 10) and end elevation (Fig. 11). The travelling filler, with its regulator (West's patent) is moved into position, the buckets are automatically filled, carried and discharged into the shoot already referred to.

The subway containing the paths for the conveyor and its chains is covered over by girders and concrete filling, whilst access to the subway (which is 7 ft. wide by 6 ft. high at the coal-breaker end, and 7 ft. 9 in. high at the other end) is gained down steps constructed outside the gable of the coal-store.

At the canal end of the coal-store is an engine-house, containing gas-engine and dynamo, which furnish current to the motor for the screen and coal-breaker placed in the adjoining room, shown in Figs. 1, 2, 6, and 7; and also to the motor placed in the roof for driving the gravity bucket-conveyor (Figs. 1, 2, 8, and 9), as well as to the motor at the head of the ordinary elevator, where it joins the band conveyor (Fig. 17). Over this engine-house, whose walls are carried to a height above the retort-house roof, is placed a water-cistern of 20,000 gallons capacity (see Figs. 1 and 2). Figs. 1 and 3 show the disposition of the roof to the coal-store, each principal of which is of different span. Figs. 2 and 4 show the relation thereto of the retort-house, and the photograph reproduced in Fig. 5, on page 404, shows the great height of the standards supporting the retort-house roof, and at the same time the roofs of the two buildings.

The wall of the coal-store next the retort-house is built of concrete, and this is tied near the ground line with 8-in. by §-in. bars set at an angle of 45 deg., to assist in withstanding the outward pressure of the coal. Adjoining this wall are the 18-in. by 7-in. steel standards supporting the retort-house roof main spans, and the feet of these are anchored to two rolled joists embedded in the concrete floor of the coal-store, and to the 8-in. tie-bars already mentioned (see Fig. 4).

The apex of the coal-store roof immediately above the gravity bucket-conveyor has a continuous opening for light and ventilation. The coal-store is 138 ft. long by 78 ft. wide at the canal end, and 38 ft. at the other, and when coal is stored to an average depth of 30 ft. it will hold 5000 tons without trimming, and probably nearly 5600 tons when trimmed.

The retort-house is 208 ft. long by 55 ft. wide, inside measure. Like the coal-store, the retort-house is built of red facing bricks, with stone dressings, carried out by the workmen of the Corporation. The roof of the retort-house was constructed in two sections. The one over the vertical retort settings is of 36-ft. span, and the heights of the roof trusses above the main framework of stanchions and girders are 4 ft. 6 in., 7 ft., and 16 ft. at the shoe, the horizontal tie, and the ventilator summit respectively; and the other a lean-to of 19 ft. 6 in. span, consisting of braced girders, resting one shoe at 32 ft. 6 in. and the other at 42. ft. above ground-level (see Figs. 4 and 17). This mode of grouping keeps down the height of the side walls, and permits of a lighter roof than would have been required for one of the whole span of 55 ft. 6 in.

The central part has the appearance of an unusually high support and a narrow span. The main stanchions are composed of 18-in. by 7-in. rolled-steel joists, 43 ft. high; these stand alongside the concrete party-wall of the coal-store, and are spaced at 10-ft. centres. Those at the other side of the retort settings are 16 in. by 6 in. in section. In the photograph, Fig. 5, the roof shown on the left is over the irregularly-shaped coal-store. This photograph, and the sectional drawing of the retort-bench (Fig. 20), show the character of the roof and its composite grouping, and the stanchions just referred to. At the apex, and for the full length of the house, the roof is for a width of 3 ft. completely open, while below the lower portion of the roof, at the side of the higher portion of the roof covering the vertical retort settings, there is a louvre ventilator, also the full length of the house.

The roofs throughout are covered with slates laid on steel angle-laths, and secured with wire nails. British steel was used, and the work carried out by Messrs. Ed. Wood and Co., Limited, Manchester, without the slightest hitch.

The tall chimney for the retort settings is completely detached from the retort-house, the main flue running underground, 5 ft. 6 in. high by 3 ft. 3 in. wide, with 14-in. walls, as shown in cross-section (Fig. 4), and receiving the waste gases from each retort setting by a series of down-cast flues. Three down-cast flues, about 3 ft. 6 in. square externally, each take the waste gases from three retort settings.

There are erected at present nine settings of four oval retorts, each 21 in. by 9 in. cross-section at top, and 25 ft. long, tapering to 29 in. by 20 in. cross-section at the bottom. Each retort is designed to carbonise 2½ tons of coal per 24 hours. Each setting occupies 10 ft. by 17 ft. 3 in. from the front to the back buckstaves. This installation could be doubled, leaving 10 ft. space between the ends of each of the two sections. The whole house would then carbonise 180 to 190 tons of coal per day, yielding, without allowance for contingencies, about 2¼ million cubic feet of gas. Experience of these retorts has satisfied the engineer that they are capable of carbonising on the average 52 cwt. to 55 cwt. of coal per day, yielding 12,600 cub. ft. of gas per ton of Burnley coal. The tar produced is of good quality, having no more than 56.8 per cent. of pitch (above 350 deg. Cent.) and 5.6 per cent. of free carbon.

The gas-producers for heating the retorts are shown in vertical section in Fig. 20, and the two gangways for access to the top and bottom thereof respectively carried by cantilevers from the 16-in. by 6-in. stanchions. They are being fed with cold coke, lifted from the ground floor in tipping-trucks to the higher of the two gangways. This hoist is worked by hydraulic pressure of 90 lb. per square inch furnished by a duplex pump. Fig. 20 also shows the floor at the base of the settings, which is 9 ft. above the retort-house floor. It is supported upon the stanchions of the general framework, with the addition of a pillar composed of two 10-in. by 5-in. joists, and it is made of 14-in. by 6-in. joists, on which rest the cast-iron mouthpieces of the vertical retorts. The space is filled with concrete, and to the underside of the floor thus formed are secured by embedded bolts the hoppers and coke-discharging gear. Each hopper is formed with a sloping back-plate, upon which rests the coke from the retort. Its capacity is sufficient for half-an-hour's make of coke, and it discharges about four times in the hour. At the bottom of this plate is situated the extractor-roll, with its helical blades, which move the coke towards the discharging-drum beneath. The speed of the extractor-roll, which is normally 1.2 revolutions per hour, is adjustable, being driven by means of a ratchet, the stroke of which is regulated by means of a screw attachment on the main driving-shaft. It is intended to fix an index to the star-wheel over the roll, to show how many revolutions have been made in a given time. A small quantity of water is introduced into the chamber above the extractor-shaft to prevent the shaft and discharging-drum getting too hot. One gallon per retort per hour is admitted, and with this the coke contains less than ½ of 1 per cent. of moisture. Analyses of the coke have repeatedly shown not more than 0.8 per cent. of water and volatile matter combined.

The discharging-drum works in a casing, and the two are turned up and bored out true to fit each other gas-tight. It is similar in principle to that by which coal is fed into the retort; but instead of continuously revolving, it automatically reverses when it has accomplished a little more than half a revolution. Its capacity is sufficient for about half-an-hour's make of coke, and it is arranged to discharge about four times in the hour. By an alternative arrangement the extractor-roll and discharging-drum can be worked by hand. At the slow speeds mentioned the power required for driving the discharging apparatus is small, and is provided, along with that for the coal-feeding gear at the top of the retorts, by a separate 8-horse-power gas-engine. Speed is reduced by driving from the gas-engine by a belt on to a countershaft fitted with a worm engaging a worm-wheel on a crank-shaft. The latter gives reciprocating motion to both the gear at the bottom of the retorts and to that at the top. That of the bottom shaft makes two rocks per minute, and that of the top fifteen rocks per minute.

The fireclay retorts themselves are made in 3-ft. lengths, with the ends flanged (see Fig. 20), in order to give a larger bearing surface at the joint. At the top they finish with a cast-iron mouthpiece, to which is fixed the feeding device and the gas outlet pipe. From each hopper A and B (Fig. 20) depends a short movable shoot, with adjustable door, through which runs the coal into the small hopper of the feed-roll. The feeding device is a truly cylindrical drum and casing; the drum, usually making one revolution in 2¼ minutes, rotates at such a speed that it always contains an excess of coal beyond that necessitated by the removal of coke from the retort, thus keeping the retort quite full. The motion of the drum is given by a rod connected to the rocking shaft shown at top of Fig. 20. If the drum does not take into the retort some coal at each revolution, it is then necessary to

find the cause of the stoppage. Means are provided by which rods can be readily introduced when the coal sticks. Stoppages occur most frequently with very soft dusty coal, especially if it cakes very readily. Nuts containing only a small proportion of dust do not cause much trouble. If the hanging of the coal persists for any length of time while the extraction of coke from the bottom is allowed to continue, then, when the obstruction is remedied, there is at once a fall of the coal, resulting in an empty space in the upper part of the retort. Under these circumstances, the gas given off by the charge passing through the empty part is over-cracked, resulting in the formation of pitch in the foul main and gas off-take pipe.

The cast-iron mouth-pieces are arranged to allow for expansion of the retort when heated, and they also have a space wherein water is circulated to keep them moderately cool (Fig. 20).

The heating of the retorts is on the recuperative principle, the waste gases passing upwards from the base of the retort settings, through flues that run parallel with flues, down which the secondary air is passing. This recuperator is built within the setting, on the opposite side to where the producer is placed, but is not delineated in Fig. 20. From the producer the gases pass by two vertical flues to the space around the top of each retort. Parallel to these gas-flues are the secondary air-flues brought from the recuperator just mentioned. The gas and heated secondary air thus enter the combustion chamber in parallel streams through four nostrils of large dimensions, and the gases are lighted in the combustion chamber before they come in contact with the retorts. The temperature in the combustion-chamber round the retort in the upper portion, near the top, is 1200 deg. Cent., gradually reducing and getting down to 960 deg. Cent. near the bottom of the carbonising space. These are the temperatures immediately round the retort.

The products of the combustion pass downwards around the four retorts deflected alternately right and left by four horizontal partitions (see Fig. 4, on page 535 of ENGINEERING, October 22, 1909).

The gas-producer is fitted with a somewhat novel cover, which consists of two parts. The inner and less heavy lid rests nearest the hot part of the producer, whilst above is a heavier one formed with a projecting flange which embeds in a seal of sand provided in an outer framework (see Fig. 20). The advantage of this effective sealing is that there is no flaring at the producers when the bottom doors are open, at the time of removing clinker or of shaking the grate-bars. The clinker and ash are dropped through a flap-door provided in the steel chequer-plate floor, into trucks standing on the retort-house floor.

The gas passes from the vertical retorts through pipes 4 in. in diameter into a "foul main," which is under the pull of the usual exhauster, the vacuum being controlled by a Braddock's retort-house governor. There is practically no difference in pressure between the top and the bottom of the retort, except under the circumstances named above, when green coal has been allowed to get low down in the retort. On the occasion of the visit of the writer the gauge indicated a vacuum of $\frac{3}{10}$ in. water column. The retorts sometimes run as much as thirteen weeks without scurfing, although an average of six to seven weeks is often the case, for instance, at Lausanne.

Each part is driven by an electric motor, supplied with current from the power-house near the canal. Herein is installed a "National" gas-engine of 42 effective horse-power, direct coupled by flexible coupling with a continuous-current dynamo made by Electromotors, Limited, Openshaw, giving 220 volts, 118 amperes at 230 revolutions per minute, equal to 26 kw. The winding is compound and the rating is for continuous work. The gas-engine has five cooling-water vessels (Fig. 2), an anti-fluctuator, and is fitted with tube ignition and a hand-pump starter. The capacity of the engine and dynamo is 12 electrical horse-power in excess of the motors driven—viz. :—

Motor operating screen and coal-breaker, 15 horse-power when running at 600 revolutions per minute.

Motor operating gravity bucket-conveyor, 7 horse-power when running at 650 revolutions per minute.

Motor operating ordinary elevator and band conveyor, 8 horse-power when running at 1050 revolutions per minute.

Each of these is of the totally-enclosed and dust-proof type; and the electrical starting gear is fitted with auto no-volt and overload release. The Berry resistance and starting gear was made by Electromotors, Limited.

The coal-receiving hopper is 6 ft. square at the top and 3 ft deep (Figs. 6 and 7), the outlet being large enough to pass lumps 18 in. by 12 in., and fitted with a regulator to control the flow of coal on to the jigging screen. The screen is capable of passing 30 tons of coal per hour, rejecting all pieces of more than $1\frac{1}{2}$ in. cube, delivering the latter on to the breaker. The breaker is fitted with two sets of rolls provided with jaws, the first set breaking lumps of 18 in. by 12 in., and the second set allowing no piece to pass greater than $2\frac{1}{2}$ in. cube. The filler receives the coal both from the screen and the breaker, or from any of the twelve outlets with duplex valves fixed in the floor of the coal-store (see Figs. 6, 10, and 11).

The gravity buckets are of pressed-steel plate, made without seam or joint (see Figs. 12, 13, and 14, above), and the chains from which they are suspended (see Figs. 12, 13, 14, and 18) are fitted with cast-steel renewable bushes which provide for a sufficient area of bearing surface for the joint-pins. The detail drawings given are as follow :—Figs. 12, 13, and 14, side elevation, half-plan, and elevation of tippler and bucket respectively. Fig. 15, section through chain; Fig. 16, section of West's automatic oiler.

The buckets are at 24-in. centres, each capable of carrying 28 lb. of coal; they travel at 50 ft. per minute, and are arranged so that they can be removed

THE BURNLEY CORPORATION GAS-WORKS EXTENSION.

MR. JOHN P. LEATHER, ENGINEER.

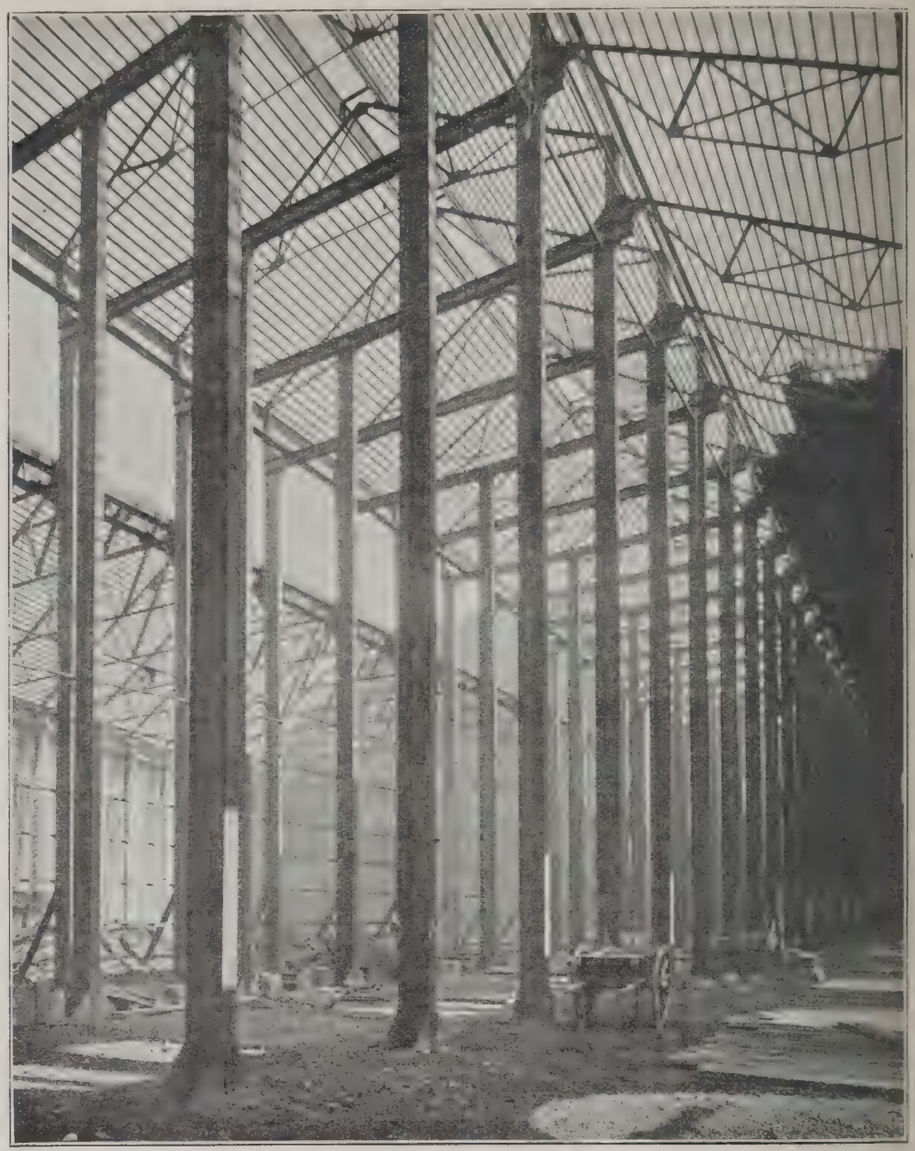
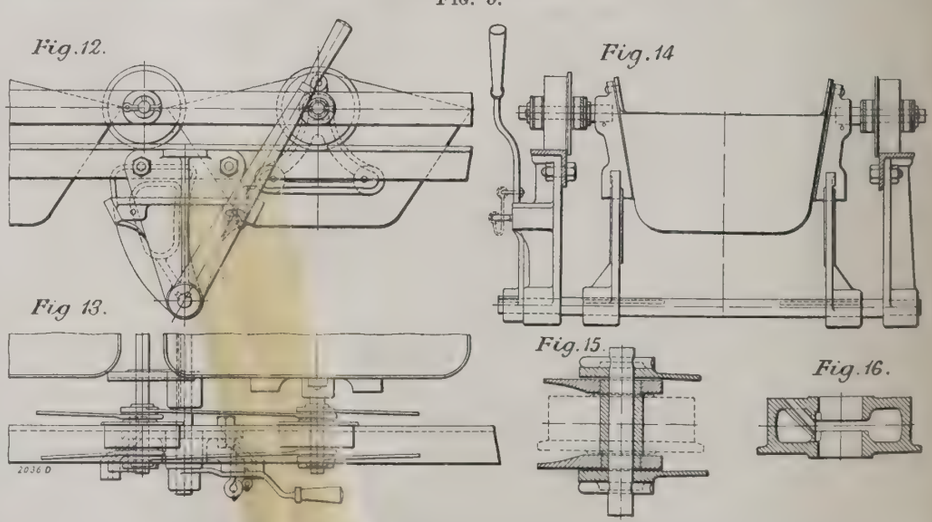


FIG. 5.



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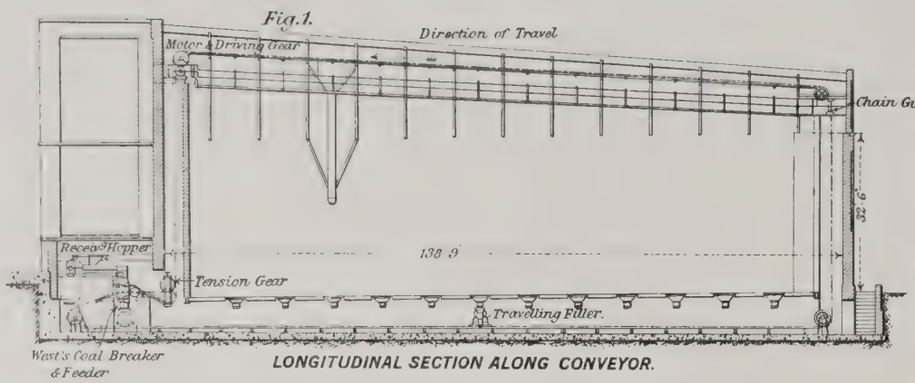
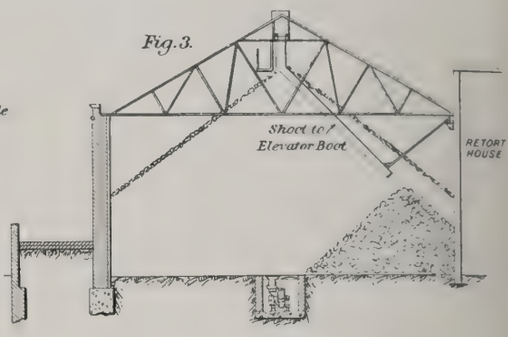
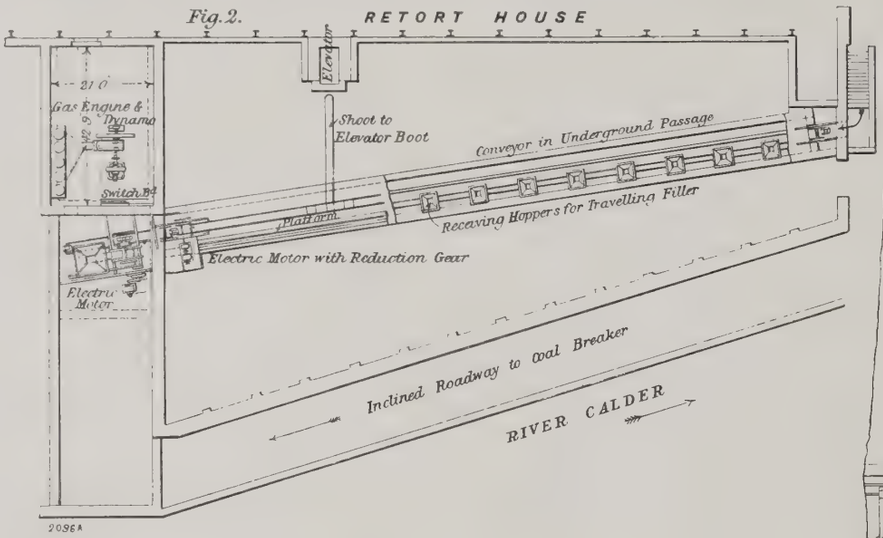
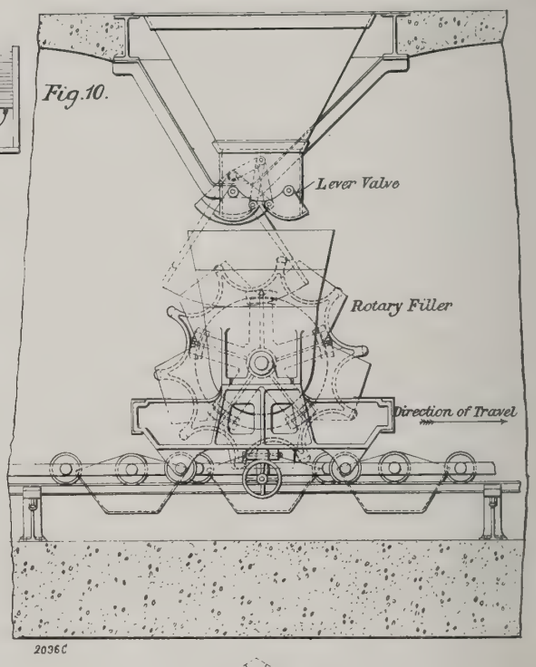


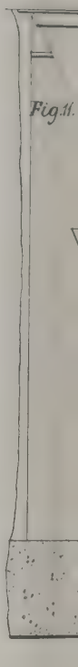
LONGITUDINAL SECTION ALONG CONVEYOR.

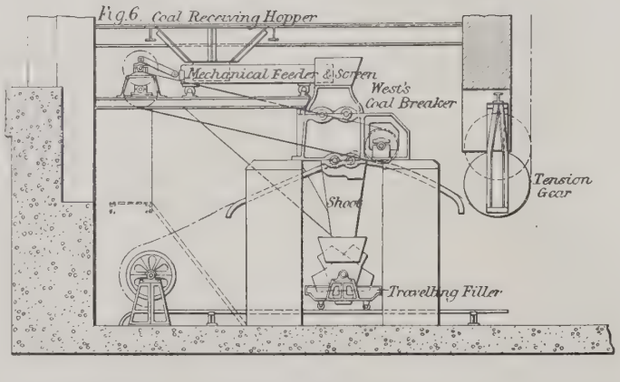


CROSS SECTION OF COAL STORE.

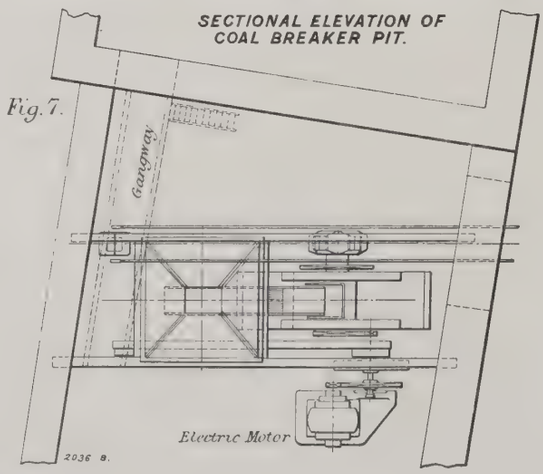


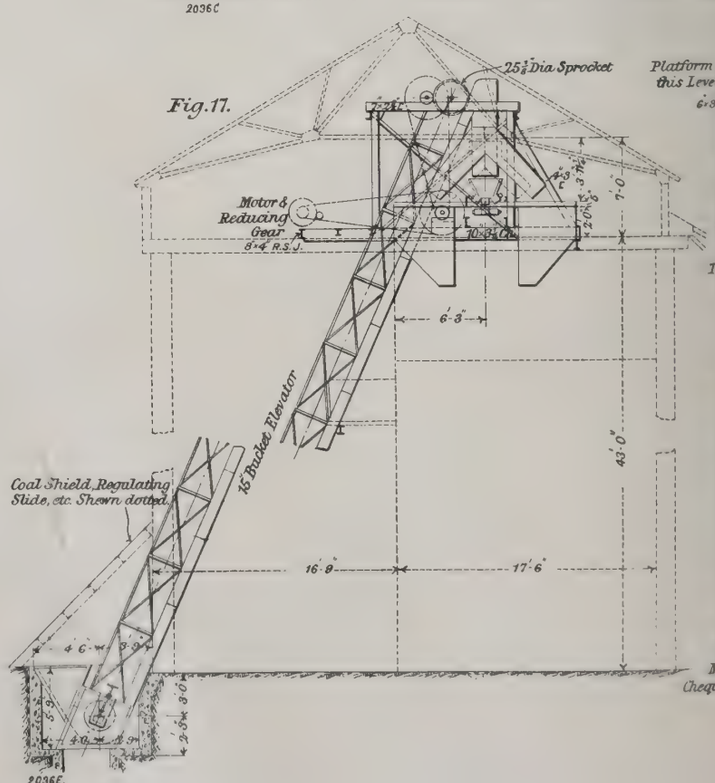






SECTIONAL ELEVATION OF COAL BREAKER PIT.

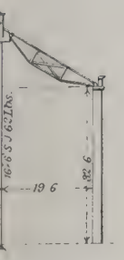




CORPORATION GAS-WORKS.

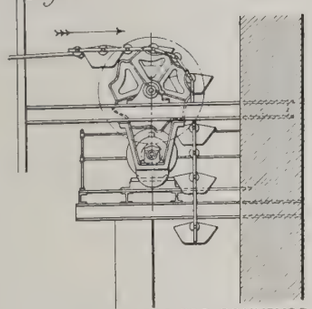
NGINEER.

93.)



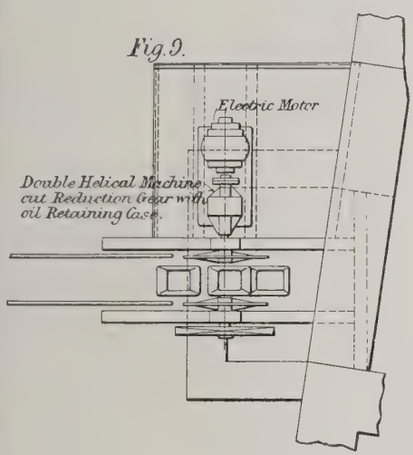
ETORT HOUSE
ID ROOF.

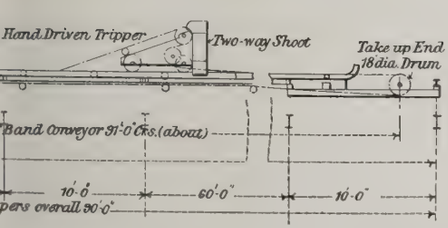
Fig. 8.



DRIVING GEAR FOR CONVEYOR.

Fig. 9.





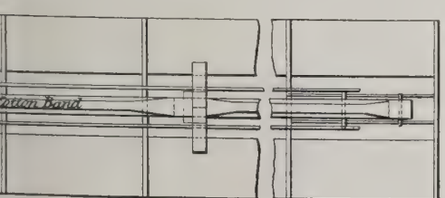
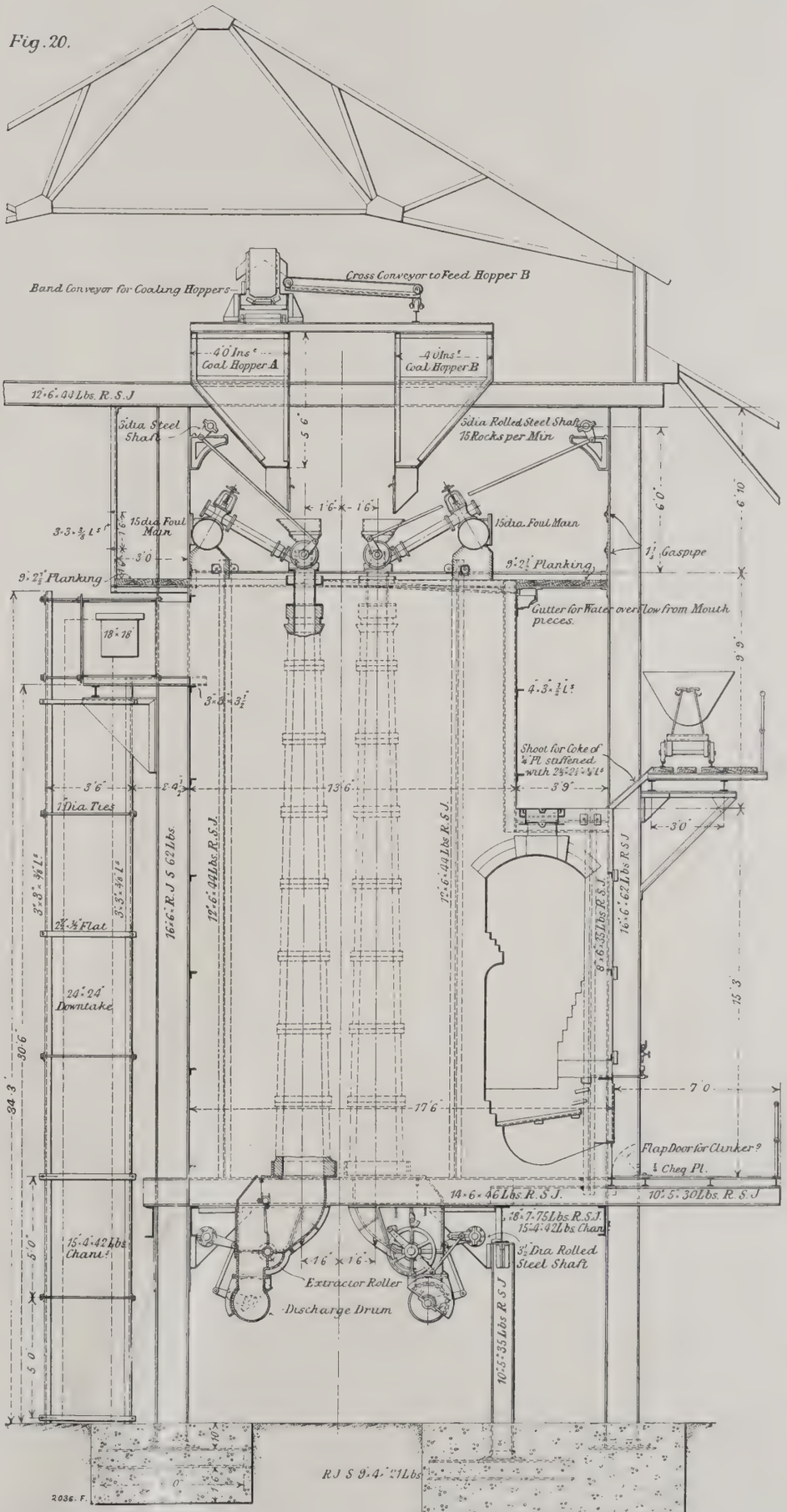
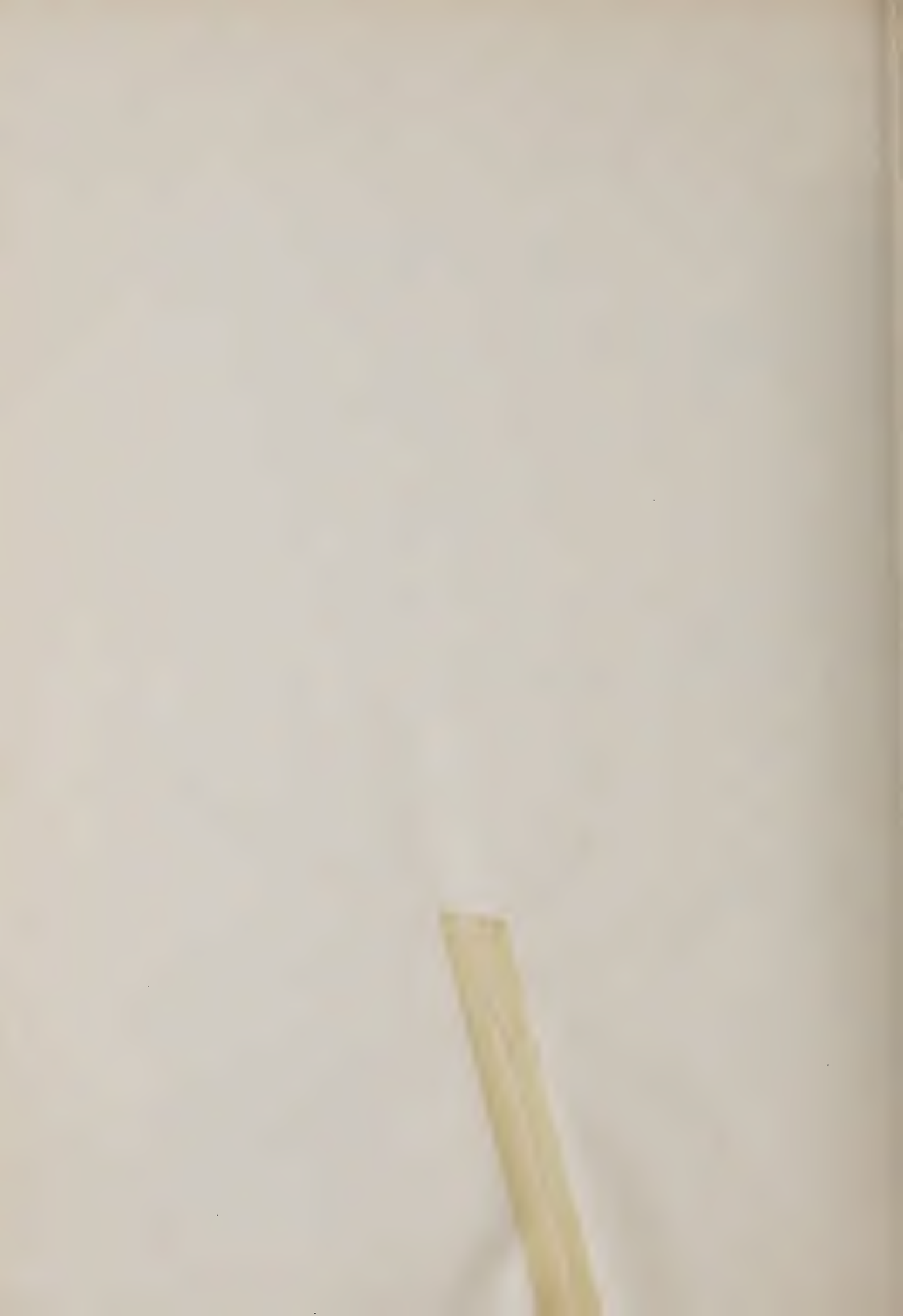


Fig. 20.





VERTICAL GAS-RETORTS AT THE LAUSANNE MUNICIPAL GAS-WORKS.

MESSRS. DUCKHAM AND CLOUDSLEY, LIMITED, CONTRACTORS, WESTMINSTER.

Fig. 21.

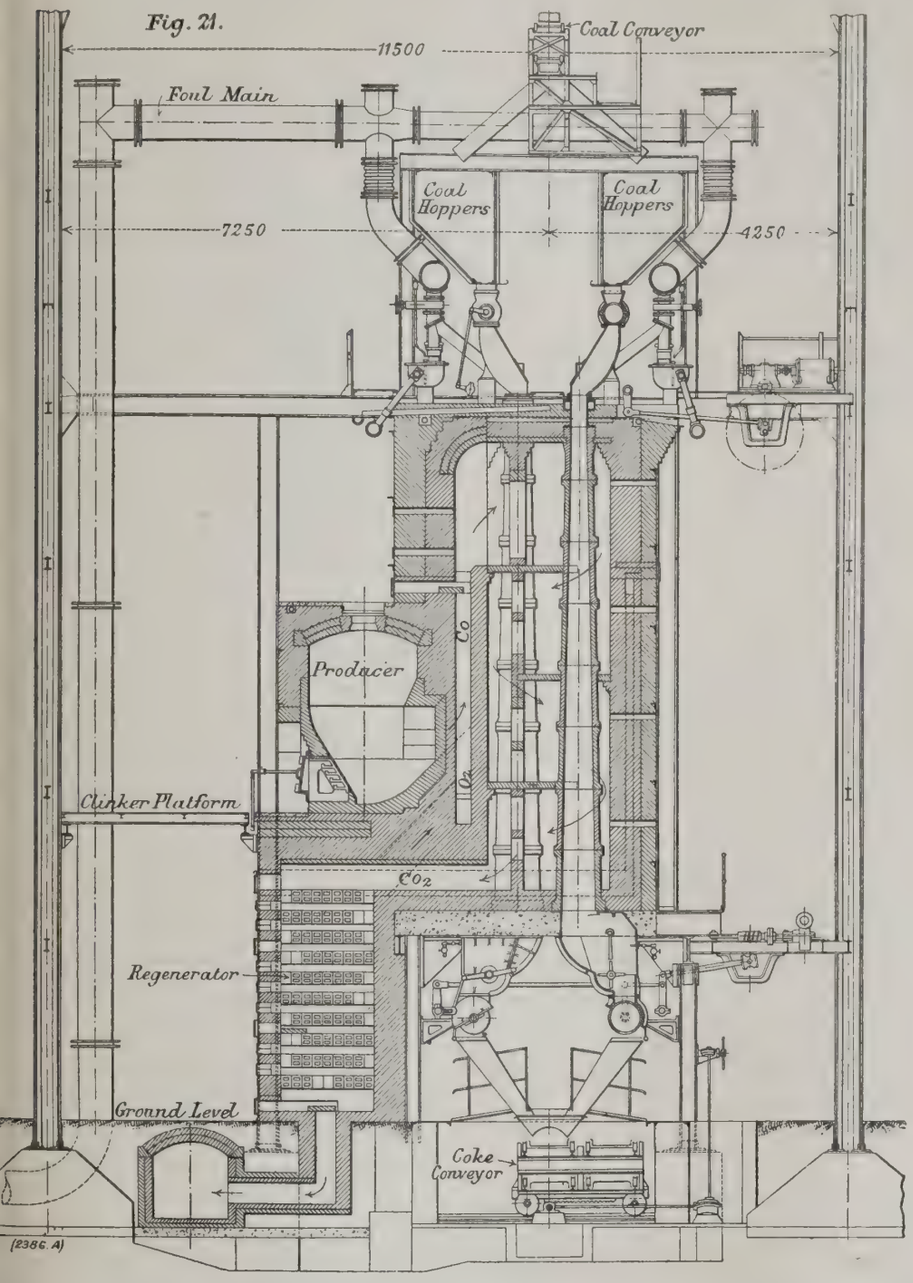
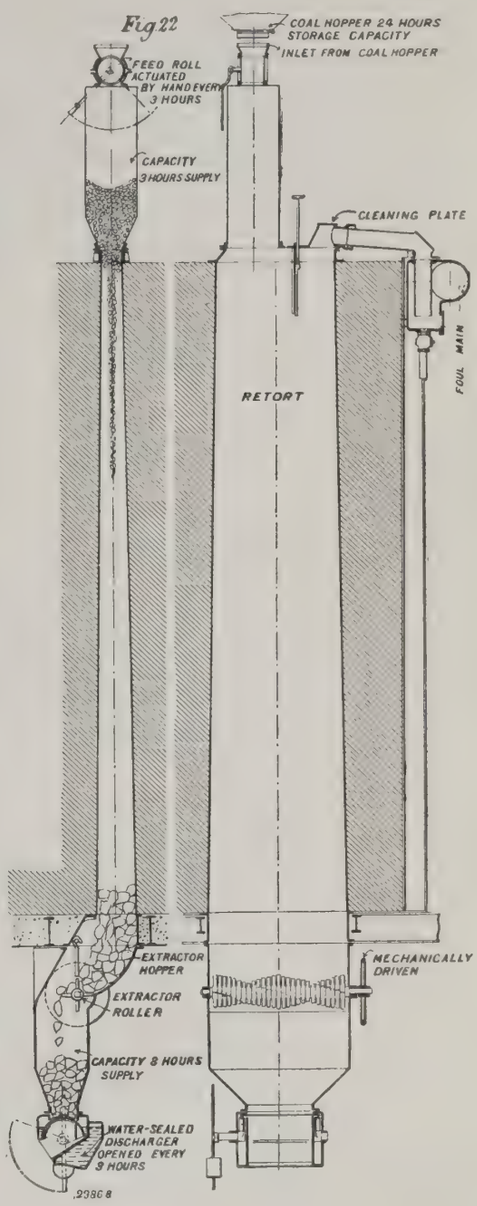


Fig 22



from the conveyor without disconnecting the chain. The self-oiling roller is found in use to be an important detail. The section shows the cavity in which the store of oil is held within the roller itself. Figs. 12, 13, and 14 show the handle, and its holding-pin, by which the tippler is brought into contact with the wings provided on the sides of the buckets, in any bay of the coal-store so desired. Twelve tipplers are provided—one in the centre of each bay of the roof except the end bays; and these are fixed under the angle-steel paths, by means of cast-iron hangers shown in Figs. 12 and 14, page 494.

The supports or paths for the rollers are securely fixed (*a*) in the subway on cradles resting upon the concrete floor, the same cradles carrying another pair of rails for the automatic filler (see Fig. 11); (*b*) in the apex of the roof trusses (Fig. 3), upon angle-steels (Figs. 12, 13, and 14), resting on the horizontal strut provided in the design of the roof truss; (*c*) near the tension gear (Fig. 6), where the direction of travel is changed, upon steel angles placed at an incline, and having curved ends. Alongside the conveyor in the roof, and depending from the same horizontal struts, is a gangway made of planks 3 in. thick, suspended by steel hangers, and protected by a double hand-rail on each side.

The gravity bucket-conveyor easily deals with 30 tons of coal per hour (Figs. 1, 2, and 3), and the shoot, constructed of $\frac{3}{16}$-in. steel plates, suspended from the horizontal strut and stayed from the shoe of the roof, directs the coal towards the boot of the retort-house elevator, liberating the coal at a height of 20 ft. from the floor, against the shield shown in Fig. 17.

The 15-in. ordinary bucket-elevator, supplied by Messrs. Gibbons, stands central as to the length of the retort-house, whilst the boot is just within the coal-store, under the shield just referred to. It is formed by a framework built of rolled joists covered with steel plates, as shown in Fig. 17, and there is a regulating slide to control the rate of feed to the boot and consequently to the buckets. From centre to centre of the end drums of the elevator is 61 ft., and from the top one the coal descends out of the buckets by means of a three-way shoot (see Figs. 17, 18, and 19), fitted with hinged flap, into either set of overhead hoppers or on to a 16-in. band-conveyor, which, in its turn, delivers the coal into the hoppers A and B (Fig. 20) by means of one of Gibbons' improved automatic throw-off carriages. The band itself is of the solid-woven-cotton type, 3-ply thick, and runs down between two continuous lines of hoppers, each of 90 ft., discharging into them on either side, by the two-way shoot (see Figs. 18 and 19), and not by means of a cross-conveyor (top of Fig. 20). The latter, an alternative proposal, was not finally adopted, but the method shown in Figs. 16 and 17. Their storage capacity is equal to 14 hours' supply of the retorts, whilst the elevator can lift 25 tons per hour. The motor and reducing-speed gear are carried on a platform made of chequer-plates and rolled joists (see Fig. 19).

Reference has been made in the foregoing description to the fact that working difficulties were experienced with the vertical retorts; but as these have received the attention both of the engineer and of the contractors, it is desirable that they should be here referred to, with the methods adopted to overcome them. Almost coincident with the Burnley installation was one at Lausanne, and the improvements suggested by the experience at the former works has enabled modifications to be embodied in the latter, which have enabled the retorts to be operated with most satisfactory results, mechanically and chemically.

Experiments were made at Burnley with an arrangement in which the coal-feed roll is elevated somewhat from the retort, thus providing a small store of coal between the feed-roll and the retort. This alteration is found to conduce to more regular working. The engraving given of the Lausanne installation (Fig. 21, above) illustrates the principle of this. It is also found advisable to have a partition-plate between the coal-feed and the gas off-take, so that the coal may find its way into the hot part of the retort before the outflowing gas has had any opportunity to deposit in the coal pitchy matter tending to impede its easy flow. The outflow pipes are now being made 5 in. in diameter, in lieu of the 4 in. at Burnley. A further development of this arrangement, obviating the automatic mechanical feed, is illustrated in Fig. 22, which shows the method adopted most recently. A box is connected to the top of the retort, capable of containing two or

three hours' supply of coal, replenished at intervals from the overhead bunkers through what is practically a simple plug-cock. In this box is provided a simple indicator, by inspecting which the downward movement of the coal may be observed.

The long rocking-shaft driving the extractor and the discharging-drums has, at Burnley, given considerable trouble; the torsion caused by the discharging-drums not working freely resulting in irregularity at the different parts of the bench. This has been remedied in the Lausanne installation by the better design of the rocking-shaft and its method of support, as well as by a slight modification of the discharge drums, causing them to work more freely and yet certainly. In more recent installations, it has, however, been possible to replace the rocking-shaft by a reciprocating rod, which is not liable to the same faults.

A further improvement adopted on two of the retorts at Burnley is to replace the mechanically-worked discharging-drum by a water-sealed door, shown in diagram (Fig. 22). Mr. Leather doubted at first the safety of such a *modus operandi*, as explosions might be engendered by the admission at intervals of time of air into the retort. Experience has shown, however, that if a little water is admitted before opening the door, the space above the door becomes full of steam, which acts as a cushion between the gas and the air.

The new works of the Lausanne Municipality comprise a retort-house entirely fitted with Woodall-Duckham vertical retorts. There are twelve beds of four retorts each, only one-half of which, however, have as yet been required to be worked. The retorts themselves and the general arrangements are in many important respects similar to those at Burnley; but they are supplemented by a coke-conveyor placed under the retorts, and the regenerator is external to the retort setting, *en route* to the underground flue.

The producer and the regenerator are of the types constructed by Messrs. Lachomette, of Lyons, the French agents of Messrs. Duckham and Cloudsley, Limited. The producer has no permanent grate-bars or water ash-pan as in the usual English practice. Provision is, of course, made for clinker removal by means of the insertion of temporary fire-bars, and the inclined grate shown in Fig. 21 is kept cool by water spray. The regenerator is built up of tube blocks (as shown in section, Fig. 21), through which the secondary air passes continuously, the waste gases descending around them externally.

The results in Table I. have been certified by M. Cornaz, the municipal gas engineer, from the various classes of coal used, and afford an index to what would be obtained at Burnley had it been possible to measure the gas from the vertical retorts separately.

TABLE I.

Dates in 1911 at Lausanne.	Coal Used by M. Cornaz.	Per Cent. of Fuel Used.	Cubic Feet of Gas per Ton of Coal.	Calorific Power of Gas in British Thermal Units per Cubic Foot at 15 Deg. Cent. and 760 Millimetres.				No. of Test.
				Gross.	Net.	Difference.	Gross per Ton of Coal.	
February 12 to 14	Aldwarke	..	12,863	623	558	65	8,013,649	1
February 15 to 28	Saar	..	13,180	617	551	66	8,132,060	2
April 29 to May 11	Charlesworth	..	12,648	607	546	61	7,677,336	3
May 14 to 17	Rother Vale	..	13,457	603	537	66	8,114,571	4
May 1 to June 9	..	13·1	13,174	591	..	..	7,785,834	5
January 17 to June 9	Various	13.2	12,676	617	..	..	7,821,092	6
January 17 to May 3	Various	12.1	12,962	598	532	66	7,751,276	7
May, 1909, at Nine Elms Gas Works	Blackwell and Sutton	..	12,839	570.8	508.8	62	7,328,501	8

TABLE II.

Duration of Test.	Net Calorific Value per Cubic Foot of Gas due to		Net Calorific Values in British Thermal Units per Ton of Coal Carbonised.			No. of Test in Table I.
	Hydrogen.	Carbon.	Due to Carbon.	Due to Hydrogen	Total.	
2 days..	334	224	2,881,312	4,296,242	7,177,554	1
13 ,, ..	339	212	2,794,160	4,468,020	7,262,180	2
12 ,, ..	313	233	2,946,984	3 958,821	6,905,808	3
3 ,, ..	339	193	2,664,486	4,561,923	7,226,409	4
106 ,, ..	339	193	2,501,666	4,394,118	6,895,784	7
152 hours	318.8	190	2,439,410	4,093,073	6,5 2,483	8

Table I. gives results from several classes of coal, and also for mixtures of coals, English and Continental, from the day the retorts were started, January 17, 1911, to May. All the gas for the town being made in these retorts, definite results are available for a period of several months.

Table II. shows the way in which the heating power of the gas is made up, from carbon and hydrogen, and these figures enable a comparison to be made with those on page 537 of Engineering, October 22, 1909, from the working of the Woodall-Duckham system by the Gas Light and Coke Company, at their Nine Elms Works. The Yorkshire coals mentioned in the Lausanne tests are high-class, and, perhaps, may to some extent explain the superior results; but in any case the returns, both as to gross and net calorific power per ton of coal, are high.

At Lausanne the vertical retorts are carbonising 10 per cent. more coals than were carbonised at the old works employing horizontal retorts, and the number of men required is nine per day (three per shift), as against forty-five per day (fifteen per shift). Using similar coals to those stated in Table I., the make of gas per ton in horizontal retorts was 11,400 cub. ft.

The cost of the installation of vertical retorts at Burnley as described was 10,800*l.*, which is somewhat under the usual estimate of 125*l.* per ton of coal carbonised per day. The cost of the coal-handling plant within the coal-store was 1670*l.* The cost of the buildings was 7163*l.*, which included 2229*l.* for steel constructional work in roofs and stanchions and 352*l.* for slating.

For the facilities of the inspections of the writer, and for the other generous assistance which has enabled this description to be given, we are indebted to Mr. John P. Leather, the gas engineer to the Burnley Corporation. Further aid has been given by the contractors, Messrs. Ed. Wood and Co., Limited, Manchester, for the roofs &c.; West's Gas Improvement Company, Limited, Miles Platting, Manchester, for the work within the coal-store; and Messrs. Duckham and Cloudsley, Limited, Bridge-street, Westminster, for the vertical retorts, including their sub-contractors, Messrs. Gibbons Brothers, Limited, Dibdale Works, Dudley, for the coal-elevator and band-conveyor. To all thanks are due, and are here heartily tendered.

Personal.—We have been asked to state that Mr. A. B. Mallinson has severed his connection with Messrs. Mather and Platt, Limited, Park Works, Manchester, and has joined the board of directors of Mallinson and Eckerstey, Limited, Albert Saw-Mills, Worsley-street, New Bailey-street, Salford. He will, however, continue his engineering connection in a consulting capacity, specialising in works driving equipments, particularly for collieries, textile, and paper-mills.—We are informed that on September 30 last, Mr. James Rowe, J.P., retired from the active management of the business of E. Finch and Co., Limited, Bridge Works, Chepstow, after having spent over fifty-four years with that firm.—We are asked to state that Mr. R. Borlase Matthews, Wh. Ex., M.I.E.E., is relinquishing his present work as a consulting engineer, to become manager to Messrs. Ozonair, Limited, 96, Victoria-street, Westminster, S.W.

Lectures on Illuminating Engineering.—Particulars have reached us from the Battersea Polytechnic, Battersea Park-road, S.W., of a series of twelve lectures on illuminating engineering, to be delivered at that institution by various specialists in the different branches of the subject. The first six lectures will be delivered on Tuesday evenings at 7.30 o'clock, commencing on the 17th inst.; the remainder, which are to be given on Friday evenings at the same time, will commence on January 12, 1912. The course will deal with all illuminants, including electricity, gas, oil, petrol-vapour, acetylene, &c., and also with the measurement of light, effects of shades and reflectors, effects of light on the eye, the hygienic aspects of illumination, and various practical problems, such as the lighting of schools, streets, factories, &c. The lectures will be fully illustrated by lantern-slides and demonstrations. The fee for the full course is 12s. 6d., or 2s. for a single lecture. Full particulars, with an abridged syllabus, can be obtained from the secretary.

The late Mr. G. Sonnenthal.—We regret to announce the death of Mr. George Sonnenthal, of the firm of Messrs. Selig Sonnenthal and Co., and chairman of the Selson Engineering Company, Limited, of Coventry, and 85, Queen Victoria-street, London, E.C. As is well known, the firm devotes its attention to machine-tools and small tools, the former being made to their design in various British factories, while the Coventry works are almost exclusively occupied in the production of high-speed shaping-machines, radial drills, and high-speed lathes. Mr. Sonnenthal brought considerable enterprise and energy to bear in the establishment of the business of his firm. He had full confidence in the ability of British makers to meet foreign competition. Mr. Sonnenthal, who was sixty-two at the time of his death, on the 3rd inst., took part in the Franco-German war of 1870-1, and received the Iron Cross at the hands of the late Emperor Frederick for bravery on the battle-field. The business will, we are informed, be carried on by his son-in-law, son, and their co-directors.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with an easier tone, and business was confined to 2500 tons of Cleveland warrants at 46s. 4d. and 46s. 4½d. cash. Closing sellers quoted 46s. 4½d. cash, 46s. 8d. one month, and 47s. 3½d. three months. In the afternoon the tone of the market showed little change, and 2500 tons of Cleveland warrants were done at 46s. 4d. cash and 46s. 8d. one month, and the closing quotations were 46s. 5d. cash, 46s. 8½d. one month, and 47s. 3d. three months' sellers. Hematite was quoted at 62s. cash sellers. On Friday morning Cleveland warrants were nominally steady, and 5000 tons were dealt in at 46s. 4d. and 46s. 4½d. cash, 46s. 8d. one month, and 47s. 3d. three months, with sellers over in each case. At the afternoon session the dealings consisted of 3500 tons of Cleveland warrants at 46s. 4d. cash and 46s. 7½d. one month, and closing sellers' prices were 46s. 4½d. cash, 46s. 7½d. one month, and 47s. 3d. three months. On Monday morning the tone of the market was weak, and 1500 tons of Cleveland warrants were done at from 46s. 4d. to 46s. 3½d. cash. The closing quotations were 46s. 3½d. cash, 46s. 7½d. one month, and 47s. 2½d. three months sellers. The downward tendency was again in evidence in the afternoon, and only 500 tons of Cleveland warrants changed hands at 46s. 4d. one month. At the close of the session sellers were down to 46s. 1d. cash, 46s. 4½d. one month, and 47s. three months. On Tuesday morning Cleveland warrants were a trifle stronger, but business was confined to 2500 tons at 46s. 1½d. cash and 46s. 4½d. one month. The closing prices were 46s. 2d. cash, 46s. 5d. one month, and 47s. 0½d. three months sellers. In the afternoon the tone was still firm, and dealing in Cleveland warrants took place at 46s. 5d. and 46s. 5½d. one month. The turnover was 2500 tons, and closing sellers quoted 46s. 2½d. cash, 46s. 6d. one month, and 47s. 1½d. three months. When the market opened to-day (Wednesday) Cleveland warrants were steady, but only 2500 tons were dealt in at from 46s. 2d. to 46s. 1½d. cash. The closing quotations were called at 46s. 2½d. cash, 46s. 6d. one month, and 47s. 1½d. three months sellers. Hematite was quoted at 61s. 7½d. cash sellers. The market was dull and quiet in the afternoon, and 1500 tons of Cleveland warrants changed hands at 46s. 1½d. cash, and 46s. 2½d. nine days. The close was easier, with sellers quoting 46s. 2d. cash, 46s. 6d. one month, and 47s. 1d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 61s.; Gartsherrie, 61s. 6d.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 63s.; Shotts (at Leith), 62s. 6d.; and Carron (at Grangemouth), 63s. 6d.

Sulphate of Ammonia.—The market for sulphate of ammonia maintains a firm tone, and with a fair amount of inquiry the price keeps steady. The current quotation is 14*l.* 5s. per ton for prompt delivery, Glasgow or Leith.

Scotch Steel Trade.—Scotch steel-makers report that a fair volume of business is being put through at the present time, and that specifications for heavy material are still plentiful. The demand for angles is very encouraging, but although deliveries are on a good scale the output is still more than equal to the demand. Makers of black sheets continue busy, and full employment is general. Not only is the home market taking large quantities, but foreign consumers are responsible for a fairly large part of the present turnover, and in that respect the lots now going through for India and the Argentine are very satisfactory. In thin plates and sectional material a fair business is passing, some good lines having been booked this week for shipment to India, Australia, and Japan. Prices all round are firm, and have, in some connections, an upward tendency.

Malleable-Iron Trade.—In the malleable-iron trade of Scotland one week is very much like another just now, and little change comes along to vary the conditions. Specifications on hand are just sufficient to keep plant running steadily, and in several instances this state is assured for the next week or two. The current price is still on the basis of from 6*l.* to 6*l.* 2s. 6d. per ton, less 5 per cent. for crown bars.

Shipbuilding.—The first contract for a vessel to be driven by oil-engines ever secured by any firm in the lower reaches of the Clyde has just been booked by the Clyde Shipbuilding and Engineering Company, Limited, Port Glasgow. The new boat, which is for service on the Great Lakes of America, will be 325 ft. long, and will have Diesel oil-engines of over 1000 indicated horse-power. The contractors will complete the whole work themselves.—Messrs. Murdoch and Murray, Port Glasgow, have booked an order to build a passenger and cargo steamer for Australian owners.

Scotch Pig-Iron Trade.—During the past week business in the ordinary qualities of Scotch pig iron has been on the slow side, and consumers have only been taking in limited deliveries. From the South the orders have been moderately good, and fair quantities have been purchased for shipment to India, Canada, South America, and Japan. The hematite position is practically unchanged, and the price is named as round 64s. per ton. Deliveries are quite satisfactory, but new business is very poor.

Electrical Exhibition at Olympia.—To-day, Friday, October 13, at 8 p.m., Mr. R. Borlase Matthews will lecture on "The Therol System of Cooking," at the Central Supply Station's stand at the Olympia Electrical Exhibition.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Returns.—September, as was to be expected after the cessation of the strike, saw a marked increase in the amount of coal dealt with at Hull. The tonnage—542,416—was even greater than that passing through the port during the same month last year. Taking the past nine months together, however, the figures do not come near those for the same period of 1910. They are respectively 4,697,248 and 5,120,768 tons. The coastwise traffic last month accounted for 91,010 tons, making up 724,681 tons gone in this direction since the beginning of January. The foreign exports were 329,777 tons, as against 358,408 tons in September, 1910, again, as will be seen, a considerable decrease. On the year the foreign exports are behind to the extent of nearly 430,000 tons. Large fallings off are shown in the amounts taken last month by Germany, Holland, Italy, and Denmark, whilst South America, Russia, and Sweden increased their consumption.

South Yorkshire Coal Trade.—Business in both steam and house coals has been considerably restricted, and the position, as reflected on the local Exchange at the week-end, was distinctly unsatisfactory. In regard to house coal, the chief cause of complaint was the serious shortage of wagons, and the consequent failure of the railway companies to get material away from the collieries. The result was that colliery sidings were choked up, and pits in the district were continually having to cease work, notwithstanding that the brisk demand for best qualities was still in evidence. Another result, and one even more nearly touching the consumer, was an all-round rise in prices, which also applied to the hard-coal department. It is also reported that similar difficulties in carrying coal from the ports was experienced, and this is given as the cause for a decrease in shipments. For industrial consumption the demand has remained unabated, and stocks continue to accumulate at the large works as some provision against a contingent coal strike. Similarly, extra supplies are being taken of gas-fuel, of which shipments also show an increase. Slacks are strongly placed and collieries are well booked. Last Friday's 'Change quotations were:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. 6d. to 13s. 6d.; Silkstone, 11s. 6d. to 12s. 6d.; Derbyshire brights, 12s. 6d. to 13s.; Derbyshire house, 9s. 6d. to 10s. 6d.; large nuts, 9s. 6d. to 11s.; small nuts, 6s. 6d. to 8s.; Yorkshire hards, 8s. 9d. to 9s. 9d.; Derbyshire hards, 8s. 6d. to 9s. 6d.; washed nuts, 8s. to 9s.; rough slacks, 5s. 6d. to 7s. 6d.; seconds, 4s. 6d. to 5s. 6d.; smalls, 2s. to 3s.

Iron and Steel.—A good deal of iron has gone into consumption recently, and steel-makers have been buying pretty freely, covering themselves mostly until the end of the year, and in some cases contracting for well on into the first quarter of next year. On the past week, however, business has not been of any great quantity, and prices of hematite, at any rate, have tended slightly downwards. The Lincolnshire and Derbyshire common-iron makers keep up their quotations. They state that inquiries are increasing for both forge and foundry sorts, and they are well booked up. In the steel trades there seems to be no diminution of activity, in spite of anxiety in regard to the labour outlook. The weight of orders is not confined to any one branch, but is spread fairly evenly throughout the principal departments of local industry. Armament departments are very well occupied. The magnitude of home and foreign contracts is such as to keep even the very large East End shops really busy. It is also of importance from the labour point of view to remember that the production of the modern armour-plate involves much more work than was required by the similar article a few years ago. These same firms have other departments actively engaged on general shipbuilding work. The revival of business at the yards has brought much work to Sheffield, in spite of very keen competition from other industrial areas. Another department of Sheffield industry that is working under pressure is the rolling-mills, and there is an increase of orders for railway steel, tyres, axles, &c. Tool-steel makers are doing a very satisfactory trade with Continental buyers, and the exports to the Colonies are considerable. The demand for tool-steel is also much better, following upon the improvement in engineering. Similar activity prevails right through the lighter trades.

THE FRENCH NAVY.—The French Naval Estimates for 1912 have recently been submitted to the French Budget Commission. The outlay proposed for the year is 17,070,322*l.* The credits actually voted for 1911 amounted to 16,657,225*l.* The increase proposed for 1912 is, accordingly, 413,097*l.* The expenditure of 17,070,322*l.* set against 1912 does not, however, include anything for the construction of the fifth and sixth ironclads, which, according to next year's French naval programme, should be laid down during the year. If the programme is adhered to as regards these two ironclads, a further outlay of 275,585*l.* will be required.

BRITISH AND AMERICAN NAVY YARDS.—The Washington correspondent of the *Times* wires under date October 8:—The Secretary of the Navy, Mr. Meyer, who recently returned to Washington, speaks with enthusiasm of the organisation of the British shipbuilding yards which he visited this summer. Of Messrs. Vickers, at Barrow, he says that he found "the most efficient and up-to-date management, with a system and detail carried apparently as far as they could be advantageously." He believes that the methods can be profitably applied to American Navy yards, and announces that two officers, Captains Willits and Theiss, sailed on Thursday to study the system thoroughly.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The iron market is still characterised by extreme quietness. Traders continue to act with extreme caution, and transactions are on quite a limited scale, business being chiefly confined to the sale of small lots for early delivery. Orders from abroad to meet autumn requirements have come in slower than was expected, and as the northern navigation season is now rapidly drawing to a close, business over the fall of the year is likely to be smaller than was at one time anticipated. The long drought on the Continent has this year stopped supplies to inland customers, and, in fact, some parcels of iron despatched in the spring for inland buyers abroad are still lying at Continental seaports, owing to there having been no water in the inland waterways. Values of pig iron are rather easy. No. 3 g.m.b. Cleveland pig is obtainable from both makers and merchants at 46s. 6d. f.o.b., whilst No. 1 is quoted 50s. 3d.; No. 4 foundry, 46s.; No. 4 forge, 45s. 9d.; mottled and white, each 45s. 6d.; and mixed numbers of East Coast hematite pig, 60s. 6d. to 61s.—all for early delivery. Foreign ore is dull. Market quotations are still based on 19s. 6d. ex-ship Tees for best Rubio, but it is quite understood that sellers would make contracts at below that figure. Coke is firm, and sellers are not very keen for business. Average blast-furnace qualities are 14s. 9d. to 15s. delivered here. Middlesbrough warrants show a fall on the price of a week ago, the quotation now being 46s. 1½d. cash buyers.

Blast-Furnacemen's Wages.—The average net selling price of No. 3 Cleveland pig iron for July, August, and September has just been certified at 47s. 6.44d. per ton, as compared with 49s. 0.16d. for the previous quarter. This means a reduction of 2 per cent. in the wages of blast-furnacemen, which brings wages from 21.25 per cent. above the standard to 19.25 per cent. above the standard. The reduction dates from October 1.

Iron Trade Statistics.—The returns of the Middlesbrough Chamber of Commerce for the quarter ending September 30 last show that on that date, of seventy-nine furnaces built in the port of Middlesbrough, fifty-four were in blast, and produced during the third quarter of the year 565,000 tons, 370,000 tons of which was Cleveland pig and 195,000 tons hematite, spiegel, basic, and other special irons. During the previous three months the total make of pig was 580,000 tons, and for the corresponding quarter of last year the output was 575,000 tons. Imports of foreign iron ore into Middlesbrough last quarter reached 434,238 tons, as compared with 436,926 tons for the previous three months, and 498,151 tons during the third quarter of 1910. The total value of goods, other than coal and coke, exported to foreign and Colonial destinations from Middlesbrough during the third quarter of the year amounted to 2,154,153*l.*, as compared with 1,735,020*l.* for the corresponding period a year ago—an increase of 419,133*l.*, and the total value of exports other than coal and coke for the nine months ending September 30 last reached 6,379,946*l.*, as against 5,665,693*l.*, for the corresponding period last year—an increase of 714,253*l.*

Manufactured Iron and Steel.—There is very little new business doing in manufactured iron and steel, but the situation must be described as satisfactory, seeing that producers of practically all descriptions are full of orders, some firms, in fact, having contracts made which will keep them in full swing for some months to come. Under such conditions values tend upward, but as yet no quotable advances have been made. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and galvanised corrugated sheets, 11*l.* 5s.—sheets less 4 per cent. f.o.b., railway material net, and all other descriptions less 2½ per cent. discount.

Cleveland Miners' Wages.—The quarterly meeting between the Cleveland Ironstone Mineowners and the Cleveland Miners' representatives was held at Middlesbrough on Monday, Sir Hugh Bell, Bart., presiding. The owners intimated that they considered 24.40 per cent. on the standard as the wages that should be paid during the ensuing three months against 27 per cent. which had been current during the past period. This shows a reduction of 2.60 per cent. The matter will be considered again on the 23rd inst.

THE FIRE AT THE EMPIRE PALACE THEATRE, EDINBURGH.—In Report No. 157 of the British Fire-Prevention Committee the fire at the Empire Palace Theatre, Edinburgh, which took place on May 19 last, and resulted in the loss of 10 lives, is dealt with, particular regard being had to the importance of the fire as showing that the evolution of a safe theatre has proceeded on satisfactory lines, and it is thought to be a matter of congratulation that a fire occurring in a large variety theatre with a full house, should have resulted without any loss of life among the audience, either from fire or panic. The report shows that dressing-rooms in the vicinity of the flies are to be deprecated, especially when they are temporary or improvised ones. This fire also showed that more attention must be paid to fire-resisting curtains, both as to design and construction, for in this case the curtain collapsed eighteen minutes after the fire had commenced. The report is accompanied by many illustrations.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Some sensation was occasioned on Monday by a notice exhibited in the Coal Exchange intimating that the administration of the Egyptian State Railways had invited tenders for 30,000 to 40,000 tons of American steam-coal, to be delivered at Gabbari, Alexandria, in December and January. The new policy indicated on the part of the Egyptian authorities is attributed to the disturbing effect of recent labour troubles upon the South Wales coal-mining industry. The current condition of the Welsh steam coal trade shows little change or improvement. The best large steam-coal has made 16s 6d. to 17s. per ton; ordinary qualities, 15s. to 16s. 3d.; best bunker smalls 8s. to 8s. 6d.; and cargo smalls, 6s. 6d. to 7s. per ton. The market for household coal has been strong; best ordinary qualities have made 14s. 6d. to 16s. 6d. per ton; No. 3 Rhondda large, 17s. to 17s. 6d.; and smalls, 10s. 3d. to 10s. 6d. per ton. No. 2 Rhondda large has been quoted at 12s. to 12s. 3d.; and smalls, at 6s. 3d. to 7s. per ton. Foundry coke has made 24s. to 25s. per ton; and furnace ditto, 18s. to 20s. 6d. per ton. As regards iron ore, Rubio has realised 18s. 6d. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Port Talbot.—The accounts of the Port Talbot Graving Dock Company, Limited, for the past year show a profit of 230*l.*, a net balance of 192*l.* remaining after provision has been made for debenture interest. To this 192*l.* is added the amount brought forward from 1909-10, making the total to be dealt with 1645*l.* Of this amount, 630*l.* is to be added to the reserve fund, and the balance of 1015*l.* is to be carried forward. This disappointing result is attributable to the serious labour troubles and commercial unrest of the past eight months.

South Wales Coal.—The shipments of coal from the South Wales ports (foreign and coastwise) in September amounted to 2,539,591 tons, or 16,425 tons more than in September, 1910. Newport, Swansea, and Port Talbot had substantial increases in foreign shipments and decreases coastwise, while Cardiff had a small decrease both foreign and coastwise. For the nine months ending September the comparison shows that Cardiff has a loss of nearly 1,250,000 tons foreign and about 230,000 tons coastwise. Newport has a gain of about 460,000 tons foreign and a loss of 72,000 tons coastwise; Swansea, a gain of 96,000 tons foreign and a loss of 42,000 tons coastwise; and Port Talbot, a gain of 90,000 tons foreign and a loss of 8000 tons coastwise. The net loss for the nine months is about 900,000 tons, exclusive of the falling-off in bunker coal deliveries. Recent shipping and railway strikes have told upon business.

THE LATE MR. C. T. MASON.—The death is announced of Mr. Clayton Turner Mason, who was connected with much railway work in Australia. Mr. Mason was born in 1847 at Tarrington, Herefordshire, and was educated at King Edward's School, Birmingham. After serving his apprenticeship in this country he went abroad, first to America and subsequently to Australia, where, in 1874, he obtained an appointment in the railway construction branch of the Public Works Department of New South Wales. He acted as resident engineer on the Government railways in connection with the construction of the Geraldton and Northampton Railway and the Eastern Railway. In 1884 he held, provisionally, the post of Director of Public Works and Commissioner of Railways, having a seat on the Executive and Legislative Councils. In 1885 he was appointed general manager of the Western Australian Government Railways. In 1891 he became Collector of Customs, a position he retained until last year, when he retired. In 1909 he found it necessary to visit England for his health, and undergo two operations. Mr. Mason was a keen rifleman, and in 1868 came in sixth of 6000 competitors in an international competition held that year in Belgium.

INSTITUTE OF MARINE ENGINEERS.—The adjourned discussion on Mr. E. Shackleton's paper, on "Modern Developments in British and Continental Oil-Engine Practice," was held at the Institution of Marine Engineers on Monday last, Mr. John McLaren, Vice-President, occupying the chair. Mr. Shackleton opened the meeting by replying to some of the points raised at the previous meeting. He said that at present the fuel oil standard was very uncertain, and it might vary very much. In some cases it might fall below 10 per cent., and in others it might be as high as 40 per cent., over the steam-engine. Mr. R. W. A. Brewer said that the successful internal-combustion engine for marine work would have to be an engine which followed the ordinary gas-engine practice, in which the pressures were not too high, and it would have to be a two-stroke engine. A disadvantage of the oil-engine was that of carburation. On the other hand, it was pointed out by Mr. P. A. Lowther that the Diesel engine did not carburate, so that Mr. Brewer's objection did not apply to it. According to Mr. A. C. Holtzapfel there was, however, the disadvantage with the Diesel or any reversible engine working direct on the propeller that when the propeller was lifted out of the water and racing took place, the action of the governor was reduced to such an extent that when the propeller dipped back again into the water the engine was apt to stop, and had to be re-started by compressed air. Gas-engines would, he thought, be more suited to the necessities of British marine engines than oil-engines, on account of the uncertainty of the price of oil fuel. Other members also spoke. Lantern-slides of engines were shown. It was announced that Mr. F. Duncanson's paper, "Notes on Two-Cycle Oil-Engines," would be read on Monday, October 30.

THE WORKS OF THE BRITISH WELDING CO., LTD., MOTHERWELL, N.B.

(*For Description, see Page* 485.)

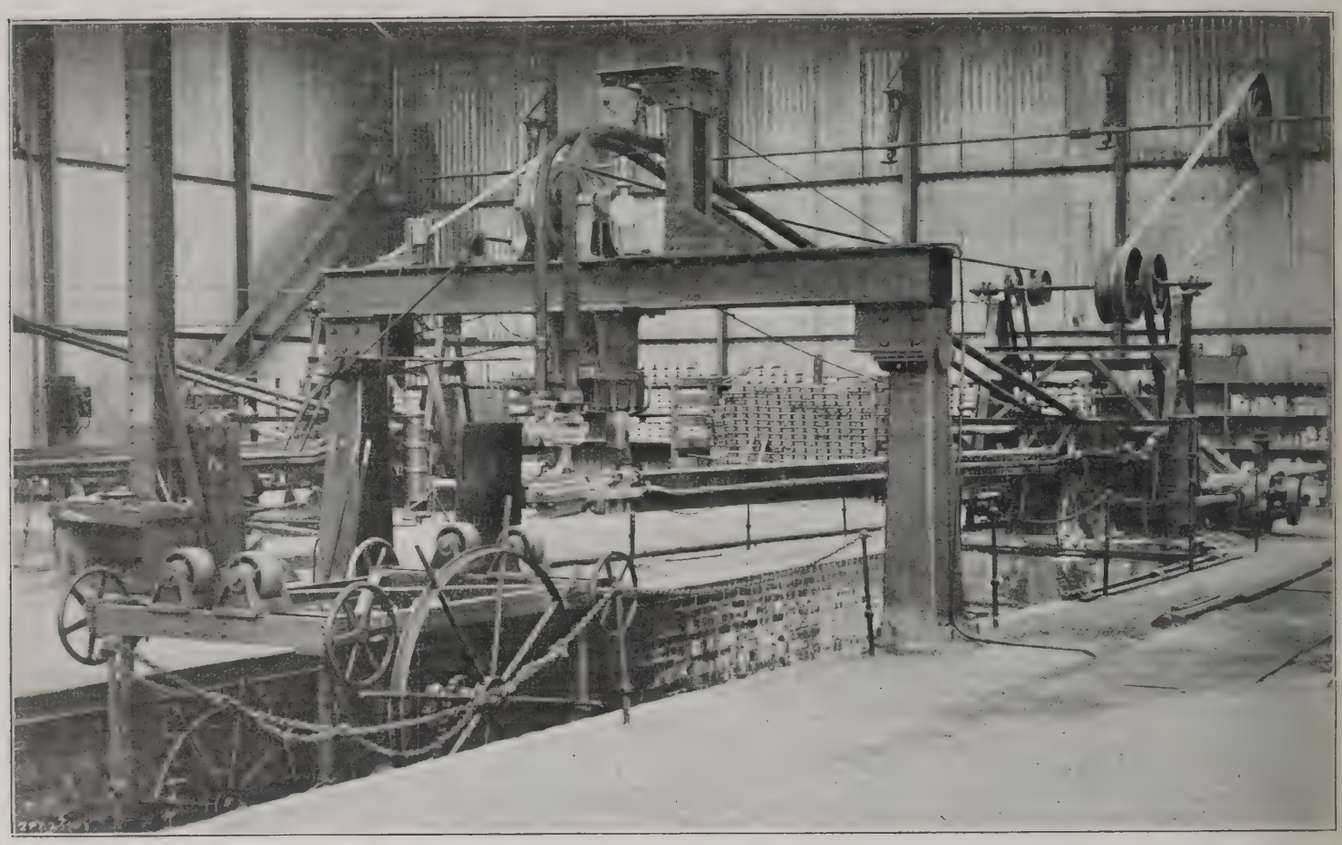


Fig. 7. Tube-Welding Machine.

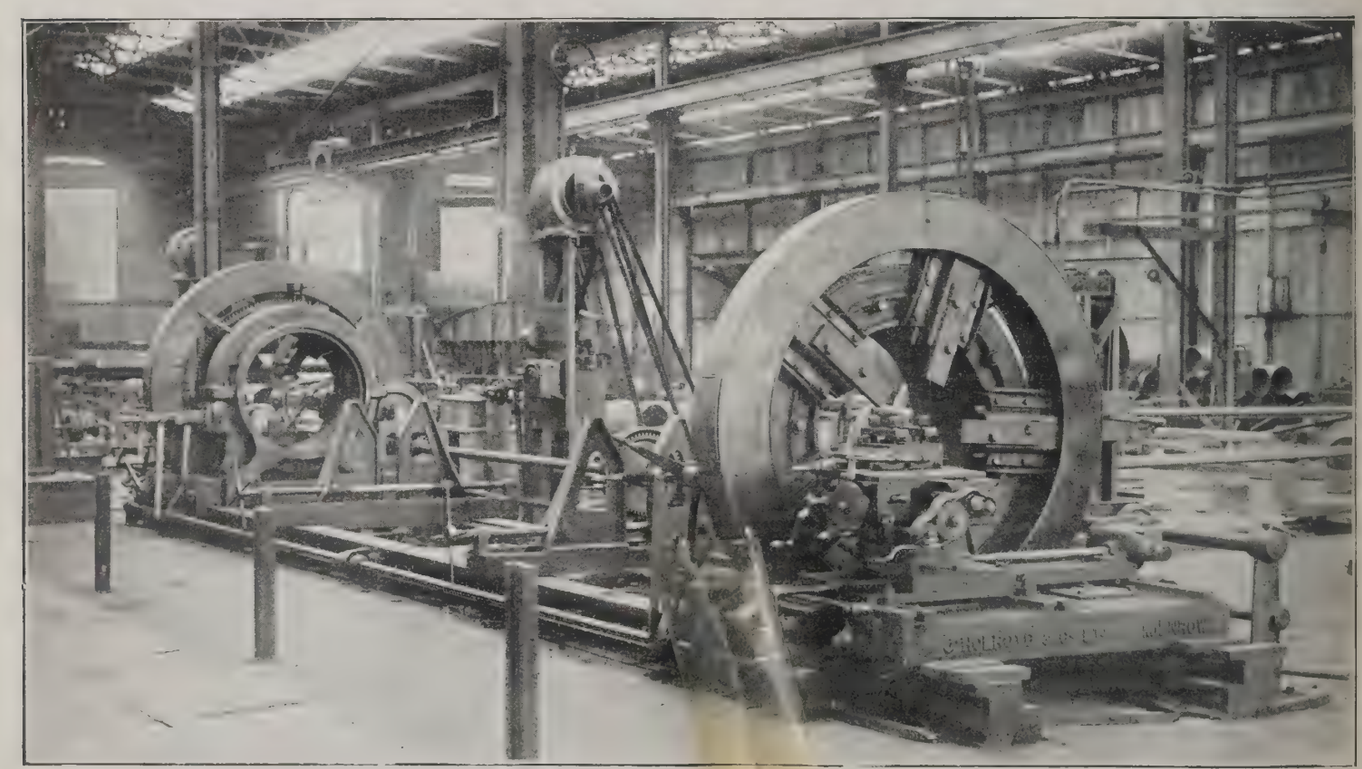


Fig. 8. Hollow-Spindle Pipe-Lathe.

Production of Titanium.—J. B. Huffard, of the Electro-Metallurgical Company, of Glen Ferris, Western Virginia, suggests the reduction of rutile, the common titanium ore, in order to produce an impure titanium, which is itself recommended as a good reducing agent for the production of highly refractory metals, such as tungsten, vanadium, molybdenum, and uranium, free from carbon. He treats the rutile together with carbon in an electric furnace; the product which Huffard calls "the reducing agent" contains titanium as metal, nitride, oxide, and carbide; the carbide percentage should be very low. To reduce the metals mentioned, and to prepare their alloys with titanium—which, owing to the high melting-point of titanium, could not directly be prepared—the respective oxide, for instance, tungstic oxide, is fused with the impure titanium, an excess of the oxide being applied, as the reduction is incomplete; tungsten is reduced, and titanium oxide formed. The slags contain both the excess of the original oxide and the titanium oxide; the original oxide is extracted from the slag by means of acids (hydrochloric acid) which do not attack the titanium oxide.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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With a Two-Page Plate of THE EXTENSION OF THE BURNLEY CORPORATION GAS-WORKS.

NOTICES OF MEETINGS.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, October 13, at 7.30 p.m., at the Grand Hotel, Manchester. Paper:—"Marine Jet Propulsion," by Mr. Rankin Kennedy, of Glasgow.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, October 14, at 2 p.m., in the Wood Memorial Hall, Newcastle-on-Tyne. The following paper will be open for discussion:—"The Advantages of Freezing as a Method of Sinking through Heavily-Watered or Difficult Ground," by Mr. William Brumwell Wilson. The following papers will be read, or taken as read:—"The Working of the Thick Coal-Seams of Upper Silesia," by Mr. Berent Conrad Gullachsen. "The Holmes-Ralph Gas-Detecting Portable Electric Lamp," by Mr. George J. Ralph (with experimental illustrations).

THE INSTITUTE OF MARINE ENGINEERS.—Monday, October 16, at 8 p.m. Paper:—"Notes on an Extract from a Refrigerator Log-Book," by Mr. W. Sinclair, Member.

THE FARADAY SOCIETY.—Tuesday, October 17, at 8 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C., when the adjourned discussion on the following papers will take place:—"The 'Paragon' Electric Furnace and Recent Developments in Metallurgy," by Mr. J. Härdén. "Progress in the Electrometallurgy of Iron and Steel," by Mr. Donald F. Campbell. "The Hering 'Pinch Effect' Furnace," by Mr. E. Kilburn Scott, M.I.E.E., A.M. Inst. C.E.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 20, at 8 p.m. Paper to be read and discussed:—"The Endurance of Metals; Experiments on Rotating Beams at University College, London," by Mr. E. M. Eden, of the Armstrong College, Newcastle-on-Tyne, Mr. W. N. Rose, and Mr. F. L. Cunningham, Graduate, of London.

ENGINEERING.

FRIDAY, OCTOBER 13, 1911.

THE GENERAL STRIKE.

THE prevailing lack of commercial confidence and of industrial stability is likely to be prolonged as a consequence of the acceptance by the Miners' Federation of the general strike as a weapon for forcing their demands upon mine-owners, because, although such a drastic measure may not be resorted to in the present issue, and, in any case, may not be fully realised in practice, further proof is already afforded of the growth of a more militant spirit behind trade-unionism, which is subversive of authority, and inimical to the interests of the State. If this decision of the Federation to resort to a general strike in the future as an aggressive measure, and not, as in the past, only as a defensive measure, were an isolated case, the portents would be serious enough. But when it is recognised as a sequence in a long series of events, in which legal and moral obligations have been flouted, and outrage and lawlessness resorted to on utterly inadequate reasons, the need is apparent for a fuller realisation of the influences at work, and for a wider demand for the counteracting of these influences. Before considering the larger issue, it is, however, instructive to review the procedure of the miners, as it bears such a strong resemblance to the earlier disputes as to establish similarity in general aims. We have had the transport workers' uprising, the South Wales strike riots, the British railway strike, and the Irish railway strike, and this week, in addition to the miners' dispute, we have had a threatened stoppage of work in the mills throughout a large area of Lancashire because the unionists in one mill objected to work along with one or two non-unionists, and the evil has only been avoided at the eleventh hour by the latter joining the union—a victory of some significance. In each case there has been a refusal to recognise working agreements, individual or collective; work has been stopped without notice or with inadequate warning; the right to work has been denied by those claiming the right to strike, "peaceful picketing" has been the cloak for unjustifiable outrage; and when attempts have been made at conciliation or settlement, it has been difficult to ascertain the cause of the trouble, or to discover agreement as to the aim other than cessation of work.

The present trouble with the miners is characteristic of labour procedure generally. The primary and main difficulty arose from a complaint that men could not earn a fair wage when working in abnormal places. This grievance was admitted by the mine-owners, who expressed willingness to consider each case in each district on its merits. This seems a most equitable proposal; but conciliation is not acceptable to those who are driving the trade unions against the interest of society generally. Arbitration is only acceptable permanently to unionists where the result is in their favour. The Federation therefore changed the procedure and decided upon a demand for a minimum wage for all miners, and amended the rule as to a general strike, so that recourse to it could be made for aggressive as well as defensive purposes. Notice has been given that unless a minimum wage is agreed to before November 14, the Federation will then meet to review the position and to consider the enforcement of a general strike. There are difficulties in the way: firstly, the Federation is made up of districts invested with separate powers; secondly, these districts, with one exception, have working agreements with the mine-owners, including in some cases minimum-wage stipulations, and the date of termination of these agreements varies, extending to 1912 in the Midlands, and to as late as 1914 in Scotland and South Wales; while, thirdly, there is no unanimity as to what should be the minimum wage—6s. to 8s. being named—a fact which shows that the question is one for settlement in each district according to the difficulties of abnormal places. The extremists see some justification for declaring a general strike in the fact that the Northumberland miners' agreement expires in a fortnight, and if they strike for a minimum wage or on any other pretext, the remainder of the miners in the United Kingdom can strike in sympathy. Thus subterfuge is strained to its limit to provide an excuse for the general strike. One would think that such an excuse would only appeal to the unthinking worker, as a general strike must affect the community most seriously, bringing all industry to a complete standstill, and, by stopping the transport service, involving the risk of starvation of the population in the urban districts.

There is thus a close parallel between the policy of the railway workers and the miners. As Carlyle put it, "a fair day's wage for a fair day's work is the everlasting right of man," and men are perfectly justified in enforcing this inalienable right. But while recognising the justice of their own case they must not refuse to act in conformity with the rights of others. The general strike is unnecessary for the enforcement of the rights of the miners or railway workers, and its success, if it became effective, would involve disaster to millions, against whom there is no grievance. It involves the same injury to the interests of the State as war, and must be treated as civil war. Thus a general strike of miners, like one of railway workers, must, in the words of the Home Secretary, create "an abyss of horror which no man can dare to contemplate." In the one case supplies of food to maintain life in the cities, and of raw material to enable industries to be carried on, would be cut off by the cessation of transport facilities; in the other instance the vast driving power essential to industry and transport would cease because of the want of the source of that power, and we should have chaos and commercial and industrial disaster. Is the whole of the population of a country to be subjected to the perils of famine and to idleness to gratify the impatience of a few extreme agitators who will not confine themselves to reasonable measures when advocating the justice of men's claims to improved remuneration for their work. Labour has its rights, but so also has the whole community, and, as Professor Lilly has pointed out, while it is unethical to pay a worker less than a living wage, "it is unquestionably unethical to plunge a whole community into the gravest distress—to bring it to the verge of irreparable disaster—in order to extort for a few hundred thousands of workers a little higher pay."

We believe that most of the miners will take a sane view. In most districts the men have no grievance under existing agreements, and will refuse to leave their work to enforce for other districts conditions which cannot profit them directly or indirectly. This, indeed, was the reason why the railway strike in Britain, as well as that in Ireland, failed. At the same time, it is imperative that the interests of the State should be conserved, and that industry and commerce should not be injured by the threats of general strikes. This is the more important, as the poorest suffer most by the increase in the prices of food and by the unemployment which results from the stoppage of great factories, of coal supply and of transport facilities. The workers throughout the country lose directly and indirectly through the impaired confidence and the forfeiture of trade to foreign producers. The middle class, who, because of those qualities of ingenuity, initiative, commercial courage, energy, and thrift, have won a competence, while at the same time advancing materially the prosperity of the State, are similarly punished directly, and have the value of their savings depreciated by the financial insecurity resulting from industrial insecurity. There can be no dubiety as to the State having a

duty in such case. In a strike where the injury is confined to the contending parties there may be ground for allowing the stubbornness of both sides to wear itself out; the disadvantage to the State is not great. But with the general strike the case is altogether different. To quote again the Home Secretary, "the weapon of a general strike is the most powerful in the world, but it can only be used for the purposes of suicide, and it is upon the working people, the working population, in the great towns, the great manufacturing towns and districts of Great Britain, that its cruel edge would fall with absolute certainty and with incredible swiftness if ever the experiment were attempted." It brings "all the horrors of war which would descend upon the working people in the cities and towns, while at the same time it would not be a case of all dying together; wealthy people, capitalists, the aristocracy, the landowners, and the rural population generally would scarcely suffer at all."

The Government have this week announced their scheme for "strengthening and improving the existing official machinery for settling and for shortening industrial disputes, by which the general public are adversely affected." This consists of an Industrial Council, representative of employers and labour, under the chairmanship of Sir George Askwith, K.C.B., than whom no one knows more of strikes. This Council, it is officially announced, is to take "suitable action in regard to any dispute referred to them affecting the principal trades of the country, or likely to cause disagreements involving the ancillary trades, or which the parties, before or after the breaking out of a dispute, are themselves unable to settle." The names are given—thirteen representing labour, and a corresponding number for capital, and no exception can be taken to any; all are chosen because they represent employers or workers. The only other statement as to the work of the Council is that it has no compulsory powers. The information is meagre. While all will wish the scheme the best of success, its future, to say the least, is doubtful. The Council cannot act until appealed to; but it creates a medium for conciliation, and thus increases the responsibility of those who enforce a strike or lock-out. But the danger of the past—and it promises to be greater in the future—has been the lack of influence on the part of the trade-union leaders to stem the tide of agitation among militant members, to command obedience to the authority of the executive or to the rules of the union, and to ensure the fulfilment of agreements made by the delegates of the union. Whether the leaders in all instances use every faculty and every occasion to establish and maintain their influence is questionable; their tenure of office, with its emoluments, is too much dependent on the goodwill of those on whom they must exercise restraint. The working man wants his wrongs righted, and not to hear about the rights of others.

But, beyond this, is there not a power outside trade unionism which is opposed to conciliation and eager for general disaffection and discontent among workers, and for the disorganisation of the whole social system The cult of Socialism in its nude state has not proved acceptable to the British workingman, and now attack is being made through trade unions on the plea that State Socialism, or Collectivism, or Syndicalism, will bring a millennium for the worker. Capitalism is held up as the aggressor—the one obstacle to the winning of a paradise for the worker. The general strike is advocated as a means to the abolition of the capitalist. Nationalisation of railways has been advanced as a palliative for general railway strikes, as it will terminate the claims of capital, and make those of the worker paramount and exclusive; but the Home Secretary and others have attempted to disabuse the minds of the workers on this score. Capital is as essential to industry as labour; under present conditions the part of mechanical power and producing appliances in manufacturing industries—even in agriculture—is greater in every respect than labour, and these represent capital in all mediums of wealth production. Thus it is not so much the capitalist as the inexorable law of competition, international and communal, which is the obstacle to the worker gaining all he demands or all that his employer would wish to give him. With State-owned railways, mines, or factories, competition would have to be reckoned with, and return would have to be made on capital, as great or greater than in the recent past, where profits have been approaching vanishing point. Labour could not be permitted any more latitude in the matter of strikes and strike riots under State ownership than under the companies. A State-owned railway in France was the most affected of all the railways during the recent strike in France. The workers, indeed, might find here that under bureaucracy their second condition was immeasurably worse than the first. It was only the soundest of principles which Mr. Winston Churchill enunciated when he claimed that the Government had no alternative than to take the most effective measures in their power to maintain order, to prevent intimidation, and to secure the working of food supplies. This applies particularly to railway strikes, and, for the reason we have stated, to coal-miners' strikes also. When all this is realised, we look for a renewed revulsion against the principles of Socialism, especially on the part of skilled workmen.

But the professional agitator has gone a step further. Socialism, or collectivism, seeks for possession of the means of production by the State. The new doctrine of syndicalism is to wrest all organisations and means of production from the capitalist and bestow it upon the workers—from the wage-payers to the wage-earners, and not to the State. This is the avowed object according to the originators of the new doctrine—the Confédération Générale du Travail—the notorious C.G.T. of the French strikes and riots, and the end is to be achieved by the general strike. Their fundamental precept is that success can only be ensured by violent means. Thus it is of the greatest importance that the general public should have their eyes opened to the strong under-current of ambition which is affecting trade-union movements. As Stevenson has put it, "parties and ideas continually move, but not by measurable marches on a stable course; the political soil itself steals forth by imperceptible degrees, like the travelling glacier," and portents must not therefore be neglected. Sir Arthur Clay has done a great national service in exposing clearly the inwardness of the association of syndicalism and labour.* The subject is one of vital importance, and he has treated it with an impartiality and knowledge which makes his contribution as welcome as it is influential. He exposes the sophistry of the claims of a religion for the aims of the new doctrine, establishes the brutality of its methods, demonstrates the impracticability of its realisation, and points out the duty of the Government to stamp out by rigorous hands any development in this country of this baneful idea. As we have contended at all times, labour is entitled to its honestly-won reward, and if circumstances involve any difference in opinion as to the amount of this remuneration, means exist for an equitable adjustment. It is the duty of the Government to ensure that during the process of adjustment the interests of the State or of non-combatants shall be conserved. All this involves drastic amendment of the law, not only in the direction of prohibiting picketing, as we have already advocated, but of enforcing the law of contract upon the part of the worker as well as employer, so that men may not, without being penalised, leave their work without due notice or disown an agreement formally made and accepted, and that leaders shall be responsible at law for the advice that they give, and the results that follow such advice.

* "Syndicalism and Labour," by Sir Arthur Clay, Bart. London: John Murray, Albemarle-street, W. [Price 6s. net.]

MUNICIPAL TRAMWAY FINANCE.

The policy which has long ruled the financial methods of a large proportion of the municipal tramway undertakings of this country has been the subject of much discussion and criticism, and yet the matter is of such importance that a return to it is at no time unjustifiable. The gravamen of the charge which has so often been brought against tramway committees is that the undertakings in their control were being run on absolutely unsound financial lines, so that many of them were rapidly approaching a state which in a commercial venture would entail ruin, and in a municipal one must result in heavy charges on the rates. Different critics have set up different financial standards to which they have held that tramway management should conform, some holding that in addition to a depreciation account there should be set aside a fund out of which the whole plant might, if necessary, be renewed, to meet cases of obsolescence and altered conditions which might arise, this fund being quite independent of, and apart from, the moneys which are necessarily set aside for the repayment of the capital debt. Other critics have set a lower standard than this and have merely maintained that as long as depreciation is adequately cared for out of the earnings, it is not objectionable that when the debt is extinguished the plant should have but a scrap value. Without arguing for the moment as to the superiority of either of these ideals, it will be admitted by the critics of either school that depreciation should be paid for out of revenue. This, indeed, will be admitted by any business-man, and yet this most elementary step towards financial soundness is neglected by a singularly large proportion of the municipal tramway undertakings of this country.

It is difficult altogether to ascribe a reason for the methods of folly which distinguish the financial proceedings of so many of our tramway committees. Much, of course, has been written on the matter, and it has been pointed out that a desire to curry favour, and ultimately to catch votes, has been at the bottom of many fare reductions and wage increases, which have in themselves been in every way unjustifiable. There is probably much truth in the criticism which centres itself in these ideas, and yet it is singular that gas committees, which are drawn from absolutely the same material as those dealing with tramways, have exhibited a much sounder judgment in dealing with the cost of their labour and the price of their product. Probably matters may be partly explained by the larger number of employees dealt with by tramway committees, and the more extended nature of their services to the public, their greater scope in both directions rendering "popular" movements more attractive and more profitable. Probably also gas committees have benefited from the fact that they are in general of much older standing than tramway bodies, so that they have inherited a financial tradition from a day when there was less tendency to sacrifice the necessities of sound finance to the demands of labour. Whatever the cause, there can be no question as to the suicidal policy of many municipal tramway undertakings in this country, and case after case may be pointed out in which surpluses are paid over to the relief of rates by committees who have made little or no provision for a depreciation that must in any case be faced in a few years.

The whole case against so much of the present municipal tramway policy was excellently put in a paper read by Councillor J. H. Rodgers, chairman of the Newcastle Corporation Tramways Committee, before the Municipal Tramways Association on the 27th of last month. This paper, apart from the excellence with which its case was presented, was of importance in virtue of the audience to which it was directed, and the official standing of its author. Mr. Rodgers contented himself with arguing in the main for a proper depreciation fund to deal with the track, and, in order not to overstate his case, limited himself to the suggestion that 200*l.* per single mile of track should be set aside each year for renewals. He took fifteen years as the average life of the track-work, so that the 200*l.* would, at 3½ per cent., give, at the end of that time, 3800*l.* per mile for track replacement. This sum is probably on the small side, especially as in hilly districts the life of the rails may be considerably under fifteen years, so that the 3800*l.* would frequently not be attained to. The sum is in any case probably low, since the Inland Revenue authorities, who are not given to over-estimating, allow the sum of 4400*l.* per mile for renewals. Confining himself, however, to his modest estimate, Mr. Rodgers had no difficulty in showing that some 51 per cent. of our tramway undertakings were working on an actuarially unsound basis, this figure, be it remembered, resulting from the assumption that the only necessary depreciation fund for the whole plant was the 200*l.* per annum per mile of track.

The paper contained a series of four tables, dividing the tramway systems into four classes, which the author considered to represent those that were doing well, those doing fairly well, those not financially sound, and those showing no surplus at all, or maintained out of the rates. The first class contained the names of most of the larger systems of the country, although such towns as Northampton, Salford, and Southampton appeared in the second list. When it is stated that last year Salford paid 18,750*l.* over to the rates, and only placed 692*l.* in their renewal fund, although even on

Mr. Rodgers's liberal system they should have payed in 7650*l.*, it will be realised that even some of the towns which now appear as doing fairly well may, in a few years, have to be relegated to one of the latter two lists, which are reserved for systems financially unsound. The third list covers many systems that handed over large sums to the rates, although their renewal fund was much below that necessary to allow for the 200*l.* per annum per mile of track. Plymouth and Kirkcaldy each gave their whole surplus to the rates. Reading gave 1500*l.* to the rates, although their renewal fund was short by 5000*l.*, while Ashton-under-Lyne gave 600*l.* to the rates, although their renewal fund stood only at 900*l.* after nearly four years' working. It is unnecessary to multiply instances of this sort, although mention must be made of the last list, which covered thirty-two systems, all but three of which were a charge on the rates. Eighteen out of these thirty-two cases showed no surplus, no reserve fund, and had made no expenditure out of reserve fund for any purpose, although they had been in operation for an average period of seven years.

The last table contains in the main the names of smaller towns, and it is probable that in some cases the potential traffic was from the first insufficient to make the tramways a paying concern, even though they had been conducted with the most rigid economy. Many of the systems in the eighteen above mentioned only carried the population of their town on an average some fifty to sixty times a year, a figure which compares very unfavourably with that which is found on the more successful systems. Pontypridd and Bexley, however, which figure among the number, carried their populations 129 times and 126 times respectively. Apart from the question of potential traffic, it is likely that in many cases the bad financial results may be ascribed to attempts to give facilities to the public that they were not paying for, and to give conditions to the workpeople that were not economically justified. Although it is doubtful if many of the smaller systems can ever pay their way, it is none the less unjustifiable and foolish to refuse to recognise existing conditions, and to let matters drift, as so many of the systems are doing. In most cases the loss is paid for out of rates, but no allowance for depreciation is made. This is bad enough, but Southport has thought of something even worse, and, instead of paying its debts, is putting its loss to a suspense account, and hoping for profits in the future. No matter how bad things may be, it is certain that the only sound finance is to subsidise the systems from the rates, not only to the extent of their actual loss, but also to a sufficient extent to cover depreciation. This system may not appeal to the ratepayers, but to refuse it is only to build up an even worse state of affairs for the ratepayers of the future to deal with. In this connection it is interesting and satisfactory to note that Burton-on-Trent, which last year made a profit of 318*l.*, paid 1000*l.* to the renewal fund, the difference being made up out of the rates. Even with this extraneous contribution, the town's reserve fund is still too low, but the principle of its action was very sound, and it is to be hoped that other places will note its example.

CHANGES IN THE FRENCH NAVAL COLLEGE.

There is now in progress a very important change in connection with the French Naval College, which is devoted to the training of naval officers. Interest is added to this change which, in the first instance, is one of locality, by the fact that it unquestionably paves the way for more considerable alteration, not only in the programme of admission to the school, but especially in the education and training of officers, somewhat on the lines followed in various foreign countries.

It will be remembered that, prior to 1839, the school—or, to be more exact, the Royal College, which served to train the future naval officers—was situated in Angoulême, in the interior of the country. It is true that from 1827 the college was completed by a training-ship for pupils who were finishing their special studies, while towards the end of 1830 the naval school was installed, and up to the present time has remained, on board a vessel anchored in the roadstead of Brest. Various ships have succeeded each other in thus affording shelter to the naval school and its pupils, and since 1841 the two vessels which have been assigned for this duty have successively taken the name of "Borda." It is for this reason that in naval circles the school is known as "Borda." The ship which now accommodates this school—always in the roadstead of Brest, and always under the same conditions—is an old transport formerly called the "Intrepide," which was appointed to this service in 1889. Needless to say, the Borda, to call it by its generic name, in spite of the quiet which it enjoys in the sheltered roadstead of Brest, is becoming very old and decrepit, for, before being used for a naval school, it had done service as a transport. It is now forty years since it was first navigated.

It has therefore become absolutely essential to replace this vessel; which might be done either by substituting a new ship for this old Intrepide, or merely by installing the naval school elsewhere. The latter course is the one which has been decided upon, and the decision to abandon the classic ship anchored in the roadstead of Brest is due to Admiral Boué de Lapeyrère. Admiral Boué de Lapeyrère has brought to his Ministry a special knowledge bearing upon this question—he was formerly Maritime Prefect at Brest—and he has been able to make clear the state of decay of the Borda, and the inconvenience which would result from continuing the naval school, in its enlarged, transformed, and improved state, in a boat which is necessarily too small for the requisite practical installations. It is certainly difficult to arrange on board a ship, be it what it may, for the commodious spaces required by the scientific and experimental education which it is now proposed to give to naval students. Moreover, where the pupils are numerous, hygiene is seriously sacrificed on board such a ship. In establishing a school on land, however, it is a simple matter so to construct new buildings that they are well adapted for their purposes, and afford the best conditions for health, as well as for the instruction of future officers.

Complete plans have now been prepared of the building about to be erected for the lodgment of the school and its pupils, and it is estimated that this building will be completed in two or three years, although it is probable, as almost invariably happens in such matters, there will be some delay. This naval college on land—a novelty for France—will be built on the rocky promontory which terminates the right bank of the River Penfeld, upon which is erected the naval arsenal of Brest. The plans of the new school have been based on the detail suggestions furnished by an officer who best understands the needs of the case; that is to say, by the present commander of the Borda, or naval school. The school will be built on an upland of about 4 hectares (10 acres), to which it is intended to annex a piece of land of about 10 hectares ($24\frac{3}{4}$ acres), planted with trees. This latter will constitute a park for exercising the corps, and for promenades for the students, and will accordingly afford the best hygienic conditions. These two pieces of land, now to belong to the school, will be separated by the moat of the Brest fortifications, and the moat itself will be utilised for the purpose of games, to which adequate attention will be paid in the future scheme for the occupation of the students' time. The buildings will comprise three parts, one of which will be a large round pavilion, containing the dining-room, and overlooking the roadstead and the commercial port, &c. It will be possible, in this new school, to instal all the requisites which hygiene demands—bath-rooms, shower-baths, lavatories, and dressing-rooms, which could not, without difficulty, be provided in the holds and store-rooms of the old boat which now serves to lodge the naval officers' school. In the dormitories, according to present intention, the hammock, the old classic bed of the ships of former days, will be preserved. Large rooms containing models will be installed, together with chemical and physical laboratories, for the instruction of students, in order that they may become scientific and completely equipped officers. Modifications have already been introduced into the programme of the naval school in the direction of making it more severe. The authorities even contemplate—although, in our opinion, this would be going too far as yet—changes in the programme for the entrance examination; this programme would approximate to that of the Polytechnic School, and would embrace a larger proportion of special mathematics. This kind of knowledge, which has not always proved of special advantage to the mining and bridge engineers, and other functionaries, turned out by the Polytechnic School, would be dearly acquired if it interfered with the practical training of the naval officer of the future.

It is quite understood that while the future naval officers will be established on land, they will be kept in intimate contact with the sea and the ships, and with all practical applications. Having in view the advantage of practical studies, visits will be paid to the Arsenal, which will be a near neighbour of the school, and these should prove very profitable; especially visits to armoured vessels of every type, which either stay in or pass along the roadstead of Brest. The students will thus be able to acquire a precise knowledge of naval and military material in every form, whereas they could learn nothing of this in the old ship in which they have been, and are at present, lodged. They will be regularly required to manœuvre a modern protected cruiser, no longer using for this purpose the old-fashioned despatch vessel, which they now move up and down the roadstead from time to time. Every three months they will go out to sea in the protected cruiser, and they will, in particular, navigate the waters of the Gulf of Gascony, where they will make acquaintance with a sea which is almost always disturbed, and also with a true sailor's life. Moreover, their practical maritime education will be completed by navigating and service in craft of all sorts, especially a certain number of torpedo-boats, which will be placed at their disposal. At the present time, in order to familiarise them with the sea and the officer's life, the students of the Borda are placed on an old transport, called the "Dugay-Drouin," in which, on leaving the school, they make a cruise, but in which there are no modern appliances. When the alterations to which we have referred have become effective, the students, their school training ended, will embark on a fine armoured cruiser. This boat will probably be the Jeanne d'Arc, of 10,000 tons, capable of steaming at 23 knots, with three engines developing collectively 28,000 horse-power. This boat, moreover, is provided with artillery in the turrets and casemates. It will constitute a school of practical application.

The students leaving the college to become officers will thus receive technical and military instruction which will correspond to the needs of modern life, and the young officers will then be able to carry out certain duties from the moment they embark. It should be mentioned that even now, under the control of the present commander of the naval school—badly equipped as that school may be—the pupils have succeeded in getting into touch with modern practice in navigation. They have thus learnt to manage torpedoes, and, in a recent inspection, the inspecting vice-admiral made an experimental trip to sea on a destroyer which was armed and equipped solely by the pupils of the naval school. All the duties on board were executed by the students, as well for manœuvring the craft as for working the engines and stoking, with the aid of coal-trimmers who also were no other than future officers. In this there is instruction of a most valuable kind, which should be enlarged and continued. The transformation of the French naval school, from the point of view of material, will undoubtedly bring about a modification in the training of future officers, and in the spirit which dominates their education. As in England, the United States, and Italy, the French naval authorities are seriously considering the abandonment of a system which places on board two sets of officers absolutely different, the one occupied with navigation and the means of combat, the other with the management of machinery. It is more than probable that, in view of the practical direction which will be given to the school on land, with its new laboratories and perfected means of study, a single body of naval officers will be established, who will unite all the special qualifications required in crews, as well those of mechanics and stokers, as those of combatants, boatmen, gunners, and torpedo-officers. Now there are, below the naval officer properly so described, men who are called "adjutants principaux," who have specialised in a particular trade—mechanic, gunner, or torpedo officer, and who, having "achieved" their rank, are capable of attending to certain details of which it is possible to relieve the naval officers. In this relation, the Minister of Marine has quite recently announced his intention to create a body of officers of the crews of fleets who will be concerned with part of the minor duties now required from officers properly

so called, and who will have a position distinctly superior in authority and advantages to that of the present petty officers. We have here then, altogether, an assemblage of changes, some of which have been already accomplished and appear likely to yield good results.

THE ELECTRICAL EXHIBITION AT OLYMPIA.—No. III.

As is only to be expected in an electrical exhibition, the display of machine-tools at Olympia is not a very extensive one; none the less, there are several exhibits of much interest and some novelty. One of the best displays is that made by Messrs. Charles Churchill and Co., Limited, of Leonard-street, Finsbury, London, E.C. This firm's exhibit is in the main devoted to grinding-machines, of which they are among the largest makers in this country, and we illustrate two of the examples, shown on the present page. Figs. 25 and 26 are views of a 12-in. by 36-in. universal and chucking grinder. In some universal grinding-machines considerable time is lost in changing over from internal to external work, and this machine has been designed specially to facilitate this operation. No shortening or lengthening of driving-belts is necessary, and the change-over can be made without any loss of time in resetting the wheels in the correct position. The machine may be compared, to some extent, to a turret-lathe. It is designed to carry three wheels, two of which may be heavy wheels for external work, and the third a lighter one for internal work. The two heavy wheels are carried on spindles built integrally with the turret, while the third wheel is carried on a spindle running in a bracket mounted on the turret. Different spindles for light or heavy work may be used for this wheel, the fitting to the turret bracket being carried out practically instantly.

The general lines of operation will be clear from the figures, and it is obvious that with a piece of work in position in the machine the turret-head may be swung round, and any of the three wheels brought to bear on it. The two main spindles are primarily intended to carry face-wheels for the grinding of shafts, but a cup wheel, as shown in Fig. 25, may be fitted for the grinding of flanges. When two face-wheels are employed, one may be arranged for rough grinding and the other for finishing, different grades of wheels for the two purposes being used if desired. When the machine is employed purely on chuck work, the tail-stock may be removed, and the whole operated simply as a chucking-machine. The headstock has a swivel base working over a scale graduated in degrees, while it carries a hardened ground spindle. The whole machine is driven from a countershaft situated at the back of its base.

The second machine, illustrated in Fig. 27, is a 10-in. by 60-in. self-contained motor-driven plain grinder, one of its special features being a patented quick hand traverse for the grinding head, which saves much time when it is required to transfer the wheel from a large diameter to a small one, or *vice versa*. A ratchet-wheel feed is arranged to give a forward motion of from 0.00025 in. to 0.004 in. at each reversal of the table, and gearing is introduced to give a ratio of 8 to 1 between the speed obtained by the fine hand motion and the special quick hand motion. This gear, however, does not interfere with the position of the automatic trip, the fine feed tripping at the same place as it was set for before using the quick hand motion. An indicator is fitted which shows the position of the wheel-head on its slide, so that the operator can bring the wheel from, say, a large diameter to a small one, without even looking at the position of the wheel. The machine is entirely self-contained, the grinding-wheel drive coming from a countershaft carried in a bracket on the wheel-head, and being driven by a belt from the motor. The tension of the belt from the grinding-wheel spindle to the countershaft is maintained by a jockey-pulley, in order to allow of the necessary travel of the wheel, while the tension of the belt pulley is maintained by the weight of the countershaft, which slides in the wheel-head. The gear-box which drives the work-head is positively driven by a chain through bevel gearing inside the bed, and then through enclosed gearing at the end of the table.

Tools are also displayed by the Consolidated Pneumatic Tool Company, Limited, of Palace Chambers, 9, Bridge-street, Westminster, S.W.,

GRINDING-MACHINES AT OLYMPIA.

CONSTRUCTED BY MESSRS. CHARLES CHURCHILL AND CO., LTD., LONDON.

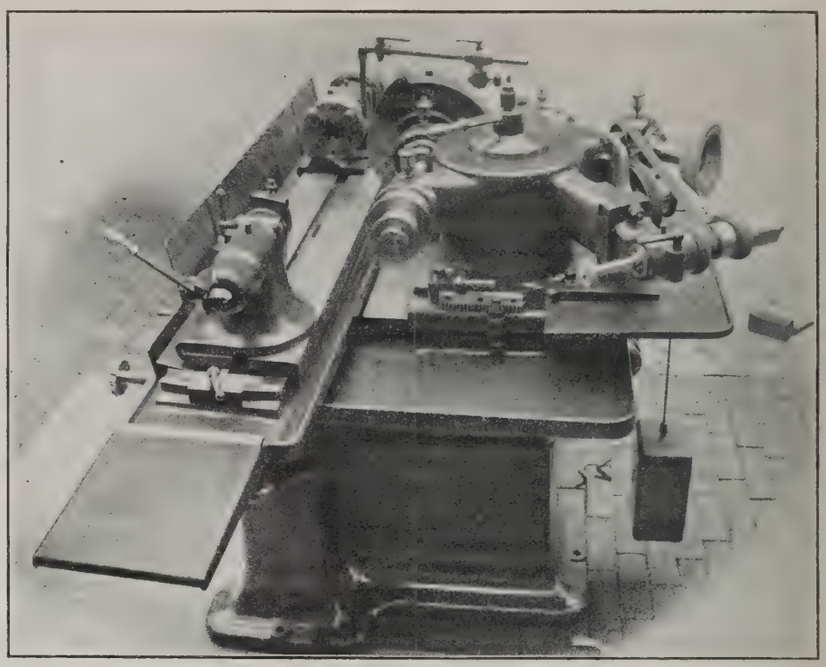


Fig. 25. Side View of 12-In. by 36-In. Universal and Chucking Grinder.

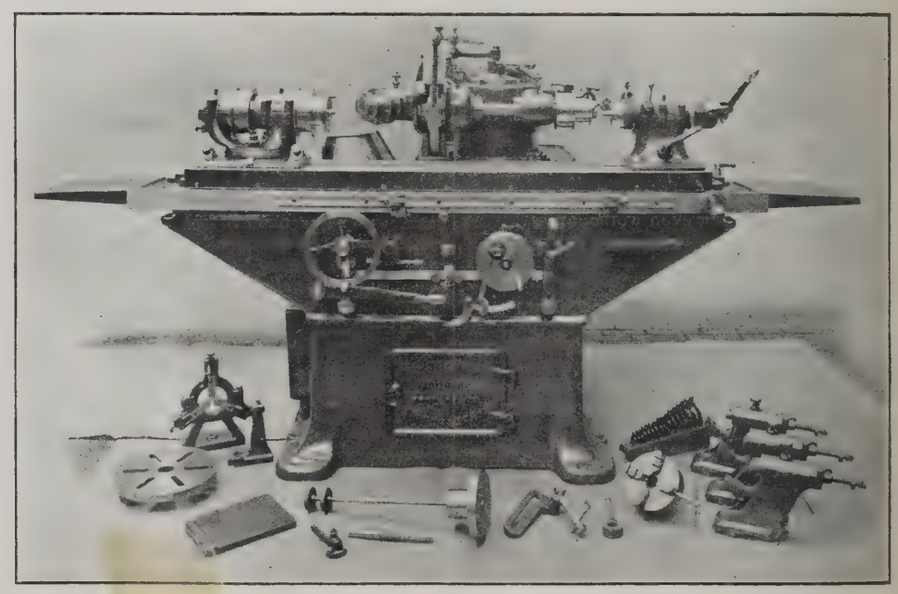


Fig. 26. Front View of 12-In. by 36-In. Universal and Chucking Grinder.

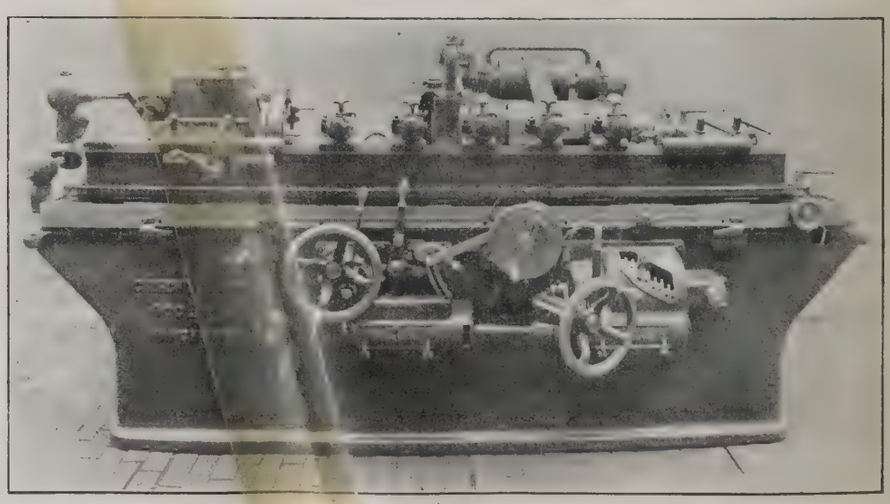


Fig. 27. Front View of 10-In. by 60-In. Self-Contained Motor-Driven Plain Grinder.

ELECTRICAL EXHIBITS AT OLYMPIA.

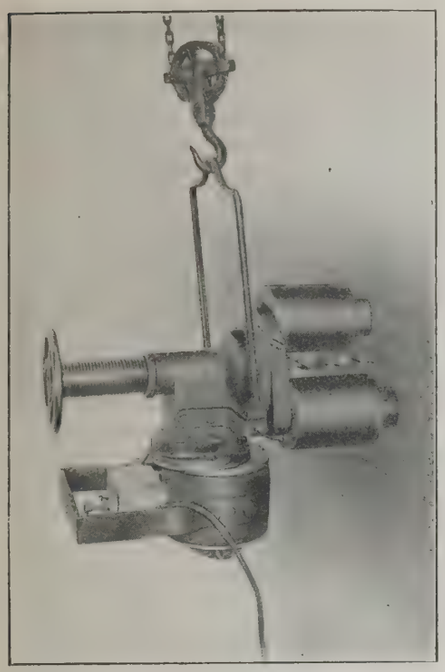


Fig. 28. Magnetic-Adhesion Type Electric Drill; the Consolidated Pneumatic Tool Company, Limited, London.

who have a large stand, containing a collection of their electrically-driven drills, grinders, &c. One of their exhibits is illustrated in Fig. 28, above. This takes the form of an electric drill furnished with holding-on electro-magnets. The general arrangement will be seen quite clearly from the figure, and the advantage in time-saving over a tool requiring the erection of a drilling-head will be appreciated without any comment from us. The switch controlling the holding-on magnets is, of course, fitted to the drill, so that for setting up it is only necessary to place the tool in position and switch on. The motor is of large power, and the tool will drill a 1-in. hole 1¼ in. deep in mild steel in one minute; while on a nine-hours' shift one of these tools has drilled 390 1-in. holes through ⅞-in. plate. The drill weighs 190 lb. and has case earthing arrangements as prescribed by the Home Office. The firm also exhibit a number of new electric drills of ordinary type, which are fitted with electric motors wound for the heaviest duty, and concerning which it is stated that it is almost impossible to burn the armatures out.

Returning to more purely electrical material, we may mention a number of further firms exhibiting switch-gear, in addition to those we have already dealt with. Among these, Messrs. Dorman and Smith, of Ordsal Electrical Works, Salford; Messrs. Parmiter, Hope, and Sugden, of Hulme Electrical Works, Ellesmere-street, Manchester; and Messrs. Berry, Skinner, and Co., of 78, Upper Thames-street, London, E.C., confine themselves in the main to ironclad switch and fuse-boxes, the two former, however, also showing water-tight fittings, and the latter some examples of skeleton type switchboards, built up with their well-known combined switch and fuse-boxes. Automatic starters and battery regulators are exhibited by Messrs. Bertram Thomas, of Worsley-street, Hulme, Manchester, and an excellently constructed range of hand-operated starting panels of various types by Messrs. Brook, Hirst, and Co., Limited, of Northgate Electrical Works, Chester. Messrs. Whipp and Bourne, of Castleton, near Manchester, may be mentioned with these firms as exhibiting gear of the same class, although, in the main, they confine their display to circuit-breakers, of which they make a speciality. They show some very interesting electrically-operated breakers both for ordinary service and naval work. The British Thomson-Houston Company, Limited, of Rugby, may also be referred to in this connection, as, although they have a large stand, the greater part of their line of manufactures is not dealt with. They show a

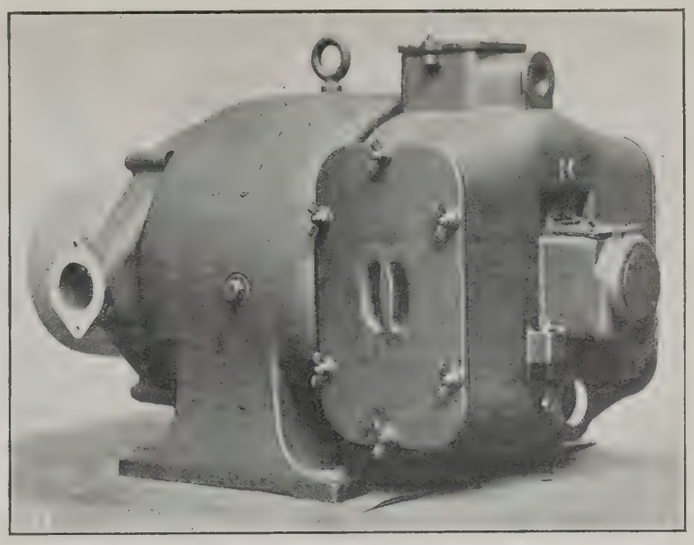
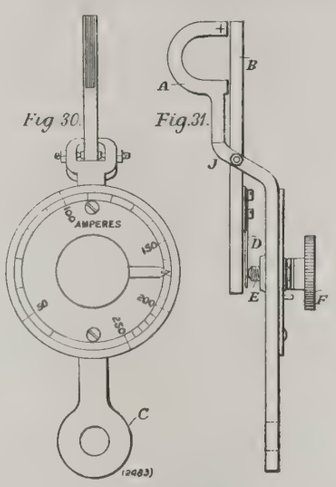


Fig. 29. Pipe-Ventilated Motor; Messrs. Electromotors, Ltd., Manchester.



Figs. 30 and 31. Mechanical Ammeter; Messrs. Drake and Gorham, Limited, London.

number of starters and controllers, but in the main confine their attention to lamps and heaters, a class of exhibit shown by many firms, but with which we have not space to deal.

A large range of apparatus is shown by the Electric and Ordnance Accessories Company, Limited, of Cheston-road, Aston, Birmingham. This includes switch-gear, starters, controllers, motors, fans, &c. An interesting exhibit takes the form of a crane cabin fitted with three tramway type controllers and a main distributing-box. The whole arrangement is very neat, the motor resistances being arranged to form a seat for the crane-driver, and the main switch and fuses and the fuses for the separate motor circuits being contained in a single box. We do not remember to have previously seen a combination box of this type containing the switch and fuses for a group of circuits, and the arrangement is remarkably compact and convenient. Another interesting exhibit is a combined starting and regulating pillar fitted with an overload and no-volt circuit-breaker, and containing the resistances inside it, so that the whole forms a single unit occupying but little space and very easy of installation. This firm also exhibit the Timken roller-bearing, which was described in our columns some time ago.

Messrs. Electromotors, Limited, of Openshaw, Manchester, have a stand on which a number of machines are displayed illustrating various applications of continuous-current electric motors. These include a ram pump with automatic float-operated starting-gear for country-house supply, a friction hoist or jigger for warehouse purposes, and two examples of electrically-driven fans. In addition there is a selection of motors of various types, including an example of pipe-ventilated construction, as shown in Fig. 29, above. Motors of this class are intended to fulfil the same purpose as totally-enclosed machines, in that they can be installed in unfavourable situations, such as flour-mills; while they retain the advantages of open-type machines in the matter of ventilation and rating. The system is a simple one, consisting merely in fitting the motor with a complete casing, to which two pipes are led, one serving as an inlet for cooling air drawn from outside or from some suitable room, and the other serving as an outlet which may discharge directly into the motor-chamber or be connected up by a pipe to the outside air, the arrangement adopted, of course, depending on local circumstances. The motor shown is fitted with an internal fan, carried directly on its spindle, which maintains the air circulation. The inlet and outlet passages can be clearly seen in the figure.

Miscellaneous apparatus is exhibited by Messrs. Vedovelli, Priestley, et Cie., of 160, 162, and 164 Rue St. Charles, Paris, and Messrs. Drake and Gorham, Limited, of 66, Victoria-street, London, S.W. The former firm show high-tension line material, porcelain insulators, switch-gear, luminous signs, &c., and the latter magnetic clutches, country-house lighting switchboards, electric heaters, &c. In addition, there is on Messrs. Drake and Gorham's stand a small exhibit of quite an attractive nature. This, which is illustrated in Figs. 30 and 31, is a form of direct-current ammeter which is adapted for reading the current passing in a cable or other conductor from the outside, and without cutting the conductor or making any connection to it. The appliance, which is known as Frisby's mechanical ammeter, consists merely of a horseshoe-shaped piece of soft iron carried by a handle and having a hinged soft-iron armature arranged to lie flat against its poles when in the closed position. The armature has a flat spring protruding from its inner end, and the handle carries a milled-head screw, the point of which is arranged to press against the flat spring, and the head of which carries a pointer working round a circular scale. To use the instrument, the pointer is set at zero, and the horseshoe is placed in position round the conductor to be tested, with the armature in its closed position. The magnetic field set up by the current then magnetises the horseshoe, so that the armature is held in place with a definite force which is a measure of the current flowing. Measurement is carried out by rotating the milled-head screw which travels forward and depresses the flat spring until finally the pressure due to it is sufficient to cause the armature to spring off the poles. The current passing may then be read off on the circular scale, which is graduated to show the current to which any position of the point of the screw corresponds, or, what is the same thing, the current to which any position of the pointer corresponds. As will

be seen, the instrument is singularly simple, and should be of considerable value to mains superintendents and others, since it enables the current passing in any conductor to be instantly determined at any time with commercial accuracy.

Messrs. Allen West and Co., Limited, of Lewes-road, Brighton, who make a speciality of controllers for heavy service, have an excellent display of their products, and we illustrate some examples in Figs. 32 to 35, on page 506. Their exhibit is of especial interest on account of the high mechanical level reached in the design of the gear. In a sense this feature is but characteristic of modern controller practice, since in the light of experience there has been a tendency on all hands to improve on the class of design which was considered adequate in the early days of heavy electrical work. None the less, Messrs. West's apparatus is of such satisfactory design and construction that it should be seen by all engineers interested in heavy controllers. The gear, in a sense, is of no great novelty in its general lines, and the features which pleased us had reference more to mechanical construction and details. This is illustrated in the crane collector column shown in Fig. 32. This piece of apparatus in itself is of no novelty, but it embodies many interesting features, of which its self-contained nature is one. The column forms a complete unit, and is provided with bearings, so that the alignment of the stationary and revolving parts is maintained, even after long operation, and is independent of the wear or otherwise of the crane to which it is fitted. The general construction of the column will be easily followed from the figure, and the method of carrying the collector fingers from one of the uprights will be noted. Mica insulation is used throughout. The column is fitted with the firm's standard controller finger, of which some mention should be made. This differs radically from the majority of makes, in that, instead of the contact tip being carried at the end of a flat spring, it is bolted to a hinged lever which is pressed into its working position by a spiral spring fitted behind it. At the same time the hinged lever is carried between flanges at its pivoted end, so that correct alignment is maintained at all times. The renewable tips are of very ample dimensions to secure adequate cooling, and are fastened to their levers by a stud with a nut at the back. This latter feature is of great assistance when the tips are being renewed, since it prevents the welding of the screw to the worn copper, which sometimes occurs when set-screws are used.

Of the remaining illustrations, Fig. 33 shows a double crane controller for two motors. Both controllers are operated by the same handle, which is arranged to have motion in a vertical plane for the lifting motor, and motion in a horizontal one for the slewing one. Both motions can be carried out at same time if necessary. The controllers are fitted with very heavy contact-rings, which not only increases their life, but is of much importance from the point of view of cooling. Magnetic blow-outs are fitted, the position of the blow-out coil being clearly seen in the controller, which is shown with the arc-shields open. Ball-bearings are used in the larger sizes. Fig. 34 shows an oil-immersed controller, which is, of course, mounted horizontally to allow of the arrangement of the oil-tank. Its detail features follow closely those of the controller just dealt with, but a point of novelty is that the drum is not fixed to the lid, but is carried on a separate frame, so that the raising of the lid for inspection can easily be carried out by one man. The frame carrying the drum is hinged, and may be lifted when necessary. It is the firm's practice to use separated contact oil-immersed switches with these controllers when of large size. Fig. 35 shows a face-plate type of controller for steel works and collieries. An advantage of this type of construction for very heavy service is that, as the contacts and fingers are very accessible, their renewal is a simple matter, so that there is little difficulty in keeping the controller in service day and night. The controller has a magnetic blow-out, the necessary flux being furnished by a coil which lies outside the back of the ring of contacts, and completely encircles them. The type of resistance used in connection with all these controllers consists either of "Eureka" resistance-wire wound on steel tubes insulated with cement, or stamped grids made of resistance metal, and practically unbreakable.

In conclusion of our article this week, we may mention several firms who have stands illustrating their special lines of manufacture. Messrs. W. Lucy and Co., Limited, of Eagle Iron Works, Oxford, have, for instance, a display of feeder-pillars, street-boxes, and lamp-posts, although they show, in addition, a few examples of the Frahm type of periodicity and revolution indicator, one comparatively novel instrument having a paper-covered rotating drum and an inked ribbon, against which the vibrating arms press, so that a continuous record of a variation of periodicity or speed may be obtained. Messrs. Ediswan, Limited, of Ponder's End, Middlesex, show lamps, switches, instruments, &c., while Messrs. J. W. and C. J. Phillips, Limited, of 23, College-hill, Cannon-street, London, E.C., have an excellent display of Bristol recording instruments for temperature, current, pressure, voltage, &c., and Messrs. Schaffer and Budenberg, Limited, of 77A, Queen Victoria-street, London, E.C., show their pressure and vacuum-gauges, boiler fittings, pyrometers, recorders, &c. The Westinghouse Brake Company, Limited, of 82, York-road, King's Cross, London, N., display their new type of vertical oil-engine, which we have already dealt with in detail, and also train-heaters, Westinghouse Morse driving-chain, &c. Messrs. Reavell and Co., Limited, of Ipswich, show oil-engines coupled to air-compressors, an interesting example being a small portable set for cleaning electrical machinery; while Messrs Allen and Simmonds, Limited, of Reading, show their well-known Allen type of piston-rings and packing. Messrs. Bullers, Limited, of 6, Laurence Pountney Hill, London, E.C., have a good display of electrical porcelain, and have included a testing set on their stand, so that demonstrations of the break-down voltage of their material may be given. They also show iron masts for overhead line-work.

NOTES.

The Gallitzin Vertical Component Seismograph.

In our report upon the discussion on Seismological Investigations at the British Association,* we mentioned Mr. R. D. Oldham's remark, that seismographs of the Gallitzin type were alone suitable for recording seismic movements in mines. Prince Gallitzin, of St. Petersburg, described his horizontal pendulum instruments in 1903, and communicated a description of his improved vertical component seismograph to the Paris Academie des Sciences last winter. The characteristic features are a strong magnetic damping to render the oscillations aperiodic, and that the deflections of the pendulum are recorded and magnified by an aperiodic galvanometer. The heavy pendulum mass is supported by a beam consisting of two frames of triangular shape. The two triangles lie in vertical planes; they are not right-angled exactly, but in order to simplify the description we may say that the hypotenuse of each triangle forms the upper horizontal side, and that the one kathete is short; the apex thus points downward, and is near the one corner, to which a fine steel lamella is attached. By this pair of lamellæ the frames are connected with the standard of the instrument in such a way that the pendulum beam can swing in the vertical plane. The standard is bent over, and a spiral spring extends from the top of the standard down to the apex, not to the hypotenuse only. The point of application (apex) of the spring is thus near the lamellæ pivots; when the pendulum swings downward, the apex is brought nearer the pivots, the leverage is shortened, and the strength of the spring is diminished. When the pendulum swings upward, the opposite effect is produced, and the strength of the spring is increased. The result is a lengthening of the period of the oscillation, which is sometimes desirable for several reasons. The two fixed points of the spring can, moreover, be adjusted. In this way Gallitzin has easily obtained pendulums which have a period of 13 seconds. The heavy pendulum mass lies beyond the spring, and the beam ends on the other side in a plate of copper; the order of the parts, reckoned along the hypotenuse, is: lamella, spring, pendulum mass, copper plate. The copper plate moves up and down in the field of a strong permanent magnet. Near the plate is, further, a coil of fine copper wire, also attached to the frame and swinging in a magnetic field. These oscillations induce currents in an aperiodic galvanometer, which photographically records these currents, and thus the amplitude and period of the pendulum oscillations. One of the advantages of the Gallitzin seismometer is its independence from the temperature fluctuations to which most other instruments are subject. Together with the temperature changes the length of the spiral or of the wires used for the suspension alters, and these effects are difficult to compensate against. But such temperature changes will be too slow to cause the induction of electric currents. We should add that Wiechert-Mintrop seismometers also give satisfactory records of seismic movements underground.

* See Engineering, September 22, 1911, page 384.

Company Laws in the British Empire.

Resolutions were unanimously carried by the Imperial Conference which met in London this year in favour of more uniformity in the law relating to companies throughout the Empire. In the year 1908 the Acts of the United Kingdom were consolidated into a single statute. At present the law and the number of statutes in force differs in all parts of the Empire. The only states where a single statute governs company law outside the United Kingdom are Prince Edward Island, British Columbia, Victoria, and the Transvaal. In other parts of the Empire there are numerous different systems of company law contained in a number of statutes. In Canada the Dominion Acts are not founded on the Imperial law, and in the provinces of Canada legislation relating to companies is in most cases a combination of the Dominion and Imperial law. Companies may be incorporated under the Dominion laws or under those of the provinces in which they are situated. Altogether there are eleven different systems of company law existing in Canada, comprising sixty-seven Acts and Ordinances. The insolvency of companies, however, is exclusively within the jurisdiction of the Dominion Parliament. In India, with the exception of two short Acts, there has been no revision of the law, which has been contained in three Acts for about twenty-eight years. Australia has a number of statutes in the different States, Victoria being the only one, so far, which has consolidated its laws under a single Act. The number of statutes in force for the whole of the Australian Commonwealth is at present forty-three. New Zealand has only two Acts. In South Africa, also, different Acts are in force in different states of the Union. As mentioned above, the Transvaal has only a single Act, which is founded on the Imperial Consolidation Act and follows it very closely, so that decisions of the courts of the United Kingdom will assist the Transvaal courts. Altogether sixteen Acts are in force in the different parts of the South African Union, including the British South Africa Company's territory. It is obviously eminently desirable that practical effect should be given to the resolutions in favour of greater uniformity in the law without delay.

Railways in China.

From the report on the trade of China, by the Acting Commercial Attaché to His Majesty's Legation at Pekin, we learn that good progress was made during 1910 on the lines under construction with foreign capital and engineers—namely, the Tientsin-Pukow and the Canton-Kowloon Railways. On the northern, or German, section, the line was opened to Techow (140 miles from Tientsin) and to Tsinan Fu, the capital of Shantung, 92 miles further (where junction is made with the German line to Tsingtau), in October. Work is proceeding on the section from Taian Fu to Yenchow, and the completion of the whole northern section of 390 miles is expected in the spring of 1912. On the southern, or British section, begun in 1909, work was delayed owing to floods in the low-lying districts, through which the major portion of the line passes. Rails have been laid to Hsüchow Fu (211 miles from Pukow), and the completion of the whole section of 236 miles is expected in 1912. The northern section was linked up with the Imperial Railways of North China at Tientsin station, and through traffic inaugurated on December 19, 1910. Tsingtau is thus placed in direct railway communication with Berlin. When connection is made between the southern section and the Shanghai-Nanking Railway at Nanking, it will be possible to travel by train from Shanghai to Calais. On the Chinese section of the Canton-Kowloon Railway good progress was made during 1910, and a section of 29 miles from Canton to Hsin-tsun was opened to traffic in December, and it is hoped that the whole section of 89 miles from Canton to Samchun will be opened shortly. The short British section

of 22 miles from Kowloon to Samchun was formally opened to traffic on October 1, 1910. The negotiations for a joint working agreement between the British and Chinese administrations have not made much progress, the Chinese resolutely refusing to agree to the proposals for joint management put forward by the Hong-Kong Government, and offering, instead, terms of joint working on a basis of entirely separate management, which the colonial authorities have so far been unable to accept. The French-built and controlled Laokai-Yunnan Railway, 291 miles long, was formally opened for traffic in April, 1910. The reconstruction and conversion to standard gauge of the Antung-Mukden Railway (187 miles), under Japanese control, has made good progress, and will shortly be completed. The progress made during the past year on railways being built by the Chinese themselves has been less satisfactory. The state of affairs in the Canton Hankow, the Hangchow-Ningpo and the Szechuan-Hankow lines has shown the Chinese the difficulty of making much progress in railway construction with their own resources and knowledge, and on May 20, 1911, a loan of 6,000,000*l.* for the construction of 1200 miles of railway in Hunan, Hupei, and Szechuan provinces was concluded between the Ministry of Communications and groups of British, French, German, and American bankers. On the Canton section of the Canton-Hankow line only 5 miles were added during the year, making a total of 60 miles in five years, and on other lines comparatively little has been done. On the Changchun-Kiriu line (80 miles), now being built with Japanese capital and engineers, more energy has been shown, and rails were laid for 15 miles in December, 1910, and it is expected that the line will be completed by the end of this year. The estimated mileage of Chinese railways (including the Manchurian lines) open to traffic was, in 1908, 3900 miles; in 1909, 4500 miles; and on December 31, 1910, 5217 miles. Those who are specially interested in the details of Chinese railways may obtain a complete list of those open to traffic on application to the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London. It is hoped to publish a revised list at the end of the present year.

THE PROGRESS OF THE PARSONS MARINE TURBINE.

Some interesting particulars as to the progress of the Parsons marine steam-turbine are given in the annual report of the Parsons Marine Steam-Turbine Company, Limited, to be submitted to the fourteenth annual general meeting of the shareholders on the 18th inst. At the Turbinia Works, there are in progress the turbine propelling apparatus for H.M. battleship King George V., building at H.M. Dockyard, Portsmouth; for H.M. unarmoured cruiser Amphion, building at H.M. Dockyard, Pembroke; three sets of turbine machinery for three torpedo-boat destroyers, recently ordered for H.M. Navy, from the London and Glasgow Engineering and Iron Ship-Building Company, Limited; two sets of geared turbine machinery for two passenger vessels, ordered from the Fairfield Shipbuilding and Engineering Company, Limited, by the London and South-Western Railway Company; two low-pressure turbines of the "combination" system, to be fitted in a steamship which is building for the Cia. Trasatlantica (Spanish), at the Neptune Shipbuilding Yard of Messrs. Swan, Hunter, and Wigham Richardson, Limited.

The extent to which the Parsons type of turbine continues to be employed in the warships of the world is indicated by the following brief summary:—

France.—Six battleships of the Danton class, fitted with Parsons turbines, have been completed, having passed through their contract steam trials with entire success. Parsons turbines for two larger battleships, which have been launched recently, have been far advanced in construction, and will soon be placed on board these vessels. Contracts have been made also for turbine machinery for two other battleships. Two destroyers, the Casque and Bouclier, fitted with Parsons turbines, have been completed, and have attained very high speeds on their trials. Three other destroyers now in hand are to have Parsons turbines.

Germany.—The armoured cruiser Moltke, fitted with Parsons turbines, has been completed. On her preliminary trials she exceeded in speed all her predecessors. The small protected cruiser Augburg has proved most successful. Parsons turbines are also fitted, or are ordered, for three battleships, two large unarmoured cruisers, two small cruisers, and six destroyers. The total horse-power of Parsons marine turbines ordered for German warships of the present year's naval programme will exceed 280,000 shaft horse-power, which represents 58 per cent. of the total horse-power to be ordered for German warships during the present financial year.

United States.—The battleship Utah, fitted with Parsons turbines, has completed her contract trials, and has exceeded her guaranteed speed by half a knot. Three other battleships and seven destroyers, now building, will have Parsons turbines.

Austria.—The turbines have been completed for the first battleship now building. Those for the second ship have been nearly completed; and during this year Parsons turbines have been ordered for the third ship, as well as for twelve large torpedo-boats.

Russia.—One battleship and four destroyers, all with Parsons turbines, have been ordered for the Black Sea fleet during the year, and negotiations are proceeding for two more battleships and four destroyers. Three battleships previously ordered have turbines of the same type.

Spain.—Work on the battleships now in process of construction with Parsons turbines has been considerably advanced. The turbines for two torpedo-boats have already been completed and tried with entire satisfaction.

Japan.—Parsons turbines have been ordered for the large armoured cruiser now building by Messrs. Vickers, and for three sister-ships to be built in Japan.

Turkey.—A contract for a battleship with Parsons turbines has been placed in this country, and a second battleship will shortly be placed.

In ships of the mercantile marine, the use of Parsons turbines is steadily advancing. The new Cunard steamship Aquitania, building by John Brown and Co., and the two new Hamburg-America steamships now building at Hamburg—three steamships which will exceed in size ships now afloat or building—are all to be propelled by Parsons turbines. The new high-speed French trans-Atlantic steamer La France, which is to be completed early next year, will be similarly propelled. The Canadian Pacific Railway Company have ordered from the Fairfield Shipbuilding and Engineering Company, Limited, two turbine-engined steamships for their Pacific service. Amongst swift cross-Channel and coasting steamers the Newhaven (built in France) may be mentioned; she has maintained a mean speed on service of nearly 24 knots. For the South-Eastern and Chatham Railway Company's cross-Channel service, Messrs. Denny have recently delivered the new turbine steamer Riviera, and a second vessel, the Engadine, has just been launched from their yard. The three Belgian cross-Channel boats now in service are giving most satisfactory results, both as to speed and economy, and in consequence Messrs. John Cockerill and Co. have received the order for two more boats embodying all the most recent improvements. In Japan the Mitsu Bishi Company (licensees of the company) have recently received an order for a vessel to be fitted with geared turbines, and inquiries for British ships are now being dealt with. The "combination" system, in which Parsons low-pressure turbines are associated with reciprocating engines, continues to gain ground, and the working of vessels of moderate speed so propelled has proved very satisfactory. It is reported that during the earlier voyages of the Olympic the working of the propelling machinery has fully realised the anticipations of the builders. Messrs. Harland and Wolff are now constructing for the Royal Mail Steam Packet Company the large steamer Arlanza, in which the combination system is to be used. Up to the present time the total horse-power of marine turbines of the Parsons type completed and under construction in the works of the company and of licensees, as well as in the works of the Continental sub-companies, and of licensees of Parsons Foreign Patents Company, Limited, amounts to about 6,400,000 horse-power—an increase during the year of about 1,900,000 horse-power. Of this total horse-power, nearly 5,300,000 horse-power are, or will be, employed for the propulsion of warships, and over 1,100,000 horse-power in vessels of the mercantile marine and yachts. At present the total number of vessels built and building for the Royal Navy and the Colonies with Parsons turbines is 167; the total horse-power is about 2,740,000.

From the commencement of the work of the company it has been recognised that great importance must attach to experimental investigation of the numerous and difficult problems which influence the efficiency of marine steam-turbines and screw-propellers, and considerable expenditure has been incurred in carrying out such investigations. It will be noted from the accounts that the directors propose to continue to work on the same lines, and they are confident that the provision made for experimental work this year (5600*l.*) will prove reproductive, as it has done in the past. The profits for the year, after providing for depreciation on buildings, plant, machinery and office furniture, upkeep of patents, &c., transferring 5600*l.* 13s. 8d. to the experimental work account, 5000*l.* in reduction of patent rights account, and writing the company's holding in Consols down to 78*l.* per cent., amount to 26,370*l.* 16s. 11d. The amount brought forward from the last balance sheet is 17,548*l.* 2s. 8d. The total amount available for distribution is thus 43,918*l.* 19s. 7d. This the directors recommend should be appropriated as follows:—A dividend of 10 per cent., with a bonus of 5 per cent., is proposed, leaving 17,508*l.* 19s. 7d. to be carried forward.

Lectures on Heating and Ventilation.—A course of six public lectures, entitled "The Real Nature of the Problems in Heating and Ventilation awaiting Solution by the Engineer," will be given by Mr. Arthur H. Barker, B.A., B.Sc., Wh.Sc., at the University College of the University of London. The inaugural lecture will be delivered on Tuesday next, the 17th inst., at 5 p.m. Sir Aston Webb, C.B., R.A., will preside on this occasion. The lectures are open free to those interested in the subject. Tickets of admission, with particulars of other lectures and courses of laboratory instruction in heating and ventilating engineering, can be obtained on application to the secretary, Mr. Walter W. Seton, M.A., University College, Gower-street, London, W.C.

THE JOHANNESBURG ELECTRIC SUPPLY STATION.

On Tuesday last, the 10th inst., Lord Ormidale gave judgment in the Court of Session at Edinburgh, in an action brought by the Municipal Council of Johannesburg against Messrs. D. Stewart and Co., Limited, of Glasgow, and Mr. William Beardmore, for breach of contract in the installation of the machinery in the power-station at Johannesburg. It will be remembered that it was in 1902 that the specifications for this station were got out and tenders asked for by Messrs. Mordey and Dawbarn, of Victoria-street, Westminster. The station was of very large size, as it had to supply the electric tramways of the town, and the lighting and power within the town, and a very considerable area outside. Alternative schemes were got out for driving by steam-engines, or by gas-engines supplied with producer-gas, and the specifications asked for tenders on both bases. As a result, Messrs. D. Stewart and Co., Limited, of Glasgow, undertook the contract, agreeing to supply Oechelhauser engines, gas-producers, and cleaning plant by Messrs. Poetter and Co., of Dortmund, and electric generators by the Siemens Dynamo Company, Limited, of Stafford. This tender was supported by the personal guarantee of Messrs. William and Joseph Beardmore for the sum of 115,134*l.* It is a matter of common knowledge that the station in question was not successful, owing to the gas not being sufficiently clean for use in gas-engines. The specified degree of cleanliness—namely, that the gas should not contain more than 1 oz. of dirt in 20,000 cub. ft.—was not even approached when the engines were started up. At the time when the tramway system had been finished, and everything was waiting, the central station was not nearly complete in regard to the plant for cleaning the gas. The contractors therefore started the plant with coke and sawdust scrubbers only; the engines became tarred up, and very many difficulties were experienced. The contractors then entered into a running contract to sell energy to the Council at an agreed price, to overhaul and complete the engine and gas-cleaning plant for service at a new defined date, and to run the plant for twelve months thereafter. The dates, however, could not be kept. The engines continued to give much trouble, and finally the contractors declined to do anything further. The Council, however, refused to take over the plant, which, from that day to this, has stood idle.

As a result of the action, Messrs. Stewart and Co. and Mr. William Beardmore have been found jointly and severally liable for payment of 115,134*l.*, with interest at the rate of 4 per cent. from July, 1908. Messrs. Stewart and Co. are also ordered to pay to the Johannesburg Corporation 27,964*l.*, with interest, also 127,907*l.*, and, thirdly, 69,175*l.*, with interest on the sums of 127,907*l.* and 69,175*l.* at the rate of 5 per cent. per annum till payment. His lordship found that the contractors had repudiated their contract; that the plant was not in a condition to allow the stipulated test to be carried out, and that the plaintiffs were entitled to treat the contracts as at an end. We do not know whether there will be an appeal against this judgment, but, pending a decision on that point, it will be better not to enter further upon the technical side of the question until the action is finally settled.

Russian Coal Industry.—The deliveries of combustible of various kinds from the Donetz coal basin in the first half of this year amounted to 446,700,000 poods (a pood is 36 lb. English), as compared with 377,500,000 poods in the corresponding period of 1910, showing an increase of 69,200,000 poods. The aggregate of 446,700,000 poods, representing the deliveries to June 30 this year, was made up as follows:—Coal, 323,700,000 poods; coke, 53,600,000 poods; anthracite, 68,300,000 poods; and briquettes, 1,100,000 poods.

Contracts.—Erith's Engineering Company, Limited, 70, Gracechurch-street, London, have received the order of the Bolsover Colliery Company, Limited, for 24 more Erith's grateless stokers, complete with the firm's system of automatic response of fuel and air to varying loads.—We understand from Mr. Arthur W. Nye, of Chapel House, 62, New Broad-street, London, E.C., who is sole representative for Ste. De Construction du Nord de la France, and Nicaire et Delcuve, that his principals have received an order from the Buenos Aires Western Railway Company, London, for 1300 45-ton bogie wagons, and that the order is being executed at the works of his company at La Louviere, Belgium.—The following orders have been received during the last month by the London Emery Works, Limited, Park, Tottenham, London, N.:—Hydraulic moulding plant, comprising pump, accumulator, and "boxless" moulding-machine for making colliery-tub wheels up to 16 in. on the flange, also sand-sifting machinery, for Scotland; hydraulic turn-over moulding-machine for boxes 40 in. by 20 in.; also a hand-ramming stripping-plate machine for gear-wheels, to be shipped to South America. Sand-mixing and sand-blast tumbling-barrel plant for a new steel foundry in the north of England. Hydraulic moulding-machine plant, comprising one turn-over moulding-machine for making plough-points, one turn-over moulding-machine for dealing with rain-water connection, one "boxless" machine for making brackets, together with hydraulic force-pump and accumulator; also sand-mixing machine for Scotland. In addition to these they have received orders for other moulding-machines for Lancashire and Essex.—Messrs. Willans and Robinson, Limited, of Rugby, have received an order from Messrs. D. Napier and Sons, Limited, for a Willans-Diesel oil-engine to drive a 200-kilowatt direct-current dynamo, for installation at their works at Acton Vale, London, W.

ELECTRICAL CONTROL-GEAR AT OLYMPIA.

CONSTRUCTED BY MESSRS. ALLEN WEST AND CO., LIMITED, BRIGHTON.

(*For Description, see Page* 502.)

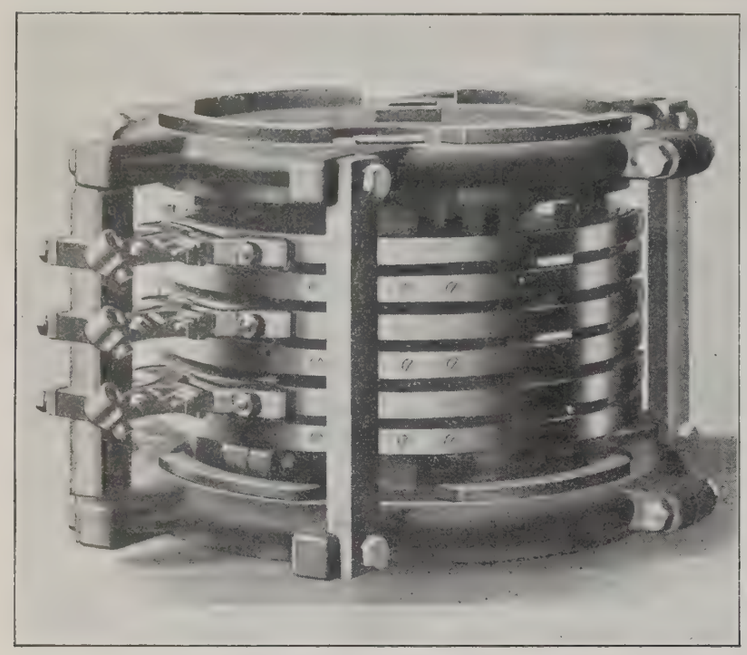


Fig. 32. Crane Collector Column.

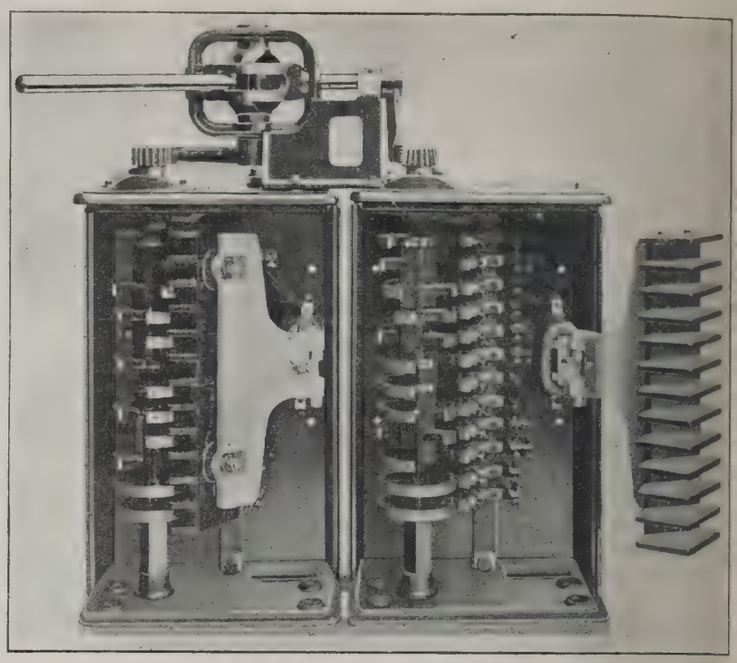


Fig. 33. Two-Drum Type Crane-Controller.

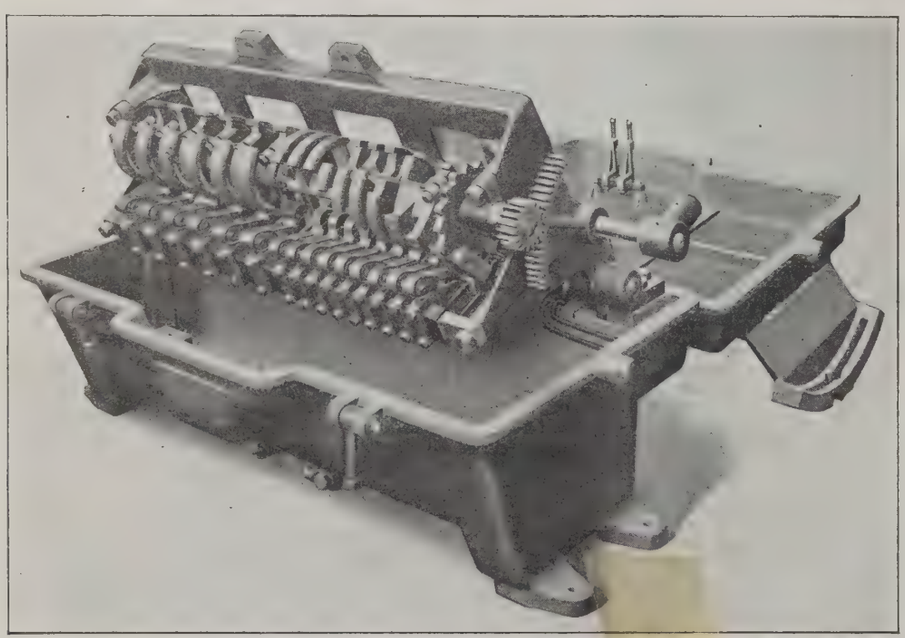


Fig. 34. Oil-Immersed Controller.

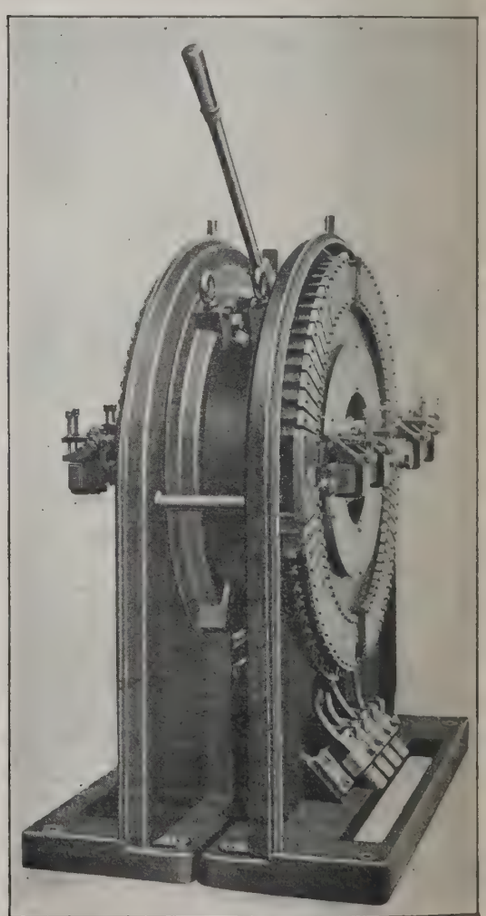


Fig. 35. Face-Plate Type Controller for Heavy Duty.

NOTES FROM THE UNITED STATES.

Philadelphia, October 4.

The general situation in the iron and steel trades remains substantially as a week ago; there have been shadings all along the line, excepting in steel rails, to induce business. The shadings of the past week have been specific to certain prospective customers, in the hope they would lead to orders. The results up to to-day have not been satisfactory. Every inducement has been offered to railroads to place a large volume of business, but the business does not come. Nothing that manufacturers can do in the way of shading prices can have any effect. It is not a question of price. The railroad people know that manufacturers will be glad to get business at any time. There is more capacity than is likely to be taken up under any probable contingency of the next two years. At the same time, the American markets are mercurial. Demands often spring up without the least indication in advance, and an infectious spirit of buying often spreads. The Santa Fé Railroad has placed an order with the Illinois Steel Company for 20,000 tons of open-hearth rails of 90-lb. sections. The Atlantic Coast Line is figuring on its next year's requirements, which will run into quite an order. The Louisville and Nashville Railroad will order 500 steel cars. The Pennsylvania Railroad has contracted with the Cambria Steel Company for 1150 steel cars for its lines east of Pittsburg, which order has been in sight for some time. All that is needed to give the market an upward turn is a little necessary enterprise on the part of the railroad companies to supply their pressing needs. They have plans completed for a great deal of bridge-work, elevation of tracks, subway work, and machine-shop construction, and if only a liberal percentage of this business were placed, it would change the outlook in other lines of iron and steel. There is a fair movement.

The Junior Institution of Engineers.—The secretaryship of the Junior Institution of Engineers, rendered vacant by the resignation of Mr. Walter T. Dunn, has been filled by the appointment of Mr. A. Clifford Swales, engineering assistant to the city engineer of Leeds. Mr. Swales served two years of his articles under the late Mr. Thomas Hewson, M. Inst. C.E., city and water-works engineer of Leeds, completing the same under Mr. W. T. Lancashire, M. Inst. C.E., city engineer of Leeds. Apart from his experience in the city office, Mr. Swales was for some time engaged on the new Leighton Reservoir for the Leeds Corporation at Masham, the holding capacity of which will be 1,136,000,000 gallons. He was for four years honorary secretary of the Yorkshire Association of the Institution of Civil Engineers, and was last year awarded a "Miller Prize" by the Institution of Civil Engineers for his thesis on "Cement and Concrete."

TEMPERATURE INFLUENCES ON CARBON AND IRON.*

By E. Adamson, Sheffield.

The author suggested in his paper of May, 1906,† that there is a wide field for investigation in regard to carbon in pig iron, and he now proposes to give data derived from observations in works practice, which go far to show that the determination of silicon alone is not sufficient in the chemical grading of pig iron.

In the paper referred to the author suggested that the separation of graphite was due to temperature rather than to silicon, and stated he agreed with Sir Robert Hadfield's statements that under certain conditions carbon would be precipitated even if no silicon were present, the conditions being temperature and time, and the percentage of total carbon thereby governed, independently of the silicon, sulphur, phosphorus, and manganese present. It has long been known that with Swedish white iron, which is usually cast in chills, if the carbon is sufficiently high and the pigs cast in sand, the fracture would be grey. It is only necessary to mention the further facts that carbon separates out as free carbon when high carbon steel is forged at a low temperature; and that in a material of the following composition, Charpy and Grenet obtained a separation of 1.87 per cent. graphite, even when it was quenched at 700 deg. Cent. :—

	Per Cent.
Carbon...	3.60
Silicon...	0.07
Sulphur	0.01
Phosphorus	trace
Manganese	0.03

Foster, at a later date, melted steel in the presence of carbon and obtained a grey fracture in material of the following composition :—

	Per Cent.
Total carbon...	4.665
Graphitic carbon	2.136
Silicon	0.098

It is not difficult to produce in the blast-furnace very open grey iron containing 0.40 per cent. of silicon, and grey iron containing 0.20 per cent. of silicon, and the author has made to specification refined iron with very grey fracture, containing silicon 0.40 per cent., as also an iron with silicon 0.15 per cent., having a hard, mottled fracture—such pigs being 4 in. by 4 in. in section and cooled in the ordinary way.

These facts show that carbon is precipitated as free carbon virtually in the absence of silicon, and in the author's opinion this precipitation, in the case of the manufacture of pig iron, primarily depends upon the original temperature to which the iron is raised in the blast-furnace.

Fig. 1.

Fig. 2.

Fig. 4.

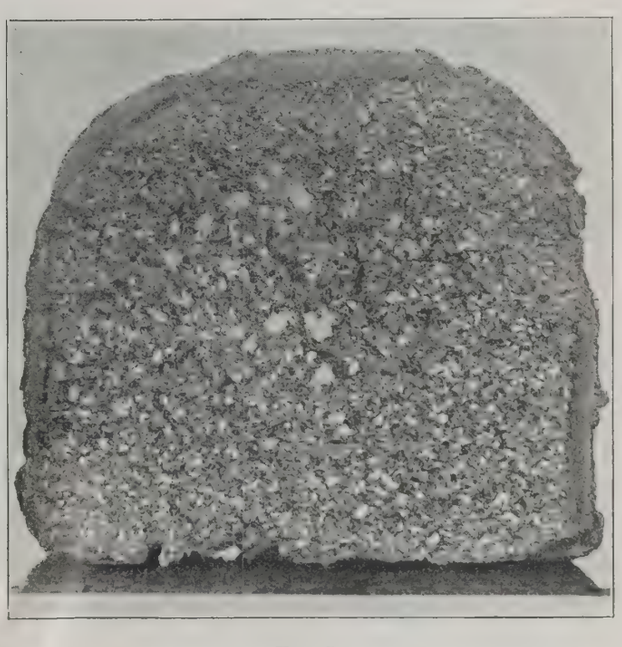


Fig. 5.

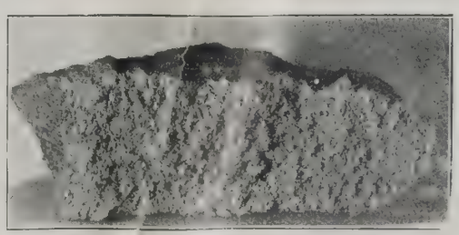


Fig. 3.

The section of this sample was exceedingly thin, Fig. 8 (page 508) being a photograph 9½ times magnified. It was purposely "chilled" in cooling, but, in spite of the thin section, it did not cool white, being quite grey, owing to the high total carbon.

The saturation point of carbon and iron has generally been taken as about 4.25 per cent., but as far back as 1846 Karsten considered iron could take up 5.93 per cent. of carbon. Later, Moissan found it could take up 6.76 per cent., and only recently Girod obtained 7.90 per cent. in his furnace, but he considers that the iron which contained this in the cold state held over 8.00 per cent. in the molten state, which confirms the author's contention. The differences in these percentages of carbon are due to the temperature to which the iron had been raised, and the time it remained at high temperatures in contact with carbon, and it is now generally accepted that the higher the temperature in the blast-furnace the higher the carbon in the product—within limits—for it is well known that cold-blast iron is lower in total carbon than hot-blast, although the full force of this fact has perhaps been overlooked. What this amounts to is that the temperature of the furnace decides the fracture of grey pig iron as well as of the lower grades, regardless of the contents of silicon, sulphur, phosphorus, and manganese.

* Paper read before the Iron and Steel Institute in London, October 5, 1911.

† See Engineering, vol. lxxxii., page 27.

This will be more apparent from the following Table I., taken from the author's paper of 1906, which gives the complete analyses, with increasing silicon, from ordinary hematite irons taken haphazard from the daily make of a furnace, and it will be observed that whilst the silicon varies from 0.67 per cent. to 5.85 per cent., the fracture is all No. 1 :—

Table I.

No.	Fracture.	T.C.	G.C.	C.C.	Si.	S.	P.	Mn.	Remarks.
1	No. 1	4.23	3.62	0.61	0.67	0.026	0.040	1.40	
2	No. 1	3.65	3.08	0.57	1.46	0.040	0.030	0.72	
3	No. 1	3.76	3.20	0.56	2.14	0.038	0.031	0.78	
4	No. 1	3.23	2.83	0.40	3.93	0.030	0.040	1.30	Very large flakes
5	No. 1 open	3.67	3.50	0.17	4.98	0.034	0.041	1.34	Same cast. Open and close
	No. 1 close	3.67	3.49	0.18	4.63	0.034	0.041	1.34	No. 1 fractures.
6	No. 1	3.14	3.02	0.12	5.85	0.033	0.043	1.00	
7	No. 1 close	3.28	2.22	1.06	0.35	0.026	0.020	0.07	Supplied by Sir R. A. Hadfield.

Table II. is taken from the author's discussion of Levy's paper,* in which the silicons vary from 0.20 per cent. up to 4.83 per cent. in grey irons.

Table II.

No.	Fracture.	T.C.	Si.	S.	P.	Mn.
1	White alloy ..	4.60	0.79	0.018	0.016	1.26
2	Grey No. 1 ..	4.23	0.67	0.026	0 040	1.40
3	White	4.20	0.20	0.020	0.020	trace
4	Grey No. 1 ..	3.50	2.00	0 030	1.560	0.30
5	,, ..	3.28	0.35	0.026	0.020	0.07
6	Grey close ..	2.95	0.95	0.065	0.980	1.65
7	Grey	2.90	4.83	0.010	1.050	0.61
8	Grey close ..	2.60	1.70	0.030	0 080	0.08

In these analyses of commercial pig irons the only explanation of the difference in fracture, total carbon, and silicons, is primarily due to the temperature of the furnace, and also to its burdening and general working, which are the primary causes of the several conditions of free carbon such as are found in the grades of grey pig iron, Nos. 1 to 5, regardless of the contents of silicon, sulphur, phosphorus, and manganese.

The author has referred to several conditions of free carbon, of which it is practically impossible to obtain complete separation or photographs to show the true crystallisation, as the surface of a fracture of a pig is so uneven, and thus casts shadows which destroy the true structure as seen by the eye. It is also equally impossible to get an adequate surface under the microscope to give a true indication of the different conditions of free carbon found in pig iron, but they can approximately be described as follows :—

(A) Very fine graphite liberated at low temperatures, and such as is generally found in a mottled iron, and Nos. 5 and 6 cold-blast irons. This appears to be the first stage of free carbon when it is separated as such in a large section of metal; the larger the section the greater the percentage of separation, due entirely to slow cooling, and such as would be largely shown when the late Sir Lowthian Bell cast a 6-ton block of white iron to prove that by slow cooling there would be a separation of graphite in the centre. This condition of graphite is shown in Fig. 1.

(B) This is another variety of graphite, showing a crystallisation not unlike frost on glass. This can be produced from white iron by annealing for a long period at a high temperature, or in hard grey iron by very slow cooling. This variety of graphite is also produced in pig iron at medium temperatures, and the peculiar formation is most pronounced in irons low in phosphorus, and also frequently in the case where rich hematite iron and steel scrap are melted together. This variety is seen in Figs. 2 and 3, the former being a fracture of pig iron, and the latter from "rich" hematite and steel scrap melted together in about the proportion of half and half.

(C) This variety is the well-known large flake of graphite found in open soft irons. It is formed at high temperatures, regardless of the constituents in pig iron, as shown in Table I. It is also the most difficult of the three varieties to oxidise or burn. This most refractory condition is that disclosed in a fracture of No. 1 pig iron showing "kish," and this condition varies from that of the most refractory nature known as "kish" down to the smaller structure, as seen in a No. 3 pig iron. The fractures are shown in Figs. 4 and 5, which are photographs of phosphoric and non-phosphoric pig iron.

None of these varieties of free carbon are necessarily completely destroyed on melting, even under slightly oxidising conditions, as in the cupola; for whilst it is generally assumed that melting iron in the cupola lowers the grade, this entirely depends upon the total carbon, and its condition in the original pig. The author has proved in works experience that it is possible to reproduce the grade under good ordinary conditions of melting, independent of the influence of the other metalloids present.

These crystallisations or formations of free carbon or graphite carbon are difficult to describe, as it is not easy to obtain samples in a suitable form to give a true indication of the appearance of the fracture containing these varieties of carbon; but all these forms are found, and are most apparent when turning a furnace off hot-blast iron on to cold-blast iron, and *vice versâ*. Under these circumstances these three varieties of carbon make their appearance in a very decided form, and when thus produced it is not difficult to understand that temperature is the primary cause of their change of form.

The author believes that cooling curves of iron containing each of these three different forms of free carbon would vary in the position and character of the critical points; but it will take a considerable time to obtain the particular fractures of iron sufficiently alike in composition. As soon as such fractures can be obtained, the author will give particulars.

With regard to these different forms of free carbon, Moissan has done some valuable work, and has produced several varieties of graphite or free carbon in the electric furnace. Whilst not able to give complete cooling curves of these varieties of carbon and iron, the author has been able to obtain cooling curves from a No. 1 hematite and an alloy made from Swedish white iron and high-grade ferro-silicon melted together to give approximately the same analysis as regards total carbon, &c. Practically the two extreme forms of carbons found in grey and white pig irons are found in these two samples. These curves are given in Fig. 6, A and B, and the analyses are as under :—

	A. Per Cent.	B. Per Cent.
Total carbon ...	4.20	3.90
Graphitic carbon...	3.62	trace
Combined carbon...	0.58	3.90
Silicon	1.02	1.04
Sulphur	0.018	0.010
Phosphorus ...	0.022	0.018
Manganese... ...	0.53	0.22
Fracture at start ...	No. 1	Practically white
,, finish...	Grey porous	Close grey

Fig. 6.

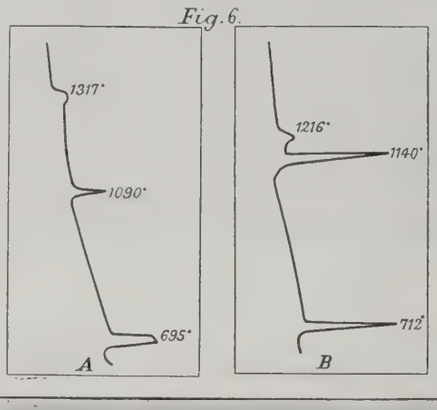


Fig. 8.

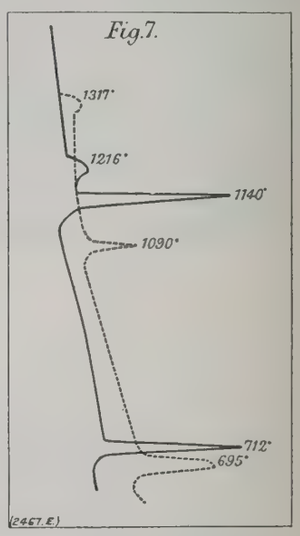
Dealing first with B, this iron was chilled on cooling to produce a white fracture, and the curve shows the first arrest at 1216 deg. Cent., the second arrest at 1140 deg. Cent. (known as separation of graphite), and the third arrest at 712 deg. Cent., of Ar.3.2.1. This is quite in accordance with expectations. Sample A was an ordinary No. 1 hematite obtained from the Millom and Askam Hematite Iron Company, pieces of which were cut off sufficiently small for use in a small crucible to obtain the curves—both metals being raised to 1500 deg. Cent.—and whilst the total carbon (4.20 per cent.) was 0.30 per cent. higher than the B alloy, the first arrest took place at 1317 deg. Cent.—101 deg. Cent. higher than the companion alloy; the second arrest occurred at 1090 deg. Cent., and was comparatively small as compared with the second arrest of the alloy B, suggesting that a large portion of the carbon had not dissolved in the iron even in the molten state; whilst the third arrest, at 695 deg. Cent., was to be expected. This third arrest of A is also different from that of B, but does not come within the scope of this paper. Much more work will probably have to be done before it can be explained. It will be noticed, however, that in the alloy B, after each arrest, the cooling comes back to normal; but in the case of the hematite pig iron, after the first arrest the curve never comes back to normal, and there is a permanent expansion, as will be seen on Fig. 7, the dotted curve below A.

The original fractures of A and B were a very open grey and a practically white iron respectively, whilst the fractures on cooling were open grey and close grey respectively. The peculiarity of the first fracture A on cooling was that the metal showed numerous "draws" or small "pipes" from the top surface, and the crystallisation throughout the A fracture was very like the form of "primary octahedral crystallites" just before being freed, such as are frequently found in the heart of thick parts of iron castings. Fracture A has an appearance something like Fig. 8.

The fracture of the B sample on cooling was perfectly solid throughout, was very tough, being slightly malleable, and when fractured showed a strong, close-grained iron.

In the discussion of Levy's paper* the author drew attention to the fact that the phase rule, upon which Levy relied for a number of his conclusions, would not apply in actual works practice; that is, that it would not apply to all grades or fractures of iron, for in the author's opinion the phase rule depends upon the iron being white when cold, or probably not further developed in free carbon than the A variety described above by the author, at the commencement of any experimental cooling curves, whilst it will be seen from the tables quoted above that this is not the case even in very low silicon iron. In his reply to the author, Levy quoted several points of solidification, but none of these could be confirmed by the temperatures given on the author's curve A now presented. The points of solidification of Carpenter and Keeling, and Wüst, quoted by Mr. Levy, are based upon white-iron alloys or containing free graphite, and the author is sure that the gentlemen quoted would readily admit that the phase rule cannot be strictly applied to works practice in the case of grey high-carbon irons, for whilst A has the higher total carbon—viz., 4.20 per cent., against B 3.90 per cent.—the first arrest of the former occurs 101 deg. Cent. higher, whereas, according to the phase rule, A should have been lower than B, and in A the second arrest due to separation of graphite largely disappears. The author's explanation of the difference in curves A and B is that the more refractory forms of graphite, such as are found in pig iron and produced at high temperatures, do not entirely dissolve in iron when in the molten state, and that some of the more refractory forms of graphite, particularly of the "kishy" character, are held in suspension in molten metal. In his paper of May, 1906, the author referred to a separation of graphite before solidification. Mr. C. A. Edwards very ably describes this phenomenon in his notes on "The Nature of Solid Solutions."†

Fig. 7.



The author's highest total carbon is 4.20 per cent., and the lowest points of solidification given by Carpenter and Keeling are: carbon, 3.98 per cent. 1171 deg. Cent.; 4.37 per cent. 1136 deg. Cent. The second of these points, 1136 deg. Cent., is from an alloy with a higher total carbon than the author's curve A, and Levy further explains that an increase in carbon beyond a certain point is accompanied by some rise in the point of solidification. The author's curves, however, are well within the limits of carbon mentioned by Levy, to which apparently the phase rule applies, and curve A proves that it is not an increase of carbon only which raises the point of solidification, but, what is of more importance, the conditions of the carbons as determined by the temperature to which the iron has been raised in contact with carbon, in which time also plays a prominent part, thus interfering with the application of phase rule as to total carbon contents, by causing a decrease in what may be termed "effective" carbon when applied to phase-rule curves. The "non-effective" carbon, or refractory graphite, also causes a permanent expansion.

On referring to Turner and Hague's paper,‡ curves 4 and 5, with silicon 0.97 and 1.19 per cent. respectively, are nearest in silicon contents to the author's curves A and B. In general principles these curves, Nos. 4 and 5, confirm B, with the exception of the first arrest, which takes place in 4 and 5 at 1247 deg. Cent. and 1244 deg. Cent. respectively, whilst B occurs at 1216 deg. Cent., making it in keeping with 4 and 5, and the slight variation is probably due to the difference in total carbon, which is as given in Table III., on the next page.

In the above three analyses silicon has been included to draw attention to the fact that under no conditions

* Journal of the Iron and Steel Institute, 1910, No. 1, page 424.

† Institute of Metals, No. I., 1911, vol. v. See also Engineering, vol. xci., page 203.

‡ Journal of the Iron and Steel Institute, 1910, No. II. page 85. See also Engineering, vol. xc., page 841.

TABLE III.

—	T.C.	G.C.	C.C.	Si.
	per cent	per cent	per cent	per cent
Turner's No. 4 curve	2.56	0.23	2.33	0.97
,, No. 5 ,, ...	2.70	1.32	1.38	1.19
Adamson's B curve	3.90	trace	3.90	1.04

can it be said to control the percentage of combined carbon or graphite, and this is confirmed by Turner and Hague's Table I.,* a careful study of which will show that it cannot be claimed that the percentage of silicon controls the percentage of combined carbon, or the graphite, or the ratio of one form of carbon to the other. Under precisely the same conditions of temperature and time, additions of silicon may even show fairly regular variations in the carbons, but under the same constant conditions phosphorus and manganese would do the same.

The curve A is of quite a different character from any of the seventeen curves given by Turner and Hague, even although some of the latter contain as much as 1.93 per cent. graphite in a total carbon of 2.77 per cent. Turner and Hague stated they found difficulty in adding silicon to iron containing carbon 3.04 per cent. by using 50 per cent. ferro-silicon alone, and they therefore prepared a special alloy to enable them to add silicon in varying percentages to white iron. This special alloy was made with over-blown steel, and contained about 20 per cent. silicon. By means of such material the authors obtained their alloys from which the seventeen curves were taken. In the present case the B alloy was made from Swedish white iron containing 4.00 per cent. carbon, and it was not found difficult to introduce silicon 1.04 per cent. by means of 50 per cent. ferro-silicon, thus confirming the author's previous experience, as stated by him in discussing Turner and Hague's paper. In this paper the authors claim "that the carbon in the washed iron prevented the silicon from entering," but this is not confirmed in the case of the present B alloy made from iron containing over 30 per cent. more carbon than was used for the alloys for the seventeen curves. Under the circumstances stated, the author is sorry he cannot agree with the conclusions of Turner and Hague, and suggests that temperature and time are important factors. Curve A was made from a natural blast-furnace product.

The difference between Turner and Hague's and B curves and curve A can be explained in the difference of total carbon and also the condition of the free carbon or graphite, chiefly the latter. The alloys of the seventeen curves varied from total carbon 2.26 per cent. to 2.95 per cent., most of them being within Professor Arnold's steel limits, and all were practically semi-steel; hence, with such low total-carbons there is small possibility, at the temperatures which would be used for dealing with these alloys, of producing any refractory forms of graphite, such as found in true cast iron. In curves A and B, however, of total carbon 4.20 and 3.90 per cent. respectively, these are the usual carbons of a non-phosphoric pig iron, and therefore the natural product of the blast-furnace; hence the irons have been subjected to the high temperatures of smelting, and are true cast irons.

In none of Turner and Hague's curves, from the lowest percentage of silicon to the highest, does the first arrest occur higher than 1247 deg. Cent., and all these curves, as well as curve B, after each arrest appear to fall back to practically the normal rate of cooling, whereas in curve A the first arrest is at 1317 deg. Cent., or 70 deg. higher than the highest first arrest of Turner and Hague, and the A curve never comes back to the normal rate of cooling. This is explained on the author's suggestion that, with certain conditions or varieties of free carbon present, there is a certain percentage of non-effective carbon when dealing with cooling curves and their application to the phase rule; this ineffective carbon also causes a permanent expansion, apparently due to the swelling character of the graphite, thus confirming Moissan's observations. In curve A the effective carbon would appear to be up to about 2.00 per cent. on the basis of Carpenter and Keeling's figure of 1443 deg. Cent. as the solidifying point of steel, as against their 1171 deg. Cent. for an alloy of 3.98 per cent. total carbon. From this it will be seen that Professor Turner, in replying to the criticism of his paper, mistook the author's remarks in referring to "expansions due to separation of graphite." The author was not referring to these expansions at all, but to the expansions of the iron due to intumescent graphite; hence, Osmond, in discussing the paper referred to by Professor Turner, was not referring to the expansion indicated by the author, and Professor Turner also did not deal with the author's expansion in his paper of May, 1906; but Professor Turner's expansion referred to that shown on B at 1140 deg. Cent., and for which there is no equivalent on A, because at 1090 deg. Cent. there appears to have been very little graphite to separate. The expansion referred to by the author is fully described in this present paper.

The author has already referred to his paper of 1906, in which he agreed with Sir Robert Hadfield in stating that under certain conditions carbon would be precipitated in the absence of silicon, and as a proof of this he is indebted to the Millom and Askam Hematite Iron Company for permission to use the following analysis:—

	Per Cent.
Graphite carbon	Trace
Combined carbon	3.87
Silicon	Nil
Sulphur	0.074
Phosphorus	0.037
Manganese	0.30

The fracture is hard mottled iron, and no doubt the cause of graphite being given as "trace" is that the grey part of the fracture was in the centre of the pig, and the proportion of graphite to combined carbon, whilst substantially true in the grey portion of the fracture, could not be accurately estimated over the whole fracture. This iron is a freak; it may never have been produced before, and may never be produced again; and whilst it is a natural blast-furnace product, no one would attempt to produce such an iron as a commercial product. Accidents sometimes, however, reveal the truths. This particular iron was produced by a slip of the burden of the furnace whilst running on rich high-grade iron. This produced a "chilling" effect, causing the fracture of the iron to be white, and only about 2 tons of this iron was made.

The facts stated in this paper are of vital importance in considering the question of the grading of pig iron, and to a large extent explain the objections of many in this country to complete change in the methods used at present to one of grading by practically silicon contents only. The author has shown on several occasions that it is not possible to regulate tests by silicon only, and has no hesitation in saying that the fracture indication is quite as satisfactory as varying the silicon, if the user is fully conversant with fracture indications.

Continual experience in the use of pig irons in the foundry shows that the same tests can be obtained within very wide ranges of silicon contents. Of course, if it is a question of commerce, there should be no objections to selling irons by silicon contents if this is demanded, and full resposibility is taken by the purchaser; but when it becomes a question as to whether such a method of grading is the best, so as to be of the greatest use to the greatest number, the reply must be an emphatic negative, for it would appear that carbon and its various conditions, due, as shown, to influences entirely outside of analyses, is of primary importance.

The author wishes to express his sincere thanks to Professor Dr. Carpenter for having kindly taken the curves A and B. Professor Carpenter has already contributed valuable matter on the iron-carbon system, and his assistance to the author in this instance was readily given.

THE TRANSFORMATIONS OF STEEL WITHIN THE LIMITS OF THE TEMPERATURES EMPLOYED IN HEAT-TREATMENT.*

By L. GRENET, Paris.

THE following account of the transformations of steels within the ordinary temperature limits employed in heat-treatment is contributed to the members of the Iron and Steel Institute, at the suggestion of Sir Robert Hadfield, by the author, who takes this opportunity of expressing the pleasure he feels in complying with the request, and his gratification at the implied appreciation of his work which it conveys. To the present paper have been added a few notes on alloys, with the object of showing how the same conceptions may be applied to the classification of the facts relating to the influence of heat-treatment upon such bodies.

I.—ALLOTROPIC MODIFICATION.

In order, at the very outset, to avoid all ambiguity, it is necessary to define the sense the author attributes to the term "transformation," most of the misunderstandings which arise on this question being verbal ones. If the properties of a body be considered as functions of the external physical conditions, it will be found that when the physical conditions vary, the properties of the body vary correspondingly, although this does not in itself constitute what is known as a transformation.

If, however, at a given moment, grounds occur for the belief that the law which correlates the properties of a body with the external physical conditions become changed, the body is described as having undergone a transformation. Thus, if a point characteristic of the properties of a body in terms of the external physical conditions, after having assumed a position in a curve A B, becomes situated in a curve C D, the body is described as having undergone a transformation between B and C (Fig. 1).

It often happens that under the same external physical conditions the point characteristic of the properties of a body may be shifted to one or the other curve. The existence of two curves relating to the properties is, in such an instance, particularly clearly established.

Thus, if the curve correlating the properties of a body under given external physical conditions assumes the form A B C D (Fig. 2), it would be possible, according to the individual interpretation that might be placed upon the facts, to assume that the body becomes transformed between B and C, or that there is no change in the curve, and that the body does not undergo transformation.

But if it is possible that, under certain conditions of external physical state, the point characteristic of the system may be displaced at will along the curve A B, or on the prolonged curve C D, the existence of two curves A B and D C E becomes undeniable. The body exists, therefore, in two states, and it becomes transformed during the passage of B to C (Fig. 3).

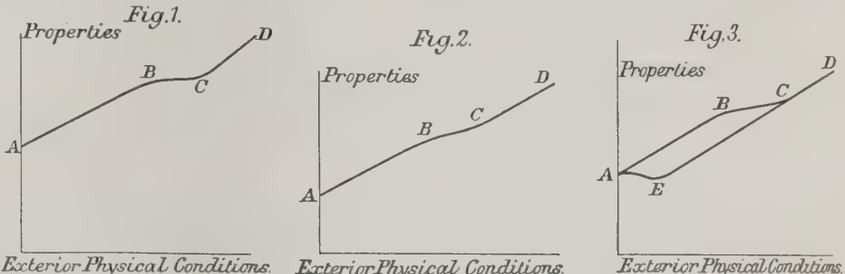
If hysteresis phenomena occur there will be, not two simple curves, but two curves relating to the simple normal state, around which the classical curves of hysteresis will group themselves.

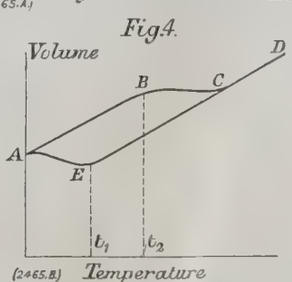
Generally speaking, the transformation of a body affects not a single property alone, but all, or nearly all, the properties. The properties which best permit the course of transformation to be observed (when they can be observed) are the crystallographic properties; and in default of crystallographic properties, the properties bearing upon the crystalline state (microstructure). When it is possible to obtain, under identical external physical conditions, both the transformed body and the untransformed body, it is found that these two bodies differ from one another as much as two bodies possessing different chemical compositions.

The only difference which exists between a body before and after transformation and a body possessing a different chemical composition is that it is possible to restore the transformed and the untransformed body to a common state. There has been transformation, not transmutation.

It would appear, therefore, that no absolute distinction can be drawn between an allotropic modification and a transmutation. An allotropic transformation is a transmutation which we know how to produce, while a transmutation is an allotropic transformation which we do not know how to produce.

It may be remarked that magnetic permeability is, roughly speaking, much the same in all known bodies, and is in the vicinity of 1. In a similar way, generally speaking, when a non-magnetic body (permeability = 1) is transformed there are no changes in the magnetic properties; the new body formed still possesses, generally speaking, a permeability=1. The change of lead into copper would not entail any very great change in the magnetic permeability.





But if, as an exception—and this exception is met with in the case of steel—the body, before its transformation, possessed a degree of permeability differing from 1, transformation would occasion a change in the magnetic properties.

The phrase "allotropic transformation" is generally confined to transformations which are not common to all bodies, or to a group of bodies. Fusion and volatilisation are allotropic transformations common to all bodies, but are distinguished by special terms.

Phenomena of interstrain, or the rapid variation, within a certain range of temperature, of magnetic properties, are phenomena common to many bodies which it is better to distinguish by their particular name, without confusing them with the special transformations which relate to bodies which have been the subject of investigation.

When several bodies are present at the same time the nature of the allotropic transformations of the system may become highly complex; there may be a continuous solution of the two bodies in one another; or, again, such solutions may take place suddenly at a given temperature (as in the case of eutectics); or, finally, one of the bodies may undergo transformation independently of its passage into solution in the other bodies.

When it is a question, not of isolated crystals, but of aggregates of the same nature, or of different natures, it is often very difficult to say definitely whether certain differences in the properties of the aggregate should be attributed to different allotropic states in the elements, or whether, on the contrary, they should be attributed to

* Journal of the Iron and Steel Institute, 1910, II., page 81. See also ENGINEERING, vol. xc., page 842.

* Paper read before the Iron and Steel Institute in London, on October 5.

the size or the distribution of the elements which together form the aggregate.

Identical phenomena can be explained in different ways; but we may reckon that every time it is possible to correlate the interpretation of the phenomena observed with a general conception capable of being applied to a group of bodies, it is better to do so than to refer them to special hypotheses designed to meet the case of the particular body studied.

II. Transformation of Steels.

Let us first take the case of steels. If a steel, which to begin with has been annealed, be heated, it is found that its properties vary with the temperature in a uniform manner up to a temperature of about 700 deg. At this temperature the properties vary rapidly, and the curve which connects the properties under investigation (density, electro-thermal power, resistivity, micrographic texture, amount of heat absorbed during heating, &c.) with the temperature undergoes a rapid change of form, to assume, later, a fresh, uniform outline, differing from the first.

In the case of certain steels the phenomenon is not reversible, so that, within a certain temperature range (t_1 to t_2. Fig. 4), the figurative point of any one property—for example, the volume—may be displaced on one or other curve A B or D C E. It may then always be said:—

The steel is in the "hot stable state" when the figurative point of the properties of the steel is displaced along the curve D C E; and it is in the stable condition, in the cold, when the figurative point in the properties of the steel is displaced along the curve A B.

The curve of the heat absorbed during the heating undergoes, like the curves relating to other properties, a rapid variation in outline from B to C.

This variation in outline reveals itself by absorptions of heat during the heating and by emissions of heat during the cooling, and is particularly noticeable in soft steels at three temperatures. These emissions of heat have given rise to the conception of several states of iron.

It appears infinitely more simple to the author to interpret these emissions of heat as phases of a single transformation spread out over a certain temperature interval. This would lead to the conception that steels may exist in two states: the "hot stable state," and the "cold stable state." As the conception of a third state will, as a result, be unnecessary, the author believes it better to adhere to this simple view of two states only for iron and for steels.

In studying transformations in general the magnetic properties have been studied apart, and it may now be seen how the occurrences take place in the case of steel.

Generally speaking, within the limits of temperature in which steels can exist in the "cold stable state," they are magnetic in this state; within the temperature range in which the steels can exist in the "hot stable state" they are non-magnetic in this state.

The transformation is, therefore, generally speaking, accompanied by the appearance and the disappearance of magnetism. Indeed, generally speaking, this is a simple means of following the process.

For soft steels, however, the magnetism disappears at about 750 deg. in the stable state in the cold, and before the transformation characterised by the variation in the other properties.

In steels containing a high percentage of nickel, known to exist in the "hot stable state," at ordinary temperatures, the magnetism can appear at a somewhat low temperature without other properties varying for this reason.

These variations in magnetism unaccompanied by variations in other properties do not take place suddenly, and although they occur with some rapidity, they are, for the most part, reversible. (See Curie's researches on mild steel, and those of Dumas on steels containing high percentages of nickel.)

If it be wished, this rapid variation in the permeability may be distinguished by the use of the term "magnetic transformation," remembering, however, that this variation has no known connection with the other properties, and especially with those mechanical properties which chiefly interest us. This is a transformation common to all ferro-magnetic bodies. A passing reference may be made to a transformation which is perhaps of the same nature as the preceding instance, and occurs at about 1300 deg. in mild steel (Ball and Curie). The temperatures of the heat-treatment of steels are always below that temperature, however, so that, in the present paper, it is unnecessary to take the instance noted into account.

To sum up: the author deduces, in iron and in steels, two states, and two states only: the "hot stable state," and the "cold stable state." The transition from one state to the other constitutes the transformation, accompanied by variations in all the known properties, including the magnetic properties when the steel is in either state magnetic. The variation in magnetic properties may occur, however, in either state, independently of any other variation in the properties, and in order to avoid confusion, this rapid variation in the magnetism alone will not, in this paper, be distinguished by the word "transformation."

An apology must be offered for this somewhat lengthy preamble, but the author was anxious, before all things, clearly to indicate the sense in which the terms to be employed in the sequel should be understood.

III. Relations between the Mechanical Properties and the Thermal Treatment Undergone by a Steel.

In the author's opinion, the known facts permit of the following law being formulated:

The hardness of an alloy is greater in proportion as the transformation which has called into being constituents at the time has occurred at a low temperature, has been effected rapidly, and that the maximum temperature to which the metal has attained since the last transformation has been comparatively low, and has been maintained for a comparatively short period.

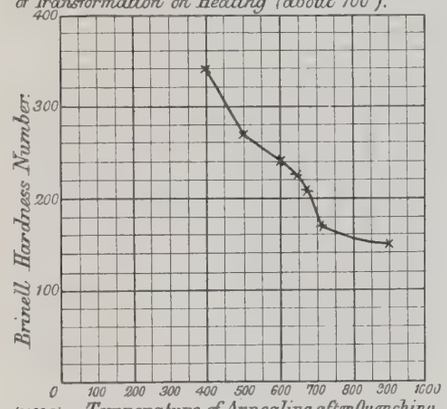
This law does not permit of a comparison of the effects of varying conditions of heat-treatment, except when there is reason for believing that the metal remains in the same physico-chemical state after the varying heat-treatment. This law indicates the direction in which variations in the hardness occur in terms of the heat-treatment only when such variations do occur, but it does not indicate the importance of these variations in hardness, which may in certain instances be very small, or even nil, despite considerable differences in the conditions of treatment. It is a qualitative law.

This law is based upon the following facts:—

1. A large number of steels can, under observable conditions, undergo their cooling transformation at a temperature perceptibly lower than that of their transformation on heating. All the forms of heat-treatment to which these steels can be submitted, and in regard to which the conditions of transformations can be observed, justify the law stated above.

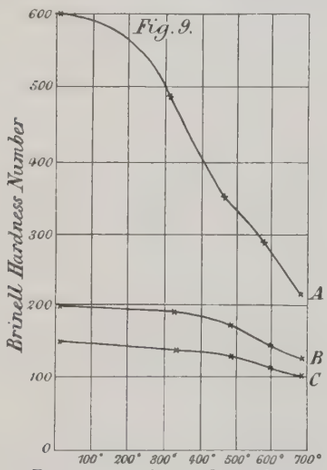
Fig. 5. The Annealing of a Semi-Hard Steel after Quenching.

The action of Annealing is limited by the Temperature of Transformation on Heating (about 700°).



(2465.c) *Temperature of Annealing after Quenching.*

The Curve is plotted for an Annealing lasting 15 Mins.



Temperature of Annealing after Quench.

Curve A. Carbon Steel (Carbon 0·52, Manganese 0·52, Silicon 0·38).

Curve B. Aluminium-nickel Bronze (Copper 89, Aluminium 9·8, Nickel 1·1, Lead 0·1).

Curve C. Brass (Copper 58·8, Zinc 40·4, Lead 0·8).

(2461.f)

Fig. 6. **Curve a (observable)**

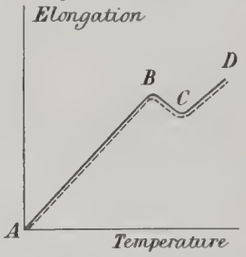


Fig. 7. **Curve b (hypothetical)**

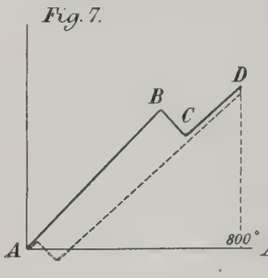
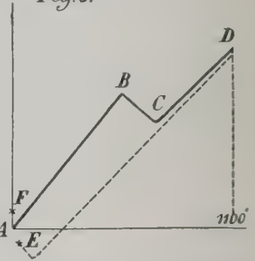


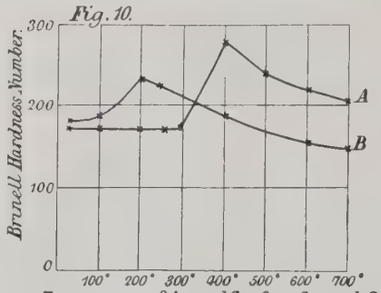
Fig. 8. **Curve C (hypothetical)**



The Curves in Continuous Line show the Heating, and the Curves in Dotted Lines the Cooling.

(2465.D)

Fig. 10.



Temperature of Anneal.g after Quench.g

Curve A. Steel containing 1·94 per cent. Carbon and 2·2 per cent. Manganese quenched in Water from a Temperature of 1050° (Maurer).

Curve B. Copper-tin-bronze containing 80 per cent. Copper and 20 per cent. Tin quenched in Water at a Temperature of 750°. Discs 4·5 Millimetres thick (Grenet).

(2465.F)

Nickel or chromium-nickel steels with a low transformation temperature, even when the transformation is carried out very slowly, and high-speed chromium and tungsten tool steels which, according to the rate of cooling, undergo their transformations, under observable conditions, at high or at low temperatures, lend themselves well to observation in this respect (Osmond, André le Chatelier, Grenet).

2. Highly carburised steels which have undergone a quenching such that all methods of observation lead to the supposition that the "hot stable state" is, in part, preserved (austenitic steels), are less hard than they would be if they had been quenched under conditions in which the conservation of the "cold stable state" is less complete or even absent (martensitic steels).

There is therefore reason for supposing that it is not to the suppression of the cooling transformation, but to the conditions under which this cooling transformation occurs that the hardening effect is due.

3. On most steels the influence of annealing is continuous, and limited only by the temperature of the heating transformation, because this heating transformation is connected with the inverse transformation on cooling to which the hardening effect is due, although the form of the curves shows that (except for soft steels) annealing is not completed at any temperature (Fig. 5).

Therefore, if the existence of a special state be admitted in order to explain the hardness of quenched steels, it should also be admitted that a certain number of steels, amongst which are the semi-hard carbon steels, always remain in this special state,

4. A fact many times observed is that the special steels, and, in particular, steels possessing a low transformation temperature, do not acquire, by any kind of treatment, so great a degree of hardness as do small samples of hard carbon steels suitably treated. It is logical to suppose that during the quenching of a carbon steel the transformation is more violent than the transformation of a steel containing a high proportion of special elements.

The greater velocity of the transformation, and perhaps the fact that, with a steel containing carbon only, it is more complete, can alone explain the greater hardening capacity of such steel.

The law applies to alloys other than steel. Most alloys which at a high temperature, no longer possess the same constitution as they do at the normal temperature, harden on quenching or on rapid cooling, a form of treatment which lowers the temperature at which the cooling transformation takes place. This is the case as regards certain brasses, certain aluminium-copper alloys, some aluminium bronzes, and certain malleable bronzes which, like the bulk of steels, harden on quenching. When the quenching of such an alloy does not occasion hardening, this may be because quenching stereotypes wholly, or in great part, the "hot stable state," but in this case it is only necessary to reheat the alloy slowly to 200 deg. or 300 deg. to restore it to the same physico-chemical state that it would have possessed had it been cooled slowly. The existing constituents having been set free at a relatively low temperature, the alloy is harder than if it had been heated to a high temperature and slowly cooled. This is the case with certain copper-tin bronzes, and some hard steels containing manganese.

IV.—Classification of Steels Indicative of the Variations in Properties in Terms of the Heat-Treatment.

The author deems it useful to recapitulate the classification made in 1898 by Mr. Osmond. This classification

will be described and accompanied by curves of the dilatation* which will serve to explain it.

A special group has been made of the high-speed tool-steels (chromium-tungsten steels), and the whole classification has been given a character independent of any theoretical views, and made of wider application by the inclusion in each group of alloys other than steel, the influence of heat-treatment on which is known.

A. *Group I.—Steels the transformation temperature of which, on slow cooling, is very nearly the same as on heating (carbon steels and steels containing but a small amount of special elements).*

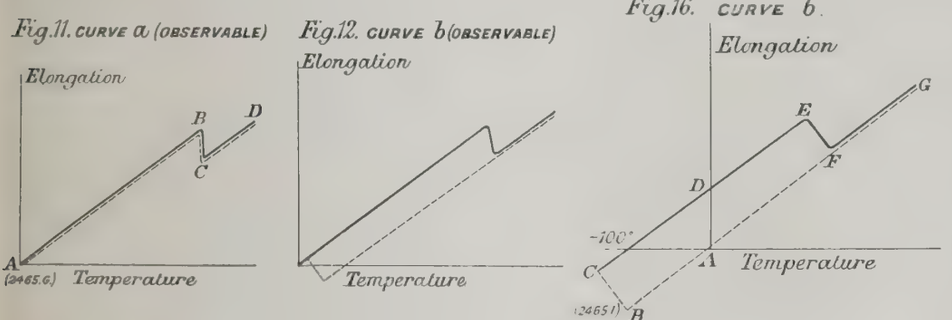
Observable Curve a (Fig. 6).—Slow cooling or moderately slow cooling (less than 150 deg. per minute). The transformation temperature on cooling remains practically the same as on heating.

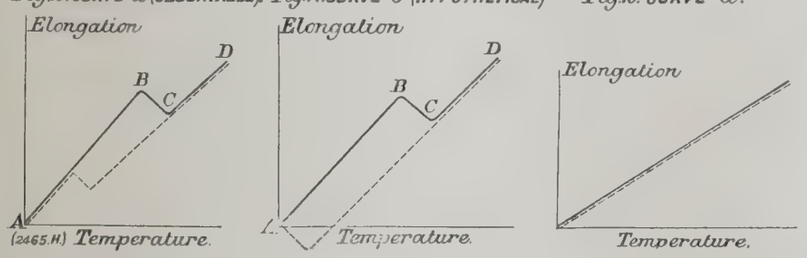
In Figs. 6, 7, and 8 the curves shown in unbroken lines correspond to the heating, and those in dotted lines to the cooling.

Hypothetical Curve b (Fig. 7).—Rapid cooling by water-quenching a steel heated to a temperature not exceeding about 800 deg.

The transformation on cooling has been brought back to the neighbourhood of the ordinary temperature. The return to the point A can only be ascertained by the fact that these quenchings do not produce any noticeable variations in the elongation (Charpy and Grenet).

According to the researches of Maurer, not on the length, but on the volume, quenching in the above manner may, under certain conditions, occasion an increase in volume. The fact that a quenched steel occupies a larger volume than the same steel annealed may be explained by the statement that the external layers have become cooled and hardened while the core is still hot and dilated. These external layers have, subsequent to the cooling of the core, partly maintained their shape,





with the result that strains are set up, and an increase in volume occurs (analogy with quenched glass).

Hypothetical Curve c (Fig. 8).—Very rapid quenching in water of samples of steel containing high percentages of carbon (1 per cent.), and of less than 10 mm. in diameter, heated to a very high temperature (1000 deg. to 1100 deg.).

The cooling transformation is delayed and partially suppressed. The return of these steels to E has been plotted from the experiments on the volume changes carried out by Maurer.

This shrinkage produced by quenching is not an absolute proof of the partial conservation of the "hot stable state" (phenomena of possible compression). Nevertheless, it is a probability which adds itself to others (important variations of the resistivity and of the micrographic texture) favouring the hypothesis of the partial conservation of the "hot stable state."

In some cases quenching may even stereotype almost entirely the "hot stable state" (hard manganese steels, copper-tin bronzes.

Naturally between these three types of curves all sorts of intermediate cases occur.

Influence of Heat-Treatment on the Steels of Group I.—(*a*) Generally speaking, these steels harden on heating to a point above the "transformation temperature on heating" with subsequent rapid cooling. They soften after quenching on heating to a point below the "transformation point on heating," no matter what the subsequent rate of cooling may be. They soften on heating to a point above the transformation point if subsequently the cooling is effected slowly.

With certain alloys (brasses and aluminium bronzes) the transformation on heating extends over a long temperature interval. After quenching, annealing in the vicinity of this temperature certainly conduces to the ordinary annealing effects, but it should be followed by a slow cooling, otherwise partial hardening will take place.

(*b*) In certain particular instances quenching produces little or no hardening, and may even occasion softening, owing to the "hot stable state" having been preserved by the quenching.

The influence of annealing after quenching is, to begin with, of a distinctly hardening nature (transformation at low temperature and a reversion to the stable state in the cold), but, once the transformation is completed, the softening influence of the annealing makes itself felt; the more so the higher the temperature (hard manganese steels, certain copper-tin bronzes).

The author has given, in order to show the identity of the influence of heat treatment on steels and on alloys, five curves showing the relation between the hardness and the temperature after quenching (Figs. 9 and 10).

Annealing Temperature.	Brinell Hardness No.		
Degrees	A.	B.	C.
20 (no annealing effect) ..	600	190	140
350	490	185	134
500	348	172	130
600	282	145	118
700	210	130	100

Certain alloys may, however, be placed in sub-group (*a*) or sub-group (*b*), according to the conditions under which they are quenched.

The samples, in the form of square bars measuring 10 mm. by 10 mm., were quenched from 800 deg. in the case of the steel and the brass, and from 925 deg. in the case of the aluminium bronze, and subsequently annealed at various temperatures and slowly cooled.

Fig. 9 shows curves relating to alloys which, on being quenched, are not stereotyped, or are only partially stereotyped in the "hot stable state" at a high temperature, which differs from the "cold stable state." Quenching hardens these alloys, and annealing carried out at a fairly high temperature after quenching softens them. The hardness numbers given are those yielded by the Shore scleroscope (height, in millimetres, of the rebound of a ball falling from a height of 500 mm., in regard to the steel studied by Maurer) and Brinell hardness numbers in respect of the bronze.

Annealing Temperatures after Quenching.	Hardness (Shore).	
deg.	A.	B.
20	170	172
100	170	172
200	170	238
250	170	228
300	170	—
400	280	186
500	265	—
600	235	178
700	215	175

Fig. 10 shows curves relating to alloys for which quenching stereotypes at least the greater part of the "hot stable state;" a slight annealing may, by occasioning transformation, harden these alloys. If the annealing be carried out at a higher temperature, its softening influence reasserts itself.

Alloys of Group I.—The following steels belong to Group I.:—Carbon steels; steels containing a small percentage of the special elements; all known alloys, other than steel, which harden on quenching, whether followed by gentle annealing or not; certain copper-zinc brasses, certain copper-zinc-aluminium brasses, certain aluminium bronzes, certain malleable brasses, and certain copper-tin bronzes.

B. *Group II.—Steels which behave like steels of the first group, but with the difference that the rate of cooling necessary to lower the transformation on cooling is sufficiently low for the phenomenon to be observed. (Tool steels containing high percentages of chromium and tungsten.)*

In the second group may be placed the group of steels which harden in air, which, in the author's earlier published researches, were classified in the third and fourth groups. In his opinion it is more logical to range them closer to Group I., which contains steels which harden only on energetic quenching. No essential difference separates the two groups, and all transitional forms occur in between them. A continuous series of steels exists which are capable of the utmost hardening, even although the quenching diminishes from the most energetic type to the weakest type (from water-hardening down to air-hardening).

Observable Curve A.—Rate of cooling, 100 deg. in 20 minutes, or even slower (Fig. 11).

Observable Curve B.—Rate of cooling, 100 deg. in 10 minutes, or even more rapid (Fig. 12).

The high chromium and tungsten steels, as a matter of fact, possess the property of being able to be maintained at about 500 deg., either in the "hot stable state" or in the "cold stable state," according to whether that temperature has been attained with greater or less rapidity.

Some alloys of Group I. also possess the latter property at ordinary temperatures at which they may be maintained either in the "hot stable state" or in the stable state in the cold (hard manganese steels, copper-tin bronze), but the rates of cooling necessary to prevent transformation taking place are too rapid to allow of the cooling conditions being observed in this group.

Alloys of Group II.—With the exception of a certain number of special steels, and, in particular, of high-speed tool steels containing chromium and tungsten, the author is not aware of any other alloys which can be grouped in this class. Other alloys may, and in all probability do, exist, but he has no knowledge of them.

Influence of Heat-Treatment on Steels of Group II.—These steels harden on heating to a temperature above that of the transformation on heating, followed by rapid or moderately rapid cooling (air quenching). They soften by heating to a temperature below that of the transformation on heating, no matter what the rate of cooling may be. They soften on heating to a temperature above that of the transformation on heating, followed by very slow cooling.

C. *Group III.—Steels for which the temperature of the transformation, on cooling slowly, is distinctly lower than that of the transformation on heating.*

Observable Curve a (Fig. 13).—Slow cooling.

Hypothetical Curve b (Fig. 14).—Rapid cooling.

The difference between curve *a* and curve *b*, and, consequently, between the properties of the quenched steels and those of the steels slowly cooled, is smaller in proportion as the temperature of transformation on slow cooling is more nearly in the neighbourhood of the ordinary temperature.

Influence of Heat-Treatment on the Steels of Group III.—A steel heated to beyond the temperature corresponding to the point *c* hardens on cooling slowly. Greater hardening occurs (although in closer approximation to that of the former in porportion as the temperature of transformation on cooling is more in the neighbourhood of the ordinary temperature) in the case of a steel heated beyond the temperature corresponding to the point *c* and rapidly cooled.

Softening occurs on heating along the curve A B, followed by either rapid cooling or by slow cooling.

Naturally all transitional forms occur between the first and the third group of steels.

Alloys of Group III.—A large number of special steels containing nickel.

The author is unacquainted with any alloys other than steels falling into the third group. Other alloys may, and probably do, exist, but he has no knowledge of them.

D. *Group IV.—Steels for which the temperature of transformation on cooling is below the ordinary temperature (steels containing high percentages of nickel or manganese).*

(*a*) If these steels have never been cooled to a temperature sufficiently low for them to become transformed, they are represented by curve *a* (Fig. 15), which is observable in the case of slow cooling, but hypothetical in the case of rapid cooling. (Such rapid cooling does not occasion variations in the hardness.)

Influence of Heat-Treatment on Steels of Group IV.—Heat-treatment has no effect. If these steels have been mechanically stressed, any heating will soften them independently of any law as to cooling.

(*b*) If these steels have been cooled sufficiently to produce the transformation on cooling (which, in some instances, is impossible), and if they be heated to a high temperature after cooling, they undergo the inverse transformation, and when again at the ordinary temperature they remain in the "hot stable state" (Fig. 16).

Influence of Heat-Treatment on the Steels of Group IV. cooled to sufficiently below the ordinary temperature to occasion their transformation.—Cooling hardens these steels owing to the transformation they have undergone; any heating along curve D E softens them independently of any law as to cooling.

If the temperature of the transformation on heating E F be exceeded, the metal, after cooling, remains at the ordinary temperature in the "hot stable state."

Intermediate forms occur between the steels of the third and fourth groups, but these steels, partially transformed at ordinary temperatures, are in an ill-defined state, and manufacturers avoid making them.

Alloys of Group IV.—All steels (steels containing high percentages of nickel and manganese) and all alloys which do not undergo any transformation during the temperature interval between ordinary temperatures and those of fusion (many brasses and bronzes consisting of but one constituent, and nearly all the pure metals other than iron).

(To be continued.)

* See Charpy and Grenet, *Société d'Encouragement*, April, 1903.

THE INFLUENCE OF DETAIL ON THE DEVELOPMENT OF THE AUTOMOBILE.*

Presidential Address to the Institution of Automobile Engineers.

By L. A. Legros, M.I. Mech. E.

Gentlemen,—I wish to thank you for the signal honour you have conferred upon me in selecting me as your President, an honour which is greatly enhanced by the illustrious names of those who have preceded me in this office, Crompton, Dugald Clerk, Hele-Shaw, and Lanchester. Before, however, proceeding with my address, there are some matters connected with the policy of the Institution which I think should be mentioned at the commencement of the session.

In the first place, it has been frequently urged that it is desirable that meetings of a less conventional character should be held, meetings at which members would feel less restraint, and at which an extempore discussion should take place on a debatable matter rather than an elaborated discussion of a paper which has taken much time and thought in its preparation, and requires a similar expenditure of thought and consideration in the framing of questions and in the direction of criticism in the discussion. Steps have been taken for providing that at least one such extra meeting shall be held during the session, at which the proceedings will be of a less formal character, and at which a debate or discussion on a technical matter of general automobile interest will take place. It is to be hoped that these meetings may prove popular with those members who have hitherto refrained from taking part in discussions on the papers read at our regular meetings, whether from feelings of nervousness or from an objection to seeing in print a verbatim report of their spoken words. In this connection I may add that the remarks even of the most experienced speakers in this Institution are, before they go to press, carefully edited by those members themselves. For this there is good reason, as in public speaking on general topics one frequently and unconsciously repeats oneself, and in speaking on technical subjects it is often more difficult still to order one's thoughts and frame one's sentences in such manner that they are clear without being tautological, whereas in writing, matter and phraseology can be easily re-read and corrected. To those members, therefore, who have felt these reasons to be an obstacle in the way of joining in the discussions, I would emphasise the fact that their fears are really groundless, and that ample opportunity will be afforded to them for putting into what they consider proper shape any remarks which they may make.

A second matter which has been raised is that of holding meetings at centres other than London. This question has been carefully considered by your Council, and it does not appear possible to arrange for ordinary meetings outside the London area until such time as our membership shall have increased very considerably. At present we have flourishing graduates' branches in Coventry and Birmingham, in addition to that in London, and these, in their own centres, have held meetings and also organised excursions to works and places of interest in their respective neighbourhoods. I am sorry to say that the attendance at these meetings and excursions has not been so good as it should have been, but all three branches show signs of re-awakening interest, and steps are being considered for assisting this.

An excursion made by the London and Birmingham graduates by invitation of the Coventry centre to the Coventry district was, however, very successful. Numerous works were visited, and from the success of this visit it has been proposed that, in the summer of next year, a visit of the whole of the membership, including the graduates, shall, if possible, be made to Paris to inspect some of the French automobile factories. It is expected that should this scheme meet with general appreciation satisfactory arrangements may be come to so that the expense to graduates who do not expect to see the whole of the sights of the city on the Seine may be sufficiently low to enable a large number to take part in the excursion.

The question of a summer meeting of the Institution to be held in some provincial centre at which papers could be read or debatable subjects discussed has also been considered by your council, but for various reasons, not least amongst which is the desirability for awaiting the result of the "extra meetings," it has not appeared to them advisable at present to depart from the usual procedure in respect of the ordinary meetings of the Institution.

Last winter, at the request of Mr. Henry Hess, of Philadelphia, who is now one of our members, a reciprocal arrangement was made between this Institution and the American Society of Automobile Engineers, whereby a member of either body finding himself in the country of the other is welcomed as a member of that body *pro tem.*, from which it is hoped that good results may accrue.

In furtherance of this object, when it was learnt by chance that several of the members of the Society were proposing to come across for the Olympia Show, your Council thought that it would be a good opportunity to show them some hospitality and arrange a friendly meeting, and it was proposed to invite the visitors to a dinner.

For the purpose of entertaining our guests, an ample guarantee fund has been raised among the membership of the Institution.

The Influence of Detail on the Development of the Automobile.

In every class of machinery, no matter how well known it may appear to be, either to those engaged in its manufacture or in its use, there are a large number of details of which many of the individuals connected with the construction have usually no knowledge, and of which the user frequently has less; in other words, he believes them to be quite different from what they actually are. From the ignorance of the small boy who thinks the boiler of the locomotive is completely filled with works, to that of the fireman who thinks the discoloration of his gauge-cocks is due to the analysis of the metal—having heard that word used and believing it to be one of the ingredients in it—there are many other forms of ignorance which have contributed throughout to cause delay in the development and use of every class of machinery, and even at the present time many of these factors are still at work delaying that progress which might take place more rapidly were greater consideration given to the minutiæ of machinery.

To examine this subject systematically, we shall find that most detail has its origin in design, but that the design is frequently marred in execution, and that the executed work is subjected to abuse by the user, and to wear by the conditions under which it works, and it is from the latter end of the story that the cycle of design must recommence, since it must take account of the possibilities involved in use and abuse, and of the certainties involved by wear and tear. The subject, of course, is one which does not admit of being dealt with in general terms for all classes of detail, but it is one which it is easy to illustrate by examples.

To take the first example which comes to hand, that of the steering-gear, it is well known that the ordinary Ackermann axle affords a fair compromise for obtaining the intersection of the axes of the front wheels at a point on the axis of the back wheels.

This gear as usually made is fitted with a number of pin-joints, all of which are liable to wear, and as wear proceeds the two front wheels of the vehicle when it is travelling in an approximately straight line, which, after all, represents by far the greater portion of the distance it runs, will, whether the steering-bar be in front of or behind the front axle, take up positions such that the horizontal diameters of the steering-wheels would intersect behind the car. After a certain stage of wear has taken place, it is thought necessary to put the wheels in gauge again, and most mechanics, if left to themselves, would set the wheels properly and truly parallel. At this point we should ask ourselves whether this is the right thing to do; whether making things "exactly right" is, after all, the proper course to adopt, and whether the present example is not an illustration of a distinct advantage to be gained by making adjustments incorrectly in the first instance. If the limit for error in parallelism, determined by experience based on the wear of tyres, is half a degree (or, in the language of the shops, the wheels should not be more than one quarter of an inch out of parallel in a length equal to their diameter), and if, when this error has been reached, it is time to put them right, then why not set them half a degree (or a quarter of an inch) inwards to start with, so that they will start with a negative error no greater than the positive error permissible, and thus double the life will be given to the steering gear before it is necessary to take it up, assuming that want of parallelism is the only reason for the taking up?

Take another case: the bearings of an engine are made and fitted so that there is no shake or knock when the engine is turned round without the ordinary amount of lubricant. Such an engine will run very stiff until its bearings have become sufficiently worn to admit of the proper thickness of oil film for supporting the load. Under present conditions, with the limit-gauges and more accurate machine-tools available, some of these factors are being incorporated in the design, as recorded by the drawings, but there are many factors which still escape and are not recorded, and it is left to the shops to do as their unwritten experience suggests to them may be right. The tendency in the bigger factories is to diminish the amount of responsibility left to the individual worker in respect to the employment of what, for want of a better term, may be termed "shop knowledge," and the reason may be found in the fact that whereas in the earlier days of engineering the same man both constructed and repaired, now, under modern conditions of output, the man who constructs is of a quite different class from the one who repairs, and the two classes are rapidly becoming almost out of touch with each other. Consequently that form of shop knowledge which was of such use to the mechanic of some years ago, and which enabled him to put through work on the imperfect instructions of not very definite drawings, must to-day be replaced by positive information supplied by the designer and embodied in the detail drawings, figured with limiting dimensions and supplemented by specifications.

In the broad and general consideration of detail, the first and most important point to be dealt with is that of standardisation, and, consequently, interchangeability. In spite of all the efforts of Whitworth and others in creating standards of size and form for screw threads and for other details, there are still numbers of manufacturers in the country who work almost as though such standards had never existed. That is to say, there are firms who will make ½-in. bolts $\frac{1}{64}$ in. large or $\frac{1}{64}$ in. large because the user will get a stronger bolt although he is buying the same size. This will account for the fact that many coach bolts and nuts are not interchangeable. Again, there are numerous makers of screws who claim that their product is within $\frac{1}{1000}$ in. or $\frac{1}{500}$ in., as the case may be, but the accuracy of which does not run beyond the written or verbal statement, the actual bolts or screws having an error many times as great. The fit of screws between proper limits is quite as important as the accuracy of pitch and of shape of thread. A loosely fitting screw in machinery subjected to so much vibration as is common with automobile vehicles will ultimately cause waste of time and trouble to the user, if not damage to other parts of the machine, whereas the too-tightly fitting screw has its obvious disadvantages.

Standardisation is looked after by committees who formulate very excellent rules, which should be followed by the manufacturer, but in many cases there is a want of uniformity in the resulting product which calls for better inspection at the start of operations and for the checking of the gauges to which the work is made. The admirable work now being done by the National Physical Laboratory in connection with all classes of standardisation cannot be overrated; but the importance of the independent checking of commercial standards by such an impartial central authority is not so fully appreciated by manufacturers as it might be.

Again, to take an example, the ordinary pneumatic tyre is supposed to be interchangeable—that is to say, the same rims will do for any of the tyres made by the leading makers. The same pump connection serves for pumping up the inner tube, but it will be found that the same uniformity does not apply to the other details which go to make up the complete tyre on its rim. Security bolts, for instance, have various threads, causing the expenditure of much bad language on the road. The diameters of covers are not always in agreement with the rims within the usual limits, with the result that a cover may prove to be tight on the rim and may give considerable trouble in getting it into place. The checking of any of these dimensions is beyond the ordinary purchaser or consumer, besides being outside his province, and the trouble caused by too great deviation from the standard dimensions is only discovered at a time when it gives great inconvenience. The question again is one of the various limiting dimensions of the rim and of the limits permissible in the cover under normal conditions.

In the wheels of pleasure vehicles ball-bearings have been used for some years with increasing success, but their application was delayed through failures, in some cases due to over-loading, and in many others through imperfect provision being made in the casing of the bearing against the entry of water and mud. In fact, a considerable period of time elapsed before the various causes which contributed to the failure of ball-bearings in road wheels were appreciated at their proper values; the several factors of the provision for taking end-thrust, the amount of the permissible radial load, the exclusion of water and dirt, and uniformity in the quality of the manufactured ball-bearings, all tending to complicate the commercial solution of the problem. This matter of wheel-bearings is essentially one of design, because the ball-bearing, when worn, is, in general, beyond repair, so that the question of prolongation of the life of ball-bearings is one which can only be referred back through the repair departments, who effect the renewal, to the designer. The presence of moisture, which has resulted in the failure of ball-bearings in the road wheels, has also been found to affect those ball-bearings which have been fitted to the crank-shafts of some engines, and it has been found that a small amount of water in the lubricating oil will cause a sufficient pitting of the surface of the ball races and of the balls to result in premature failure.

In the engine many improvements in detail have been made, resulting in an enormous advance in respect to silence, speed of revolution, and power for piston area. Apart from such questions as multiplication of the number of cylinders, these improvements, however, have been confined to reductions in the weights of reciprocating parts, alteration of the arrangement and types of valves, modification of the shape of cams and of the size of the cam-rollers, care in the selection of the materials and teeth of the gears used for driving the cam-shafts, the replacement of low-tension by high-tension magneto ignition, and in general by improvements of detail.

It is, however, in the carburettor that the main problem of advance in the internal-combustion engine appears at present to lie. Carburettors have been made giving over 50 ton-miles per gallon on ordinary touring cars when running at speeds up to 40 miles per hour, and there appears to be no reason why such results should not be easily and regularly obtainable when the carburettor has attained a development as far advanced as that of the high-tension magneto. At present the tuning up of the carburettor is still frequently effected by the expensive method of running the car on the road, involving a considerable expenditure of the time of a skilled tester, the wear and tear of the whole machinery of the car, and the wear and tear of the tyres, which, even if only old tyres are used, must be added to the other costs. It is true that on the road the conditions under which the carburettor is working are quite different from those of the testing-bench. The forward movement of the car may give increased air-pressure at the intake of the carburettor; the vibration of the car may appreciably alter the mean level in the float chamber, and the amount of petrol which flows through the nipple. Usually these matters are adjusted by the tester by varying the size of the orifice in the nipple, but from an examination of the conditions which lead to the necessity for this adjustment, it would appear that frequently it is the level in the petrol chamber which requires adjusting quite as much as does the size of the orifice, and in but few carburettors is any provision made whereby the tester can set the level of the petrol to the desired height otherwise than by filing down the nipple or adding solder to the float.

In the clutch there is less complaint than was formerly common; in fact, the peculiarities of leather, cone, and disc clutches have become sufficiently well understood by designers to render this detail one of those which now cause but little difficulty; in the case of metal disc clutches, the difficulties first met with in their use were mainly due to the imperfect knowledge on the part of the user of the proper conditions under which to work them, and, in this case, it is the improvement in the mechanical

* Delivered at the meeting held at the Institution of Mechanical Engineers, October 11, 1911.

education of the user that has permitted their continued employment.

In the last few years the question of the reduction of the noise on motor vehicles has been almost entirely dealt with in the engine and gear-box, apart from the change from chain drives to live axles. In the gear-box noise was found to be produced by errors in the shape of the gear teeth, which caused irregularity in the velocity of the driven shaft, accompanied by separation of the driving surfaces at speeds beyond a certain minimum. The improvements in gears have entirely been improvements in detail; the involute form of tooth has been retained, and the angle of inclination to the tangent of the path of the point of contact has seldom been varied; on the other hand, not only have the cutters been made of greater accuracy than those employed for the construction of other classes of machinery, but methods have been adopted, such as those for developing gears by hobbing, which of themselves produce an approximation to the true form of tooth much more accurate than was obtainable by older methods. Again, the distortion of the gear-wheels which may occur in cementing and in case-hardening has been more thoroughly appreciated, and precautions have been taken by manufacturers which have resulted in a much smaller error in the finished product. In the back axle a source of noise has remained in the bevel gears, which, even though made on developing machines, are liable to the introduction of more error than is the case with spur gears. Machines have already been devised, and some are obtainable, for correcting the errors in spur and other gears by grinding, and, should it become necessary to run gearing of light weight transmitting large powers at still higher linear speeds, it may be necessary for manufacturers seriously to consider the subject of grinding the bevel gears as well as the spur gears to the final degree of accuracy required. The back-axle difficulty can, of course, be overcome by the use of a properly designed worm gear, and here again it is detail of design which fully determines the difference between the unsatisfactory and the satisfactory.

In the ordinary touring-car there is still one detail which looks as though it should be altered before long, and that is, the want of alignment between the propeller-shafts and the shafts in the gear-box when the car is under its normal load. It would appear that a simple modification should be possible by which the whole length of shaft would be in alignment from the front of the engine to the centre of the back-axle when under normal load. At present the chief difficulty appears to lie in the lubrication arrangements for the engine. Now the angle of inclination of the shafting, if it is made lineable, is but small, and is, in fact, much less than that of any of the gradients up which the engine is required to work at full load. If the uniform lubrication of the engine were assured for a larger range of angle, covering the total inclination of the engine to the frame added to that of the maximum gradient to be ascended, this difficulty would disappear. In the case of the transmission on commercial vehicles, the chain has been found far from unsatisfactory, especially since it has been possible to obtain chain-cases which are at the same time simple and sufficiently oil-tight to ensure chain running continuously in an oil-bath. Under such conditions the chain is much more silent, its life is increased to such an extent that the cost of chains as a factor in the running becomes negligible, and chains running in proper oil-tight chain-cases can now be guaranteed for a life of over 25,000 miles.

In the case of public service vehicles, the improvements made in detail are immediately noticeable on the London streets, where some of the earliest taxicabs are still running side by side with the latest types. In motor-omnibuses the contrast is still more marked between the old pattern with the chain-gear and the new pattern with the worm drive, and here we have a paradox, for some of the more silent omnibuses, though they have no chains in the transmission from the gear-box to the back-axle, yet have a greater number of chains running at much higher speeds continuously within the gear-box itself. The chain itself, therefore, should not be held to blame for the noise, but the cause should be attributed to the faulty method of application of the chain.

Provision for wear and tear is now made more ample than it was in the early days of the self-propelled vehicle, when the motor was frequently constructed in the form which may be called the "sandwich" engine. In this a single plane joint divided the upper from the lower half of the casing, with the half bearings contained in each of the respective casing halves, so that when it was required to take up such wear as had taken place, it was necessary, after dismantling the engine, to take a cut over the whole surface of one-half of the casing, or else to replace entirely the whole of the brasses in the bearings. This arrangement, which would not have been tolerated for a moment by a constructor with ordinary engineering experience, had, however, one great advantage, and that was, that it ensured oil-tightness in the casing. Later, when engine-cases were first designed so as to make provision for taking up the wear of the main bearings, difficulties in securing oil-tightness were met with which required to be overcome by various arrangements of detail for preventing the loss of oil, or for ensuring its return to the crank-chamber, and, amongst others, in many engines it was found necessary to provide a vent for the escape of such gas as leaked into the crank-chamber, a provision seldom necessary with the sandwich engine. The provision of this air-vent might, with advantage, be adopted in some gear-boxes and back-axle casings, in which the warming of the lubricant which unavoidably takes place when power is being transmitted causes sufficient expansion of the air contained in the casing to force a small quantity of oil continuously along the shafts, and to cause not only wastage, but, in some cases, the unintentional oiling of the brake surfaces.

Experience has now determined the amount which should be provided for wear in the brakes; brake surfaces have been increased, and provision has been made for an ample range of adjustment in the brake-gear. In the earlier designs of automobiles, the designer seldom compared the new or maximum form of the brake shoes or drums with the worn-out or minimum thickness, with the result that frequently it was necessary, when adjusting the brakes, to cut the rods for length and re-thread the ends, or to set the levers in order that the necessary adjustment could be effected.

The Safety of Automobile Traffic.—The popular denunciation of mechanical traction on account of its alleged danger, usually based on the single factor of its speed, is contradicted very effectively by the figures given in the police statistics for the total number of accidents caused by vehicles which have occurred in the metropolitan area within the last three years for which the returns are available—that is, from 1907 to 1909. During this period the total number of street accidents caused by all classes of vehicles, involving injury, actually shows a slight decrease, while the population is estimated to have increased by 1.5 per cent. per annum, and the number of automobile vehicles registered has increased by about 19 per cent. per annum. Considered on the basis of the population, the accidents per million increased by 50 per cent. in the last six years (1891 to 1897) prior to the advent of the automobile; they attained their maximum in 1907, and have decreased by 2½ per cent. in 1908 as compared with 1907, and by nearly 5 per cent. in 1909 as compared with 1907.

Accidents caused by automobile vehicles, excluding those due to the human fallibility of drivers and others, may arise from neglect, from defective material, or from defective design. The elimination of the first of these causes is largely a question of management and of the responsibility carried thereby; defective material may be guarded against by proper specification and efficient supervision, but questions of defective or inadequate design, especially in regard to such vital details as the steering gear and the brakes, call, in certain cases, for examination by an independent body. There are many public vehicles now on the road covering long distances from their base, and though these may have passed the local police inspection and be considered adequately fitted for local conditions, yet outside the area of operations of the local authority they may be required to run under very different conditions of maximum gradient and of road surface. From some of the serious accidents which have occurred to such vehicles it would appear necessary that the approval of the design and the inspection of these vehicles prior to their going on the road should be performed by a staff having special technical knowledge. The experience of this staff, as in the case of others appointed to examine into boiler explosions and railway accidents, should be supplemented by an inquiry into the cause of all fatal automobile accidents due to mechanical failure, as in the case of the above-mentioned classes of fatality. These inquiries and inspections should be performed by a department of the Board of Trade represented by an expert official.

Accessibility is a question which has had a great influence on the design of the automobile, and in some instances may have determined the type which has set the fashion, and fashion in the automobile vehicle plays a more important part than it does in any other class of machinery within my experience. The necessity for frequent access to the engine, to its ignition gear, to its carburettor, and to its valves, has ensured the placing of the engine in the front of the car, where it could be quickly and most easily reached with the minimum of disturbance to the main portions of the vehicle. This fashion in position of the engine is likely to die very hard, so accustomed have we become to giving up the front of the car to the engine.

Accessibility may be divided into two main heads:—First, accessibility to those parts which frequently require adjustment requiring no special skill, such as the adjustment of the brakes, of the strength of the clutch-spring, of the spark of the ignition devices, and the like, most of which have already been dealt with by the designer in arranging them, and, second, accessibility to details requiring skilled attention. In the latter class come the overhauls of engines, gear boxes, axles, &c., and the influence of commercial and public service vehicles on this branch of the subject is only now commencing to make itself felt. The importance of being able to remove parts of a car, unit by unit—that is, engine, gear-box, back axle, &c.—has now become recognised by those responsible for the vehicles of public services such as those of the motor-omnibus and cab companies, since the conditions of working such services are much more closely allied to those of the railway and the tramway than are the conditions of the private car or the commercial vehicle. The easy removal of these units complete, and their interchangeability with other similar units on the same class of vehicle, is a large factor in economically keeping a fleet of public-service vehicles upon the road.

Apart from the two broad questions just mentioned, a third and very important factor is that of accessibility to the various parts by those tools used in making the adjustments. With the necessity for keeping down weight has come the reduction in the size of nuts below those selected by Whitworth for a material the use of which in automobiles only occurs in body work—reduction in the size of nuts has been accompanied by reduction in the width of flanges—the whole of the work has become more cramped, and the clearance between the faces of the nut and other adjacent surfaces has been greatly reduced. To put the parts together in the first instance may require the use of special spanners, owing to the fact that the designer has not laid a scale-tracing of an ordinary spanner on his drawing, and ascertained that it can be effectively used, that he has not tried the clearance between the corners of the nut and the adjacent surfaces to ascertain whether a box spanner will overcome the difficulty, or, if so, that he has not allowed for the height of the box spanner. Ignorance of these factors contributes heavily to the repair bill, especially if such inaccessibility is assisted by the super-imposition of small details, and particularly piping, which requires removal before the main parts become accessible. If these features were considered in design bolts would often be substituted for studs, long bosses would be cast on parts to enable the nuts or bolt-heads to be reached; channels would be milled across faces, into which bolt-heads could fit to prevent them from turning, and such parts as guardings and covers would be so made that their detachment would be dependent on very few devices, and those of kinds easily secured and readily locked.

The difficulties connected with lubrication in the engines of cars have been already alluded to briefly: but far more important is this subject in the case of the marine motor, in which continual changes of inclination are taking place; and even greater still is its importance in the case of the aeroplane engine, in which the engine-shaft is inclined considerably from the horizontal for long periods of time, and in which the question is often further complicated by the use of engines with fixed crank-shafts and revolving cylinders.

In the case of engines employed for locomotion on the water or in the air, we come again to the carburettor question as one of the greatest importance for the immediate future. It is a question of such moment that a large proportion of the energy of research workers might well be devoted to it, and if their efforts were assisted by the loan of modern engines adjusted by the makers, and supplemented by details of the power and consumption obtained on the test bench, the work would be much facilitated. The work done by Willans on steam-engines in the testing-house at Thames Ditton has left its mark on high-speed steam-engine design. It is therefore reasonable to hope for similar results from well-directed research on the modern petrol-engine.

The existence of the automobile as a practical commercial machine has been shown by others to be largely dependent on materials previously neither readily obtainable nor extensively used, such as rubber, aluminium, and petrol; the same applies to the steels used in construction, which, though previously known, were not only difficult to obtain in the necessary commercial forms, but their proper heat treatment was but imperfectly understood, owing to lack of research and of experimental data. In the early days of engineering steel was steel—that is to say, there was wrought iron or cast steel (tool steel), and mild steel, a comparatively recent product, but with the large number of special steels used in the construction of the automobile, it has become difficult to distinguish by simple tests any one quality from another. Under these circumstances it is necessary that the automobile manufacturer should adopt a system in his works for marking the different qualities of steel (as by painting them a different colour at one end of each bar, for instance), in order that a storekeeper or other unskilled worker may be able to issue or receive the proper quality for any detail required.

Leaving the vehicles of the present, and the position which detail has taken in their development, we may pause to ask ourselves what are the possible detail improvements which will influence the future evolution of light automobile machinery, whether for transport by earth, water, or air, and what effect will they have on the design and construction of the vehicles of the future.

Fuels.—Regarding fuel as a storage of energy, we have in petrol nearly 50 per cent. more energy per unit weight than is stored in coal, and, moreover, we have it in a more convenient form, owing to the advantage which a liquid possesses over a solid.

Among so-called improvements may be cited solidified petrol; but it is difficult to imagine what possible advantage a solid which is troublesome to handle can have over a liquid which can be readily led from its reservoir to its destination through a pipe, by gravity, or by pressure if gravity will not suffice.

Among gaseous fuels, acetylene has been proposed, and though this compound is to some extent endothermic, yet it has not a sufficiently high thermal value to render it a competitor of petrol, particularly as it is unsafe when compressed. It gives, however, a wider range of explosive mixture when mixed with air than the other well-known hydrocarbons, and the mixture of acetylene and air fires at a lower temperature than is the case with other gases. In considering the applications of such gases of high calorific value as acetylene or hydrogen, it is only necessary to make a rough calculation to realise that at present no saving, but, on the other hand, a great increase of weight, would result were they generated on the vehicle, owing to their small weight relatively to that of the compounds used in their production. Moreover, the same applies to the storage of compressed gases, which can only be considered commercially practicable in the case of town gas applied to heavy vehicles engaged on runs of but short mileage between fixed charging points.

The fact that acetylene gives a larger range of explosive mixture than other well-known gases, and that the mixture fires at a lower temperature, would point to a possible saving in the weight of the ignition apparatus. This saving would, however, be but small, and affects but little the question of the total energy obtainable within a limit for the combined weight of fuel and engine.

Lubrication.—In the desire to reduce the weight of the transmission gear, the diameter of shafts in the early vehicles was reduced to the minimum, and, in order to obtain the requisite area of bearing for carrying the load, the bearings in the gear-box were of necessity made long. The spring of the shafts under the heavy loads to which

they were subjected resulted in bending to such an extent as to reduce the thickness of the oil film locally below that necessary for efficient lubrication, with the result that in many of these earlier cars difficulties arose in maintaining the bearings in efficient order. This difficulty has been largely overcome by the use of the ball-bearing, which, as it takes up less length of the shaft, reduces the effective span between the supports and diminishes the spring. But this is not the only advantage given by the ball-bearing; still more important is the fact that it is capable of working satisfactorily with a greater error of alignment than is possible with a plain bearing. The ball-bearing working under suitable conditions, and provided it is not overloaded in the first instance, appears capable of running almost indefinitely when immersed in an oil bath and kept free from small pieces of abraded metal. In fact, in the gear-box, ball-bearings generally give less trouble than on other portions of the car. Although the ball-bearing has such marked advantages when treated in a suitable manner, yet under conditions less favourable, such as those of the road wheels, where a bearing may be called upon to stand excessive and obliquely applied loads, failure is much more easily produced, especially if accelerated by the penetration of water, even without dirt, into the bearings as previously mentioned. The effect of water in destroying the smoothness of the surfaces leads to rapid disintegration, and once the ball-bearing has begun to fail either by the breakage of the balls, or of the race, its end occurs more rapidly than is the case with the plain bearing.

Increased Motor Efficiency.—The improvements in the efficiency of motors have been almost inseparably linked with improvements in carburettors; nevertheless improvements in the motor itself have to no small degree contributed to the advance in the amount of power obtainable per unit of weight of motor and in the efficiency of the motor itself as a thermodynamic machine. The consumption of fuel per brake horse-power hour in the petrol motor has now been reduced to 0.63 lb. Allied to the question of efficiency is the question of obtaining small commercial motors capable of working with a less highly inflammable fuel, such as ordinary paraffin oil. Many attempts have been made to effect this by slight detailed modifications of the engine or of its carburettor, but the problem is one on which mechanical engineers have already spent vast quantities of time and money, the Priestman and the Hornsby-Ackroyd oil-engines being examples. The problem has, however, been tackled recently in a different manner by a method which combines the carburettor with a gas-producer.

It is well known that if a candle be blown out, the gas which rises from the wick is inflammable, and that a light held some distance above the wick will ignite the mixture of gas and air resulting from the incompleted combustion, and that the flame will travel down the ascending column of gas, re-igniting the candle. A similar principle underlies the action of the suction-gas producer now used on many gas-engines.

A paraffin gas-producer has now been evolved on the lines of a suction producer in so far that a portion of the oil supplied to it is partially burnt, but, unlike the case of the ordinary producer in which anthracite or other coal is used, a portion of the heat generated in the partial combustion may be utilised to vaporise an excess of the fuel, so that a mixture of producer-gas enriched with oil vapour can be admitted to the engine. By keeping the percentage of vapour sufficiently low it is possible to avoid the difficulties which occur by the clogging of rings and the deposition of carbon when paraffin oil is used direct in the ordinary petrol-engine.

Further hope of using heavier and cruder fuel lies in the adaptation of the Diesel principle to the ordinary form of automobile engine. The efficiency of the Diesel engine has now been brought to so high a pitch that engines of 500 horse-power are built with a guaranteed consumption of crude oil as low as 0.42 lb. per brake horse-power per hour at full load. The Diesel engine, however, as at present constructed, is unduly heavy, and some time must elapse before it has been sufficiently modified to be of suitable weight without having lost the efficiency obtainable in its heavy form. Not only is the Diesel principle in its 4-cycle modification a possible rival to the ordinary Otto cycle-engine, but the same may occur with the 2-cycle Diesel, to which some considerable amount of attention is being devoted at the present time. Another rival in the field to these engines at some future time will undoubtedly be the internal-combustion turbine. In 1884, in a lecture on turbines given by Professor Unwin before the Institution of Civil Engineers, the difficulty in the way of the construction of a steam-turbine was tersely summed up by him in the following words:—

"So soon as we can find a material strong enough and durable enough to stand an excessive speed of that kind (1000 ft. per second), so soon we may have steam-turbines much smaller and cheaper and not less efficient than ordinary steam-engines."

After the successful progress made by the steam-turbine, and its development as predicted by Professor Unwin, it has gone on until it has passed the reciprocating steam-engine in economy. A very similar prediction could be made at the present date in regard to the internal-combustion turbine, modified in this respect, however, that temperature as well as velocity are the factors to be considered. An efficient rotary pump, working as a reversed turbine, is also an essential to the commercial solution of the problem, and this, in a highly efficient form, has yet to be evolved and perfected.

Improvements in Transmission.—Many attempts have been made to obtain transmissions which are either variable in speed, or not merely variable in speed, but which also give facilities for storing excess of energy in the motor, and utilising this stored energy when required. The latter class has been fully dealt with by my predecessor in the chair, and the former has been developed at the present time by another former President of this Institution which promise immediate fruition.

Improvements in Materials of Construction.—Not only have steels and aluminium alloys been improved in their ultimate tensile strength and in those other physical qualities necessary for the safe employment of such materials in constructional work, but increased knowledge has been obtained as to the proper treatment which these materials should undergo in order to give the best commercial results. The heat-treatment of steels, whether for oil tempering or case-hardening, the proper treatment of aluminium alloys in order that the properties of the original mixture may be retained in the castings, and the diffusion of knowledge of rubber treatment and vulcanising outside the highly specialised tyre factories, are instances in point. There are, however, certain possibilities in the case of steel which may yet have to be considered. It has been found that metallic tantalum has very great hardness and power of resisting wear by abrasion; it is recorded that an attempt to drill a tantalum sheet by means of a diamond drill run at 5000 revolutions per minute for 72 hours resulted in a penetration of the metal to the extent of $\frac{1}{4}$ mm. only, and was accompanied by considerable wearing of the diamond tool. Now, if we suppose that the surface of a prepared piece of steel could be treated with tantulum in the same way as it can be treated with carbon in the ordinary case-hardening operation, and that, in fact, it could be superficially coated with a firmly adhesive coating of metallic tantalum, it should be possible to reduce any bearing surfaces so treated to dimensions hitherto unapproached under the heaviest loading. In other words, whereas the ball-bearing may be narrower than the plain bearing carrying the same load, a bearing dependent for its rubbing surfaces on a material so much harder could be made still narrower, and accompanying the narrowing of the bearings a large reduction in weight could be effected in many instances.

Constructional Material.—The treatment of ductile materials has up to the present taken the form of drawing into wire and tube, and rolling into plate and bar, so that the forms available have been those of uniform cross-section or of uniform thickness. For many purposes the tube is an extremely efficient constructional factor; the ordinary bicycle affords one of the best examples of its utility in obtaining a light and rigid structure capable of carrying a heavy load while subjected to considerable shock; but nearly half the difficulties in bicycle construction, apart from those of the bearings (solved, as in the case of the motor-car, by the ball-bearing) were encountered in the difficulties of making tubes of sections other than cylindrical, of making them tapered, and, above all, of joining the various elements in such manner that strength was not sacrificed at the joint. Attempts to use tube for heavier and larger constructional work have also been made, and a company was formed for producing tubular frame railway goods wagons. The facilities at present existing for preparing and joining the ends of channel sections, and the absence of such facilities in the case of tubes militated greatly against the success of the type. For the standards carrying the trolley wires of the electric tramway tapered steel tubes are used, and it is a matter probably only of a few years before tapered tubes will become more generally available as constructional material. The instances to which their use would apply are numerous and obvious.

Cellular Structures.—The distribution of a given mass of metal into that form in which it will carry the greatest load in bending when employed as a beam of given span, or the greatest load in compression when employed as a strut, is in each case dependent on ability to resist buckling due to failure under compression, rather than to actual failure under compressive stress. The stiffening of beams and struts against such failure is a matter studied by the big bridge builders, and it is in large bridge work that one finds the problem of tubular construction seriously considered. In the case of light struts and structures, particularly the parts of aeroplanes, were it possible to construct such parts of cellular form, and of metal of high tensile and compressive strength, it is obvious that the weight of many structures could be reduced greatly below that which is at present attainable. The difficulty in the problem lies in the joining of one piece of thin metal to another without sensibly impairing its physical qualities. For certain classes of work of large section, electric welding has been available, and by its aid good work has been done; for others acetylene welding is being tried at the present time, and it would appear that there is a field open for research on the construction of beams and struts of minimum weight in which the elementary forms are produced from thin sheet or tubes, joined by such methods as are commercially available.

In concluding this broad and imperfect survey of recent progress, and the possibilities of the immediate future, it appears to me that the development of the automobile vehicle for the next decade lies most largely in the hands and heads of the younger members of the profession who are engaged in the design of vehicles and their accessories. Along the lines laid down by their observation, and the intelligent conclusions drawn therefrom, the evolution of the vehicle will in a great measure take place. Broad and striking advances in any particular direction appear likely only to affect certain classes of vehicles, and it is not probable that such will come into general use until they have been tried by the test of time and found commercially proved.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a list of colonial and foreign engineering projects, for some of which tenders are asked. Further information concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Canada: The Imperial Trade Correspondent at Toronto reports that the Toronto shipyards, covering about 4.76 acres, are for sale. There is water on three sides for vessels to come in. The premises contain railway switches, shops, boiler and engine, and are equipped generally with machinery for shipbuilding.

Spain: The issues of the *Gaceta de Madrid* of September 24 and 25 contain notices to the effect that Cortés, Guillén y Compañia have applied to the Dirección General de Obras Públicas, Ministerio de Fomento, Madrid, for concessions for the construction and working of secondary railways from Cáceres to Trujillo and from Trujillo to Logrosán. The *Gaceta* of September 26 announces that a concession has been granted to the Sociedad Minas de Cala for a railway from Zufre Station to Santa Olalla. Construction work is to be begun within three months, and completed within 30 months, from the date of publication of the concession.

German South-West Africa: With reference to the notice on pages 307 and 308 of the *Board of Trade Journal* of August 17, relative to the projected construction of a new pier at Swakopmund at a cost of 2,500,000 marks (about 125,000*l.*), H.M. Consul at Lüderitzbucht (Mr. E. Müller) reports that the contracts for the construction of the pier have been signed, and work is expected to be begun at an early date.

Mexico: The *Diario Oficial* of September 9 notifies that a concession has been granted to Señores D. Cusi é Hijos to utilise 12,000 litres (2770 gallons) of water per second of the Cupatitzio River, in the State of Michoacán, for the purpose of carrying out irrigation works. Twelve months are allowed in which to complete the work.

The Netherlands: The *Nederlandsche Staatscourant* of October 3 contains a notice to the effect that tenders will be opened on October 17 at the offices of the Ministerie van Koloniën (Technisch Bureau), The Hague, for the supply of metal superstructures, with accessories, for sixteen railway bridges, Specification No. 547; locking-bolts, fish-plate bolts, &c., Specification No. 548; 880,100 cast-iron cramps, Specification No. 549; 427,800 rolled and galvanised spikes, Specification No. 550; 374,400 cast-iron sole-plates and 248,500 cast-iron cramp-plates, Specification No. 551; steel spiral springs, Specification No. 552; strengthening-plates, Specification No. 553; and spare parts for wagons, axle-boxes, axles, bearings, wheels, Specification lit. I. 17. Copies of the specifications may be purchased from Mart. Nijhoff, Lange Voorhout 9, The Hague, on payment of 2 gulden (3s. 4d.) each for Nos. 547, 551, 552, and lit. I. 17, and 1 gulden (1s. 8d.) each for Nos. 548, 549, 550, and 553.

CATALOGUES.

Flame Arc-Lamps.—A leaflet dealing with their "Standard" flame arc-lamps, for direct and alternating-current circuits, has reached us from the Globe Electric Company, Limited, 11, Farringdon-avenue, E.C. Prices are quoted for the lamps, and for accessories such as resistances, auto-transformers, carbons, &c.

Linings for Blast-Furnaces.—From Messrs. Jarvis, Brothers, Limited, of Middlesbrough, we have received a card illustrating the application of "Erkrath" carbon-lining blocks to a modern Continental blast-furnace having a daily capacity of 500 tons. The carbon linings are used for the hearth, well, and bosh of the furnace, fire-brick being employed for the base and shaft.

Tobin Bronze.—From the Ansonia Brass and Copper Company, 99, John-street, New York, U.S.A., we have received a small booklet relating to their Tobin bronze. The booklet describes the properties of the metal, and gives instructions for ordering and using it. The results of tensile, crushing, corrosion, and other tests are included, together with a selection of testimonials from users.

High-Pressure Gas-Lighting.—From the James Keith and Blackman Company, Limited, 27, Farringdon-avenue, E.C., we have received a pamphlet relating to the use of their high-pressure gas-lighting system in textile mills. The pamphlet contains several reproductions of photographs of the interiors of textile factories taken at night by the aid of Keith light. Some testimonials from the proprietors of these factories are also included.

Drill-Grinding Jigs.—The Standard Machine Works, Limited, of Spring Close, Lenton, Nottingham, have sent us a copy of a pamphlet entitled "Notes on Drilling." Besides these notes, the pamphlet contains an illustrated description of the "Reliance" drill-grinding jig (Crowther's patent), which, it is claimed, enables twist-drills to be ground accurately on any ordinary grinding-machine, lathe or grindstone. Instructions are given for fixing and using the jigs, which are made in two sizes dealing respectively with drills up to 1 in. and 2 in. in diameter. We have also received from the same firm a leaflet giving particulars of a handy tool for accurately sharpening all kinds of small drills by hand. The appliance consists of a carriage mounted on two rollers and provided with a holder set at the correct angle. The drill is clamped in this holder, so that its point projects below the carriage between the two rollers, the drill being adjusted by means of a screw until its point just touches the whetstone on which the device is placed. Grinding is effected by working the carriage backwards and forwards on the stone, the drill being fed downwards by the screw as required. The appliance is suitable for drills of all sizes between $\frac{1}{16}$ in. and $\frac{1}{2}$ in. in diameter.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

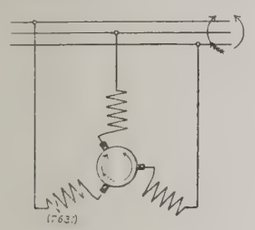
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

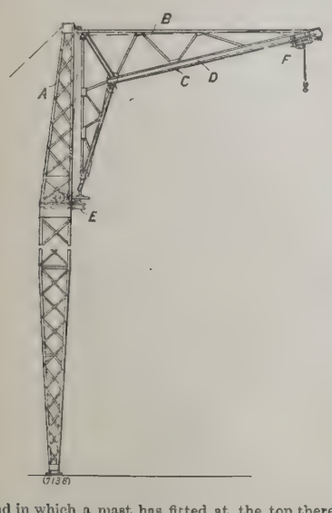
7631/11. Siemens Brothers Dynamo Works, Limited, London. (*Siemens Schuckertwerke G.m.b.H., Berlin, Germany.*) **Polyphase Series Motors.** [2 *Figs.*] March 27, 1911.—Electric motors for working lifts, cranes, capstans, and the like are most conveniently braked, when the weight descends, by an electrical method. This invention comprises a method of braking polyphase series motors controlled by the displacement of the brushes, and, according thereto, the motor operates as a generator when the load reverses the direction of running and causes energy to be returned to the supply mains. If a polyphase series motor is driven against the direction in which it rotates as a motor, without changing the connections, it operates as a polyphase series generator. This can be effected very simply, by gradually increasing the angular displacement of the brushes from the short-circuit position. The turning couple on the motor becomes gradually less until it is overpowered by the couple due to the load, so that the motor turns in the direction of the plain arrow. Theory and practice have shown that polyphase series generators can only be self-excited when the direction of the displacement of the brushes from the short-circuit position coincides with the direction of rotation. This will be the case when the load descends and the brush displacement is



increased, if the connection of the brushes is not changed. The frequency of the self-excited currents of the polyphase series generator has no relation with the frequency of the supply mains to which the machine is connected. They have, on the other hand, a frequency of their own, which is directly proportional to the speed of rotation of the rotor, and is also dependent on the brush displacement and the winding relations between the rotor and stator. Consequently the order of rotation of the phases of the self-excited currents depends on the direction of running of the rotor, and, as shown by the plain arrow, will be in the opposite direction to that of the supply mains, which corresponds with the normal direction of running of the motor. The self-excited currents will always have a much lower frequency than the currents in the mains, on account of the speed of the motor, which is confined to low values during the braking operation. Both these sets of currents may overlap and flow in the mains without any mutual interference, and the self-excited braking currents will give up their energy to the mains. Since the frequency of these braking currents is very low, the mains will act almost as a short circuit for them, so that a very powerful braking effect is produced, and the braking action can be adjusted to any required extent. (*Accepted August* 16, 1911.)

LIFTING AND HAULING APPLIANCES.

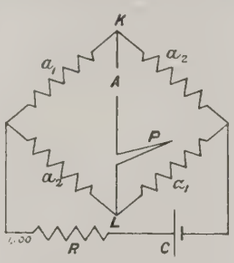
7138/11. Sir William Arrol and Co., Limited, and E. Jullien, Glasgow. Derrick-Cranes. [1 *Fig.*] March 22, 1911.—This invention relates to high derrick-cranes, especially adapted for use in shipbuilding yards where the area of working is large and the height required very considerable, and



of the kind in which a mast has fitted at the top thereof a jib arranged for movement around a vertical axis, and having a track or guideway for a trolley adapted to run therein and support the load. According to this invention, the trolley for supporting the load is adapted to run in an inclined track or guideway. The crane comprises a mast A fitted at the top with a jib B, including a lower boom C which affords an inclined track D; the jib B is arranged to be slewed by a motor and worm gearing carried on a platform E. A trolley F, from which the load is supported as by means of a rope passing round guide-pulleys, is arranged to run on the track D, the trolley F being movable the length of the boom C, and capable of being retained in any desired position intermediate the ends of the boom. The trolley F is driven by a rope adapted to be wound on and unwound from a drum driven by gears from the same motor as serves for slewing the jib B, or any other motor. (*Accepted July* 26, 1911.)

MINING, METALLURGY, AND METAL-WORKING.

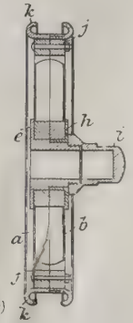
1100/11. F. Stroude and E. Josephs, London. Thermo-Electric Pyrometer. [1 *Fig.*] January 16, 1911.—This invention relates to thermo-electric pyrometry, and comprises a system of compensation for "cold junction" temperature which depends for its action upon an arrangement of conductors of different resistance temperature coefficients similar to a Wheatstone bridge, in which the potential difference of two diagonally opposite points is always equal to and in opposition to the "cold junction" thermo-electromotive force. a^1, a^1 are resistances composed of material having a large temperature coefficient of resistance. a^2, a^2 are similar resistances having a different resistance temperature coefficient. A represents the terminals of an instrument or apparatus for measuring potential differences (and thus giving a measure of the temperature of the "hot junction"). P represents the thermo-couple; C represents a source of direct current; R represents a rheostat for the purpose of adjusting the current from C. The resistances a^1, a^1, a^2, a^2 are mounted in close proximity to the "cold junction" of the thermo-couple—as, for example, inside the terminal head of the pyrometer. In this arrangement, "cold junction" temperature is compensated for as follows:—The resistances a^1, a^1, a^2, a^2 are adjusted to be of the same resistance value at the particular



"cold junction" temperature for which the indicator is calibrated. The resistance values of these resistances are so chosen with regard to their resistance temperature coefficients and the current from C that the potential difference of the two points K, L varies directly as, and is in opposition to, the change in electromotive force generated at the "cold junction," due to its temperature being above or below the standard temperature. To vary the limits of the range covered by the measuring apparatus the resistances a^1, a^1, a^2, a^2 are arranged so that, at the standard "cold junction" temperature, the potential difference between the points K, L has a value equal to the "hot junction" electromotive force at the temperature T, which is required to be the inferior limit of the indicator scale. This potential difference opposes the "hot junction" electromotive force, so that at a temperature of "hot junction" equal to T no current passes through the indicator. The values of the resistances are also so chosen with regard to their resistance-temperature coefficients that, for an increase of t in "cold junction" temperature, the potential difference between the two points K, L shall be diminished by an amount which is equal to the increase in "cold junction" electromotive force, and for a decrease of t in "cold junction" temperature this potential difference shall be increased by the same amount. A "centre zero" instrument can also be used, in which case the temperature T represents the centre point on the scale. (*Accepted July* 26, 1911.)

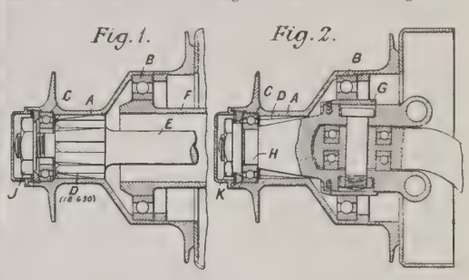
MOTOR ROAD VEHICLES.

19,122/10. F. Probert and A. Probert, Llanelly. Wheels. [2 *Figs.*] August 15, 1910.—In accordance with this invention, a wheel is divided in the plane of rotation into two halves, each half of the wheel being distinct in itself, and comprising half of the rim, felloe, spokes, and hub, the two halves of the rim on which the tyre is mounted being so made that when the wheel is assembled the bottom of the half rims overlap so as to avoid pinching or otherwise damaging the inner tube or air-chamber. *a* and *b* are the two halves of the wheel, and are adapted to be secured together by bolts and nuts. One half of



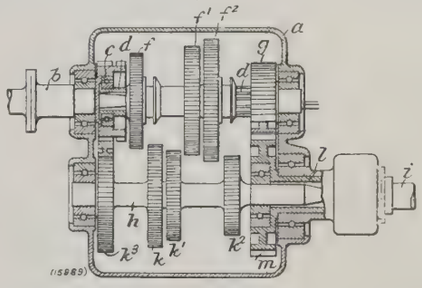
the wheel is provided with a hub portion *e*, screw-threaded, and having a shoulder adapted to receive the hollow hub portion *h*, which is rigidly secured to the other half of the wheel. *i* indicates a screw-cap adapted, when the wheel is fitted together, to be screwed tightly on to the threaded portion of the hub *e*. Mounted upon one half of the felloe *j* is one half of the rim *k*, one portion of said rim having an overlapping portion, adapted, when the two halves of the wheel are assembled, to lie in the recess formed in the other half of the rim, so preventing the inner tube of the tyre from being pinched or damaged when placing the same thereon. (*Accepted August* 2, 1911.)

18,630/10. F. W. Lanchester, Birmingham. Detachable Wheels. [2 *Figs.*] August 8, 1910.—This invention relates to detachable wheels for road vehicles, and consists, in brief, in applying to a road wheel a construction of hub and bearing containing at once the essential bearing and keying elements proper to its function either as driving or steering wheel. The invention also consists in an arrangement of the bearing and keying elements such as to render the process of applying the wheel to either the driving or steering axles selective, so that the elements and parts automatically perform their required functions according as the wheel may be applied to the steering or driving axle. In the construction of the invention illustrated, which is applicable to the road wheels of an automobile vehicle, a hub A is constructed containing two ball-bearings B and C of the usual annular type, and which will be referred to as the inner and outer bearings respectively. The inner bearing is of larger diameter in its bore than the outer bearing, and in the barrel of the hub, in the space between the two bearings, keyways D are cut, or other provision is made to convey the torque from the driving axle E to the hub body A. The difference between the keyway diameter and the bore diameter of the hub is less than that between the bores of the inner and outer bearings, so that the keys or castellations with which the driving-axle is furnished can pass freely through the inner bearing when the wheel is being placed in position. The steering-axle is not fitted with keys, but is turned smaller than the bore in the hub, so that when the wheel is fitted to the steering-axle there is no driving connec



tion. When the wheel is fitted to the driving-axle, the inner bearing takes its seat on the end of the axle-frame F, a turned snout being provided, and thus it forms the main axle-bearing; the outer end of the axle is turned a clearance and the wheel is centred upon the keywayed portion, so that the outer bearing is functionally inoperative. When the wheel is applied to the front axle (Fig. 2), both inner and outer bearings are seated on portions of the axle G and H respectively turned to receive them, and no contact exists between the axle and the hub directly. On both rear and front axles the wheel is secured in place by a nut on the axle end; but whereas in the former case (on the rear axle) the nut J takes its bearing on the hub itself, or on a cover directly bearing on the hub, in the latter (on the front axle) the nut K grips the inner element of the outer bearing to a shoulder formed on the axle, or so that it performs the function of a thrust-bearing. The selective action of the nut in gripping the hub when the wheel is applied to the driving-axle, and in gripping the thrust when applied to the steering-axle, is automatic, the prolongation by which the outer bearing is gripped being omitted on the driving-axle. The nuts for steering and driving-axles may have threads of different diameters and pitches to automatically ensure the correct one being used. (*Accepted July* 26, 1911.)

15,989/11. Daimler-Motoren-Gesellschaft, Unterturkheim, Germany. Change-Speed Gears. [1 *Fig.*] July 12, 1910.—This invention relates to change-speed gears for motor-propelled vehicles of the kind in which the motor shaft can be clutched to a co-axial spindle in the gear-box, the spindle supporting slidable toothed gears. The motor shaft carries a pinion which is in constant mesh with a pinion on a spindle carrying non-slidable gear-wheels. The invention consists in arranging the driven shaft co-axially with the spindle of the non-slidable gear-wheels, a pinion upon the driven shaft being arranged in constant engagement with a pinion on the spindle of the slidable gear-wheels. *a* is the box for the change-speed gear; *b* is the motor-shaft, and *c* is a driving pinion fixed thereon. Within the driving-wheel *c* a bearing is provided for one end of a spindle *d*, which is co-axial with the shaft *b*, and carries the sliding-gears *f*, f^1, f^2, as well as a pinion *g*, which is fixed on the spindle *d*. A counter spindle *h*, co-axial with the driven shaft *i*, is arranged parallel with the spindle *d*. On this spindle *h* the wheels *k*, k^1, k^2 are mounted, and the spindle *h*

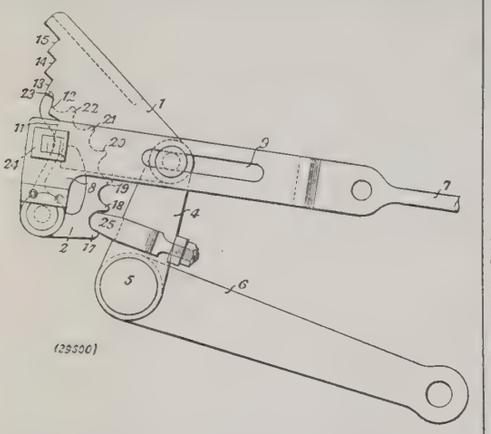


rotates relatively to the driven shaft *i*. The latter is connected to a sleeve *l*, running in a bearing in the casing *a*, and carrying within the latter a pinion *m*, which is in constant mesh with the pinion *g* on the spindle *d*. The highest speed is obtained by sliding the gear-wheel *f* into engagement with the driving-wheel *c*, and thereby causing the spindle *d* to be driven at the same speed as the motor-shaft *b*. The motion is transmitted from the spindle *d* to the sleeve *l* through the pinions *g*, *m*, and the shaft-sleeve *l* revolves the driven shaft *i*. The shaft *i* is connected with the driving-gear, which transmits the motion to the road-wheels. A lower speed is obtained by sliding the gear-wheel *f* to the right, so that it comes out of engagement with the driving-wheel *c* and into gear with the wheel *k*. The driving-wheel *c* now transmits motion to the spindle *h* through the pinion k^3 thereon. The motion is transmitted from the spindle *h* to the spindle *d* by means of the pinions *k*, *f*, and the spindle *d* to the sleeve *l* by means of the pinions *g*, *m*. By sliding the gear-wheel f^1 into mesh with the wheel k^1, or the gear-wheel f^2 into mesh with the wheel k^2, the speed is altered according to the gear ratios of those wheels. (*Accepted August* 2, 1911.)

RAILWAYS AND TRAMWAYS.

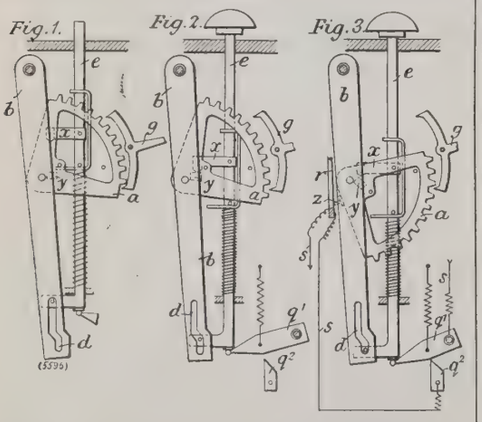
29,600/10. J. P. O'Donnell, London. (*J. N. Curtis and E. D. Sampson, Hubli, India.*) **Brake Apparatus.** [4 *Figs.*] December 20, 1910.—This invention consists in improved apparatus for automatically adjusting the brake-gear to compensate for wear of the brake-shoes, so that the stroke of the brake-operating piston will remain substantially constant not-

withstanding wear of the brake-shoes. Two stepped or toothed cams 1,2 are employed, one, 1, is pivotally mounted on the power-arm 4 on the brake-shaft 5, that is, in the case of vacuum-brake apparatus, operatively connected with the piston of the brake-cylinder by means of an arm ; the other, 2, is mounted on the end of the main pull-rod 7 of the brake-gear, being shown pivoted on a projection 8 at the end of the pull-rod 7. The pivot of the cam 1 works in a slot 9 in the pull rod 7. The cam 1 is preferably a double cam, and may consist of a steel casting. Steps 10, 11, 12, 13, 14, and 15 are formed on the end faces of each side wall of the casting, and the cam 2 works between these side walls ; 17, 18, 19, 20, 21, 22, and 23 are teeth on the cam 2. The teeth of the cams are so arranged that each succeeding tooth is at a greater radial distance from the pivots than the preceding tooth, and the teeth on the cam 1 are formed so that their faces, which are adapted to engage a pin 24 carried by the end of the pull-rod 7, will give a direct thrust on the pin and consequently a direct thrust to the pull-rod 7 in applying the brakes, each of the



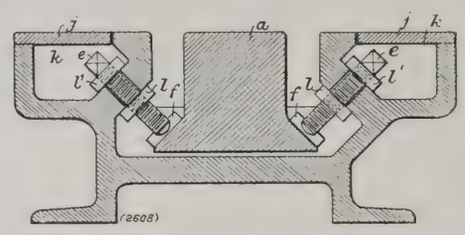
said faces being preferably at a right angle to a radial line from the pivot of the cam. The teeth of the cam 2 are rounded at their outer ends, and a stop 25, fixed to the power-arm 4, is adapted to engage between the teeth of this cam. In working, assuming the brake-gear and adjuster to be in the normal position, and no wear on the brake-shoes, when power is applied to the arm 6 for putting on the brakes, the lowermost step 10 of the cam 1 engages the pin 24, which is thus actuated to apply the brakes. During this operation a sliding movement of the stop 25 on the tooth 18 of the cam 2 takes place. When the brake-shoes have become worn to a predetermined extent, the travel of the pull-rod 7 increases to such an extent that the tooth 18 of the cam 2 drops over the stop 25, so that the space between it and the next tooth 19 is then in engagement with the stop 25 ; in the return movement of the pull-rod 7 in releasing the brakes, the cam 1 will also drop so that its second step 11 will then be in engagement with the pin 24, the working length of the pull-rod being thus shortened by an amount corresponding to the wear that has taken place on the shoes. (*Sealed September* 21, 1911.)

5596/11. Siemens Brothers and Co., Limited, London. (*Siemens and Halske Aktiengesellschaft, Berlin, Germany.*) **Railway-Signalling Apparatus.** [3 *Figs.*] March 6, 1911.—In the specification of Patent No. 19,558, of 1907, an electrical blocking apparatus for railway signals is described, in which the downward movement of the scape segment into the blocking position is effected by its own weight when the plunger-rod is depressed, so that the segment is moved out of engagement with the anchor which forms the armature of the electro-magnet. The present invention relates to a development of this arrangement by which the circuit of the current for unblocking the panels, which work in conjunction with that at which the plunger-rod is depressed, cannot be closed should the scape segment for any reason not complete its downward movement. The supervision, according to the invention, depends, on the one hand, mechanically on the downward movement of the plunger-rod, which movement cannot be completed so as to close certain block



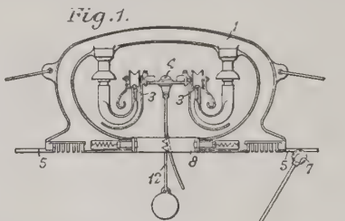
contacts if the scape segment has not fallen, and, on the other hand, the operation is electrically supervised, since the electric circuit is only completed when a contact has been closed by the actual movement of the scape segment into a definite position. The pivot on which the segment *a* turns is carried by a lever *b* ; at the lower end of this lever is a cam slot *d*, in which engages a pin rigidly connected with the plunger-rod *e*. When the plunger-rod *e* is depressed, the pin attached thereto at first slides down the slot *d* without displacing the lever *b* to which the pivot of the segment is fixed. On the further depression of the plunger-rod, the pin enters the inclined part of the slot *d*, the lever *b*, and with it the segment *a*, is moved to the left, so that the teeth of the segment no longer engage with the pallets of the anchor *g*, and the segment *a* then moves down by its own weight into the position required for blocking. The mechanical supervision over this condition of the blocking apparatus is effected by an arm *x* attached to the plunger-rod *e*, since this arm meets a projection *y* of the scape segment, should the latter fail to descend into the lower position. This condition is shown in Fig. 2. In this case the scape segment is either forcibly brought into the blocked position by the further depression of the plunger-rod *e*, or the latter is prevented from completing its downward movement and the blocking contacts q^1 and q^2 cannot be closed. The electrical supervision of the condition is also shown in Fig. 3, where the circuit 8 of the operating current is led over a contact *r*, closed by an insulated projection *z* on the scape segment only when the scape segment is in its lowest position. (*Accepted July* 26, 1911.)

2608/11. Edgar Allen and Co., Limited, F. Bland, and E. Larmuth, Sheffield. Points and Crossings. [5 *Figs.*] February 1, 1911.—This invention relates to tramway points and the like which are made of manganese steel or other hard metal, and consists in the arrangement and combination of parts and appliances, by means of which the movable tongue, which has a portion of its heel formed with diagonal sides, may be prevented from rising out of the groove of the point-box, and by means of which it may be adjusted and retained in position both



longitudinally and transversely, and comprising adjusting screws *e*, *e* placed at an angle of 45 deg., or thereabouts, on both sides of the heel of the tongue *a*, and nuts *l*, *l* inserted into recesses, through which the adjusting screws are screwed, and locking-nuts l^1, l^1 placed on the outside of the adjusting screws ; liners *f*, *f* at the ends of the adjusting screws, adapted to the angle and curvature of the enlarged part of the heel of the tongue, and recesses *k* formed in the body of the point *b* for obtaining access to the ends of the set-screws, with lids *j*, *j*. (*Accepted August* 2, 1911.)

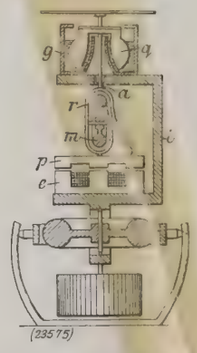
4397/11. Oesterreichische Daimler-Motoren-A.G., Wiener-Neustadt, Austria. Overhead Trolley-Wire Construction. [2 *Figs.*] October 22, 1910.—The object of the invention is to enable a railless electrically-propelled vehicle, to which current is supplied by a contact-trolley, to cross the overhead conductor of an ordinary electric tramway in which in the trolley-wire of a tramway a movable gate is arranged and is characterised by the feature that the gate consists of two movable strips in line with the trolley-wire, which, being pushed aside by the trolley-hauling cable of the railless vehicle, lets it pass. The whole construction is supported by a bow-shaped frame 1 to which are secured also the insulating supports for the conductors 3, 3 of the contact trolley 4 of the railless vehicle. The two inter-



rupted ends 5, 5 of the ordinary trolley-wire are attached to the frame 1. To enable the trolley-wheel 7 to pass over the break, the gap is bridged by one or two pivoted strips 8, 8. These strips have hinges which permit them to revolve in a horizontal plane, and are normally pressed into line with the trolley-wire 5 by springs attached to arms which extend beyond the hinges. As is shown by Fig. 1, this construction allows the trolley-wheel 7 to pass smoothly over the bridged gap in the trolley-wire 5. If a railless vehicle is to cross the tramway its collecting conductor and pendulum 12 will push the strips 8 aside as indicated in Fig. 2, until the conductor and pendulum can pass through the gap. Then the springs return the strips 8, 8 to the initial position in line with the trolley-wire. (*Accepted August* 23, 1911.)

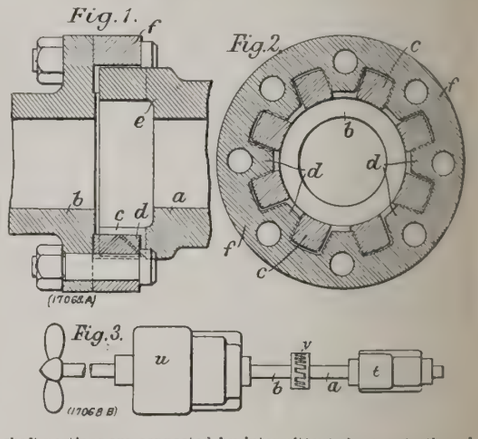
SHIPS AND NAUTICAL APPLIANCES.

23,575/10. G. G. M. Hardingham, London. (*Hartmann and Braun, Actiengesellschaft, Frankfort-on-Main, Germany.*) **Gyroscope-Compasses.** [5 *Figs.*] October 11, 1910.—A gyroscope intended for employment as a course indicator, and constructed with a Foucault tendency, the effect of which is to maintain a constant parallel position in relation to, and turning in the same sense as, the earth's axis, is, when used



on shipboard, so influenced by variation in the speed, and in the direction of the vessel, that a deviation in the vertical axis results ; and hitherto, in order to reduce this disturbance to a practically permissable quantity, gyroscopes having very great periods of oscillation in the vertical axis have had to be employed. The present invention relates essentially to gyroscope-compasses with Foucault tendency designed to secure a short period of oscillation concurrently with a reduction in the deviation due to the disturbing influences before referred to. According to this invention, a further field of force operating symmetrically on all sides to the vertical axis is added to the effect of the force of gravity ; such further force, without interfering with the free revolution of the gyroscope-compass on its vertical axis, exercises an influence which tends to reduce the period of oscillation, and at the same time to reduce any deviation due to disturbing influences. The drawing shows diagrammatically and by way of example a constructional form with an electro-magnetic auxiliary field. The gyroscope consists of the massive disc *m*, which is mounted to revolve freely in the rim *r*, and is driven electrically. The rim *r* is connected with the vertical axis *a* in order that it may freely revolve in its bearing, and is supported by a float *q* which dips into a reservoir of mercury *g*. Below the rim *r* is contrived the auxiliary field of force, which is here supplied by an electromagnet *e* constantly in circuit, and acts upon the armature *p* fixed to *a*, a certain distance above its poles ; the magnet being constructed in pot-form so as to offer practically no resistance to the turning of its armature with the axis *a*. It is necessary to protect this electromagnet against the effect of the pitching and rolling movements of the ship, and in this connection the customary devices serve. For instance, either the whole supporting frame *t*, or the part on which the electromagnet *e* is fixed, can be suspended on the Cardan system ; or the part can be supported on a plate which is continually kept horizontal by a special gyroscope system as is diagrammatically shown. (*Accepted July* 26, 1911.)

17,068/10. The Hon. C. A. Parsons and S. S. Cook, Newcastle-on-Tyne. Marine Propulsion. [7 *Figs.*] July 18, 1910.—This invention relates to marine turbine installations, and particularly in the arrangement by which the thrust propelling the ship is transferred from the parts which are generating this thrust to the structure of the ship. Instead of providing thrust-blocks or balancing surfaces subjected to fluid pressure, it is common practice to arrange that this thrust is taken, wholly or partly, by the pressure of the steam between the rotor and the turbine-casing and transmitted by the latter to the structure of the ship. In such cases, the balancing thrust of the fluid has been arranged to be approximately proportional to the torque, and therefore approximately proportional to the thrust of the propeller at all powers. It is found, however, especially where cruising or additional turbines are employed, that difficulty may be experienced in thus effecting the balancing of the thrust, and the object of this invention is to provide a solution of the difficulty. The invention consists in a marine turbine installation having additional or cruising turbine parts connected to a propeller-shaft by couplings so arranged that the additional thrust produced by the added power of such turbine parts may be balanced in these parts or transmitted to suitable absorbing means. The form of coupling adopted is immaterial so long as it fulfils the condition that it shall produce, between two portions of a line of shafting, a thrust which is proportional to the torque transmitted between these portions. Such couplings usually have two corresponding parts with engaging surfaces, such as teeth, the inclination of which surfaces is determined so as to give the required ratio between the thrust exerted between the two portions of the line of shafting, and the force which, acting at the radius of the component parts of the coupling to produce rotation, gives the torque it is required to transmit by the coupling. A coupling fulfilling the above condition is shown in Fig. 1, in which the shaft portion *a* is transmitting its torque to the other portion *b*, the rotation being clockwise when looking from *a* to *b*. The two



shaft portions are connected by intermittent claws or teeth *c*, *d* having helical faces projecting at the proper helical pitch from a pair of concentric sleeves *e*, *f*, respectively, carried by the shaft portions *a*, *b*. A particular application of this invention is shown in the marine installation diagrammatically illustrated in Fig. 3, and comprising one or more cruising turbines *t* for use at low powers, coupled to the shaft of one or more main turbines *u*. At all powers the propeller-thrust due to the power generated by the main turbines is approximately balanced by the steam-thrust in these turbines, or in any other suitable manner. When, however, some or all of the cruising turbines *t* are in use, it will be seen that additional power is generated and the propeller-thrust consequently increased on the shaft on which these turbines are mounted. In the construction hitherto adopted, this additional thrust has been absorbed by the main turbine thrust-block, or, in some cases, has been transmitted by a rigid coupling between the shaft of the cruising turbine and the shaft of the main turbine, and balanced by the steam-thrust in the cruising turbine itself. Both these methods of absorbing the extra thrust are objectionable, as in the first alternative, the main turbine thrust-block is subjected to a considerable force, while in the second the use of a rigid coupling prevents the adjustment of the cruising turbine-rotor with regard to its stator, and differential expansions of the two turbines lead to increased leakage losses in the cruising turbine. According to the present invention, both these disadvantages are overcome. Thus in the installation shown, the shaft portion *a*, on which the cruising turbine *t* is mounted, is connected to the main shaft portion *b* of the main turbine *u* by a flexible coupling *v*, as already described. The engaging faces of such a coupling are designed to produce a thrust which substantially balances the additional propeller-thrust due to the torque developed by the cruising turbine *t*. The thrust thus transmitted by the coupling *v* from one shaft portion *b* to that driven by the cruising turbine *t* is thus equal, or substantially equal, to the additional propeller thrust which, in the arrangement illustrated, is balanced by the steam thrust in the cruising turbine *t*. By this means the cruising turbine *t*, it will be seen, is free to be moved axially so that its axial clearances can be adjusted by its own adjusting block without undue pressure, and, further, without interfering with the adjustment of the main turbine *u*. (*Accepted August* 2, 1911.)

CRANE SPECIFICATIONS.

By Edward G. Fiegehen.

Technical specifications for new machinery may be of two kinds: that issued by the customer (or his consulting engineer), and outlining his requirements; and again, that put forward by the manufacturer, setting forth the capabilities and desirable features of his goods. The chief aim of the purchaser, when issuing a stringent and detailed specification, is to establish a definite basis of comparison whereby the various proposals submitted to him may be impartially judged. The manufacturer's specification, upon the other hand, is drafted in such a manner as to demonstrate in an attractive manner the value he offers for the price quoted. The wording of each type of specification is usually so arranged as to form a convenient basis of a subsequent contract when necessary. The clauses of a purchaser's specification may be divided broadly into two parts:—

1. A description of the established local conditions to which the machine must be made to conform.

2. An indication as to the manner in which the machine required should be constructed in order to meet with his approval.

In the installation of some kinds of machinery the local conditions can be modified to a certain extent to suit the selected machine, but in the case of cranes this is rarely the case. It is, however, with the constructional requirements of such specifications that we are more particularly concerned in what follows.

The tendency in all branches of manufacture at the present time is indisputably in the direction of standardisation; great efforts are made by experts to ascertain conclusively the best method of attaining a certain end under existing conditions. The knowledge thus obtained enables a definite standard of comparison to be established, which, being recognised by buyer and seller alike, greatly facilitates the processes of inquiry, tendering, manufacture and testing. As classical examples we may instance the universal acceptance of the Whitworth standard for screw-threads, and that proposed by Professor Morse for the taper shanks of drills. It is difficult to realise the chaotic state of affairs that would result if, by some means, these two standards were made unavailable, since so much depends upon their universal acceptance.

The labours of the British Standards Committee afford further examples of such standardisation, and there can be no doubt that their wide adoption has resulted in great benefit to all parties concerned in the manufacture and use of the items already standardised. For example, it is recognised as a *sine quâ non* of modern manufacturing, having regard to the increasing importance attached to quick delivery, that an adequate supply of material, and also of finished component parts, should be kept in stock at all times, to enable quick deliveries to be confidently guaranteed. If, therefore, the manufacturer can feel fairly confident that the bulk of his orders will be based upon recognised standard specifications, he will have no hesitation in maintaining such a stock, obviously to the benefit of the purchaser, both in the matter of prompt delivery and of uniform excellence of the product that is thereby rendered possible.

As a contrast, we may ask ourselves what stock of twist-drills, for instance, a maker would be likely to carry if no definite standard for the shanks of such drills was in existence?

Turning now to larger units, we note that boilermakers have an important standard of comparison in the Board of Trade Rules, upon which both inquiries and tenders can be based. In the field of electrical engineering, again, it is possible by an intelligent reference to accepted standards of temperature rise, overload capacity, insulation resistance, and so forth, to obtain tenders for a dynamo upon an entirely satisfactory basis; and other instances of the value of accepted standards will readily occur to the reader.

The scope of crane-building has increased to such a remarkable extent during the last few years, and now involves so many distinct industries, that we are able to avail ourselves to a certain extent of the standards of each, so far as they apply; but the fact remains that for crane-work pure and simple very few standards are available, and that upon many points of vital importance no general agreement exists at all. It is therefore a daily experience for the estimator to be confronted with voluminous specifications obviously drawn up with great care, and at no small expense, containing stringent requirements with regard to details of construction, but through the provisions of which, in spite of all, the traditional "coach-and-four" could be driven, owing to their haziness upon basic requirements alone.

As a violent contrast to such the writer may, perhaps, mention an inquiry reading as follows:—"Please quote us for a crane to lift 5 tons—must be stout"!

One of the chief points in connection with cranes upon which uniformity is urgently needed is their "rating" expressed in tons capacity, and further agreement is required as to the most suitable proportion between this "rated load" and a recognised "test load," the ratio depending to some extent, of course, upon the service for which the crane is intended, just as the allowable stress upon gear-teeth is made to depend upon the working speed. It is a remarkable fact that the majority of crane inquiries make no mention of a test-load, and hence for a "10-ton crane" we find that one maker will offer a machine equal to a test of, say, 12½ tons, whilst another will put forward in good faith a smaller size, tested to 10 tons, possibly at a lower figure.

Since the allowable working stresses in the various members of a crane structure are fairly well understood, they afford a satisfactory basis for specification clauses, provided, of course, that the important effects of inertia-loading in these machines is not overlooked.

It would seem natural, therefore, to define the "rated tonnage" of a crane as that of the maximum working load that the crane is designed to handle under normal conditions, and without exceeding the specified safe working stresses in any part. The ratio of the "test-load" to the above would depend to a great extent upon the possibility of the normal load being exceeded occasionally by accidental circumstances, and it is possible that different test-loads should be imposed, the lighter to prove the power of the gearing, &c., and the heavier the structural strength of the framework. In any case, as in boiler practice, care should be taken that the nature of the test is not so severe as to inflict permanent injury upon any part of the crane. In this connection the writer has in mind an official specification that required the 25 per cent. overload to be lowered *freely* through 6 ft., and then arrested by the brake.

In this instance it seems hardly possible that the person responsible for the clause was fully aware of the extreme severity of the test contemplated, and no doubt a comparison of tenders submitted upon such a basis would be an interesting study in the relative conscientiousness of the firms quoting.

As an example of the need for reliable standards, it may be said that in hand-crane inquiries it is quite the exception for the force required at the handles to raise the maximum load to be mentioned. The number of men required for the work is certainly specified in some instances, but as estimates of a man's working capacity vary by at least 100 per cent., this information is hardly scientific, and a great divergence in the designs submitted is to be anticipated.

Again, in the case of steam-cranes it is equally rare for speeds of working to be mentioned in the average inquiry. As a matter of fact, the nominal sizes of the engines offered by the leading makers for ordinary cranes do not differ materially, but inasmuch as the port area provided by one maker will very possibly be twice that offered by a competitor, the speeds of all the motions will be materially increased, and the former crane in this respect represents better value for the money.

A further example of looseness in definition is to be found in the term "height of lift," as applied chiefly to overhead cranes. Some makers provide sufficient rope to enable the lifting-hook to be lowered to touch the floor, whilst others consider that if the hook is arranged to descend to within 2 ft. of that level, it is sufficient for all practical purposes. This lack of agreement as to the bottom limit frequently leads to misunderstandings.

Again, we often find a high nominal factor of safety specified in connection with wire ropes, without any restriction as to the grade of rope or the diameter of the barrel or pulleys over which it works, whereas it is well known that both these factors profoundly affect the real margin of strength.

In the case of an electrically-driven crane absurdly severe tests are frequently specified in the matter of the temperature rise of the motors, owing, undoubtedly, to a misconception of the conditions under which the machines work. The tendency is to dissociate the motors in such cases from their gear, for the purpose of testing for temperature rise, whereas it would seem more rational to stipulate that *the entire crane* should be tested by dealing continuously with its test-load for a definite time, the temperature rise of the motors at the end of the period not to exceed a specified amount. Such specifications will frequently contain clauses calling for exceptional insulation resistance tests upon the motors, and possibly the controllers also, but ignoring altogether the insulation resistance of the crane *as a whole*, which, it may be added, is occasionally dangerously low, due to careless wiring.

The foregoing remarks will, we trust, serve to indicate to some extent the scope that exists for improvement in connection with the terms employed in specifications covering cranes of ordinary types. Special cranes will always be required, but even in connection with these many items of a standard specification would apply. With respect to the bulk of crane inquiries and orders there can, however, be no doubt that a definite understanding between buyer and seller with regard to the meaning of many of the terms now so loosely employed would result in a better state of things generally, and it would then be possible to consider all tenders for a job upon a level basis. The purchaser, on his part, would have the unaccustomed satisfaction of knowing with fair accuracy what he was going to get for his money, and there can be no question that the labour of the estimator would be materially lightened, since the necessity for mastering a nicely-printed, but somewhat hazy, dissertation upon crane construction would not be, as now, the inevitable prelude to dealing with a goodly proportion of his inquiries.

There can also be no doubt that an inquirer who referred to a standard specification as outlining his requirements would obtain more favourable prices than the compilers of the neatly-bound treatises previously mentioned. There will, of course, always be heretics; but at the present moment, unfortunately, we have no true faith, and are compelled to worship many strange gods.

FEED-WATER HEATING AND SUPERHEATING ON LOCOMOTIVES.—No. V.

The Combination of Feed-Water Heating and Waste-Gas Superheating in Service.

In our last article* a description was given of the feed-heating and superheating apparatus fitted to a class of engines working on the Upper Egypt section (420 miles in length) of the Egyptian State Railways. The class was composed of thirty-five engines, and sixteen of them were fitted with heaters in the early part of 1910. With a view to ascertaining the value of Mr. Trevithick's system applied in this way on a considerable scale, the General Manager arranged for an extensive trial to be made between the heater and non-heater engines of this, the "612," class. These trials corresponded to regular service working on the Cairo-Luxor division. The Upper Egypt main line is made up of three sections—viz.: Cairo-Minieh (154 miles); Minieh-Sohag (138 miles); Sohag-Luxor (128 miles). Hereafter, for simplicity, these will be termed Sections I., II., and III. respectively. Section I. only is double line, the remainder being single, and worked on the staff system. The trains covered by the test were two fast trains daily each way, known as the Upper Egypt expresses. The running is naturally fastest on Section I., though, deducting stops and slacks, the timing on the two other sections is also fairly good. On Section I. the 154 miles is covered in 3 hours 57 minutes, with three intermediate stops of together from 12 to 17 minutes. Over Section II. the trains are timed at 5 hours 19 minutes for the 138 miles, with 10 slacks for staff changing, and 11 stops. On Section III. the timing is 4 hours 45 minutes for 128 miles, with 7 staff slacks and 13 station stops.

The coaling of the engines for these tests was altogether in the hands of the stores, as is ordinarily the case on these railways; but in order that stricter check than usual might be kept on this important

* See page 445 *ante*.

TABLE VI.—Results of Service Trials between Feed-Heating and Superheating Engines and Ordinary Engines of the "612" Class on the Upper Egypt Division, Egyptian State Railways.

	Section I.		Section II.		Section III.		Sections I., II., & III.	
Number of engines with or without heaters..	3 with	6 without	5 with	5 without	8 with	7 without	16 with	18 without
Aggregate train-mileage	18,172	18,172	13,524	13,524	12,544	12,544	44,240	44,240
Average tare behind tender .. .. tons	302.6	301.6	300.6	301.8	300.5	302	302.3	301.8
Coal Consumption.								
Average pounds per mile	29.6	37.8	32.5	43 0	33.6	44 8	31.6	41.4
Economy in favour of heater engines p.c.	21.7		24.4		25.0		23.6	
Average pounds per ton-mile	0.0977	0.1255	0.1082	0 1427	0.1110	0.1490	0.1047	0.1373
Economy in favour of heater engines p.c.	22.1		24.1		25.5		23.7	

item, all coal was weighed into sacks at Cairo, sealed, and despatched thence for use. Engines were stationed at Cairo and Sohag, and coaling was only done at these two places, a sufficient number of sacks of coal being given to cover the outward and return journeys. The stores staff was specially augmented at Sohag, and at Cairo special arrangements were also made by the stores department to ensure accuracy in the records, and proper treatment of the engines throughout the trial. The coal recorded per double trip included twice lighting up, once at the home shed after washing out, which is found advisable after every double trip, and once after standing for a period, not less than ten hours, at the out-shed. The Cairo engines worked between that station and Minieh. From Sohag one set of engines worked to Minieh and back, and another set to Luxor and back. Locomotive inspectors were delegated at Minieh and Sohag to see that instructions for the trial were properly observed. The accuracy of the coal consumption records was thus adequately assured; equal care was taken with the recording and independent checking of the tare weights of the trains worked. The test extended to an aggregate of 88,480 miles run, of which 36,344 train-miles were worked by the engines on Section I., 27,048 train-miles by engines on Section II., and 25,088 train-miles by engines working Section III. In addition to the rather shorter distances, the mileage on Sections II. and III. was also affected by an unavoidable delay in supplying Sohag with the necessary amount of weighed coal, so that on these sections a start was only made at a later date than on Section I. In considering the results it must be borne in mind that the proportion the lighting-up coal bears to the total used has a distinct influence on consumption figures, and the varying nature of the service, in the three sections, also affects comparisons. For these reasons most of the figures have been abstracted for each section separately. The principal results are given in Table VI., herewith, from which it will be observed that on the ton-mile base the lowest economy recorded in favour of the heaters in these trials, which conformed in every respect to service working, was just over 22 per cent. In Sections II. and III., where stops were more frequent than in Section I., the consumption naturally went up for all engines. The increase was less marked with the heater than with the non-heater engines. In explanation of this some remarks are made below. The consumption figures in pounds per mile for Sections II. and III. compared with those of Section I. show, moreover, the relative influence of station stops and slacks. For Section II., with ten slacks and eleven stops, the increase in consumption is not so marked as in Section III., with seven slacks and thirteen stops.

Combined for the complete trial over the whole of the Upper Egypt Division main line, an economy of 23.7 per cent. in coal per ton-mile was realised, as also shown in Table VI. in the last columns. Incidentally it may be noted that this figure exceeds that cited for the Trevithick system, during the discussion at the Institution of Mechanical Engineers, on Mr. G. Hughes's paper on "Compounding and Superheating."* The trials were at that time actually in progress, and the figure of 22 per cent. saving was purposely quoted so that all risk of error on the side of exaggeration should be avoided. It will be remembered, however, that the speaker on that occasion stated that there were indications that that figure would be exceeded. This proved to be the case, while, as will be subsequently shown, results still better than those indicated in Table VI. are now obtained with the system.

Some explanation may appear to be necessary with regard to the exceptional uniformity of the train-loads. The four trial trains were purposely

* See Engineering, vol. lxxxix., page. 501.

Table VII.—*Coal Consumptions of Feed-Heating and Superheating, and of Ordinary, Engines, Upper Egypt Division Trials, Classified according to Tare Train-Loads Behind Tender.*

Nominal Train-Load.	Type of Engines with (+) or without (−) Heaters.	Actual Average Tare-Loads.	Coal Consumptions. Average per Mile.	Economy in Favour of Heaters.	Average per Ton-Mile.	Economy in Favour of Heaters.
tons		tons	lb.	p.c.	lb.	p.c.
			Section I.			
260	+	262.8	28.4	22.6	0.1082	23.4
	−	259.5	36.7		0.1414	
303	+	306.9	30.0	22.0	0.0977	21.8
	−	308.2	38.5		0.1250	
337	+	339.0	30.6	20.3	0.0904	20.5
	−	337.3	38.4		0.1138	
362	+	362.3	31.6	23.3	0.0874	23.2
	−	362.1	41.2		0.1139	
			Section II.			
260	+	262.4	32.5	22.8	0.1239	23.0
	−	261.7	42.1		0.1611	
308	+	307.8	32.2	24.2	0.1048	24.4
	−	306.4	42.5		0.1388	
337	+	331.6	32.9	25.7	0.0994	24.4
	−	337.3	44.3		0.1315	
			Section III.			
260	+	265.7	33.5	21.9	0.1261	22.7
	−	263.0	42.9		0.1633	
308	+	307.5	33.2	24.5	0.1080	24.7
	−	307.0	44.0		0.1436	
337	+	337.0	34.4	26.9	0.1020	27.2
	−	336.0	47.1		0.1403	

kept of the same composition during the period covered by the trials, except that from time to time an extra coach was added to each. During the earlier part of the test the trains were of normal load—*i.e.*, about 260 tons tare behind the tender. After a time they were increased up to 308 tons, and subsequently to 337 tons. Finally the trials were extended in Section I., when the load behind the tender was made up to 362 tons tare. Table VII. gives the results classified according to tare train-loads behind tender. The influence of stops is still more clearly brought out in this table than in the previous one, in the figures given for Section III. The consumption of the non-heater engines on Section III. is high for all loads compared with that of engines on Section I., and the coal used increases rapidly with the load in the case of these engines. With the heater engines, however, neither the additional stops nor the increase of load have nearly so marked an influence on consumption, though, of course, there is an appreciable rise. For this section with light loads the non-heaters record 42.9 lb. of coal per mile, compared with 36.7 lb. with similar loads in Section I., a difference of 6.2 lb. per mile. With heavier loads the figures are 47.1 for Section III., and 38.4 for Section I.—a difference of 8.7 lb. The difference between the consumption at light and heavy loads in Section III., with many stops, is nearly 5 lb. for the non-heater engines, but for the heater engines there is under 1 lb. per mile difference.

A scrutiny of the figures for the individual engines engaged in the test shows their performance to be wonderfully uniform, with one or two small exceptions, so that the results as given are in all probability reliable. It may be stated that though built to the same drawings, these engines were constructed by three different makers, of which one was a British firm and two were Continental. Curiously enough, there is, at loads of 300 and 337 tons, a slightly smaller consumption for the British non-heater engines compared with the other makes; but the engines were not distributed sufficiently evenly for reliable conclusions to be drawn on this point, which, of course, is in no way cognate to the present subject.

In order to consider the trial in a sufficiently broad aspect for it to be of practical value, account must be taken of the time-keeping qualities of the two types of engines at different loads. During the trial proper the total amount of lost time which can in any way be debited to the steam-generating power of the engines was only 224 minutes. Two insignificant delays of 1 minute each are eliminated. This amount of lost time was made up of 15 delays, and, for the 628 trains handled, gives an average of less than 21½ seconds on journeys averaging 141 miles, which, it must be allowed, is a very creditable record. When the matter is gone into in slightly more detail the performance shows up better still. The 224 minutes were made up of 78 minutes lost by the non-heater engines, and 146 minutes lost by the heater engines. Of the latter, however, 81 minutes were dropped on one day, due to exceptionally bad weather. If this be considered as a case apart, the time lost by the heater engines is reduced to 65 minutes, so that for the range of loads prevailing during the trials proper there was little amiss with either class of engine. With the heaviest loads of all, however, for which the trials were specially prolonged in Section I., quite a different result is shown. With these loads of about 362 tons, the non-heater engines lost, in 80 journeys of 154 miles, a total of 216 minutes, against 40 minutes for the heater engines, or more than five times the amount of time lost by the one as by the other. An average of a ½-minute delay per journey of 154 miles is an excellent record for the heater engines when taking a load more than 39 per cent. in excess of the normal for the class.

As confirming the results of these Upper Egypt tests, the figures given in Table VIII. have been abstracted from the railways' registers, and show the practical value of the apparatus. The figures for heater and non-heater engines for the same period (nine months in 1910) confirm in a remarkable manner the results of the Upper Egypt test. Not only is the system serviceable in this way, but it has provided the means of handling additional train-loads. The greater average load taken by heater-fitted engines, brought out clearly in Table VIII., shows that advantage has been taken of this regularly.

Table VIII.—*Service Results Abstracted from Registers.*

Year.	——	Average Tare Load Behind Tender.	Coal per Ton-Mile.	Economy in Favour of Heaters.
		tons	lb.	per cent.
1909	16 engines before fitting with heaters	240.2	0.1692	29.0
1910	Same engines after fitting with heaters	263.5	0.1201	
1909-10	19 engines not fitted with heaters..	246.4	0.1626	26.1
9 months 1910	16 engines fitted with heaters	266.6	0.1194	23.7
9 months 1910	19 engines not fitted with heaters.. ..	246.4	0.1565	

The possibility of realising economy with waste-gas superheating having been so frequently disputed by some locomotive engineers, a test extending over 13,500 train-miles was instituted on the Egyptian State Railways, to determine to what extent the saving resulting with engines fitted with the Chief Mechanical Engineer's system was due to the feed-water heating, and what due to the superheating of the steam. For this purpose two engines, of average performance in the foregoing trial, were fitted up, the one with the standard exhaust-steam feed-heaters for this class of engines, and the other with a smoke-box superheater only. At the end of this trial it was found that the consumption of one engine figured out to within 0.0003 lb. per ton-mile of the other. The effect of one part of the combination is thus apparently as great as that of the other. Reference to Fig. 12, page 445 *ante*, will show that this may reasonably be expected. From Fig. 12 it is evident that, providing the base figures of the argument which it illustrates were fairly chosen, about half the advantage would be due to the feed-heating and about half to superheating. It is rather interesting that the figures for these tests suggest that, although the saving due to each part separately is so nearly identical, together they show a saving rather less than double the amount each shows singly, which is exactly what one would expect.

Each part of the combined system contributes to the relief of the boiler. On a former occasion we have shown to what an extent feed-heating to high temperatures by waste products lessens the work

of the boiler, and similarly, though to a reduced extent, feed-heating by exhaust-steam alone, as is done in the Egyptian State Railways' combined system, reduces the necessary heat input. Superheating, by reducing the rate of output, also lowers the rate at which heat has to be supplied. The question of the reduction of the loss by unburnt coal has already been fully dealt with in a previous article, where it was shown that a reduction in this serious waste was a valuable feature of this system embodying an enclosed blast and feed-water heating by exhaust steam, since the former results in an even draught. and the latter permits the use of a large blast-pipe. Both these are factors favourable to reduced consumption.

Impartiality requires note to be taken of the fact that, as in other advantageous systems, certain risks must be safeguarded against. It is little use installing a theoretically good apparatus if in its application the engine may in some way be robbed of the advantage it offers. In the waste-gas heater system we have dealt with in these and former articles, the heater tubes, through which the gases are drawn, offer a certain amount of resistance, and they must be proportioned, and their aggregate flue area adjusted, so as to provide sufficiently free passage to the gases under the induced action of the blast. If the resistance offered is greater than it should be, the blast-pipe orifice must be reduced, and part of the advantage will be lost on account of increased back-pressure in the cylinders. The blast being enclosed in a small chamber, a comparatively high vacuum is there feasible with a large blast-orifice. The resistance offered by the heater tubes reduces this vacuum in the smoke-box itself to a degree only about half the usual amount. The feed-heating and superheating both reducing the demand on the boiler, this low smoke-box vacuum, rather than being detrimental, is advantageous, while, as previously pointed out, the larger blast-orifice, and, still more, its virtual enlargement, due to the abstraction of part of the exhaust steam by the feed-heaters, has an extremely beneficial effect on the back-pressure in the cylinders. The gain is a compound one in both directions.

It will now be evident why the effect of stopping and starting with heavy trains is so much more marked in an ordinary engine than in one fitted with heaters. As is well known, when starting with the lever in full gear, in the ordinary engine the fire is lifted at each exhaust, and the loss in unburnt coal passing out of the chimney is then excessive. The heavy pulsations of the blast have a most disastrous effect. With the type of smoke-box heater used on the Egyptian State Railways the resistance offered by the heater tubes damps these pulsations to a very considerable degree. It is well known that a strong, even blast is not nearly so wasteful as one with heavy beats, and the heater engine benefits by this, but also by the fact that the smoke-box vacuum will, at its greatest, be much lower than that of an ordinary engine, owing to the added resistance due to the heater. The pull on the fire is therefore much reduced, and the economy shown by the heater engine when there is much work to be done at or near full gear would naturally be expected to be greater.

It may be argued that as the system embodies superheating, some of this advantage would be nullified by the lower efficiency of the heater of an engine making many stops. This does not apply to the waste-gas superheater as it does to the smoke-tube superheater. On the one hand, the waste-gas superheater is designed for gas temperatures not exceeding, say, 750 deg. Fahr., and whether the engine is working or not, the furnace gases must pass over and through it and keep it at a temperature not far below the working temperature. If the jet or the vacuum ejector be at work, the current of waste gases passing through the heater is considerable. In fact, blowing-off the brakes prior to starting probably results in the heater being raised to working temperature, ready for the incoming steam, and the first steam reaching the cold cylinders is therefore superheated and able to impart to them some of the superheat. On the other hand, the smoke-tube superheater is designed to work at temperatures ranging from a maximum somewhere, perhaps, in the neighbourhood of 1700 deg. Fahr. at the fire-box end, to about 600 deg. Fahr. at the smoke-box end. During a stop, however, the temperature of the elements tends to fall to that of the surrounding water (perhaps as low as 370 deg. Fahr.), for the damper being then shut, the supply of hot gases is practically suspended, and the gas still in the tubes gradually falls to the temperature of the surrounding water, the superheater elements finally giving up their heat also. On restarting the superheater has first to be heated up, but this is only accomplished after the engine has got to work, a lapse of over four minutes occurring, according to Mr. G. Hughes, from starting till the superheated steam reaches the desired working temperature. The result is that when the cylinders are comparatively cold from inaction, they are fed for a short space of time with saturated steam, just when, as a matter of fact, superheat would be most advantageous in order to warm them up again. This is an unfortunate feature of the smoke-tube system, which has an undoubted effect on the consumption of an engine working stopping trains of any class.

The effect of usage has been carefully watched in connection with the heater apparatus used on the Egyptian State Railways. As far as can be judged, practically no loss of efficiency is found after a considerable mileage. In confirmation of this two runs may be quoted, made without preparation of any kind except the fitting of the necessary thermometers. One was made after an engine had been at work for only 2716 train-miles, and the other after 47,036 train-miles. On the first run superheat of 84 deg. Fahr. and a feed temperature of 213 deg. Fahr. were recorded; and on the second, superheat of 80 deg. Fahr. and a feed temperature of 211 deg. Fahr., showing an apparent drop of 4 deg. Fahr. in the superheat and 2 deg. Fahr. in the feed temperature, both very small amounts; and, when it is noted that the load in the first case was 336 tons behind the tender, and in the second 320.5 tons, it will be admitted that even this small diminution is much more apparent than real, since, as we have shown on a former occasion, all conditions tend towards an increase of temperature with increased loads. The question of the formation of deposit in the exhaust-steam heaters has been thoroughly discussed in connection with the feed-water heating system previously described. It was shown that with high velocity the deposit in these heaters did not become at all a serious matter. As regards the smoke-box heater, it is found that when used as a superheater the tubes remain clean of all incrustation, since the salts have been thrown down in the previous processes, and are apparently only carried over in very small quantities with the rush of steam, if at all. The use of this heater as a feed-heating appliance does, it must be admitted, result in a certain amount of incrustation with bad, unsoftened water. For this reason, and also because of the smaller risk of the tubes leaking with steam, the use of this apparatus for feed-heating has not been persisted in on the Egyptian State Railways, the combination system having thus certain manifest advantages. If, for any reason, this form of superheating were unnecessary, and feed-heating could be used with advantage, a small alteration in the usual Egyptian State Railway practice of drifting and beading the tubes over will ensure their remaining tight, though under these conditions the men need to be cautioned against flooding the smoke-box heater with cold water. In order to safeguard against this, live steam may, if necessary, be used to warm the feed passing through the heaters when the regulator is closed, and, of course, the injector is always available if its use be preferred then. The question of depreciation will be dealt with fully later.

Before concluding this article, reference may appropriately be made to one or two practical points in connection with the heater system. Originally it was found that these engines, fitted with heaters, took longer than usual to light up, this being due, of course, to the relatively high resistance of the heater to the passage of the gases, when neither the blast nor blower is in use. To expedite the raising of steam, a by-pass or flue-door was therefore fitted in the back of the up-take or blast-chamber. During lighting up this is opened, giving the gases free access to the chimney, and altogether doing away with the former difficulty. The heater tubes themselves require no attention during working. As already pointed out, they are self-clearing. At the sheds all that needs to be done to the heaters is to brush the front tube-plate down with a wire brush. This is easily done when cleaning the smoke-box. Before the flue-doors were fitted the tarry soot carried through the tubes, during the early stages of raising steam, tended to deposit at the mouth of the heater-tubes. Risk of this is now avoided, and brushing down is therefore not so important a matter as it was formerly. Finally, it may be stated that the exhaust heaters are blown through after every double trip or so. The frequency with which this becomes necessary depends, naturally, on the class of water used, but the arrangement is such that it can be done with little trouble whenever the engine is over a pit or drain. A special clack, already described in ENGINEERING, is fitted for the purpose, with a tumbler-cock on the pump side of the first heater, leading to the branch pipe directed into the pit. The arrangement is clearly shown in Figs. 13, 14, 17, and 18 of the last article, where notes are given referring to the use of the various parts. To blow through, the tumbler-cock is first opened, and then the clack is raised, allowing both heaters to be blown through in series. If the smoke-box heater be used for feed-heating, the raising of the clack allows this to be cleared in series, of course, with the others. A clack is placed on the delivery side of the pump, not only to prevent the hot water getting back to the pump, but also to prevent dirt from being forced back to it along the delivery-pipe when blowing through.

The comparative simplicity of the system is evident. All that it involves in the way of knowledge is some acquaintance with the working of an ordinary steam-pump, which may very readily be acquired. In fact, in the Upper Egypt trials the engines were worked by native drivers and firemen, who, for the most part, had had no previous working acquaintance with the system, the tests being commenced practically as soon as the engines were sent out from the shops after conversion.

In our next article we propose to deal with the effect of the experience gained with the 612 class of engine, and with trials of Mr. Trevithick's, and the high-degree superheat, system.

FOUNDRY PLANT AND MACHINERY.

No. XXXIII.

By JOSEPH HORNER.

PNEUMATIC moulding-machines are favourites in shops where an installation of compressed air is available. They compete with machines operated by hydraulic power. Both systems are suitable for either shallow or deep work. Compressed air has a slight advantage in one respect—it can be used for blowing loose sand away from partings and from patterns.

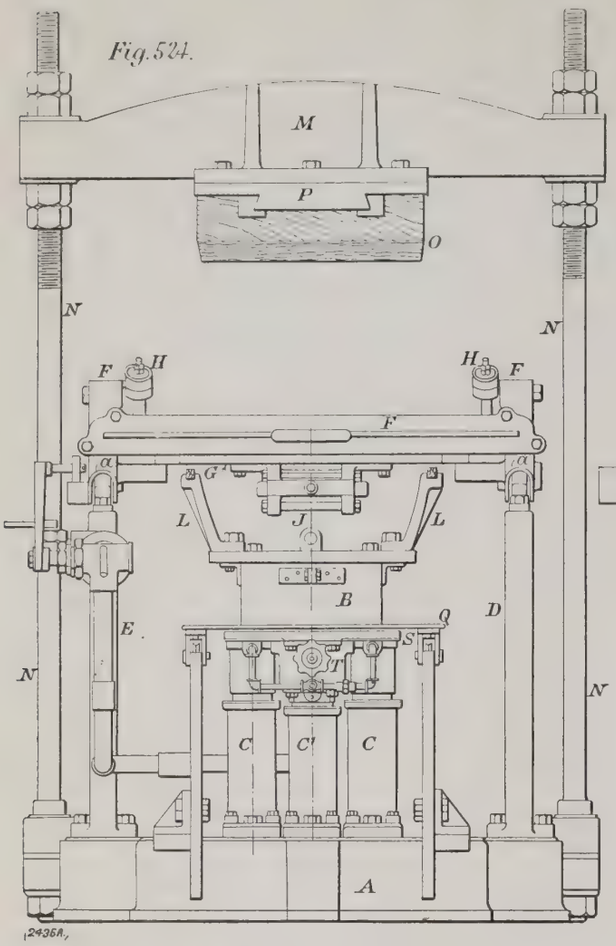
Figs. 524 to 541, on pages 520 and 521, illustrate a power-operated pneumatic machine, the Brookhouse, manufactured by Messrs. Hodgson Hartley (1909), Limited, of Cleckheaton. Though machines of simpler designs will be shown later, this will give a good idea of the elaboration which moulding-machine design is rapidly developing. Fig. 524 is a front elevation of the machine, Fig. 525 a side elevation, Fig. 526 a vertical section in the plane of Fig. 525. The remainder of the drawings will be referred to as we proceed. In these figures the base A is of box form, with cross-ribs to offer ample resistance to the ramming of the moulds. On it fits by a planed joint the ramming-cylinder B, the draw-cylinders C, C, C^1, and the side frames D, E. Either of these elements can be removed without disturbing the others. The side frames have a V-shaped rail planed on the top to receive the wheels of the table-carriage or frame F, with stop-brackets at each end position. The rails are protected by guards *a*, *a*. On one side frame E is formed an air-receiver, from which all connections are made.

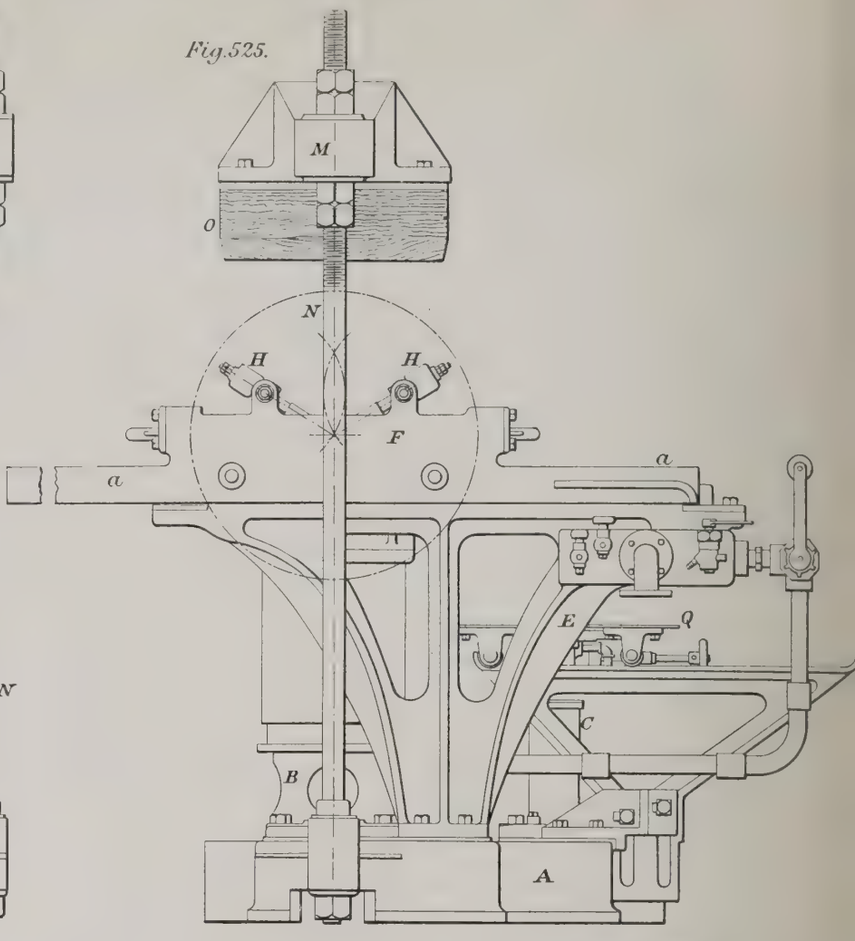
The table G, seen enlarged, with its carriage F, in Figs. 527 and 528, is planed on both sides, and has a recess planed out in the centre, into which the pattern-plate fits on lugs at each corner; this allows for receiving patterns on both sides of the plate. The recess is seen in Fig. 528, and it measures $15\frac{3}{8}$ in. by $15\frac{3}{8}$ in., planed to a jig (see Fig. 542).

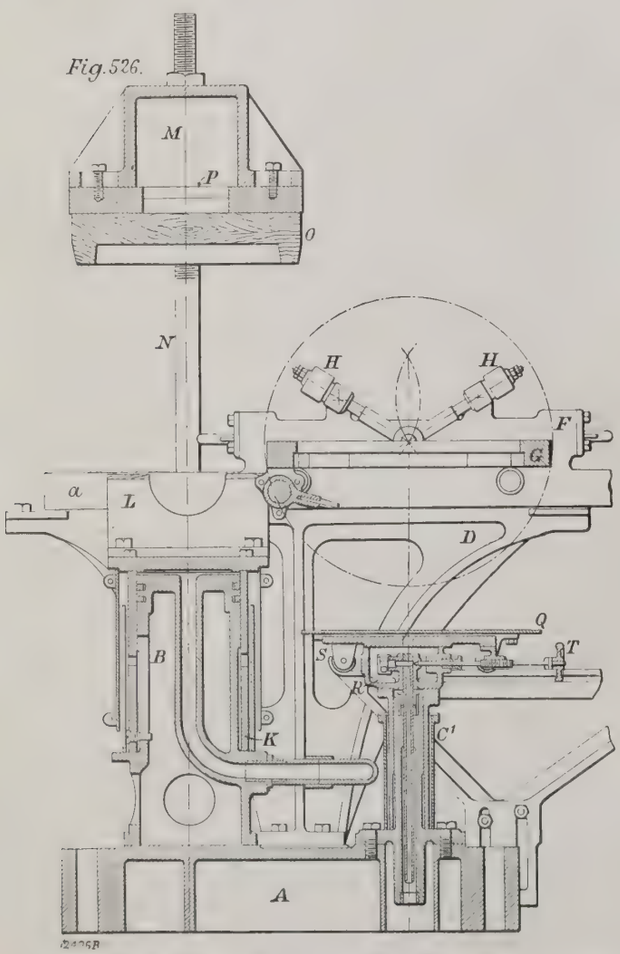
Swinging links H, H at each side of the carriage are attached to the table. The height at which it is held is adjusted by lock-nuts inside the dust-proof cases on the swing links, indicated in sections in Fig. 527. The table is also free to revolve, and to rise and fall when ramming has to be done, and it adjusts itself to any inequalities of the box edges when being delivered from the pattern. The moulding-box fits on the table by the pins placed on the centre line, and is clamped quickly to it by swivel-hooks at each side.

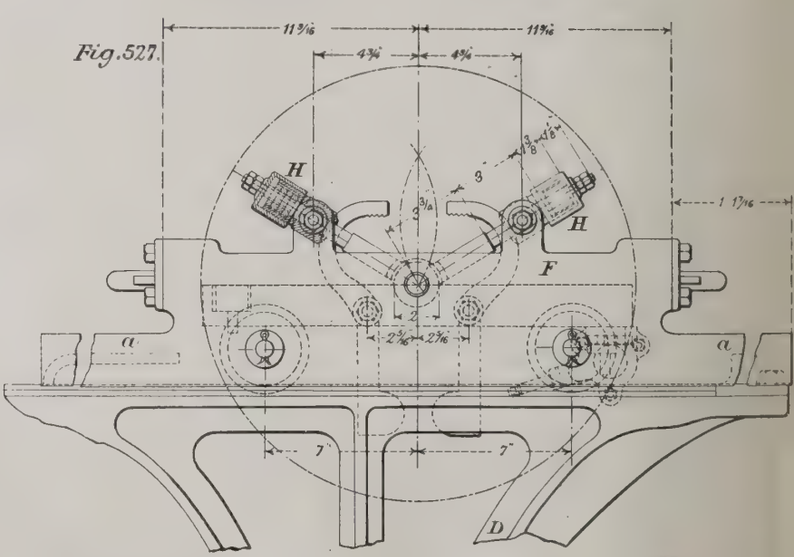
The ramming-cylinder B, Fig. 526 (see the en-

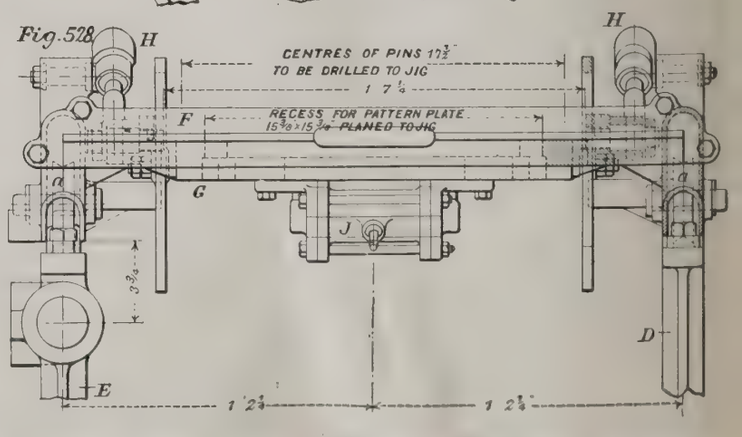
FOUNDRY PLANT AND MACHINERY.





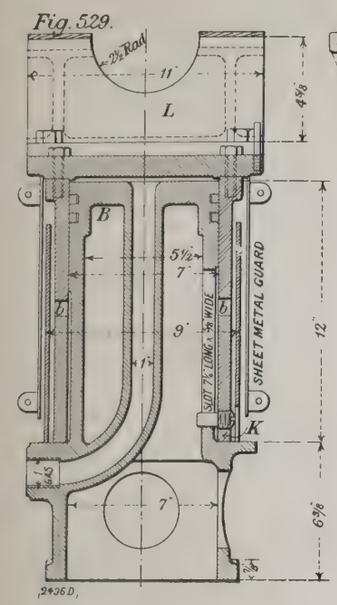


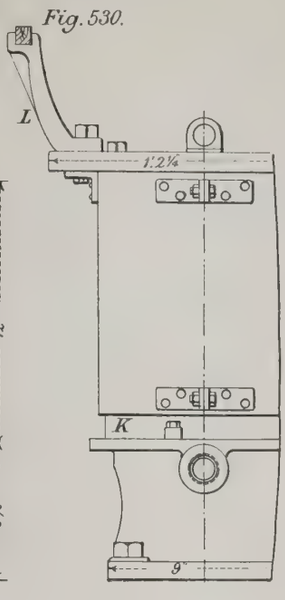


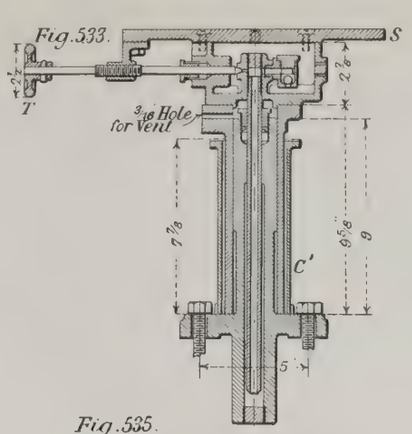


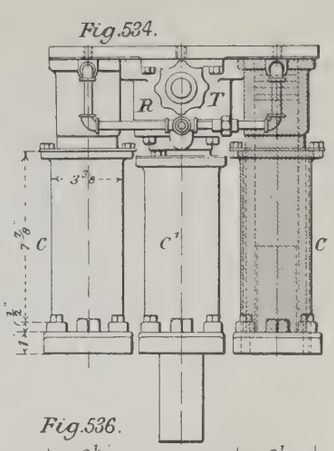
Figs. 524 to 528. The Brookhouse Pneumatic Moulding-Machine; Messrs. Hodgson Hartley (1909), Limited, Engineers, Cleckheaton.

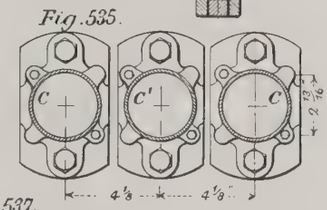
FOUNDRY PLANT AND MACHINERY.

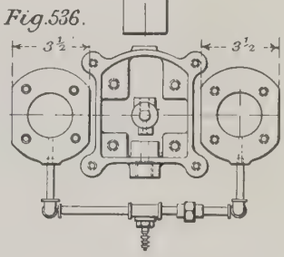


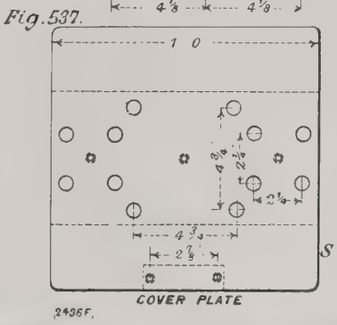


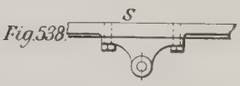


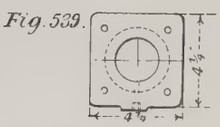


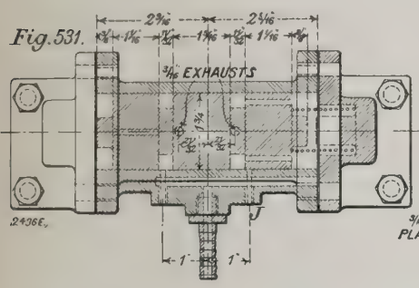


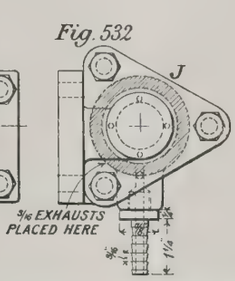












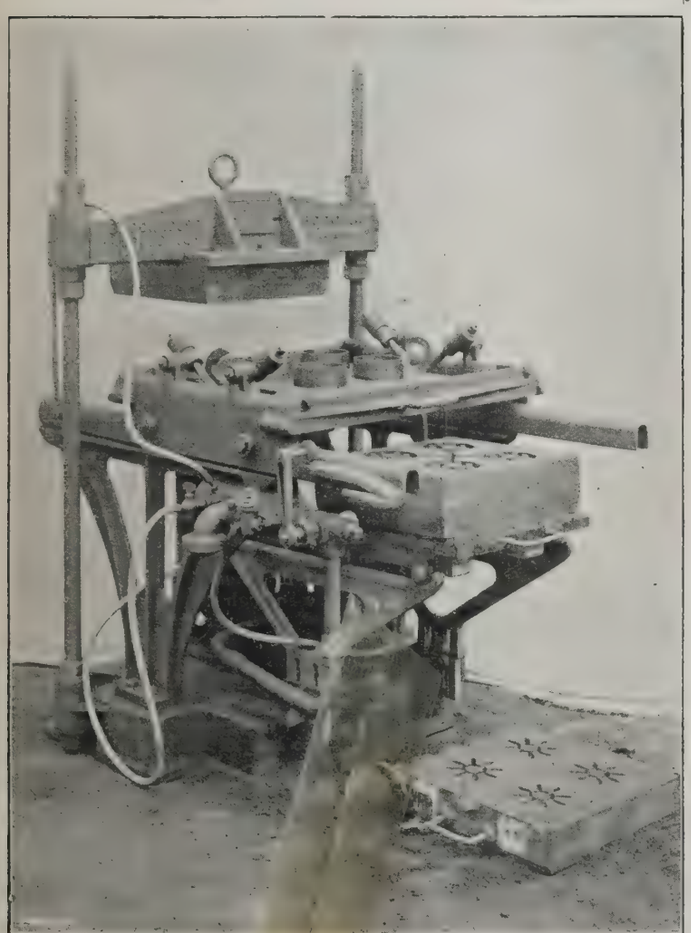


Fig. 540.

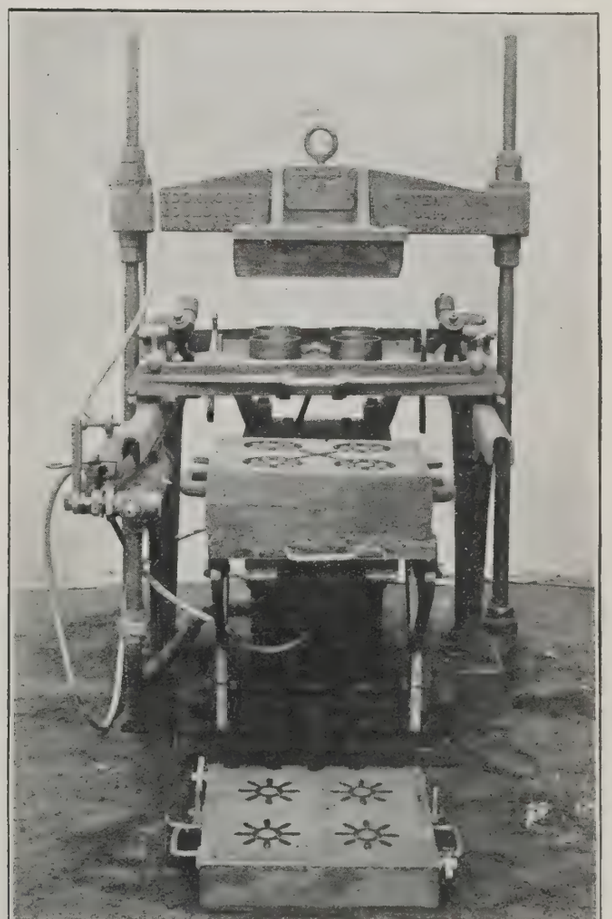


Fig. 541.

Figs. 529 to 541. The Brookhouse Pneumatic Moulding-Machine; Messrs. Hodgson Hartley (1909), Limited, Engineers, Cleckheaton.

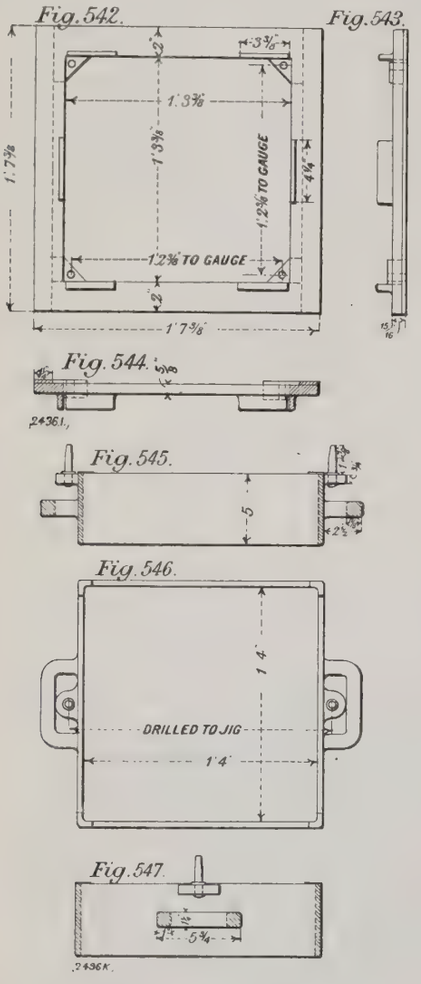
larged detail, Figs. 529 and 530), placed on the base below the table, has a sleeve K, which is free to slide vertically over the central part when air is admitted by the valve, the stem having relief ports *b* to permit the air to escape when the sleeve is raised to its limit. Sheet-metal guards are fitted to the outside to exclude sand from the moving parts. Brackets L, L at each side are bolted on top (compare with Fig. 524) with hard-wood strips to strike against the table and force it up in opposition to the presser-head M over the moulding-box.

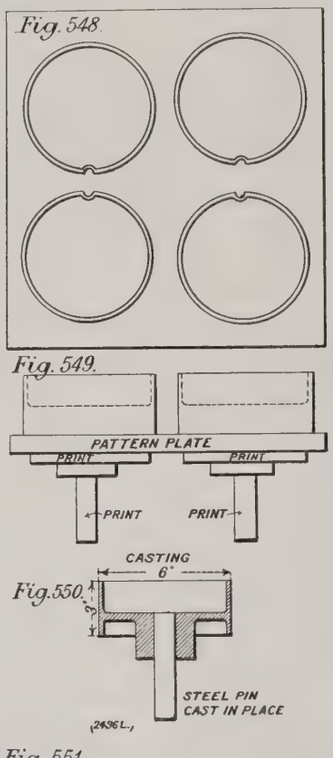
The head M is supported from the base by the side-bolts N, N. These have each a long threaded portion to permit of making vertical adjustments of the head to suit boxes of different depths. Wooden presser-blocks O are fitted to suit the work in hand. They are carried on an intermediate slide P to permit of making changes in the heads with facility.

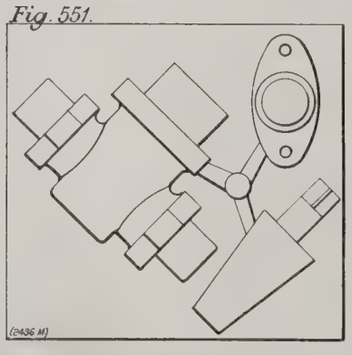
The vibrator J, Figs. 524 and 528, seen in detail in Figs 531 and 532, is bolted against the underside of the table, and is connected to the air-reservoir by rubber tubing. The pressure of air moves the centre body from end to end with great rapidity. The movement is cushioned by a spring at each end, and the air exhausts through the holes indicated.

The two outer of the three draw-cylinders C, C, Fig. 524 (compare with the details, Figs. 533 to 539), are connected by rubber hose and small pipes to the reservoir. These are used for lifting the trolley Q through the medium of the plate S to the underside of the box after it has been turned over. The centre cylinder C^1 has an oil-reservoir R on top, under the cover-plate S, with a steel tube descending almost to the bottom of the centre part, Fig. 533, through a packed oil-tight gland. The oil can enter the tube by gravity past the ball check-valve at the top, but can only return through the cone-valve, which is regulated by a small hand-wheel T at the front. In this way the box and mould, after being released from the table, are allowed to descend steadily while the sand is delivering from the pattern, and to move rapidly during the remainder of the descent. The working surfaces are protected from the entry of sand by cast-iron guards. The reproductions of photographs, Figs. 540 and 541, will assist to the better understanding of the form and details of the machine.

The operation of the machine is as follows:—The moulding-box, provided with an auxiliary sand-frame, is filled with sand and pushed under the ramming-head, first adjusted for height. The air-valve is opened, admitting air at a pressure of from 80 lb. to 100 lb. per sq. in. to the cylinder B. This forces the piston upwards, pressing the box against the ramming-head, which compresses the sand. The valve is then reversed, shutting off the air and opening to exhaust, allowing the box to descend to its original position. The box is withdrawn along the rails from under the head, the sand-frame removed and the sand strickled level, and the table and box turned over. The carriage Q is then brought up underneath the box by the outer cylinders C, C, and lowered by the central cylinder C^1, so completing the actual moulding.







This machine is made to take a box measuring 16 in. by 16 in. maximum dimensions. Smaller boxes can be employed, and patterns can be used on one or on both sides of the pattern-plate, being either fitted to it or cast with it. The illustrations, Figs. 542 to 551, show the system employed in fitting these. Figs. 542 to 544 is a jig, into which the pattern-plate is fitted by planing its edges. It is also planed on both sides to ⅝-in. thick, and rests on the internal corner pieces. The standard moulding-box is shown by Figs. 545 to 547. Two pattern-plates are seen in Figs. 548, 549, and 551. The first carries four patterns for roller-ends. The casting is seen in Fig. 550, which may be compared with the pattern mountings. On one side of the plate the entire rim is carried, and one of the recessed portions down to the disc centre. On the side opposite there is a portion of the boss. The remainder of the boss and the recessed portion of the rim on that side is made with a ring core in a box, not shown, the core being carried in the flat prints, Fig. 549. The steel pin, which is cast in place in the roller, is carried in the long cylindrical prints seen in Fig. 549. Fig. 551 shows the parts of a blow-off cock mounted on one plate. The body and plug are in halves on opposite sides of the plate. The gland is carried on one side only.

LITERATURE.

Notes on Irrigation Works: A Course of Lectures delivered at Oxford, under the Auspices of the Common University Fund. By N. F. Mackenzie, Hon. M.A. (Oxon.), M. Inst. C.E. London: Constable and Co., Limited. [Price 7s. 6d.]

In a course of six lectures on such a wide-reaching subject as irrigation, delivered to a class of university students to whom engineering and geography are equally important, it would be impossible to present any thorough discussion of the technicalities which make this subject one of the most difficult with which the engineer has to deal. The lecturer, or author, has aimed rather at exhibiting the principles which underlie the construction of a scheme of irrigation, the conditions that render its introduction economically desirable, the methods employed to meet the varying circumstances that obtain in regions of defective rainfall, and the mistakes to be avoided. It is a book that is not addressed solely to the technical student; it should be widely read, for it presents an outline of the history of the processes by which irrigation has acquired its usefulness and proved its importance, both in India and in Egypt. It is a subject especially interesting to the sociologist and the economist. The author recognises this interest, and devotes one whole lecture to the consideration of the revenue derived from water-distribution, the justness of its incidence, and the fairest methods of collection. A particular value attaching to this sketch as a whole arises from the fact that we are listening to one who has taken part in the actual work described, and who, by his experience, is able to present the principles and methods of irrigation in their most practical and modern aspect. He has suffered the consequences of sound scientific principles being disregarded, and while admitting the necessity of attention to pure theoretical formulæ, knows that these must be modified by the physical conditions of the country or accommodated to meet financial and other considerations.

The simplest sources of water supply for irrigation purposes are rivers which overflow their banks in the flood season and inundate the lower-lying country. The most familiar example is that of the Nile. As a rule, however, the banks must be higher than the surrounding country, owing to the greater portion of the silt in the muddy waters being deposited when the river loses its velocity on overflowing the banks; consequently inundations would occur only at the time of high floods, and would spread irregularly over the land, according to variations of level. To overcome this initial difficulty, and to construct a machinery that shall be able to supply to arid regions the quantity of water required on account of the deficient natural supply, is the whole problem of irrigation. It is one to which a great deal of ingenuity has been applied, and from which a very satisfactory return has accrued.

As the author points out with quite proper emphasis, the drainage requires as much attention as the supply, since the neglect of this important point can be attended with disastrous consequences. By insufficient drainage the level of the subsoil water may rise so high that water-logging ensues, the soil is rendered impervious to the roots of most plants, while the deposition of a saline efflorescence permanently impoverishes the soil. It seems axiomatic, when reminded of the consequences, that drainage of low-lying lands must go hand-in-hand with irrigation, but its importance has often been overlooked. So late as 1883, when the control of the irrigation system of Egypt came into our hands, the neglect of this obvious and fundamental principle of preventing any obstruction of the natural drainage led to a large acreage being thrown out of cultivation, and the expenditure of a very considerable sum to remedy the evil. It might be thought that not more water would be given to the fields than the crops could transpire in the course of growing to maturity. This quantity is much larger than is usually suspected. In this country, where the evaporation is not excessive, a field of mangold

will return to the atmosphere as much as 1200 tons of water per acre, or 12 in. of rain, a not inconsiderable portion of the total received. In a dry climate, when a man can get abundant water, there is a temptation to use it freely; and to prevent mischief from over-irrigation, drainage has to be carefully considered. On the other hand, it is possible to carry drainage too far. The subsoil may be robbed to such an extent that wells and other economic sources of supply may be rendered ineffective. Wells, be it remembered, are second only in importance to canals from rivers. In India 17 million acres are irrigated by canals to 13 millions by wells. It is evident that there must be a nice adjustment of means to ends to ensure success.

This adjustment is shown in various ways, generally involving the employment of bold schemes of construction, which could not have been ventured upon when modern irrigation was in its infancy. One plan for securing greater uniformity is to disregard obvious hydrographical boundaries. Formerly, the supply from each river was distributed to the area which could be commanded by its own waters, but now it is found more judicious and more economical to divert the surplus water of one catchment area to supplement the deficient supply in another. For instance, Travancore, on the western side of the Ghats, is a rainy district, and the excess fall is carried seawards by the River Periyar. The arid district of Madura, on the eastern side of the range, frequently suffers from drought. Consequently a scheme was arranged by which the valley of the Periyar could be dammed, and the impounded waters carried into the Vigai River on the east side by a tunnel pierced under the rocky watershed. The tunnel, which is fitted with regulating sluices, is more than a mile in length, and a volume of 30,000 millions of cubic feet of water is annually diverted from the western to the eastern side of the Peninsula. In the Punjab, again, where the Jhelum, the Chenab, and the Ravi are all used for irrigation purposes, it is found that, while the supply from the two latter is rather scant, the Jhelum can supply its own district, with something to spare. Therefore, the surplus water of the Jhelum is carried 90 miles across country, supplementing existing irrigation on its way, and is finally discharged into the Chenab just above the head of the canal works. The augmented Chenab is now in a position to supply an extra canal, to be carried boldly across the Ravi, notwithstanding the sometimes dangerous floods of this last-named river, into the arid districts of Montgomery and Multan. The estimated cost of the works is over five millions sterling, and an irrigated area of two million acres is expected.

Irrigation works soon become remunerative, as is shown in the case of Egypt, whose system the author discusses after having given some interesting descriptions of weirs across rivers in India. The feature of particular importance is the Egyptian scheme for irrigating the land on the "basin system," by which a uniform distribution of the fertilising silt as well as of the water is secured. To obtain a supply of water at a sufficiently high level, advantage is taken of the general slope of the Nile Valley, which is about 6 in. to a mile. If a canal be constructed with a slope of 2 in. to a mile, it will gain 4 in. on the river, and therefore at some 15 miles from the head of the canal the water in the canal will be capable of flooding the country to a depth of 3 ft.; though the ground surface at the head of the canal be 2 ft. above the water surface. At the same time the water is admitted into a series of low-lying basins through sluices at the side of an embanked canal, drawing its supply direct from the river at the level of the highest up-stream basin of the set. "A complete basin system thus requires two canals: first, a low-level canal running parallel to the river and delivering to each low-lying basin its fair share of muddy water; and, secondly, a high-level canal, the tail of which is syphoned under the head of the low-level canal and supplying water to the high-level basins near the river bank."

The Zifta and other barrages, as well as their method of working, are very well described. The Esneh, or Isna, dam, completed probably after the author had left the service, is barely mentioned. This latter, however, is of the highest importance, for it secures perennial irrigation where previously only inundation irrigation existed. This means that in addition to producing crops of cereals over a large area, a second, or summer, crop of sugar or cotton will be possible. If this work were confined solely to the engineering side, we should not be able to see clearly what has been the result of all this labour and capital expenditure. But the author is one who has always kept in view the necessity of securing an adequate return on the outlay, and he gives figures which show emphatically the happy results arising from an efficient system of control and distribution of Nile waters. "The cotton crop has increased in value from 7,500,000*l.* to 15,000,000*l.* The maturing of the maize—the peasants' food crop—has been assured by its timely sowing being made a certainty; the cost of raising crops has been lessened by improved means of irrigating them; the cultivable area has been increased from five to six million acres; the value of land has been more than doubled; and the system of forced and unpaid labour, with its attendant abuses, has been abolished. The capital expenditure which produced these results was about 4,000,000*l.*" In addition to this may be added that in years like 1902, when the annual flood was a very poor one, the water stored by the dam at Assiout saved a crop to the value of half a million, and prevented untold suffering among the poorer peasantry. Nor are the resources of irrigation yet exhausted. Still more ambitious schemes exercise the engineering mind, further water supplies can be tapped, some of which the author considers, providing another fascinating chapter in the history of irrigation development, into which we regret we cannot follow him.

BOOKS RECEIVED.

The Testing of Engines, Boilers, and Auxiliary Machinery. By W. W. F. Pullen, Wh.Sc., M.I. Mech. E. Second Edition. Manchester: The Scientific Publishing Company. [Price 12s. 6d. net.]

Railway Accounts and Finance: An Exposition of the Principles and Practice of Railway Accounting in all its Branches. By J. Alfred Fisher. Third Edition. London: George Allen and Co., Limited. [Price 10s. 6d. net.]

Annual Report of the Minister of Mines for the Year ending December 31, 1910, being an Account of Mining Operations for Gold, Coal, &c., in the Province of British Columbia. Victoria, B.C.: Richard Wolfenden, I.S.O., V.D., Printer to the King.

Lista Navale Italiana. Pubblicazione periodica sul Personale e Materiale della Marina Militare e Mercantile. Fascicolo Trimestriale Doppio; Gennaio, 1910-Aprile, 1911. Roma: Officina Poligrafica Italiana.

Canadian Department of Mines, Mines Branch, No. 69. Chrysotile-Asbestos; its Occurrence, Exploitation, Milling, and Uses. By Fritz Cirkel, M.E. Second Edition (enlarged). Ottawa: Government Printing Bureau.

Annual Report of the United States Life-Saving Service for the Fiscal Year ending June 30, 1910. Treasury Department Document No. 2607. Washington: Government Printing Office.

The Art of Aviation: A Hand-Book upon Aeroplanes and their Engines, with Notes upon Propellers. By Robert W. A. Brewer, Fellow of the Society of Engineers, &c. With numerous illustrations and dimensioned drawings. Second Edition, revised and enlarged. London: Crosby Lockwood and Son. [Price 10s. 6d. net.]

Jahrbuch der Schiffbautechnischen Gesellschaft. Zwölfter Band, 1911. Berlin: Julius Springer. [Price 40 marks.]

La Irrigación en la Argentina. Por F. A. Soldano. Buenos Ayres: G. Kraft.

The Design and Construction of Dams, including Masonry, Earth, Rock-Fill, Timber, and Steel Structures; also the Principal Types of Movable Dams. By Edward Wegmann, C.E., M. Am. Soc. C.E. Sixth Edition, revised and enlarged. New York: John Wiley and Sons; London: Chapman and Hall, Limited. [Price 25s. net.]

The Railroad Library, 1910. (Second Series): *A Collection of Noteworthy Addresses and Papers mostly Delivered or Published during the Year named.* Compiled and edited by Slason Thompson. Chicago: The Gunthorpe Warren Printing Company.

Boy Labour and Apprenticeship. By Reginald A. Bray, L.C.C. London: Constable and Co., Limited. [Price 5s. net.]

Shipyard Practice as Applied to Warship Construction. By Neil J. McDermaid. London: Longmans, Green, and Co. [Price 12s. 6d. net.]

Syndicalism and Labour: Notes upon Some Aspects of Social and Industrial Questions of the Day. By Sir Arthur Clay, Bart. London: John Murray. [Price 6s. net.]

The Theory of Determinants in the Historical Order of Development. By Thomas Muir, C.M.G., LL.D., F.R.S. Vol. II. *Period* 1841 *to* 1860. London: Macmillan and Co., Limited. [Price 17s. net.]

Lines in the Arc Spectra of the Elements, Arranged in the Order of their Wave-Lengths. From Wave-Length 7950 *to Wave-Length* 2200. Compiled by F. Stanley. London: Adam Hilger, Limited. [Price 12s. 6d.]

Analytical Mechanics, Comprising the Kinetics and Statics of Solids and Fluids. By Edwin H. Barton, D.Sc. (Lond.), Professor of Experimental Physics, University College, Nottingham. London, New York, Bombay, and Calcutta: Longmans, Green, and Co. [Price 10s. 6d. net.]

British Rainfall, 1910. *For the Distribution of Rain in Space and Time over the British Isles during* 1910. Edited by Hugh Robert Mill, Director of the British Rainfall Organisation. London: Edward Stanford, Long Acre. [Price 10s.]

Royaume de Belgique, Ministére de l'Industrie et du Travail. Le Minimum de Salaire et les Administrations Publiques en Belgique. Brussels: J. Lebégue et Cie.

The Hunterian Lectures on Colour Vision and Colour Blindness. By Professor F. W. Eldridge-Green. London: Kegan Paul, Trench, Trübner, and Co., Limited. [Price 3s. 6d. net.]

Railway Shop Kinks, Compiled under the Direction of a Committee of the International Railway General Foremen's Association. By Roy V. Wright, Mechanical Editor, *Railway Age Gazette.* London, New York, Chicago, and Cleveland: The *Railway Age Gazette.*

Geological Surveys of Western Australia. Bulletin No. 41. *The Geology and Ore Deposits of the West Pilbara Goldfield.* By H. P. Woodward. With *Petrological Notes,* by Ludwig Glauert. Perth: Fred. Wm. Simpson, Government Printer.

Kompressoren Anlagen insbesondere in Grubenbetrieben. Von Dipl.-Ing. Karl Teiwes. Berlin: Julius Springer. [Price 7 marks.]

Maschinentechnisches Lexicon. (Parts 1 to 7 inclusive.) Prepared by Ing. Felix Kagerer. Vienna and Leipzig: Verlag der Druckerei- und Verlags-Aktiengesellschaft, vorm. R. v. Waldheim, Jos. Eberle and Co. [Price 70 Pf. per part—complete in thirty fortnightly parts.]

Étude Théorique et Pratique sur les Turbines à Vapeur Marines: Fontionnement Thermique, Construction, Installation, Appareils Auxiliares—Essais et Résultats. Par R. Lelong, Ingenieur-en-Chef de la Marine. Paris: Augustin Challamel. [Price 7.50 francs unbound, 10 francs bound.]

White's Engineering Pocket-Book, Mechanical and Electrical, with Notes, Tables, and Formulæ in General Use. By T. P. White. Wigan: Thos. Wall and Sons, Limited. [Price 1s.]

Proceedings of the Incorporated Municipal Electrical Association, 1911. Published under the supervision of the Editing Committee. London: Wyman and Sons. [Price 5s.]

The Soya Bean of Manchuria. By Norman Shaw. Published by order of the Inspector-General of the Imperial Maritime Customs, China. II.—Special Series, No. 31. London: P. S. King and Son; Shanghai, Yokohama, and Singapore: Kelly and Walsh, Limited; New York: G. E. Stechert and Co. [Price 1.5 dol. silver.]

Addresses to Engineering Students. Edited by Waddell and Harrington, Consulting Engineers. Kansas City, Missouri: Waddell and Harrington.

Betrachtungen über Fahrten und Havarien der Zeppelin-Luftkreuzer sowie Vorschläge zum Bau und Betrieb von Motor-Luftschiffen starren Systems. Von Franz Lönholdts. Frankfort-on-Main: Gebruder Knauer. [Price 0.80 mark.]

The Sewerage of Sea-Coast Towns. By Henry C. Adams. London: Crosby Lockwood and Son. [Price 5s. net.]

Railways and Nationalisation. By Edwin A. Pratt. London: *The Railway Gazette.* [Price 2s. 6d. net.]

THE TRADE OF OSAKA.

Osaka has been called the Manchester of Japan, and the analogy is justified if we look at the nature and the variety of the industries in the two cities. From the latest consular report about Osaka we learn that the total foreign trade for the year 1910 amounted to 8,593,164*l.*, represented by exports 5,459,658*l.*, and imports 3,133,506*l.*, the total increase in the trade of the year being 1,138,872*l.*, or 15 per cent. over the previous year. Notwithstanding this increase, the Vice-Consul reports that complaints were common on the part of foreign firms as to the increasing difficulty of doing satisfactory business, due to the competition of Japanese doing a direct import and export trade. This feature is a noticeable one in Osaka, where the Japanese are gradually extending their direct relations with foreign countries, especially with regard to metals and textile goods, though the tendency to trade direct exists in every line. One striking feature was that the imports of raw cotton in 1910 reached a figure far in excess of any hitherto, and amounted to 44 per cent. of the import trade of the port. This is partly to be accounted for by the depletion of stocks at the end of 1909, and partly by the activity of spinning and weaving mills throughout the year. The cotton mills during the year ended June 30, 1910, consumed 200,652,149 lb. of raw cotton, in the following proportion:—

	Lb.
Indian	135,981,380
American	30,735,421
Chinese	26,093,545
Egyptian	6,451,484
Other nationalities	1,390,319

The consumption of Indian cotton was some 36,000,000 lb. and that of Egyptian cotton some 2,000,000 lb. greater than in the previous year, and there is an increasing tendency to import raw cotton direct to Osaka, instead of through Kobe. The cotton-carrying trade to Japan is monopolised by a shipping ring, comprising the Nippon Yusen Kaisha, the Peninsular and Oriental, and the Norddeutscher Lloyd, who carry raw cotton from Bombay to either

750-KILOWATT COMPOUND DE LAVAL GEARED TURBO-DYNAMO.

CONSTRUCTED BY THE DE LAVAL TURBINE COMPANY, STOCKHOLM.

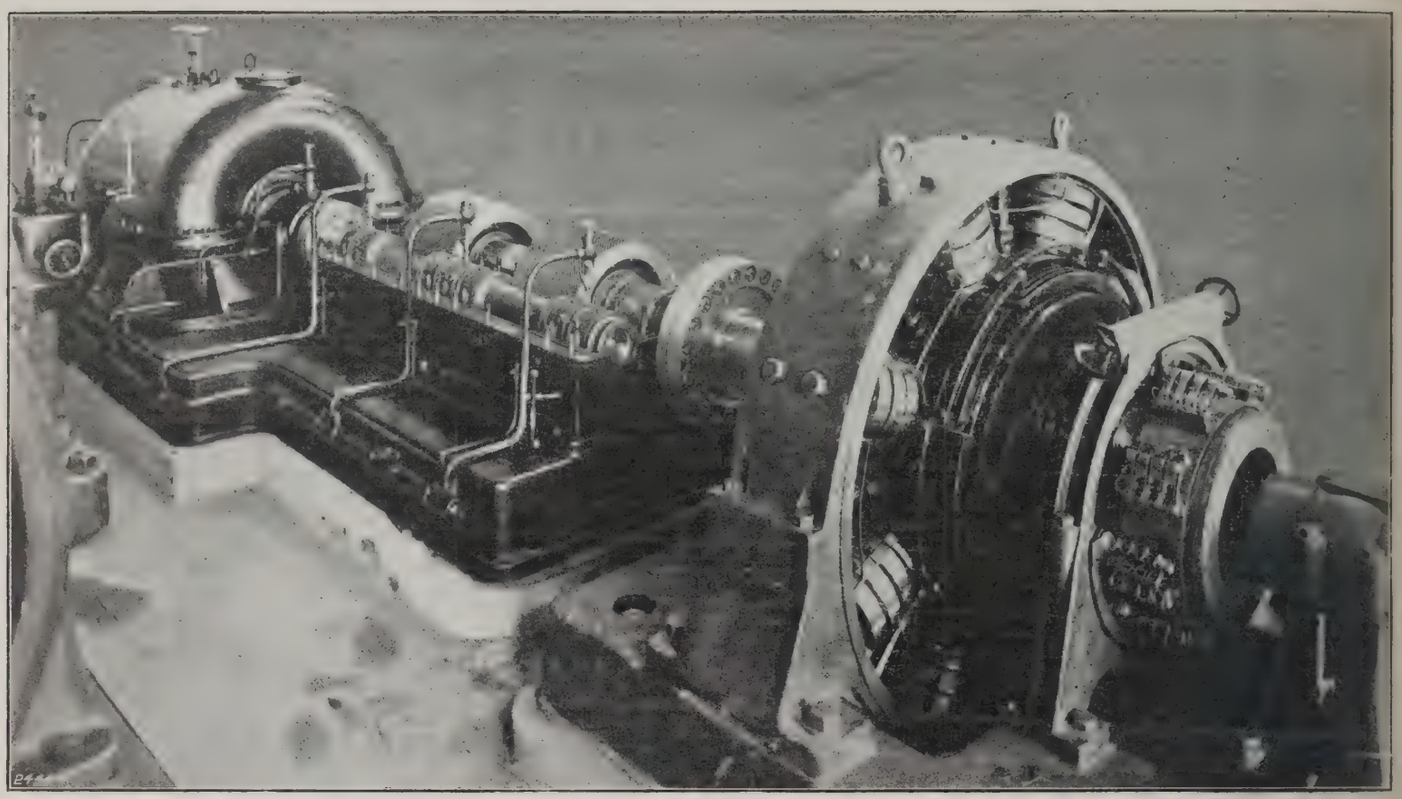


Fig. 1.

Kobe or Osaka, at 10s. per ton (regular freight rates being 17 rupees, or 1*l.* 2s. 8d.), under a guarantee by the shippers to pay freight on not less than a fixed minimum on each voyage. The effect of the large import of raw cotton on the amount of cotton yarns and goods imported is, of course, very great, as the Japanese mills are now able to supply not only a great part of the wants of the country, but also to produce sufficient to export considerable quantities to China and neighbouring countries. The position in Japan as regards imports and exports of cotton goods has become entirely reversed within the last few years; whereas in 1905 there was an excess of imports over exports of some 6,500,000 yen, in 1910 the excess of exports over imports was no less than 7,000,000 yen. There is a rapidly increasing demand for woollen goods, owing to the rising scale of living, and although the Japanese woollen mills have made great progress in recent years, the production is not yet sufficiently great to check the increased import of these goods from the United Kingdom and Germany. The other manufactures of Osaka are of a most miscellaneous kind in the mechanical and chemical industries. A large new harbour has been constructed, but the undertaking has, as yet, failed to have the result anticipated. The cost of construction of the harbour, as far as its present stage, has already exceeded 3,000,000*l.*, from which little return is being reaped, and it is to be hoped that the Government will not refuse to sanction the outlay necessary for the construction of the railway, by which alone the harbour can become of practical utility to the city. The Osaka municipal tramway system has proved a profitable source of revenue to the city, which is yearly being brought into closer connection with the outlying towns by the construction of electric lines. As in other parts of Japan, electric enterprises are greatly to the front in Osaka, and many proposals are being made not only for the production of electric light, but also motive power. There are numerous sources of water supply in Japan, and many of these are being utilised in a most efficient manner for the development of industries of all kinds.

COMPOUND DE LAVAL TURBINE AND REDUCTION GEAR.

As is well known, Dr. de Laval was the first to use spur gearing for lowering the speed of revolution of a turbine spindle to a figure better suited to the requirements of the machine to be driven. The original De Laval turbine, it will be remembered, comprised a single stage only, and hence the speed of revolution of the wheel was very high, ranging from 30,000 per minute in small sizes to some 10,000 in larger. Experience showed, however, that this system of operation was not very suitable for really large outputs, and in consequence the De Laval Steam-Turbine Company, of Stockholm, are now constructing compartment-compounded turbines of considerable capacity; but in the case of machines driving direct-current generators they are still retaining the reduction gear between the turbine and generator spindles. One of these new types of plant is illustrated above in Figs. 1 and 2.

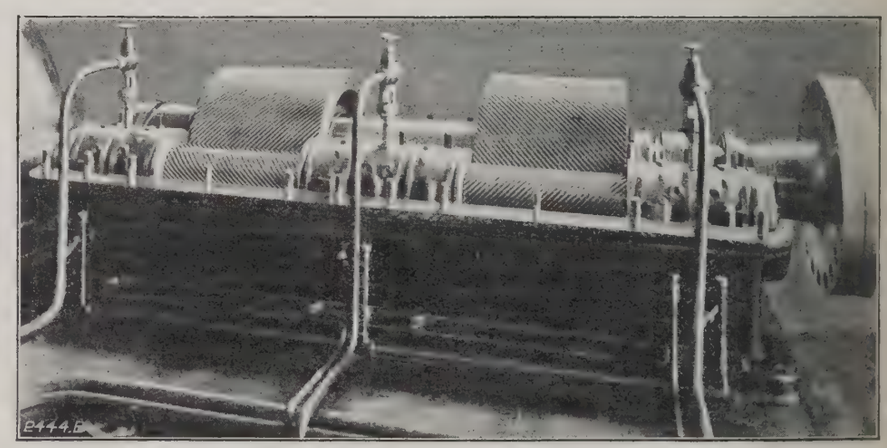


Fig. 2.

It is of 750 kw. capacity. The turbine is designed to run at 3000 revolutions per minute, and the generator at 750, the required reduction in speed being effected by a 4 to 1 double helical spur gear, of which a separate view is given in Fig. 2. In essentials the gear is similar to that already used so successfully in the single-wheel type of De Laval turbine. The pitch line speed is, however, much less. A relatively lesser width of tooth can therefore be used. The pinion-shaft is of considerable stiffness, and is, it will be seen, supported on three bearings. The noise produced is stated to be very small, and at the official reception tests was not greater than that due to the generator. The plant shown has now been running day and night for a period of several months, and in a recent test with steam supplied at a pressure of 150 lb. per sq. in. and 160 deg. Fahr. superheat, the consumption was 16.8 lb. per kilowatt-hour.

The plant has been supplied to the order of the Luossavaara-Kirunavaara Company, and is at present running in Kiruna.

Caucasian Manganese Ore.—A special committee appointed by the Russian Ministry for Commerce and Industry, for the purpose of considering what measures should be taken for the advancement of the manganese-ore industry in the Government of Kutais, has completed its labours, and arrived at the following results:—In the first place, a number of small branch lines should be built, by the Crown, from the Tschiatur railway to the different manganese-ore mines. Secondly, mechanical appliances should be installed to convey the ore from the mouth of the pits to the level of these branch lines. The cost of these installations is to be defrayed from loans made by those interested in the manganese-ore industry, which loans are to be paid back by an additional tax on the ore, probably about $\frac{1}{4}$ kopeck per pood. An additional extra $\frac{1}{4}$ kopeck is required by the controlling board of the industry in question.

TORPEDO-BOAT "SORIDDEREN," FOR THE DANISH NAVY.

CONSTRUCTED BY MESSRS. YARROW AND CO., LIMITED, SCOTSTOUN, GLASGOW.

We illustrate above the Danish torpedo-boat Soridderen, which has just been constructed by Messrs. Yarrow and Co., Limited, at their works at Scotstoun, near Glasgow, and has completed her official trials with most successful results. This vessel is 181 ft. 9 in. long by 18 ft. beam, and has a moulded depth of 10 ft. 4 in. High-tensile steel has been used in the hull for those portions of the structure which influence the longitudinal strength of the vessel, and mild steel for other portions. The hull is divided into ten main compartments: fore-peak, chain-locker, forward crew's space and bow torpedo-room, second crew's space, forward boiler-room, after boiler-room, engine-room, ward-room and officers' cabins, petty-officers' quarters, and steering compartment. Accommodation is provided for five officers (three of whom have separate cabins), eight petty officers and twenty-six men. The vessel is also installed with a wireless telegraph apparatus.

The armament consists of two 7.5-cm. quick-firing guns, one forward on the raised forecastle deck and one aft on the main deck; there are five torpedo tubes—viz., one built into the bow and two on each side.

The machinery consists of Brown-Curtis turbines constructed by Messrs. Yarrow, and steam is supplied by two of the latest type of Yarrow water-tube boilers designed for a working pressure of 265 lb. The boilers are both fitted with Messrs. Yarrow's latest arrangement for passing the main feed up the two outermost rows of tubes most remote from the fire. This system not only increases the efficiency of the boiler, but is conducive to the greater length of life of the tubes, as any oil carried over in the feed-water is deposited on the outside rows of tubes, which are those furthest from the intense heat. The official full-speed trial was of three hours' duration, and was run on the deep-water mile at Skelmorlie, at the mouth of the Clyde. The mean speed for the three hours was 27.217 knots, with between 4700 and 4800 shaft-horse-power, the load carried on the trial being 50 tons. The contract speed with this load on board was 27 knots. The slow-speed consumption trial was run at a speed of 14 knots with very satisfactory results, proving the high efficiency of the Yarrow boiler, and also the economical results of the Brown-Curtis turbine.

The trials were attended by Sub-Director Adolf, representing Captain Tuxen, the Chief Constructor of the Danish Navy, Captain H. Wenck, the captain of the vessel, and Mr. Henrichsen. It may be mentioned that Captain Rasmussen, who was unable to be present on the trials, was one of the first to realise the gain in speed due to running a vessel in shallow water, and great credit is due to him for the valuable investigations he made on this subject. It is now common knowledge that with high-speed craft the British Admiralty insist on all trials being run in deep water.

THE LATE SIR W. J. CROSSLEY, BART.

We regret to have to announce the death of Sir William J. Crossley, in a Manchester nursing home, on Thursday, the 12th inst., following upon an operation. Sir William Crossley had only been ill a few days. In him Manchester loses one of her most active citizens.

Sir William was in his sixty-seventh year. He came of Irish parentage, being the second son of the late Major Crossley, of Glenburn, Dunmurry, Co. Antrim. His early education was obtained at the Royal School, Dungannon, and was subsequently completed at Bonn. His engineering apprenticeship was served in the Elswick Works of Messrs. Sir W. G. Armstrong and Co., where he remained until he was twenty-three years of age. Thereupon, in the year 1867, he entered into partnership with his brother, the late Mr. Francis William Crossley, in the starting of the Openshaw Works, the firm of Messrs. Crossley Brothers ultimately developing into the gas-engine manufacturing business now known throughout the world. The brothers purchased the patents of Dr. Otto, whose name is identified with the one feature which

Photograph by Lafayette, Limited.

rendered gas-engine development possible in the earlier days, and is for most purposes still the best. The development of the industry was at first comparatively slow, though ultimate success was practically assured, the convenience of the new engine for small power units being indisputable. In the development of the engine the late Mr. Francis Crossley was responsible for many improvements. The foresight of the two brothers in acquiring the Otto patents placed their firm in the very front of the industry, giving them a good start in the field. Manchester thus had the honour of witnessing in its midst the early struggles of an industry which has had an immense influence on modern engineering.

As one of the founders of so important a firm, Sir W. J. Crossley somewhat naturally took an active part in the life of the city with which his business was associated. Manchester has in many ways benefited by the interest he took in the welfare of those less able to help themselves. He was chairman of the Manchester Hospital for Consumption, and founded, built, and endowed the Crossley Sanatorium for Consumptives at Delamere. In social work he took a very keen interest, especially in lads' clubs, the Y.M.C.A., and other organisations intended to turn the youth of the country into valuable national assets.

In 1903 the Corporation of Manchester conferred upon him the honour of Freeman of the City. He represented the Altrincham Division of Cheshire in Parliament from 1906 to 1910, but in the last election of the latter year failed to retain his seat. A baronetcy was conferred upon him in 1909 by his late Majesty King Edward VII. He was a member of the Cheshire County Council and Justice of the Peace for Manchester and Cheshire. He took an active interest in the Manchester Ship Canal, and was one of the original directors of the Canal Company. He was elected a member of the Institution of Mechanical Engineers in 1875, but seldom took a prominent part in the proceedings of that body.

He married in 1876 and leaves three sons, the eldest, Mr. Kenneth Irwin Crossley, succeeding to the baronetcy.

PASSENGER LOCOMOTIVE FOR THE BELGIAN STATE RAILWAYS.

Amongst the locomotives shown at the Turin Exhibition are two engines of the 4-6-2 type, constructed from the designs of Mr. J. B. Flamme, the Chief Engineer of the Belgian State Railways, for heavy passenger service on that system. One of these locomotives has been built by the Société John Cockerill, of Seraing, and the other by the Société Anonyme de St. Léonard, of Liége. Of the former of these engines, we this week publish general views in our two-page Plate LII. As we intend in an early issue to illustrate this engine in considerable detail, we shall for the present postpone our description.

Progress of the Parsons Marine Steam-Turbine: Erratum.—We regret that in our article under this head in last week's issue, page 505 *ante*, we stated that the dividend to be declared was 10 per cent., with a bonus of 5 per cent., whereas this latter should have been 2½ per cent.

The Royal Sanitary Institute: South African Branch.—The South African Branch of the Royal Sanitary Institute are arranging to hold a Congress in Cape Town on November 9, 10, and 11. This is the first sanitary congress to be held in British South Africa, and it is hoped that a large number of delegates will be sent by the municipalities and other authorities interested in sanitation. Among the subjects set down for discussion are, the disposal of sewage, the prevention of tuberculosis, the inspection of food, milk supplies, and school hygiene; papers will also be read dealing with other aspects of public health work. The South African branch, which has only recently been established by the Royal Sanitary Institute, seems to be energetically carrying on the traditions of the parent institution, and no doubt its work will have a beneficial effect in the development of public health administration in the Union of South Africa. The honorary secretary to the branch is Dr. A. Jasper Anderson, the Medical Officer of Cape Town.

INDUSTRIAL NOTES.

According to the Board of Trade *Labour Gazette*, issued on the 17th inst., the state of the labour market in September was as follows :—

Employment in the month showed, on the whole, some recovery as compared with August, partly in consequence of the termination of disputes in the transport and other industries. There was some decline in building and shipbuilding, but all the other principal trades improved, especially cotton.

Compared with a year ago there was an improvement in most of the principal industries, but there was a considerable decline in connection with blast-furnaces, and in the jute, linen, and lace industries.

In the 394 trade unions, with a net membership of 779,761, making returns, 22,850 (or 2.9 per cent.) were reported as unemployed at the end of September, 1911, compared with 3.3 per cent. at the end of August, 1911, and 4.3 per cent. at the end of September, 1910.

Returns from firms employing 457,903 workpeople in the week ended September 23, 1911, showed an increase of 3.6 per cent. in the amount of wages paid compared with a month ago, and of 5.1 per cent. compared with a year ago.

The changes in rates of wages taking effect in September were all increases, and affected 21,300 workpeople. The most important of these changes were those affecting 5500 coalminers in the Forest of Dean, 6500 workpeople in engineering and iron-moulding works at Lincoln, 1450 bakers at Glasgow, and 1220 gas-workers at Sheffield. The net amount of the increases is computed at 1200*l.* per week.

The most important disputes in progress during the month were those involving 7000 railway workers in Ireland, 4000 locomotive workers at Horwich, 3000 engineers' labourers at Manchester, 2000 holders-on in the Clyde district, 1300 coalminers at Wigan, and 1200 biscuit-makers at Carlisle. The number of new disputes beginning in September was 82, and the total number of workpeople involved in all disputes in progress during the month was 56,780, or 316,835 less than last month, and 12,638 less than in September, 1910. The total number of working days lost during the month by these workpeople was 560,400, or 1,763,400 less than in August, 1911, and 303,800 less than in the corresponding month of last year.

Cases dealt with under the Conciliation Act include those affecting cement-workers on the Thames and Medway; short-sea traders, London; ship and boiler repairers, London; dock workers, Deptford; stevedores, Queenborough; railway carriage workers, Manchester district; locomotive workers, Horwich; steel workers, Scotland; workers in steel trade, West Scotland; steel-workers, Shotton; coal-miners, Bristol; cigar-makers, London and Cardiff; chemical workers, Leicester; and carding-machine cleaners, Dumfries.

The monthly report of the Steam-Engine Makers' Society for October, in reviewing the work of the year 1911, which is now rapidly drawing to a close, advocates the "inculcation of sound trade-union principles that stand for stability and progress in everyday life, trade, and industry, as distinct from the pernicious nostrums and plausible fallacies which have been disseminated fairly broadcast by self-constituted leaders or misleaders, with but few, if any, tangible results of a lasting character, and certainly in value by no means compensating for the suffering and misery entailed. There are no short cuts to the millennium in trade unionism, as in everything else, and let us hope we have seen the last of recent fiascoes in the unhappy ending to the workers concerned in the miserable collapse and defeat of the railway workers in Ireland. If this is the latest industrial unionism—Syndicalism, or whatever other high-flown name it is known by—let us avoid it as we would the plague, and all its frothing and loud-mouthed prophets of the Tom Mann type, unless it is desired to place the trade-unionists where our forefathers were in the 'Hungry Forties.' The cant of these gentry is, indeed, nauseous, deliberately enticing their followers to do their best to put the clock of progress back, and shut their eyes, and, for that matter, their ears, to hard facts. That, the history of the nineteenth century clearly set forth and indicates." These are strong words, but they appear in a trade-union journal that represents a union of no mean success. It is needless to say that we heartily endorse them. The report evidently fully recognises the dangers which attend much of the latter-day unionism, and advocates a slower and surer method of progress than that extolled by the Socialistic group of unionists, for it continues :—"We want more recognition and collective bargaining with the employers; but this is alone obtainable in proportion as we are soundly organised, and willing to take on, through accredited representatives, responsibility for the due carrying out of mutual agreements between ourselves and the employers, and no flash-in-the-pan unionism (so-called), with strikes as its one and only weapon in the place of justice and reason, will achieve anything except disaster, nor will it carry us one single inch along the path we one and all desire to follow." We can only wish that such words of wisdom could be taken to heart by other unions, and the path they indicate followed, for then we should doubtless hear less of sectional strikes, faithlessness to agreements, and rebellion against the advice of leaders that have proved a scandal during the last two years.

The monthly report of the Society of Amalgamated Tool-Makers for October shows that the membership in September stood at 5727, against 4360 in September, 1910—an increase of 1367, which may be regarded as very satisfactory. There was a slight decrease in the number of unemployed, the number being 96 in September last, and 99 in September, 1910. The reserve stood in the same months at 23,500*l.* and 17,500*l.* respectively. This is certainly very satisfactory, and naturally is the cause of congratulation among the members. During the last two months 500 new members joined. The half-year ending June last showed an increase in membership, in income, and in the reserved fund. The gain in membership during the first six months of the year was 631, as against 358 for the first half of 1910. During the same six months there was, however, a slight increase in the benefits paid over the similar period in 1910, which was due to the fact that this year 700*l.* 1s. sick dividend was paid, as against 591*l.* 3s. in 1910. The report contains an appreciative notice of the late Mr. Henry Broadhurst, a representative of the old type of unionism.

According to the monthly report of the Associated Iron-Moulders of Scotland for October a satisfactory state of affairs exists in the society. The report closes the third quarter of this year, and takes in the four weeks from August 26 to September 23. The total membership at the close of the quarter was returned at over 8000. The net income for the last month was 2272*l.* 18s. 11½d., and the outlay 2129*l.* 14s. 4d. The dues and contributions for the month showed an increase of 206*l.* 1s. 4d., while the levies were up by 43*l.* 6s. 8½d. The idle benefit for the month was less by 210*l.* 15s. 4d. than in the previous month, the superannuation benefit being higher, amounting to a rate of 10d. per week to each member chargeable.

The October number of the monthly report of the United Society of Boiler-Makers and Iron-Shipbuilders shows that, at the end of September, the total membership was nearly 60,000, which figure will, it is hoped, be actually reached by the end of the year. The increase during the month was 435, which is regarded as very satisfactory. There was an increase of 2597*l.* 8s. 10d. in the expenses for the month over the expenses for August. The report contains an appreciative account of the life of the late Robert Knight, J.P., who for 29 years was general secretary of the society.

The monthly report of the Associated Blacksmiths' and Ironworkers' Society for the six weeks ending October 7, 1911, states that there has been an increase in membership during that time of forty-six, which is looked upon as satisfactory. As a result of a conference with the London Ship Repairers' Association a minimum wage of 45s. per week has been conceded, which means an advance of from 3s. to 5s. per week, and in the shipyards advances in wages have been conceded throughout the whole area, amounting to ¼d. per hour where payment is made by the hour, and 5 per cent. is added to piece rates, the advance to take effect from October 11, 12, or 13. The income for the past six weeks was returned at 1094*l.* 6s. 10½d., and the expenditure at 768*l.* 9s. 6d. for the same period, the details being as follow :—Employment benefit, 98*l.* 10s. 5½d.; superannuation allowances, 251*l.* 14s. 3d.; sick benefit, 184*l.* 10s. 4½d.; funeral benefit, 45*l.*; management expenses and grants, 189*l.* 4s. 5d. This indicates a net gain to the funds of 327*l.* 3s. 10½d.

Another stoppage of work occurred in South Wales last Saturday, when 4000 men at the Cambrian Trust Collieries at Clydach Vale, Glamorganshire, were rendered idle by the action of one of their number, who had, it was stated, been removed by the management from the pit bottom to the coal face. It had been announced by the management that, owing to the fact that the colliery horses had become tender after nearly a year of idleness, steps had been taken that the animals should not be overworked, and it had been intimated to the haulers that any ill-treatment would be put down with a firm hand. In spite of this, twenty-six horses are in the stables suffering from injuries. One hauler in particular, who was engaged at the pit bottom, was accused, and it was decided that he should be put to work at the coal face, where he would be under the supervision of the master hauler. It is stated that on Monday last the man struck an official, and a summons was issued against him. He was, on Tuesday, sentenced to six weeks' imprisonment, the stipendiary contending that discipline must be maintained by the colliery officials. A meeting was held by the haulers, and they decided to demand the reinstatement of the man in question in his old position, but this demand was withdrawn on Tuesday, when it was agreed that work should be resumed.

The recent railway strikes in England have naturally attracted much attention in Scandinavia, and caused serious apprehensions on the Continent, and a high German official has pointed to what he considers the only efficient remedy. A great railway strike is a most serious calamity in times of peace, and still more so in times of war; light punishments, or threats of punishment, discharge, or the employment of other systems of transport by motor-cars, steamers, &c., are absolutely inadequate. A strong and reliable remedy is needed, and this can only be found by the army being trained for railway service in cases of railway strikes. The few special railway regiments are entirely unable to grapple with such a situation, when in Prussia alone there are more than 600,000 railway men. If, however, soldiers, according to their position in private life, were told off to the various branches of railway work and afforded temporary practice, an efficient staff of railway men would be available in cases of emergency. The work in question is not difficult in reality, and fairly intelligent soldiers within a comparatively short time could become so skilled that the railway service could be carried on without any risk. The training which this plan would entail would not, it is urged, be wasted, at least so far as many are concerned, inasmuch as it might be useful to them in after life. That the Social-Democrats would oppose a measure like the above goes without saying.

During the year 1910 there were in Austria 708 strikes and lock-outs; but full particulars do not appear to be forthcoming as yet. The strikes affected 2185 concerns, with 96,160 employees, of whom 47,166, or 49 per cent., went out; 106 strikes, with 14,402 hands, were group strikes, and 435, with 32,764 hands, were isolated strikes. Of each 100 strikes 42.9 per cent. lasted up to 5 days, 18.7 per cent. from 6 to 10 days, 9.6 per cent. from 11 to 15 days, 19.1 per cent. from 16 to 50 days, and 7.6 per cent. from 50 to 100 days. Dissatisfaction with wages was the cause of the conflicts in 350 cases, dissatisfaction with the hours in 81 cases; 67 strikes originated from the discharge of workmen; 43 strikes had their cause in dissatisfaction with the labour and other arrangements; thirteen strikes were brought about by reduction of wages, and thirteen were due to dissatisfaction on the part of the men with their superiors. In 98 cases, which affected 4935 hands, the men gained their point fully; in 263 cases, comprising 30,502 hands, the men were partly successful; whilst 177 strikes, affecting 11,692 hands, had no successful results for the men, so that 65.1 per cent. of the strikes, with 75.2 per cent. of the men who had gone out, were attended by success for the men. Of the strikes, 386, or 71.4 per cent., were offensive strikes, and 104, or 19.20 per cent., defensive strikes, the nature of 50, or 9.4 per cent., being undefined. The lock-outs affected 121 firms, with 17,602 hands, of whom the lock-outs comprised 16,962 hands,

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Delegates of the Scandinavian Employers' Union (Swedish, Danish, and Norwegian), forming a permanent committee, recently held a meeting in Copenhagen preparatory to a congress of the Scandinavian Employers' Unions to be held in the course of November. This congress will, it is stated, be largely attended, and some very important questions will come up for discussion. The programme comprises the subjects of Syndicalism and the subject of the importance of long-period agreements and effective collective agreements. Arbitration and insurance against strikes will also be dealt with.

Contracts.—The directors of the Great Central Railway have decided to open out the Darnall Cutting and make four lines of railways in an open cutting in place of the two lines which at present go through the tunnel. They have let the contract for this to Messrs. Robert McAlpine and Sons, of Glasgow and London. The amount of excavation in opening out this tunnel is about 300,000 cubic yards, mainly rock.—The United States fleet collier Neptune, which is a vessel 542 ft. long, 65 ft. broad, 39 ft. 6 in. deep, and of a displacement of 19,400 tons, is to be fitted with the porhydrometer. The steam-coal dépôt owners, Messrs. G. H. Collins and Co., Limited, of Dartmouth and Portland, have likewise fitted the porhydrometer on their hulk Haytian.—The Rheinische Stahlwerke, who installed one of the first electrically-driven reversing rolling-mill plants, and whose plant showed remarkable results, both as to the economy and the output obtained, have recently placed a repeat order with Messrs. Siemens Brothers Dynamo Works, Limited, for an additional electrically-driven reversing rolling-mill plant. That firm now have twenty-four electrically-driven reversing rolling-mill plants on order or at work, and a number of firms who have adopted the electrical drive for their reversing-mills have decided to instal further plants of this type.

WOLSELEY MOTOR-CARS.

The Wolseley motor-car has long held a high reputation, not only for economy in fuel, but in the more important desideratum of reliability, a result of continuous study and experiment as to mechanical details, by which alone simplicity in arrangement and freedom from breakdowns can be ensured. Just as there can be no finality in mechanical science, so in the design of the structural parts and machinery of motor-cars improvements are ever possible; and the exhibit of the Wolseley Tool and Motor-Car Company, Limited, at the forthcoming show at Olympia will once more establish that the company are fully conscious of the importance of progress dictated by a wide experience. The improvements made are illustrated on pages 528, 529, and 532; but before entering upon a detailed description of them, some reference may be made to what may be termed the general programme of manufacture; and first it will be noted from the table of particulars of this year's models of cars, given below, that only one new type has been introduced: the 35—40 horse-power car, which gives an acceptable power for clients who desire a car ensuring in hilly country an average speed equal to the maximum allowed by law; with a heavy limousine body and load it can run up steep gradients at a good speed, so that no excess need be resorted to on down gradients or on the level to give a high average speed. More than this is not sought by the great majority of British motorists, less is unacceptable to those willing to pay for it. This 35—40-horse-power car takes the place of the 30—34 horse-power and the 40-horse-power cars in previous years' programmes. The other models remain the same: the 12—16 horse-power, the 16—20 horse-power, and the 20—28 horse-power four-cylinder engined cars, and the 24—30 horse-power and 50 horse-power cars with six-cylinder engines. The dimensions, &c., of this year's cars are given in the table.

Fig. 5.

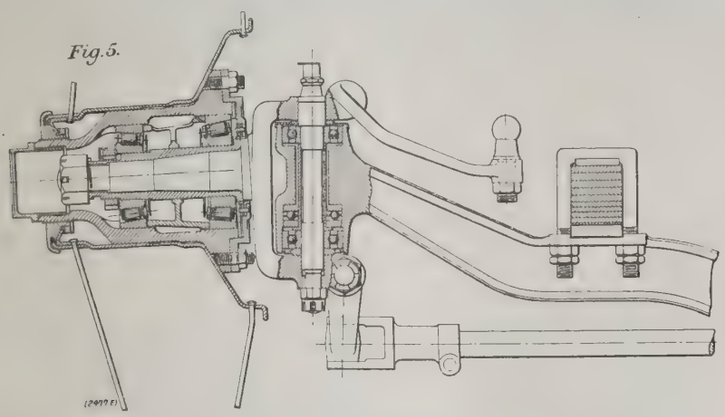


Fig. 5. Bearings for Side Load and Thrust on 12—16-Horse-Power Car.

for the extra power given by the engine. The 20—28 horse-power model has been considerably altered as regards dimensions with a view to reducing its weight. The width of the frame has been decreased to 32 in., but the track remains unchanged. The chassis is produced in two forms, both of the same wheel-base. One form, intended for open bodies, is fitted with 32-in. wheels and easy-riding springs; the other, for closed bodies, is fitted with 34-in. wheels, and springs intended to take large, heavy bodies. In both models three-quarter elliptical springs are embodied.

The 24—30 horse-power chassis model has had little modification except those incidental to all cars, to be described later, and a few detailed modifications to the machinery, such, for instance, as an increase of the bevel-teeth surface to enable lower gears to be used without overstressing. The only serious alteration to this car individually is in the clutch. This has been improved in various minor details to improve its pick-up, and make it more durable when very heavy bodies are mounted.

The 35—40-horse-power chassis, as already stated, is an entirely new model. The engine has four cylinders of $4\frac{3}{4}$-in. bore by $5\frac{1}{8}$-in. stroke. The crank-shaft is mounted in five bearings. The carburettor is of the three-jet type. The 50 horse-power car has been considerably changed. Modifications of the lubrication arrangement have been made to improve the accessibility of the strainer, and to provide means for cleaning the oil-tank and other parts of the lubrication system. The radiator has had its cooling surface increased to compensate for the increased engine-power at high speeds. Improvements have been made in the clutch, particularly with a view to making it more durable when very heavy bodies are fitted. The gear-box has been entirely re-designed, as will be described later. The arrangement of ball-bearings and of mounting the gears is also improved, with a view to increasing the durability of the gear-box, as will presently be described. Detail modifications have been made to the live axle to reduce the stresses in certain parts when lower gears are fitted, to take advantage of the increase of power of the engine at high speeds. The suspension has been improved by fitting longer springs at the rear, the transverse arrangement being retained, and as a result of experiments stiffer springs are fitted at the front. The width of both front and rear springs is also increased to increase the lateral stability of the suspension. A longer wheel-base than heretofore has been introduced to give better accommodation for large bodies, particularly of the cabriolet type. The introduction of this extra long wheel-base is in a great measure responsible for the modifications to the springs and clutch.

Particulars of Wolseley Motor-Cars, 1912 Models

Makers' Horse-Power.	R.A.C. Rating (also H.P. by Treas. Formula).	Engine. Bore.	Stroke.	No. of Cylinders.	Normal Revolutions.	Wheel Base.	Track.	Body Space. Dash to End of Frame.	Width of Frame.	Number of Gears.	Drive.	Axle Standard Ratio.	Road Speed (Miles per Hour) at Normal Engine Revolutions. 1st.	2nd.	3rd.	4th.	Tyres. All Wheels.
						ft. in.	ft. in.	ft. in.	in.								mm.
12—16	15.6	$3\frac{1}{8}$ in. by	$4\frac{3}{4}$ in.	4	1200	9 3	4 1	7 8	30	3	Worm	8/35	$7\frac{1}{2}$	15	26	..	810×90
16—20	20 3	$3\frac{5}{16}$ in. by	$4\frac{3}{4}$ in.	4	1200	9 8	4 $4\frac{1}{2}$	7 11	32	4	Worm	9/37	7	14	21	28	815×105
16—20	20.3	$3\frac{5}{16}$ in. by	$4\frac{3}{4}$ in.	4	1200	10 4	4 $4\frac{1}{2}$	8 7	32	4	Worm	8/35	$6\frac{1}{2}$	13	19	26	820×120
20—28	25.6	4 in. by	$5\frac{1}{2}$ in.	4	1000	10 9	4 6	8 7	32	4	Bevel	18/65	$7\frac{1}{2}$	12	18	26	820×120
20—28	25.6	4 in. by	$5\frac{1}{2}$ in.	4	1000	10 9	4 6	8 7	32	4	Bevel	18/69	$7\frac{1}{2}$	12	18	26	880×120
24—30	30.4	$3\frac{9}{16}$ in. by	$5\frac{1}{2}$ in.	6	1000	10 10	4 6	8 11	34	4	Bevel	18/65	8	13	19	28	895×135
35—40	36.1	$4\frac{3}{4}$ in. by	$5\frac{1}{8}$ in.	4	1000	10 10	4 6	8 11	34	4	Bevel	18/65	8	13	19	28	895×135
50	48.6	$4\frac{1}{2}$ in. by	$5\frac{3}{4}$ in.	6	1000	11 9	4 8	9 0	34	4	Bevel	18/62	10	16	22	31	935×135
50	48.6	$4\frac{1}{2}$ in. by	$5\frac{3}{4}$ in.	6	1000	12 3	4 8	9 6	34	4	Bevel	18/62	10	16	22	31	935×135

The alterations made in dimensions, &c., may be briefly indicated before we come to details in the changes in mechanism. In the 12—16 horse-power car—first in the table—the stroke has been increased from $4\frac{1}{2}$ in. to $4\frac{3}{4}$ in., which gives a most appreciable increase in power. The rear springs have been increased in length and flexibility to improve the suspension. The under-frame has been abandoned, principally for manufacturing reasons, but an incidental result is a slight decrease in chassis weight.

As regards the 16—20 horse-power chassis a considerable number of alterations have been made, to be referred to later, and the short wheel-base chassis has been slightly increased in length to give more room for the door in torpedo bodies. The radiator, still of the honeycomb type, as in the case of other cars, has had its cooling surface increased to compensate

We come now to the changes in details made and more or less common to all sizes and powers of cars, the more important of which are illustrated on pages 528, 529, and 532. Figs. 1 and 2, on page 528, show the elevation and plan respectively of the 20—28-horse-power chassis, and these drawings can be taken as representative of the chassis for all the cars enumerated in the table. The chassis is generally the same as that made last year by this company, but a number of detail improvements have been made in this as well as in the other models, as indicated by the further illustrations. In accordance with previous practice, the cylinders are cast in pairs, the lubrication is automatic, the carburettor is pressure-fed, the clutch is of the multiple-disc type, the gear-box provides four speeds forward and one reverse, the axle is bevel-driven and is of the free floating type, and the wheels run on extensions of the axle-tubes. When we come to the suspension, however, we find that there is a considerable change. After a series of extensive experiments the Wolseley Company have adopted, on certain models, a system of three-quarter elliptical springs, in which the main spring is slung below the axle and pivoted on to a swivelling bracket at the front end, in line with the hub of the road wheel. The position of the pivot in combination with the camber of the spring provides a vertical straight-line motion for the wheel over a considerable range, and this has the effect of considerably improving the comfort of the suspension, and also makes the car ride and steer better on rough roads. The arrangement of this suspension will be readily followed by reference to Figs. 3 and 4, on page 528, the latter being a photograph of the rear end of a 16—20 horse-power chassis, which model is also fitted with this new suspension.

Another feature which is now embodied in all of this company's productions, with the exception of their smallest (the 12—16 horse-power) car, is a ball-bearing swivel, in which separate bearings are arranged to take the side load and thrust. Although this additional application of ball-bearings has the effect of making the steering slightly easier, the principal reason for its adoption is to increase durability. The arrangement of these bearings is shown in Fig. 5, annexed, which also illustrates the taper-roller bearings employed for the hubs, and the plan adopted for fitting the now well-known Rudge-Whitworth detachable suspension wire wheels, which this company has for the first time adopted as standard on all its productions, following on from the previous policy of fitting them to order at an extra charge.

No serious change has been made in the arrangement or use of various ball and roller bearings, except that the use of Timken bearings has been extended; this type of bearing is now being used on the 20—28-horse-power car for all hubs as well as on the hubs of the 12—16-horse-power and 16—20 horse-power, as before.

In the case of the engines, little change has been made in the working parts. Figs. 6 and 7, on page 529, show sections through the 16—20-horse-power engine; this is representative of all the models, with the exception again of the 12—16 horse-power, which, although largely similar, has the four cylinders cast *en bloc* (Fig. 12, page 532). The only serious alteration made in any of the engines is carried through the whole series, and consists in the provision of silent chains for driving the cam-shaft and other auxiliaries in the place of spur-gears. This arrangement is new to this company, but is not by any means novel, and has been adopted by them after a protracted series of experiments. The arrangement of chains on all models is similar, and is illustrated in detail by Fig. 8, on page 529, and is further shown in the perspective view, Fig. 11, on page 532. This latter is an end view of the 16—20-horse-power engine with the end casing and fan removed.

The 12-horse-power engine, which has its cylinders cast *en bloc*, as above mentioned, is shown in the perspective view, Fig. 12, on page 532. The 24—30-horse-power engine, which has six cylinders, $3\frac{9}{16}$ in. bore, cast in pairs, but is otherwise very much on the same lines as the other engines, is shown in Fig. 10, on page 532. Covers are provided over the valve tappets and springs. It is well known that valves can only maintain silence if the plunger bearings are in perfect condition, and it is the wear of these bearings that largely contributes to the noisiness of the valves on worn engines. The casing over these parts does not tend in any way directly to the reduction of noise, and makes no difference to the silence of new engines, but, by keeping out dirt, lengthens the life of the tappet bearings, and thus helps to minimise wear and reduce noise. It will be recollected that these covers were used throughout last season on the 40-horse-power and 50-horse-power models, where they proved their success, and they are now embodied on all models. After a series of exhaustive experiments on cam form, as affecting horse-power, it has been decided slightly to alter the lift and timing of the valves and the cam form, the effect being to increase the power of the engines, particularly at high speeds, without increasing the noise made by the tappets.

It is now fairly well known that a lot of the rattles and knocks that become apparent in a car after considerable wear are caused by slack in the spring-pins

WOLSELEY MOTOR-CAR; CHASSIS OF 20—28-HORSE-POWER CAR.

CONSTRUCTED BY THE WOLSELEY TOOL AND MOTOR-CAR COMPANY, LIMITED, ADDERLEY PARK, BIRMINGHAM.

Fig. 1.

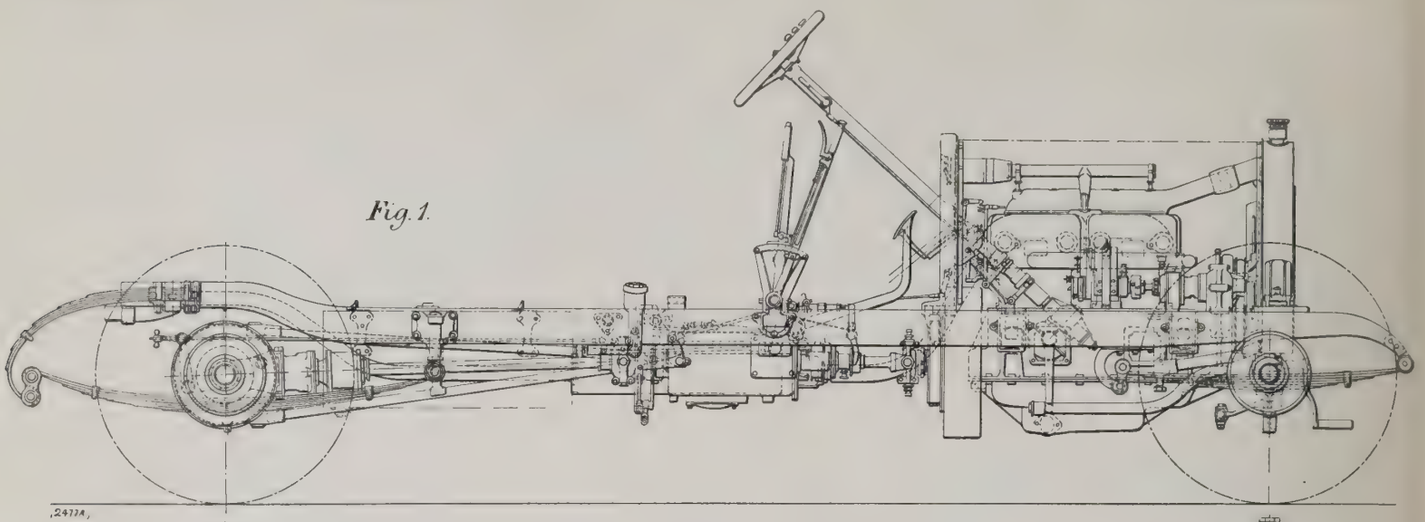


Fig. 2.

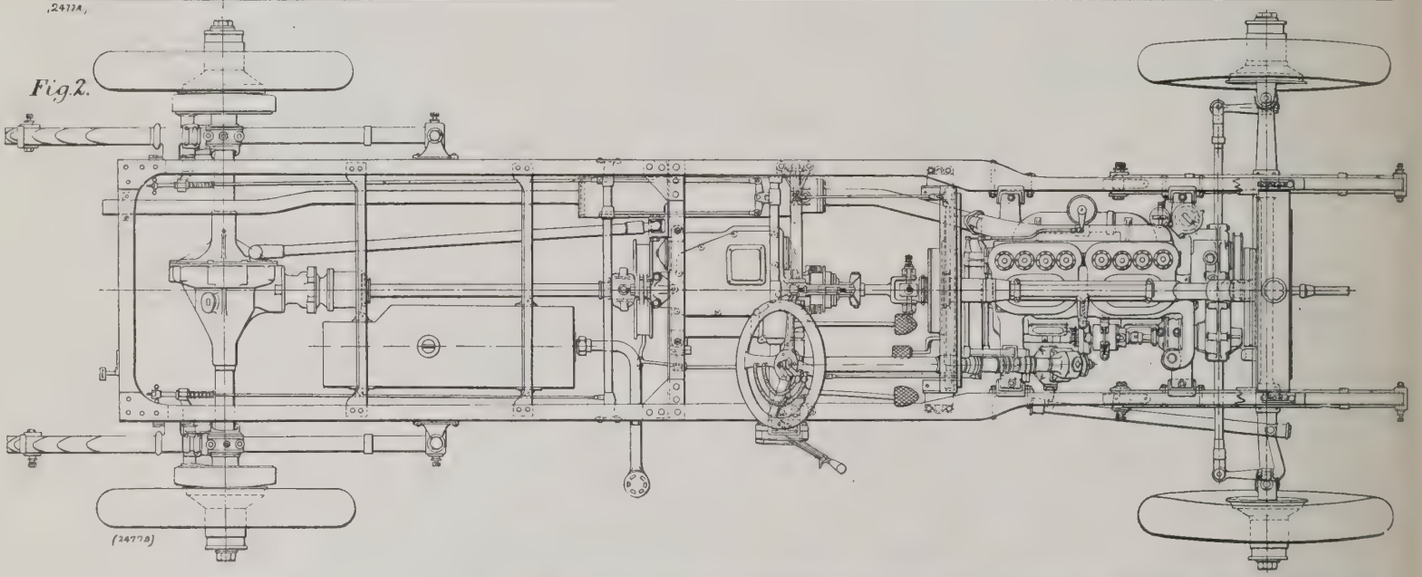
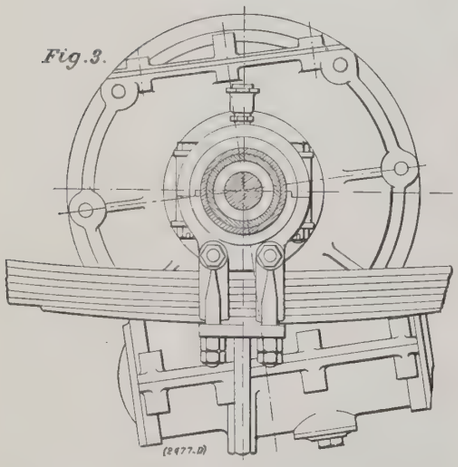


Fig. 3.



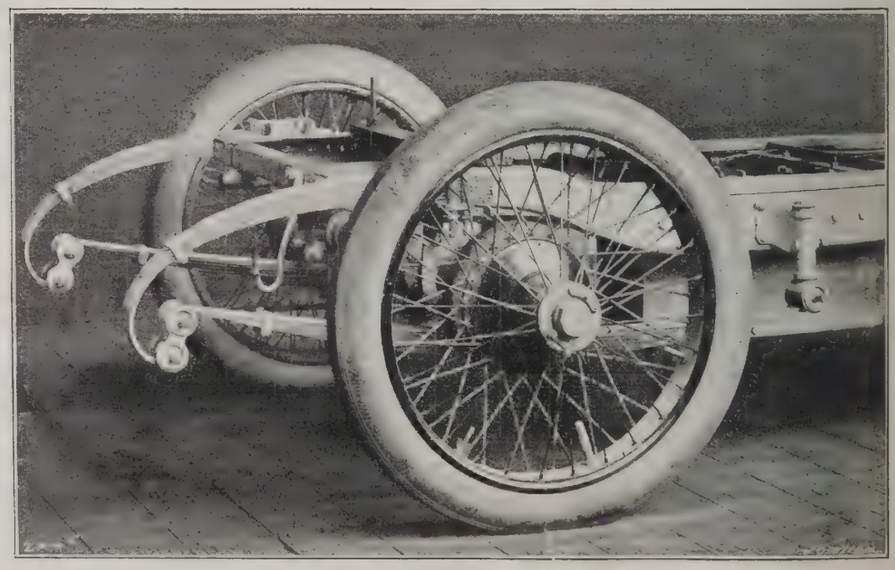


Fig. 4.

both endwise and in the bearings. The slackness is produced more quickly in some chassis than in others, and is partly due to small bearing surface and partly due to lack of lubrication, either by negligence or the difficulty of ready lubrication. Every spring-pin joint on all models is now provided with a hardened pin, which is fixed in such a manner as to prevent its rotation even through the smallest angle. This pin is hollow, and is provided with a grease lubricator and proper grooves for leading the grease all over the bearings. The bearings working on the pins and carried by the springs are composed of two flanged P.B. bushes. Owing to the size of the pin the bearing surface is ample, and the end thrust is taken by the large flanges above referred to. These flanges work on properly faced steel housings, which are in all cases of the box type, to exclude water and grit as far as possible.

In the case of the 16—20-horse-power and 20—28-horse-power cars, where underslung three-quarter elliptical springs have been adopted, the front bracket is made to swivel (somewhat after the style of a plain bearing steering-head) to improve the lateral flexibility of the live axle. The fact that the C-shaped quarter-spring has very little lateral stability assists this action in the same way as does the cross-swivel link attachment to transverse springs on the larger models. This arrangement of three-quarter spring has been found to give better riding qualities than semi-elliptical springs, particularly on light cars, by enabling the cars to hold the road better, and is considerably lighter than the transverse arrangement still retained for the large models that are used principally for closed carriages.

Both 6-cylinder models are fitted with the new

WOLSELEY MOTOR-CARS; 16—20-HORSE-POWER ENGINE, CAM-SHAFT CHAIN-DRIVING GEAR AND SILENCER.

CONSTRUCTED BY THE WOLSELEY TOOL AND MOTOR-CAR COMPANY, LIMITED, ADDERLEY PARK, BIRMINGHAM.

Fig. 6.

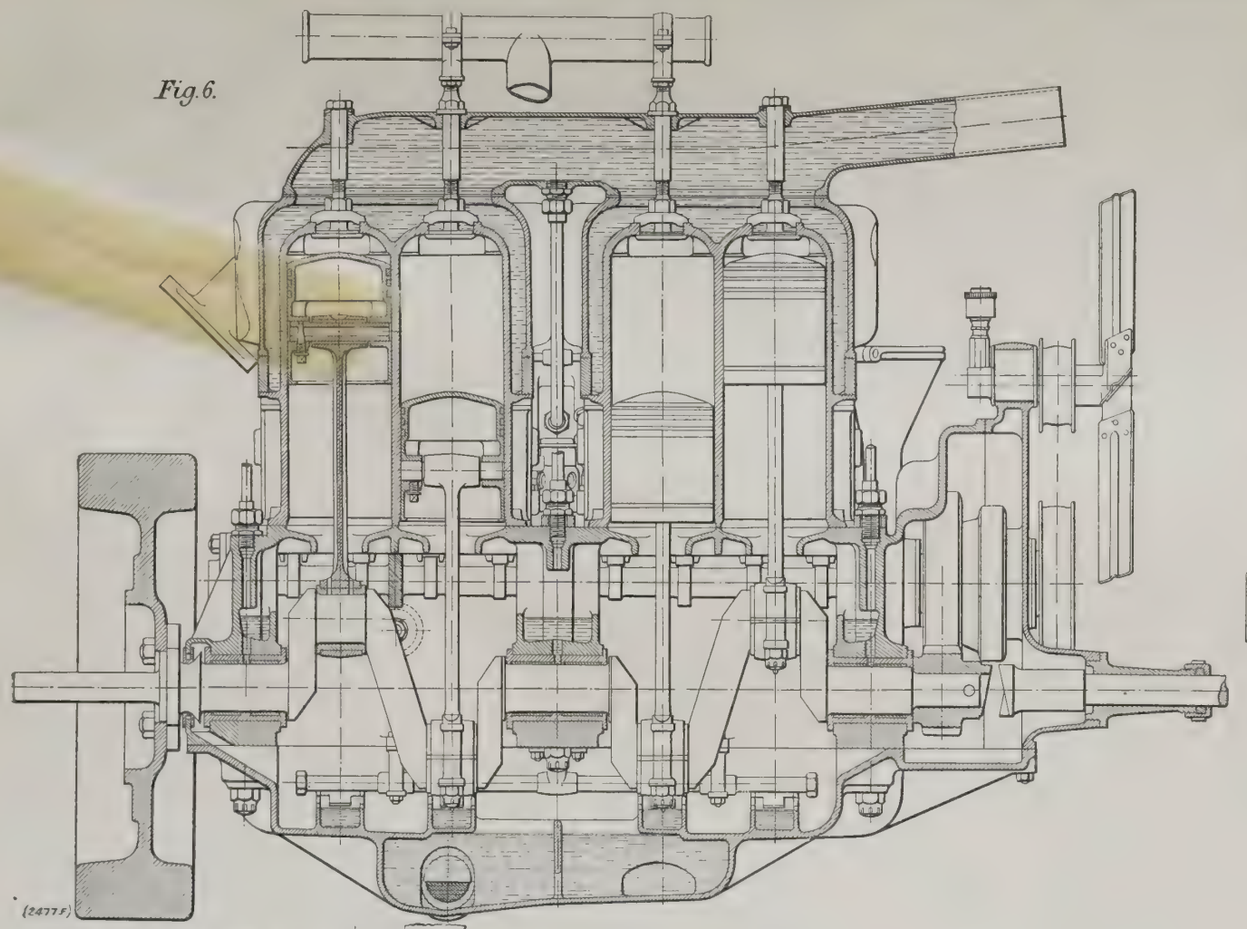


Fig. 7.

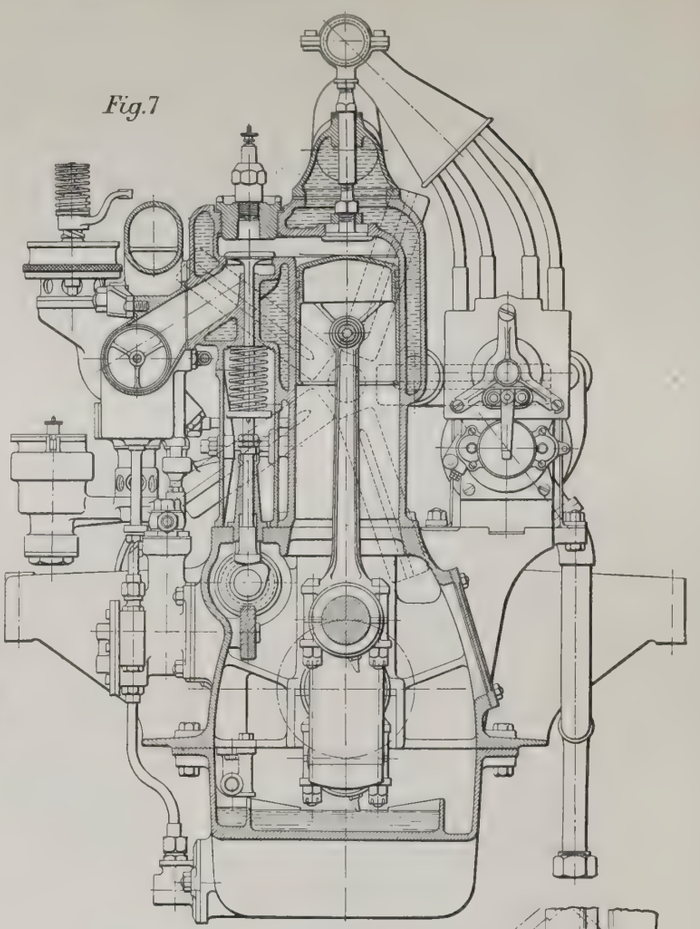


Fig. 8.

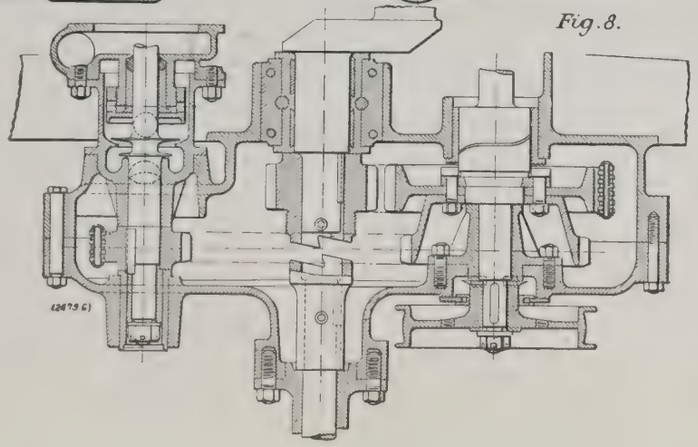
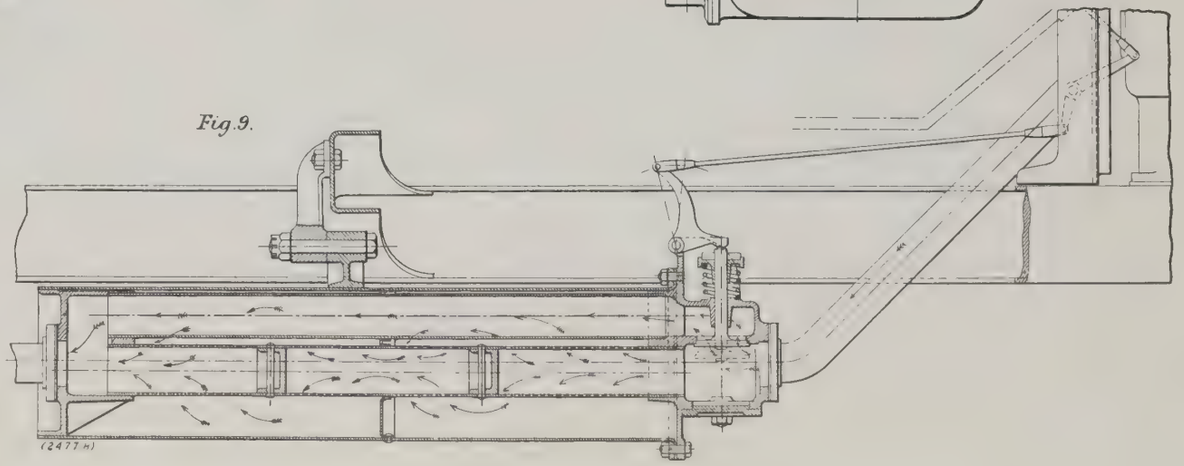


Fig. 9.



comparatively well-known independent dual form of Bosch magnetos, in which two sets of plugs are used, and the coil-switch so arranged that either ignition may be used separately or both simultaneously.

Detail modifications have been made to the air-pump which supplies the pressure for the petrol feed in all models with the exception of the 12—16 horse-power, which has gravity feed. A sleeve has been provided on the air intake, so that the amount of air pumped can be regulated, and slight modifications have been made to the delivery valve to render it more durable and facilitate dismantling.

As a result of a large amount of research in connection with carburettors, it has been decided to adopt a carburettor of the floating-weight taper-needle type on the smaller models, where the power range is not so great as in the larger engines. This carburettor will perhaps not give much better results than the 3-jet type of carburettor heretofore in use, but gives quite equal results on small cars, is much simpler, and likely to require less attention in the way of adjustment, to compensate for wear or leakage. No control for the air is provided or required, and this simplifies the control in the case of the smaller cars. On the larger cars the 3-jet carburettor heretofore in use is still retained, and is provided with the third lever on the steering wheel for altering the strength of the mixture.

It will be noticed that, in adopting chain-drives, this company has altered the position of the pump and magneto, which are now placed in tandem, the magneto being driven by a spindle which passes right through the pump, both pump and magneto being mounted very high on the off side of the engine, for accessibility.

A rather novel silencer for the engine exhaust is about to be standardised on certain models. It is a combination of the standard silencer with a "cut-out" operated by a special valve, which short-circuits a portion of the gas, and thus relieves the inevitable back pressure of the silencer without producing anything approaching the noise usually associated with a "cut-out." The arrangement of this new silencer will be obvious from an inspection of Fig. 9, on page 529.

Gear-boxes show little alteration, as this part of the company's product is now fairly well standardised and open to little improvement. A new gear has been designed especially for the 50-horse-power six-cylinder model, and this is shown in Fig. 13, on page 532. It will be noticed that, contrary to usual practice, the gears constantly in mesh are at the rear end of the box, which has the effect of reducing the momentum of the parts directly coupled with the member comprising the driven portion of the clutch; and, furthermore, that when the gear is in neutral position, no meshed gears are driven by the clutch.

NOTES FROM THE UNITED STATES.

Philadelphia, October 11.

The disposition of the great body of the larger consumers of iron and steel is not to take immediate advantage of the present continuing weakness in quotations. While the weakness shows itself only in a fractional way, and in reply to inquiries, the fact of the willingness of makers to yield even to the least has the effect of holding up business. Strange as it may appear, a hardening tendency in prices at this time would bring quite a volume of business. In a general way iron and steel-making capacity is employed from 60 to 80 per cent. of total capacity. The wire-mills are more fully engaged, the rail-mills less fully. This unfavourable condition is more apparent when measured by percentage, because of the large additions made to manufacturing capacity during the past year or so. In other words, capacity has been expanded faster than consumptive capacity has grown. This would not have been so apparent had no discouragements been thrown in the way in the shape of the enforcement of legislative control over corporations, under the Sherman Law. There is a strong feeling manifesting itself against the rigid enforcement of this law, and it was sincerely hoped that the executive branch of the Government would give heed to the protests made by business interests against a too active campaign against corporations for alleged violation of this law. But it seems that the Administration will follow its mapped-out course, and that corporations must conform their business methods and managements to comply strictly with its provisions. The week's business has been of fair proportions. Structural material and plate have been shaded to the lowest quotations known for years. The most favourable indication is that the withheld demands must sooner or later be precipitated on the market.

Light Railways Act, 1896.—The Board of Trade have recently confirmed the undermentioned Order made by the Light Railway Commissioners:—Burry Port and Gwendreath Valley Railway (Light Railway Extension) Order, 1911, authorising the reconstruction and working as a light railway of a further part of the railways of the Burry Port and Gwendreath Valley Railway Company, in the county of Carmarthen.

TRIALS OF AN OERLIKON 3000-KILOWATT TURBO-GENERATOR.

Last year the Oerlikon Company received an order for a 3000-kw. turbo-generator, which was installed in the Stand-by Central Station of the Société Lyonnais des Forces Motrices du Rhone, at Cusset-Villeuxbanne, and which was recently tested.

The turbine is designed for a steam pressure of 15 atmospheres, a steam temperature of 350 deg. Cent., and a speed of 1500 revolutions per minute. The generator was specified to give a normal continuous output of 3000 kw. at a power factor of 0.65, as also 3500 kw. during two hours at the same power factor. The excitation current is supplied by a separate exciting machine. The condensing plant is of the Paris Westinghouse Company's make, consisting of a surface-condenser and the requisite rotary air, circulating and force pumps, all three direct coupled to a 72-brake-horse-power Oerlikon small steam-turbine, running at a speed of 1500 revolutions per minute. The measured condensed steam includes the steam consumed by this small machine.

The results recorded are tabled below:—

3000-Kilowatt Oerlikon Steam Turbo-Generator at the Central Station of Cusset, April, 1911.

	Number of Test.			
	1.	2.	3.	4.
1. Date	April 10	April 10	April 11	April 11
2. Duration of trial in minutes	120	120	120	40
3. Load	½	½	¼	⅛
4. Revolutions per minute	1510	1509	1506	1507
5. Steam pressure at the turbine in atmospheres	14 0	14.1	14.0	13.8
6. Temperature at inlet in deg. Cent	347.9	351.7	350.3	349.5
7. Steam pressure in front of second set of nozzles in atmospheres	3.8	3 8	11.9	12.3
8. Temperature of exhaust steam measured at low-pressure end of turbine in deg. Cent.	19.1	19.5	26.4	29.5
9. Vacuum in condenser in per cent. absolute	97.83	97.80	97.5	97.1
10. Total steam consumption in pounds per hour, including steam consumption of 72 B.H.-P. turbine	20,827	20,779	38,799	45,749
11. Three-phase energy in kilowatts	1555. 8	1594.9	3165 6	3574.9
12. Power factor	0.675	1.0	0.665	0.715
13. Steam consumption per kilowatt-hour at above power factor, including condenser work, but excluding excitation, in pounds	13.37	13.02	12.25	12.80
14. Energy consumption for excitation at power-factor unity, in kilowatts	18.48	18.57	21.12	22.88
15. Steam consumption per kilowatt-hour at power-factor unity, including excitation energy, but excluding condenser energy in pounds	12.38	12.32	11.62	12.19
16. Efficiency of generator	89.5	89.5	93.0	93.5
17. Steam consumption per B.H.-P.	8.16	8.12	7.94	8.40

The electrical measurements were made by means of precision wattmeters, calibrated after the tests by the laboratories of the Swiss Electro-Technical Institution in Zurich. The condensed steam was measured by means of carefully calibrated tanks. The steam of the condenser-pump turbine is, as already aforesaid, included in these figures, and the tabulated values cannot, therefore, without adjustment, be compared with the figures usually recorded at official trials; and in making comparisons it must be borne in mind that during the test trials Nos. 1, 3, and 4, the power-factor at which the generator worked was exceptionally low. The influence of the small condenser turbine is, of course, particularly adverse to the over-all results, as naturally a 72-brake-horse-power turbine running at 1500 revolutions per minute works with a relatively small efficiency. The influence of the power-factor can be easily ascertained for half-load from the test-points 1 and 2 of the tabulated figures.

At test No. 1 the generator worked with a power factor = 0.675, and at test-point No. 2 on a water resistance. If the difference in the temperature interval is taken account of in comparing above two trial points, the steam consumption increase at power factor 0.675 amounts to 2.2 per cent. above that when running at power-factor unity. For the recalculation of the direct readings of test results, under 3 and 4, the steam values are assumed to be correct; though it is only natural that at greater loads the average influence of the lower power factor is larger.

Careful measurements, which were made with the pump-turbine, showed that at full load, test No. 3, the turbine-driven condenser-pumps consume 3.3 per cent. of the total steam; at half load, test Nos. 1 and 2, 6 per cent., and at overload, test No. 4, about 2.9 per cent. of the total steam consumption values, which values are considered as rather low for turbine-driven pumps. The energy consumption of the excitation at non inductive load was actually measured for trial No. 2, whilst that for the trials 1, 3, and 4 have been ascertained by calculation.

In order to obtain the steam consumption per brake horse-power, measured at the turbine shaft, the efficiency of the current-generator has to be inserted in the figures of the individual tests in accordance with line 16 of the table.

Canadian Elevators.—The number of grain-elevators in the Dominion of Canada is returned at 1909—viz.: British Columbia, 6; Alberta, 249; Saskatchewan, 904; Manitoba, 707; Ontario, 19; Eastern Transfer, 24. The aggregate capacity of the 1909 elevators is 106,462,700 bushels.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday the pig-iron market was quiet, and at the morning session no dealings of any kind were recorded. Cleveland warrants were quoted by sellers at 46s. 2½d. cash, 46s. 6d. one month, and 47s. 1½d. three months. Hematite was quoted at 60s. 3d. cash buyers, and 61s. 6d. cash sellers. The market was stronger in the afternoon, when 3000 tons of Cleveland warrants were done at 46s. 3d. and 46s. 4d. cash, and at the close there were sellers at 46s. 4½d. cash, 46s. 8d. one month, and 47s. 3½d. three months. Cash buyers of hematite again offered 60s. 3d., and sellers quoted easier at 60s. 6d. On Friday morning Cleveland warrants were nominally firmer, but no dealings took place, and closing sellers' quotations were 46s. 5d. cash, 46s. 8½d. one month, and 47s. 4d. three months. Sellers of cash hematite quoted 60s. 6d., but buyers only offered 60s. The tone was stronger in the afternoon, and some 5000 tons of Cleveland warrants were done at 46s. 5d. cash, and 46s. 8d. one month; and at the close the quotations were 46s. 5½d. cash, 46s. 8½d. one month, and 47s. 4½d. three months sellers. Hematite was still offered at 60s. 6d. cash sellers, while buyers' quotations were up a little at 60s. 1½d. On Monday morning the market improved, and Cleveland warrants were put through at 46s. 6d. cash and eight days, 46s. 7d. nine days, 46s. 9½d. one month, and 47s. 6d. three months. The business amounted to 4500 tons, and closing sellers quoted 46s. 7d. cash, 46s. 11d. one month, and 47s. 6d. three months. Hematite was stronger at 60s. 3d. buyers and 61s. cash sellers. The afternoon session was quiet but steady, and 2500 tons of Cleveland warrants changed hands at 46s. 10d. one month and 47s. 5½d. three months. Sellers' closing prices were 46s. 7d. cash, 46s. 11d. one month, and 47s. 5½d. three months. Buyers of hematite offered 60s. 6d. cash, but there were no sellers. Cleveland warrants were the turn easier on Tuesday morning, and 4000 tons were done at 46s. 6d. cash and 46s. 9d. one month, and at the close sellers quoted 46s. 6d. cash, 46s. 9½d. one month, and 47s. 5d. three months. In the afternoon the market was dead idle, and quotations for Cleveland warrants were 46s. 6d. cash, 46s. 9½d. one month, and 47s. 4½d. three months. When the market opened to-day (Wednesday) an easier tone prevailed, and 4000 tons of Cleveland warrants were dealt in at 46s. 3½d. cash, 46s. 4½d. five days, and 46s. 5d. nine days. The closing quotations were 46s. 4½d. cash, 46s. 8d. one month, and 47s. 3d. three months sellers. Cash hematite was quoted 60s. 6d. buyers, and 61s. sellers. In the afternoon there was little doing, but Cleveland warrants were nominally steady, and one lot changed hands at 46s. 4½d. cash. At the close of the session there were sellers at 46s. 4d. cash, 46s. 8d. one month, and 47s. 3d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 61s. 6d.; Gartsherrie, 62s.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 63s. 6d; Shotts (at Leith), 62s. 6d.; and Carron (at Grangemouth), 63s. 6d.

Sulphate of Ammonia.—Little change has lately taken place in the sulphate of ammonia market, and a good demand still prevails. The present tendency in price is certainly upward, and the current quotation is from 14*l.* 5s. to 14*l.* 7s. 6d. per ton for prompt delivery, Glasgow or Leith. The amount shipped from Leith Harbour last week was 2497 tons.

Scotch Steel Trade.—The Scotch steel trade has not undergone any particular change since last report, and producers of heavy material are very well employed. The volume of new business being booked is exceedingly small, and the present activity is almost entirely due to the large number of specifications being given out against old contracts. Shipbuilders are busy and have the prospects of booking a number of new orders in the near future, and the outlook for steel-makers is, therefore, quite bright. The export trade continues very satisfactory, and some respectable lines in plates and angles have just been fixed up for shipment to Australia and Japan. Black-sheet makers report no change in their branch of the industry, but producers of thin plates, &c., are not booking new business quite as freely as they would like, although the shipping departments are still fairly busy.

Malleable-Iron Trade.—The malleable-iron makers in the West of Scotland are still fairly well employed, and as specifications have recently been moderately plentiful, the output is presently very good. Prices are not at all satisfactory, however, and while some makers will not sell under 6*l.* 2s. 6d. per ton, less 5 per cent., for crown bars, there are others who are still quite willing to take business at 6*l.* per ton, less 5 per cent. A higher level of values is likely to come into force very soon, as the tendency all round is for a rise in prices, as raw material generally is advancing.

Scotch Pig-Iron Trade.—Business in the ordinary qualities of Scotch pig iron has not been of very large dimensions this week, as local consumers have been buying but sparingly. It cannot be denied that the demand from the south is not as large as makers here would like, but, on the other hand, a fair tonnage is going through for export, and India, Canada, and Japan have each been free purchasers this week. The hematite position is very weak, and, with a poor demand, the price is no better than 64s. per ton, and some buyers are even offering 63s. per ton.

Shipbuilding.—Messrs. Russell and Co., Port Glasgow, have received the order to build a large steamer for Messrs. Andrew Weir and Co., of London and Glasgow. The engines will be supplied by Messrs. Rankin and Blackmore, Greenock.—Messrs. Ferguson Brothers, Port Glasgow, have contracted to build and engine a

powerful single-screw tug for the Clyde Shipping Company. This will be the eighth tug turned out during the past few years for that company by Messrs. Ferguson.—Messrs. Alexander Stephen and Sons, Linthouse, have secured the contract to build two of the four steamers recently ordered by Messrs. Elders and Fyffes, London. The other two are to be built at Belfast, and each of the four is to have extensive cold-storage accommodation.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

A Wave of Prosperity.—Unlike one or two winters of recent years, when the pinch of unemployment has been keenly felt in Sheffield, there is every prospect of highly prosperous conditions for the next few months, granted immunity from serious labour troubles. A wave of good trade is at present passing through the city, and in the heavy trades particularly employment is thoroughly good. Curiously enough, and paradoxical as it seems at first sight, the cause of this is partly to be traced to the very factors which may at a later date have an adverse effect upon trade. It is more than probable that the present unrest throughout Europe is responsible for a good deal of the activity in the armament departments, and, so far as general shipbuilding is concerned, the great developments in ocean-going liners, and the keen competition between the companies, have caused corresponding developments at the Sheffield firms, which do much of the heavy work for these vessels. New and more costly machinery has had to be installed, and there have been all-round extensions to meet these new demands. In other departments, such as engineering and railway steel, there has been a big growth of activity.

South Yorkshire Coal Trade.—Anxiety in regard to a possible coal strike is not now so pronounced, and things in the coal trade have been somewhat easier. There is practically no change in shipments of hard coal, or, if anything, a decrease. Manufacturers continue to take large quantities for industrial consumption, and this is stated to be the reason for further price advances. Both in steam coals and gas fuels, where the demand continues active, the difficulty of getting through supplies is still acutely felt, owing to the shortage of wagons. There have been further price advances in house coal, and this fact, with the continuance of mild weather, has had the effect of checking buying. Consequently merchants have not, during the week, had to deal with such large tonnages, but they have been busy despatching arrears, and the recent fogs have further aggravated the existing railway delays. These orders on hand are likely to keep merchants busy for some time, even if few new orders come forward. Quotations on the local Exchange last Friday were:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. 6d. to 13s. 6d.; Silkstone, 11s. to 12s. 6d.; Derbyshire brights, 12s. 6d. to 13s.; Derbyshire house, 10s. to 11s.; large nuts, 10s. to 11s.; small nuts, 6s. 6d. to 8s.; Yorkshire hards, 9s. 3d. to 10s.; Derbyshire hards, 9s. to 10s.; washed nuts, 8s. 6d. to 9s. 6d.; rough slacks, 6s. 6d. to 7s. 6d.; seconds, 4s. 6d. to 5s. 6d.; smalls, 2s. to 3s.

Iron and Steel.—Even the most conservative estimates agree in describing the present busy condition of the Sheffield industries as exceptional. In fact, it is a long time since prosperity was so generally spread throughout the various departments. The staple trades are all well supplied with orders, and their dependent branches are, as a consequence, actively engaged. The iron market remains in much the same condition as for a few weeks past. Reports to hand show that the consumption of steel-making irons recently has been very heavy, amounting to something like a record. The result of the quarterly meeting at Birmingham was further to strengthen the market, and hematite has been a little firmer in price. Quotations for common irons are maintained at the same level. Billets and basic iron generally are selling well at firm prices. Scrap is weak. When the general improvement in trade has been taken into consideration, the activity of the Sheffield trades may be partly accounted for by the pressure on contracts delayed at the time of the strike. Then the prospects of trouble in the coal world are causing a speeding-up in various departments. Whilst the labour trouble is averted things promise to continue very busy, as a good many firms are in arrears with their orders, amongst them many of the rolling-mills. The engineering departments are benefiting, especially from the volume of work coming into the heavy trades. The demand for tool-steel and tools, both at home and abroad, is very good, and a better inquiry is expected shortly from America, whose takings have latterly shown a considerable falling off.

PERSONAL.—Messrs. Ozonair, Limited, 96, Victoria-street, Westminster, S.W., advise us that, in consequence of the extension of their business, they have appointed Mr. R. Borlase Matthews, Wh. Ex., M.I.E.E., to the position of manager.—We understand that Messrs. Franco Tosi, the well-known engineers of Legnano, Italy, have sold their turbine which attracted so much notice at the Turin Exhibition to the Municipality of Rome for their City Central Lighting Station. This firm have a large number of orders in hand both for their steam-turbine and Diesel engines.—The British Thomson-Houston Company, Limited, are removing their Leeds office from Greek-street Chambers to Standard Buildings, City-square, and the telephone number will be the same as previously—namely, 3244 Central.—Messrs. Haslam and Schontheil, Limited, 11, Windsor-place, Cardiff, have been appointed selling agents in South Wales and Monmouthshire for Messrs. Ed. Bennis and Co., Limited, Little Hulton, Bolton, for the sale of their various types of stokers, conveying and elevating plant, coal-bunkers, &c.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—After a brief turn of activity and an upward movement in values, the market is once more flat and lifeless. Buyers are again backward, and values are moving downward. This is quite contrary to general expectation, for it was hoped and believed that the rise which set in last week would be continued. Deliveries of pig are heavy, and promise to continue so on contracts made some little time ago, but new orders are, at present, very difficult to obtain. No. 3 Cleveland pig, after having rather readily realised 46s. 9d. for early f.o.b. delivery, has been sold by both makers and merchants at 46s. 7½d., and the latter are now offering the ruling quality at 46s. 6d. There is some gratification in the fact—as indicating that confidence in the future is not altogether gone—that rather more has to be paid for forward than for early delivery. Business over next month cannot be done under 46s. 9d., and for delivery of No. 3 to the end of the year the quotation is fully 47s. No. 1 was put at 50s. 3d.; No. 4 foundry, 46s. 3d.; No. 4 forge, 46s.; and mottled and white iron, each 45s. 9d.—all for early delivery. East Coast hematite pig is lifeless, and weak in price. The recognised market quotation for early delivery of Nos. 1, 2, and 3 is 60s. 6d., but business is possible at less, and, in fact, as low as 59s. 10d. has been accepted. There is very little doing in foreign ore, Market quotations are based on 19s. 6d. ex-ship Tees for best Rubio, but it is understood that that rate could be shaded.

Shipments and Stocks of Pig Iron.—Shipments of pig continue on a satisfactory scale, averaging to date this month 3791 tons per working day, as compared with 4212 tons to the same date last month, and a daily average of 3558 tons for the corresponding part of October last year. Stocks of Cleveland pig in the public warrant stores are being steadily reduced. So far this month the decrease has been at the rate of 628 tons per working day. To-night the stock stands at 584,576 tons.

Manufactured Iron and Steel.—In all branches of the manufactured iron and steel industries a vast amount of work is being turned out. Consequent upon large contracts made, some firms have orders booked which will keep them fully employed over the greater part of next year. There are a fair number of inquiries still in the market, but, so far as can be ascertained, they do not seem to lead to much business just now. Principal market quotations stand: Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 7s. 6d.; iron boiler-plates, 7*l.* 7s. 6d. to 7*l.* 10s.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 7s. 6d. to 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and galvanised corrugated sheets, 11*l.* 5s.—sheets less 4 per cent. f.o.b., railway material net at works, and all other descriptions less 2½ per cent.

BUILDING RISKS ON TWO FOREIGN BATTLESHIPS.—What is believed to be the largest individual insurance ever placed has just been completed, according to the *Times*, in connection with a battleship to be constructed by Sir W. G. Armstrong, Whitworth, and Co., Limited, for the Brazilian Government. The exceptional amount is accounted for partly by the fact that insurances on the hull, armour, and guns were effected at the same time, whereas hitherto it has been customary to insure the hull of a new warship at first, and then to come to the underwriters again when work was progressing for insurance on the armament. The hull of the Brazilian vessel is valued at 850,000*l.*, the armour at 520,000*l.*, and the guns and mountings at 900,000*l.*, making a total of 2,270,000*l.* When arranging this important business the brokers also effected insurances on a battleship to be constructed by the same company for the Chilian Government. In this case the hull and materials are valued at 665,000*l.*, the armour at 410,000*l.*, and the guns and mountings at 975,000*l.*, giving a total of 2,050,000*l.* The risk in both instances includes that of launching and lasts until the vessels are handed over to the buyers, with a limit of two years, while provision is made for extending the insurances beyond this period if necessary.

NEW TEES TRANSPORTER BRIDGE.—Prince Arthur of Connaught visited Middlesbrough on Tuesday, the 17th inst., and, among various public functions, inaugurated the transporter bridge erected by the Corporation across the River Tees, as illustrated in a recent issue of ENGINEERING (see pages 629 and 755 of vol. xci.). The Prince, who was the guest of Sir Hugh and Lady Bell, Mayor and Mayoress of Middlesbrough, in the course of the ceremony, referred to the great advantage of free intercommunication in facilitating the progress of commerce, and commended the enterprise of the Corporation in this and in other respects. He spoke of the wonderful progress which had been made owing to the active measures pursued by the Borough Council and by the Tees Commissioners. Addresses were also presented by the Corporations of Stockton and Thornaby. Having been presented with a gold switch by Lady Arrol, the Prince set the transporter in action. Alderman McLauchlin, pioneer of the scheme, Sir William Arrol, contractor, Messrs. C. F. Dixon and G. Imbault, of the Cleveland Bridge Company, Mr. Burgess, the borough engineer, and others were presented to the Prince. The party crossed the river in the car, and subsequently made a trip down the Tees upon the invitation of the Commissioners.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Most of the holders of Admiralty steam-coal, being well stemmed and fairly well placed for the remainder of the month, show little or no disposition to make concession—if anything, they exhibit, indeed, an opposite tendency. Upon the whole the steam-coal trade has shown no material change. The best large steam-coal has made 16s. 9d. to 17s. per ton; secondary qualities have ranged between 15s. and 16s. 6d.; best ordinary bunker smalls between 7s. 6d. and 8s.; and cargo smalls between 6s. 6d. and 7s. per ton. The best ordinary household coal has been quoted at 14s. 6d. to 16s. 6d. per ton; No. 3 Rhondda large at 17s. to 17s. 6d.; and smalls at 10s. 3d. to 10s. 6d. per ton. No. 2 Rhondda large has realised 11s. 9d. to 12s. 3d.; and smalls, 6s. 3d. to 6s. 9d. per ton. Foundry coke has been quoted at 18s. to 20s. 6d.; and furnace ditto at 16s. to 17s. per ton. As regards iron ore, Rubio has made 18s. 6d. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Welsh Coal for Italy.—The Italian Government is showing a disposition to make large purchases of Welsh steam coal. The South Wales colliery proprietors, who are on the British Admiralty list, have been invited to quote prices and quantities available for delivery to the Italian navy from the middle of November, 1911, to the close of May, 1912.

Dowlais.—The Goat Mill has been engaged upon heavy steel rails and tin-bar, and has been fully employed. The Big Mill has been turning out light and small section steel rails for colliery purposes, as well as fish-plates. The Bessemer and Siemens furnaces have had a capital output.

Swansea.—The Swansea Harbour Trustees are utilising part of the canal property, which they purchased from Mrs. Tennant, by filling it in where it intersects the properties at the King's dock and the Prince of Wales' dock. When the tipping is finished there will be 50 to 100 acres of land between the two docks available for letting.

More Welsh Coal.—A colliery company working in Glamorganshire and Monmouthshire has taken from the Llanarth estate an area of about 2000 acres of coal property in the Sirbowy Valley, and will open new sinkings near Pontilanfraith. It is expected that these will be some of the deepest sinkings in South Wales, reaching possibly to 700 yards. They are down to the steam coal, which has already been tapped by Messrs. Burnyeat, Brown, and Co., near Ynysddu. The Sirbowy Valley is being opened out to a large extent, and it is predicted that it will become a second Rhondda.

OUR LOCOMOTIVE EXPORTS.—The value of our locomotive shipments in September showed a heavy decrease, the total for the month coming out at only 62,780*l.*, as compared with 176,271*l.* in September, 1910, and 173,263*l.* in September, 1909. There was a great contraction in the South American, the South African, and the Antipodean demand; the shipments made to India were, however, fairly good.

MR. JOHN F. M'INTOSH, M.V.O.—Many of our readers will be pleased to learn that Mr. John F. M'Intosh, the chief mechanical engineer and locomotive superintendent of the Caledonian Railway, had conferred upon him the decoration of "Member of the Victorian Order" by the King, on his recent journey from Balmoral. Mr. M'Intosh has held his present position for sixteen years, and completes his jubilee of service with the Caledonian Railway Company in February next, so that this Royal recognition comes most appropriately, and signalises distinguished services, not only to the Caledonian Company, but to locomotive engineering generally, in view of the originality in design and success in practice of Mr. M'Intosh's engines.

SUPERINTENDING ENGINEER, ROSYTH NAVAL HARBOUR.—We understand that Colonel S. H. Exham, R.E., who has been superintending engineer of the Rosyth Harbour since the inception of the scheme seven years ago, retires under the age regulation on January 1 next, and that he will be succeeded by Mr. H. Cartwright Reid, M. Inst. C.E., who is at present superintending civil engineer at Chatham. Mr. Reid was responsible for the works at Malta, which we fully illustrated and described two years ago, and no doubt the experience he gained there, and the successful character of the work performed, influenced the Lords of the Admiralty in appointing him as successor to Colonel Exham in the responsible position of superintendent of probably the largest engineering work at present in progress in England or Scotland.

THE 13.5-IN. GUN-MOUNTINGS FOR H.M.S. "CONQUEROR."—During last week the pit trials of the 13.5-in. barbette mountings for the new battleship Conqueror were carried out by the Admiralty officials at the erecting works of the Coventry Ordnance Works, Limited, at Scotstoun, near Glasgow. The mountings passed all the tests with great success, and will now be transferred to the battleship, which is in process of construction at Messrs. Beardmore's shipyard at Dalmuir. These are the first hydraulic mountings to be made by the Coventry Ordnance Works, and the design includes many new features and improvements upon former types, especially with regard to the rapidity and certainty of manipulation of the guns. The armour of the gun houses is composed entirely of curved plates, a practice which of late years has been avoided in favour of straight plates on account of the difficulties of manufacture with modern armour.

WOLSELEY MOTOR-CARS; ENGINES AND GEARING.

CONSTRUCTED BY THE WOLSELEY TOOL AND MOTOR-CAR COMPANY, LIMITED, ADDERLEY PARK, BIRMINGHAM.

(*For Description, see Page* 527.)

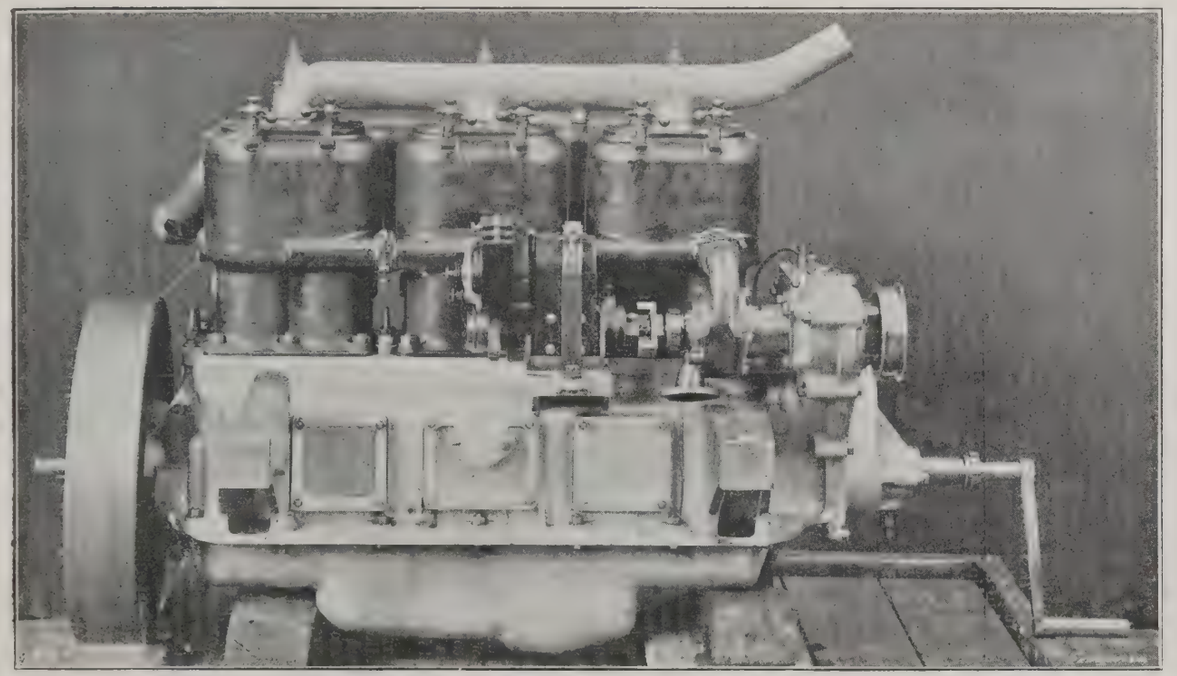


Fig. 10. Six-Cylinder 24—30-Horse-Power Engine.

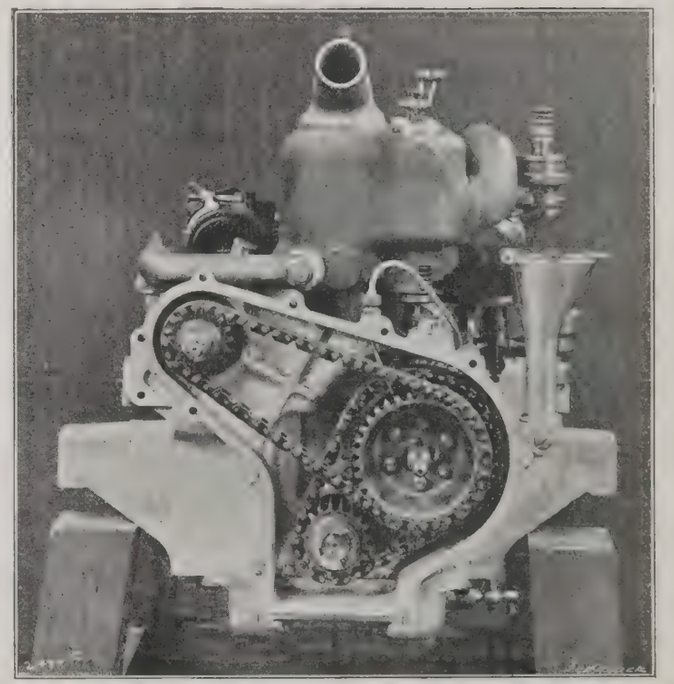


Fig. 11. Cam-Shaft Chain-Driving Gear; 16—20-Horse-Power Engine.

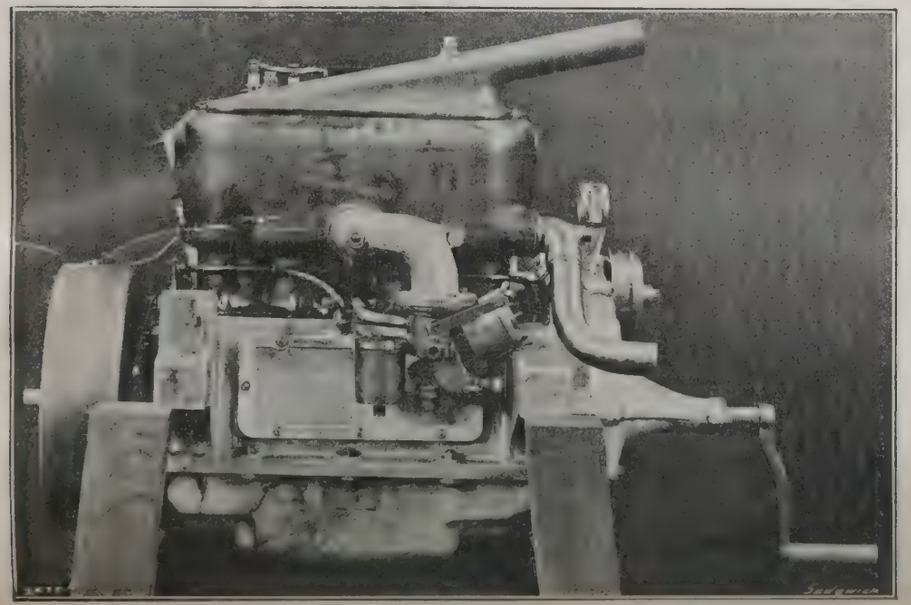


Fig. 12. 12—16-Horse-Power Engine with Four Cylinders Cast *En Bloc*.

Fig. 13.

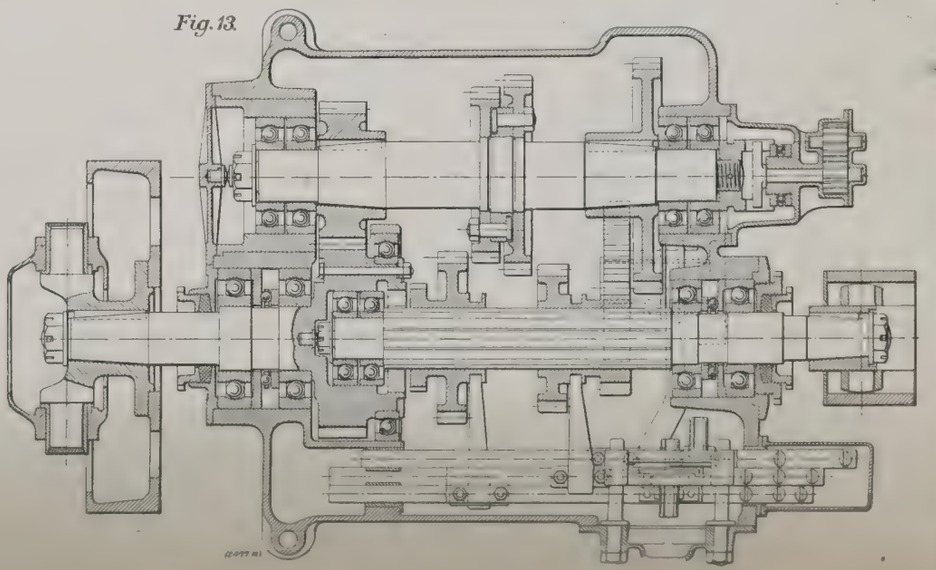


Fig. 13. Gear-Box of 50-Horse-Power Car.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 20, at 8 p.m. Paper to be read and discussed:—"The Endurance of Metals; Experiments on Rotating Beams at University College, London," by Mr. E. M. Eden, of the Armstrong College, Newcastle-on-Tyne, Mr. W. N. Rose, and Mr. F. L. Cunningham, Graduate, of London.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, October 21, at 7.15 p.m., at the Institute, Wolverhampton-street, Dudley. Mr. Alex. G. Strathern, M.I. Mech. E., will read a paper on "The Manufacture of Weldless Steel Chains."

THE INSTITUTE OF MARINE ENGINEERS.—Monday, October 23, at 8 p.m. Paper:—"Steam-Turbine Theory," by Mr. F. J. Kean, B Sc. (Member).

THE INSTITUTE OF SANITARY ENGINEERS.—Monday, October 23, at Caxton Hall, Westminster, S.W., when a discussion will be opened on the Parliamentary Bill on "Sewers and Drains," by Mr. Percival M. Fraser, A.R.I.B.A. (Fellow). Mr. A. J. Martin will take the chair at 7.30 p.m.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, October 24, at 8 p.m., the first general meeting of the fifty-fifth session will be held in the Rankine Hall of the Institution, at which Mr. E. Hall-Brown, President, will deliver his inaugural address.

THE CONCRETE INSTITUTE.—Thursday, October 26, at 8 p.m., at Denison House, 296, Vauxhall Bridge-road, Westminster, S.W. An address will be given by Mr. Richard L. Humphrey, of Philadelphia, President of the National Association of Cement-Users, &c., on "Fireproofing."

THE PHYSICAL SOCIETY OF LONDON.—Friday, October 27, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. Agenda:—"Further Observations on the After-Glow of Electric Discharge and Kindred Phenomena," by the Hon. R. J. Strutt. "Homogeneous Fluorescent X Radiation of a Second Series," by Professor C. G. Barkla and Mr. J. Nicol.

ENGINEERING.

FRIDAY, OCTOBER 20, 1911.

POWER-PLANT FAILURES

MR. MICHAEL LONGRIDGE, the Chief Engineer to the British Engine, Boiler, and Electrical Insurance Company, has just issued another of his interesting and most illuminative reports on the breakdowns of various types of power generating plant. For many years past these pronouncements have formed a mine of data of the utmost value to the mechanical engineer. An engine-builder's experience is commonly somewhat limited. He hears enough, perhaps indeed, he might claim, too much, as to the weak points of his own productions, but has not often much opportunity of getting accurate information as to what accidents arise with machinery supplied by his rivals and competitors. An insurance company, on the other hand, has experience with engines of all makes, and is in a peculiarly favourable position for ascertaining the good and bad points of every type.

The steady progress of the gas-engine, as recorded by Mr. Longridge, is particularly noteworthy, and out of every forty-five engines now insured, twenty are driven by gas. So far as mere statistics go, it would seem that the gas-engine is now less liable to breakdown than its older rival; since whilst one out of every 9.7 of the steam-engines insured suffered from some kind of breakdown, the proportion in the case of gas-engines was 1 in 10.8. As they stand, however, the figures are misleading, since a large proportion of the steam-engines insured are old and give way by fatigue.

Mr. Longridge gives, as usual, a number of tables, which we reproduce on the next page, showing the relative liability to failure of the different parts of steam and gas-engines, and also what was the distribution of the originating causes. The causes of these breakdowns may be roughly classified as under:—

	Steam-Engines. per cent	Gas and Oil-Engines. per cent.
Accidents and causes unascertained	37	35
Old defects or deterioration by wear and tear	34	29
Weakness, bad workmanship, design, or material	16	19
Negligence of owners or attendants	13	17
	100	100

Commenting on these figures, Mr. Longridge remarks that, whilst the proportion of failures to the total of the engines insured is slowly diminishing, there is an increasing percentage of failures due to breakages of valves and gearing—that is to say, of small parts—and consequently the number of accidents to heavier and more important parts has been correspondingly reduced. The credit for the change, he states, "may be claimed by the universities and technical colleges, which have replaced rules of thumb by calculations based on the laws of applied mechanics." Considering Mr. Longridge's exceptional position and experience, this declaration is the most striking testimony we have yet met with as to the value of the work done at our engineering colleges. It is apparent, however, from an examination of the tables that the view expressed is not based directly on the figures given. Thus accidents to bed-plates, pedestals, &c., seem to be as bad as ever. The only "heavy repair" item which has been substantially diminished is that relating to spur-gearing, and it is probable that a substitution of other methods of coupling together the crank and second-motion shafting is mainly responsible for this. Mr. Longridge, moreover, attributes to the teaching of the technical schools the reduction in the proportion of failures of gas-engine cylinders. Here, however, we should have imagined that the proper proportioning of gas-engine cylinders was mainly a matter of design, involving little in the way of calculation. It is obvious, therefore, that Mr. Longridge's expression of opinion is not based on a mere study of statistics, which is in general exceedingly likely to be misleading. The character of the failures naturally does not appear in the statistical columns, where a trivial accident counts for as much as one leading to a complete wreck of the engine, and we thus see no reason for questioning the correctness of the view expressed. Moreover, it has to be remembered that a very considerable proportion of the steam-engine failures are attributable to very old engines, and no distinction can be made in such a tabulation as given above between a failure of an engine first set to work, say, some three years ago and one which has finally failed from fatigue after the labours of three-quarters of a century. The real test as to whether modern methods of calculation are superior in practice to the older rules depends on whether or no the failures of new engines are less than they used to be, and this, we gather, Mr. Longridge finds to be the case.

The extraordinary difficulty of fixing the dimensions of parts from simple theoretical principles is nevertheless amply illustrated in the report. Thus one wrought-iron shaft is recorded as breaking finally under a calculated stress of 2500 lb. per sq. in. The only reason assignable was that it carried a spur-pinion, and it is presumed that the failure was due to vibrations set up by the teeth. The life was long, being some 643 million revolutions. A steel crank-pin failed after 14 to 15 million revolutions under a calculated stress of ± 17,500 lb. per sq. in., and a wrought-iron crank-pin after 442 million revolutions under a stress of 11,000 lb. per sq. in. Yet another pin failed under a calculated stress of ± 4800 lb. per sq. in. after 390 million revolutions. Here, however, there was a definite cause assignable for the fracture. The brasses were supplied with oil through the crank-pin, and the hole, instead of being drilled at right angles to the line of thrust, was drilled along the latter. Hence the middle section of the pin was less stiff than the remainder, and straining actions were accordingly localised there.

Similarly discordant results were obtained in the case of gas-engine crank-shafts, but there was also here a very remarkable coincidence recorded. Two similar engines, built by the same maker, and bearing consecutive numbers, were at work 100 miles apart, and broke their crank shafts on the same day. The cause was bad design, the calculated stress being 21,000 lb. per sq. in. In another instance a gas-engine crank-pin broke after 263 million revolutions under a calculated stress of ± 12,000 to 13,000 lb. per sq. in. Yet another carried a stress of ± 28,000 to 39,000 lb. per sq. in. for 150 million revolutions. A case of fracture under a low stress was that of a crank-shaft which, after 288 million revolutions, failed under a stress of 8000 lb. per sq. in.; but here there was no proper fillet at the shoulder. Whilst on this subject attention may be called to two cases of extraordinary endurance of cast iron used for parts to which no one nowadays would venture to apply it. One of the cases was that of the cast-iron crank-shaft of an engine built in 1850, which finally failed last year. Mr. Longridge gives in Table III., on the next page, particulars of the stresses it had carried during its career.

The other instance noted is that of a cast-iron gudgeon, which dated from before 1838. It has withstood, without fracture, at least 750 million applications of a stress equal to ±1500 to 1700 lb. per sq. in.

A few failures are recorded due to sheer bad workmanship. Thus, in one case, a crank-pin had worn ⅛ in. oval, and the intelligent fitter, in putting in new brasses, merely fitted them to the larger diameter and let it go at that As a consequence,

at every stroke the pin was driven as a wedge into the forward brass, and finally succeeded in bursting the strap. Another instance is noted in which the pins on an air-pump cross-head had worn no less than $\frac{3}{4}$ in. oval. The owner refused his engineman's request to have matters put right, and, to stop the knock, the latter packed the free space up with leather, thus preventing the detection of the fault when the engine was inspected.

As is well known, McNaught gudgeons, when they go, generally do so inside the beam. The reason for this has not been very apparent, but in a case now recorded by Mr. Longridge it was found that in the course of time the holes in the beam had "bell-mouthed," so that the central portion had to carry a heavy bending stress, which is calculated to have amounted to ± 16,000 lb. per square inch. In one breakdown due to bad design one end of a high-pressure piston-rod was screwed to the end of the low-pressure rod, whilst the other end was cottered to a cross-head. It is nearly impossible to make both connections in such a case really tight, since the rod at the cottered end has to match the slot in the cross-head. A curious fracture was that of a big-end bolt of a gas-engine connecting-rod. This broke through the screw-threads, and the failure is attributed to the action of centrifugal force on the cap. At the ends of the stroke this centrifugal force would, of course, merely produce direct stress on the bolt, but when the rod is tangential to the crank-pin circle, the centrifugal action would give rise to bending stresses, which are calculated to have amounted to something like ± 6000 per square inch.

Several instances of gas-engine failures arising from bad design were recorded. In one instance, the forward bearing of the side shaft was, as is often the case, somewhat inaccessible, and the lubrication was according neglected. Mr. Longridge recommends the fitting in such cases of a sight-feed lubricator, or, better still, of a ring oiler. The latter type of lubricator is, however, he suggests, out of place on electric motors, where his experience leads him to prefer the use of ball bearings. An instance of a gas-engine bed being blown to pieces is amongst the accidents recorded. This arose from the fact that the air supply was drawn through the bed, an arrangement at one time much favoured by builders. The space inside the bed became filled with gas, which was in some way ignited. Liner troubles are now less frequent than they used to be, since the necessity of providing for expansion is generally recognised. Mr. Longridge remarks that in the absence of deposits it is quite probable that there is little difference in the expansion of the liner and cylinder; but if scale collects in the jacket, the temperature of the liner rises, and unless expansion is provided for, fracture may be anticipated. If the jacket discharge rises above 120 deg. Fahr., it may, he says, be taken as an indication that the waterway wants cleansing.

Mr. Longridge gives in the annexed Tables IV. and V. data showing the relative liability to injury of the component parts of electrical machinery. The alternating-current machines are, it appears, making slow but steady progress, and now number 14.5 per cent. of the total insured.

Loose cable-ends seems to be one of the most frequent occasions of trouble. In the case of enclosed and semi-enclosed motors Mr. Longridge protests against the frequent practice of coupling up the leads with "dry joints" inside the casing. These are liable to heat at the contact surfaces and to set fire to the insulation. A curious point raised in the report is the possibility of the insulation of dynamos being injured by the fumes from suction gas plants. Mr. Longridge thinks that there is sufficient evidence of this to afford reason for further investigation.

From the section of the report devoted to boilers, it appears that the number insured is diminishing, owing in part to the increasing use of gas-engines, and for the rest to the adoption of larger units. A notable instance of ignorance on the part of a builder of a heating boiler is recorded. It was desired to fit a safety-valve, and the builder calculated out the weight needed on the basis of the size of the opening into the boiler, and not on the area of the valve, which was only one-quarter as great. In another case a safety-valve was discovered with no opening whatever into the boiler.

Some interesting experiments with a Pitot tube, as used for measuring the flow of air through pipes, are recorded. For a range of air velocities from 77 ft. up to 210 ft. per second, the radius at which the velocity of flow had its mean value was found to be pretty uniformly equal to 0.8 the radius of the pipe.

Amongst the tests made was one of a turbo-generator installed to drive a mill. This was of 1500 horse-power capacity, and the results showed that, after debiting it with the losses incurred in electrical transmission, the turbine was still as economical in fuel as the best mill-engines. On the other hand, the first cost of the turbine, including condenser, switchboard, motor, and cables, was about 8500*l.*, whilst an ordinary steam-engine of 1500 horse-power, together with its second-motion drive, would not exceed some 5000*l.* to 6000*l.*

Table I.—*Failures of Steam-Engines.*

Description of Parts which are believed to have Given Way First.	Before 1884.	1884 to 1888	1889 to 1893	1894 to 1898	1899 to 1903	1904 to 1908	1909	1910
	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
Valves and valve gear	17.4	19.8	19.0	18.4	26.5	28.0	34.1	26.6
Spur-gearing	19.5	18.1	16.4	12.8	9.7	11.9	8.7	8.9
Air-pump motions	12.8	10.7	10.4	7.4	9.8	10.4	4.6	10.3
Air-pump buckets and valves	8.1	7.8	7.3	9.4	6.1	5.8	10.7	8.0
Columns, entablatures, bedplates, and pedestals	6.1	5.4	9.3	7.7	6.4	6.3	5.6	7.5
Cylinders, valve-chests, and covers	2.3	2.8	3.0	6.3	3.4	6.8	5.6	4.9
Bolts*	4.8	7.6	7.2	4.6	2.5	0.8	1.0	2.2
Parallel motions and links	4.3	5.5	5.6	5 0	3.5	3.4	2.0	0.9
Main shafts	5.3	4.5	4.5	5.1	3.2	3.5	2.6	5.8
Piston, with their covers, rings, and bolts	3.2	2 8	2 2	2.0	4.6	4.4	4.6	5.3
Governors and governor gear	1.4	2.1	2.2	3.9	3.6	1.8	1.0	2.7
Connecting-rods, straps, and bolts	0.6	0.9	0.9	3.8	4.1	3.4	3.1	5.3
Piston-rod crosshead	2.2	2.1	2.3	2 4	2.2	2.5	3.1	2.2
Fly-wheels	2.7	1.6	1.6	1.9	2.4	2.0	2.6	2.2
Air-pumps and condensers	2.2	0.9	1.4	2.8	1.8	2.5	2.0	0.9
Piston-rods	2.0	2.2	2.3	1.3	1.7	2.5	2.6	1.8
Crank-pins	0.7	1.4	0.9	2 0	1.2	1.0	0.5	0.5
Cranks	1.7	2.1	0.6	1.1	0.6	0.6	1.5	0.0
Beams and side levers	0 9	0.7	0.6	1.2	1.0	0.7	0.0	0.5
Gudgeons in beams	1.2	0.5	1.6	0.7	0.4	0.6	0.5	0.9
Main driving ropes and belts	..	..	0.3	0.1	0.2	0.4	0.5	0.0
Total wrecks, cause not ascertained	0.6	0.3	0.2	0.0	0.0	0.4	0.0	0.0
Second motion shafts	..	0.2	0.2	0.1	0.1	0.3	1.6	1.3
Turbine rotors	..	..	..	..	..	..	1.5	1.3
Total	100	100	100	100	100	100	100	100

* These bolts do not include bolts in pistons, air-pump buckets, connecting-rods, and other moving parts, the bolts in these parts being tabulated with the parts to which they properly belong.

Table II.—*Failures of Gas and Oil-Engines.*

Description of Parts which are believed to have Given Way First.	Average before 1904.	1904-1908.	1909.	1910.
	p.c.	p.c.	p.c.	p.c.
Valves and valve-gear	30.1	33.3	29.6	42.8
Cylinders and cylinder-ends	19.3	16.1	15.4	8.5
Pistons	9.7	5.0	2.7	5.1
Connecting-rods and their bolts	11.9	10.3	9.4	9.1
Main shafts	5.1	11.2	13.4	7.9
Governors and governor-gear	5.1	7.0	5.4	3.4
Silencing-boxes and exhaust-pipes	2.8	3.6	1.3	2.8
Fly-wheels and driving-drums	5.1	5.4	0.7	2.8
Clutches and couplings	1.7	0.0	0.0	0.6
Frames and pedestals	3.4	1.8	1.3	1.7
Bolts*	4.6	1.5	2.0	1.7
Total wrecks, cause not ascertained	0.6	0.4	0.0	0.6
Main driving-ropes and belts	0.6	0.6	0.0	0.0
Miscellaneous	..	2.2	7.4	4.5
Gas-producer plants	..	1.6	11.4	8.5
	100.0	100.0	100.0	100.0

* These bolts do not include bolts in connecting-rods, valve-gear, or other moving parts, the bolts in these parts being tabulated with the parts themselves.

Table III.—*Stresses on a Cast-Iron Crank-Shaft.*

—	1850-1873.*	1873-1897.	1897-1910.
Millions of revolutions of engine	70	76	41
Load on piston, initial lb.	90,000	56,540	51,000
Stress on neck at beginning of stroke lb. per sq. in.	3,650	2,270	2,050
Load on piston at cut-off lb.	76,500	36,800	33,960
Estimated point of cut-off p.c. of stroke	0.22	0.4	0.3
Stress on neck at cut-off lb. per sq. in.			
Equivalent bending $M_1 = \frac{1}{2}(M + \sqrt{M^2+T^2})$	3,750	1,930	1,580
Equivalent shearing $M_1 = \sqrt{M^2+T^2}$	4,470	2,390	2,040

* The mill was standing for twelve months during this period.

Table IV.—*Failures of Dynamos and Electric Motors.*

Description of Part which is believed to have Failed First.	Dynamos. Average for Eight Years Previous to 1909.	Dynamos. 1909.	Dynamos. 1910.	Motors. Average for Eight Years Previous to 1909.	Motors. 1909.	Motors. 1910.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Rotating parts carrying current—Armatures and rotors	54.0	40	43	49.5	37	33
Commutators and slip-rings	22.4	29	25	22.5	27	26
Stationary parts carrying current—Magnet coils & stators	8.9	12	13	13.9	20	17
Brush gear and terminals	..	3	2	..	4	5
Rotating parts not carrying current—Shafts, spiders, cores, binders, pulleys, & gear-wheels	14.7	12	13	14.1	7	9
Stationary parts not carrying current—Frames, pole-pieces, bearings, &c.	..	4	4	..	5	10
	100.0	100	100	100.0	100	100

Table V.—*Failures of Starting-Switches and Controllers.*

Description of Part which is believed to have Failed First.	Average for Four Years Previous to 1909.	1909.	1910.
	p.c.	p.c.	p.c.
Parts carrying current—			
Resistance coils	52.0	52	57
Contacts and switch-arms	10.8	9	12
Automatic apparatus	14.0	21	18
	76.8	82	87
Parts not carrying current—			
Frames, slabs, carriers for coils, springs, &c.	23.2	18	13
	100.0	100	100

THE BREWERS' EXHIBITION.

The present year has not been a favourable one for brewers so far as the supply of English-grown barley is concerned, for though the crops ripened early, and were of good quality, the quantity, owing to the long drought, was short. Hops appear, however, to be excellent both in quality and quantity, as is shown by samples now on view at the thirty-third Exhibition of the Brewing and Allied Trades now open at the Royal Agricultural Hall, Islington. Whatever the condition of the crops on which the brewing trade depends, its effect on the appearance of the general exhibits in the Hall does not appear to cause much change from year to year, and the show of machinery varies little. This year there are the usual exhibits of machines for treating beers, and for dealing with processes connected with carbonating, bottle-washing, bottling, &c., and improvements in certain directions are noticeable. The body of the hall is pretty well filled, as is also the annexe, and we find many of the old firms as exhibitors. One aspect of the present exhibition is the encouragement that has been given by the Malting and Seed Barley Competitions which have been instituted, and which it is hoped will tend to the production of improved grain.

Messrs. G. J. Worssam and Son, Wenlock-road, City-road, London, N., have on view a new Harris-Fox patent sprayer, which has not been exhibited before. This has been designed to meet the present employment of finer grist than was usual some time ago, for it is claimed that no matter how excellent the mash-tub equipment may be in other respects, the use of the old type of sprayers, delivering coarse streams of liquour over the goods, does not tend to really good results. When used for fine grist, inefficient apparatus results in such troubles as "flooding" and "set" mashes, irregularity in drainage, and a lack of uniformity in top gravity. The apparatus consists of a rotary sprayer driven by mechanical means—in this case by an electric motor—which is quite independent of the pressure of water in the hot liquor tank. The admission of water to the sprayer is controlled by a float-valve in the sprayer itself, which keeps it at one constant level. In this way the water is distributed equally over the whole area of the mash-tub with very little velocity. The pressure of the supply and the control of the driving mechanism enable the quantity of water delivered to be varied as desired, the result being that the water is distributed throughout the whole of the area of the tun, each part of the surface receiving its proportionate share. It is claimed for the apparatus that heating or consolidating the contents of the mash-tun are avoided.

Another new machine to be seen at this stand is an air-filter for blowing pure air into filter-presses

or refrigerating-rooms. It consists of a cylindrical casing, within which is a rotating drum formed of a series of concentrically arranged shells of corrugated iron, the section of the shells being such that a maximum of efficient absorbent surface is obtained over which the air in its passage must flow. The absorbent substance is a liquid, into which the concentric cylinders dip as they revolve. This absorbent, adhering to their surfaces, is carried round in a thin film through the air that has to be purified, while the latter is drawn through the apparatus by means of a fan. When the absorbent film descends into the liquid, the impurities that have been extracted are washed off as the cylinders revolve. During each revolution the whole of the surfaces are automatically moistened afresh with the absorbent. To clean the apparatus it is filled with water. Steam is then turned on, and the water is boiled in the machine, making it absolutely sterile.

The Seck Engineering Company, Limited, 48, Mark-lane, London, E.C., exhibit a new air-purifier and dust-collector, which consists of a cast-iron vessel, the size of which is regulated by the quantity of air which has to be treated. It is entirely enclosed, and the air is drawn in by means of a suction-fan at the delivery end, the inlet end being connected by means of air-ducts to either the air outside or to a machine from which it is desired to extract the dust. Inside the vessel are some revolving brushes which are connected together by gearing, and are driven by a belt or other suitable means. To the top cover of the machine, baffle-plates are fixed between the brushes, as a means of regulating the flow of air through the machine, and supply-pipes for the admission of the cleaning liquid are suitably arranged, the outlet for the dirty liquor being regulated by a weir at the end of the machine, so that the level is always kept constant. When in action for dust-collecting alone, all that is necessary is to connect the liquor inlet to the water-main and regulate the supply as required. The air travels the full length of the vessel, and in its passage is split up by the revolving brushes, which provide a constant supply of clean liquor to the incoming air. The dust which the air contains, as it comes in contact with the bristles, is held by the moisture carried up, but is washed off when the bristles descend into the liquid. The outlet for the dirty water being constantly open, the dust is carried away in the water, while the purified air, before leaving the machine, is met by the incoming liquor, which enters in the form of a spray. When it is desired to obtain purified air alone, the action is exactly as described, with the exception that the liquid used is of an antiseptic nature.

The Farringdon Works and H. Pontifex and Sons, Limited, Shoe-lane, London, E.C., exhibit what is said to be the largest beer-chiller in the show. It is really an improved design of their "Perfection" patent chiller and carbonater, to which attention has been called on previous occasions. It is capable of chilling and carbonating from 100 to 120 barrels of beer per day, each barrel containing 36 gallons. It consists of four cylindrical vessels. The front of each of these has in it a glass window, through which the level of the beer can be seen, behind the window being a thermometer, which is entirely immersed in the liquid, and which can be read through the window. There are also smaller sizes of these chillers on view, and one of the firm's 25-barrel size copper tin-lined closed tanks, for conditioning and bottling beer. Messrs. Bennett, Sons, and Shears, Limited, the Farringdon Works, Shoe-lane, E.C., who are incorporated in the previous firm, exhibit at the same stand an Apsey heat-intensifier, which is intended for the superheating of steam in cases where very large quantities are not required,, and is suitable for calendering machines, jacketed evaporating and boiling-pans, steam-coils, radiators, &c. Such appliances have hitherto been heated by comparatively low-pressure steam, for they are usually constructed with thin walls, and the temperature is, therefore, frequently not as high as desired. By the use of this intensifier the temperature of the steam may be increased without increasing the pressure, a superheat of from 50 deg. to 100 deg. Fahr. being gained. The apparatus consists of a coil, heated by gas, through which the steam is passed, the coil being contained in a metal casing lined with asbestos.

Messrs. H. J. West and Co. (1908), Limited, Saxilby Iron-Works, Saxilby, Lincolnshire, whose stand is next to that to which we have just referred, exhibit an entirely new natural fermentation gas plant for the utilisation of the volatile products of wort fermentation for carbonating non-deposit beers, as well as a new design of the West patent power-driven rotary beer-bottling machine, with air-lift for bottles and automatic shut-off valves.

A very efficient cask-cleaning machine is exhibited by Messrs. G. Hopkins and Sons (Clerkenwell), Limited, 148 to 154, St. John-street, Clerkenwell, E.C., the capacity of which is from 100 to 180 casks per hour, according to the length of time occupied in soaking. The machine consists of a long soaking-tank in which the barrels are placed, where they remain for about three or four minutes. While in the tank they roll down inclined rails to the end, where they are picked up at the rate of three per minute, the water in the tank being at such a level that the barrels cannot become too full. When they are lifted out they are dropped on to a lever, which acts on the brushes that operate on the ends of the barrel. These brushes are automatically drawn back as the barrel passes on to the tumbler, which rotates it while under the action of the brushes. When the cask is free from the lever that actuates the end brushes, these latter are forced inwards by means of springs, and clean the ends of the cask while it revolves, a brush on the top acting on the bulge of the cask at the same time. After this operation the cask is delivered automatically on to rails, where it is allowed to drain, and is then placed on a rinsing-nozzle, where it receives a final washing.

Among brewing vessels a very fine show of aluminium goods may be seen at the stand of the Aluminium Plant and Vessel Company, Limited, Point Pleasant, Wandsworth, London. Aluminium as a material for brewing vessels has not taken the place that many people thought, when it first became a commercial product, would be the case. It seems hardly likely now, however, that its use will continue to be as restricted as it has been, seeing that the difficulties of its manipulation have been largely solved—at any rate, if we may form a judgment from what is exhibited in the Agricultural Hall. All difficulty with regard to welding appears now to have been overcome by a process patented by the Aluminium Plant and Vessel Company, Limited, the results of whose efforts are in evidence at the Exhibition. No foreign metal is used in the process, and the joints are as pure and as homogeneous as the rest of the sheet. Among the exhibits on view are a 25-barrel conditioning vessel and a 1500-gallon tank lined with aluminium of 99½ per cent. purity.

One of the small exhibits in the Hall, which, although not connected directly with brewing, will doubtless prove of interest to brewers, and will, we are sure, attract many other visitors, is to be seen at the stand of the British Vacuum Ice-Machine Company, 124/7, Minories, London, E.C. This is a small portable apparatus for freezing water very rapidly, or it may be used for cooling various liquids. It is known as the "W. K." machine, and works on the Carré principle of the absorption of water vapour by sulphuric acid. The machine on view is driven by hand-power, and will freeze an ordinary carafe half-full of water in about three minutes. If it is not desired to freeze the water, it can be cooled. The apparatus consists of a base which carries the container for the sulphuric acid, and the vessel containing the water or other liquid to be cooled or frozen, and also supports a vacuum pump which is worked by a hand-lever and gearing. By a simple system of cranks and levers a slight rocking motion is given to the vessel containing the sulphuric acid and the vessel containing the liquid to be frozen. The container for the acid holds about half a gallon of commercial H_2SO_4. Before starting the machine, the bottle and the acid vessel are connected by means of a pipe, which has at each end a rubber plug, fitting the mouth of each respectively, and making a perfectly air-tight joint. A pipe connects the pump with the upper part of the vessel containing the H_2SO_4, so that when the handle of the machine is turned a vacuum is produced, and the air is drawn out from the two vessels, the vapour which comes from the water in the carafe being absorbed by the H_2SO_4. This absorption is so rapid that ebullition soon commences in the water, the temperature of which is very quickly reduced, until in about 1½ minutes from the commencement the water begins to freeze, and in about three minutes contains large pieces of ice. This freezer may also be used for cooling brine in a refrigerator with very little trouble. The size of the apparatus is 21 in. by 18 in. by 15 in., and the net weight about 50 lb. One charge of acid may be used a great many times before it is too weak to be of any service, and it must then be renewed. The machine appears to be particularly well suited for tropical climates, and we understand that more than 10,000 of them have already been sold since the beginning of this year.

Messrs. J. and P. Hill, Caxton House, Westminster, S.W., have on view the Galloway-Hill boiler furnace, which is now being adapted to brewery work. The furnace was originally designed for steam-boilers, but it has latterly been modified and improved so as to adapt it to a great variety of purposes. It can now be fixed to any boiler. The fire-bars are practically indestructible; it will burn slack, smudge, sawdust, coke-breeze, and the smallest coal, and clinkers come off the bars quite easily. At the same stand may be seen some samples of solid-oil fuel made by the Armstrong-Morgan process. The fuel is a solidified hydro-carbon oil, and has not been exhibited before. It is made from refuse petroleum, and can be moulded in any desired form. The blocks are said to resist weather influences perfectly, being impervious to the action of rain, heat, and cold; they burn practically smokelessly, and no appreciable alteration of the fire-grate is required.

There are, of course, other exhibits of interest in the Hall, but space will not allow us to mention them here. The Exhibition closes to-day.

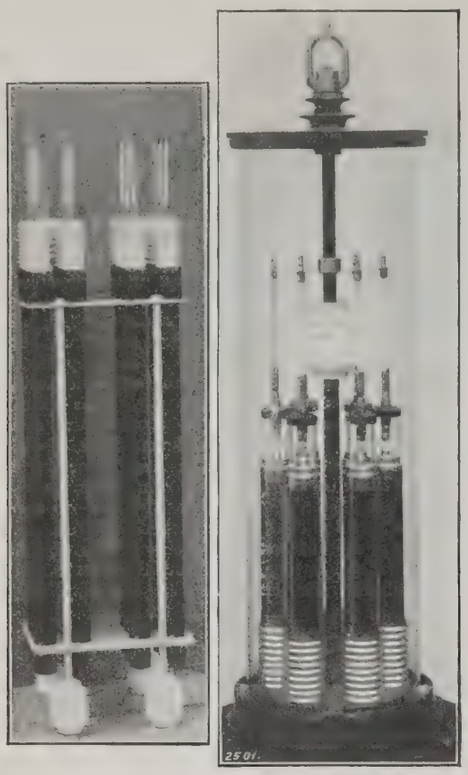
THE ELECTRICAL EXHIBITION AT OLYMPIA.—No. IV.

In our concluding notice of the Olympia Exhibition we may well give the first place to the Edison storage battery, since this piece of apparatus has been the subject of so much rumour and contradiction during recent years that all those interested in storage battery work will be glad of the opportunity afforded by the Exhibition to see in what it actually consists. It is shown on the stand of the Edison Manufacturing Company, Limited, of Edison Works, Willesden Junction, London, N.W. As is generally known, the battery is an iron-nickel one, and differs radically from other types, the highly mechanical nature of its construction being one of its special features. The positive plate is built up of a series of perforated steel tubes filled with alternate layers of nickel hydroxide and pure metallic nickel in excessively thin flakes. The tubes are about $\frac{3}{16}$ in. in outside diameter, and are carried in a nickel-plated steel supporting grid, to which they are attached by means of a punching process, which closes the horizontal ribs of the grid on to the ends of the tubes. The tubes themselves are built up from a perforated ribbon of nickel-plated steel. They have spirally lapped seams, and are reinforced by eight steel bands, equally spaced, which prevent the tubes expanding away from, and breaking contact with, their contents. The nickel hydroxide in the tubes forms the positive element, and the flaked metallic nickel is merely introduced because the hydroxide is of somewhat high resistance. The nickel takes no part in the reaction. The method employed to obtain the flaked nickel is of interest, and may be referred to. It consists in depositing alternate layers of copper and nickel on a graphite drum until a cylinder about $\frac{1}{16}$ in. thick is built up, of about 250 alternate layers of the two metals. The cylinder is then cut up into minute square plates, which are treated with acid which dissolves the copper out and leaves the flaked nickel.

The negative plate of the battery consists of a number of cold-rolled nickel-plated rectangular pockets, carried by a grid. The pockets are filled with powdered iron oxide, and, after filling, are placed in position in the grid, which is then subjected to heavy pressure by dies; these corrugate the surfaces of the pockets, and at the same time force them into close contact with the grid. The cell in which the plates are carried is also made of nickel-plated steel. It is welded at the seams by the autogenous method, and is corrugated to give the greatest possible amount of strength with minimum weight. The plates are insulated from each other, and from the cell, by means of hard rubber. The electrolyte consists of a 21 per cent. solution of potash in distilled water, and a small percentage of lithia. No acid is used, and the density of the electrolyte does not change on charge or discharge.

The highly mechanical nature of the battery is at

ELECTRICAL EXHIBITS AT OLYMPIA.



Figs. 36 and 37. Moscicki Condenser and Giles Valve for Overhead Line and Cable Protection; Messrs. Isenthal and Co., London.

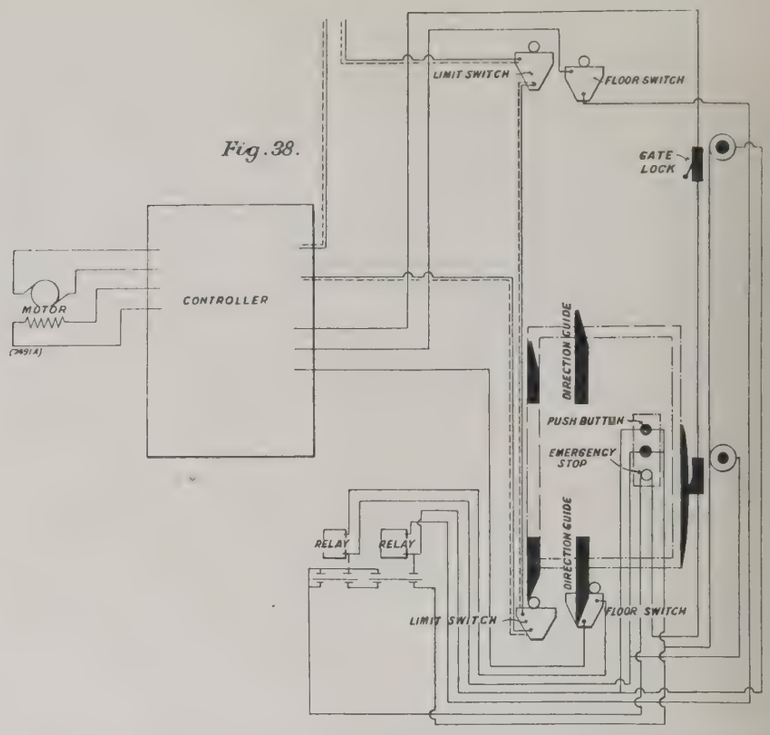


Fig. 38. Diagram of Connections for Push-Button Lift Gear; Messrs. Etchells, Congdon, and Muir, Limited, Manchester.

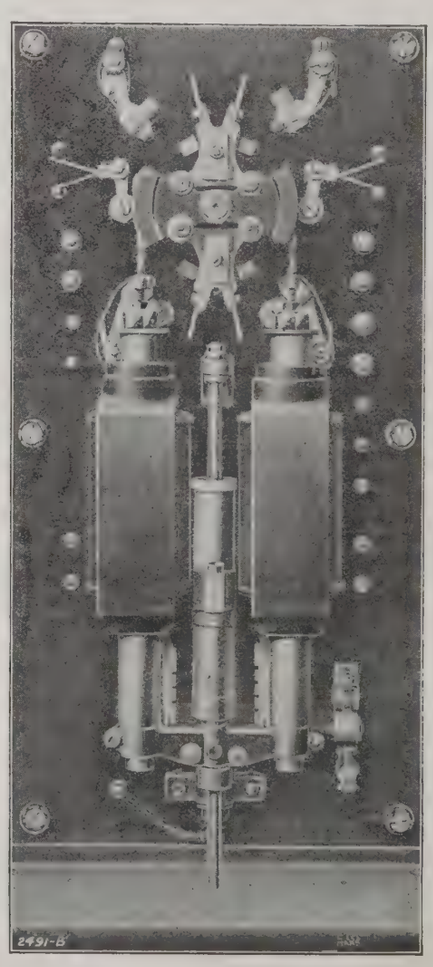


Fig. 39. Controller for Push-Button Lift; Messrs. Etchells, Congdon, and Muir, Ltd., Manchester.

once evident from inspection of it, and it is stated that no deterioration takes place in ordinary service over a number of years. The voltage for normal rates of discharge is 1.2 per cell. A peculiar feature, and one of great importance, is that the battery improves in efficiency after being put to work. When the cell is new it has an efficiency of from 60 to 65 per cent., which is lower than is obtained with a new lead battery; but as the Edison battery increases in efficiency with use, this aspect of it is of little consequence. As the construction of the cell prevents the throwing down of any active material, no sediment is formed, and it is stated that it is never necessary to clean out the cells; in fact, they are made so that the covers cannot be removed to do this, for they are welded on. It is also stated that prolonged standing in an uncharged state has no deleterious effect on the cells.

An interesting and quite special type of exhibit is made by Messrs. Ozonair, Limited, of 96, Victoria-street, Westminster, S.W., who show various applications of their apparatus for the production of ozone. The essential feature of all their plant lies in the ozone generator, which consists of metal grids between which a high-tension discharge takes place, resulting in the production of ozone from atmospheric oxygen. The plant consists of the generator, a step-up transformer, and, if intended for operations on a direct-current circuit, a converter. Various applications are shown, mainly for ventilation, although the chief position on the stand is occupied by a water purification plant, in which the ozone is caused to pass upwards through the water as it falls from an atomiser. Several of the small ventilating plants, intended for direct-current working, are interesting, as the converter is built as an integral part of the fan motor, so that the control of the whole plant is obtained by two tumbler-switches—one for the fan and one for the transformer. Examples of palm-oil and other vegetable products bleached by ozone are also shown on the stand.

Special apparatus is also exhibited by Messrs. Isenthal and Co., of 85, Mortimer-street, London, W., who display their protective gear for overhead lines and cables. Characteristic examples of the two types of apparatus are shown in Figs. 36 and 37, above. The gear is intended to deal with surges created by lightning discharge, switching, breakdown, or other cause. In the case of overhead lines the former is much the more important class of phenomenon, and the gear is specially designed to deal with it. Such discharges produce currents of enormous frequency in overhead lines, and in order to deal with them Messrs. Isenthal use a type of discharger having a resistance which is inversely proportional to the frequency. The danger of the very high frequency currents produced by lightning discharges is that they build up very high voltages on the end windings of transformers and machines, resulting in breakdowns. Messrs. Isenthal's discharger is a pure and simple condenser of the Moscicki type, and has no spark-gap or wire resistance. The condensers have an enormous resistance at normal periodicities, but are easily able to pass the very high voltage inductive currents due to lightning. The dischargers are built up of a battery of condensers, as shown in Fig. 36. Each condenser consists of a glass tube, silver-plated inside and out, and afterwards copper-plated outside, and covered with a metallic protective enamel. The tubes are carried in sheet-iron cylinders, filled with a non-freezing mixture of glycerine and water. The cylinders are connected to earth, and the inside of the glass tubes to the line.

For underground cables Messrs. Isenthal use a Giles valve, as illustrated in Fig. 37. This is intended mainly to deal with surges due to switching or breakdown, as such surges are the chief cause of trouble in underground work. The high periodicities met with in overhead cables are not characteristic of underground surges, but heavy dynamic currents due to the machinery connected to the mains are frequently a cause of trouble. Such dynamic currents are passed to earth through spark-gaps as in usual types of protector, but the special feature of the Giles valve is that the first gap is connected to earth through a condenser, so that it is possible to carry a very sharp potential gradient over the gap without any danger of continuous sparking when the gap has operated. The arrangement consists of an upper spark-gap connected through a resistance to a series of further spark-gaps at the bottom of the apparatus. Each gap is shunted by a condenser, so that when the apparatus discharges, the potential across any gap is limited by its condenser. The spark-gaps are made of zinc, and the resistance, which forms the black part of the cylinder shown in the illustration, is of wire wound on a mica tube.

Many of the electric cable manufacturing firms have stands at the Exhibition, and among them we may mention Messrs. Callender's Cable and Con-

ELECTRICAL AND MACHINERY EXHIBITS AT OLYMPIA.

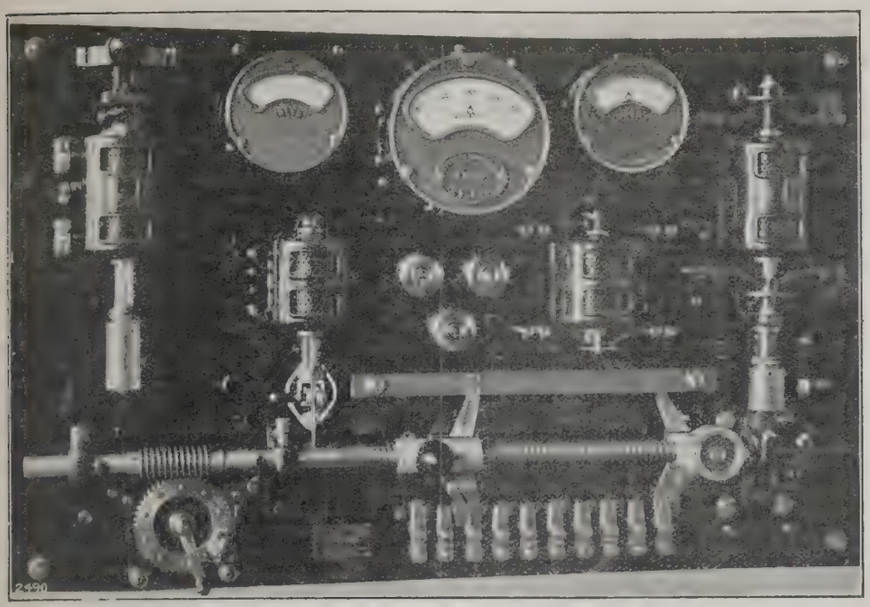


Fig. 40. Control-Board for Automatic Electric-Lighting Plant; Messrs. Walker, Horrocks, and Co., Limited, Birmingham.

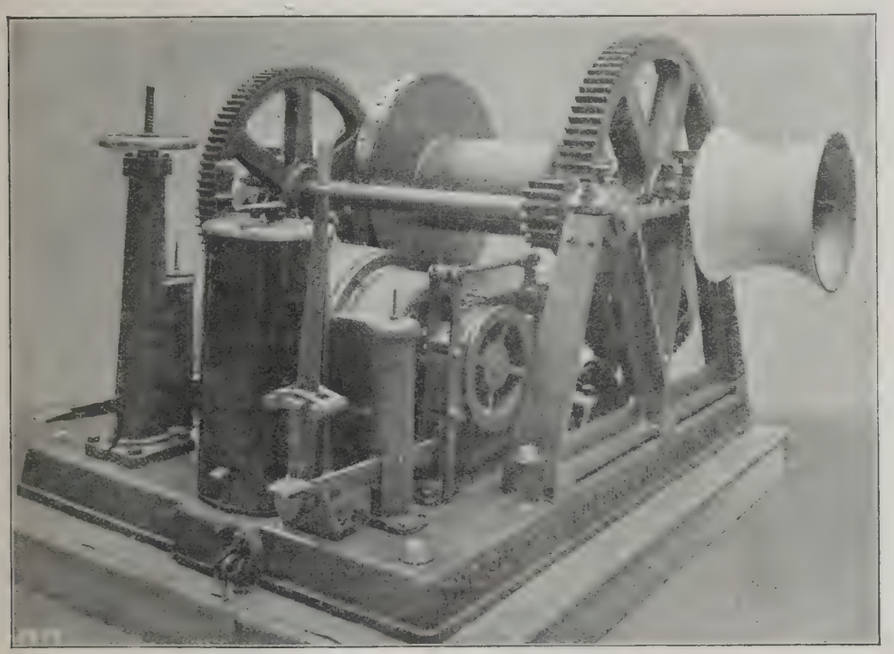


Fig. 42. Three-Ton Electric Winch; The Sunderland Forge and Engineering Company, Limited, Sunderland.

struction Company, Limited, who, in addition to cables, show joint-boxes, feeder-pillars, &c.; Messrs. W. T. Henley's Telegraph Works Company, Limited, who show cables of all types, rubber goods, distributing-boxes, &c.; Messrs. Pirelli, Limited, who show flexibles, cables, ebonite parts, &c.; and Messrs. Johnson and Phillips, Limited, who, in addition to cables, display a large selection of their range of manufactures, including switch-gear, instruments, a 24-in. searchlight projector, &c. The Union Cable Company, Limited, must also be mentioned as showing cables, wires, and joint-boxes; and the Western Electric Company, Limited, who show cables, telephones, batteries, &c.

Electrical instruments are also represented by a number of firms, including such well-known names as Messrs. Elliot Brothers; Messrs. Everett, Edgcumbe, and Co., Limited; Messrs. Nalder Brothers and Co.; Messrs. Nalder Brothers and Thompson, Limited; Messrs. Evershed and Vignoles, Limited; and Messrs. R. W. Paul. It is impossible to deal in detail with the comprehensive exhibits of these firms, but it may be said that in addition to electrical instruments, Messrs. Elliot show the Anschutz gyro-compass, which was recently described in our columns, ships' telegraphs, speed-indicators, &c.; while Messrs. Everett, Edgcumbe, show a very large range of switchboard instruments, and, in addition, speed-indicators, photometers, &c. Messrs. Nalder Brothers and Co. show galvanometers and other testing apparatus, while Messrs. Nalder Brothers and Thompson display switchboard, recording and portable instruments of various types. Messrs. Evershed and Vignoles exhibit testing sets for mains, &c., and switchboard and portable instruments; and Messrs. Paul show galvanometers, high-frequency instruments, and pyrometers. In connection with this class of exhibit the names of the Leskole Company, Limited, of Palace Works, Enfield, who show distance thermometers, steam-meters, &c.; the Auto Recorder Company, of Kent Street Works, Leicester, who show CO_2 recorders; and Messrs. Alexander Wright and Co., Limited,

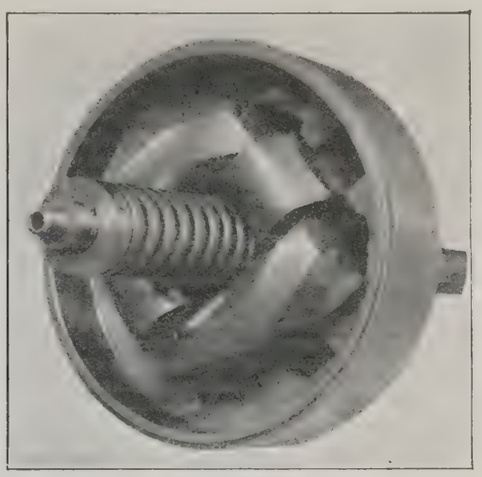


Fig. 41. Engine Governor; Messrs. Wilson Hartnell and Co., Limited, Leeds.

of 1, Westminster Palace-gardens, S.W., who show combustion recorders, water-meters, &c., should be mentioned. The Lea Recorder Company, also exhibit their well-known form of V-notch meters; and Messrs. Winston and Co., show thermometers and general optical goods, while Messrs. Gambrell Brothers show potentiometers, &c.

We have already dealt with some of the machine-tools shown at the exhibition, but among other firms displaying this class of plant which should be mentioned is Messrs. C. W. Burton Griffiths and Co., who show a large variety of tools, among which we would specially mention a portable universal radial drilling-machine with a self-contained motor. The tool is mounted on wheels for ease in moving and has screw-jacks, so that it may be lifted from its wheels when in use. The drill-spindle is capable of travelling through a complete circle in two planes, and as the tool is of a heavy type, it should be very useful for a large class of rather awkward work. A radial head slot-drilling machine is also exhibited which is intended mainly for cutting slots in petrol-engine valve-stems and similar work in which slots have to be made in comparatively light spindles. The drill is mounted horizontally and has a rocking motion, while the feed is applied to the table. Messrs. Burton Griffiths also show a proportional counting-machine under the name "National." The machine is intended for counting screws and other small parts by means of weighing them, and consists of two scale-pans, in one of which a known small quantity of the article is placed, a larger number being placed in the other pan. By moving a jockey along a horizontal scale the number in the second pan may then be directly read off, or the jockey may, of course, be set at a definite number and the counting carried out by filling the second pan until balance is obtained. Machine-tools are also displayed by Messrs. J. Rhodes and Sons, Limited, of Wakefield; Messrs. Wallach Brothers, Limited; Messrs. the Armorduct Manufacturing Company, Limited, and Messrs. G. W. Goodchild and Partner, the former firm showing power-presses for sheet-metal stamping, the two following electric tools, and the latter automatic stud machines. In this connection the commutator grinder exhibited by Messrs. Phillips' Commutator Grinder Company, Limited, of 27, Walbrook, London, E.C., may also be mentioned.

Electric lifts are represented by such well-known firms as Messrs. R. Waygood and Co., Limited; Messrs. Medway's Safety Lift Company; Messrs. Marryat and Place; Messrs. Etchells, Congdon, and Muir, of Manchester. A diagram of connections of the push-button lift arrangement of this latter firm is shown in Fig. 38, on page 536. The lift is fully automatic, in that it cannot be moved while a gate is open, and that a landing call is inoperative until the passenger inside the cage has previously opened the gate and then reclosed it. A set of buttons is fixed in the cage, so that a passenger has full control over its movements, and can stop instantly if required. The arrangement shown in the diagram is for two floors only, but the system is applicable to any number. The controller

shown in Fig. 39, on page 536, is a self-contained article, so that trouble owing to bad mounting, resulting in lack of alignment, is avoided. The action of the gear may be followed from Figs. 38 and 39. The controller, as will be seen, consists of two vertical solenoids attached by chains to a change-over switch mounted above them. This switch determines the direction of rotation of the motor, and the first operation of either solenoid on being energised is to pull this switch over to either the rising or falling position. The pressing of one of the lift buttons energises one side of the controller only. When the change-over switch has been closed, a small relay switch, which can be seen on the lower part of the casting carrying the change-over switch, puts the two solenoids in series, so that they lift their lower plungers, which are connected by a cross-arm, as shown in the figure. The lower plungers are independent from the upper plungers which operate the change-over switch, but are connected to them by internal chains, so that they cannot move until the change-over switch has been operated. The lifting of the lower plungers gradually cuts out the resistance connected to the starting contacts, which can be seen behind them, and starts the motor, the rate of starting being regulated by the oil dash-pot, which can be seen between the solenoids. After starting, the motor runs until the circuit is broken, when the cage has reached a predetermined floor, after which the solenoids move into their first position again.

The pressing of any button, either on a landing or in the cage, operates a relay, which receives power from the incoming mains, and closes the circuit of one of the controller solenoids. This circuit is then maintained until the cage reaches the floor corresponding to the button which has been pressed, when the direction guide on the cage opens the circuit on the floor switch; this breaks the relay circuit, and the current is cut off from the controller. The relays belonging to each system of press-buttons are arranged so that when the lift is above or below the corresponding floor they energise the controller solenoid corresponding to the direction in which the cage must travel to reach that floor. As the cage must alternately be above and below any specific floor, it will be seen that the relays must have an alternate change-over action. Limit-switches are fitted at the top and bottom of the travel, as will be seen in the diagram. These are operated by a skate, and are capable of breaking the main circuit in case of over-running. A lock is fitted to each well-gate, which breaks circuit when any gate is opened.

Among the firms with which we have not yet dealt, exhibiting more purely electrical apparatus, there is the General Electric Company, Limited. This firm, as is well known, make practically every class of electrical apparatus and plant, and their two stands contain a wonderfully varied range of exhibits, including lamps, heaters, motors, instruments, &c., a special feature being made of the firm's new 16-candle-power high-voltage metallic filament incandescent lamp. A very varied display is also made on the stand of Messrs. Pooley and Austin, of 25, Victoria-street, London, S.W. This firm exhibit high-tension switch-gear, manufactured by Messrs. Spagnoletti, Limited, of Goldhawk Works, London, W.; continuous-current dynamos and motors, by Messrs. Mawdsley's, Limited, of Zone Works, Dursley, Gloucestershire; and ironclad and mining switch-gear, by Messrs. Engineering Instruments, Limited, of Skerne Works, Darlington. The Union Electric Company, Limited, of Park-street, Southwark, London, S.E., also have a very general display of plant, including several types of mining switch-gear, and a motor with impregnated windings, and working with an open commutator in a water-spray. The firm also show an automatic paralleling apparatus for alternators, and an interesting automatic field-regulator for generators. This latter consists of a solenoid, which is connected across the terminals of the generator, the voltage of which is to be regulated. The solenoid has a movable core, carrying at its top end a trough made of insulating material and containing mercury. The core, with its trough, is supported at one end of a pivoted lever, weighted at the other end, and swinging in a vertical plane. The mercury-trough is open at the top, and above it there is fixed a series of contacts leading to the field-resistance of the machine. The contacts are arranged in the form of a comb, and the effect of the arrangement is that as the machine voltage varies, and with it the pull of the solenoid, the core is lifted in or out of the solenoid, so that the trough is slightly tilted in one direction or the other. The effect of this is that more or fewer contacts dip into the mercury, so that field-resistance is automatically cut out or in, and a voltage regulation is obtained.

There are a further number of exhibits in the Show of a more mechanical than electrical nature, among which we may mention the boiler-stoking exhibits of Messrs. Ed. Bennis and Co., Limited; and Messrs. James Proctor, Limited, Burnley. Messrs. Bennis's exhibit comprises an example of their well-known coking-stoker and one of their newer chain-grate stokers. In this latter the grate drive is fitted with a six-speed gear, running in oil, to give a drive adapted to various classes of coal and loads. The exhibit also includes a Bennis elevator and conveyor and a CO_2 recorder and calorimeter. Messrs. Proctor show their shovel-stoker with moving fire-bars, and their coking-stoker with self-cleaning bars, together with a coal-elevator and conveying plant. Messrs. J. Hopkinson and Co., Limited, of Huddersfield, also have an excellent display of boiler mountings; they also show valves of various types, the whole of which, as is Messrs. Hopkinson's practice at exhibitions, being beautifully finished and displayed so that their working parts can be seen. We may specially mention the two-seated stop-valve which is shown, and the new type of gauge-glass drain-cock. The former of these has two disc-valves, one above the other, and the mechanism is arranged so that one of the discs always opens first. The result of this is that any cutting of the valve-face due to the first rush of steam through the opening valve is confined to one of the faces only, so that the other always remains tight. The drain-cock illustrates another application of the same principle, and consists of a disc-valve in series with a ball, the disc opening first, so that the ball-valve receives any cutting action which there may be. Boiler plant is also shown by Messrs. James Gordon and Co., of 81 to 83, Knightrider-street, London, E.C., in their sectional superheater, in which rectangular rolled-steel headers are used and bent tubes expanded into mild steel plates, which are secured to the headers with set-screws. The superheater is designed so that any group of tubes can be removed for inspection or cleaning without interfering with the superheater setting or breaking any steam-pipe joints. This firm also exhibit a special two-way valve and samples of hydraulic turbines and governors.

Small prime movers are shown by the Aster Engineering Company, Limited, of Wembley, Middlesex; the Heatley-Gresham Engineering Company, Limited, of Letchworth, Herts; and the Crypto Electrical Company, of Bermondsey-street, London, S.E., these firms exhibiting petrol or paraffin sets coupled to electrical machines; and Messrs. R. Hornsby and Sons, Limited, of Grantham, who show both gas and oil-engines. Ball-bearings are exhibited by the Hoffmann Manufacturing Company, Limited, of Chelmsford, who make a most excellent display, showing various applications of their bearings to electrical machinery; and the Skefko Ball-Bearing Company, Limited, of Carlton House, Regent-street, London, S.W., whose bearing we hope to deal with later; while general mill-gearing, roller-bearings, and friction clutches are shown by the Unbreakable Pulley and Mill-Gearing Company, Limited, of West Gorton, Manchester. Driving-chains are displayed by Messrs. Hans Renold, Limited, of Manchester, and the Coventry Chain Company (1907), Limited, of Coventry.

An interesting automatic electric-lighting plant for country house and similar work is shown by Messrs. Walker, Horrocks, and Co., Limited, of 45, Newhall-street, Birmingham. The object of the plant is to reduce the attendance required to a minimum, and arrange that it may be given when convenient. The plant consists of a petrol or paraffin-driven set of standard type, and the novel features are confined to the control-gear, which is illustrated in Fig. 40, on page 537. The plant is installed in connection with a battery as in common practice, and the gear is arranged automatically to cut one or more cells in or out as the voltage falls or rises, and to start the engine when necessary. The control-gear consists of an automatic motor-driven battery-switch, a set of relays, a main circuit breaker, and an engine-starting circuit-breaker. The battery-switch is operated by the energising of a relay through a contact on the voltmeter, which is reached when the voltage has fallen too low. The relay starts the battery-switch motor, which then runs, and cuts in another cell, the cutting-in of the cell breaking the battery-motor circuit. This process is continued until no more cells can be cut in, and the battery switch-arm reaches its end position, the effect of this being to close the dynamo circuit by means of a second relay. This causes the dynamo to motor, and start the engine. The connection between the battery and the dynamo is made through a time-limit reverse-current circuit-breaker, so that in case the engine will not fire or run properly it shall not continue to take current from the battery for an indefinite period. The charging of the cells is looked after by a pair of relays which are connected across alternate end cells, one being connected across, say, cell "six," and the next across cell "five." When cell "six" has risen in voltage to a predetermined value, the relay causes the charge battery-arm to move, and so cut it out of circuit, the moving of this arm at the same time transferring the first relay connection from cell "six" to cell "four," and so on, so that two relays look after all the end cells. When all the end cells are cut out, the charge-arm causes the engine to start as before, and the cells are recharged.

In conclusion, we may mention the display of Messrs. Wilson Hartnell and Co., Limited, of Volt Works, Kirkstall-road, Leeds, who make a very good display of their governors of various types. One form attracted our attention particularly, and an example of it is shown in Fig. 41, on page 537. This governor is of very small overall dimensions, and yet is very powerful. As will be seen from the figure, it contains four weights or balls, all acting on the same spring, so that there is practically no lost space in the casing containing the working parts. An interesting modification of this form of governor is also shown, in which two of the weights are much smaller than the other two. The arrangement is intended for a special winding gear, and the respective weights are arranged so that while the heavy ones come into operation at 200 revolutions, the light ones do not act until 2000 revolutions have been reached. Both sets of weights act on the same spring, exactly as in Fig. 41. An interesting tachometer, made by the Lunken Company, Limited, of 35, Great Dover-street, London, S.E., is also shown on Messrs. Wilson Hartnell's stand. This instrument is a magnetic one, and has a permanent magnet which revolves at the speed of the shaft to be measured. Between the poles of the magnet there is an armature, attached to the indicating pointer, and working against a spiral spring. The revolving of the magnet induces a current in the armature, so that it is pulled round against its spring. The instrument is stated to be accurate within $\frac{1}{2}$ per cent., while it indicates down to its lowest reading equally well as at its higher. The magnets are said to show no signs of change of strength even after many years' work. We must also refer to Fig. 42 on page 537, which shows the 3-ton electric cargo winch which is displayed by the Sunderland Forge and Engineering Company, Limited, of Pallion, Sunderland, and to which we have already referred, but which we were not able to illustrate earlier.

THE "MODEL ENGINEER" EXHIBITION.

This Exhibition, which is now open at the Royal Horticultural Hall, Westminster, S.W., is full of attractions for those who are mechanically inclined; for although there does not appear to be much change from the one that was held in the Hall two years ago, some notable advances have been made which in themselves constitute a feature quite sufficient to attract visitors. The Exhibition is the third of its kind that has been organised under the auspices of the *Model Engineer*. Though many models are, of course, merely toys, there are others which cannot be classed as such, having attained a much more scientific position. Of these many are to be seen at the present exhibition. The building of models is an occupation that has grown enormously of late years, due largely, no doubt, to the many facilities that have been placed before amateurs, for only comparatively a few years ago the difficulties to be overcome in the construction of any model were vastly greater than they are now, with the result that the art was followed only by enthusiasts. At that time such an exhibition as the present one could not have existed.

Model engineering has so far advanced that it has in many cases merged into what we may call "small power engineering." Moreover, the literature on the subject of model construction has grown enormously during the last ten or twelve years, and has given a great impetus to the pursuit. The standard of the writing on the subject has also risen, descriptions of models and the proper way to make them being undertaken by men who really understand more what they are writing about than was formerly the case, although there is still much to be desired in some directions in regard to this. There is, however, no doubt that on the whole great advance has been made. One of the directions in which advance is noticeable is that of high-speed boats, an indication of which is that the record speed now stands at 20.63 miles per hour, whereas at the time of the exhibition held in 1909 the record speed was 15 miles per hour. The public will, however, be best able to judge of these advances by a visit to the Exhibition.

As was the case two years ago, the stand of Messrs. Stuart Turner, Limited, Henley-on-Thames, is well worth a visit, for it not only shows what progress has been made in model engineering by the firm, but also in the construction of small engineering plants. Nine years ago this firm did not exist, whereas now they are one of the best-known by model-makers and amateurs, both for the high-class workmanship turned out and the great variety of their productions. A special change that has been made by the firm since the previous exhibition is that they have, in addition to a considerable enlargement of their model department, made an entirely separate department for small engineering plants, such as electrical plants, small oil-engines for pumping, &c., driving small boats, &c. Among the new things they have on view in the engineering department is a 300-watt lighting and charging set, which has only been on the market for about nine months. It is entirely self-contained, and occupies very little space. These plants are made in many sizes, the largest being 1 kw. The engines are driven by petrol, and are of the two-cycle Stuart valveless type. The plant comprises the engine, the dynamo, and the cooling-tank, all of which are fixed on a substantial base. A specially designed float-feed carburettor is fitted to the engine, and the dynamo has self-oiling bearings, carbon brushes, and a flanged belt-pulley, which is driven from the engine fly-wheel. The set will light thirty metallic-filament lamps of 10 candle-power each, or charge a battery of fourteen cells requiring 35 volts and 8 to 9 amperes. The net dimensions of the plant are 2 ft. 9 in. long by 2 ft. wide and 2 ft. 4 in. high, and it weighs 2 cwt. Other sizes are made. We understand from Mr. Turner that there is a great demand for this class of plant, when it is really an "engineering job." There is also a model pumping set on view. It consists of a two-cylinder single-acting steam-engine direct coupled to a Gwynne type of centrifugal pump, the engine cylinders being $\frac{3}{4}$ in. in diameter by $\frac{3}{4}$ in. stroke, and the impeller of the pump $1\frac{1}{2}$ in. in diameter. The engine runs at about 3000 revolutions per minute, and the delivery and suction-pipes are $\frac{5}{16}$ in. and $\frac{3}{8}$ in. in diameter respectively. Steam is supplied from a vertical boiler made of copper, the shell of which is riveted and the fire-box brazed. The shell is 4 in. in diameter and the fire-box is fitted with fifteen tubes $\frac{1}{2}$ in. in diameter, above which is placed a small superheater.

At this stand there is also a very good display of Stuart's castings for model-makers and amateurs; but an exhibit that will interest those visitors who have been won over to the fascinating study of flying-machines is what is called the "A E" petrol engine for model aeroplanes. This engine is really an excellent example of workmanship, if the one we saw is any guide. It consists of two opposed cylinders, each $1\frac{1}{2}$ in. in diameter by $1\frac{1}{2}$ in. stroke, which are either water or air-cooled as desired. The engine has a fly-wheel $1\frac{1}{2}$ in. in diameter and is fitted with a carburettor. The whole, complete, measures $14\frac{1}{2}$ in. in length, $6\frac{1}{4}$ in. in width, and $4\frac{1}{2}$ in. in height, and weighs about $6\frac{1}{2}$ lb., the power developed by it being, we understand, about $\frac{1}{2}$ brake horse-power. The engine has been designed to produce the greatest possible power with a minimum of space, weight, and vibration. It can also be used for model motor-boats. In the case of aeroplanes no fly-wheel is needed. The cylinders are of light steel, carefully ground, the pistons and cylinder heads are of fine cast iron, the crank-shaft is forged steel, the gears are machine-cut, and all the steel parts are case-hardened. The firing gear is plain make-and-break, with iridium contacts. All the parts are made interchangeable, and spare parts can always be supplied.

Among exhibitors of machine-tools for model and small work, Mr. Arthur Firth, Atlas Works, Cleckheaton, has a very complete show of lathe bench shaping-machines, bench drilling-machines, all kinds of chucks, and small tools of all descriptions. Messrs. Buck and Ryan, 312, Euston-road, London, N.W., also have a fine stand of tools on view, a collection of chucks suitable for Drummond lathes, and a collection of small bolts and nuts from $\frac{1}{16}$ in. diameter upwards to the maximum sizes used by amateurs. A very handy tool, which is also on view here, is a soldering set heated by a petrol or benzene lamp, which latter can be detached and used separately for small brazing jobs. As on previous occasions, the firm of Messrs. R. Melhuish, Limited, 84, 85, and 87, Fetter-lane, London, E.C., are well represented at the Exhibition, and they have on view a very fine collection of "Ferret" ratchet spanners, to take fourteen sizes of nuts, a feature particularly useful to motorists. There are also some new foot and hand-driven emery wheels, which can be used either wet or dry.

To lovers of locomotives, the stand of Messrs. Bassett-Lowke, Limited, Northampton, will doubtless prove of special interest, for there one naturally expects to find the latest improvements and novelties in model locomotives. A feature of the stand is an electrically-driven model of a Great Northern Railway locomotive running on a line of $1\frac{1}{4}$-in. gauge. This firm is also noted for its garden railways, many of which have been equipped. A line to which the firm have especially devoted themselves is that of complete signalling outfits, and they have on view a very fine complete installation showing a typical junction on an English railway, equipped with all signals, points and crossings, levers, interlocking gear, &c. This installation has not been exhibited before, and the opportunity for inspecting it should be taken, as we understand that it is going abroad, on to one of the Spanish railways, as a means of training and instructing railwaymen on the line. At the stand of Messrs. James Carson and Co., Limited, Cricklewood, London, may also be seen some very fine model locomotives, among them being a model of the Mallet articulated compound to a scale of $\frac{3}{4}$ in. to 1 ft., and running on a gauge of $3\frac{1}{2}$ in. The high-pressure cylinders are $1\frac{1}{4}$ in. in diameter, and the low-pressure $2\frac{1}{4}$ in. in diameter, the stroke being $2\frac{1}{4}$ in. The valve-gear is of the Walschaert type, and the frames are articulated as in the actual engine. The model is coal-fired, although in the actual locomotive oil fuel is used, but the alteration has been made without in anyway interfering with the general appearance of the engine. This locomotive has, we understand, pulled a load of eight men. The length over all is 6 ft. 9 in., and the weight 180 lb.

Among exhibits of machine-tools, Messrs. Drummond Brothers, Limited, Rydes Hill, near Guildford, Surrey, have on view a collection of their well-known lathes, drilling-machines, &c., which are so much esteemed by amateurs. As we have, however, previously described all of these tools, we need not say anything further regarding them now. Mr. Henry Milnes, of Brown-road, Bradford, also has a very good show of machine-tools on view, including a $4\frac{1}{2}$-in. centre lathe with 4-ft. 6-in. bed, self-acting, sliding, and screw-cutting, with hollow mandrel, automatic cross-feed, boring-table, &c.

In addition to what we have mentioned there is a collection of loan models, a model engineering workshop and a model railway track, besides a large collection of model aeroplanes. The Exhibition closes to-morrow, the 21st inst.

NOTE.

Tests of Reinforced-Concrete Telegraph Poles.

Through the courtesy of the British Improved Construction Company, Limited, 47, Victoria-street, Westminster, S.W., we recently had the opportunity of witnessing some tests carried out on a large reinforced-concrete telegraph pole at the company's works at Fulham. The length of the pole over all was 44 ft. 6 in, of square hollow section, 17-in. square outside at the base, and 13 in. square inside at the same point, while the outside and inside dimensions at the top were 8 in. and 4 in. respectively. The reinforcement consisted of $\frac{3}{16}$-in. diameter high-tension steel wires, having an ultimate tensile strength of from 80,000 lb. to 85,000 lb. per sq. in., 56 being assembled together at each corner. These wires were held together by $1\frac{1}{16}$-in. by $\frac{1}{16}$-in. mild-steel tie-plates pitched about 2 ft. centres. No binding wires whatever were used in the construction of the reinforcement. The pole was firmly embedded in concrete for 5 ft. 6 in. of its length, and the load was applied 38 ft. 6 in. above the top of the concrete foundation. On October 10 the pole had been tested up to $35\frac{1}{2}$ cwt., when the crab was found insecure, and the test was postponed till the 13th. The method of testing was by attaching a wire-rope to a clip at the top of the pole, the rope being carried over a pulley sheave on a crane-jib at approximately the same level as the top of the pole, and the wire was led from the sheave down to within about 10 ft. of the ground, and a Salter spring-balance was attached to it there. A chain was then fixed to the balance and wound round the drum of a 2-ton geared crab-winch. On continuing the test on the 13th a slight hair crack was observed on the tension side about 5 ft. 6 in. above the surface of the foundation, when the load was $33\frac{1}{2}$ cwt., and, when the load was increased to 36 cwt., slight hair cracks appeared, pitched regularly about 6 in. to 9 in. apart. At 41 cwt. a slight shear crack appeared, starting at about 33 in. above the foundation and extending vertically at a distance of 2 in. from the tension side for 3 ft. 6 in. in length upwards. At 46 cwt. hair cracks occurred on the tension side regularly every 3 in. or 4 in., and at 51 cwt. cracks were noticed to be travelling across the sides of the pole to within 6 in. of the compression side. At 61 cwt. the shear crack was more pronounced, and hair cracks on the tension side occurred, pitched about 1 in. apart, but no signs of failure were observed on the compression side at this load. The test was then discontinued, as the limit of the gauge on the testing apparatus had been reached. It was, however, continued on the 16th. After each of the tests we have recorded the load was released and the permanent set was recorded. The set was not measured after each increment of 1 cwt. in the load, but at varying additional loads of $2\frac{1}{4}$ cwt. in the earlier tests, to 18 cwt. in the test which brought the final load up to 60 cwt. The total deflection at 31 cwt. was $16\frac{1}{2}$ in., with a permanent set of $\frac{1}{2}$ in. on release, to a deflection of $37\frac{1}{2}$ in. at 60 cwt., when the permanent set was $1\frac{1}{8}$ in., measured an hour and a-half after the load was released. On continuing the test, at 61 cwt. the shear crack was more pronounced, and hair cracks on the tension side were pitched about 1-in. centres, but no signs of failure were observed on the compression side. At 94 cwt. the pole had a deflection of 66 in., and the cracks on the tension side were more pronounced. There were, however, no signs of failure on the compression side. On the load being released the permanent set was found to be 21 in. The load was again applied, and the first signs of failure on the compression side were noticed when the deflection was 72 in.; complete failure occurring when the deflection reached 78 in. It was found that the pole had failed almost equally for the whole of its length both on the tension side and the shear sides. On the compression side the pole showed no signs of failure, except at the base, to about 2 ft. up. The total bending moment at the base of the pole was 4,863,936 in.-lb. It may be mentioned that when the load was $57\frac{1}{8}$ cwt., with 34-in. deflection, the chain on the drum of the winch broke, releasing the pole suddenly. The pole flew back, and, after vibrating violently for a few seconds, regained its normal position, and on examination it was found that no permanent set was indicated.

Canadian Electric Power. — In connection with hydro-electric undertakings a water-power at Waddington, on the St. Lawrence, has been investigated. Waddington is in the United States, almost directly opposite Morrisburg, and there are many towns in Canada urgently requiring a supply of electrical energy situated within easy reach of Waddington, while at a considerable distance from the Niagara Falls installation. As a consequence, the Hydro-Electric Commission has entered into a contract with a Waddington company for the supply of electricity over transmission lines to be erected by the Commission to such towns as Kingston, Brockville, Lynn, Morrisburg, Cardinal, and Prescott. The charter under which the company holds the property emanates from the United States; but it is understood that a Canadian or English company will probably hold the entire stock, and make a bond issue in order to bring in English investors.

STEAM-TURBINES.

To the Editor of Engineering.

Sir,—In a recent issue of your journal you published a reprint of a paper read on the subject of "Steam-Turbines," by Mr. H. Zoelly, before the Zurich meeting of the Institution of Mechanical Engineers. As this paper contains disparaging references to the compound velocity impulse turbine, we, as the principal makers in this country of the Curtis turbine—the only turbine in which this system is employed in its entirety—ask you to publish the following:—

Mr. Zoelly states that governing by means of successive groups of nozzles is unsatisfactory, and unsuitable for parallel running. So far as our machines are concerned that statement is not in accordance with the facts, as we have over fifty machines in this country running in parallel with engines or turbines, and in every case this form of governing is operating successfully.

Mr. Zoelly also specially remarks that he has proved, after many years of experimenting and testing, that it is not possible, under most favourable conditions, to obtain with the compound velocity turbine a higher thermal efficiency than 58 per cent. We can only say that his researches could not have been complete, as the thermal efficiencies of Curtis turbines given below are considerably higher than 58 per cent., and compare well with those given by Mr. Zoelly as having been obtained with his turbines.

In order that the results may be readily compared, we have reproduced Mr. Zoelly's table, and, in doing so, we have given the superheat of the steam instead of the total temperature, as this gives at a glance a better idea of the conditions. Below his schedule we have tabulated test results on Curtis turbines, built by this company at Rugby. It should be noted that we have omitted the column of efficiencies based on conditions behind the stop-valve, as these are of no interest to the user, who is only concerned with the efficiency of the machine based on the steam conditions in front of the stop-valve.

In accordance with the more conservative practice in this country, the superheat in our tests is generally lower than in the tests published by Mr. Zoelly, with the result that our efficiencies are somewhat lower than would have been the case had our tests been carried out with a higher degree of superheat, it being well known that the thermal efficiency of a turbine increases with an increase of superheat. We should add that all the test results of Curtis turbines given in the above tables were obtained on official tests.

Yours faithfully,
(For the British Thomson-Houston Co., Ltd.),
F. Samuelson,
Engineer, Turbine Department.

Rugby, October 10, 1911.

Some Test Results Obtained with Zoelly Steam-Turbines.

Installation.	Kilowatt Load.	Pressure, Lbs. per Sq. In. Gauge.	Superheat.	Vacuum.	Steam Consumption.		Thermal Efficiency.
			deg. F.	per cent.	lb. per kw.-hr.	lb. per h.-p. hr.	per cent.
4000-kilowatt turbine, Charlottenburg, 1000 revolutions per minute. Tested December, 1910	4189	164.7	184	95.8	13.25	9.36	68.7
	3092	168.3	184	96.2	13.77	9.58	66.2
	2199	161.9	147	97.4	14.40	9.84	63.2
	1138	166.9	147	97.8	16.00	10.12	59.9
2000-kilowatt turbine, Helsingfors, 3000 revolutions per minnte. Tested November, 1910	2052	179.0	205	94.9	13.04	9.18	70 5
	1514	181.7	183	95.5	13.67	9.52	67.2
	1026	177 5	187	95.8	14 53	9.76	65.2
	510	171.8	167	96.6	17.33	10.68	58.8
1700-kilowatt turbine, Hagendingen, 3000 revolutions per minute. Tested December, 1910	1691	206.0	280	93.3	13.04	8.9I	69.7
	1366	202.3	284	94.2	13.77	9.18	66.5
	851	205.2	272	95.2	15.52	9 81	61 0
	457. 5	208.0	256	94.9	18.91	10.68	57.1
1200-kilowatt turbine, Aurich, 3000 revolutions per minute. Tested December, 1910	1235	162.3	79	94.0	15.34	10.77	67.0
	949	164.0	70	95.5	15.99	11.08	62.8
	606	166.7	53	96.5	17 1	11.48	59.0

Some Test Results Obtained with Curtis Steam-Turbines. (The British Thomson-Houston Company, Limited, Rugby.)

Installation.	Kilowatt Load.	Pressure, Lbs. per Sq. In. Gauge.	Superheat.	Vacuum.	Steam Consumption.		Thermal Efficiency.
			deg. F.	per cent.	lb. per kw.-hr.	lb. per h.-p. hr.	per cent.
3000-kilowatt 1500-revolutions-per-minute turbine; Olympia Oil and Cake Company, Selby. Tested April, 1911	2987	140	144	89.4	15.96	11.2	70.2
	2280	145	137	91.3	15 90	10.9	68.9
	1584	150	151	91.7	17.10	11.43	64.8
1500 kilowatt 1500-revolutions-per-minute turbine; the Fife Power Company, Dunfermline. Tested September, 1911	1541	135	8	93.4	17.46	12.12	65.7
	1185	129	15	94 7	18.05	12.3	63.1
	739	129	7	95.3	19.3	12.52	60.9
1250-kilowatt 3000-revolutions-per-minute mixed-pressure turbine; the Bedwas Navigation Colliery Company, Limited. Tested December, 1910	1566	140	106	92.1	16.95	12.04	63.7
	1185	140	102	91.7	17.2	12.05	64.4
	893	141	98	91 7	18.55	12.78	60.7
	626	140	100	91.7	20.35	13.6	56.9
	1268	1.5	23	91.6	29.8	20.95	73.4
	916	1.4	23	91.7	31 5	21.65	70.9
	548	1.6	24	94 5	37.5	24.72	62.0
1000-kilowatt 2000-revolutions-per-minute turbine; Messrs. W. N. Brunton and Sons, Limited, Musselburgh. Tested May, 1911	1221	120	98	90.8	17.75	12.5	65.1
	995	120	99	92.7	17.3	12.07	65.0
	500	120	89	91.8	19.9	13.1	61.1

"PAPERS FOR DISCUSSION."

To the Editor of Engineering.

Sir,—I beg to protest against the method of criticism adopted in your journal against my paper, read before the Society of Engineers, on "Railway Improvements" in an article entitled "Papers for Discussion," on October 6. If your critic, whoever he might be, objected in so astonishing a fashion to my paper, why did you not come out into the open and give your readers the opportunity of discussing it? Instead of that, you indulge in a tirade of criticism alternating between the ponderously humorous and the acrimonious. The paper was one to invite discussion, and it has aroused considerable interest; and I do not think your readers as a whole would agree with the un-English and inquisitorial method adopted—I imagine, in a moment of aberration—by your journal. I do not ask you to agree with all I have brought forward in my paper, but I ask at least for fair play and no misrepresentation.

Yours truly,
C. Reginald Enock, C.E., F.R.G.S.

Valley Croft, Northwood, Middlesex,
October 17, 1911.

[We have, of course, no quarrel with the writer of the above letter. Individuals are quite at liberty to commit to paper whatever they please. Technical societies are, however, in a different case. Not only for the reputation of their individual members, but also for their credit as corporate bodies of some responsibility, no less than in the interests of the profession at large, should such institutions do their utmost to discourage, rather than to assist in ill-directed labour of this character. Mr. Enock states that his paper "was one to invite discussion." To this extent therefore at least we have not misrepresented him, for this appeared to us to be the only possible idea behind it. It was of no value in itself. There is enough serious work to be done in the world by the engineering profession for us to be spared the trouble of raising dummies for the sole purpose of knocking them down, in the hope that the noise made in the process may lead a few people to think that something is really being done. "Considerable interest" of a serious character cannot, we fear, be claimed for this paper in professional circles. Only some twenty persons or so even paid the author the compliment of listening to it at the meeting. What happened in the world outside our profession is, of course, no concern of ours here.—Ed. E.]

MOULDING-MACHINES.

To the Editor of Engineering.

Sir,—I feel sure that neither Mr. Joseph Horner, in writing his article on "Foundry Plant and Machinery," No. XXXII., in your issue of September 29 last, nor the London firm acting as agents for Mr. Pridmore, nor this gentleman himself, would desire to claim anything more than they are entitled to, and I feel satisfied that when they have the following information they will define more particularly the design which Mr. Horner claims Mr. Pridmore "originated and developed over twenty years ago," in the early part of the article, as I am sure all parties concerned will equally agree with me in the old saying of "honour to whom honour is due."

I am sorry when Mr. Horner wrote to me some little time ago for my firm's lists of moulding-machines, some of which have already been illustrated by him in your journal, that I did not foresee that he was going to touch upon the "historical points" of this business, as otherwise I should have been delighted to have sent him an invitation to Banbury, and to have shown him moulding-machines which have been in constant work in our foundry for over five-and-thirty years, and which, I think, would have convinced him that Mr. Pridmore did not originate the "die" form of moulding-machine. This gentleman, in his Patent No. 520, 1900, only claims a few "mechanical details" in this design of machine, and these may be improvements upon some of the older forms; but it will doubtless interest both the writer of the article and the public if they will refer to Patent No. 313, 1856, of the late Mr James Howard, to whom—unless a still earlier patent was taken out—belongs the credit of inventing the "die" moulding-machine, and this has been developed greatly since by others.

I send you, in proof of above, the two patent specifications in question, which kindly return.

I also enclose you an illustration, taken from Messrs. Howard's catalogue, with the date, 1858; whilst in this catalogue, with the description of the machine, the following note is made—namely:—

"That the above machines have been in operation for two years, whilst the following eminent firms have seen Messrs. J. and F. Howard's machines in operation at Bedford, and have purchased a licence to use the patent—viz., the Coalbrookdale Company; Garrett and Son, Leiston; Ransome and Sims, Ipswich; and Mr. B. Samuelson, Banbury.

I can only add that this type of machine has been in use since that date, and is in daily use at the moment in our foundry. Doubtless some of the details, as described in the article, so far as "the withdrawal of the pattern through the 'die,'" have been improved by Mr. Pridmore; but these have also been improved by others more than twenty years ago; further, with regard to the use of "Babbitt" or other soft metal, mentioned later on in the article in question, I have the assurance of Messrs. Howard that they can find a moulding-machine in their stores, made about the year 1868, in which this form of making the "die" was employed, and also, I may add, used by my firm at least twenty years ago.

I should be very pleased indeed to show Mr. Horner these machines, and I have no doubt Messrs. Howard would also.

Apologising for taking up so much of your valuable space,
I remain, yours faithfully,
Ernest Samuelson.

Britannia Works, Banbury, October 13, 1911.

To the Editor of Engineering.

Sir,—Mr. Samuelson has favoured me with a copy of a letter of criticism sent you for publication, relating to my account of the Pridmore machines, described in Engineering of September 29, page 414.

Mr. Samuelson has quite misunderstood the statements which I gave. He makes me say that Mr. Pridmore originated the "die" form of moulding-machine, which is not correct, as may be seen by referring to the opening paragraph of that article. The stripping-plate is a part of the machine, as it is of scores of others. But the essentials are: the main frame; the movable, or "yoke," frame, with its upper and lower guides; the hand-lever and crank-shaft, duplicated in the larger machines; and the coiled counterweighting or counterbalancing springs, clearly shown in the illustrations. If Mr. Samuelson can show me these combinations in any machine built previously to the Pridmore, I shall be obliged.

Returning to the stripping-plates, on page 713 of the issue of June 2, column 3, thirty-two lines from the bottom, I distinctly stated, when describing a babbitted plate, that it "was embodied in the earliest moulding-machines made, being included in the Jobson machine." Those who have an old copy of "Spretson" may turn up a description of the plate:—"Afterwards, when the pattern is in its place, a fusible metal, consisting of 8 parts of tin, 4 lead, and 1 bismuth, is poured or filled into the space between the pattern and the plate" ("Casting and Founding," page 234).

No claim could now be patented for a stripping-plate, when almost all machines have it. It must have preceded the moulding-machines. It occurs in many old patents of the earliest machines. I have made stripping-plates years ago for ordinary moulding to draw twisted patterns through, apart from the use of machines. In the face of these facts the criticisms of Mr. Samuelson are without a basis.

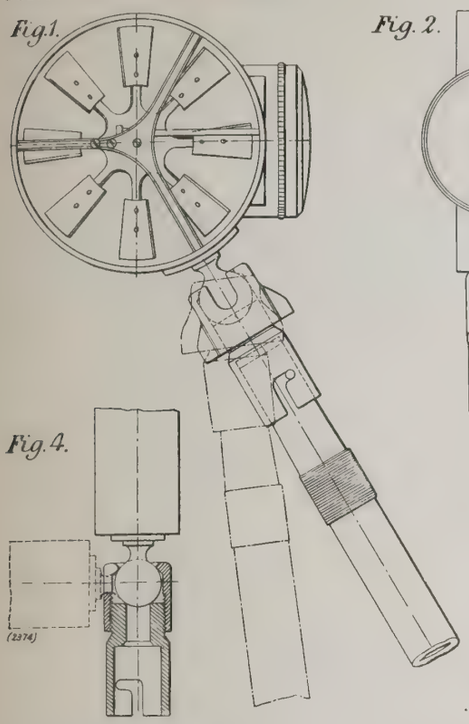
Yours faithfully,
Bath, October 14, 1911. Joseph Horner.

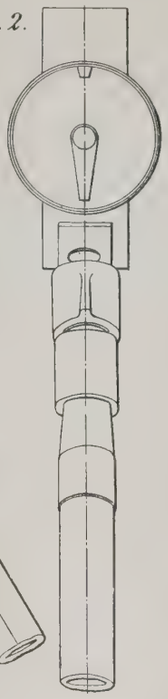
Light Railway in Crete.—A narrow 1-metre-gauge railway is to be built from Candia, the capital of Crete, which is situated on the northern coast of the island, right across the southern shore. The length is 118 km. (73 miles), including a railway in the docks of Candia, about a mile in length. Tenders should be submitted before December 2, 1911. The decision rests with a Parliamentary Committee of the island, which requires that the contractor should start a Greek company at Candia,

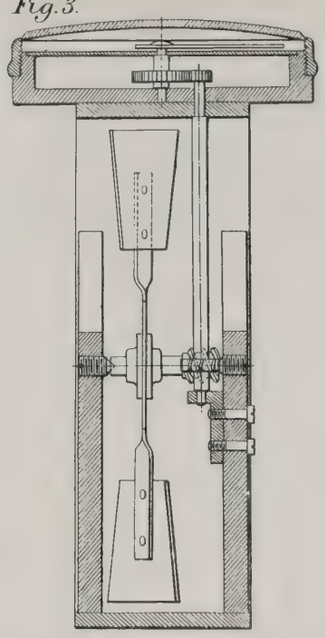
White Star Liner "Zealandic."—This vessel, just delivered by Messrs. Harland and Wolff, Limited, for the White Star Line Australian service, is 477 ft. long by 62 ft. 9 in. beam, and about 8000 tons gross register. She has very large cargo capacity in six holds—two for general cargo, and four holds insulated for carrying frozen cargo. For working cargo there are, in addition to the steam windlass, nineteen steam winches and twenty-one derricks. A feature of the ship is the accommodation specially arranged for over 1100 third-class passengers in enclosed rooms, with space on shelter deck arranged for third-class smoke-room and dining-room, and also a third-class ladies' room. The propelling machinery consists of two sets of quadruple-expansion engines on the balanced principle.

THE LEA-BIRAM ANEMOMETER.

CONSTRUCTED BY MESSRS. JOHN DAVIS AND SONS (DERBY), LIMITED, DERBY.







We illustrate on this page a new form of anemometer, patented by Mr. Henry Lea, M. Inst. C.E., of Birmingham, who found that the usual form of anemometer, with multiple dials, was not altogether satisfactory in daily use, for he wanted some means of instantaneously starting and stopping the pointers synchronously with the starting and stopping of a chronograph watch. It was found the application of such an addition to an ordinary anemometer was difficult and not trustworthy. The reading of multiple dials also requires great care. Only those people who are accustomed to read several dials to get at a total result know how easy it is to make a mistake. These drawbacks led to the designing of the instrument we have under notice, the actual construction of which will be best understood on reference to Figs. 1, 2, and 3, which are respectively a front elevation, a side elevation, and an enlarged section.

In the Lea-Biram anemometer only one pointer, one dial, and one mark on the dial are required, and the pointer is so broad that it is easily visible while in use. The dial, with its pointer, may be seen in Fig. 2. The long handle by which the instrument is held is shown in Fig. 1, where the bayonet joint, by which it is fixed, may also be seen. As the revolutions of the pointer do not exceed 20 per minute, even when measuring 2000 lineal feet of air per minute, there is no difficulty in counting the revolutions, even when the long handle is attached. By means of the ball-and-socket joint shown in Fig. 1, and in section in Fig. 4, the dial can be made to face any direction as desired. In order to use the instrument the observer holds it in a current of air, regardless of the direction of rotation, and, as soon as the proper speed has been acquired, the operator starts his chronograph watch at the exact time that the pointer passes the mark on the dial. Then, counting a convenient number of revolutions (for a slow current it may be only one), the chronograph is stopped when the pointer passes the mark at the end of the count, and the number of seconds that have elapsed are noted. Then, 6000 multiplied by the revolutions counted, and divided by the number of seconds, equals the lineal feet of air passing per minute. This calculation is very quickly made; but, if preferred, several observations may be noted down in two columns—revolutions and seconds—and the results worked out at leisure.

Three extensions of the handle are supplied with the instrument, 18 in., 24 in., and 30 in. long respectively, and they may be separate or joined together; when they are all used they make a total length of 6 ft. If desired, these lengths of handle can be supplied separately. The instrument is manufactured by Messrs. John Davis and Son (Derby), Limited, All Saints Works, Derby.

Our Rails Abroad.—There is now little doubt that 1911 will prove a disappointing period in connection with British rail exports, the shipments for September only amounting to 26,252 tons, as compared with 32,366 tons in September, 1910, and 39,152 tons in September, 1909.

THE TRANSFORMATIONS OF STEEL WITHIN THE LIMITS OF THE TEMPERATURES EMPLOYED IN HEAT-TREATMENT.*

By L. Grenet, Paris.

(*Concluded from page* 511.)

V. Nature of the Transformation of Steels.

It has been shown that, in order to classify the phenomena relating to the heat-treatment of steel, it is sufficient to allow that, within the limits to which such heat-treatment is carried steel undergoes one, and only one, transformation.

There are thus two states to be considered: the state of stability in the cold, which will be described as State F, and the state of stability when heated, which will be described as State C.

The hardness of a steel at the ordinary temperature is connected, above all, with the maximum temperature reached by the steel subsequent to its latest transformation.

The author has not yet dealt with the mechanism of this transformation, and, moreover, it will, in his opinion, be more interesting to effect it by limiting himself to the case of steel, properly so-called (containing less than 2 per cent. of carbon), and to the temperatures usually employed in heat-treatment (– 180 deg. to 1100 deg.).

A. ALLOYS.

Iron Carbon.

1. *Equilibrium Diagram of the Iron-Carbon Alloys.*—The nature of the transformation in steels containing carbon alone is very clearly represented in the now classical Roozeboom diagram.

Taking into consideration only that region of the diagram immediately concerned, and eliminating from the diagram a line which corresponds only to the rapid variation in the magnetic properties (a variation which is not distinguished by the term "transformation"), it may be said that a carbon steel is formed of two constituents—cementite, or carbide of iron (Fe_3C) containing 6.66 per cent. of carbon, and ferrite, practically pure iron.

At a sufficiently high temperature these two constituents are capable of dissolving in one another to form a solid solution, that is to say, a constituent which investigation reveals to be homogeneous, and which may, within certain limits, vary in composition in a uniform manner.

The diagram (Fig. 17) enables the phenomena occurring in a carbon steel, the temperature of which varies slowly and follows very nearly its equilibrium diagram, to be taken into consideration.

Let the case of a steel containing a per cent. of carbon be considered.

When a figurative point of this steel is above the curve A B (P to Q) this steel consists solely of solid solution, the carbon percentage of which is that of a steel containing a per cent. The steel is in the "hot stable state" (State C).

On the temperature being lowered the figurative point reaches the curve A B and Q; the steel is still formed of a solid solution containing a per cent. of carbon, but this solid solution is saturated with ferrite.

The temperature being lowered still further, from Q to M, the steel is formed of ferrite and of solid solution saturated with ferrite, of the composition shown by the abscissus of the curve A B at the temperature under consideration. The composition of the constituents and the composition of the steel being known, it is easy to ascertain the proportion of these constituents by the rule of mixtures.

Finally, the temperature being still further lowered, the figurative point of the steel reaches the point M (at a temperature of about 700 deg.). The steel still remains formed of ferrite and of solid solution saturated with ferrite (curve A B), but at this temperature the curve A B intersects the curve B C which shows the saturation of the solid solution by the cementite. This solid solution saturated by both constituents contains about 0.85 per cent. of carbon.

On the continuation of the cooling a simultaneous deposition of these two constituents takes place; this is the pearlite, or fine-grained aggregate of ferrite and cementite possessing the composition of the eutectic alloy—namely, 0.85 per cent. of carbon.

The transformation commenced at Q is complete; the steel is in the "stable state in the cold."

If the steel under consideration contained more than 0.85 per cent. of carbon, analogous phenomena would take place, but cementite would be deposited up to the temperature of 700 deg., at which the solid solution remaining would possess the eutectic composition of 0.85 per cent. of carbon.

It would appear logical to admit that ferrite is not absolutely pure iron, but a solid solution capable of dissolving but very little carbide. Roozeboom has foreshadowed the possibility of this conception. But this solubility of carbide in ferrite must be exceedingly low, for pearlite is already seen to make its appearance with carbon percentages below 0.10 per cent. It may similarly be imagined that the cementite is not a definite compound, but a solid solution rich in carbon, and of a composition varying slightly with the temperature.

It does not appear logical to the author to discuss the slight discordances between the experiments and the diagram. On the one hand, experiments made on aggregates are very difficult of interpretation; and, on the other, there are always, in what are called the iron-carbon alloys, gases present, and we are ignorant of the part played by these gases in the phenomena of equilibrium.

If the practical point of view be kept in sight in following out the mechanism of the transformation of steel, it is sufficient to refer to the simple diagram just described.

2. *Constituents of Steels Heated to a High Temperature and Slowly Cooled.*—A steel slowly cooled down from the temperature in which it exists in the state of solid solution is therefore formed of two constituents, ferrite, and cementite; the whole of one of these constituents, and a portion of the other, form an aggregate containing 0.85 per cent. of carbon (pearlite). The constituent in excess (ferrite in steels containing less than 0.85 per cent. of carbon, and cementite in steels containing more than 0.85 per cent. of carbon), which separates prior to the decomposition of the eutectic, is found grouped in elements of a comparatively big size.

3. *Nature of the Transformation of pure Iron.* (*Iron-Carbon Alloys are in the same General Category as all other Alloys, the Constituents of which are Capable of Forming Solid Solutions.*)—Reference should be made to the transformation which pure iron undergoes at about 900 deg. If reference be made to diagram Fig. 17, it will be seen that the curve A B intersects the ordinate corresponding to pure iron at about 900 deg.; at this temperature pure iron passes into a solid solution (gamma iron) even when no carbon is present—that is to say, that above 900 deg. there is a transition, without discontinuity, of the pure iron constituent to the constituent containing a per cent. of carbon, a circumstance which cannot occur at a temperature below 900 deg. (alpha iron).

Thus the transformation of pure iron is nothing less than its passage into solid solution, and there is nothing to distinguish it from the transformation of steels by mutual solution of cementite and ferrite.

The case is absolutely identical with that of the fusion of any two bodies which form a liquid solution. The fusion of ice is nothing less than the dissolution of ice in the liquid salty solution (water and common salt) when the proportion of common salt tends to approach zero, and there is no reason for recognising any difference between the phenomena.

Thus in diagram, Fig. 17, the very fact that the curve A B intersects the ordinate corresponding to pure iron before either fusion or volatilisation takes places, leads inevitably to this conception of the transformation of pure iron. It is unnecessary, therefore, when the alloys of iron and carbon are under investigation, to make any distinction, as is so often done, between the change in the state of the iron and the dissolution of the iron in solid solution. They are one and the same thing. Steels belong, therefore, to the general case of alloys formed of two constituents, and capable, at certain temperatures, of dissolving to form a solid solution.

4. *Quenching: Hypothetical Diagram of Unstable Equilibrium During Quenching.*—The equilibrium diagram being represented in unbroken line, the constitution of a steel heated, to begin with, at a temperature sufficiently high (region ABC, Fig. 18) for the metal to pass into a state of solid solution, will be, during rapid cooling, represented in the diagram by a dotted line. Quenching will for an instant retain the elements in supersaturated solid solution, and this solution decomposes into its elements along the line P Q, the position of which varies according to the temperature to which the steel has been heated and rate of cooling. Decomposition of this supersaturated solution at a low temperature yields a very fine-grained aggregate of ferrite and of cementite. The conception of an eutectic (an aggregate of definite com-

* Paper read before the Iron and Steel Institute in London, on October 5.

position) disappears when the case of quenched steels is considered.

In reality, the "transformation on cooling" of a supersaturated solid solution does not occur suddenly like the precipitation of a liquid solution, for at each temperature the transformation is limited as the result of the pressure occasioned by the augmentation of volume which results from this transformation in a metal of which the elastic limit is already high.

Transformation occurs in this case between the lines P Q and P′ Q′. If, as has been shown in the figure, the line P′ Q′ cuts the abscissus corresponding to the ordinary temperature, the quenching of steels containing sufficient carbon will preserve at this temperature a portion of the "hot stable state" (austenite).

This solid solution will decompose into its elements if the metal be reheated sufficiently to lower its elastic limit, or if it be cooled sufficiently for the tension of transformation to become greater than the pressure.

This intervention of the pressure as a limitation of the transformation at each temperature was pointed out long ago by Mr. Osmond.

Fig. 17

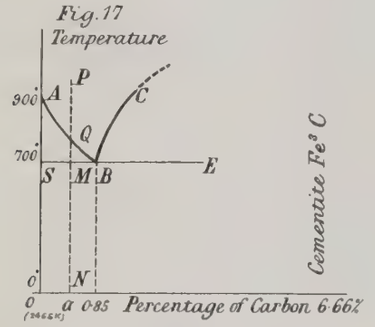
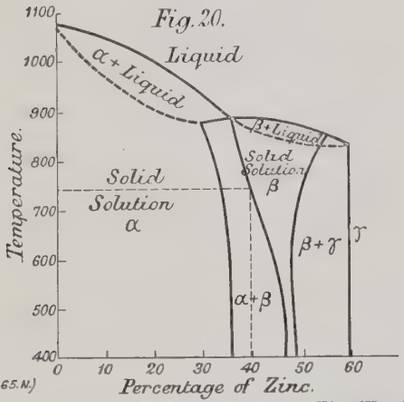


Fig. 20.



Portion of Shepherd's Diagram (Copper-Zinc Alloys), showing that some Alloys may be formed of Solid Solutions, the Composition of which varies with the Temperature.

It has been stated that, in the author's opinion, it is not logical to refer the hardness of quenched steels to the partial preservation of this solid solution; but, on the contrary, to the, at least partial, decomposition of this solid solution into its elements on cooling.

5. *Constituents to be Taken into Account in Quenched Carbon Steels.*—From what has already been said, it is possible to recognise in quenched steels three distinct physico-chemical constituents: ferrite, cementite, and solid solution (steel with austenite or gamma iron).

It does not seem reasonable to the author to interpolate other constituents.

Nearly every one nowadays is agreed in recognising that the constituents troostite, sorbite, and osmondite are fine-grained aggregates of cementite and ferrite. On the other hand, a general consensus of opinion recognises two distinct solid solutions, martensite and austenite.

This conception of two solid solutions cannot be made to agree with the simple diagram which has just been described, in which there is room but for one solid solution, and in which no transformation of iron can be recognised independently of its passage into solid solution.

Mr. Osmond has observed* that the distinctions in the transitional forms which occur between the mixed gamma crystals (which is described above as solid solution) and pearlite, although entirely justifiable from the point of view of the micrographist and of the engineer, cannot be considered from the physico-chemical point of view as phases properly so-called.

Martensite may just as well be regarded as a very fine aggregate of two (cementite and ferrite), or sometimes three (cementite, ferrite, and solid solution) constituents, as also as a homogeneous constituent. It does not seem reasonable to complicate the conceptions which have served as a guide in order to classify ill-defined aspects, even although they may be designated by terms which lend them an illusory precision. For all practical purposes, the conception of three physico-chemical constituents, and three only, grouped in aggregates of more or less fine grain, has always sufficed for the classification of the observed facts; and the author sees no necessity, for the classification of such facts, to entertain a conception of two solid solutions.

* "Remarque sur le Memoire de M. Roozeboom," *Bulletin de la Société d'Encouragement*, November, 1900.

B. SPECIAL STEELS.

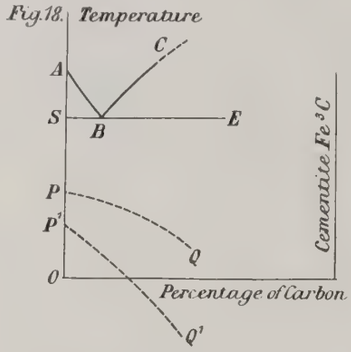
1. *The same views may be adopted as in the case of carbon steels.*—The equilibrium diagram certainly varies with the composition of the steel, but the general conception which serves to classify the facts actually known remains unaltered.

It may be said special steels are formed of two constituents, a ferrite or solid solution containing very little carbide, and a complex carbide of iron and of the special elements.

At a sufficiently high temperature, these two constituents are capable of dissolving in one another with the formation of a solid solution.

As there are more than two independent components, it is legitimate to allow of the possibility of a more complicated conception in regard to special steels than in the case of carbon steels alone. The simple conception which has served to classify the facts relating to carbon steels suffices, however, up to the present moment for the classification of the known facts relative to the special steels.

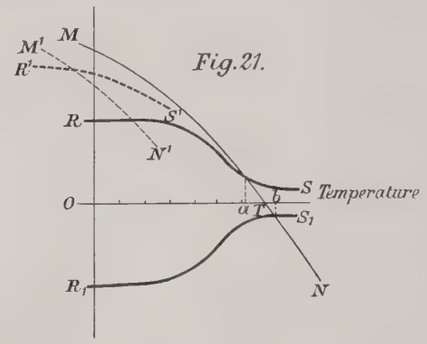
Fig. 18.



CONSTITUTION OF A STEEL DURING QUENCHING.

Above P Q — *Solid solution (Hot stable state)*
P Q, P′ Q′ — *Solid solution, Ferrite, Cementite.*
Below P′ Q′ — *Ferrite & Cementite (Cold stable state)*
(1465.I)

Fig. 21.



T = normal temperature of transformation.
M N = curve of tension of transformation of the metal; the region M T, in which the ordinates are positive, shows that the metal has a tendency to pass from "C state" to "F state," and inversely the region T N shows a tendency at these temperatures to go over from "F state" to "C state."
R S, R_1S_1 = curves of passive resistance opposing either transformation.

On heating—
Temperature below T .. .. Stable state F.
T to *b* .. .. Unstable state F.
Temperature higher than *b* .. Stable state C.

On cooling—
Temperature higher than T .. Stable state C.
T to *a* .. .. Unstable state C.
Temperature below *a* .. .. Stable state F.

2. *The Case of Steels with a Low Transformation Temperature.*—As has been pointed out, a carbon steel slowly cooled is, at each temperature, practically constituted as shown in its equilibrium diagram.

With some of the special steels there are, even with very slow cooling, retardations analogous with those which are produced on quenching carbon steels.

The equilibrium diagram being represented by unbroken lines, the diagram representing the constitution, on cooling, of a steel originally heated to a sufficiently high temperature for the figurative point to occur within the region A B C (solid solution) will be represented in dotted lines (Fig. 19).

The decomposition of the supersaturated solid solution is limited at each temperature by the pressure resulting from this transformation, with its accompanying change in volume in a metal possessed of a high elastic limit. Quenching, or rapid cooling down to the neighbourhood of the ordinary temperature, will lower the region P Q, P′ Q′ in the vicinity of that temperature.

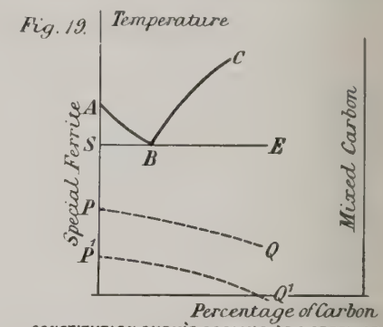
It will be seen that the influence of quenching will differ so much the less from that of annealing at high temperature in proportion as, at slow cooling, the region P Q, P′ Q′ is nearer the ordinary temperature. So long as, for the steel under consideration, the ordinary temperature is below P′ Q′ in the region P Q, P′ Q′, or above P Q," the result will be a steel in the "stable state in the cold" at the ordinary temperature (ferrite and carbide), a steel partially transformed at the ordinary temperature (ferrite, carbide, and solid solution), or a steel in the "hot stable state" at the ordinary temperature (solid solution).

It will be seen that in the case of these steels the conception of an eutectic loses much of its importance inasmuch as on cooling the deposit consists of the components of a supersaturated solution, and no deposited aggregate of definite composition is obtained.

C. VARIOUS ALLOYS.

Equilibrium diagrams may vary considerably. A frequent instance is that afforded when the alloy is not composed of definite constituents, or of constituents capable at certain temperatures of forming a solid solution, but where it is composed of several solid solutions, the range of composition of which varies with the temperature.

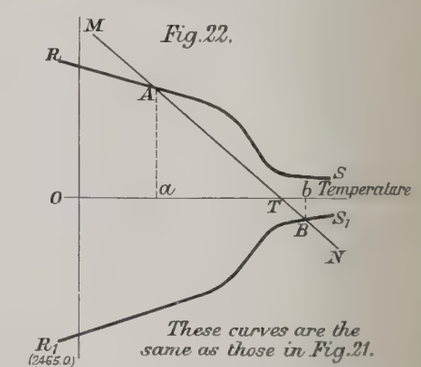
Fig. 19.



CONSTITUTION DURING COOLING OF A STEEL AT LOW TEMPERATURE OF TRANSFORMATION.

Above P Q — *Solid solution (Hot stable state)*
Region P Q, P′ Q′ — *Special Ferrite, Carbide, Solid Solut.ⁿ*
Below P′ Q′ — *Special Ferrite, Carbide (Cold stable state).*
(2465.M)

Fig. 22.



On heating—
Temperature below T .. .. .. Stable state F.
T to *b* .. .. Unstable state F.
Temperature higher than *b* .. .. Stable state C.
In the cold—
Temperature higher than T .. .. Stable state C.
T to *a* .. .. Unstable state C.
Temperature below *a* .. .. .. Stable state F.

The constitution of the metal will therefore vary with the temperature so long as it is not composed of a single solution.

The influence of quenching will therefore vary continuously within a certain very extended temperature interval. This is the case with certain copper-zinc brasses, and is very probably the case with complex brasses and aluminium bronzes. Thus, if reference be made to Shepherd's diagram (Fig. 20) for brasses, it will be seen that a brass possessing a composition copper 60, zinc 40, will possess a constitution which will vary with the temperature from the moment when the curves M N and R S cease to be vertical and parallel to the ordinate corresponding to the composition of the alloy up to a temperature of about 740 deg., at which this ordinate intersects the curve R S, and where the metal is composed of a single solid solution.

The influence of quenching is therefore absolute and variable between 400 deg. and 740 deg. It is highly probable that the special brasses and aluminium bronzes which haruen on quenching possess a similar diagram (Fig 20). The constitution of an alloy containing 40 per cent. of zinc, and composed of two solid solutions, alpha and beta, both saturated respectively, will vary between 400 deg. and 740 deg., which is the temperature at which the alloy will be composed of a single constituent, beta solid solution, which will not vary any further up to the commencement of fusion.

An alloy containing 20 per cent. of zinc composed of a single constituent (non-saturated alpha solution) will not undergo any modification in its constitution up to the commencement of fusion.

It may be supposed that below 400 deg. the constituent of the alloy no longer undergo modification (the lines in

the diagram would be vertical), which is probably not absolutely correct.

VI. MODE OF ACTION OF THE DIFFERENT ELEMENTS ON THE TEMPERATURE OF TRANSFORMATION BOTH ON HEATING AND ON COOLING.

To simplify what follows, it may be imagined that the transition from one state to another takes place normally at a given temperature, instead of occurring within a certain temperature interval which may sometimes be very considerable, particularly when alloys other than steels are involved. If the steel under consideration at any given temperature is not, at that temperature, in its stable state, it tends to revert to it; and it may be imagined that the tension with which it tends to revert to that stable state is great in proportion as the temperature of the steel differs from the normal temperature of transformation. In contradistinction there is reason also for taking into consideration the passive resistance opposed to any transformation, no matter of what nature, a passive resistance which may be imagined to be greater in proportion as the metal is less malleable, and may also be conceived as being connected with the temperature by a curve having the same appearance as the curve which connects elastic limit with temperature.

The various elements introduced into a steel will act more or less along one or other of these curves. In order that a transformation can occur, it is necessary that the tension of that transformation shall, irrespective of its direction, be higher than that of the passive resistance.

The "cold stable state" is designated by the term "F state," and the "hot stable state" by the term "C state." The following figures allow of the phenomena being followed (Figs. 21, 22, and 23).

1. *The temperature of the transformation on slow cooling coincides nearly with that on heating* (Fig. 21).—The temperature region *a b*, within which no transformation in any direction takes place, possesses but very little extension.

It can be explained that quenching maintains at the ordinary temperature a portion of the "hot stable state" C, the transformation not having had time to complete itself at a high temperature by the fact that the pressure arising from the increase in volume in the regions already transformed modifies the curves M T and R S to M′ N′ and R′ S′. Most of the steels in the first group, and most of the alloys which harden on quenching, belong to this category.

2. *The temperature of transformation on cooling differs considerably from the temperature of transformation on heating* (Fig. 22).—On heating, the absolute value of the tension of transformation increases, while the passive resistance diminishes. There cannot, therefore, be much displacement of transformation, and, as H. Le Chatelier has pointed out, the temperature of transformation on heating ought to be considered as being in the near neighbourhood of the normal temperature of transformation.

When the temperature *a* is higher than the ordinary temperature, the steels belong to Group III. When the temperature *a* is lower than the ordinary temperature, the steels belong to Group IV., maintaining at the ordinary temperature the "hot stable state." Temperature *a* may be below absolute zero—that is to say, may have no existence (steels which undergo no transformation below the temperature of fusion).

As has already been pointed out, all alloys which do not undergo transformation between ordinary temperature and that of fusion may be compared to the steels of Group IV.

3. *The transformation on cooling occurs in several temperature regions, although in regions intermediate between those in which the transformation occurs no transformation occurs* (Fig. 23).—The transformation commenced at A C may, if it is not complete, cease, and begin again at a lower temperature, thus appearing as though two distinct transformations take place, whereas it is the same transformation which is being completed after having been suspended at a certain temperature region.

It has already been pointed out that the steels of the second group, the transformation temperature of which is considerably lowered by moderately slow cooling (high-speed tool steels), exhibit the peculiarity of having a transformation on cooling which may be completed at about 600 deg., but which, if not commenced or not completed at this temperature, no longer recommences to complete itself until 200 deg. is reached. The author has found certain chromium-nickel steels in this category.

Maurer has recently described hard manganese steels which are able at ordinary temperatures to maintain a "hot stable state" if they are cooled with sufficient rapidity while they are undergoing transformation either above or below that temperature. This is really the same phenomenon: the ordinary temperature is comprised between *c* and *d*.

Some of the tin-copper bronzes which are capable of being modified by quenching are in the same category, the ordinary temperature is comprised between *c* and *d*. It may, however, be that *d* is below absolute zero—that is to say, that no matter what cooling may follow quenching, it is never possible to restore the alloy to the "cold stable state," whereas heating to *c* occasions this transformation.

Finally, Mr. H. Le Chatelier pointed out long ago that Hadfield steels (manganese steels in the "hot stable state" at ordinary temperatures) become transformed and magnetic on prolonged reheating at a nascent red heat. This magnetic transformation probably corresponds to the transformation from the "hot stable state" to the "cold stable state."

It is only necessary to admit that, so far as this metal is concerned, the ordinary temperature is comprised within the range *c d*, and that the temperature of 500 deg. is comprised within the range *c a*, and that the passive resistance within this range is in close proximity to the tension of transformation, which would explain the slowness with which the phenomenon occurs.

4. *Various Considerations.*—When the transformation, even on slow cooling, takes place at a temperature sufficiently low for the metal to possess a high elastic limit, the pressure resulting from the partial transformation displaces the curves M N and R S, as has been shown in the case of the quenched steels (Fig. 21), and the transformation extends over a lengthy temperature interval.

The maximum temperature reached on heating, and the length of time during which the metal remains at this temperature, may produce slight variations by hysteresis in the form of the curves, and thus modify the temperature of transformation; interstrain influences and diminishes the passive resistances which are opposed to transformation (according to Dumas).

Slight variations in chemical composition may considerably lower the temperature of transformation on slow cooling. There may even be discontinuity in the law which connects chemical composition with the temperature of transformation on cooling.

In any case, below 300 deg. the malleability of the metal varies but slowly, and it becomes necessary to modify to a perceptible extent the curves characteristic of the metal and, consequently, the chemical composition, in order to lower still more the temperature of the transformation on cooling. It may easily be seen that it often requires only a small proportion of special elements to lower transformation on slow cooling from 700 deg. to 300 deg., after which the action of these elements becomes much weaker.

Thus, for steels containing 0.2 per cent. of carbon and 0.4 per cent. of manganese, it only requires 8 per cent. of nickel to lower the temperature of the transformation on slow cooling from 700 deg. to 250 deg. With 21 per cent. of nickel the steel still becomes transformed in the vicinity of the normal temperature. It is sufficient to add 1.7 per cent. of chromium to a steel containing 4 per cent, of nickel to lower the temperature of its transformation on cooling from 600 deg. to 200 deg., whereas larger additions only act more slowly. The author has not studied the series of steels with sufficient attention to investigate the discontinuity which he has pointed out as possible. In any case, it is useful to note that with the chromium-nickel steels ordinarily employed there is but little difference in chemical composition (1 per cent. of nickel and 1 per cent. of chromium) between the steels which undergo that transformation on slow cooling at about 700 deg. and those which undergo it at about 300 deg.

Keeping to the steels habitually employed (with a maximum of 6 per cent. of nickel and 2 per cent. of chromium) the author has not been able to obtain a simple coefficient of equivalence representing the action of the different elements on the temperature of transformation on cooling.

Nickel lowers the temperature of the transformation on heating which may be considered as closely in the neighbourhood of the normal temperature of transformation. It is therefore reasonable to suppose that this substance influences considerably the curve of the tension of transformation.

As other substances, such as chromium, manganese, tungsten, and molybdenum, lower but slightly or not at all the temperature of transformation on heating, they should more particularly influence the curve of passive resistance. Simultaneous action on the two curves allows of the temperature of transformation being lowered in the vicinity of the ordinary temperature when a relatively small proportion of the special elements is present (Fig. 26).

CONCLUSIONS.

1. The iron-carbon alloys partake of the general category of alloys, and no complications due to allotropic transformation of the element iron need be taken into consideration.

2. It is quite easy to represent by simple diagrams the mode of influence of the special elements on the temperature of transformation on cooling.

3. Quenching (rapid cooling from a temperature sufficiently high that the constituents of an alloy should not be the same as at the ordinary temperature) may, as compared with annealing (slow cooling), act as follows:—

(*a*) By changing the nature of the constituents, and notably by preventing wholly or partly the transformation on cooling. In this case, which is rare, so far, that is, as steels are concerned, the quenched state and the annealed state are physico-chemically different states, and their properties cannot be foreseen. It may, however, be said that in the few instances in which such quenchings are known the quenched state is often softer than the annealed state.

(*b*) Quenching may also act by lowering the temperature of the transformation on cooling. In this, which is the most usual case, the quenched metal is always harder than the annealed metal.

4. The following very general law, which satisfactorily groups the facts which have been observed as to steels of the most varied description, and appears to agree with what is known as to alloys, may be formulated. An alloy is the harder in proportion as the transformation which has given birth to its constituents at the time has taken place at a lower temperature, has been more rapid, and as the maximum temperature reached since the last transformation has been at a lower temperature, and has been maintained for a shorter period of time.

The pure metals are alloys in which one of the constituents is in the proportion of nil, and the law applies in this extreme instance, in which there is but one constituent (pure, or nearly pure, iron).

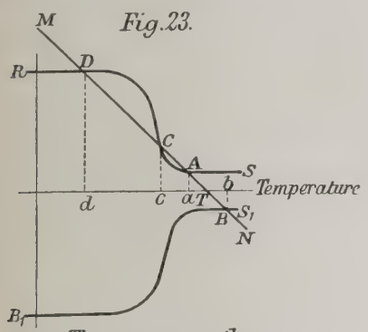
When it is distinctly higher than the temperature of transformation, the action of the maximum temperature reached since the last transformation preponderates, and it is this which should serve as a guide in the treatment of steel.

It would appear that the law enunciated above applies equally when the constituents for the time being result from a transformation which causes the metal to pass from the liquid state to the solid state (influence of the method of casting), as, for example, in sand or in a chill; and when they result from a transformation of the metal to the solid state either before or after transformation (as in the quenching of steels).

The phenomena relating to the hardening of a steel by quenching belong, therefore, to the exceedingly common category.

So far as the real cause of hardening is concerned, it cannot be said to be known. We are thus led to the conclusion that hardening produced by quenching is due solely to the fineness of the structure. The comparison of the quenching of a solid solution to the quenching of a liquid solution (cast in chills) appears, there-

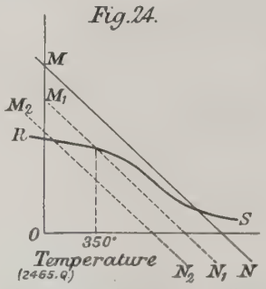
Fig. 23.



These curves are the same as those on Fig. 21. (2465.P)

On heating:—
Temperature below T .. .. Stable state F.
T to *b* .. .. Unstable state F.
Temperature higher than *b* .. Stable state C.
On cooling very slowly:—
Temperature higher than T .. Stable state C.
T to *a* .. .. Unstable state C.
Temperature below *a* .. .. Stable state F.
On cooling, but when the cooling is sufficiently rapid to prevent the transformation on cooling within the temperature interval *a c*:—
Temperature higher than T .. Stable state C.
T to *a* .. .. Unstable state C.
Temperature below *d* .. .. Stable state F.

Fig. 24.



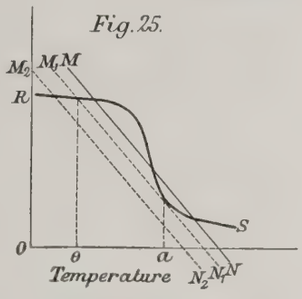
(2465.Q)

In certain series of steels a slight variation in the chemical composition may considerably lower the transformation temperature (down to about 300 deg.).

Below this temperature, as the malleability of the metal varies but slightly, it is necessary to influence the curves much more strongly, and therefore to influence the chemical composition in order to lower to an appreciable extent the temperature of the transformation on cooling.

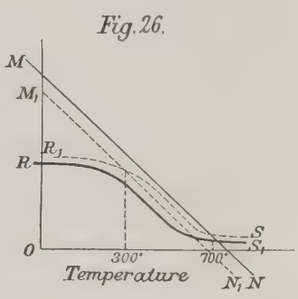
For the sake of simplicity, both in this figure and in the figure following, the special elements have been conceived as modifying only curve M N; in reality they act simultaneously on M N and on R S.

Fig. 25.



In certain series of steels a continuous variation in the chemical composition, producing a continuous modification in the curves, makes the temperature of the transformation on slow cooling vary discontinuously from *a* to *θ*.

Fig. 26.



Showing that the simultaneous addition of a small quantity of nickel and chromium to a carbon steel, by lowering considerably the temperature of the transformation on cooling (from 700 deg. to 300 deg.), modifies the curve M N at M′ N′ and the curve R S at R′ S′.

fore, to the author to be nearly perfect. In some instances the constituents of a metal vary with the rate of cooling (white or grey pig iron, austenitic steels); but, generally speaking, the constituents of the metal are independent of the rate of cooling, and the law connecting the hardness of the metal with the conditions under which the transformation has been effected applies. Annealing is liquation within a solid, and this liquation would appear to be limited only to the extent of the complete separation of the constituents. Exceedingly slow cooling isolates the constituents in steels or in alloys.

Between the quenching of metal in a state of solid solution and the quenching of a liquid metal there are naturally enormous differences from the practical point of view. The cooling of a solid solution takes place without the intervention of a mould, and may be very rapid; the constituents separating from the liquid solution are more readily able to segregate by the intervention of the liquid solution not as yet decomposed than the constituents separating from the solid solution. The quenching of a solid solution is therefore more energetic than the quenching of a liquid solution.

Further, while a liquid solution presents no discontinuity, a solid solution is divided into grains like the metals formed of a single constituent; the grains are larger in proportion as the metal has been heated longer and at a higher temperature. At the time of the formation of the "cold stable state," the texture of this state may depend partly on the texture on the "hot stable state" which has preceded the state at the time being.

What is important to remember as a guide in the treatment of alloys is the relation—independent of any special conceptions as to the metal iron—which connects the hardness of an alloy with the conditions under which the transformation on cooling is produced, and, in particular, with the maximum temperature to which the alloy has been raised since the setting in liberty of its constituents at the time being.

British Naval Expenditure.—The growth of British naval expenditure is forcibly illustrated by the following table, showing the amount paid out for the decade ending with March 31, this year, inclusive:—

Year.	Expenditure. £	Year.	Expenditure. £
1902 ..	31,030,000	1907 ..	31,434,000
1903 ..	31,170,000	1908 ..	31,141,000
1904 ..	35,476,000	1909 ..	32,188,000
1905 ..	36,830,000	1910 ..	35,807,000
1906 ..	33,300,000	1911 ..	40,386,000

Local Indebtedness.—The indebtedness of town and county councils and other local authorities has increased very heavily during the last few years, although recently there has been greater check upon this movement. The actual indebtedness of these bodies stood as follows in each of the ten years ending with 1909 inclusive:—

Year.	Indebtedness. £	Year.	Indebtedness. £
1900 ..	293,864,224	1905 ..	466,459,269
1901 ..	316,704,222	1906 ..	482,983,929
1902 ..	343,416,582	1907 ..	494,487,512
1903 ..	370,607,493	1908 ..	503,645,616
1904 ..	393,888,148	1909 ..	512,487,522

It will be seen that the increase in local indebtedness in the ten years was 218,623,298*l.* The amount raised by new loans during each of the ten years was:—

Year.	Loans. £	Year.	Loans. £
1900 ..	23,438,816	1905 ..	33,408,316
1901 ..	29,931,138	1906 ..	24,485 932
1902 ..	34,376,115	1907 ..	20,393,901
1903 ..	35,271,367	1908 ..	20,686 656
1904 ..	31,134,470	1909 ..	20,028,195

These figures exhibit an aggregate of 273,154,906*l.* The actual increase of indebtedness having been no more than 218.623,298*l.*, it follows that old loans were paid off in the period under review to the extent of 54,531,608*l.*

The "Copper Hand-Book."—The tenth edition of this manual of the copper market of the world, which has just appeared, is quite up to its predecessors in size and general "get up," and contains, as usual, much valuable and interesting matter. Since the last edition appeared, in the early part of last year, the book has had added to it as many as 300 pages, and now contains 1900 pages, which are of specially thin paper, a feature rendered necessary in order to keep the weight below 2 kg., in order to comply with postal regulations. The present volume contains nearly eight times as much matter as was given in Vol. I., and describes 8130 mines and mining companies, as compared with 256 properties described in the first volume. The arrangement is very much on the same lines as in the last volume; the first eight chapters being devoted to the history, geology, chemistry, mining, and metallurgy of the metal. Then follow chapters on alloys, brands and grades, uses and substitutes for copper, and a glossary of terms. The next eleven chapters are devoted to the copper mines of the world, while in the last chapter general statistics are given, in which may be found the world's copper production by countries, the production by continents, and the world's total production. Prices are also given, and other financial matter. The volume represents an enormous amount of labour and should prove of great value to everyone interested in copper, either as producers, users, or financiers. It is compiled and published by Mr. Horace J. Stevens, of Houghton, Michigan, U.S.A., the price being 5 dols. The editor will, however, send the book prepaid, without advance payment, on one week's approval, to any one ordering it.

THE ELECTRICAL CONDUCTIVITY AND CONSTITUTION OF ALLOYS.*

By W. M. Guertler, Ph.D. (Berlin).

The equilibrium diagram is now almost universally taken as the basis for any systematic study of the properties of alloys, and from a knowledge of it alone it is often possible to predict numerical and quantitative relations for the variation of any property with concentration and temperature. It is only necessary under ordinary circumstances to take account of the concentration and temperature, as pressure may be regarded as remaining constant, and therefore left out of consideration. The relation between concentration, temperature, and any given property is best brought out by the employment of a co-ordinate system in three dimensions. Thus, taking concentration and temperature as the base, we can erect ordinates whose lengths are proportional to the numerical values of the property under consideration, and so obtain a surface which can, in general, be subdivided into a series of curved surfaces, for each of which a mathematical formula can be deduced. These surfaces either intersect one another in certain curves, or else terminate abruptly at others, when the values fall or rise perpendicularly, and a new surface is formed at a different distance vertically from the base. In either event, the projection of these surfaces on the base will give the boundaries of the different phase-regions of the equilibrium diagram. As mentioned above, a mathematical formula with certain special constants can be found for each such surface, and we must now endeavour to discover the values of these constants. Since a full series of observations would be necessary for each service, and since the number of alloys that could be studied is so vast, it follows that we cannot hope in every particular case to predict the property of any alloy by ascertaining the values of these constants experimentally, but that we must endeavour to ascertain the general principle underlying the phenomena, and then proceed to argue by analogy in the particular case.

The converse problem is one of great importance—viz., that of obtaining the equilibrium diagram (when it is unknown) by projection from the surface on to the basal plane. In general, a series of observations will be made representing any property either at constant concentration or at constant temperature, and discontinuous curves will be obtained showing the dependence of the property on concentration or temperature. Every break or discontinuity will furnish one point of the phase limits of the equilibrium diagram, and the form of the different portions of the curves will be characteristic of the particular phase region, homogeneous or heterogeneous, to which they correspond.

With respect to the measurement of any property,† it is necessary to distinguish between quantitative methods, which give absolute values, and qualitative, which give values in a constant, though unknown, measure. The best known of these methods, and that hitherto most frequently employed, is that known as "thermal analysis," in which special account is taken of the variations in the "total heat." It can now fairly claim to be worked out, and of great value in the determination of the constitution of alloys. Other properties just as capable of similar application are magnetic permeability, specific volume, specific resistance, &c.

II.

The property of "total heat," which is so important in the determination of the constitution of alloys, is unique in one way as compared with all other physical properties. Whilst in the cases of electrical resistance, specific volume, electrolytic potential, and so forth, the data obtained can be expressed in absolute measure, this is not the case for "total heat." The absolute value of the "total heat" of a body is unknown. In other words, we do not know how high the "total heat" surface stands above the basal plane. We can only determine by experiment differences of this property. Thus, by "specific heat" we mean the difference between the total heats of the same body at different temperatures; by "heat of combination" the difference of total heat between the reacting bodies before and after chemical union has taken place. *A priori* this impossibility of giving absolute values for the "total heat" is the cause of the fact that its application is subject to two limitations that do not hold in the case of other properties. In the first place, it is impossible to define rigorously a given initial state and to compare it with a later definite state. In any system, as, for example, in a series of alloys, the question that must invariably arise is, whether or not it is in stable equilibrium. Any gradual change of constitution will, in general, be accompanied by a change of volume, electrical conductivity, thermo-electric potential, &c. (as well as by a change in the "total heat"). It is possible to determine the value of any of the first-mentioned quantities between certain arbitrary and prolonged intervals of time, and if absolute values are obtainable, we may compare the results and prove that any given change is either still proceeding, or has come to an end. But this cannot be accomplished by "thermal analysis," because it cannot be proved by absolute measurements that a given system has at the end of a given interval a different "total heat" from that which it had at the beginning, but only that it has either absorbed or evolved a certain quantity of heat during the interval. And even this cannot be proved if the interval of time lasts over many hours or days. We determine this quantity of heat by transferring it to some other body, at a known temperature and of a known thermal capacity, and measuring the difference of temperature produced thereby. This can only be done if we take care to prevent any interchange of heat with the surrounding space, and this is only possible if the experiment requires but a few seconds, or at most minutes, for its execution.*

Fresh instances of this inherent defect in the method of thermal analysis are being brought to light almost every day, as the number of exact and systematic investigations upon the constitution of alloys increases. The data obtained hitherto in the large majority of researches upon binary metallic systems are seen to refer only to states of more or less incomplete equilibrium. For example, in most alloy series solid solutions are formed, but it rarely, if ever, happens that, whilst a so-called "cooling curve" is being taken, the rate of fall in temperature can be made so small as to give time for the components to diffuse completely, and so form perfectly homogeneous solid solutions. True equilibrium between the liquid phase and the solid solution crystallising from it is probably never maintained, and therefore the solidus curves and the ends of the eutectic horizontals cannot be accurately determined. Thermal analysis is but of little avail in studying the various reactions that can occur in the completely solid state. It is impossible by means of it to investigate slow changes, to prove that a definite state of equilibrium has been reached, or that during a certain lengthy period some internal change in the alloy occurred.†

In order to demonstrate the excellent results, however, of which certain other methods are capable, it is only necessary to cite the interesting work of Masing‡ (1909) and of Bruni§ and Meneghini (1911) upon the measurement of diffusion in the solid state by means of electrical conductivity determinations. In Fig. 1, the primary values of certain lead-thallium alloys of intermediate composition are given both initially and after the formation of solid solutions due to different kinds of heat treatment. The dotted line gives the value of the electrical conductivity for a lead-thallium alloy of the same composition according to the author's measurements, taken when perfect homogeneity had been reached.

In a like manner the other methods mentioned above permit of unlimited care being taken to ensure that complete equilibrium has been reached, and also of indicating the occurrence of fresh and unforeseen processes. A second and important disadvantage of the method of thermal analysis arises from the following reason: the absolute temperature coefficient of the various physical properties capable of measurement is defined as the absolute value of the increase or decrease of this property over a given interval of temperature. The relative coefficient, therefore, being a ratio of two quantities, each of which is expressed in the same units, is a pure number, and consequently its determination is independent both of the units in which this property and that of the absolute value are expressed. The relative temperature coefficient is thus measurable even if it is not possible to determine the absolute measure of the property, and this is very important when considering its dependence upon the concentration and the temperature. By means of these relations we can ascertain the form of the curves, the locus of the breaks or discontinuities, and also the limits of the phase regions, with as much certainty as if we knew the absolute values of the given properties. A study of the thermal phenomena does not assist us in this line of investigation, because, although we can find the absolute temperature coefficient—that is, the increase of heat from one temperature to another, *i.e.*, the specific heat—we cannot measure its absolute value initially, and

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* Paper read before the Institute of Metals at Newcastle.

† Micrography is not a property to which numerical values can be assigned—it simply deals with the description of the structure of alloys. Its study has often been proved to be of the highest utility, but a treatment of it does not lie within the scope of this paper.

* An alternative to the above method would be to transfer the initial state A as well as the final state B to a third known state C, and to determine in each case the difference in the quantity of heat between A C and B C, which would be equivalent to A B. Quite apart from the fact that there would be considerable difficulty in ensuring that the same state C was reached in both cases, the method would be unsuitable on account of its tediousness. This method, cumbrous as it is, has, however, been successfully applied by Mazzotto in a recent research on the constitution of the lead-tin series. *International Journal of Metallography*, vol. vii. (11), page 289.

† If we carry out a series of thermal experiments at different concentrations under approximately similar conditions, it is possible to compare the results and to construct cooling and time duration curves, from which much help can be derived in the study of the equilibrium diagram—as was first suggested by Tammann.

A still further advance was introduced and subsequently worked out by Mazzotto, who showed how to determine quantitatively in absolute measure the amounts of heat liberated by different alloys in given intervals of temperature. This method enables us to construct the complete surface of total heat, but not to ascertain how far above the zero plane it lies, though we are safe in assuming that its absolute height above the zero plane will be enormously great, as compared with the differences in height between the maxima and minima on the surface. Tammann published in 1908 the surfaces of certain simple types of alloys, but seems to have made unduly simple assumptions.

1. Mazzotto, Proceedings of the Institute of Lombardy (Rendiconti Reale Istituto Lombardo), vol. ii., page 19; (1886), page 485.

2. Tammann, *Zeitschrift für Elektrochemie*, vol. xv. (1909), page 486.

‡ Masing, *Zeitschrift für Anorganische Chemie*, 1909.

§ Bruni and Meneghini, *International Journal o Metallography*, vol. ii. (1911).

therefore we cannot determine the ratio representing the relative coefficient. We can fix the boundaries of the phase regions in the equilibrium diagram by noting the breaks or discontinuities on the isothermals or on the curves of constant concentration, and we shall find that certain fields are homogeneous whilst others are heterogeneous. Now the characteristics of the surface of the property under consideration must correspond to those of the various phase regions. The reliability of the various methods that have been proposed depends upon the degree of accuracy with which the dependence of the selected property upon the concentration or the temperature can be measured—that is, upon the sharpness of the breaks on the curves at the limits of the phase regions.

It will be shown in this paper that the electrical conductivity method has the pre-eminent advantage that it accentuates the difference between homogeneous and heterogeneous systems much more markedly than do any of the other methods.

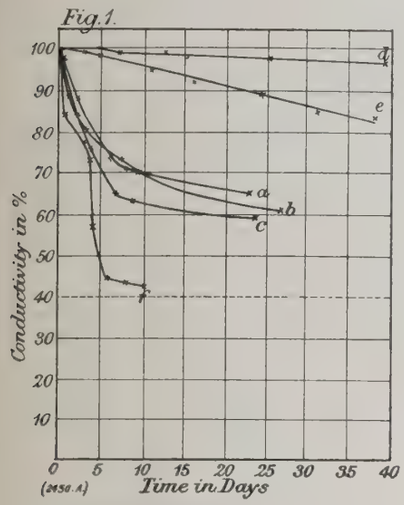
III.

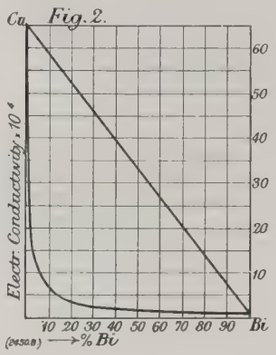
We shall now consider the property of electrical conductivity at some length. The earliest experimental data upon electrical conductivity were published by Matthiesen* upwards of fifty year ago, and subsequently amplified by later observers, but it was not until over thirty-five years afterwards that the first attempt was made by Le Chatelier† to draw any theoretical deductions from them. The conclusions at which Le Chatelier arrived have since undergone some modifications and extensions both by the author‡ of the present paper and by Kurnakow and Zemczuzny.* Though severely criticised at the time, the correctness of these later deductions has since been conclusively proved experimentally by several authors.†

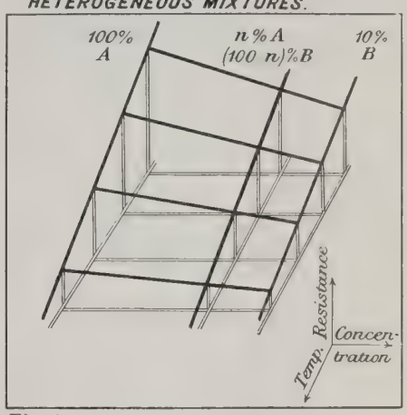
A question of fundamental importance now occurs—Which are we to consider, electrical conductivity or specific resistance? The answer is that we must consider them both, though Benedicks has very correctly pointed out that it is only upon the specific resistance, and not upon the electrical conductivity, that a theory can be based. The dependence, for example, of resistance upon temperature or concentration is more nearly linear than is that of conductivity, whilst the occurrence on the other hand of discontinuities, and especially of those indicating the saturation point of solid solutions, is generally much better marked on conductivity curves. We shall first consider the characteristic form of the surface within a single heterogeneous or homogeneous region, and, secondly, the transition between two regions.

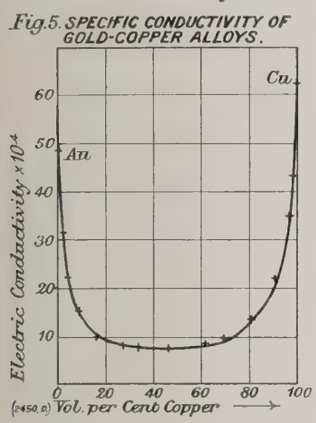
It is a remarkable, and at first sight surprising, fact that the heterogeneous region as regards electrical resistance has proved to be much more simple, and we will therefore start by considering it first. Le Chatelier has stated (1895) that for heterogeneous mixtures of two metals, the electrical conductivity was a linear function of the concentration, at constant temperature. Roozeboom‡ showed that this was not correct, and the author§ was able later to confirm Roozeboom's view. *À priori* the problem whether in a simple heterogeneous mixture the resistance or the conductivity in relation to the concentration should be a straight line is a difficult one to solve even by the aid of mathematics. Lichtenecker* has recently attempted to give a mathematical solution, but it only holds good if the difference between the conductivities of the two components is small, and in that case there is no great difference between the extremes in any event. As there is still at the present time some misconception as to how far Roozeboom and the author differ from Le Chatelier in not considering that the conductivity is a linear function of the concentration, it may not be out of place to give a concrete instance. In Fig. 2 we have the conductivities of the copper-bismuth alloys plotted in the straight line according to the view of Le Chatelier as a linear function of concentration, whilst the curve represents the reciprocals of specific resistance. The figure clearly shows that the curves are by no means identical, but, on the contrary, that for certain concentrations the one value is five times greater than the other.

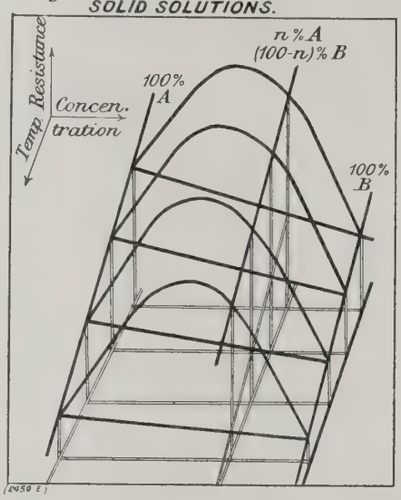
With respect to the variation of electrical resistance with temperature, we know that at the ordinary temperatures this varies as though it would become nil at the absolute zero of temperature. But it has been demonstrated that the rate of decrease of resistance with falling temperature diminishes at very low temperature, and that consequently the resistance tends ultimately not to vanish, but to reach a certain small limiting value. Hence we shall confine our present treatment of the subject to temperatures above zero deg. Cent. Above zero deg. Cent., and for small differences of resistance of the two components, we can assume that the graphic construction used in Fig. 3 correctly represents the specific resistance for heterogeneous mixtures. This form for the surface holds not only for heterogeneous mixtures of pure metals, as Le Chatelier thought, but also for any crystalline mixture of two phases in a system, and as a result such a surface as that represented in Fig. 3 will be found as

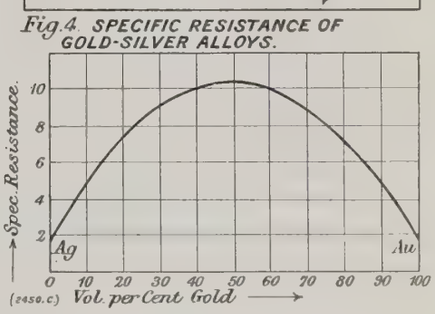


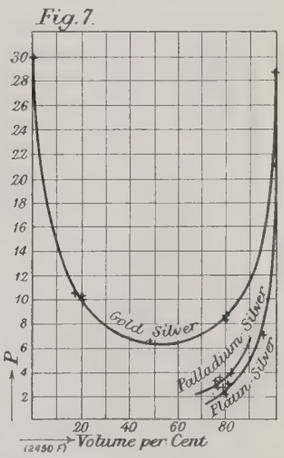


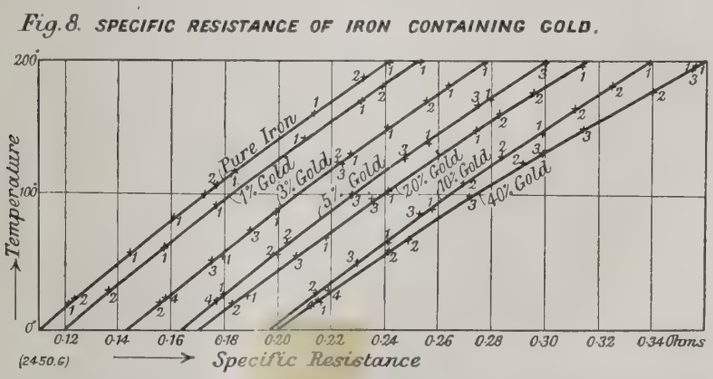












* Matthiesen, *Philosophical Transactions*, 148 (1858), 343; 150 (1860), 85; 162; 154 (1864), 167.

† Le Chatelier, *Revue Générale des Sciences* (1895), 529.

‡ Guertler, *Zeitschrift für anorganische Chemie*, 51 (1906), 397; 54 (1907), 58; *Jahrbuch für Radioaktivität und Elektronik*, 5 (1908), 17.

* Kurnakow and Zemczuzny, *Zeitschrift für anorganische Chemie*, 60 (1908), 1.

† See Bjornssen, "Untlersökning av Tenn-Silverlegeringarnas Elektriska Egenskaper," *Lunds Universitäts Arskrift*, N.F. II. 5, 6; and Haken, "Beitrag zur Kenntnis der thermoelektrischen Eigenschaften der Legierungen," Dissertation. Berlin, 1910.

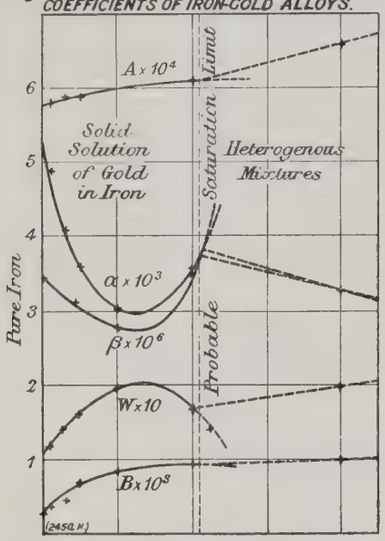
‡ Roozeboom, *Die Heterogenen Gleichgewichte*, vol. ii.

§ Guertler, *loc. cit.*, page 36.

* Lichtenecker, *Physikalische Zeitschrift.*

a part of a surface in any system containing heterogeneous regions. For a continuous series of solid solutions, such as the alloys of gold and silver, the curve showing the relation between the resistance and the concentration is given in its typical form in Fig. 4. The corresponding curve for the electrical conductivity (for gold-copper alloys), however, is given in Fig. 5. Both curves represent cases of complete miscibility in the solid state of the two components. In cases where only small homogeneous regions of solid solutions occur, we have to cut out small parts from this curve in the various corresponding places, and hence it is often not easy to recognise the characteristic features, as shown in Fig. 4. The rapid decrease in conductivity is only found next to the two pure components, and this led the author to predict that in cases where solid solutions consist entirely of undissociated molecules of one particular compound, this sharp decrease in conductivity on both sides, giving rise to a peak on the conductivity curve, would also be observed. The experiments of Haken and others have confirmed this view, and the existence of these peaks on the conductivity curves has assumed great importance, as they seem to afford the only direct evidence we have at present for assuming the existence of chemical compounds in a series of solid solutions.

Fig.9. SPECIFIC RESISTANCE & TEMPERATURE-COEFFICIENTS OF IRON-GOLD ALLOYS.



The resistance of a true solution being much higher than that of a conglomerate of the two components simply mixed, we can consider the resistance W of a solid solution as being made up of two parts, of which W_1 = original resistance *à priori*, and W_2 = solution resistance due to solid miscibility. Many attempts have been made since the discovery of this resistance to explain its origin, but none has been completely successful. For W_2 the author gave the following formula:—

$$W_2 = K.C\,(1 - C)$$

where C is the concentration of the one component, and K is a constant for the series.

Strictly speaking, the concentrations should be given in volume per cents., but the application of this expression to the gold-copper alloys showed that it was not sufficiently accurate, and so the author suggested that some correction in the atomic weights of the components was required. Subsequently, however, Kurnakow and Zemczuzny obtained good results for this system of alloys, taking atomic per cents. But even this modification would not suffice for any other system. It is also necessary to make a special allowance for the relative volumes of the two components in the solid solution, as these do not seem to be the same as for the pure metals.

The author showed that from a law given by Matthiesen it can be deduced that this so-called "solution resistance" does not vary with the temperature, but must be added to the original resistance in a constant amount which does *not* vary with the temperature. It follows from this that the "absolute" temperature coefficient is unchanged by the formation of solid solutions, and that furthermore the "relative" coefficient shows an enormous decrease, as is shown for the gold-silver and other alloys in Fig. 7.

Fig.10.

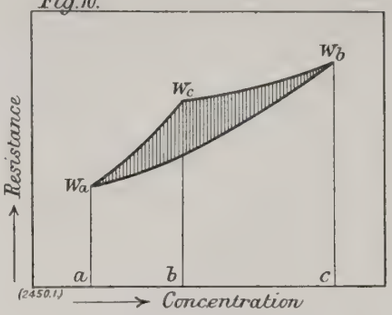


Fig.12. CONDUCTIVITY OF COPPER-COBALT ALLOYS.

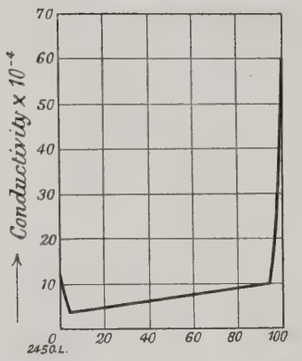


Fig.13. COPPER-ANTIMONY.

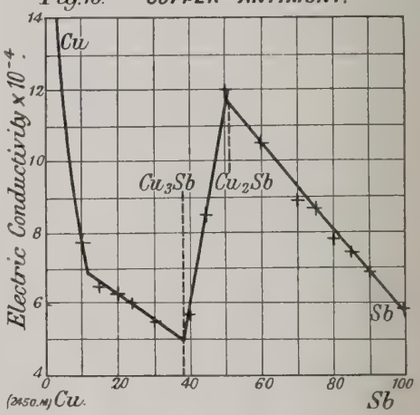


Fig.11. VARIATION OF RESISTANCE OF BISMUTH-THALLIUM ALLOYS WITH TEMPERATURE.

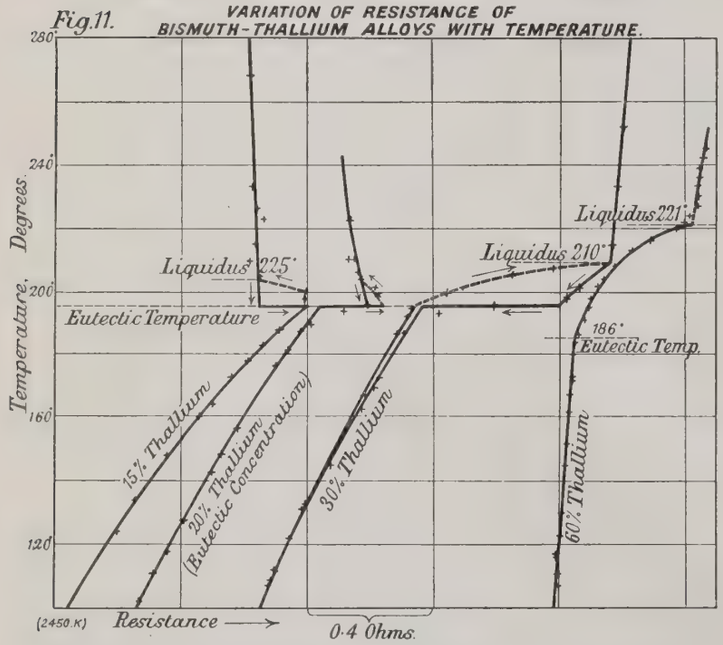
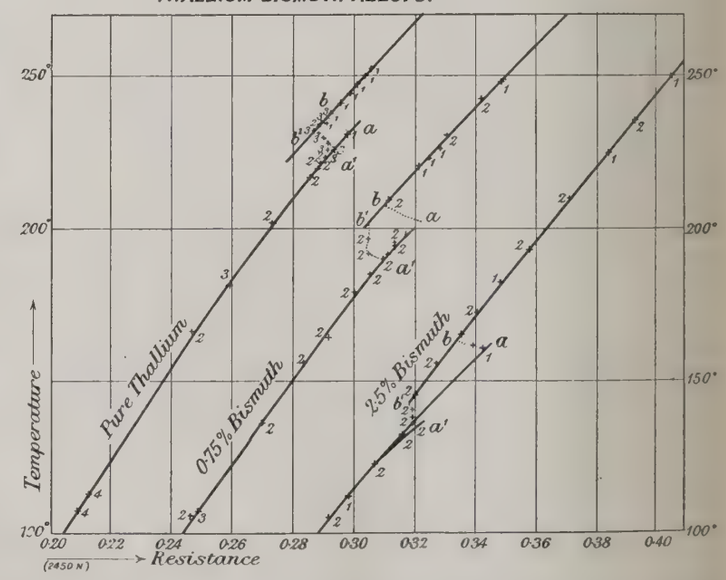


Fig.14. TEMPERATURE RESISTANCE CURVES OF THALLIUM BISMUTH ALLOYS.



As there are exceptions to Matthiesen's law, the author thought it worth while to investigate a system of two metals, one of which has a normal temperature coefficient and a very low resistance—viz., gold—and the other a very high temperature coefficient and a high resistance—viz., iron. In Fig. 8 are given the curves obtained by adding gold up to 20 per cent. to pure iron. Isaac and Tammann, who worked out the equilibrium diagram for this pair of metals, showed that iron can retain as much as 20 per cent. gold in solid solution, and we find that between these limits the temperature coefficient varies regularly with the temperature. We have

$$W = W_o(1 + \alpha t + \beta t^2)$$

and

$$\frac{dW}{dt} = A(1 + Bt)$$

where

$$A = W_o\,\alpha \text{ and } B = \frac{2\beta}{\alpha}$$

A being the absolute, α the relative temperature coefficient, and B and β determining the variation of the coefficient with temperature; the coefficients are represented graphically in Fig. 9.

The law is thus proved to be correct, notwithstanding the great difference in character, specific resistance, and temperature coefficient of the two metals. Only in the case of the 40 per cent. alloy, which exceeds the limit of solid saturation, is a value obtained which does not lie on the curve.*

We shall now discuss the various possible transitions between one phase region and another of the equilibrium diagram. We have to distinguish the following three cases:—

1. The passage from one heterogeneous two-phase region to another, with changing temperature, a three-phase equilibrium horizontal being crossed.
2. The transition from a homogeneous region into a heterogeneous one, due to separation of a second phase.
3. In certain cases there is a transition from one homogeneous region to another, on passing through a transition or melting-point, involving no change in the composition of any of the phases.

In the first case we shall observe "breaks" in the resistance curve, as shown in Fig. 10. Let A and B be the two phases, having the resistances W_a and W_b respectively. These will unite at a certain temperature to form a third phase C, having a resistance W_c. Consequently, we have above the transition temperature mixtures of A and B, the resistances of which vary from W_a to W_b, and below, mixtures of A + C and B + C. Each of the three heterogeneous regions which are in contact with one another at the given non-variant temperature has its own surface of resistance, and this will intersect the plane on which the transition temperature lies in those curves, as shown in Fig. 10. The region W_a, W_b, W_c, therefore, gives the locus of the "breaks," and we can see that it will invariably show a maximum at the concentration of the intermediate phase, just as when following thermal changes we find a maximum at the true

* The curve for the 20 per cent. alloy could almost be doubted, were it not for the fact that the temperature coefficient, which agrees very well with that of the other alloys, proves that no error has been made. We have here an illustration of the dual control that this method affords.

eutectic point,* and in the same way the sudden change in direction at the eutectic and the break at the liquidus are clearly seen, electrically.

We cannot give, at the present, any exact description of the form of these composite temperature-resistance curves, though we hope to be in a position to do so before long. By varying the concentration instead of the temperature we meet with the same transitions, and here our information is more complete. In Fig. 12 it will be noticed that the two breaks in the conductivity curves of the copper-cobalt alloys are very sharply marked, and that they are also shown in the corresponding position on the resistance curves, though not so well marked. The breaks will be less sharp the smaller the heterogeneous region, and will show up most clearly when the two homogeneous fields at the sides are very small—a case when other methods are scarcely applicable at all with any success.

The transition from one homogeneous region to another by passing through a heterogeneous interval of transformation will now be understood without further application. The process is compounded from two single transitions, as shown on the resistance curves of certain bismuth-thallium alloys (Fig. 14). On raising the temperature the two breaks a and b include the transformation, and the narrower this is the sharper are the breaks. On lowering the temperature, on the other hand, the breaks occur at b^1 and a^1 respectively, and hence we see that the reaction, strictly speaking, is not reversible. We see further that the transition-point of thallium is lowered by the addition of bismuth.

The case of a transition from one homogeneous region directly to another is one which can only occur either with pure metals or at maxima or minima. This is, in reality, the limiting case of the type we have just been considering—the points 1 and 2 are shifted to one and the same temperature, the transition part becomes horizontal, and the two breaks merge into one very sharply-marked break or abrupt change in direction. Such a transition-point was discovered in thallium by Levin,† and also observed by Chikashige,‡ both of whom employed the method of thermal analysis. But whilst the thermal indication was very weak, we have just seen how strongly marked it is when the conductivity method is followed.

IV.

The following is the method of procedure suggested. We shall see how it enables, in point of fact, a triple control to be exercised over the results obtained. The temperature resistance must first be obtained for each concentration. This we can do without determining the absolute values, and in cases where it is impossible to prepare specimens of regular dimensions we can only obtain relative values for the resistance. The method of electrical conductivity can, indeed, be employed as a means of obtaining the necessary data for the construction of an equilibrium diagram, in a manner analogous to the application of "thermal analysis" for the same purpose.

But the conductivity method has the great advantage that it is independent of time, and no measurement need be taken until we are assured that perfect equilibrium has been obtained. Given that we know the equilibrium diagram with certainty, we can, if we have the absolute values, compare the different concentrations with one another and construct isothermals from them, from which in their turn we can find the breaks which correspond to the passage of boundaries of the phase regions, and more particularly of those which run vertically, and which cannot consequently be obtained by the first method.

Finally we must investigate the shape of the resistance curves, both in their dependence upon temperature as well as upon concentration; or, in other words, the form of the individual parts of the resistance surface in space, in order to see if these conform in shape to the general laws of homogeneous and heterogeneous equilibrium.

The shape of these curves is, as we have seen already, very characteristic, and here it must be mentioned that it is preferable by far to determine the specific resistance than any other property, such as the specific volume, for example. For no other property brings out so well the difference between a heterogeneous mixture and a homogeneous solid solution. And here again we need not know the value of the resistance in absolute units.

It has also been shown above that the temperature coefficient has very characteristic properties, and that its form differs widely in homogeneous and heterogeneous phase regions. We have thus another and valuable means of control over results, not met with at present in the case of any other method. Experimental researches of the last decade have, it is true, thrown much light upon the constitution of nearly all the most important systems of binary alloys, but nevertheless we are obliged to acknowledge that our information is far from being complete. Fresh problems are continually confronting us as we pursue our studies more minutely, and so fresh methods of inquiry are needed more and more urgently almost every day. The author hopes that the methods dealt with in this paper will prove of far-reaching significance and practical utility.

Norwegian Exports.—According to official statistics the Norwegian exports for August of the present year show a decrease of 5,000,000 kr. as compared with the same month last year, which decrease is a consequence of the lock-out.

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* It is not, however, inconceivable that the resistance W_c may come so close to the line $W_a W_b$ that no break in the resistance curve may be noticeable, and so we may unwittingly overlook the equilibrium point.

† Levin, *Zeitschrift für Anorganische Chemie*, 45 (1905), 31.

‡ Chikashige, *Zeitschrift für Anorganische Chemie*, 51 1906), 328.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a list of colonial and foreign engineering projects, for some of which tenders are asked. Further information concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Canada: His Majesty's Trade Commissioner for Canada (Mr. R. Grigg) reports that tenders are invited by the Lethbridge Municipality for the supply and erection at that place of power-station equipment, including boilers, economiser, steam turbo-generator, condenser, and substation equipment. Tenders, accompanied with a deposit of 10 per cent. of the value of the offer, will be received by Mr. G. W. Robinson, Secretary-Treasurer, Lethbridge, Alberta, up to November 24. Plans and specifications may be obtained from Mr. A. Reid, Superintendent Engineer, Lethbridge.—The Imperial Trade Correspondent at Toronto (Mr. F. W. Field) reports that tenders will be received by the Chairman of the Board of Control, City Hall, Toronto, up to noon on November 1, for the construction of three miles of reinforced-concrete subway and subway stations. A deposit of 2000 dols. (about 410*l.*) is required in respect of each half-mile tendered for. The object of calling for tenders for this work is to enable the Toronto Municipality to arrive at the actual cost of a subway system, so that a by-law to provide the necessary money may be prepared for submission to the ratepayers for their approval. On approval being obtained the contract will be awarded.

South Africa: H.M. Trade Commissioner reports that a large irrigation scheme is under consideration by the Water Board of Van-Rhynsdorp, in the western portion of the Cape Province. It is proposed to irrigate on a perennial basis, by means of a canal system fed from a higher weir with considerable storage capacity, as much land as possible on both banks of the Olifants River, and along the lower reaches of the Doorn and Hol rivers. The net irrigable area commanded by the channels is estimated to be 6580 morgen (about 13,900 acres). The cost of the works is placed at 155,000*l.* The works include the following:—Weir and head-works, regulator, scour-sluices, excavation of canals, two tunnels, retaining walls, syphons to feed distributary canals, aqueduct, road bridges, automatic escape-ways, &c.

Switzerland: The *Feuille Fédérale Suisse* of October 4 notifies that a concession has been granted to a syndicate, presided over by M. Auguste Barras, of Bulle, for the construction and working of a narrow-gauge electric railway from Fribourg to Bulle, proceeding by way of Pérolles, Marly, La Roche, Thusy, and Riaz. Four years are allowed for the construction of the line. The cost of the undertaking is estimated at 6,500,000 francs (260,000*l.*).

Entropy Charts for Superheated Steam.—Messrs. Oliver and Boyd, of 33, Paternoster-row, E.C., are issuing, at the price of 3d. each, two steam charts which should prove very serviceable to all engaged in calculations relating to steam-engine and steam-turbine efficiencies. Both charts have been prepared by the department of mechanical engineering in the Glasgow and West of Scotland Technical College. The one is a temperature entropy diagram for steam, at all pressures from 0.25 lb. absolute up to 300 lb. absolute, and for qualities ranging from a dryness fraction of 0.69 up to the superheats corresponding to a temperature of 700 deg. Fahr. In addition to the quality and temperature lines, the lines of constant heat content are also engraved. The companion chart is a Mollier diagram, which covers practically the same range of steam conditions, and the advantages of which for certain thermodynamic calculations is now too well known to need further emphasis here. Both charts are very clearly engraved on stout paper, which should be capable of standing a considerable amount of hard wear.

Granary for Glasgow Harbour.—At the monthly meeting of the Clyde Navigation Trustees on the 3rd inst., the Special Committee on Meadowside Granary reported that they had under consideration tenders received for the new granary buildings at Meadowside, and that they recommended the Trust to accept the offer of Messrs. John Train and Taylor at 56,697*l.* The design chosen by the committee specified for the silo portion ferro-concrete faced with brickwork, and the floor portion outside walls of solid brickwork, cast-iron columns, rolled steel joists, and concrete floors. Mr. Raeburn, in moving the adoption of the minute, said tenders for the machinery had already been accepted. They were asked now to approve the recommendation regarding the building, which would be 300 ft. in length, 80 ft. in breadth, and 131 ft. in height. It would consist of eleven storeys, and would be capable of turning over in one year 250,000 tons of grain. The original forecast of the cost of the scheme was 102,700*l.*, but the detailed figures he now submitted were as follow:—Cost of ground, 4943*l.*; buildings (including foundations), 56,697*l.*; rails, &c., 3100*l.*: machinery, 40,911*l.*—total, 105,650*l.*, or an increase of 2957*l.* as compared with the sum originally mentioned, the buildings having cost 5296*l.* more and the machinery 2339*l.* less. The increase was accounted for to some extent by the fact that the original estimate was for a building entirely of reinforced concrete. The building they now put before the Trust for approval was to be of a composite character, and some of their expert members, to whose judgment in these matters he cheerfully bowed, considered it would be better, stronger, and more reliable than the one originally proposed. The work of construction was expected to occupy about eighteen months, and the system to be adopted is that designed by the Considère Construction Company, Limited, Westminster, London.

CATALOGUES.

Drop-Forgings.—From the Carron Company, of Carron, Stirlingshire, N.B., we have received two catalogues containing reproductions of dimensioned drawings illustrating a selection of the drop-forgings they manufacture. The forgings, which can be supplied rough or machined, include such articles as spanners, hooks, eye-bolts, eye-plates, swivel-eyes, handrail-stanchions, crank-shafts, and connecting-rods, as well as many parts used in shipbuilding work.

Pyrometers.—A sectional catalogue of pyrometers for industrial purposes has been issued by the Alldays and Onions Pneumatic Engineering Company, Limited, of Great Western Works, Birmingham. Prices and full particulars are given of two types of pyrometers, one being a thermo-couple instrument for temperatures up to 2500 deg. Fahr., and the other a fixed-focus radiation-type instrument, for temperatures from 700 deg. to 3300 deg. Fahr., or higher. An instrument of the latter type was illustrated and described in Engineering of May 26 last, on page 708.

Steam-Separators.—A copy of the Cochrane Engineering Leaflet No. 10, issued by the Harrison Safety-Boiler Works, Seventeenth-street, and Allegheny-avenue, Philadelphia, Pa., U.S.A., has come to hand. The pamphlet discusses the causes and effects of priming, and deals with the use of Cochrane receiver separators for removing the water from the steam. These separators are also claimed to be effective in minimising vibration, which is sometimes set up in steam-pipes by the pulsations of the steam. The pamphlet also deals fully with the removal of oil and grease from exhaust steam, illustrating and describing separators for this purpose.

Pit-Prop Drawing Apparatus.—Messrs. John Davis and Son (Derby), Limited, of All Saints Works, Derby, have sent us a leaflet illustrating the Davis-Brown apparatus for withdrawing pit-props. This appliance comprises a sprocket-wheel mounted in a frame, and turned by means of a hand-lever and double ratchet. A chain is made fast to the prop to be drawn, and its free end is passed round the sprocket, the teeth of which engage with it. Another chain is attached to the frame and anchored to some fixed object. A powerful pull is exerted by the chain when the sprocket is turned, and this pull is used to draw the prop. The apparatus can also be used for moving heavy loads through any distance.

Locomotives.—We have received from the Baldwin Locomotive Works, of Philadelphia, Pa., U.S.A., copies of two of their recent records of construction. The first of these (No. 69) illustrates and describes Mallet articulated locomotives of the 2-6-6-2 type, forty of which have recently been completed for freight traffic on the Atchison, Topeka, and Santa Fe Railway. Two of these engines have been fitted with flexible boilers, while the remainder have rigid boilers of the separable type. No. 70 deals with Walschaert's valve-gear, describing it fully with the aid of diagrams and half-tone engravings. Very complete instructions are given for setting the valves with this gear.

Mechanical Stoker.—A pamphlet relating to their well-known chain-grate stoker has been received from Messrs. Ed. Bennis and Co., Limited, of Little Hulton, Bolton. The pamphlet gives a brief description of this type of stoker, and calls particular attention to the new form of link, the ends of which are halved together in such a way that the air spaces are uniform in width for the whole length of the grate. This form of link also effects considerable economy of space at each end of the furnace. Particulars and illustrations of five important installations are also given, and the results of tests included. Messrs. Bennis have made no mention of the other types of stokers they manufacture, as it is intended to send this pamphlet to inquirers interested in the chain-grate type only.

Water-Meter.—Messrs. Glenfield and Kennedy, Limited, of Kilmarnock, Scotland, have sent us a copy of a pamphlet relating to Gardner's patent integrating and recording weir-meter. The instrument is capable of measuring the flow of water, sewage, or corrosive liquids over triangular or rectangular weirs, or in open or closed channels, recording the rate of flow on a chart, and indicating the total quantity passed on a series of dials. The mechanism is operated by two clocks, one of which is an ordinary time-piece, while the other has the length of its pendulum altered by the movement of a float on the up-stream side of the weir, so that the rate of the latter clock depends on the quantity of water flowing. The counting dials, which are driven through an epicyclic gear by the combined motion of the two clocks, can be arranged to read according to Francis's, Thomson's, Kutter's, or other formulæ. The pamphlet gives a brief description, with illustrations of the meter, and also contains some information relating to its adjustment. Notes on weir construction and formulæ are also included.

The New Allan Liners.—Mr. Hugh Allan, the chairman of the Allan Line Company, who arrived at Liverpool on the 6th inst., states that twelve leading firms of shipbuilders are tendering for the two large steamers for the company's Liverpool-St. Lawrence service. The vessels will be each of 15,000 tons gross, 570 ft. in length, 69 ft. in breadth, 46 ft. in depth, and will carry 250 first-class, 525 second-class, and 1000 third-class passengers. The firms tendering had been given a free hand with regard to propelling machinery, and the engines may be reciprocating or a combination of reciprocating and turbine. The sea speed will be 18 knots—one knot faster than that of the Victorian and Virginian.

COMMUNICATIONS FROM THE GÖTTINGEN MODEL-TESTING INSTITUTE.*

6. Resistance of Wires and Ropes.†

(*Concluded from page 273.*)

In the last communication from the Model-Testing Institute some brief remarks were made as to the results of the preliminary experiments to determine the resistance of wires in a wind. The object of the present communication is to supply more detailed information on this question, and to give the more accurate numerical results since determined.

The wires were suspended in the manner shown in Fig. 26. The wires 1, 2, and 3, which transmit to the balance the force due to the resistance, were arranged as in all the previous experiments. They lie in a horizontal plane, and meet in one point at angles of 120 deg. Wire 2 is fastened to the wall, wire 3 communicates with the balance, which is placed outside the channel, and serves for the measurement of the resistance. Wire 1 leads to a ring, which is supported from the top of the channel by wire 4. The wire to be tested (x) also hangs from this ring. It passes, hanging freely, through a slit in the floor of the channel, and carries a weight G. The slit must be of sufficient length, so that x, when driven back by the effect of the wind, may not touch the channel floor. Wires 1, 2, 3, and 4 and the ring remain in the same positions for all the measurements; only the measuring wire x is changed from one experiment to the other. The first experiments were made on platinum wire 0.05 mm. in diameter, and for each new experiment in succession a

Fig. 26. TESTING ARRANGEMENTS FOR THE MEASUREMENT OF THE RESISTANCE OF WIRES.

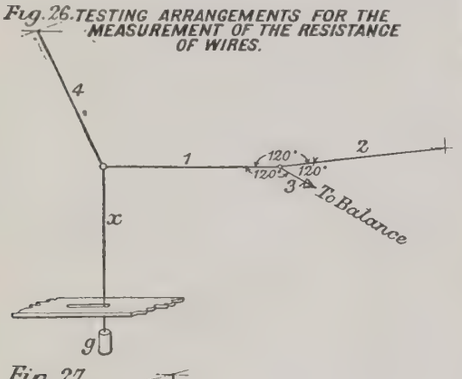
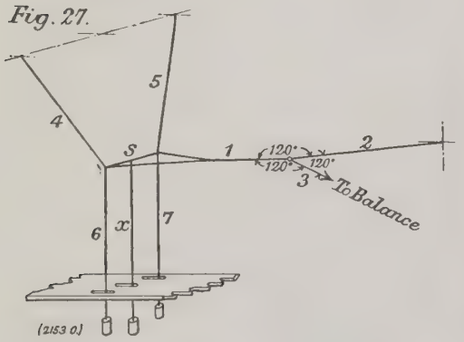


Fig. 27.



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thicker wire was used. In all sixteen wires (and rods or tubes) were examined, of the following diameters:—

mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0.05	0.07	0.09	0.125	0.153	0.207	0.291	0.610
1.007	1.39	2.80	4.465	8.06	11.93	18.9	29.9

Each wire or tube was tested for four velocities: 4.6, 6.5, 8.0, and 9.6 metres per second; the temperature was about 15 deg. Cent. The resistance of the wires 1, 2, 3, 4, and of the ring may be determined for the four velocities by extrapolation. For this purpose the results given by the balance for the resistance of suspension plus wire under test are plotted against the diameter of the wire dealt with. Through the points so determined a curve can be drawn, which can be continued to the axis of ordinates. The intersection of the axis gives the value of the resistance for zero diameter of the tested wire—that is, for the suspension alone.

For the thinnest wires this extrapolation seemed somewhat uncertain. It appeared possible that the law of the resistance of a wire showed peculiarities, for very small diameters, about which sufficient information could not be obtained from our experiments. On the suggestion, therefore, of Professor Prandtl, a check measurement was made, which allowed of the direct determination of the resistance of the wire under test by a procedure free from objection. For this purpose the method of suspension shown in Fig. 27 was adopted. The ring of Fig. 26 is here replaced by the bar s, which is supported from the roof of the channel by the wires 4 and 5. From this bar hang the three wires 6, 7, and x, led through three slits in the floor of the channel, and each kept taut by a weight. The wires 1, 2, and 3 transmit, as previously, the forces to the balance, and, as before, the wire x is changed from one experiment to another. Since, in this case, the suspension wires, without the wire x, still retain their tautness, it is now possible to determine the resistance of the suspension alone, which was not possible with the arrangement for the previous experiment. It must be remarked, however, that this method of suspension had the disadvantage that the three tension weights were easily set swinging, thereby preventing an accurate reading of the balance. Consequently this arrangement was only employed in measuring the resistance of thin wires. The results so obtained for the wires under test were subtracted from those measured for suspension plus wire, and so served to give an accurate determination of the resistance of the suspension in the first experiment.

From the resistance values for the different wires the coefficient ψ was calculated by means of the formula

$$R = \psi \frac{\gamma v^2}{g} . l d,$$

where l is the length and d the diameter of the wire.

It was found that ψ does not assume a constant value except for somewhat large diameters and velocities. According to Osborne Reynolds, complete similarity in the stream-lines around two similar bodies, when account is taken of the internal friction of the fluid, is only obtained if the linear dimensions of the bodies are inversely proportional to their velocities. According to this theory, two wires in a wind for which the product $v\,d$ is the same should have the same resistance coefficient. In the two following formulæ, which express our results very well, ψ appears accordingly as a function of $v\,d$ only:—

1. $\psi = 0.66 - 14\,v$ m./sec. d m for $v\,d \leq 0.015$ m.²/sec.
2. $\psi = 0.45$ for $v\,d \geq 0.015$ m.²/sec.

We must add that the formula (1) does not hold for values of $v\,d$ less than 0.001 m.²/sec. For smaller values of the product the measurements give such varying results

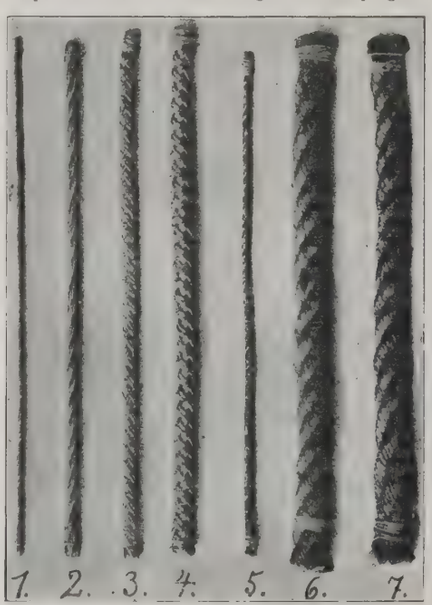


Fig. 28.

that no legitimate inference can be drawn. In practice, however, wires of such small diameters at velocities so low do not come into consideration, so that the resistance coefficients for $v\,d$ less than 0.001 m².sec. are only of scientific interest. Leaving such cases out of account, the greatest deviations of the formulæ from the experimental results were under 5 per cent.

Besides the wires, the resistances of the seven wire and hemp ropes, shown in Fig. 28, were also determined in the air-current. The diameters given in the table were measured by means of a slide-gauge, and the setting made was such that the rope could just turn easily between the two limbs of the gauge. The ropes were suspended in the manner shown in Fig. 26 in the place of the wire x. The resistance of the suspension was taken from the measurements with wires. The results are given in the table.

No.	Material.	Diameter d in mm.	Length l in cm.	Velocity v m./sec.	Resistance in Grammes. R	$\psi = \frac{R}{\frac{\gamma v^2}{g} . l . d}$	ψ Mean.
1	Wire rope (six strands)	3.2	92.9	4.63	4.26	0.546	0.54
				8.00	12.46	0.536	
				9.65	18.52	0.547	
2	Ditto	7.5	92.6	4.63	9.46	0.518	0.55
				8.00	30.55	0.56	
				9.65	45.25	0.572	
3	Plaited hemp rope	7.0	92.7	4.63	10.08	0.59	0.60
				8.00	31.02	0.607	
				9.65	45.55	0.616	
4	Ditto	10.1	91.9	4.63	13.46	0.551	0.57
				8.00	42.1	0.575	
				9.65	62.4	0.588	
5	Smooth cord ..	4.3	93.6	4.63	4.82	0.456	0.45
				8.00	14.18	0.45	
				9.65	20.95	0.459	
6	Hemp rope (four strands)	16.0	91.1	4.63	20.48	0.533	0.53
				8.00	61.05	0.533	
				4.63	18.96	0.495	
7	Hemp rope (threads singed)	16.0	91.1	8.00	57.05	0.50	0.50

* Translated by permission from the *Zeitschrift für Flugtechnik* (Munich and Berlin: R. Oldenbourg).

† *Zeitschrift für Flugtechnik*, October 29, 1910.

RUSSIAN IRON INDUSTRY IN 1910.

Recent official statistics show that the Russian output both of pig iron and of half-finished iron and steel during 1910 increased considerably in the different districts compared with that of the preceding year. The aggregate production of pig iron, for instance, shows an increase of over 160,000 tons, or nearly 6 per cent., and at the same time the stocks have been very materially reduced, from 520,000 tons on January 1, 1909, to 333,000 tons on January 1, 1910. The demand has been steadily increasing, and on the whole been a very active one. The increase in the production of half-finished goods is still more striking, amounting to 400,000 tons, or more than 13 per cent., the increase principally falling upon Martin steel, and yet it must yield to that in the manufacture of finished iron and steel, the increase for these branches amounting to 390,000 tons, or about 15½ per cent. The increase to a great extent refers to articles used in the building trades, within which great activity has prevailed, and the result is a very material reduction in stocks in spite of the increased production. The year 1910 is pronounced, on the whole, to have been an extremely favourable one for the iron industry of Russia, even compared with the year 1909. The continued firmness of the market and the increased demand which resulted in many stocks being practically exhausted towards the end of the year, gives promise of further favourable developments. The appended tables contain some particulars referring to different manufactures in various districts, in poods (63 poods equal 1 ton):—

Pig Iron.

	Foundry Pig.		Steel Pig.	
	1910.	1909.	1910.	1909.
	poods	poods	poods	poods
Southern Russia ..	18,545,000	19,317,000	79,561,000	76,348,000
The Ural	1,824,000	1,757,000	23,062,000	20,895.000
Poland	2,001,000	779,000	12,304,000	10,455,000
Central district (Moscow)	930,000	794,000	2,283,000	2,244,000
North and Baltic ..	25,000	19,000	105,000	82,000

Half-Finished Iron and Steel Goods.

	Martin.		Bessemer.	
	1910.	1909.	1910.	1909.
	poods	poods	poods	poods
Southern Russia ..	83,999,000	68,686,000	22,567,000	25,302,000
The Ural	38,959,000	34,993,000	2,554,000	1,532,000
Poland	23,871.000	20,382,000	—	—
Central district ..	20,147,000	15,518,000	—	—
North and Baltic ..	9,473,000	8,540,000	—	—

Further, non-specified or special manufactures bring the total production of pig in Russia during 1910 up to an aggregate of 2,950,000 tons, against 2,800,000 tons for the previous year. For half-finished steel and iron goods some additional minor manufactures, in addition to those specified above, make a total of 3,400,000 tons for 1910, against 3,020,000 tons for 1909.

Among the finished steel and iron goods, of which the aggregate reached a total of 2,950,000 tons for 1910, against 2,540,000 tons for 1909, girders for 1910 figure with 188,000 tons, rails with 475,000 tons, form iron with 1,000,000 tons, wire with 230,000 tons, tin-plate with 325,000 tons, plate for roofing with 360,000 tons, &c.

Extension of Messrs. J. and E. Wright's Works, Birmingham.—We understand that important extensions are in progress at the Universe Works, Birmingham, of Messrs. J. and E. Wright, Limited. During the past eighteen years it was found necessary from time to time to make extensions to the wire-rope departments, and though each succeeding addition was upon a scale which it was thought would be equal to all demands for some years to come, the growth of the business has been such that the present portion of the works devoted to the production of wire-ropes is, in output capacity, far from equal to the demands made upon it, and the directors have decided to make a substantial addition to both building and plant. So far as the former is concerned, this will consist of 320 ft. by 90 ft., which will have three storeys, and will afford a total floor space of some 2 acres. The floors are being constructed of strongly reinforced concrete, and the building will be particularly well lighted. Another important change in progress is the electrification of the whole works. Hitherto the various shops have been driven by gas-engines, working on producer-gas, generated in a central producer plant, and carried in underground mains to the various units. A central power-station is now being built, in which Crossley gas-engines direct-coupled to electric generators will be installed. The necessary additions to the producer plant will also be supplied by Messrs. Crossley, and will consist of their recently improved type of producers.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

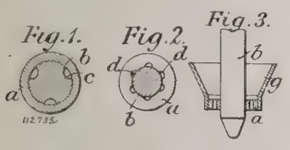
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

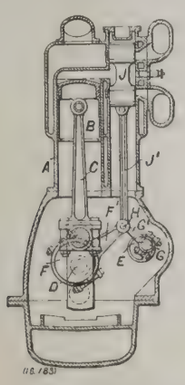
12,735/11. Siemens Brothers Dynamo Works, Ltd., London. (*Siemens Schuckertwerke, Berlin, Germany.*) **Arc-Lamps.** [6 *Figs.*] May 26, 1911.—This invention has reference to arc-lamps of the kind in which combustible materials are led into, or supplied to, the arc from one side, and has for its object the better distribution of such combustibles. In previous arrangements the combustibles were led into the arc by a single pipe or channel from one side, and the material supplied had a tendency to heap up on that side of the receiving electrode, drawing the arc over and causing extensive slag formation over other parts of the receiving electrode. These disadvantages are overcome by the present invention, according to which a plurality of supply channels are provided which distribute the fuel supply



evenly over the surface of the receiving electrode. With the provision of, say, three channels or pipes set at an angle of 120 deg. with each other around the electrode, an improvement in the behaviour of the arc is already obtained. In a further improved form of fuel-distributing device, collars are provided which surround the electrode tips, and the fuel being led on to these collars descends through channels formed in or by the same in equi-distantly spaced streams. Fig. 1 shows a plan of a ring *a* which, by reason of channels *c* formed on the electrode *b*, allows the fuel to drop in three streams equally distributed about the electrode centre. Fig. 2 shows another form in which channels *d* are formed in the ring *a*. Such rings or collars are advisedly provided with a funnel-shaped attachment, such as *g* in Fig. 3, to prevent the scattering of the fuel. (*Accepted August* 16, 1911.)

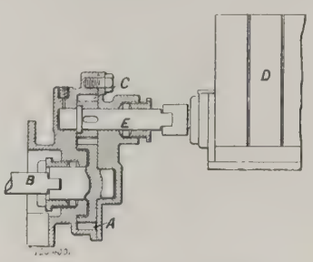
GAS ENGINES, PRODUCERS, HOLDERS, &c.

16,783/10. The Wolseley Tool and Motor-Car Company, Limited, A. A. Remington and A. J. Rowledge, Birmingham. Valve Gear. [5 *Figs.*] July 14, 1910.—In valve mechanism of the type in which a piston-valve controls the admission and exhaust into and from the cylinder of a four-stroke cycle internal-combustion engine, and is operated through the medium of two eccentrics or cranks, or of an eccentric and crank, the valve having imparted thereto a movement which is compounded of the movements of the two eccentrics or the eccentric and crank, an eccentric-rod or link is connected at one end with an eccentric or crank-pin of a shaft which travels at half the speed of the engine-shaft, and is connected at its outer or vibrating end with an eccentric-rod or link connected at its other end with an eccentric or crank-pin of a shaft which revolves at the same speed as the engine, and which is conveniently itself the engine-shaft, such eccentric-rods or links, or eccentric-rod and link, forming together a toggle-joint, through the medium of which the valve is operated through a suitable link. A is the cylinder, B the piston, C the connecting-rod, D the crank-shaft of the engine, E the half-speed shaft, F an eccentric carried



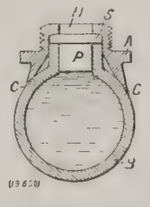
by the shaft D, G a crank-pin of the shaft E, F¹ an eccentric-rod of the eccentric F, and G¹ a link which is connected with the crank-pin G. The rod F¹ and the link G¹ are connected together at H, forming a toggle-joint; J is a piston-valve and J¹ a valve-rod, which connects the toggle-joint formed by the rod F¹ and the link G¹ with the valve J. The effect of the operation of the mechanism, when the eccentrics or crank-pins, or eccentric and crank-pin, thereof are properly adjusted as to their relative angular positions, is to cause the point H to travel in a path which somewhat resembles the figure 8, the line of movement which commences about the middle of the compression stroke and continues to about the middle of the explosion stroke, being approximately at right angles to the middle position of the vibrations of the valve-rod, thus ensuring that the valve will be substantially stationary in its position closing the cylinder to both the inlet and exhaust, the line of travel then turning rapidly in a direction to ensure the opening of the exhaust, then turning rapidly in a direction to close the exhaust, and, continuing in such direction, rapidly crossing the line first above-mentioned and quickly opening the inlet, and then turning rapidly and closing the inlet, and joining, by a quick turn, into the commencement of the line first above-mentioned, thus completing the cycle. The invention therefore enables the time of opening and closing of both induction and exhaust to substantially coincide with the time that usually obtains in internal-combustion engines which are fitted with ordinary poppet-valves, and enables the advantages to be secured which are incidental to the employment of poppet-valves with the advantages which are incidental to the use of a piston-valve. (*Accepted August* 23, 1911.)

26,409/10. J. C. Merryweather, London. Internal-Combustion Engines. [2 *Figs.*] November 14, 1910.—This invention relates to the driving of the magneto-electric machine of an internal-combustion engine, such drive being effected through the medium of a rotary water-circulating pump. The invention consists chiefly in the construction of the rotary circulating-pump, which is of the gear-wheel type; the two gear wheels are of unequal diameters, and are so proportioned that when one of the pump-wheels is driven by a cam-shaft, or by other suitable gearing, the other pump-wheel rotates at magneto speed. The pump gear-wheels A, C are in the proportion of two



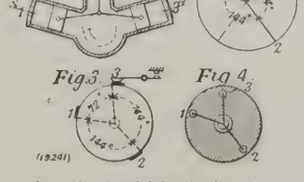
to one, so that when A is driven at cam-shaft speed by means of the shaft B, the magneto D can be coupled directly to the shaft E, which carries the gear-wheel C. It will be seen that the invention provides for the operation of the magneto without the use of any gearing other than that necessary to drive the circulating-pump. It is to be understood that the proportion of two to one between the two pump-wheels may be varied if necessary, the essential point being that the two pump-wheels are of such proportions that whatever method is adopted for driving the circulating-pump, one of the pump-wheels rotates at magneto speed and drives the magneto directly. (*Accepted August* 16, 1911.)

19,650/10. C. L. Sumpter and H. K. Foster, Sheffield. Internal-Combustion Engines. [1 *Fig.*] August 23, 1910.—This invention relates to apparatus for automatically emptying the water from the cooling circuit of internal-combustion engines, or the contents of any vessel, when in danger of being damaged by freezing. According to this invention, use is made of a small vessel with a relatively large cooling surface containing a very small volume of water so that it can be directly and closely attached to, and be portable with, the vessel to be protected, and yet when exposed to the same temperature will freeze just sufficiently in advance of the contents of the vessel to be protected, but, owing to heat conduction, not while the contents of that vessel are still warm. A small steel bottle B is filled with hot distilled water to a certain level, a small quantity of grease is put in



and then a closely-fitting plunger P is inserted in the bottle-neck. More or less water and grease is put in according to the highest temperature to which the device will ever be subsequently subjected. The bottle is then fitted to a screwed metal collar A and lightly soldered at the joint C. The device is now ready for fixing to any point low down on the vessel to be protected, and its action is as follows:—On the temperature falling sufficiently, the water in the bottle in freezing expands with great force, forcing the plunger P against the shoulder S of the screwed collar A until the joint at C is broken, and the bottle B and plunger P fall away from the collar A, leaving the contents of the vessel to be protected free to drain away through the hole H. Alternatively, the movement of the plunger P can be utilised to open a drain-cock or tap. (*Accepted August* 23, 1911.)

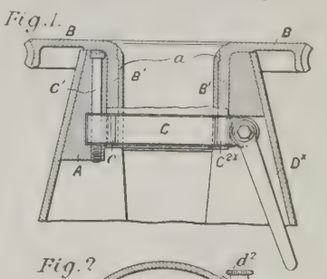
19,241/10. The Firm Robert Busch, Stuttgart, Germany. Internal-Combustion Engines. [13 *Figs.*] December 18, 1909.—This invention relates to an arrangement for ignition in internal-combustion engines requiring irregularly succeeding ignitions, but in which the lengths of all the periods of time between successive ignitions have a common divisor and consists in coupling an ignition machine of known construction to the distributor shaft by gearing which makes the lengths of the periods between successive maxima of potential equal to the greatest common divisor, and in providing devices which render

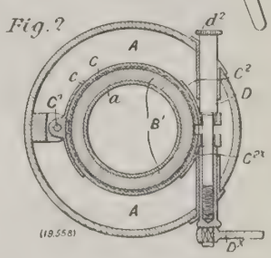


the surplus maxima of potential ineffective. Fig. 2 is the ignition diagram for the engine in Fig. 1. The ignitions in the cylinders succeed each other in the series of cylinders 1, 3, 2 after the distributor shaft has moved through angles of 72 deg., 144 deg., 144 deg. To effect ignition in the engine, a transmission gear ratio 2 : 5 is interposed between the distributor shaft and the armature shaft of the magneto-machine. To suppress the surplus sparks, an interrupter cam disc, as shown in Fig. 3, may be used, in which cams are omitted in the positions at which a potential maximum occurs between the ignitions 3, 2, and 2, 1; there are therefore no current impulses at these intervals. For this case a distributor, as shown in Fig. 4, is sufficient. (*Accepted August* 23, 1911.)

GUNS AND EXPLOSIVES.

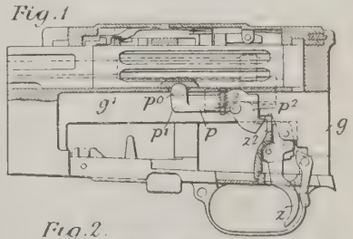
19,558/10. Sir A. T. Dawson and G. T. Buckham, London. Gun-Mountings. [2 *Figs.*] August 20, 1910.—In pedestal gun-mountings of the kind in which there is provided a clamping device comprising a band that is attached to the pedestal, and is furnished with means whereby it can readily either be tightened against the training worm-wheel to hold it rigid with the pedestal, or can be slackened so that relative movement can take place between the worm-wheel and the pedestal, and the gun be thus rendered capable of being moved rapidly through large training angles, the clamping band is arranged inside the pedestal, instead of outside, as heretofore. A is the pedestal mounting, B is the training worm-wheel and B¹ its boss, C is the clamping band adapted to engage with the boss B¹. The boss B¹ is disposed between the pedestal A and the bush *a* for the pivot, and the clamping band C is provided with a strip *c*, the lug of which is disposed in a recess in the pedestal. A screw-





threaded pin C¹ passes through the pedestal and the lug, and retains the clamping band C in position. The free ends of the band are provided with strips C², C²*, having lugs through which, and through the pedestal, passes a horizontally arranged bolt D. The one end of the bolt is formed with a knurled head d^2 which projects beyond the face of the pedestal, and provides for the ready withdrawal of the bolt D when required. The other end is screw-threaded to receive an internally-threaded sleeve to the outer end of which an actuating handle D* is attached, the handle being situated outside the pedestal as shown. The bolt D and the threaded sleeve are supported in bearings secured to the pedestal. The angular movement of the said handle D* in one direction causes the lugs on the strips C², C²* to move towards each other to tighten the clamping-band C on the boss B¹, and in the other direction allows them to separate so as to slacken the said band from the boss. (*Accepted August* 23, 1911.)

3104/11. P. Mauser, Oberndorf-on-the-Neckar, Germany. Small Arms. [5 *Figs.*] March 19, 1910.—This invention relates to a modification of the trigger locking device described in the specification of Letters Patent No. 181, of 1910, in which, for the purpose of preventing the pulling of the trigger when the breech is unlocked, there is provided, within reach of the trigger device, a safety-lever, which is positively acted on by one or both of the locking-levers, and which, when these levers are in the unlocking position, is maintained by them in such position as to exert a locking action on the trigger parts. Now, whilst in the construction described in the prior specification, the

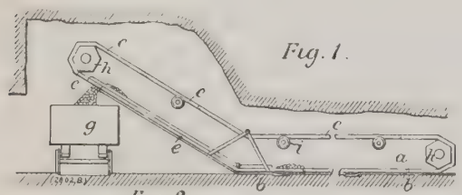


safety-lever, like the locking-levers, is arranged as a one-arm lever moving inward and outward, in the construction to which this application relates there is adopted a much simpler arrangement, which dispenses with the safety-lever above referred to moving inward and outward with the locking-levers, and substitutes for it a safety-lever having the form of a two-armed locking-lever, which moves vertically, and the front arm of which engages with a locking-lever, whilst its rear arm engages with the trigger-catch lever. The drawings illustrate the present improvement to the construction to which the above-mentioned patent relates, as applied to a recoil loader with fixed barrel of the Mauser system. Fig. 1 shows the position of the parts when the

breech is properly locked, and when the safety-lever, and consequently also the trigger-catch lever, are set free to permit of the pulling of the trigger. Fig. 2 illustrates the position of the safety-lever in the locking position with the breech unlocked, whereby the safety-lever, which is in the locking or safety position, engages the trigger-catch lever, and consequently prevents its downward movement when the trigger is pulled—that is to say, it prevents the discharge of the weapon. Fig. 3 illustrates the co-operation of the trigger-catch lever and the sear lever, the trigger-catch lever being shown partially in section. Referring to the general arrangement of the breech mechanism, the locking-levers are arranged, as heretofore, as a pair of levers which support the breech-block from the rear, and are pivotally mounted in the rear wall of the breech casing, and which, when turned inwards, are in the locking position, and when turned outwards, are in the unlocking position, the levers in the former position exerting a locking action on the breech-block, and in the latter position permitting of its movement to the rear between the locking-levers. Beneath the left locking-lever there is pivotally mounted on the central web or fillet g^1 of the stock g, the two-armed safety lever p, which latter is provided on its front arm p^1 with an upwardly projecting nib p^0, which, when the locking-lever is in the locking position, corresponds with a recess therein. The safety lever p is normally held out of engagement with the locking-lever by a spring, and its rear arm p^2 terminates in a projection or catch, above which engages the hook-shaped end of the trigger-catch lever z^2. This hook-shaped end of the trigger-catch lever, however, not only engages above the catch of the arm p^2 of the safety-lever, but at the same time also over the hook of the sear lever s^2, which is rotatably mounted in the usual manner on the pin s^1 from the lower projection of the minor breech, and which engages with the firing-pin r by means of the sear s. When the mechanism is properly locked—that is to say, when, as already stated, the nib p^0 of the safety-lever engages with the recess of the locking-lever—the trigger z can be drawn back without obstruction, as in consequence of the fact that the safety-lever can perform its oscillatory movement, the sear lever can be swung downwards by the trigger-catch lever, and can consequently release the firing-pin. If, on the contrary, the locking has not been effected, so that the locking-lever is turned outwards, the nib p^0 will be unable to enter the recess in the locking-lever, with the result that the safety-lever will be held fast in the position shown in Fig. 2, and that the trigger cannot move the arm p^2, together with the trigger-catch lever z^2, downwards, but such parts will be so held as to be incapable of downward movement, the pulling of the trigger and the consequent release of the firing-pin thus becoming impossible. (*Accepted August* 16, 1911.)

MINING, METALLURGY, AND METAL-WORKING.

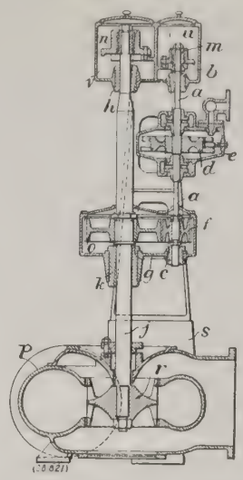
2802/10. J. Allardice, Lesmahagow. Conveyors. [5 *Figs.*] August 30, 1910.—The object of the invention is to provide means for conveying coal from the working face to the main road. According to this invention, a conveyor consisting of an endless chain of links jointed together travelling upon the ground or upon a pavement composed of plates is employed in contradistinction to the endless scraper conveyors at present used in mines, and which require the use of a specially-constructed trough or sides. The conveyor a, as constructed under the present invention, works on the pavement b, and is continuous in its action, so that the coal can, by means of the special construction of this conveyor, be loaded on to it at any part of the face. The pavement b, particularly shown at Fig. 2, and which is of flat formation, and not of trough shape, as heretofore, is formed of steel sheets. Each sheet is cut at one end in suchwise that a portion is taken out of each corner of one end of each length b, whilst slits d are made in the other end, and the tongues thereby formed are made to slip in under the cut portion of the adjacent length, so that the several lengths are thereby joined to form a



whole pavement, and a suitable stationary, yet portable, pavement b thereby made. These plates are only used in the event of the pavement being very soft or wet, or where the pavement is very uneven. On the top of the pavement b travels an endless chain comprising the conveyor proper, and composed of flat links e having extending between them scrapers. The conveyor being so constructed is in itself a complete conveyor, the links of the chain constituting the sides of the conveyor parallel to the face, and the scrapers constitute the front and rear sides, travelling over the stationary pavement to draw the coal along the pavement at right angles to the main road; these scrapers discharging continuously into a hutch g on the main road, which is bridged at this point. The links e, which form an endless chain, are actuated by hexagonal drums h, the links e passing over the pavement b, as shown, and returning above the conveyor by passing over pulleys i. Where the main road is on a level with the pavement of the working face the roof is brushed out over the main road and the end part of the metal pavement b and of the conveyor carried at an angle such that the delivery end projects over the hutch, all as shown in Fig. 1. (*Accepted August* 16, 1911.)

PUMPS.

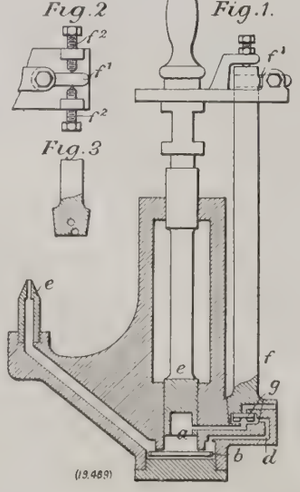
26,821/10. G. and J. Weir, Limited, and J. Petermoller, Cathcart. Rotary Pumps. [4 *Figs.*] November 18, 1910.—In a rotary pump which rotates upon a vertical, or nearly vertical, shaft, and is driven through speed-reduction gearing from a motor arranged on a parallel shaft, the two shafts are provided, in accordance with this invention, each with a suspension bearing, the bearings being arranged side by side and at the top ends of the shafts, and each shaft is also provided with a steadying bearing, adjacent to the suspension bearing and with a second steadying bearing, or pair of bearings, situated below the motor and below, or adjacent to, the gear-wheels, the bearings being all supported from a common standard which is rigidly attached to, or formed integrally with, the pump casing, which latter acts as a bed-plate or base for the standard. The motor-shaft a is provided with the steadying bearing b near its upper end, and with the steadying bearing c at its lower end. Between these bearings the shaft carries the turbine rotor d enclosed in the casing e, and also carries the gear-wheel f enclosed in the gear-box g. The pump-shaft j is likewise provided with the steadying bearing h situated near its upper end and adjacent the bearing b. The bearing k is located adjacent the bearing c. o is a gear-wheel on the pump-shaft located between these bearings. r is the pump



rotor. Each shaft is provided with a suspension or axial-thrust bearing m, n conveniently arranged at the upper end of the shaft. The pump-casing p acts as a base for the whole apparatus, and carries the standard s, which is rigid with it. This standard supports all the bearings and also supports the gear-box g, the turbine casing e, and the boxes u, v, which contain the suspension bearings. In addition to the steadying bearings h, k, the pump-shaft may obtain support at the point where it enters the pump-casing. (*Accepted August* 23, 1911.)

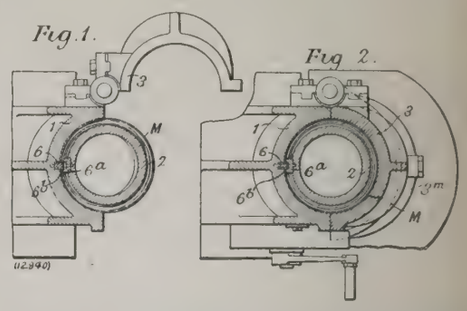
PRINTING AND ALLIED MACHINERY.

19,489/10. G. O. J. Stubbs, London. Type-Casting Machines. [3 *Figs.*] August 19, 1910.—With that class of type-casting machine wherein it is desirable that the molten metal should be drawn back from the pump nozzle during the intake stroke of the pump piston to the required extent to prevent chilling, such drawback has heretofore been more or less constant under all circumstances, whatever the size of the type being cast, and has not been affected to any appreciable extent by the usual adjustments necessary when changing over from one size of type to another, or otherwise. This invention has for its object to provide means whereby this drawback from the pump nozzle may be positively varied, as found necessary, when so changing over, to render possible the prompt production of good sound type. With this object a non-return valve is provided in the pump outlet, such valve being, however, without the usual vent therein to allow of the drawback. The outlet from the lower end of the pump barrel a is fitted with a non-return valve b of disc form, and adapted to float in the molten metal, and close said outlet during the upstroke of the pump piston c. One end of a



by-passage d communicates with the pump outlet at a point between the pump nozzle e and this non-return valve b, and its opposite end communicates with the pump inlet through the plug f of the inlet regulating tap at a point below a non-return valve g. This valve g controls the pump inlet, and comprises a disc arranged in said plug f, and provided with grooves or channels in its underside to permit of the free passage of metal under it when it is in its lowered position. The passages through the plug f controlling the inlet from the pump well to the pump barrel, and communication between the by-passage and the pump inlet passage respectively are so arranged that by operating the plug these may be varied simultaneously to regulate both the pump inlet and the drawback from the nozzle in the desired ratio. With this object the passages are preferably arranged out of line as shown in Fig. 3, so that the one will open as the other closes and *vice versâ*. In order that the adjustment of the plug f to vary the pump inlet and the drawback from the nozzle may be effected as desired, the stem of the plug is fitted with an arm f^1 (Figs. 1 and 2), and on each side of this arm set screws f^2 are arranged by means of which the required adjustment may be effected and the whole then secured. (*Accepted August* 23, 1911.)

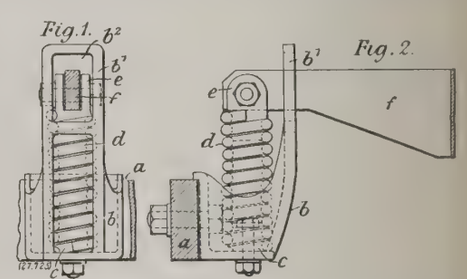
12,940/11. The Duplex Printing Press Company, and H. F. Bechman, Battle Creek, U.S.A. Stereotyping. [3 *Figs.*] May 30, 1911.—The present invention consists of improved means for positioning and clamping a matrix in a mould for slotted tubular stereotype plates. According to the present invention, the drag 1 has a vertical rib 6 fast to the centre of its concave face, and parallel with its axis. The core 2 has a vertical rib 6*a*, which is fast to it, and has a groove 6*b*, both rib 6*a* and groove 6*b* being parallel with the axis of the core. The rib 6*a* and groove 6*b* are so proportioned and positioned that when the core 2 is in casting position (Fig. 2) the groove 6*b* fits over the rib 6, the rib 6*a* clamps the edges of the matrix to the drag 1 on the respective sides of the rib 6, the radial projection of the rib 6*a* beyond the core 2 establishes the thickness of the stereotype



plate, and its width establishes the width of the slot in the said plate. The invention acts as follows:—The core 2 being in the position shown in Fig. 1, a matrix M is bent round it, and its edges pushed by hand into the spaces between the core and the drag 1, as far as it is possible to so push them. The cope 3 is then closed against the drag 1, and locked to it by the yoke 3*m*. This closing of the cope makes it bear against the matrix M opposite to the ribs 6 and 6*a*, force it inwards until its said edges abut against the rib 6, thereby positioning it in the mould, and push the core 2 into the casting position (Fig. 2) thereby making the rib 6*a* embrace the rib 6, and clamp the matrix edges against the drag 1. (*Accepted August* 23, 1911.)

RAILWAYS AND TRAMWAYS.

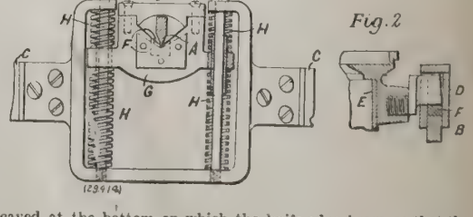
27,725/10. The Brush Electrical Engineering Company, Limited, and S. Leech, Loughborough. Railway Vehicle Trucks. [3 *Figs.*] November 22, 1910.—This invention relates to the motor supports of vehicle trucks for use on electric railways and consists in the combination of a bracket adapted to be secured to the frame of a truck, with a spring attached thereto, and to the end of a motor-suspension beam for the purpose of supporting the motor-beam, the said beam being controlled by the spring and movable in any direction within limits governed by the looped portion of the bracket through which the end of the motor beam is passed. In carrying out the invention, brackets b are secured to the side frames a of the truck. To these brackets b are attached screw nipples c which



are threaded into one end of the springs d. At the other end of the springs d, nipples e, having jaws or other means of attachment to the motor-beams f, are threaded in. The brackets b have on each of them an extension-piece b^1, which is pierced with a hole b^2 larger than that part of the motor-beam f which is to pass through it. By this arrangement of parts, the springs d may act either in compression or tension, and, at the same time, owing to the flexibility of the spring d, the motor-beams f are allowed to vary their position in any direction, the amount of movement being limited by the clearance between the sides of the hole b^2 in the extended part b^1 of the bracket b and the part of the motor-beam f which passes through the hole b^2. (*Accepted August* 23, 1911.)

SHIPS AND NAUTICAL APPLIANCES.

29,414/10. Kelvin and James White, Limited, and F. W. Clark, Glasgow. Compasses. [2 *Figs.*] December 19, 1910.—This invention relates to a suspension for mariners' compasses, and, according thereto, the knife-edges A (Fig. 1) on the gimbal ring B (Fig. 2), supported by the binnacle flange C, and the knife-edges D on the compass bowl E (Fig. 2), supported by the gimbal ring B, are made of non-magnetic hard steel or other specially hard metal, and rest on very hard V-jewels F, such as ruby or agate stones. The V-jewels are slightly curved or con-



caved at the bottom on which the knife edge bears, so that the knife-edges, which are also slightly rounded, shall bear upon a rounded polished surface; the ratio of the radius of curvature of the knife-edge to the radius of curvature of the agate being such as to secure pure rolling action. Each jewel-block is also encased in a sliding-piece G, which rests upon shock-absorbers consisting of two sets of helical springs H, each connected at one end, as by means of sleeves, to the sliding-piece G. (*Accepted August* 23, 1911.)

THE STEAM-TURBINE.

(*Continued from page* 483.)

The rational formula for the speed with which steam flows into a group, given in our last article, as will be seen, is complicated, but it can be thrown into the form—

$$v_0 = R\sqrt{\frac{p_0 V_0 \log x}{N + \mu}},$$

where R and μ are read from curves calculated once for all, and reproduced in Figs. 2 and 3, page 245 *ante*. To calculate R and μ it is necessary to know M and m, which denote respectively the fractions of the "carry in" of energy, and of the energy of expansion, which become effective in producing flow through a stage. The values of these coefficients have been deduced from a series of tests on a large high-pressure marine turbine, of which the following are the main characteristics :—

Diameter of rotor...	68 in.
Revolutions per minute...	330
Shaft horse-power	5432
Steam pressure before first row of blades	179 lb. abs.
Pressure at discharge	22.5 ,,

The blading consisted of six groups of 24 rows each, of $\frac{3}{8}$ standard blades, the heights and clearances being as follow :—

Group No...	1	2	3	4	5	6
	in.	in.	in.	in.	in.	in.
Blade height	$\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$2\frac{1}{4}$	$3\frac{1}{2}$	5
Tip clearances	0.05	0 055	0.055	0.060	0.065	0.07
Values of p_0	179	126.7	89.69	63.48	44.92	31.80

The values of p_0, the initial pressure before each group, as tabulated, are deduced on the assumption that the distribution follows the logarithmic law, and the figures given are probably more reliable than the actual gauge readings. No observations were made as to the quality of the steam, but in the boiler trials of the Hyacinth, the steam, though practically dry at half speed, and below, contained 6.44 per cent. of suspended moisture at three-quarter power, and 4.67 per cent. at full load. Recent tests made with a marine type Yarrow boiler by Messrs. John Brown and Co., Clydebank (see ENGINEERING, vol. xci., page 269), showed by the throttling calorimeter a dryness fraction of $96\frac{1}{2}$ per cent. at full power. A "separator" calorimeter showed even a larger percentage of moisture. It has been assumed, therefore, that in the present case the steam after passing the turbine stop-valve was 96.2 per cent. dry. A check on this assumption is obtained by comparing the indicated horse-power calculated from formula (2) *ante* (corrected for tip leakage, as explained below) with the actual shaft horse-power. The result is that the calculated I.H.-P. = 5566, corresponding to a mechanical efficiency of $97\frac{1}{2}$ per cent. The total amount of steam used was 45.3 lb. per second. The gland leakage was, however, rather high, since there was both a high-pressure reverse turbine and a cruising turbine, requiring to have their spindles packed. The total supply through the glands as calculated by the formula for flow through a labyrinth packing (see ENGINEERING, vol. lxxxv., page 35) was 0.3 lb. per second. Applying the same formula to the high-pressure dummy, the leakage through the latter is found to be 3.3 lb. per second, so that the total steam actually passing the high-pressure blading was 41.7 lb. per second.

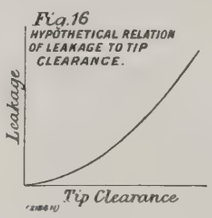
The area available for flow, were there no tip clearance, would be equal to the annulus between the drum and the casing multiplied by sin a, where a denotes the angle of discharge. A very ingenious method of measuring this angle has been adopted by Messrs. J. H. Chilton and J. M. Newton, to whom has been due the marked success of the turbines built by the Brush Electrical Engineering Company, Limited, Loughborough. To make the measurement in question, a number of blades were assembled in a block, and carefully set to pitch and gauged. Steam was then passed through the blades into the atmosphere, with a pressure drop of about 1 lb. Pieces of black cotton strung through the blades then gave the angle of flow, which could be measured with certainty to a fraction of 1 deg. of arc. The arrangement used is illustrated in Fig. 15.

It is usual to set the blades in the casing to a wider pitch than those of the rotor. In the former case the pitch for $\frac{3}{8}$-in. blades is $\frac{1}{4}$ in., and in the latter $\frac{3}{16}$ in. In each case the blades are commonly set so that the narrowest part of the opening between two blades is equal to one-third the pitch. On test the two arrangements were found to have rather different discharge angles. Somewhat paradoxically, this angle is smallest in the case of the more widely-pitched casing blades, where for the $\frac{3}{8}$-in. standard it lies between 17 deg. and 18 deg. The $\frac{3}{8}$-in. rotor-blades, on the other hand, have a discharge angle between 18 deg. and 19 deg. The best average value for the two sets of $\frac{3}{8}$-in. blades appears to be about $18\frac{1}{3}$ deg.

The question of the direction taken by the steam leaking over the blade-tips is a very important one. In the absence of direct experiment it was not unnatural to believe that the main flow, through the blading, would deflect the leakage flow from an axial

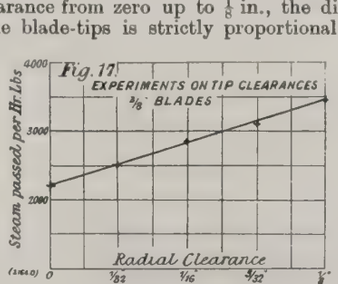
Fig. 15.

into an inclined direction. The result of this would be to greatly diminish the importance of tip leakage. If this were so, however, the degree of deflection experienced should vary with the ratio of tip clearance to the width of the blade. To take an extreme case:—The flow through a blade $\frac{1}{2}$ in. long and $\frac{1}{4}$ in. wide could not be expected to have much effect on the leakage flow if the clearance was as much as $\frac{1}{2}$ inch. If, however, the clearance were reduced in successive steps, it would be natural to anticipate a greater and greater deflection of the leakage current, which might be expected to have nearly the same direction of flow as the stream through the blade, when the clearance was reduced to a few mils. If, then, the leakage flow were deflected by the main flow, a curve in which flow over blade-tips, was plotted against the ratio of the clearance to the blade width, should have a form somewhat similar to that indicated in Fig. 16. In fact, on the hypothesis under discussion, an increase in the tip clearance will cause an increase of the leakage loss



in two ways. The effective area for leakage will be equal to π D c sin θ, where D denotes the mean diameter of the annulus through which the flow takes place, c the clearance, and θ the angle along which the flow is directed. If the main flow through the blading deflects the leakage flow, this angle will be greater the greater the ratio of the tip clearance to the blade width, and hence the leakage will increase at a faster rate than the clearance does. We should thus get a curve of the character indicated in Fig. 16.

Actual test, however, shows that, on increasing the clearance from zero up to $\frac{1}{8}$ in., the discharge over the blade-tips is strictly proportional to the



clearance. This is well shown by Fig. 17, in which are plotted the results of some experiments, also made by Messrs. Chilton and Newton, to whose kindness in communicating results, of such extreme importance from a theoretic standpoint, the writer is deeply indebted.

If we denote the area available for flow, when there is no tip leakage, by Ω^1, whilst Ω represents the actual effective area, we have, in the case of standard $\frac{3}{8}$-in. blades,

$$\Omega^1 = \frac{h\ C \sin (18° 20')}{144} \text{ sq. ft.},$$

where h denotes the blade height in inches, and C the mean circumference of the group, also taken in inches.

If c denotes the tip clearance, then the actual effective area of flow is the same as if the blade height were increased to $h + \sigma c$, where σ is a coefficient. Since experiment shows that the leakage flow is axial, we have

$$\sigma = \frac{1}{\sin a} - 1,$$

where a = the discharge angle of the blades. Taking a as 18 deg. 20 min. for standard blades, we get 2.15 as the value of σ. Similarly for semi-wing blades $\sigma = 1.1$, the corresponding value for wing blades being about 0.6.

Thus the effect of the clearance is to increase the nominal area available for flow in the ratio of $\frac{h + \sigma c}{h}$. Of the total flow passing through the group the proportion doing work on the blades is thus reduced to $\frac{h - c}{h + \sigma c}$, so that the group efficiency is diminished in this ratio by the necessity of providing tip clearance. The remainder of the steam passes through the clearance and does no useful work.*

In this connection it has, however, to be borne in mind that this figure does not represent the reduction in the efficiency of the turbine as a whole, since the proportion of clearance to blade height diminishes from group to group. Thus, suppose a certain weight of steam w passes through the turbine when Group I. has a clearance equal to c_1, then the proportion, of the steam passed, which acts effectively on the blades is, as stated, $\frac{h_1 - c_1}{h_1 + \sigma c_1}$, or, if h_1 be 1 in. and c_1 be 0.05 in., the "effective weight" of the steam, which we may call $\overline{w_1}$, is given by the relation

$$\overline{w_1} = w\left[\frac{1 - 0.05}{1 + 0.108}\right] = 0.86\, w.$$

Now if in Group II. the blade height is $1\frac{3}{8}$ in., and the clearance 0.055 in., the "effective weight" of the steam in this group is given by

$$\overline{w_2} = w\left[\frac{1.375 - 0.055}{1.375 + 0.119}\right] = 0.88\, w,$$

so that the "effective" steam flow is about 2 per cent. more in Group II. than in Group I. Now suppose both clearances are doubled, then $\overline{w_1}$ becomes equal to 0.73 w, and $\overline{w_2}$ to 0.78 w, so that a considerable fraction of the increase in the "ineffective" steam in Group I. becomes "effective" in Group II. In fact, careful experiments have shown that if the clearances of a turbine are expressed as the fraction $\frac{c}{h}$, then the actual efficiency of such a turbine is less than that of one having no tip clearances, in the ratio $\frac{h - 2c}{h}$, and not in the ratio $\frac{h - c}{h + \sigma c}$, which is true only of the groups considered individually, and not of the series taken as a whole.

Returning to the marine turbine under discussion, if we take the brake horse-power as 0.98 of the indicated horse-power, the efficiency ratio, estimated on the basis of the steam actually passing through the blading, is 61.6 per cent. Hence the volume of the steam on discharge from the last row is 16.17 cubic feet per pound, and the value of γ in the equation $P V^\gamma = C$ is $\gamma = 1.0992$. Hence the following particulars can now be tabulated, as in Table II., on the next page.

As already stated on page 246 *ante*, it is convenient for mathematical reasons to consider the first row of blades of a group to be preceded by an imaginary row, which may be called row No. 0. Then

* With wet steam, it appears possible that the proportion of the total weight which escapes over the blade-tips is even greater than the formula given would imply. Owing to centrifugal action, the steam passing over the tips of the rotor blades may well contain more than its proportionate amount of moisture.

TABLE II.

Group No.	1.	2.	3.	4.	5.	6.
Nominal area of discharge .. .. sq. ft.	0.4134	0.5940	0.8375	1.1966	1.7171	2.5043
True effective area of discharge .. sq. ft.	0.4649	0.6511	0.8950	1.2593	1.7869	2.5810
V_0 .. cub. ft. per lb.	2.454	3.362	4.605	6.298	8.628	11.815
$w_0 = \frac{w V_0}{\Omega}$ ft. per sec.	220.1	215.3	214.6	208.6	201.3	199.9
Mean blade speed s ft. per sec.	99.17	99.71	100.4	101.5	102 9	105.1
r_0^2	48,444	46,354	46,053	43,514	40,522	36,443
s^2	9,435	9,942	10,080	10,302	10,588	11,046
$2\, v_0\, s \cos \alpha$	41,432	40,752	40,897	40,188	39,318	38,081
$p_0 V_0$	439.2	425.9	413.0	399.8	387.6	375.7

* From the data given in the table the indicated horse-power can be calculated by means of equation (2), corrected for tip leakage, as explained above. The indicated horse-power, thus computed, aggregates 5566, as against 5432 shaft horse-power as measured.

the "carry in" to stage 1, or $\frac{r_0^2}{2g}$, is equal to

$$\frac{1}{2g}\left\{v_0^2 + s^2 - 2\, v_0\, s \cos \alpha\right\},$$

where v_0 is the velocity of flow from this imaginary row.

Hence we get, for the sum of the "carry in" for the first stages of the whole six groups,

$$\Sigma \frac{r_0^2}{2g} = \frac{1}{2g} \Sigma\, (v_0^2 + s^2 - 2\, v_0\, s \cos \alpha) = 1274 \text{ foot-pounds}$$
$$= 1.6379 \text{ B.Th.U.}$$

From the equation,

$$\frac{n + \frac{1}{2}\log_\epsilon \rho}{N + \frac{1}{2}\log_\epsilon \rho_N} = \frac{1 - \frac{1}{\rho\, x}}{1 - \frac{1}{\rho_N\, x_N}},$$

we can calculate ρ_1, which is the ratio of the volume of the steam after it has passed through the first row of blades to its initial volume $\overline{V}_0$. We thus get

$$\rho_1 = 1.00975.$$

Hence the kinetic energy escaping from stages No. 1, taking all the groups together, is

$$\frac{1}{2g} \cdot \Sigma\, v_0^2 \times \rho_1^2 = \frac{1}{2g} \times 261{,}330 \times (1.00975)^2 \text{ foot-pounds} =$$
$$5.2166 \text{ B.Th.U.}$$

The energy liberated by the expansion through stage 1 is equal to

$$144 \cdot \overline{V}\, \Delta\, p \text{ foot-pounds, where } \overline{V} = V_0\, \frac{1 + \rho_1}{2}$$
$$= 1.00488\, V_0$$

and Δp is the drop of pressure in the stage; that is,

$$\Delta p = p_0 \left(1 - \frac{1}{x_1}\right) = p_0 \left(1 - \left(\frac{1}{\rho_1}\right)^\gamma\right) = p_0 \times 0.010610$$

Hence the aggregate expansion energy liberated in the first rows of all the groups is

$$\Sigma\, 144 \cdot \overline{V}\, \Delta\, p$$
$$= 144 \times 0.01061 \times 1.00488\, \Sigma\, p_0\, V_0 \text{ foot-pounds}$$
$$= 144 \times 0.01061 \times 1.00488 \times 2441.2 \text{ foot-pounds}$$
$$= 4.8166 \text{ B.Th.U.}$$

Hence we get

$$1.6379\, M + 4.8166\, m = 5.2166 \quad . \quad . \quad . \quad (8)$$

the left-hand side representing the total energy tending to produce flow through the first rows of blades, and the term on the right the consequent kinetic energy.

From the equation

$$\frac{n + \frac{1}{2}\log_\epsilon \rho}{N + \frac{1}{2}\log_\epsilon \rho_N} = \frac{1 - \frac{1}{p\, x}}{1 - \frac{1}{\rho_N\, x_N}}$$

We can also find the pressure and volume of the steam before it expands through the last stage of the group. Thus we get

$$V_{N-1} = 1.3460\, V_0 \text{ and } p_{N-1} = 1.38645\, p_0.$$

Then, in exactly the same way as in the case of stage 1, we find that the total "carry in" to the last stages of the six groups aggregates 4.2088 B.Th.U. The energy developed by expansion in these last stages will be found to amount to 8.338 B.Th.U., whilst the relative kinetic energy of the steam on escaping is 9.7806 B.Th.U.

Hence, as before, we get

$$4.2088\, M + 8.3380\, m = 9.7806 \quad . \quad . \quad . \quad (9)$$

Now the value of m should be much the same as if there were no "carry in" of energy. In that case m is known from direct experiment to be about 0.92 for such velocities of flow as we are here concerned with. Putting this value into equation (8) gives M = 0.541, and a similar substitution in equation (9) gives M = 0.500.

These values of M, it is interesting to observe, are practically identical with the values found by Professor Rateau for the relation between the "relative" kinetic energy entering an impulse bucket and the "relative" kinetic energy leaving it. He found* that if l denotes the relative velocity of the steam entering such a bucket, and l^1 the relative velocity of the steam on leaving, that $l^1 = 0.7\ l$ to $0.75\ l$. The square of 0.7 is 0.49, and the square of 0.75 is 0.56; so that when there is no expansion within the bucket the ratio of the "relative" kinetic energy entering the bucket to that leaving is 0.49 to 0.56. The investigation just given indicates that this remains true even when there is expansion within the bucket, a result which there were no *a priori* grounds for anticipating. Dr. Briling has independently obtained about the same values as Rateau.

In what follows we shall take $m = 0.92$ and M = 0.50, and use these values to determine the coefficients R and μ in equation (1). To this end

* See Engineering, vol. lxxxviii., page 804.

TABLE III.—N = 6. $\gamma = 1.108$. M = 0.92. $m = 0.5$. Standard Blades. Cos $\alpha = 0.9492$.

..	$x = \frac{p_0}{p_N}$	1.25	1.5	2.0	2.5
..	$\rho = \frac{V_0}{V_N}$	1.2230	1.4419	1.8694	2.2863
..	$N + \frac{1}{2}\log_\epsilon \rho$	6.104	6.183	6.313	6.414
..	$\frac{\gamma+1}{\gamma-1} \cdot \frac{1 - \frac{\rho}{x}}{1 - \frac{1}{x\rho}}$	1.2140	1.4068	1.7408	2.0213
..	$0.5\,(N + \frac{1}{2}\log_\epsilon \rho)\, \frac{\gamma+1}{\gamma-1}\, \frac{1 - \frac{\rho}{x}}{1 - \frac{1}{x\rho}}$	3.7052	4.3489	5.4946	6.4327
..	$\frac{2.5}{4}(\rho^2 - 1)$	0.3098	0.6744	1.5582	2.6412
..	$0.5\,(N + \frac{1}{2}\log_\epsilon \rho)\, \frac{\gamma+1}{\gamma-1}\, \frac{1 - \frac{\rho}{x}}{1 - \frac{1}{x\rho}} + \frac{2.5}{4}(\rho^2 - 1) = z =$	4.0150	5.0233	7.0628	9.1239
..	$\frac{1+\gamma}{\gamma}\, \frac{1 - \frac{1}{x}}{1 - \frac{1}{x\rho}} = b =$	1.1000	1.1796	1.2986	1.3886
..	$b\,(N + \frac{1}{2}\log_\epsilon \rho)$	6.7140	7.2935	8.1958	8.8740
..	$\rho - 1$	0.2230	0.4419	0.8698	1.2863
..	$b\,(N + \frac{1}{2}\log_\epsilon \rho) - (\rho - 1)$	6.4910	6.8516	7.3287	7.5877
..	$[b\,(N + \frac{1}{2}\log_\epsilon \rho) - (\rho - 1)] \cos \alpha = D =$	6.1612	6.5038	6.9563	7.2022
..	$\frac{144\,\gamma}{\gamma - 1}\left(1 - \frac{\rho}{x}\right) = l =$	31.782	57.248	96.516	126.23
$\delta = 0.4$	$z + \delta \cdot D - 0.5\,\delta^2 \cdot N$	5.9993	7.1445	9.3553	11.5246
	$v_0^2 = 2g \cdot M \cdot p_0 V_0 \cdot l \div (z + \delta \cdot D - 0.5\,\delta^2 \cdot N) = p_0 V_0 \times$	313.83	474.68	611.26	648.84
$\delta = 0.6$	$z + \delta \cdot D - 0.5\,\delta^2 \cdot N$	6.6317	7.8453	10.1466	12.3651
	$v_0^2 = 2g \cdot M \cdot p_0 V_0 \cdot l \div (z + \delta \cdot D - 0.5\,\delta^2 \cdot N) = p_0 V_0 \times$	283.93	429.40	563.57	604.80
$\delta = 0.8$	$z + \delta \cdot D - 0.5\,\delta^2 N$	7.0220	8.3058	10.6978	12.9654
	$v_0^2 = 2g\,M\,p_0 V_0 \cdot l \div (z + \delta \cdot D - 0.5\,\delta^2 N) = p_0 V_0 \times$	268.11	408.29	534.46	576.81
$\delta = 1.0$	$z + \delta \cdot D - 0.5\,\delta^2 N$	7.1762	8.5265	11.0091	13.3261
	$v_0^2 = 2g \cdot M\,p_0 V_0 \cdot l \div (z + \delta \cdot D - 0.5\,\delta^2 N = p_0 V_0 \times$	262.32	397.76	519.46	561.21
$\delta = 1.4$	$z + \delta \cdot D - 0.5\,\delta^2 N$	8.7732	9.3980	10.3155	10.9365
	$v_0^2 = 2g \cdot M\,p_0 V_0 \cdot l \div (z + \delta \cdot D - 0.5\,\delta^2 N) = p_0 V_0 \times$	278.53	411.20	524.03	561.19

TABLE IV.—Values of v_0^2 for Different Conditions of Expansion, Blade Speed, and Number of Rows.

—	$\delta = \frac{s}{v_0}$.	0.4	0.6	0.8	1.0	1.4
$x = 1.25$	N = 6, $\gamma = 1.0675$	312.70	282.92	267.09	261.31	277.20
	N = 6, $\gamma = 1.108$	313.83	288.93	268.11	262.32	278.53
	N = 30, $\gamma = 1.0675$	65.555	53.911	55.020	53.980	57 027
	N = 30, $\gamma = 1.108$	65.580	58.890	54.985	53.940	56.99
$x = 1.50$	N = 6, $\gamma = 1.0675$	469.50	427.68	403.90	393.22	405.30
	N = 6, $\gamma = 1.108$	474.68	429.40	408.29	397.76	411.20
	N = 30, $\gamma = 1.0675$	102.88	92.510	86.172	83.808	85.848
	N = 30, $\gamma = 1.108$	103.24	92.851	86.546	83.772	86.485
$x = 2.0$	N = 6, $\gamma = 1.0675$	600.00	553.74	525.30	510.20	513.46
	N = 6, $\gamma = 1.108$	611.26	563.57	534.46	519.46	524.03
	N = 30, $\gamma = 1.0675$	141.68	127.98	119.08	114.86	114.00
	N = 30, $\gamma = 1.108$	142.39	128.60	119.69	114.60	115.07
$x = 2.5$	N = 6, $\gamma = 1.0675$	633.14	591.01	563.92	548.50	547.20
	N = 6, $\gamma = 1.108$	648.84	604.80	576.81	561.21	561.19
	N = 30, $\gamma = 1.0675$	160.02	145.25	135.30	130.13	127.40
	N = 30, $\gamma = 1.108$	160.94	146.06	136.11	130.94	128.53

TABLE V.—Values of R and μ for Different Pressure Ratios and for Different Ratios of Blade Speed to Steam Speed.

—	$\delta = \frac{s}{v_0}$	0.4.	0.6.	0.8.	1.0	1.4.
$x = 1.25$	Wet steam .. .. μ	0.3323	0.2774	0.1921	0.2379	0.1790
	Wet steam .. .. R	143.3	135.7	130.9	129.8	133.3
	Superheated steam .. .. μ^1	0.2785	0.2314	0.1555	0.1798	0.1563
	Superheated steam .. .. R^1	143.9	136.3	131.6	130.5	134.5
$x = 1.50$	Wet steam .. .. μ	0.6609	0.5858	0.4477	0.4465	0.3865
	Wet steam .. .. R	133.9	126.8	122.2	120.5	121.9
	Superheated steam .. .. μ^1	0.5363	0.4483	0.3465	0.3482	0.2992
	Superheated steam .. .. R^1	134.9	127.7	123.1	121.5	123.5
$x = 2.0$	Wet steam .. .. μ	1.2672	1.0779	0.9088	0.8528	0.7377
	Wet steam .. .. R	121.5	115.1	110.7	108.7	108.2
	Superheated steam .. .. μ^1	1.0041	0.8552	0.7073	0.6662	0.5680
	Superheated steam .. .. R^1	122.7	116.2	111.9	109.9	109.9
$x = 2.5$	Wet steam .. .. μ	1.8880	1.6158	1.3913	1.2840	1.1097
	Wet steam .. .. R	113.4	107.6	103.5	101.3	100.0
	Superheated steam .. .. μ^1	1.4598	1.2451	1.0524	0.9773	0.8318
	Superheated steam .. .. R^1	114.4	108.5	104.4	102.3	101.5

we have determined from equation (7) *ante* the value of v_0 when N = 6 and when N = 30, when γ in the equation $P V^\gamma$ = constant was 1.0675, and when it had the value 1.108, and whilst x was varied from 1.25 to 2.5 and $\delta = \frac{s}{v_0}$ from 0.4 up to 1.4.

It will be found that within the range of turbine practice the value found for v_0 is almost absolutely independent of γ when N is large, and nearly so even when N is small. Details of the calculation for the case of standard blades having a discharge angle of 18 deg. 20 min. are given in Table III. for N = 6 and γ = 1.108. Taking M = 0.5, equation (7) may be written

$$\frac{v_0^2}{2g}\left\{0.5\,(N + \tfrac{1}{2}\log_\epsilon \rho)\,\frac{1+\gamma}{\gamma-1}\cdot\frac{1-\frac{\rho}{x}}{1-\frac{1}{\rho x}} + \frac{2.5}{4}(\rho^2-1) - \frac{N\delta^2}{2}\right\} + \delta\cos\alpha\left\{b\,(N+\tfrac{1}{2}\log_\epsilon\rho) - (\rho-1)\right\} = \frac{\gamma}{\gamma-1}\cdot m.\,144\,p_0\,V_0\left(1-\frac{\rho}{x}\right).$$

For shortness this may be written

$$\frac{v_0^2}{2g}\left[z - \frac{N\delta^2}{2} + \delta D\right] = 0.92\,p_0\,V_0\,l.$$

Here z is quite independent of δ, as also is l. The values of z, D, and L are given in Table III., for the conditions stated, and from them v_0^2 is calculated for different values of δ.

Similarly, if N = 30 we get with the same values of m, M, and γ the values of v_0^2 given in Table IV.

The value 1.108 taken for γ represents very fairly an average value for the case of wet steam passing through a modern steam-turbine. How little the value of v_0 depends in such cases on this index is well shown by the figures in Table IV. Here the conditions have been taken the same in both cases, save that, instead of 1.108, γ is taken as 1 0675, a value which would only be met with in the case of a turbine having an efficiency of less than 30 per cent.

Here it will be seen that for values of x less than 2 the velocity of flow with thirty rows in the group is, for all practical purposes, identically the same as with the higher value of γ. With six rows in the group the agreement is not quite so good, but with the values of x usual in turbine practice the velocity is only about half of 1 per cent. less than with the higher index. Even with a value of x equal to 2.5 the difference in the velocity, calculated from the two values of γ, then hardly exceeds 1 per cent. Hence, if we calculate the velocity on the hypothesis that γ = 1.108, we shall be substantially correct, whatever the efficiency of the turbine and consequent value of γ in the expression $p\,V^\gamma$ = constant.

As already stated, equation(7)is not very manageable, being troublesome to evaluate. If, however, we write

$$v_0 = R\sqrt{\frac{p_0\,V_0\log x}{N+\mu}}$$

we can from the values of v, already calculated and given in Table IV., find values of R and μ which can then be plotted, as has already been done in Figs. 2 and 3, page 245 *ante*. Then, whatever the value of x and of δ, we shall get the same value of v by taking R and μ from this diagram as if we used equation (7).

In the simplified formula log x is introduced to "flatten" the resultant curves, and thus enable the value of R to be read with all necessary accuracy. Those who desire to plot the diagram to a larger scale values of R and μ will find useful the values given in Table V. (above). The limiting value of R when x=1 is, of course, ∞.

(To be continued.)

WIRE ROPEWAY PLANT AT THE ORCONERA IRON-MINES, SPAIN.

In the Province of Biscay, North Spain, iron ore is found, not only in rocky formation, but also in the form of small stones mixed in the clayey soil. In former days only deposits of the first description were worked—the ore being separated from the rocks by means of blasting—but in recent times ore-washing has been introduced in order to turn into account the large beds of ore-yielding earth. These washeries are mostly constructed as shown in Fig. 1, annexed, use being made of streams flowing down the mountain sides. The earth is deposited in front of the washery, on an inclined plane, where it is sprinkled with water and thus caused to slide direct to the wash-drum.

A number of years ago the Orconera Iron-Ore Company, who are engaged in working the deposits in this district on a large scale, came forward with a project for constructing a modern washery, and pumping the necessary water from the sea to the pit, situated at a height of 1300 ft. Very great difficulties, however, confronted the scheme. Above all, means would have had to have been provided to prevent the choking of the streams with mud. It would further have been necessary to lay the water-pipes through the property of many other mines, which would have led to difficulties both in construction and working. The chief obstacle, however, was the marsh land through which the pipes would necessarily have been conducted.

The company, therefore, considered the question of sending the earths to a washery erected on the coast, and, in spite of many impediments, the concession was obtained in about three years. The profile and plan of the line thus decided upon are shown in Figs. 2 and 3, subjoined.

As seen in Fig. 4, page 554, the Orconera Company has erected the washing plant on a hill about 300 ft. above sea-level, and it comprises six drums 9 ft. 9 in. greatest diameter and 19 ft. 6 in. in length. Each drum is capable of washing 375 tons of earth daily, the total capacity of the washery being, therefore, over 2000 tons per day. The feed-water is supplied by two pumps constructed by Messrs. Sulzer Brothers, Winterthur, each with a capacity of 317 cub. ft. per minute. The company's Spanish engineer made a careful survey of the route decided upon, and, as a means of connection between the mine and the washery, a wire ropeway on the bi-cable system was decided upon. The working survey for, and execution of, the plant were entrusted to Messrs. Adolf Bleichert and Co., London and Leipzig. This decision indicates the confidence shown at the present day in the wire ropeway, as quite unusual capacities are involved in this case. As a single line would have been rather heavy, the plant was constructed as a double ropeway of two parallel lines, each of which, when in work, would be absolutely independent of the other. Thus a reserve has been provided for, which, under all circumstances, so far as it is possible to judge, will ensure an uninterrupted traffic. Even if one line should be stopped, the conveyance of material can be maintained on the other.

It would, perhaps, have been possible to erect a ship-loading station near Povena. The company, however, has a staith of its own in the Bilbao River, and a railway—likewise the property of the company—runs from there to the mining district, so that it was preferred to return the washed ore—which amounts to about one-third of the total bulk—to a point situated approximately in the middle of the line, and then to convey it to the railway station at Gallarta by a branch line. The total length of the main line is about 5 miles, the way back to the junction station at Pucheta about $2\frac{3}{4}$ miles, and the distance between Pucheta-Gallarta about one mile. In calculating the details an hourly transport of 210 tons of earth and 105 tons of washed ore was taken as a basis, so that, expressed in ton-miles, the capacity is—

$$210.5 + 105\,(2\tfrac{3}{4} + 1) = 1450 \text{ ton-miles per hour.}$$

This may well be by far the greatest ton-mile capacity yet achieved on a wire ropeway.

Fig. 1.

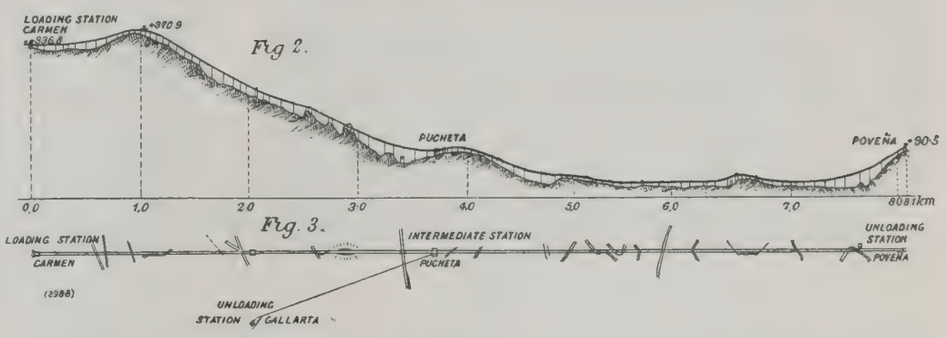


Fig. 2.

Fig. 3.

In Figs. 2 and 3, the entire plant, the longitudinal profile, and the stations are represented in their most important parts in a diagrammatic form. At the mine Carmen VII. a hopper plant was erected by the Orconera Company, before the mouths of which a suspension railway track is located, on which the ropeway cars of both lines—after uncoupling from the traction rope—are loaded by the opening of the escape-gates. The cars are then again coupled to the traction rope, to which they remain securely fastened during the whole trip, and in passing through the intermediate station, Pucheta. On arrival at the end station, Povena, the cars are discharged from the tippling-bridge on to the storage ground, which is arranged with a moderately sloping bottom and from which the material slides to the drums of the washery. The washery has been fitted with Robins Conveyors, designed and fitted up by Messrs. Fraser and Chalmers, Limited, London. A band-conveyor arranged parallel to the tippling-bridge collects the washed ore and takes it to two further zig-zag transport bands, which raise it about 100 ft. and throw it into a hopper, from which a corresponding proportion of the ropeway-cars returning empty from the tippling-bridge

WIRE ROPEWAY AT THE ORCONERA IRON-MINE, SPAIN.

CONSTRUCTED BY MESSRS. ADOLF BLEICHERT AND CO., ENGINEERS, LEIPZIG.

Fig. 4. General View of Ropeway.

Fig. 5. Discharging Gear.

Fig. 9. Cars at the Coupling Point.

are again loaded. The cars used for the return journey are supplied with automatic disengaging appliances, by which they are tipped at the station Pucheta, and then proceed empty to the mine. The discharge is effected during the journey at a point regulated by the placing of the detent (see Fig. 5, annexed), so that even on the return journey no uncoupling of the cars from the rope takes place.

From the large iron hopper erected by Bleichert and Co., at the station at Pucheta, the ore is now drawn off again into the cars of the branch line which runs to the station Gallarta, more than a mile away. Both lines, and the station Pucheta, are to be seen in Fig. 6, from which it will also be observed that the line crosses a thickly populated country. From the hopper at Gallarta the ore is finally taken to Bilbao in the automatic unloaders of the railway (see Figs. 7 and 8, page 555).

The drive for both sections of the main line is arranged at the loading-station at the mine, and consists of two electro-motors of 100 horse-power each, provided by Messrs. Siemens, these motors being connected by gearing to the shafts carrying the winding drums. The drives can be worked independently, or they can be coupled together.

For connecting the cars to the traction-rope the Bleichert patent "Automat" is employed, and, as is usual for heavy gradients, with under-type rope. The weight of the car and the load is utilised for gripping the rope by fitting the pendulum-pin of the hanger facing the carriage with movable bearings, and thus transferring the weight of the load to the long arm of a lever situated in the lengthened carriage-plate, the shorter arm forming the jaw-grip. The rope is pressed against a rigid surface, thus creating a grip resistance which is equal to the car weight × leverage × coefficient of friction × 2, as the friction operates on both sides of the rope. In practice, gradients up to 41 deg. have been taken with this grip apparatus regularly and with complete safety. Up to the present it has not been found necessary to make use of steeper gradients. A dislocation of the connection during the trip is quite impossible, as the car weight always maintains a uniform effect.

From Fig. 9, which shows the cars at the coupling point, it is to be seen how the man has simply to push each car to the station crossing, whereupon the apparatus automatically grips the rope by which it is drawn along the line. The coupling is effected smoothly, without any bumping or jarring. A special advantage of the coupling apparatus is that the grip-jaws have plenty of play and exercise their full effect without intermission. Within certain limits it is therefore immaterial what diameter the rope has; it is always gripped with the same safety. This feature is important even on small lines, as the splicing of new pieces in a partially defective rope is simplified, or even made possible, for, as is well known, the diameter of every rope is considerably reduced in working, and the new pieces are therefore thicker than the old ones. The adaptability of the coupling apparatus to the rope diameter is, moreover, of vital importance in cases where a line consists of several sections, the ropes of which are not stretched uniformly, but which should all, however, carry the same cars. The case here is very similar; it is a great advantage that the cars should be available for use on both lines, whether the one rope has been subjected to a greater strain, and has, therefore, stretched more than the other, or whether the traction rope on one side has been renewed while an old one does duty on the other.

The building of the ropeway plant has, apart from the delay caused by the strike in the summer of 1910, been carried out exactly in accordance with the plan originally decided upon. In May, 1909, the detailed surveying work necessary was begun by Messrs. Bleichert and Co., and immediately afterwards the Orconera Company put the foundations in hand. In May, 1910, the whole of the masonry work was complete. In August, 1909, the erection of the supports and

WIRE ROPEWAY AT THE ORCONERA IRON-MINE, SPAIN.

CONSTRUCTED BY MESSRS. ADOLF BLEICHERT AND CO., ENGINEERS, LEIPZIG.

Fig. 6. General View of Ropeways and Pucheta Station.

Fig. 7. Washed Ore Hopper at Pucheta Station.

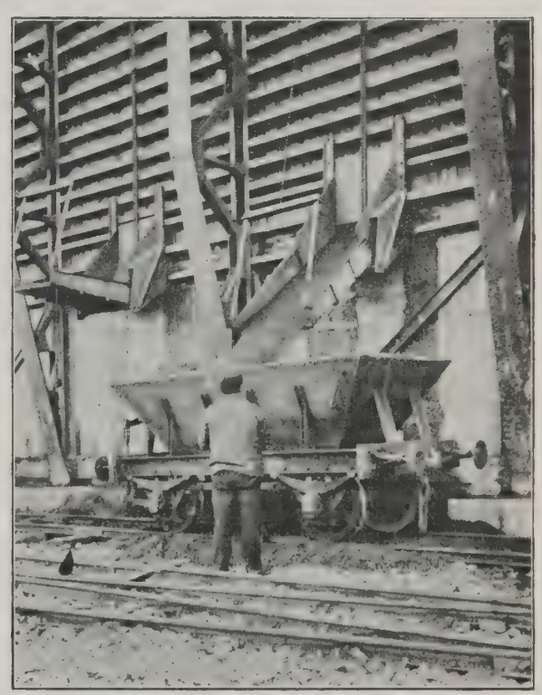


Fig. 8. Loading Railway Wagons at Pucheta Station.

stations was commenced, these being supplied and put up by the Basconia Company, Bilbao, from the drawings of Messrs. A. Bleichert and Co. The setting in work of the plant was planned for the end of August, 1910, but owing to the strike the work suffered three months' delay, and, consequently, it was November, 1910, before the line was ready for inauguration.

THE INSTITUTION OF MECHANICAL ENGINEERS.

The first ordinary general meeting of the above Institution for 1911-12 was held on Friday last, the 20th inst., at the Institution, Storey's Gate, Westminster, the President, Mr. E. B. Ellington, being in the chair.

The late Mr. T. Hurry Riches.

The President, before proceeding to the formal business of the meeting, referred to the great loss which the Institution had sustained by the death of Mr. T. Hurry Riches. Mr. Riches had long been associated with the Institution. He had been elected a Member in 1874, was a Member of Council in 1885 to 1898, a Vice-President from 1899 to 1906, and, receiving the highest honour the Institution could bestow, was President during the years 1907-8. During that time Mr. Riches had endeared himself to everyone with whom he came into contact, and had rendered great service to the Institution. All deeply lamented his loss. At their recent meeting the Council had passed a resolution of condolence to the widow and family; this resolution had been embodied in a suitable letter, and the latter had been acknowledged by Mrs. Riches.

The minutes of the summer meeting at Zurich were then read. Subsequently the President observed that, in order to do honour to the Swiss engineers who had so greatly assisted the recent visit of the Institution, the Council had nominated Professor Dr. Stodola as an honorary life member of the Institution. By his work in the past, Dr. Stodola had attained such a position that, in accepting the nomination, he was paying a great compli-

ment to the Institution. Dr. Stodola had acknowledged in very pleasant terms the honour which the Institution had sought to do him.

The President further directed the attention of members to the presentation which had been made to the Institution of an illuminated address from the American Society of Mechanical Engineers, in commemoration of the joint meeting which had been held last year in Birmingham and in London. A photograph of that address would be reproduced in the Proceedings in due course.

The results of the ballot list for the election of new members were then announced, 134 candidates having been duly elected; the several transferences made by the Council were also notified.

Endurance of Metals.

The paper set down for reading and discussion was one entitled "The Endurance of Metals: Experiments on Rotating Beams at University College, London," by Mr. E. M. Eden, of the Armstrong College, Newcastle-on-Tyne, Mr. W. N. Rose, and Mr. F. L. Cunningham, graduate, of London. This paper was read by Mr. Eden and partly discussed, and we commence to reprint it in full in another part of this issue.

At the conclusion of the reading of the paper, Mr. Eden pointed out that Professor Cormack had lent a double-unit portion of the testing-machine for exhibition at the meeting, and at the University College a number of tests had been quite recently made on pieces of mild steel to show the nature of the fractures and the corrosion caused by rusting; that was, the corrosion where the test-piece went into its holders. These specimens were exhibited.

In proposing the vote of thanks, the President observed that the paper was a record of interesting experiments on a very abstruse and difficult subject—the fatigue of metals. A very important point, which it seemed the experiments brought out, was that it could not be positively stated whether there were any degree of alternating stress which, if applied to these steels, would result in practically unlimited endurance. He hoped the discussion would elicit some views on the nature of stresses, which, if carried on long enough, would ultimately cause the material to break down.

Dr. W. C. Unwin opened the discussion. He thought the authors were to be complimented on the great ingenuity displayed in the form of the machine they had adopted for carrying out their tests. He could not say the machine did more than the simple cantilever rotating machines, but it was very interesting to have the experiments made in a different way. He believed that, with Sir William Fairbairn, his chief at that time, he had carried out the earliest experiments on the endurance of metals, about the year 1860. In the course of a controversy with the Board of Trade they had put up a wrought-iron riveted girder, loaded and unloaded it at a regular rate, and broke it down successively five times with different loads. These experiments had been carried on for three or four years. Not long after that came the extraordinarily interesting tests by Wöhler, which had essentially modified the whole view of what should be the working stress in machines subjected to alternating or varying stresses.

A good deal was said in the paper about the elastic limit. He considered that the point had been reached at which it was no longer right to talk about *the* elastic limit. What was imported in the paper by "elastic limit" was the elastic limit of a bar determined by a statical tension test. That was one elastic limit, but it was known that that elastic limit for that same bar might be varied in a number of ways. Any straining action altered it. In the case of mild-steel or wrought-iron bars in general—bars which had been subject to a rolling action—the elastic limit determined by a statical tension test was artificially raised. Such bars had been subjected to straining, and by straining the elastic limit could be made almost anything desired. The late Professor Bauschinger had shown—a very important result—that if a bar were subjected to a gradually increasing alternating stress of equal amount in thrust and tension, two equal elastic limits would be set up in the bar, one for tension and one for compression. These two equal elastic limits, determined in the bar by the process to which it was subjected, were called the "natural elastic limits," and when Bauschinger came to compare the natural elastic limits with the limiting stress which the bar would stand for an indefinite number of repetitions of loading, he found that they appeared to be the same. Natural elastic limits were lower usually than the artificially raised elastic limit determined in the tension test, and the stress which the bar would stand for an indefinite number of repetitions of loading was also lower than the ordinary tension elastic limit. The speaker thought that that point should be kept in mind. If Bauschinger were right—and his results had, to a certain extent, been confirmed by the National Physical Laboratory experiments—that would explain why it was that an annealed bar would not stand so much stress for an indefinite number of repetitions of loading as a bar which had not been annealed, for the annealed bar always had lower natural elastic limits.

One important point in the paper was the indication that there was no speed effect in fixing the limit of stress which could be withstood indefinitely. So far as the speaker knew, it was only the Reynolds experiments which had thrown any doubt on the point. For himself he had had no doubt, and he had always believed that the Reynolds experiments were in some way or other misleading. The authors' experiments seemed to show conclusively that there was no speed effect, at any rate up to any speeds to which the tests had been carried. The point was very important. The authors appeared to think that the limiting stress for an indefinite repetition of load depended more on the tenacity than on the elastic limit; the speaker doubted that conclusion. He also regretted that the authors seemed to throw doubt on the belief that there was a limit of stress which a bar would bear indefinitely. They had scarcely shown sufficient reason for doubting. He did not think that any one would suppose that the stress which a bar would carry for a million repetitions of loading was the same thing as the stress which a bar would carry for twenty millions. Most of Wöhler's experiments were carried to more than one million repetitions of loading; some of them to at least twenty millions, and one, he believed, to thirty-eight millions. Looking at the curves, the logarithmic curves threw no light on the matter, but the natural curves all tended to become horizontal. Personally he believed there was a limit of stress which a bar would carry indefinitely, and it would ultimately be proved that Bauschinger was right, and that that limit was the limit of the natural elastic limits. It was not at present absolutely settled.

Mr. C. E. Stromeyer said he knew how wearisome experiments of this class were, and he was inclined to condole with the authors at not being able to come to any definite conclusions. His own experiments extended over nearly thirty different qualities of steel, and, although they had been concluded over a year, he was still searching for some correlation between these and other tests. So far as he had progressed, he had found no relation between the fatigue limits and the ordinary elastic limits, nor the ultimate tenacity or compression limits, nor the chemical analyses. As far as he could gather, the various materials seemed to behave much as they liked. What was worse, the bad materials, such as were very treacherous in practice, mostly came out best under test. Particularly was this the case with steels rich in phosphorus and nitrogen. With regard to the authors' test-machine, the speaker said that by having a double load on a beam supported on two ends, the authors had ensured a uniform bending moment over the centre length, and by making the centre length parallel, a uniform stress extending over a considerable length of test-piece could have been obtained; whereas with the cantilever arrangement the test-piece would have to be made taper if it were desired that there should be a uniform stress on the surface over the whole length of the test-piece. The authors had adopted a very ingenious arrangement for attaining this object, but by shaping the centre portion they had thrown it away.

With regard to the plotting of the results, he might say that he had worked with logarithmic co-ordinates for many years, and he had found that they nearly always eventuated in straight lines. It was one of the beauties of exponential co-ordinates that any system of experiments could be plotted in straight lines, but generally they did not show anything. He had worked out a lot of logarithmic curves for steamship resistance, and the lines were all straight, but they gave no definite constants. That, he thought, was the case with the authors' curves, and it would have been preferable had the authors given the actual number of revolutions. If such figures could not be embodied in the paper, perhaps the authors would let him have them privately, as he would like to study the matter in detail. From a large number of experiments he had made, Mr. Stromeyer had derived a curve which gave a definite fatigue limit. He had roughly applied it to Figs. 14 and 15, and had in both cases obtained a limit of about 10.5 tons per square inch; that was to say, 21 tons extreme range; but, as he had already observed, the fatigue limit, and also the stress which results in fracture after a million revolutions, did not seem to fit in with any other properties of the material which he had been investigating. It was therefore doubtful to him whether or not these fatigue tests assisted one to a knowledge of the best material, say, for a shaft. For the present, at all events, he would rather trust steel-makers, who knew by experience whether a particular steel was good or bad for shafting, than put his faith in experiments which, as yet, threw no light on the matter. He regretted that the authors had not made a chemical analysis of the material tested, and if they would send him some steel he might analyse it himself, and see if he could bring the results into correlation with his tests.

Another point that needed careful investigation was the microstructure of the materials. He would not go so far as to say that he had found a relation between it and other tests, but there appeared to be an indication that the coarser the grain the more easily the material broke down. That was to be expected, but it was difficult to measure this coarseness of grain, or, rather, to get any definition of the coarseness. He had found that the number of specks of pearlite per square millimetre could be taken as one criterion, which, together with the size of the specks of pearlite, afforded an indication of the size of the grains both of the ferrite and pearlite. There seemed to be some peculiar relation between one or the other of these factors of the coarseness and some other properties of the material, but it would require very careful investigation by persons really versed in the microscopy of steels to determine this relation. Perhaps someone would undertake this matter. It would, at any rate, be interesting to get a definition of what might be called the "coarseness of grain," and then fatigue tests might be undertaken on a single quality of steel, of which successive test-pieces would have to have their grain made coarser and coarser by properly regulated heatings.

Professor J. O. Arnold said that the paper was of great interest, the machine used was of an exceedingly ingenious type, and the results obtained so carefully worked out that they might certainly be accepted as accurate. The paper before the meeting assisted him to "point a moral and adorn a tale" in which he had been trying to get engineers to believe for many years. Certain work which the speaker had done in the direction of the authors' tests was buried in the Transactions of the Institution of Naval Architects, and it was quite evident that the authors were unacquainted with the careful work done at Sheffield many years ago. To illustrate this work the speaker explained a series of slides which were thrown on the screen. These were taken from Professor Arnold's paper, which was reprinted in full in Engineering at the time.* The figures given herewith are reproduced from that paper. The first slide (Fig. 1) exhibited showed a cantilever type of machine for the Wöhler tests. Accompanying it was the bar diagram, and the stress cycle of Wöhler, which might be termed the kinetics of a particle. Starting at the top, the particle, as the bar came round, was under the maximum tensile stress. This died away in the first quadrant, reaching a neutral line of the zero at the horizontal diameter. It then passed into compression, and the maximum compression stress was reached at the lowest point; it then passed on to zero again, and finally assumed the maximum tensile stress. That was presumably Wöhler's cycle of stresses. He would venture, on the authority of good engineers, to suggest to the authors what it was they had been measuring. He interpreted the "factor of safety" of an engineer to mean a factor devised to meet all possible contingencies under which a crank-pin of a locomotive driving-wheel or a tail-shaft of a steamer might fracture. The factor

* See Engineering, vol. lxxxv., pages 565, 598, &c.

of safety was composed of four sub-factors, as given in Table I., herewith, reproduced from the Transactions of the Institution of Naval Architects. As it seemed to him, the authors had been measuring sub-factor *b*, the other factors, particularly the two latter, *c*, the rapidity of loading, and *d*, the unknown contingencies, not having been measured at all. Therefore, although the authors' tests might have a relation to the elastic limit, or to the tenacity of the material, they had no relation whatever—and he here agreed with Mr. Stromeyer—to the ultimate liability of the material to fracture in use. At Sheffield he had some time since devised a machine in which the material was always stressed to the limit of the elastic limit.

Professor Arnold showed a diagram of this machine, of which the principle is shown in Fig. 2, the bar being held in a die and forced over to one side or the other by a plunger, giving alternations under standard conditions of 650 reversals of stress per minute. Thousands of tests had been carried out with that machine, and the results had been most satisfactory from the point of view of accurately predicting in a minute what would happen over a long period in practice. The machine was a costly one, and the speaker had hesitated to put it on the market. Only four were in existence, one at the Sheffield University, one at Krupp's, one at Schneider's, and one at the Ordnance Works, Coventry. He would show some of the results obtained, which disagreed absolutely with those recorded by the Wöhler rotating tests, but agreed with results obtained in actual practice. The authors' paper referred to tests on bright-drawn bars. Both the maximum stress and elastic limit were obtained by rolling the bars down and leaving them $\frac{1}{32}$ in. too large, and then cold-drawing them. His own investigations had their origin in the fact that a well-known firm of engineers found that the holding-down bolts they were turning out broke constantly. Some of them had been sent to him for investigation. Table II. gave the results of tests on his machine on those holding-down bolts which broke down in practice. The only questionable chemical feature was the rather high phosphorus. The figures were 76, 46, 46, 50, compared with 300 reversals specified. The bolts were hopelessly brittle. These results so astonished the engineers concerned that they commissioned the speaker to investigate the whole matter. These same bolts which had fractured so badly in practice gave excellent Wöhler bending tests. As Mr. Stromeyer had said, and as the speaker would presently show, the worse the material—the more brittle and the more liable to go in practice—the better the results on the Wöhler bending tests; that he had proved over and over again. In Table III. particulars were given of a series of structural steels of varying carbon content, all high-class Siemens hematite quality steels. The first set had been hot-rolled in the ordinary way, and allowed to cool on the plates. The maximum stress was given in that table, and as the authors appeared to regard the maximum stress as the more important feature, he would take that, though he preferred the yield-point. It would be seen in Table III. that in the material which was rolled and allowed to cool naturally the yield-points varied from 24 to about 30 tons per square inch. The very same steels had been cold-drawn to the extent the speaker had specified; that was to say, the $\frac{3}{4}$-in. bar had been cold-drawn $\frac{1}{32}$ in. Figures for the cold-drawn bars were given in the second set in Table III. There could be no doubt that the effect was marvellous. Broadly speaking, the yield-points in each case had gone up 10 tons per square inch. It was precisely at the time to which these tests referred that engineers had become obsessed by the idea of the reliability of the Wöhler tests, and cold-drawn material was going all over the country, and bolts were breaking all over the country, although they gave splendid Wöhler tests. In Table IV. the figures for the corresponding set of Professor Arnold's kinetic tests of the bars of Table II. were given. Taking A, for instance, of the 0.26 carbon steel, the first—the hot-rolled—had a yield-point of 24 tons, and endured, on his machine, 346 alternations; the rolled and drawn steel had a yield of 37 tons, and had practically endured 248 alternations. With the other hot-rolled steels with increasing carbon and higher yield-points, the alternations obtained were 344, 336, 320. With the rolled and cold-drawn materials in the same order the corresponding figures were 222, 206, 156. Those results reflected what was actually taking place in the case of a very large number of the bolts distributed in various machines, all giving excellent Wöhler tests. Fig. 3 showed the

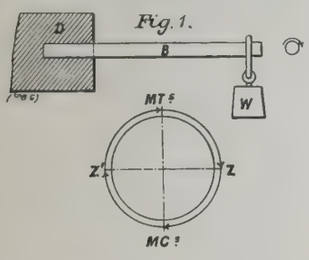


Fig. 1.

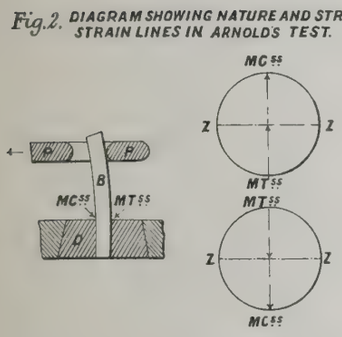


Fig. 2. DIAGRAM SHOWING NATURE AND STRESS STRAIN LINES IN ARNOLDS TEST.

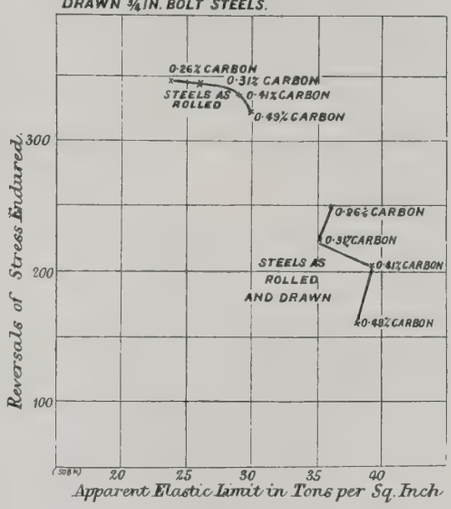


Fig. 3. ARNOLDS STANDARD ALTERNATING STRESS AND YIELD POINT CURVES ON ROLLED AND ROLLED & DRAWN ¾IN. BOLT STEELS.

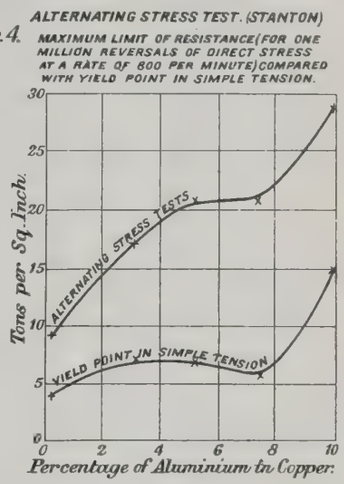


Fig. 4. ALTERNATING STRESS TEST. (STANTON) MAXIMUM LIMIT OF RESISTANCE (FOR ONE MILLION REVERSALS OF DIRECT STRESS AT A RATE OF 800 PER MINUTE) COMPARED WITH YIELD POINT IN SIMPLE TENSION.

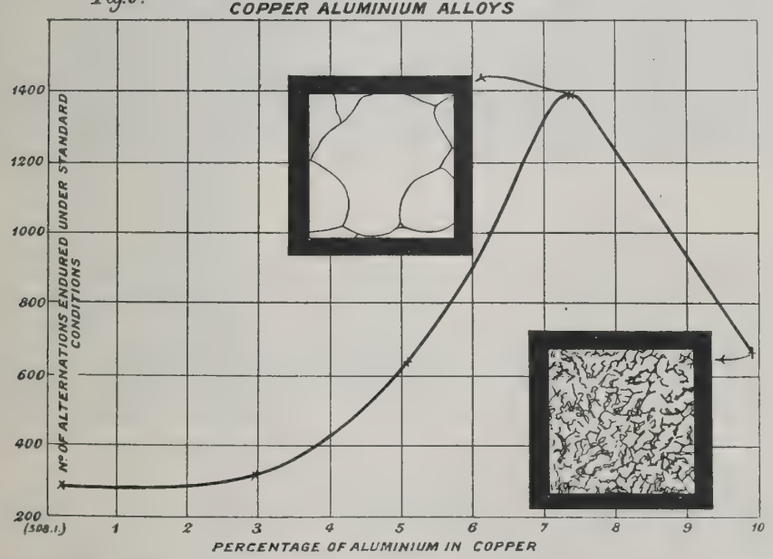


Fig. 5. ARNOLD'S ALTERNATING STRESS CURVE OF COPPER ALUMINIUM ALLOYS

Table I.—*Factors of Safety from the Component Sub-Factors.*

Type of Purpose for which Steel is to be Used.	Nature of Sub-Factors Involved. *a* (Elasticity).	*b* (Wöhler Phenomenon).	*c* (Rapidity of Load.)	*d* (Unknown Contingencies.)	$n = a \times b \times c \times d$ = Factor of Safety.
Boilers	2	1	1	2-2.5-3	4.5-6
Double-acting connecting-rod ..	1.5-2	3	2	1.5	13.5-18
Single-acting connecting-rod ..	1.5-2	2	2	1.5	9-12
Shaft-carrying propeller	1.5-2	3	1	1.5	6.75-9
Steel-cast wheel rim	2	1	1	4	8
Steel castings ..	2	1	1	2	4
Oil-tempered steel	1.5	1	1	1.5	2.25
Nickel steel ..	1.5	1	1	1.5	2.25

Table II.

No.	Alternations Endured under Standard Tests.	Ratio of Reversals below the Specification. Per Cent.
1	76	75
2	46	85
3	46	85
4	50	83

Table III.

Mark.	C. per Cent.	Yield-Point. Tons per Sq. In.	Maximum Stress. Tons per Sq. In.	Elongation Per Cent. on 2 In.	Reduction of Area. Per Cent.
Hot-Rolled Set.					
A	0.26	24.1	35.3	34.5	61.6
B	0.31	25.7	37.6	31.8	59.6
C	0.41	28.9	42.7	26.5	48.0
D	0.49	29.9	46.9	25.5	50.8
Rolled and Drawn Set.					
A	0.26	36.7	38.9	19.0	50.8
B	0.31	35.1	41.9	17.5	47.2
C	0.41	38.9	46.6	16.0	40.4
D	0.49	38.0	52.4	15.0	42.0

5500-HORSE-POWER TWO-CYLINDER CORLISS WINDING-ENGINE.

CONSTRUCTED BY THE SANDYCROFT FOUNDRY COMPANY, LIMITED, ENGINEERS, SANDYCROFT, CHESHIRE.

(*For Description, see Page* 560.)

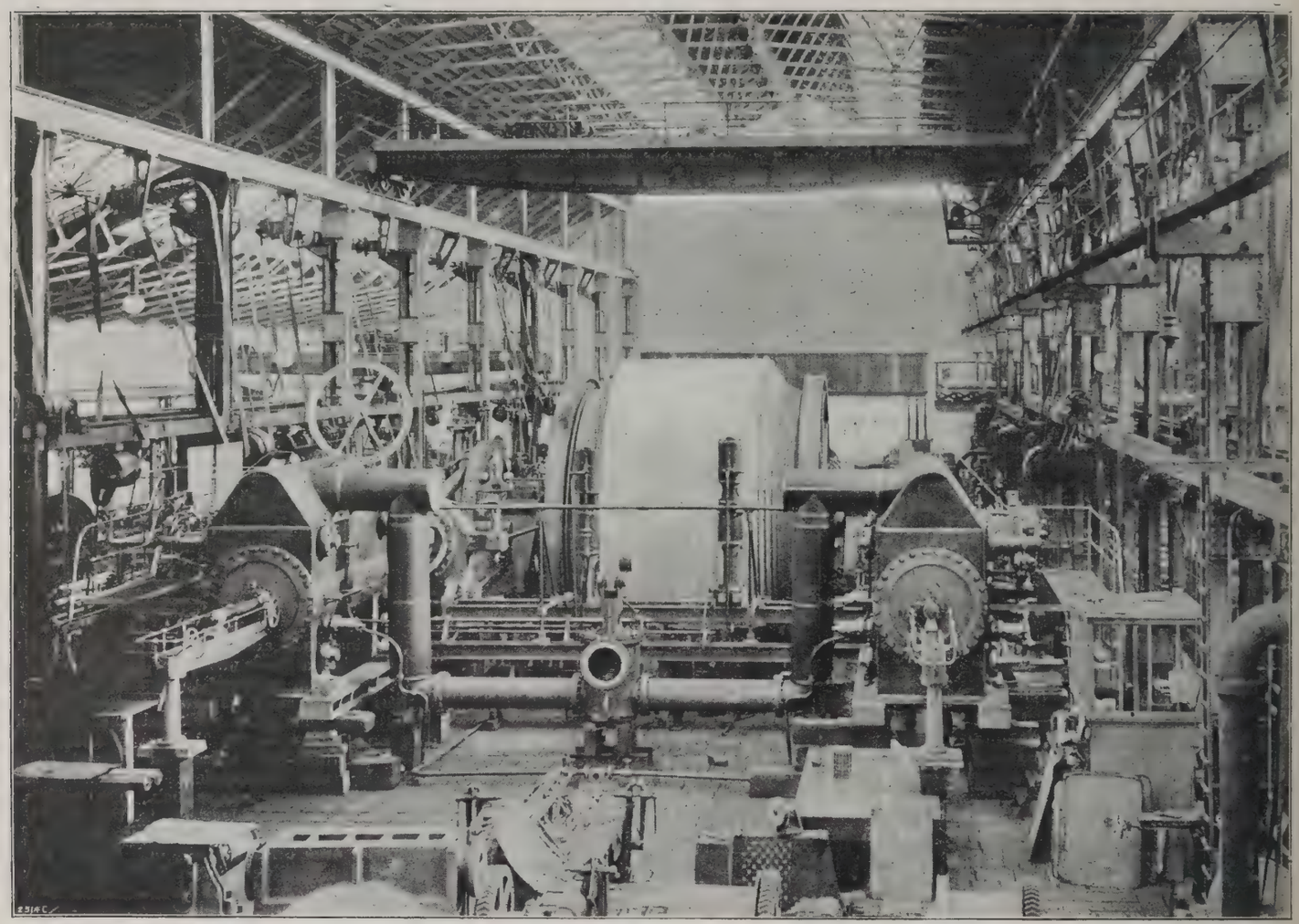


Fig. 1.

plotting of the results. The specification line was 300 alternations, and it would be seen that the results for the hot-rolled bars showed some relationship with the rising carbon, and gave a very fair curve. But cold-drawn bars, which, with the higher elastic limit, should have given very much better results, were hopelessly below the specification line, and were extremely erratic. It was known from prac-

Table IV.

Mark.	C. Per Cent.	Yield-Point. Tons per Sq. In.	Alternations Endured.	Conditions of Steel.
A	0.26	24.1	346	Hot-rolled.
A	0.26	36.7	248	Rolled and drawn.
B	0.31	25.7	344	Hot-rolled.
B	0.31	35.7	222	Rolled and drawn.
C	0.41	28.9	336	Hot-rolled.
C	0.41	38.9	206	Rolled and drawn.
D	0·49	29.9	320	Hot-rolled.
D	0.49	38.0	156	Rolled and drawn.

tical experience that they were breaking very badly, and he believed that the practice had, to all intents and purposes, been since abandoned by engineers.

Professor Arnold, continuing, said he considered that the measurement effected by the Wöhler test was a more or less faithful reflection of the elastic limit—he would not say the absolute, but what was ordinarily known as the elastic limit. At the National Physical Laboratory, in connection with the Alloys Research Committee of the Institution of Mechanical Engineers, Dr. Carpenter and Mr. Edwards had made a series of aluminium bronzes, and had discovered that as aluminium was added to the copper up to a certain amount it dissolved, but when a proportion of about 7½ per cent. of aluminium had been reached, a saturated solution was obtained. By the aid of the microscope they then found that a new constituent appeared which enveloped the crystals of the saturated solution, harder and richer in aluminium—a sort of cell-wall. By the instructions of the Alloys Research Committee, these alloys, in addition to being tested by Dr. Stanton at the National Physical Laboratory, were subjected to tests by the speaker at Sheffield University. Dr. Stanton's results were given in Fig. 4, and he had shown in a very beautiful manner that as the aluminium rose the alternating stress test offered a faithful reflection of the yield-point in simple tension. The speaker's results—obtained in complete ignorance of Dr. Stanton's results—since he knew nothing about the alloys as they came from Dr. Carpenter; they were merely numbered—were shown in Fig. 5. Up to about 7.5 per cent. there was a solid solution of aluminium in copper, with plain crystals, as shown in the upper micrograph. Above 7.5 per cent. a new component came in, forming hard cell-walls round the alloy, as would be seen from the lower micrograph. A very good curve was obtained by the Sheffield test. As the solution of aluminium in copper increased, so the endurance rose until it reached a maximum at the saturation-point. It then sharply fell off, as would be expected from the micrograph. The evidence was therefore accumulating to show that what was measured by the Wöhler bending test was the yield-point.

He would advance a yet stronger argument. Dr. Stead and he had differed upon this question of the Wöhler test, and the former had suggested a practical test to settle the question, preparing for the purpose some steels at Middlesbrough, with phosphorus increasing from 0.04 up to 0.5 per cent, which, of course, meant thoroughly bad steels. There was no question as to the increasing inferiority of steel as the phosphorus rose; but when Dr. Stead had tested the steels by the Wöhler cantilever bending tests, the results showed that the mild steel with 0.5 per cent. phosphorus was ten times as capable of enduring alternating stress as steel with 0.04 per cent. phosphorus! Dr. Stead had numbered the steels and had forwarded them to the speaker, giving him, however, no information about them. On testing in his own machine, Professor Arnold obtained curves which were in exactly the opposite direction, and showed that a steel with 0.5 per cent. of phosphorus had one-third of the resistance to alternating stress which a steel with 0.04 per cent. phosphorus possessed. Again the results came out as, from long experience, they were known to come out in actual practice. He would therefore ask the authors and members to think the matter over from a new point of view; further, he would ask the authors to glance at the facts which he had laid before the Institution of Naval Architects in 1908, upon which he had largely drawn in the foregoing remarks.

Dr. H. S. Hele-Shaw, who spoke next, referred to a diagram exhibited which showed records for muscular fatigue in cycling, running, and rowing, &c. Dr. Hele-Shaw drew an analogy between the endurance of the human frame and the fatigue of materials. The curves exhibited were of the same form as those in the author's paper. There was reason to believe that the curves shown corre-

5500-H.-P. TWO-CYLINDER CORLISS WINDING-ENGINE; GOTT'S CONTROLLING GEAR.

CONSTRUCTED BY THE SANDYCROFT FOUNDRY COMPANY, LIMITED, ENGINEERS, SANDYCROFT, CHESHIRE.

(*For Description, see Page* 560.)

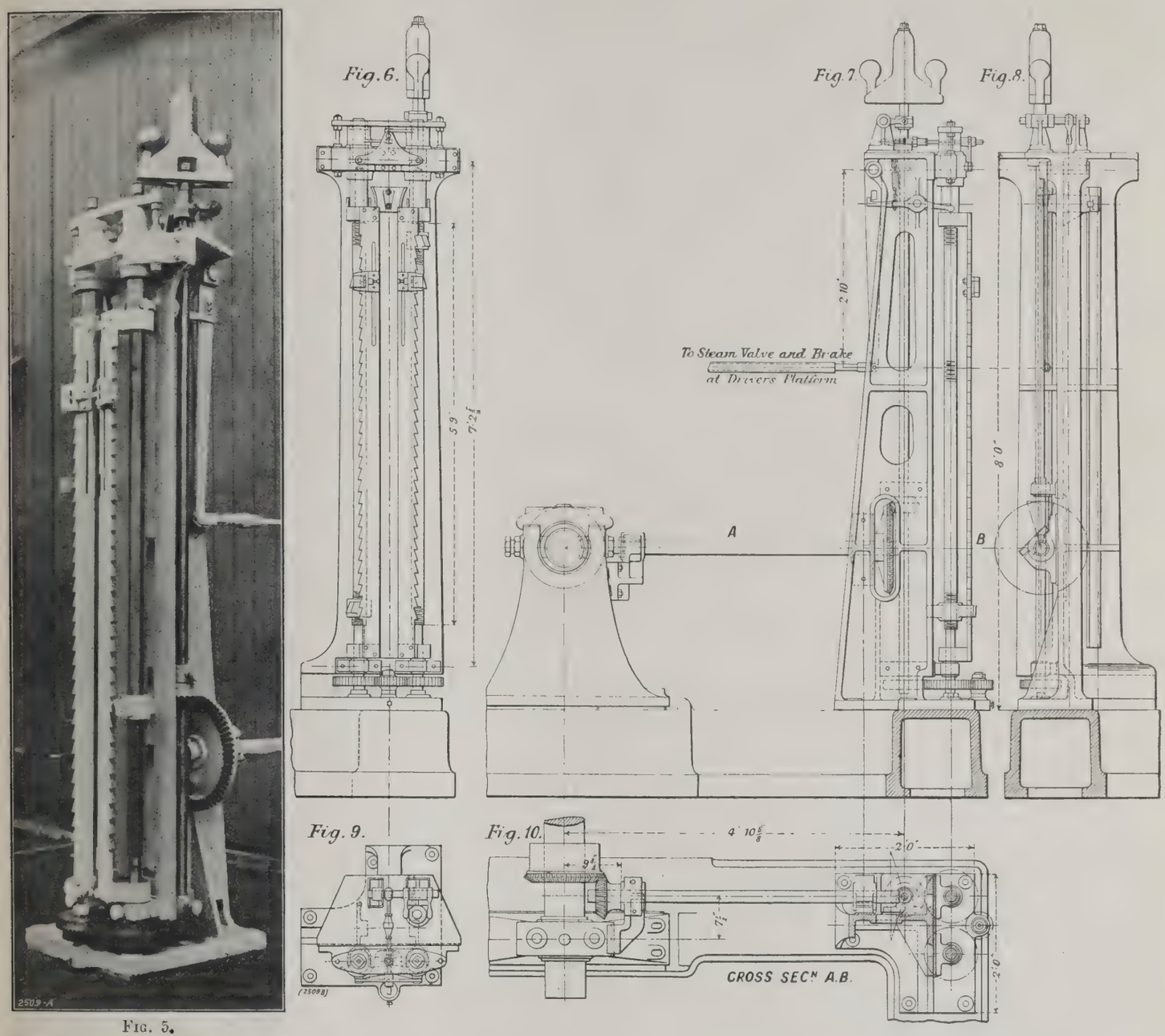


FIG. 5.

sponded in a certain way to endurance tests of metals. To-day we were in possession of an explanation of the phenomenon of fatigue. In the lectures delivered last spring by Dr. Rosenhain before the Institution this explanation was given. It was based on the teachings of micro-photography. It was found that a certain number of crystals were in unfavourable positions, and yielded on certain stress being reached. He did not at all take exception to the authors' view about time. If the crystals were allowed to remain in that position, they might possibly fix themselves there; but if the stress were reversed, it found those particular particles in a weakened position, and a greater stress would be placed on the surrounding particles. A fracture would take place along the crystal surfaces. This was the ultimate cause of the apparent crystallisation of a fractured specimen. Only a little while ago it was thought that a metal which was subjected to alternating stresses crystallised. That was, however, directly contradicted by the micro-structure theory. The crystals were there before, and were there afterwards. The line of fracture was along the facets of the crystals. This line was gradually produced by the alternation of stresses, and led to the breakdown of the specimen. One thing was evident from the remarks of Dr. Unwin, Mr. Stromeyer, and Professor Arnold, and that was, that there was still a long way to go before the nature of the fatigue of metals was really understood.

As time did not permit of continuing the meeting, the President announced that the discussion would be adjourned until the next meeting, but as Mr. E. L. Cunningham would probably be unable to attend the further discussion, he would call upon him now to make any observations he might wish.

Mr. Cunningham said that there appeared to be a direct contradiction between the supporters of the Bauschinger theory and the Arnold tests. He had not been able to read the Naval Architects' Transactions, so as to see Professor Arnold's tests described in full, but he would imagine that the question of whether these tests showed the true value of the material in practice would greatly depend upon the actual use to which the material was to be subjected. The tests made on the authors' machine were made under conditions which were absolutely identical with the application of material in a great many practical cases, although not, of course, with the uses of foundation bolts or anything of that sort. He would imagine, in using the Arnold test, great regard would have to be paid to the purpose for which the material was to be applied. He might be under a misapprehension, but he supposed from Professor Arnold's description of his machine that it would be unable to fracture a specimen of india-rubber. He had not had access to Professor Bauschinger's original researches, but had had to trust to second-hand information, some of which, however, was very good. The total result of Bauschinger's theory appeared to be this, that, for a given material, no heat treatment or cold drawn treatment would increase its resistance to alternating stress permanently; that was to say, it would not increase the stresses under which the specimen would withstand an indefinite number of revolutions, but it would increase the number of revolutions that it took with a very heavy stress to break the material. If curves were drawn for such cases, he imagined

that, compared with the curve for an annealed specimen, that for hard-drawn material, which was at first made stronger, but of only the same strength after a number of repetitions, the curve at first would be a good deal further out on the diagram, dropping afterwards and approaching the other curve as the horizontal was neared. From an inspection of their own curves, it appeared probable that the curves for the same material would ultimately become parallel instead of meeting. The logarithmic curve was of very slight value.

At this point the President adjourned the discussion until the next ordinary meeting of the Institution to be held on Friday, November 17, when, if time permitted, a paper by Mr. Hartley Wicksteed, Past-President, on "Double-Cutting and High-Speed Planing Machines," would also be read. The meeting then terminated.

5500-HORSE-POWER CORLISS WINDING ENGINE.

A very fine example of a large Corliss winding-engine is illustrated on the two preceding pages, and on our two-page plate this week. The engine, which is intended for installation in Southern India, is one of two being built by the Sandycroft Foundry Company, Limited, of Sandycroft, near Chester. The main lines and details of the engine will be easily followed from Fig. 1, on page 558, and Figs. 2 to 4, on Plate LIII. It has two cylinders, each 42 in. in diameter by 84 in. stroke, and works with superheated steam at 120 lb. pressure. It is intended to wind from a depth of 3700 ft., at the rate of 3000 ft. a minute, the unbalanced load being 15.5 tons. The drum is of the cylindro-conical type, and has a maximum diameter of 20 ft. The engine is fitted with steam reversing gear and steam-operated brakes, and a Gott's controlling gear to prevent over-speed, over-winding, and starting in the wrong direction. The total weight of the engine is 250 tons.

Referring to the engine in detail, it will be seen that it has two cylinder units, similar to each other, working one at each end of the crank-shaft, the drum being in the middle. Each cylinder is made in three pieces, the body being cast separate from the ends which carry the valves, while each cylinder has a working liner and is steam-jacketed. The pistons have adjustable metallic packing, while the rods, which are 8 in. in diameter, are fitted with United States metallic packing. The cross-heads are of steel with cast-iron slippers, and work in guides of circular form and 41 in. in diameter. The detail of the method used to secure the piston-rods to the cross-heads is of interest. It can best be seen in Fig. 3. The ends of the rods are screwed and pass through steel-plates, which are secured to the cross-heads by four bolts. The rods are attached to the plates by means of nuts on either side of them. It is obvious that the arrangement allows easy disconnection of the cross-head from the rod, and adjustment of the distance between them. The valves are of the Corliss type, and are placed on the outer sides of the cylinders. They are fitted with spherical metallic packing and have spiral springs to balance the end pressure. The valve-gear is operated by eccentrics fixed to special shafts co-axial with the crank-shaft, but carried by independent outer bearings. These shafts are driven by drag-links from the crank-pins. The arrangement will be followed from Figs. 2 and 4. The connecting-rods have screw and wedge adjustments at both ends.

The main shaft is 25 in. in diameter at the drum and 21 in. in diameter in its bearings. It is 27 ft. over all in length, The bearings are cast with the bed, and are lined with white metal. They are 33 in. long each. The crank discs are 9 ft. 2 in. in diameter, and are each made in two pieces, the centre hubs being separate from the discs proper. The hubs are cast with a flange at one end, and the discs are bored to fit the hubs, and are bolted to the flanges. The arrangement has the advantage that the discs can easily be removed, so that the weight of the shaft may be reduced for transport. The drum is made of cast iron, and is built up in sections. The centre plane part is 8 ft. 9 in. wide and 20 ft. in diameter, while the coned parts are grooved for rope $1\frac{3}{4}$ in. in diameter. Two small internal drums are fitted inside the main drum for carrying spare rope, which can be payed out as required. The engine is fitted with two sets of brakes, one set, consisting of wood-lined straps working on the edges of the crank-discs, being operated by a foot-lever or hand-wheel and screw from the driver's platform. These brakes are connected up through a lay-shaft running across the back of the drum. The arrangement of the brakes, connecting-links, and shaft can be seen in Figs. 2 and 3. The second set of brakes are of the suspended curved-post type, and operate on the ends of the drum. They are actuated by a steam-brake engine, the brakes being put on by means of a weight, and held off by steam, although, if desired, steam can be admitted to the upper side of the brake engine piston, and extra pressure put on the brakes. The brake-posts are hung so that wear is automatically taken up. The arrangement of the brakes will be clearly seen from Figs. 2 to 4; but it will be noticed that they were not in position when the photograph from which Fig. 1 is prepared was taken.

The complete control of the engine is carried out from the driver's platform which is situated outside the left-hand cylinder in the position shown in Figs. 1 and 4. This platform accommodates the foot-lever and hand-wheel for the crank-disc brakes already mentioned, a hand-lever for operating the steam-brake, the reversing lever and the main-valve lever. These levers connect up to their various gearings through lay-shafts running at the back of the drum. Their position can best be seen in Fig. 1, while the arrangement of some of their connecting levers and links can be seen in Fig. 2. The levers controlling the main valve and steam-brake are connected up to their lay-shafts through trips, which are arranged to be operated when necessary by the Gott controlling gear, which will be described later. The main valve is $18\frac{1}{2}$ in. in diameter, and is of the single-beat type. It is balanced by a steam-piston to assist towards ease of operation. Reversing is carried out by a steam reversing gear having an oil locking and controlling cylinder. The position of this gear can be seen at the left-hand side of the drum in Fig. 1. This figure also shows the brake engine at the right-hand side of the drum. These gears can also be seen in Figs. 2, 3, and 4. The governor, which is of the spring-loaded type, is fixed on the back cross-head guide of the left-hand side cylinder. It is driven by bevel gear from the drum shaft, as shown in Fig. 4. The valve gear is arranged so that when accelerating the engine takes steam up to about seven-eights of the stroke, but when it is nearing full speed the governor begins to lift, operates the cut-off gear, and governs the speed.

The Gott controlling gear is illustrated in detail in Figs. 5 to 10, on page 559. It is fitted at the front left-hand side of the bed-plate, as shown in Figs. 2 and 4. The arrangement consists of a vertical frame carrying a vertical shaft with a spring-loaded governor fixed at the top. The shaft, and with it the governor, is driven by bevel gears from the left-hand eccentric shaft, as shown in Fig. 4. At the front of the vertical frame there are two vertical leading screws driven from the vertical shaft by means of spur-gearing fitted at the lower part of the frame. On these leading screws two nuts are carried, which, of course, travel up or down, depending on the direction in which the engine is running; and as one of the leading screws has a right-hand thread and the other a left-hand thread, one nut is always rising as the other is falling. The two leading screws have plane parts at their top and bottom ends, and on these plane parts racks are carried, as shown in the figure. Trip-levers rest on the top of these racks, and the plane parts of the leading screws are long enough to allow the racks to lift and raise these trip-levers. The trip-levers have a catch connection to a long lever, which is connected by a rod to the trip-gearing below the driver's platform. This catch arrangement can be clearly seen in Figs. 5 and 7.

The operation of the gear is brought about by the lifting of the governor, which is connected up to the vertical racks by a link-motion, which is shown in detail in Fig. 9. The lifting of the governor causes the racks to swing outward around the leading screws on which they are suspended, so that the teeth of the racks come in contact with the projecting arms on the nuts carried by the leading screws. As, owing to the two leading screws being respectively right and left-handed, there is always one nut travelling in an upward direction when the engine is running, the effect of the swinging out of the racks is that the teeth of one of them catch on the nut, so that the rack is lifted, and the catch connecting it to the valve-lever is thrown out of gear. This movement of the racks and tripping of the gear, of course, takes place whenever the engine speed becomes high enough to cause the governor to lift the necessary amount. In addition to this arrangement, however, and owing to the fact that the permissible speed of the engine when the cage is nearing the end of its travel is lower than when it is in the neighbourhood of the mid-position, there are two adjustable catches on the racks, which can be moved up or down. These catches project further out than the teeth of the racks, so that the gear is tripped with a smaller movement of the racks, or, what is the same thing, a smaller lift of the governor, at the ends of the engine travel than elsewhere. Overwind at any speed is prevented by the travelling nuts coming into contact with the top supporting arms of the racks, and again lifting them and tripping the gear. The connecting-link from the controller both shuts off steam from the engine and applies the steam-operated brakes. It does this by tripping a roller connection which holds up the valve-operating links under the driver's platform, so that the links fall by their own weight and operate the valves.

It is clear that in addition to looking after overwind and overspeed, the controller will also shut down the engine if, when standing with the cage at the top or bottom of the shaft, it is started in the wrong direction. The effect of such starting is, of course, to cause the nuts to lift the racks exactly as described above for cases of overwind. The moving nuts on a Gott controller might obviously be used as a depth-indicator by connecting one of them to a pointer travelling over a vertical scale; but in the engine we are dealing with a dial type of indicator is used. This can be seen at the left-hand side of Fig. 1 and in Figs. 2 and 4. The arrangement consists merely of a pointer travelling over a circular scale and driven by a bevel gear from an extension of the left-hand eccentric shaft.

H.M.S. "MEDINA."

H.M.S. Medina, the Peninsular and Oriental liner, chartered for the conveyance next month of their Majesties the King and Queen to India for the Durbar, is now practically ready, and has been commissioned under the flag of Rear-Admiral Sir Colin R. Keppel, with Captain A. E. M. Chatfield in command. She was open for inspection on Wednesday, when opportunity was afforded for viewing the special suites of rooms provided for their Majesties. The ship, which has been built by Messrs. Caird and Co., Limited, of Greenock, is 570 ft. long, 62 ft. 9 in. beam, 12,500 tons gross register, and about 20,000 tons displacement when loaded for service. There are seven decks, and cabin accommodation has been provided for about 450 first and 220 second-class passengers, and a crew of 160. There is thus adequate accommodation for the numerous suite of their Majesties as well as for the naval crew of 485 all told. The arrangements against untoward events are satisfactory, as there are ten watertight bulkheads extending to the spar deck, and a double bottom from stem to stern. The cuisine arrangements are exceptionably favourable, conforming to the highest standard of the P. and O. Company. As, however, we published the deck plans and fully described the earlier vessel of the "M" class (see Engineering, vol. lxxxi., pages 304, 384, and 413), it is not necessary to deal further with the general features of the accommodation and equipment. The Medina embodies the best features of the earlier ships with various improvements along the same lines.

The machinery consists of two sets of quadruple-expansion engines, having cylinders of $30\frac{1}{2}$ in., 44 in., 63 in., and 89 in. in diameter, and a stroke of 54 in. Steam is supplied by four double-ended and four single-ended boilers with a working pressure of 215 lb. on the square inch; the air is supplied to the thirty-six furnaces on the Howden forced-draught system. The condensers are of the Weir type, with a cooling surface of 7800 sq. ft. in each. The propellers are three-bladed, 18 ft. in diameter, the pitch being between 22 ft. and 25 ft., with 80 sq. ft. of surface to each propeller. There are two of Weir's "Dual" air-pumps, the other usual auxiliaries including refrigerating and electric generating machinery.

The Medina last week made a prolonged cruise in order to accustom the crew to their new surroundings, and to test thoroughly the machinery at all powers. The engineers of the Peninsular and Oriental Company remain in charge of the machinery; but the firemen, &c., consist of Navy stokers, with the full complement of chief and petty officers, controlled by an engineer-lieutenant, R.N. The indicated horse-power is 12,000, and this had to be maintained during a six hours' trial. During the recent progressive runs on the measured mile at about 12, 14, 16, and 18 knots, there was an entire absence of vibration, and the machinery worked up to full expectations. On these progressive speed trials it was found that with 51 revolutions the mean speed was 10.45 knots; with 68 revolutions, 13.97 knots; with 75.6 revolutions, 15.29 knots; and with 85.4 revolutions, 16.87 knots; while at full power the speed was $18\frac{1}{2}$ knots. As the vessel will steam at 16 knots or $16\frac{1}{2}$ knots, it will be possible by increasing speed to ensure the correct times of arrival on the programme irrespective of the weather. The trials were attended on behalf of the Admiralty by Engineer-Captain W. Onyon, R.N., the engineer officer on the staff of Rear-Admiral Sir Colin Keppel.

Mr. Stefan von Fodor.—Mr. Stefan von Fodor, better known perhaps under the French form of his name which appeared on the title pages of his books which were written in French, Etienne de Fodor, was entertained at a banquet last week, held at Budapest, to celebrate the thirtieth anniversary of his connection with electrotechnics. Fodor attended the Paris Exhibition of 1881 as confidant and representative of Edison to introduce the incandescent lamp, and he has since been active in promoting the interests of electric lighting and of applied electricity in general by his practical work and by his pen. He was born at Pressburg, the ancient capital of Hungary, in 1856, and is now general manager of the Budapest Electricity Works. In the early days of electric illumination he offered to light the Rákóczi-street of Budapest for two years at his own risk.

5500-HORSE-POWER TWO-CYLINDER CORLISS WINDING-ENGINE.

CONSTRUCTED BY THE SANDYCROFT FOUNDRY COMPANY, LIMITED, ENGINEERS, SANDYCROFT, CHESHIRE.

(*For Description, see Page* 560.)

Fig. 2. OUTSIDE ELEVATION OF LEFT HAND ENGINE

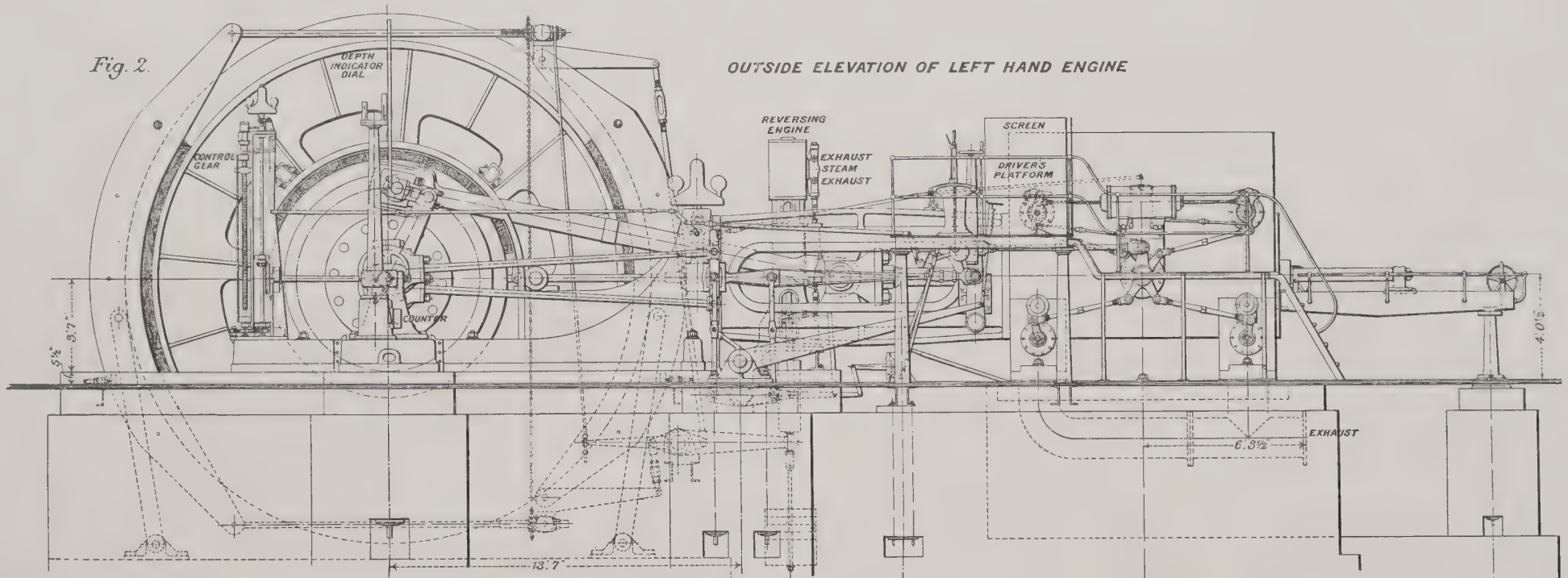


Fig. 3. INSIDE ELEVATION OF RIGHT HAND ENGINE

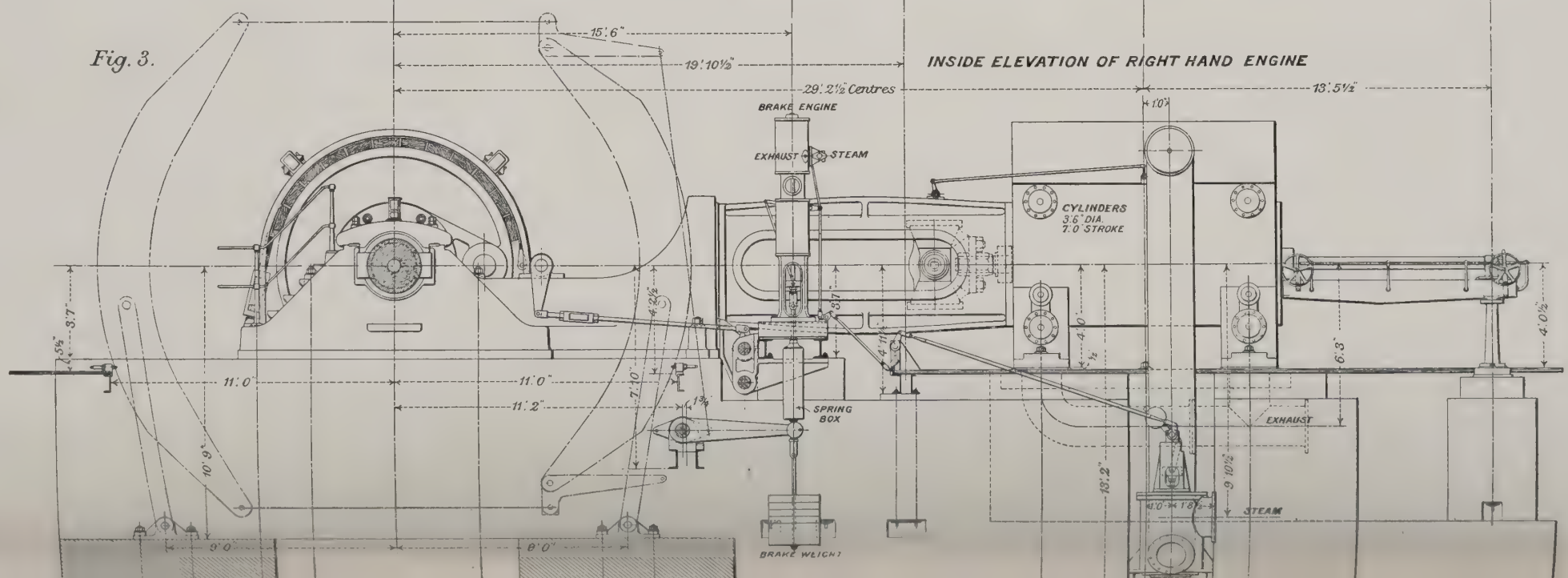
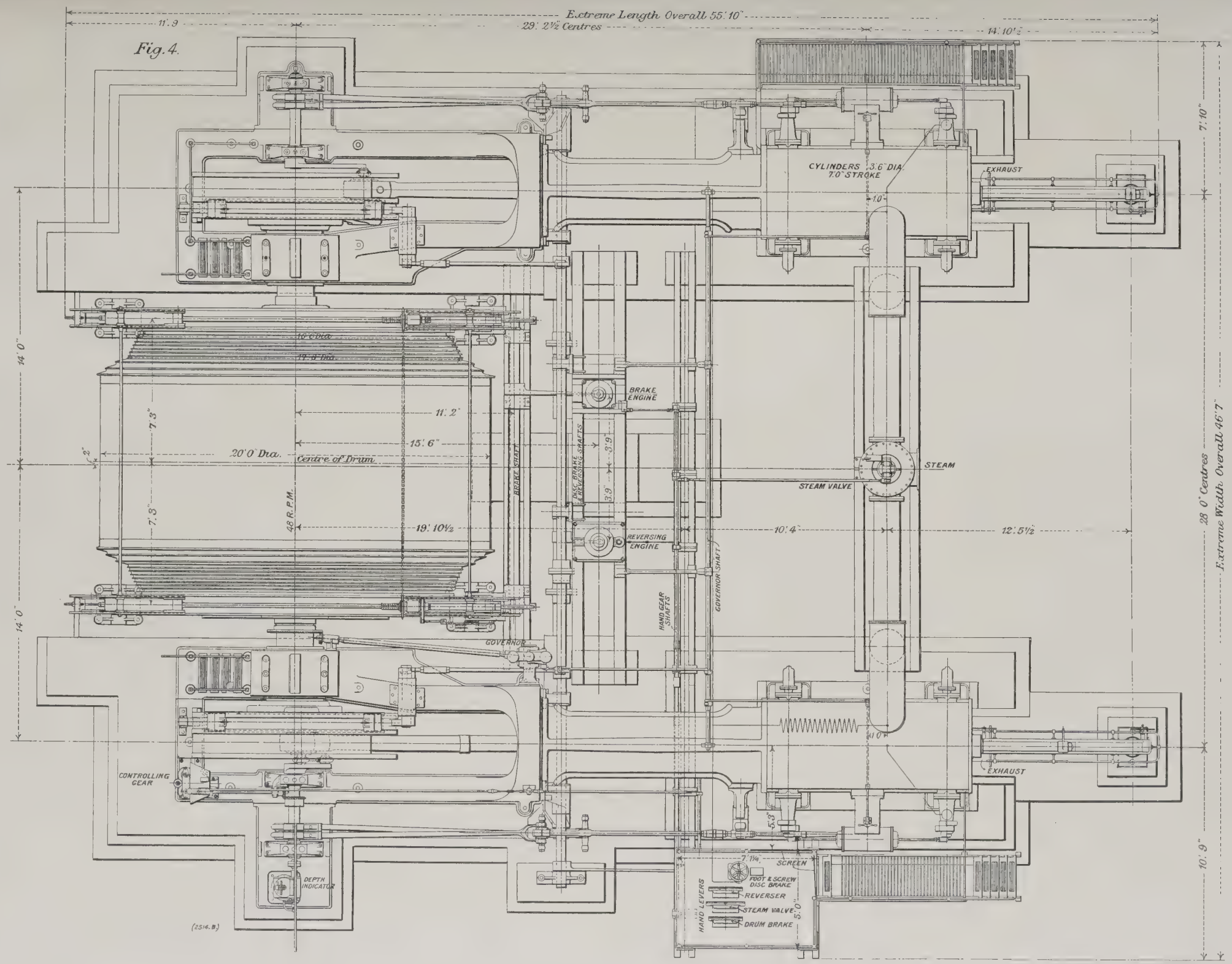


Fig. 4.


Extreme Length Overall 55'10"
11'9
29'2½ Centres
14'10½
7'10"
CYLINDERS 13.6" DIA.
7.0" STROKE
EXHAUST
10"
16 Dia.
19'8 Dia.
14'0"
11'2"
15'6"
20'0 Dia.
Centre of Drum
2"
7'3"
7'3"
48 R.P.M.
19'10½
BRAKE ENGINE
BRAKE SHAFT
DISC BRAKE & REVERSING SHAFTS
3'9"
3'9"
REVERSING ENGINE
HAND GEAR SHAFTS
GOVERNOR SHAFT
STEAM
STEAM VALVE
10'4"
12'5½
GOVERNOR
CONTROLLING GEAR
DEPTH INDICATOR
(2514. B.)
5'3"
7'1½"
SCREEN
FOOT & SCREW DISC BRAKE
REVERSER
STEAM VALVE
DRUM BRAKE
HAND LEVERS
5'0"
10'9"
28'0" Centres
Extreme Width Overall 46'7"

INDUSTRIAL NOTES.

In a remarkably short time after the appointment of the Royal Commission to investigate the working of the Railway Conciliation and Arbitration scheme of 1907, its report has been issued, for it appeared last Friday night—only about two months after the appointment of the Commission. Perhaps its most remarkable feature is its unanimity, all the members who constituted the Commission having signed the report. This will no doubt prove its great strength. It does not appear, however, to meet with the approval of the unions. As we refer to the matter more fully in another part of the paper, we need not say anything further about it here.

A strike at the Birmingham Small-Arms Factory commenced on Saturday last in order to emphasise the demand of the men for an increase of 1s. per week in wages. The demand appears to be connected with a general movement for a rise in wages, which other engineering establishments have received. A willingness has been expressed by the directors to give the nominal increase, but this concession is coupled with the proviso that the working hours, which some time ago were reduced experimentally, shall be increased from fifty to fifty-two hours per week. The men, however, have refused to agree to this, preferring to go on strike. The trouble developed on Monday, to the extent that 3000 men and women were idle. It was intended by the men to hold a meeting outside the works, but this was prevented by the police, much to the annoyance of the strikers. The men who have gone out belong to all the affiliated trades and to ten societies, including the Engineers, Steam-Engine-Workers, Toolmakers, Tinplate Workers, Carpenters and Joiners, United Machine Workers, Smiths and Strikers, Hammermen, Coachmen, and Pattern Makers. Should the men agree to accept the 1s. per week rise with the extra two hours a week in time added, it would still leave their working week an hour shorter than that of engineers employed at other works in Birmingham.

The Coalowners' Association have received a communication from the South Wales Miners' Federation Executive in which proposals are made for a minimum wage in abnormal places. It may be remembered that the original proposal fixed the rate at 8s. a day, but this would prevent the men from receiving benefit from the percentage advances beyond 50 per cent. above the standard. According to the last communication, however, the redrafted proposals are for a base wage of 5s. 4d. for miners, 4s. 8d. and 4s. for workmen, and 3s. 4d. for labourers, with an addition of at least 50 per cent. The minimum wage for miners would, under this arrangement, be 8s. per day, and for labourers 5s. per day. They would, however, get the advantage of any rise in the percentage beyond 50 per cent. on the standards.

An agreement has been come to between the Shipwrights' and Engineers' Employers of London and the Ship-Constructive and Shipwrights' Association and the Shipwrights' Provident Union of London that the recognised trade-union rate of pay for shipwrights in the London district shall be raised to 49s. 6d. per week, from 45s. per week, and that 48 hours per week shall be the standard working week.

On Saturday last a meeting was held in Newcastle between the members of the Northumberland Coal-Owners' Association and representatives of the Northumberland Miners' Association to discuss certain proposals which the workmen wished to put forward, and which were as follow:—(*a*) A minimum of 30 per cent. on the 1879 basis wages. (*b*) An individual minimum wage for all classes of men and boys working in the mines. (*c*) The abolition of the three-shift system at all mines. (*d*) The restoration of the short shifts for stonemasons and shifters as prevailing prior to the Eight Hours Agreement. The arguments put forward by the men in support of their proposals would, the masters said, be duly considered, and a reply would be given at an early date.

On Monday last the men who have for three weeks been on strike at the Morfa, Middle Bank, and Hafod Copper Works, returned to work, their grievances having been satisfactorily settled.

Messrs. Harland and Wolff, of Belfast, have decided to advance the wages of their ship-joiners engaged on refrigerating work on meat and fruit-carrying vessels built by them. Hitherto this class of work has been sublet to Liverpool and London firms, but now Messrs. Harland and Wolff are going to do it themselves. The amount of the advance will be from 1s. 6d. to 2s. per week, according to the nature of the insulation packing. This decision will affect between two and three hundred men.

The Union of Technical Officials in the important Dortmund district recently celebrated the twenty-fifth anniversary of its foundation. This quarter of a century is one of remarkable development within the Rhenish-Westphalian coal-mining industry, both technically and financially, this being reflected in the growth and the work of the union. During the two decades 1890-1910 the number of technical officials showed an increase of 6320, or 149 per cent.; that of the hands, an increase of 210,635, or 170 per cent. The output of coal increased 51,395,000 tons, or 145 per cent. Of 21,309 technical mining officials who, according to the statistics, are engaged in the Prussian mining industry, 16,826, or 79 per cent., are connected with the coal-mining industry, and of this latter total, 10,136 belong to the Dortmund district. In the same way that large mining concerns have sprung into existence so has the number of technical officials increased. In the year 1890 the average number of these officials was 25 per mine, whilst in 1910 it had risen to 69 per mine, and no saving appears to have been effected due to this, in spite of the technical concentration of the working. If any reduction took place above ground, it was outweighed by increased expense in the mines themselves, owing to the greater depth, &c. Whilst amalgamation thus has brought no decrease in the number of technical mining officials, it has wrought a distinct reduction in the number of the heads or managing persons.

The technical mining officials have had to grapple with difficult work in diverse directions, not only as regards the mining industry proper, its developments, and their application to altered conditions, but also in the matter of advance in machine construction. Under each of the technical mining officials there are on the average sixty-nine hands. Mining schools are now found in Bochum and Essen, and the number of scholars who passed the schools was 428 during last year. In addition there are twenty-five preparatory mining schools, either to be used as stepping-stones to the former, or for such miners as want to extend their knowledge, and it is claimed for the mining industry in Germany that it offers its employees in the different grades more facilities for bettering themselves than any other industry. The development within the Nether-Rhenish and Westphalian coal-mining industry has, naturally, also benefited the mining officials, and during the last 20 years their pay has increased 54 per cent. The separate unions of technical mining officials formed, in December, 1888, a union of the societies of technical mining officials in the Dortmund district, which now comprises sixteen societies, with an aggregate of 5500 members. The union has worked on the principle of operating hand-in-hand with, rather than against, the respective managing concerns. The union has within the last year or two had the satisfaction of seeing its assiduous work for the establishment of a pension fund for widows, &c., crowned with success.

Over twenty years ago, what are known as demarcation disputes were dealt with on the Tyne through the medium of a Federal Board, which subsequently passed out of existence Such disputes arose out of the difficulty of deciding as to how much one trade was to be allowed to encroach on the preserves of another. It is now proposed to revive the board. With this object a meeting was held at Carlisle on Friday last between the Shipbuilding and Engineering Employers' Federation and representatives of the shipbuilding and engineering trade unions. There are local arrangements for the adjustment of these questions, and they appear, so far as the shipwrights, carpenters, and joiners on the North-East Coast are concerned, to have worked well. The men now require more comprehensive and effective machinery to meet modern conditions and to facilitate settlements. In March last the matter was gone into very thoroughly by masters and men, but no agreement was come to. It appears also that at the meeting held last Friday no agreement was arrived at.

According to the recently-published report of the International Secretariat in Berlin, the aggregate number of trade-union members in the twenty attached national organisations amounts to 9,573,493, showing an increase of about 400,000 members as compared with the preceding year, which increase comes upon France, Holland, and Italy. Of this aggregate, however, only 6,008,262 belonged to the national organisations of the respective countries, the rest being outside these organisations. Thus, in England only 703,091 were attached. The Anarchists and the Roman Catholics in Holland, as well as the Christian and the Hirsch-Duneker trade unions in Germany are outside. Germany, according to the report, now heads the list as regards organised hands, having passed England, Germany's aggregate being 2,447,578 members. The trade unions in the fifteen countries from which reports had been received had the control of an aggregate revenue of 132,000,000 marks (6,600,000*l.*), and their funds in hand at the end of the year amounted to 182,000,000 marks (9,100,000*l.*). More than 22,000,000 marks (1,100,000*l.*) had been paid as aid to unemployed, 1,500,000 marks (75,000*l.*) had been given as aid for travelling, 20,000,000 marks (1,000,000*l.*) to sick persons, and 7,000,000 marks (350,000*l.*) to invalids. An aggregate of 26,000,000 marks (1,300,000*l.*) went in connection with labour conflicts, &c.

A memorial signed by Lord Courtney of Penwith, Mr. Burt, M.P., Mr. Fenwick, M.P., Sir W. H. Lever, and others has been issued by the Labour Co-Partnership Association, 6, Bloomsbury-square, W.C., and draws attention to the value of co-partnership in reconciling the interests of capital and labour. The present widespread unrest has lent an additional desire to the supporters of the memorial, who maintain that co-partnership is more than a theory, and has been proved by long years of practical experience to be a powerful means of promoting unity between capital and labour. It is claimed that the bulk of the large industries of the country might come under its equitable operations. Many of the large gas companies are now working under the system with perfect success, and more than half the capital of the gas companies in England is under the system.

The forty-ninth quarterly report of the General Federation of Trade Unions has recently appeared, and calls attention to the fact that the quarter which ended in September last was remarkable for the number of disputes registered. The same thing must have struck most people. There appeared to be a succession of disputes during the whole three months, for the strike disease was apparently exceedingly catching. The actual number of the disputes involving claims on the Federation was 211, but these, it must be remembered, were only among unions in the Federation. These disputes affected 17,276 persons, making an average of 81.87 persons per dispute, which is much higher than usual, and the total benefits paid during the quarter amounted to 6845*l.* 17s. 4d., as against 6780*l.* 12s. for the previous three months. The excess of contributions over the benefits during the last quarter was 1755*l.* 14s. 3d.

The report calls attention to the increasing cost of living, which, it states, continues in spite of the assertion that science and invention have reduced the cost of production, and, presumably, the cost of living. The cause of this is, it is maintained, to be found in the fact that science and invention have not been allowed to operate freely and naturally in the interests of the people at large, and it is claimed to be the business of trade unions to see that normal wages, at least, rise with the cost of living, and it is the business of governments to see that the cost of living is kept as low as possible. How governments are to do this is not shown.

The report contains an interesting article by Frank H. Ross, on "Who it is that Really Pays the Cost of any Increase of Wages to the Workers." It is against strikes, its object being to show that strikes really benefit the capitalist more than they do the worker, The author says: "It seems to me that the defenders of the strike—I do not refer to the industrial unionist strike which is suggested as the final implement of social reconstruction—must be prepared to prove that the consumer does not pay, or to admit that his methods are fallacious. With the recrudescence of the strike spirit we have new conceptions of collective bargaining and strangely unaccustomed ideas as to the observance of bargains collectively struck. It is not because a man thinks that honourable agreements should be honourably kept that he must necessarily feel friendly towards the capitalist. It is only that he realises that as long as the workers conscientiously accept the wage system it is suicidal to repudiate agreements no matter how unsatisfactory they may be to him. All his agreements are based upon the fact that the consumer pays, and all the strike can do is to effect agreements or understandings which practically and uniformly charge him with the cost both of his effort and the ostensible benefits of such changes as are effected. It is then clear that the increase of wages and the betterment of conditions (which are only variants of wages or charges upon capitalistic production) must always be paid for by the worker, and can never be paid for by the capitalist. And if it be true that 'the consumer pays,' will some defender of the strike tell us the precise benefit to be derived from the acquisition of a shilling in the pay-bag on Friday and its abstraction from the housewife's purse in the market on Saturday?"

H.M.S. "Archer."—H.M.S. Archer, the first of five destroyers of special type under construction for the British Admiralty at the works of Messrs. Yarrow and Co., of Glasgow, was launched on Saturday, the 21st inst. The vessel is 240 ft. long by 25 ft. 7 in. beam, propelled by twin-screws driven by turbines of the Brown-Curtis type constructed by Messrs. Yarrow. Steam is supplied by three Yarrow water-tube boilers fired by oil fuel, and fitted with a special form of superheater designed by the firm.

THE "TENSIO" RAILWAY SCREW-COUPLING.

On several recent occasions we have dealt with matters connected with the problems affecting railway couplings, arising out of changes introduced in traffic conditions. It was shown that, especially in the case of couplings for 5-ft. 6-in. gauge stock, the question has assumed a considerable degree of importance, since the convenient limit of weight for the screw and shackle coupling has been about reached.

The effort required to engage a screw-coupling with the draw-bar hook is proportional to the weight, if the clearance available between the end of the shackle and the point of the hook is constant. The ease of manipulation may, however, be considerably increased, especially when vehicles are standing on curves, with greater length of travel for the nuts on the centre screw. The increase in the length of coupling thus obtained, reduces the amount of straightening out necessary in order that the shackle may clear the hook; it is obviously easier to couple, when the linked members hang in catenary form of considerable sag, than when they must be stretched straight out. An increase in the length of the screw is advantageous, but, owing to the risk of contact between its extremities and the hook when tightly-coupled vehicles are buffered up, is not possible of attainment. A spur is commonly provided towards the back of the throat of the hook, and the end of the shackle coming in contact with this causes the screwed portion of the coupling to drop, when the distance between the hooks is suddenly diminished.

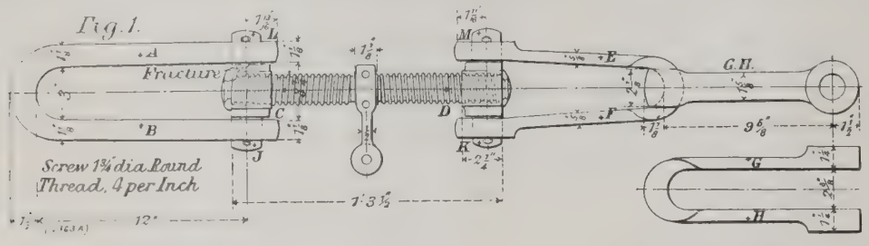
In the type of coupling used on the Indian railways, of which illustrations were given in Engineering, vol. xci., page 754, a double shackle is employed to give the necessary flexibility. This arrangement unavoidably diminishes by about 3 in. the space available for the travel of the trunnion nuts of the screw, which, without it, could be increased to this extent, or, in the alternative, this distance might be deducted from the excessive length of buffer projection. In the Indian standard coupling the combined length of the trunnion nuts is 6½ in. The ball-lever attachment occupies a length of 3 in., so that with a screw 17⅞ in. long between end washers, a maximum travel of only 8⅜ in. is secured. In order to effect improvement in this and other respects, the couplings illustrated in Figs. 1 and 2 herewith have been introduced by Messrs. McKerrow and Co., Limited, 38, Victoria-street, Westminster, S.W., and couplings of this type are now being supplied, we understand, to Indian and other systems.

Fig. 1 shows a coupling which conforms in all essentials to the Indian standard pattern with, however, numerous differences in detail. For instance, in the ordinary Indian screw and shackle coupling the trunnion nuts are barrel-shaped, the support to the thread being reduced at either end to a fine edge. In the coupling shown in Figs. 1 and 2 the trunnion-nuts are rectangular, giving equal support to the thread throughout its length. The pins are placed eccentrically to the body of the nut, instead of centrally, as in the older type. This change allows the eyes of the shackles to be of sufficient depth, without interfering with, and curtailing, the travel of the nuts as they approach the ball lever. The depth of each nut is 2¼ in., and when screwed home they are no more than 1½ in. apart. The travel on a 17⅞ in. screw would thus be 12¼ in. with this arrangement, or 47 per cent. more than with the standard coupling. It is found, however, that an increase of 1½ in. over the standard travel suffices to facilitate manipulation, and the screw is therefore reduced to 15½ in. between washers, giving a travel of 9⅞ in.

Another feature of the coupling shown in Fig. 1 is the design of the contact surfaces of the shackles. It will be seen that at the end of the loops the metal is shaped so that they are in mutual contact over a large area, instead of merely at one point, as in the ordinary coupling with shackles made of round bar. This change, of course, materially reduces the wear at the shackle ends, and also supports the shackles against the tendency to draw in under load.

Instead of the double-shackle type, however, the coupling represented in Fig. 2 is recommended. Here a pair of links are provided attached to the draw-hook by a barrel-shaped trunnion-pin, which thus provides a ball-joint, giving a range of lateral movement quite sufficient for working on curves. The eyes of the links are shaped to allow of this necessary play. The arrangement as illustrated in Fig. 2 is suitable for vehicles having buffers projecting 25 in. beyond the headstock. By reducing the length of the links it may be made suitable for a projection of 21 in. or less. The high ratio of travel to screw length is valuable, in enabling new stock of shorter buffer length to be gradually introduced.

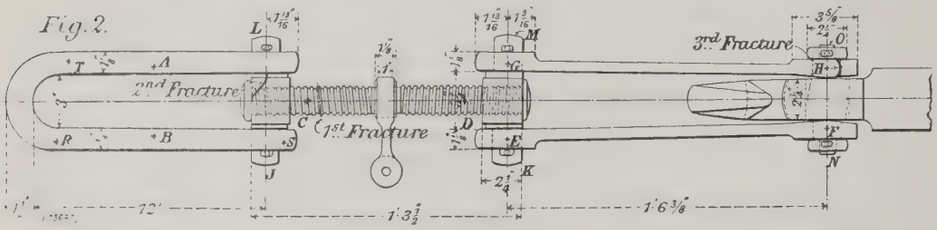
The standard coupling, illustrated in connection with a former article, made of Yorkshire iron, and weighing 77¼ lb., failed, according to the report then reproduced, at 42.63 tons. The usual guaranteed load is 42 tons. The test figures reproduced under Figs. 1 and 2 herewith, also from reports by the Sheffield Testing Works, show these "Tensio" couplings, of carbon steel of a quality suited to withstand shock, to be well up to similar requirements, while the figures for permanent set given by the latter are better than with the older type. A permanent elongation of 0.16 in. results from a load of 35 tons with the coupling shown in Fig. 2, whereas with the usual shackle type this amount of set is recorded with only 18 tons load. The coupling shown in Fig. 1 was tested without the ball lever. Complete with lever this coupling weighs 67 lb., against the 77¼ lb. above quoted for the standard type.



Report No. 95,800.

Gauge points were marked on the screw coupling and shackle at A B, C D, E F, G H, J K, and L M, and the movement of these points was noted as the load was gradually increased. After certain loads had been applied, the pressure was released, and any permanent set noted.

Position of Gauge Points.	Movement and Set in Inches. Load in tons	15	20	25	30	40	50	Maximum Load. Tons.	Remarks.
A B = 4 in.	Closing in	None	0.04	0.12	0.21	0.37	0.48		
	Set		0.02	0.09	0.20	—	—		
C D = 9½ in.	Extension	None	None	0.05	0.15	0.30			
	Set				0.05	—	—		
E F = 3½ in.	Closing in	None	None	None	None	None			Broke through the trunnion nut of the link A B.
	Set								
G H = 3½ in.	Closing in	None	0.02	0.04	0.09	0.11		59.10	
	Set		None	0.02	—	—			Fracture :—Finely granular.
J K = 13 in.	Opening out	0.03	0.08	0.10	0.24	0.44			
	Set	0.02	0.03	0.08	—	—			
L M = 13 in.	Opening out		0.07	0.12	0.22	0.44			
	Set		0.05	0.09	—	—			



Report No. 98,869.

Gauge-points were marked on the screw coupling at A B, C D, E F, G H, J K, L M, K N, M O, H T, and R S, and the movement of these points was noted as the load was gradually increased. After certain loads had been applied, the pressure was released, and any permanent set noted. After the first fracture had taken place, the remaining portions of the coupling were re-tested, until all the parts were broken.

Position of Gauge-Points.	Movement and Set in Inches. Load in tons	18	20	25	30	35	40	50	Maximum Load. Tons.	Position of Fractures.	Appearance of Fractures
A B = 4 in.	Closing in	0.08	0.10	0.16	0.20	0.27	0.35	0.48			
	Set	0.05	0.08	0.10	0.16	0.20	0.28	..			
C D = 9 in.	Extension	..	..	..	None	0.03	0.09	0.20			Very finely granular.
	Set	..	..	..	..	0.02	0.07	..	69.12	1.—Screw	
E F = 18½ in.	Extension	..	..	..	..	..	None	0.02			
	Set	..	..	..	..	..	..	..			
G H = 18½ in.	Extension	..	..	..	..	..	None	0.04	70 40	2.—Trunnion nut of link A B	Finely granular.
	Set	..	..	..	..	..	..	..			
J K = 13½ in.	Opening out	..	None	0 02	0.03	0.04	0.15	0.36			
	Set	..	..	..	..	None	0.12	..			
L M = 13½ in.	Opening out	..	None	0.02	0.04	0.10	0 19	0.40			
	Set	..	..	..	None	0.05	0.15	..			
K N = 18½ in.	Opening out	..	..	0.02	0.02	0 02	0.03	0.09		3.—This portion of the coupling had carried a load of 69.12 tons during the test, but on re-testing this portion, the eye of the link broke with a load of 65.30 tons	Finely granular.
	Set	..	..	..	..	..	None	..			
M O = 18½ in.	Opening out	..	..	0.02	0.02	0.02	0.03	0.09	65.30		
	Set	..	..	..	..	..	None	..			
H T = 3 ft. 9 in.	Extension	0 08	0.09	0.13	0.15	0.20	0.30	0.60			
	Set	0.05	0.05	0.06	0.07	0.16	0.20	..			
R S = 13 in.	Extension	..	..	..	..	..	None	0.04			
	Set	..	..	..	..	..	..	..			

Belgian Steel-Making.—The production of finished steel in Belgium in the ten years ending with 1910 inclusive was as annexed:—

Year.	Tons.	Year.	Tons.
1901	217,150	1906	333,175
1902	166,810	1907	303,380
1903	231,180	1908	234,530
1904	393,270	1909	316,990
1905	322,930	1910	378,815

The St. Lawrence.—A commission has been appointed to deal with navigable conditions on the St. Lawrence. The commission is composed of Professor C. H. McLeod, of McGill University, and Mr. W. I. Gear and Mr. Arthur, surveyor, of Montreal. The appointment of the commission was made by an Order in Council dated August 29, 1911, and the new body is to be known as the St. Lawrence River Commission. The duties of the new organisation will be to examine conditions prevailing in the river and to report upon the many power schemes now before the Federal authorities, and the effect of such works upon the navigation of the river. Its jurisdiction will extend from the head of Lake St. Francis to Montreal. The commission will also study the improvement of the river channel and the possibility of deepening the water highway to the sea to a depth of 22 ft. or 25 ft.

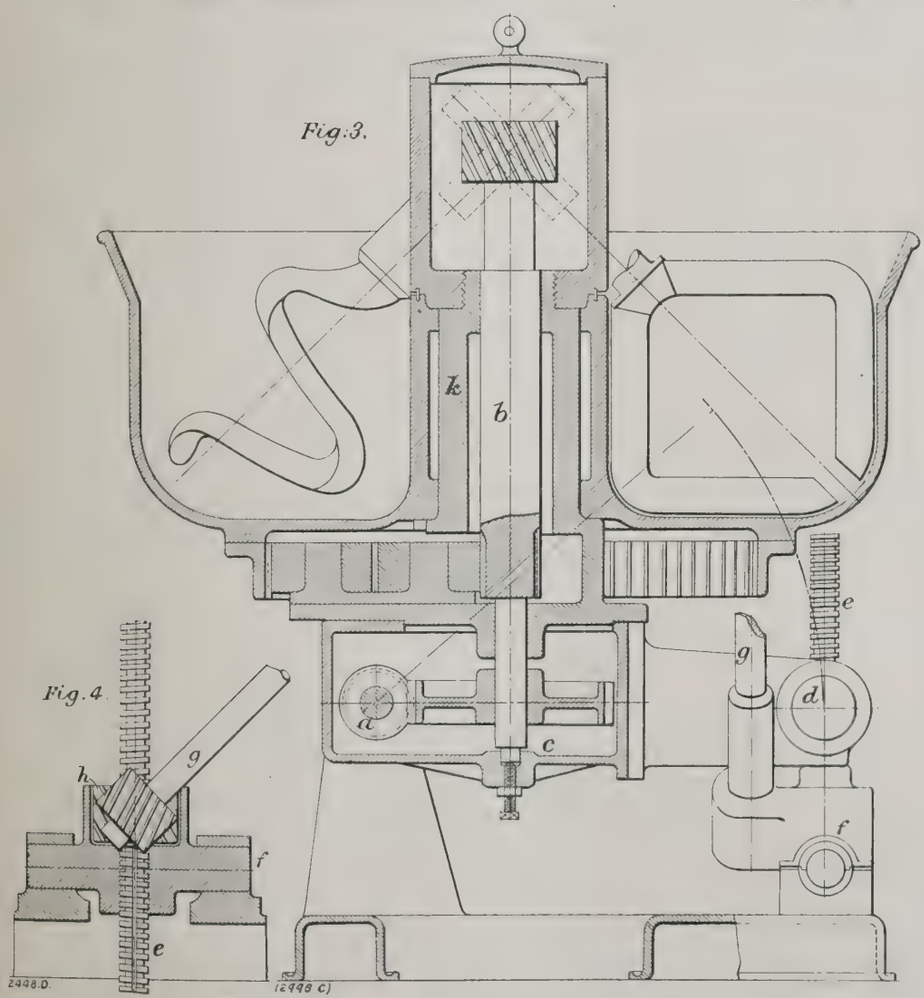
The Chinese Navy.—According to the *Agence d'Extrême Orient* the previously published comprehensive Chinese naval programme has been very materially reduced. The revised programme comprises three maritime groups: firstly, a coast-defence; secondly, a section on the Yangtse River; and thirdly, some training-ships. The first of these groups consists, at present, of four cruisers and some gun-boats and torpedo-boats, but to this group will be added four new cruisers, to be built abroad. The second group numbers twelve gun-boats, and the third, two cruisers, ten gun-boats, and some torpedo-boats. Three small cruisers have recently been ordered in Germany, two in England, and one in the United States. At present there are several naval colleges, but it is proposed to reduce their number to two. After having completed their education at home a number of young Chinese will be despatched to Europe and the United States for further studies. In addition to the above contracts China has ordered some torpedo-boats and destroyers in Japan. Present events may, however, completely alter the plan.

REVOLVING-PAN MIXING-MACHINE.

CONSTRUCTED BY MESSRS. MARIO FRIGERIO AND CO., LECCO, ITALY.

Fig. 1. Tilting-Pan Machine.

Fig. 2. Horizontal Pan Machine with Pan Removed.



Figs. 3 and 4. Details of Tilting-Pan Machine.

The machine which we illustrate above, although primarily intended for the mixing of dough for bread-making, is claimed to have a much wider application for the mixing of both dry an wet materials for industrial purposes. The machine has only recently been introduced into this country by Mr. A. G. Graziani, 22, Billiter-street, E.C., who is the agent for the makers, Messrs. Mario Frigerio and Co., of Lecco, Italy, and was exhibited at the Confectioners and Bakers' Exhibition lately held at Islington, as mentioned in our issue of September 15 (see page 362 *ante*).

The machine consists essentially of a revolving horizontal pan having one or more revolving mixing-blades set at an angle with the bottom of the pan, the number and form of these blades being varied according to the nature of the materials to be dealt with. Two types of machine are built, the pan in one case being provided with a tilting arrangement for facilitating the removal of the mixing, as shown in Fig. 1, above, whilst in the other the pan remains in a horizontal position, as in the case of the machine shown in Fig. 2. The method of driving the mixer is the same for both types of machine, and will be seen from the drawings reproduced in Figs. 3 and 4, and the illustrations already referred to. Upon the main driving shaft *a* is mounted a worm, gearing with the worm-wheel on the vertical spindle *b*. This vertical shaft serves to drive both the revolving pan and the mixing-blades, and runs in bearings provided in the pillar casting *k*; a footstep bearing is also provided at its lower end to take the thrust from the skew gearing driving the mixing-blades. The pan, which revolves upon the central pillar, is driven from a pinion forming part of the vertical shaft, which gears with two spur-wheels, clearly shown in Fig. 2, the outer one of which in turn engages the annular rack fixed to the bottom of the pan. The method of driving the revolving blades is clearly shown in Figs. 2 and 3, and it will be seen that the whole of the driving mechanism forms a very compact arrangement. Efficient lubrication is provided, the worm gear running in an oil-bath, whilst an oil reservoir, formed by the gear-box mounted on the central pillar, supplies lubricant to the centre spindle and pan bearings. In order to prevent oil finding its way into the mixing-pan, a packing-ring is provided between the top of the pan and the gear-box; for the same purpose the bearings of the mixing-blades are provided with oil-retaining grooves, as will be seen on reference to Fig. 2.

The mixing-blades illustrated, as will be seen, are of two forms, the one, being of rectangular shape, practically conforming to the outline of the pan, whilst the other is in the form of a helix, these forms being found most suitable for dealing with the wet mixing of such materials as dough, clay, &c.

In addition to the revolving blades, two fixed blades are fitted; the one (shown to the back of the pan in Fig. 1), being bent to the shape of the pan, serves to keep material from sticking to the pan, whilst the other, termed a "stripper" (seen to the left side of the pan), removes material from the rectangular mixing-blade.

In the case of the tilting-pan machine the central

pillar k is mounted on a casting c, which is hinged at one end on the main driving-shaft, and thus the mixing may be continued, if desired, with the pan at any angle. In this machine the main shaft is carried in trunnion bearings, as seen in Figs. 1 and 3.

The tilting of the pan is effected by the screw e, the upper portion of which has a right-hand thread working in a swivel-nut d, carried in a forked arm, which is bolted to the tilting casting c mentioned above; the lower portion of the screw is left-handed, and works in a swivel-nut f mounted on the base-plate. This nut has a bearing formed in it for the hand-wheel spindle g, upon which is fixed a skew gear engaging with the sleeve-nut h, running upon the screw. This sleeve-nut carries a feather, which engages in a key-way cut in the lower portion of the screw, and thus, on turning the hand-wheel, the screw is revolved. A rapid lifting action thus takes place, since the nut d rises on the screw at the same time that the screw itself is raised in the nut f.

From the description and illustrations given it will be seen that the machine is one that is easily cleaned, and that there are no parts where lodgments of the materials mixed can take place; the working parts, also being covered in, are entirely protected from damage when gritty materials are being dealt with.

NOTES FROM THE UNITED STATES.

Philadelphia, October 18.

The lower range of prices for crude iron and steel has stimulated some buying, most of it for delivery during the rest of the year, and only moderate buying for next year, because of the unwillingness of most of the producing interests to enter into long contracts at current rates. It is not at all certain that the pig-iron interests may not conclude to make the best of it and accept long-running contracts at present prices. Both basic and Bessemer are wanted for delivery far into next year. The most important inquiries that have come to hand this week have been for structural material and steel cars. One Pittsburg car works has contracts calling for the delivery of 4700 cars before the close of this year, and this, with other contracts on hand, will keep this one plant crowded to maximum capacity to the end of the year. The extraordinary prices for structural steel has brought to the surface a good many orders, and opened up negotiations for the delivery of material running into next year. A local contract hanging fire calls for 10,000 tons for a municipal structure, and this material will be contracted for in case a dispute concerning the matter is decided favourably. The Bethlehem Steel Company captured an order for 2600 tons for an office building in Pittsburg, and the American Bridge Company secured an order for 4200 tons. Steel-makers are bidding on a 3100-ton contract for Cincinnati. The rush for steel pipe is extraordinary. The Republic Iron and Steel Company secured a contract for a 150-mile 6-in. pipe-line, calling for 18,000 tons, all to be delivered before December. The National Tube Company is rushing work on a Canadian order for 40,000 tons. Two Pittsburg concerns have placed orders for 8000 tons of pipe, extra heavy, for a 10-mile line, and a pipe for a 15-mile line of 12-in. pipe. Other pipe-line interests are in the market, and further contracts will soon be closed. The demand for tin-plate is heavy, and one-fifth of the output of the American Sheet and Tin-Plate Company is being shipped to outside countries. Some other tin-plate makers are not quite so well off. Some large domestic consumers are trying to work the market for a reduction.

THE INSTITUTE OF MARINE ENGINEERS.

At the Institute of Marine Engineers, on Monday, October 23, a paper on "Steam-Turbine Theory" was read by Mr. F. J. Kean, B.Sc. (Member). The Hon. Sir Charles A. Parsons, K.C.B. (Past President), occupied the chair.

In the course of his paper the author said that the most convenient way to measure the energy liberated in a turbine in thermal heat units was to use the temperature entropy diagram. In the ideal case of the Rankine-Clausius cycle the expansion was perfectly adiabatic; no heat was being taken in or given out; the entropy remained the same. In an actual steam-engine there was loss by condensation and radiation from the cylinder walls, while in the case of a steam-turbine of the Parsons type the energy wasted in steam friction returned to the steam, and more than counterbalanced the radiation losses. The speed of the steam in that turbine was never less than 100 ft. per second, and often reached 500 ft. per second, so that even with well-formed blading the surface friction must be considerable. The secret of power in expansive working was to cause the steam to give up its heat; the wetter the steam at exhaust, the more efficient the turbine, provided the dryness fraction at exhaust was not less than the adiabatic value.

He had attacked the question of turbine efficiency by collecting and tabulating the properties of steam at a number of different pressures, starting on the 150 lb. absolute as the initial condition. He then found the work done and the dryness fraction as the expansion continued adiabatically, until a pressure of 1 lb. absolute was reached. This represented the case of an ideally perfect turbine. He then outlined a method of calculating friction losses, and drew up tables showing at all points the entropy and dryness fraction of the steam under varying conditions of expansion. Summarising the figures, it was found that when the steam expanded adiabatically from 150 lb. absolute down to 1 lb. absolute, the heat available for work per pound was 315 B.Th.U.; when there was a loss of 10 per cent. in each expansion the heat available for work was 320.9 B.Th.U.; with 20 per cent. loss it was 326.6 B.Th.U.; with 30 per cent. loss it was 332.1 B.Th.U.; and with 40 per cent. loss it was 337.4 B.Th.U.

In opening the discussion which followed, Mr. J. Veitch Wilson said he understood it sometimes occurred that the turbine blades became coated with foreign material, and the velocity of the steam was thus impeded; also that the orifices were perceptibly reduced from the same cause. He referred to the difficulty of lubrication by reason of water becoming mixed with the oil.

Mr. G. W. Newall commented upon a comparison made by the author in regard to the steam friction in a turbine and an ordinary steam-engine, and Mr. P. Smith, R.N.R., also spoke.

Sir Charles Parsons, in continuing the discussion, said that when turbine work was first commenced great difficulty was experienced in stopping the leakage over the blades, which in some cases amounted to between 30 and 40 per cent. In reaction turbines of the marine type especially, the initial pressure was less efficient than the low pressure. In the low-pressure blades on the Mauretania the leakage was practically nothing, and their efficiency was about 85 per cent. In turbines of the impulse type, such as the Curtis, there was greater efficiency in the initial stages, but the frictional loss was higher. A compromise had been arranged by which the Curtis turbines were made with the Parsons blading for the low-pressure, and the Parsons turbine with the Curtis blading for the high-pressure; about 70 per cent. of the whole power being of the reaction type. He considered that reaction blading would finally supersede all others. In actual practice error in blade area made very little difference in the turbine efficiency; a difference of 50 per cent. in the area of the blading would not, perhaps, make more than 2 or 3 per cent. difference in the efficiency. The blades and orifices got silted up sometimes, especially in small turbines, through the use of fatty compositions. The coating could be cleaned off with paraffin. It was best to use pure mineral oil for lubrication.

Mr. Kean replied briefly to the various points raised. A vote of thanks was accorded to the author on the proposal of Mr. A. H. Mather, seconded by Mr. F. M. Timpson. Mr. John McLaren proposed a vote of thanks to Sir Charles Parsons for his services in the chair; the motion was seconded by Mr. P. T. Campbell, and carried with acclamation.

The Vickers Company in Canada.—The plans of the Vickers Company with regard to its Canadian enterprise were made known at Montreal on the 19th inst. Mr. F. Orr Lewis, president of the Canadian company, stated that an initial outlay of 1,000,000*l.* would be made on the company's plant. Thirty-five acres of land, adjoining the riverside at Maison Neuve, have been acquired for the shipyard, in addition to a shipyard basin which will occupy five acres. Dredging operations have now been begun by the Harbour Commissioners. The basin will have a depth of 30 ft. at low water. It will be 1000 ft. in length, 500 ft. in width, and will be enclosed on three sides by concrete wharves, 28 ft. above low-water level. In this basin the floating dry dock now being built in England will be moored.

The late Mr. D. C. Davey.—The death is announced by cablegram, on October 7, of Mr. Darnton Charles Davey, known to his friends as "Don," who was a son of the late Mr. C. M. Davey, a partner in the firm of Messrs. Davey, Paxman, and Co., Limited, of Colchester. Born in 1856, Mr. "Don" Davey served his apprenticeship with Messrs. Davey, Paxman, and Co., and went out to South Africa in 1881. In 1885 he entered the services of the Government in the Natal Harbour Board Department. Some five years ago he was appointed their chief engineer-in-charge, and during his time with them he superintended and carried out the very large improvements that have been made in the harbour at Durban. His chief hobby was cricket, and he was a member of the first South African team to visit England in 1894.

Engines as Brakes.—An action was brought some time ago against the Basalt Roadstone Company, Limited (members of the C.M.U.A.), for damages to a horse and landau caused by the defendants' "Sentinel" steam-wagon slipping in Terrace-road, Buxton, and colliding with plaintiff's cab. It was held by the Judge on the occasion of the first hearing that the sufficiency of the brakes had to be settled, the point having been raised that a steam-engine was not admissible as a second brake under the requirements of the Motor-Car Use and Construction Car Order. The C.M.U.A. advised the members on the legal position, and at the adjourned hearing instructed an engineer to attend to give evidence on the question of the use of the engine as a brake. In summing up his honour said that the plaintiff had failed to establish negligence on the part of the driver, of his mate, or of the owners of the vehicle. The judge did not feel called upon to decide the point that the engine was an independent brake, but in his own mind he was quite clear that the engine of a steam-propelled vehicle was equally as good as a brake as that on the differential of a petrol-driven motor-car, and he dismissed the action.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a steady tone, and 5000 tons of Cleveland warrants were done at 46s. 3½d. cash, 46s. 7½d. one month, and 47s. 2d. three months. Closing sellers quoted 46s. 4½d. cash, 46s. 8d. one month, and 47s. 2½d. three months. In the afternoon the market was quite idle, and closing sellers of Cleveland cash warrants were quoting ½d. easier, but forward prices were unchanged. On Friday morning business was quiet, but a firm tone prevailed, and 3500 tons of Cleveland warrants were put through at 46s. 4d. cash, and 46s. 4½d. five days. At the close the quotations were 46s. 4½d. cash, 46s. 8d. one month, and 47s. 3½d. three months sellers. The afternoon session was also quiet, and dealings were limited to two lots of Cleveland warrants at 47s. 2d. three months, and closing sellers quoted 46s. 4½d. cash, 46s. 7½d. one month, and 47s. 2½d. three months. On Monday morning the market was easier in tone, and 6000 tons of Cleveland warrants were dealt in at 46s. 3d. cash, with sellers over, and at 47s. 1½d. three months. Sellers of forward warrants quoted, at the close, 46s. 6½d. one month and 47s. 2d. three months. In the afternoon business was at a standstill, and the quotations for Cleveland warrants were unchanged from the morning. The tone was steady on Tuesday morning, and the turnover consisted of 4000 tons of Cleveland warrants at 46s. 2½d. cash, 46s. 6d. one month, and 47s. 1½d. and 47s. 1d. three months. Sellers' closing rates were 46s. 3d. cash, 46s. 6½d. one month, and 47s. 1½d. three months. In the afternoon Cleveland warrants were inclined to get easier, and 2500 tons were done at 46s. 2d. cash and 47s. 1d. three months, and at the close the prices were called 46s. 2½d. cash, 46s. 6½d. one month, and 47s. 1d. three months sellers. When the market opened to-day (Wednesday), a firm tone prevailed, but only 2500 tons of Cleveland warrants changed hands at 46s. 3d. cash and 47s. 2d. three months. Closing sellers quoted 4s. 3d. cash, 46s. 7d. one month, and 47s. 2½d. three months. The tone in the afternoon was again firmer, and Cleveland warrants were done at 46s. 3½d. cash and 47s. 2½d. three months. The turnover was limited to 2500 tons, and the session closed with sellers quoting 46s. 4d. cash, 46s. 7½d. one month, and 47s. 3d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 61s. 6d.; Gartsherrie, 62s.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 63s. 6d; Shotts (at Leith), 62s. 6d.; and Carron (at Grangemouth), 63s. 6d.

Sulphate of Ammonia.—A steady tone prevails in the sulphate of ammonia market, and the demand continues fairly good. The price is still firm, and at from 14*l.* 5s. to 14*l.* 7s. 6d. per ton for prompt lots, Glasgow or Leith. The amount shipped from Leith Harbour last week was 61 tons.

Scotch Steel Trade.—The state of affairs in the Scotch steel trade shows little change, and producers of heavy material are very well supplied with specifications. Deliveries of plates to shipbuilders are on a heavy scale. The booking of new business is almost nil, and the bulk of what is going through is for abroad, and in the latter connection some lots of both ship and boiler-plates have been sold this week for export to Holland. The home demand may improve whenever consumers learn the details of the new rebate scheme, the full particulars of which are promised shortly. Satisfactory inquiries are in the market at present for considerable quantities of heavy material for the Far East and South America, as well as for some of the Colonies. Makers of black and galvanised sheets continue very busy, and the output is being rapidly absorbed. Structural sections are again in better demand, and the prospects are rather brighter. Prices all round are firm and unchanged.

Malleable-Iron Trade.—The position of the malleable-iron trade in the West of Scotland is, if anything, a shade better this week, and the works are mostly very well employed. There is now less disposition to accept business under 6*l.* 2s. 6d. per ton for crown bars, less the usual 5 per cent. discount, but buyers still endeavour to secure lots at 6*l.*

Scotch Pig-Iron Trade.—In the Scotch pig-iron trade makers report that the general demand is still slow, but that some lots of No. 3 iron have been sold locally this week, and that inquiries for No. 1 iron for shipment are encouraging. Colonial consumers are taking delivery of quite a decent tonnage of the ordinary qualities, but the demand from buyers in the south has fallen off a little. There is only a limited movement in evidence in hematite at present, but deliveries are very fair. The price is still round 64s. per ton.

Institution of Engineers and Shipbuilders in Scotland.—The annual meeting of the Institution of Engineers and Shipbuilders in Scotland was held last night (Tuesday) in the Rankine Hall, Elmbank-crescent, Glasgow, when the recently elected President, Mr. E. Hall-Brown, was introduced by Professor Barr, and then occupied the chair. The secretary, Mr. E. H. Parker, read the annual report of the Council, which stated that the affairs of the Institution were in a prosperous condition. The membership continued to show an increase, and the balance of income over expenditure was satisfactory. The presidential address of Mr. Hall-Brown was exceedingly interesting, and he took as his subject "Marine Engineering from the Point of View of Present-Day Practice" The arrangements for the session are well forward, and some interesting papers are promised.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The briskness in the steam-coal trade towards the end of the shipping season is accounted for by the fact that merchants are endeavouring to regain ground lost during the recent strike. They are still experiencing difficulty, owing to restricted facilities at the ports. The industrial demand is about the same, and prices have a firmer tendency. Collieries are well off for orders. There is a similarly good inquiry for gas fuel, and reserves are still being stocked. Slacks, owing to larger production, are easier. One effect of this is likely to be that contract renewals, for which collieries are asking advances, will not be so readily taken up. There has been a marked change in house coal in the week. The continuance of high prices has done much to check any increase in the demand, and mild weather conditions have also operated unfavourably upon the market. A big falling off has been shown in London inquiries. The quotations on the Sheffield Exchange at the week-end were:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. 6d. to 13s. 6d.; Silkstone, 11s. 6d. to 12s. 6d.; Derbyshire brights, 12s. 6d. to 13s.; Derbyshire house, 10s. to 11s.; large nuts, 10s. to 11s.; small nuts, 6s. 6d. to 8s.; Yorkshire hards, 9s. 3d. to 10s. 3d.; Derbyshire hards, 9s. to 10s.; washed nuts, 8s. 6d. to 9s. 6d.; rough slacks, 5s. 6d. to 7s. 6d.; seconds, 4s. 6d. to 5s. 6d.; smalls, 2s. to 3s.

Iron and Steel.—Although there has been little iron sold during the week the market has been steady, and prices, if anything, firmer. The small amount of ordering is, of course, accounted for by the fact that most makers have got enough stock to meet requirements. With brisk business in bar iron the makers are reaping a double benefit from the action they took a little time ago in raising the price. The demand is so great just now that consumers are making no demur about buying at the 7*l.* figure. Continental competition is much less severely felt. All kinds of billets are in growing request, but there is a particularly heavy call upon the highest quality of basic material, which the furnaces are experiencing considerable difficulty in meeting. In billets also there is not much Continental material being received. Nothing has so far occurred to check the steady progress of the general industries of the city. Activity in many departments is almost phenomenal. Armament departments have a quantity of orders of the highest class which will provide an abundance of work for the winter. Although the shadow of labour unrest still remains, it is pressing less heavily upon the minds of those who would be most affected by any disturbance. It is fervently to be hoped that this is not the calm which precedes the storm. There is some indication that the great bugbear of local manufacturers, the prices obtained for finished goods, is not quite so troublesome, and that in this direction there is a brighter tendency. It is stated that the steel foundries are fully occupied, and more work is certainly being accomplished at the forges. The makers of special steels seem to be always sure of a market, and this branch of Sheffield trade has been prosperous for a long time. The tool-steel and tool manufacturers are perhaps experiencing greater pressure than any others. A large number of them are working overtime, and a few are only deterred from making extensions by the fact that they have no room in which to extend. How much of the prosperity in this branch is due to the superiority of Sheffield goods, and how much is merely the tapping of a large natural demand, it is difficult to say; but, at any rate, there are no signs that Sheffield is suffering in prestige. Indications to the contrary are, in fact, frequently being received. Two Sheffield firms have just been awarded honours at the Turin Exhibition—the one a gold medal and the other the Grand Prix.

DAILY WEATHER FORECASTS BY TELEGRAPH.—On Thursday, the 12th inst., a deputation appointed by the Conference of Municipal and County Engineers waited upon Dr. W. N. Shaw, Sc.D., F.R.S., Director of the Meteorological Office, in order to place before him a proposal that a daily weather report should be sent to every post-office, or local authority's office. Dr. Shaw is reported to be in favour of the project. The *Surveyor and Municipal and County Engineer* has particularly interested itself in this matter.

ANGLO-CONTINENTAL TELEPHONE SERVICE.—The beneficial results attending the adoption of the new type of submarine cable between this country and France have again been demonstrated during the past few days, in a series of speech trials which have been conducted by English and Continental telephone experts. As has been previously reported, the distinguishing feature of the new cable is the insertion at regular intervals of inductance or loading coils, which help to counteract the ill effects upon speech transmission produced by the electrostatic capacity of the cable wires, and the earlier trials demonstrated the fact that telephonic facilities would, in future, be possible between towns so far separated as Aberdeen and the French capital, a distance of 800 miles. The immediate object of the later trials was to determine the possibility of offering telephonic facilities between Great Britain and Switzerland, and this end has been achieved. Connections were established between London and Geneva (560 miles), *via* Paris and Lyons, and between London and Bale, *via* Paris and Belfort, and in each instance satisfactory commercial conversation was obtained. The results of the test calls are such that a telephonic service between subscribers in Inner London and in Geneva and Bale will be inaugurated when the necessary arrangements between the two administrations are completed.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Quietness still characterises the pig-iron trade. Many makers have good contracts made, but some customers are not taking full deliveries, and new orders are difficult to obtain, notwithstanding the great activity in the consuming industries. Buyers continue to act with much caution, and as a rule will only place orders to meet early requirements. Seldom, indeed, in the history of the northern iron trade has business been on so limited a scale as it is just now. Some of the leading producers of pig iron are holding a'oof. They will not accept current rates, and are waiting in the hope and belief of improvement in values in the very near future. Sales of No. 3 g.m.b. Cleveland pig iron have been recorded this week at 46s. 6d. f.o.b., and as low as 46s. 4½d. is said to have been accepted in odd cases, but the general market quotation is now 46s. 7½d., whilst No. 1 is 50s. 3d.; No. 4 foundry, 46s. 3d.; No. 4 forge, 46s.; and mottled and white iron, each 45s. 9d.—all for early delivery. There is very little doing in East Coast hematite pig. If anything, values are slightly firmer than they have been, but little disposition to operate is shown. The general market quotation for early delivery of Nos. 1, 2, and 3 is 60s. 6d., and few makers will entertain offers at below that figure, but orders might be placed with second hands at rather less. Prices of foreign ore are firm, and have been strengthened by the fact that Messrs. Krupp have placed an order for 1,000,000 tons of best Rubio, to be delivered to that large concern over ten years, at a price said to be equivalent to about 20s. ex-ship Tees. The market quotation here at present is 19s. 6d., but several sellers are inclined to ask rather more. Coke is steady and firm, and in good request. The local consumption is heavy, and medium blast-furnace kinds stand at 15s. delivered here.

Stocks and Shipments of Pig Iron.—At makers' yards stocks of both Cleveland and hematite pig are understood to be steadily accumulating, but Cleveland iron is being taken from the public warrant stores, 10,779 tons having been withdrawn to date this month, which is at the rate of 567 tons per working day. Shipments of pig iron are on a fairly satisfactory scale. To date this month they average 3563 tons per working day, as compared with a daily average of 3823 tons to the same date last month, and 3601 tons for the corresponding part of October last year.

Manufactured Iron and Steel.—Producers of all descriptions of manufactured iron and steel continue very actively employed, and, in fact, so excellent are the order-books of some firms that they are not keen on making further contracts just now. Rail-makers are turning out a great deal of work, as are also producers of shipbuilding material. Under these favourable circumstances quotations show an upward tendency, but no actual advances have as yet been made. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron girder-plates, 6*l.* 17s. 6d.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 7s. 6d. to 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 11*l.* 5s.—sheets less the usual 4 per cent. f.o.b., railway material net at works, and all other descriptions less the customary 2½ per cent.

Ironstone Miners' Wages.—At a meeting of Cleveland ironstone mine-owners and miners' representatives held this week it was agreed, after lengthy discussion, that for the ensuing quarter wages be reduced by 2 per cent. This is the same amount as the reduction recently effected at the blast-furnaces.

PERSONAL.—The firm of Messrs. Walker, Maclaren, and Co. has now become Messrs. Mason, Maclaren, and Co., of 26 and 27, Bush-lane, and 3, Suffolk-lane, Cannon-street, E.C. An entirely new staff, which will be under the management of Mr. F. W. Cornwell, has been engaged by the firm.

COST OF IMPURE WATER.—On June 9 of this year we published an article under this title, calling attention to the very high death-rate in American cities due to typhoid fever, caused by the distribution of impure water. We have since learnt of a striking effect of filtration of water in an American city, which shows with what certainty the present death-rate can be reduced by the construction of filter-beds, and the fever-rate in American cities reduced to proportions which are comparable with those in this country. In 1906, when Cincinnati was still using unfiltered water from the old works, there were 239 deaths from typhoid fever. The total for the three years 1904-5-6 was 667 deaths. In 1908, the year following the installation of the new water-works system, which cost 2,400,000*l.*, the number of deaths from typhoid fever dropped to 67. In 1909 there were only 45 deaths from this cause, and in 1910 only 21, the total for the three years being 133. The number of lives saved, therefore, was 531, the death-rate last year being 5.7 per 100,000 people. There is an additional financial saving, as the old water works cost 6*l.* 8s. per million gallons for pumping, while the cost of the new system is only 2*l.* 12s., the actual saving in operating cost having been 106,000*l.* It is clear that at least one great American city has successfully faced the problem of providing pure water, and has found the cost, both in money and life, less than that of impure water.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has ruled quiet. Difficulties have arisen in consequence of tonnage arrivals for the week-end having fallen short of expectations. The best Admiralty coal has been held with firmness, but lower descriptions have been easy. The best large steam-coal has made 16s. 9d. to 17s. per ton; secondary qualities have ranged between 15s. and 16s. 6d.; best ordinary bunker smalls between 7s. 3d. and 7s. 6d.; and cargo smalls between 6s. and 6s. 9d. per ton. House coal has shown little change; the best ordinary qualities have made 14s. 6d. to 16s. 6d.; No. 3 Rhondda large, 17s. to 17s. 6d.; and smalls, 10s. 3d. to 10s. 6d. per ton. No. 2 Rhondda large has been quoted at 11s. 9d. to 12s. 3d.; and smalls at 6s. 3d. to 6s. 9d. per ton. Foundry coke has been making 18s. to 20s. 6d.; and furnace ditto, 16s. to 17s. per ton. As regards iron ore, Rubio has realised 18s. 6d. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

The Welsh Coal Trade.—Lord Merthyr (better known as Sir W. T. Lewis) has been entertained at a dinner at Merthyr. In responding to the toast of his health, Lord Merthyr reviewed the marvellous growth of the South Wales steam-coal trade since Mr. R. Thomas commenced the shipment of steam-coal at Cardiff in 1828. By 1831 Mr. Thomas was sending by the Glamorganshire Canal to Cardiff about 100 tons of coal per day, while in 1910 the deliveries had grown to 66,000 tons per day at Cardiff alone. Dealing, however, with the present and future, Lord Merthyr said he considered the prospects of the South Wales coal trade gloomy, especially having regard to the American and German competition which had recently sprung up in consequence of the high prices ruling for Welsh coal

Southampton.—It is stated that the London and South-Western Railway Company have acquired a stretch of foreshore on the eastern side of Southampton Water, between Woolston and Netley.

Welsh Coal for France.—The Southern of France Railway Company has placed contracts with Welsh firms for 130,000 tons of small coal, 80,000 tons to be delivered at Bordeaux, and 50,000 tons at Bayonne. Deliveries are to extend well into 1912. The price has not transpired, but it is understood to be about 12s. 10d. per ton, French import duty included.

The Tin-Plate Trade.—In speaking at the annual meeting of the Swansea Metal Exchange, Colonel Wright said our exports of tin-plates had increased to several countries, but an ominous feature of the exports for the first nine months of the year was the continued decrease of shipments to Canada, the figures being as follows:—Nine months ending September 30, 1910, 19,776 tons; corresponding period of 1911, 8682 tons; or a falling-off of 11,094 tons. We were faced by a serious menace in connection with our exports to other countries, for United States tin-plate manufacturers had this year greatly increased their exports to countries hitherto supplied by us. The falling-off in our exports this year was, however, confined to four countries—viz., the United States, Canada, Argentina, and Russia.

The late Mr. J. Conacher.—The death is announced of Mr. J. Conacher, a distinguished veteran railway official. Mr. Conacher was long associated with the Cambrian Railway, and subsequently he occupied a prominent position upon the staff of the North British Railway. Latterly he had become managing director of the Barry Railway. He was regarded as a highly honourable and capable railway man.

COAL AT THE FÄRÖE ISLANDS.—The coal deposits at the Färöe Islands, of which a French syndicate had acquired the working rights without being able to carry the undertaking through, are again attracting attention, this time in America, and some American engineers have this summer visited the islands. The deposits are found in the island of Suderö, near the settlements of Trangisvaag and Koalhö, and vary in quality. The quantity is calculated to amount to some 50,000,000 tons of coal, of which 30,000,000 tons are situated above and 20,000,000 tons beneath the level of the sea. There are also copper ore deposits of good quality on the west side of the island.

THE INSTITUTION OF POST-OFFICE ELECTRICAL ENGINEERS.—At the first meeting of the session 1911-12 of the above institution, which was held on Monday, the 16th inst., at the Institution of Electrical Engineers, Major W. A. J. O'Meara, C.M.G., the engineer-in-chief to the Post Office, delivered his inaugural address, which dealt chiefly with the education of engineers. Subsequently he read a paper on "The Various Systems of Multiple Telegraphy," in which were considered saving of wire mileage, saving in labour costs, saving in maintenance costs, and general convenience of system with special reference to the handling of messages and the correction of errors.

"OUTLINES OF ELECTRICAL ENGINEERING."—This is the title of a new book written by Harold H. Simmons, M.I.E.E., which is being published in fortnightly parts by Messrs. Cassell and Co., Limited, Paternoster-row, London, E.C., and New York, Toronto, and Melbourne. The first part has just appeared, and contains articles on "The Electric Circuit," "Conductors," "Simple and Complex Circuits," "The Voltaic Cell," and "Types of Cells." The work is very well got up, being clearly printed on good paper, and on the whole the illustrations are excellent, though in some cases we notice that the tick marks to the dimension-lines are mitted. The price of each number is 7d. net.

THE AUSTRALIAN CRUISER "AUSTRALIA."

CONSTRUCTED BY MESSRS. JOHN BROWN AND CO., LIMITED, SHIPBUILDERS AND ENGINEERS, CLYDEBANK, N.B.

(*For Description, see Page* 570.)

Fig. 1.

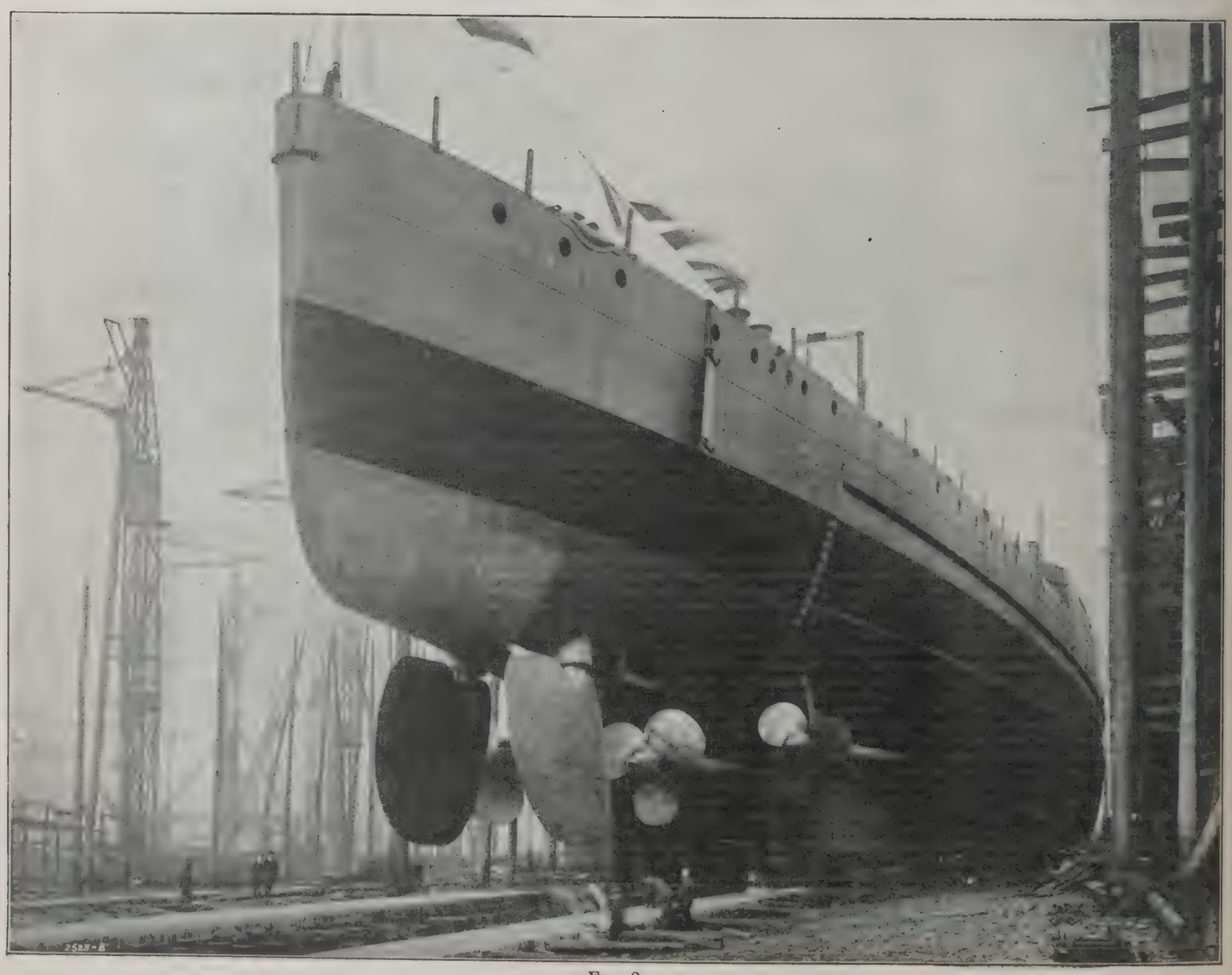


Fig. 2.

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ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

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NOTICES OF MEETINGS.

THE INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER LOCAL SECTION.—Friday, October 27, at 7.30 p.m., in the banqueting hall of the Midland Hotel, Manchester, the chairman, Mr. W. Cramp, will deliver his address.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, October 27, at 7.30 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-upon-Tyne. The President will deliver a brief address, to be followed by a paper on "The Relationship between Residuary Resistance Horse-Hower and Forms of Vessels," by Mr. Ernest Saxton White, B.Sc., Member.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, October 27, at 7.30 p.m., at the Grand Hotel, Manchester. A paper on "Experiments with Cutting Tools" will be read by Mr. Dempster Smith, of the Municipal School of Technology, Manchester.

THE BRITISH FOUNDRYMEN'S ASSOCIATION: BIRMINGHAM BRANCH.—Saturday, October 28, at 7 p.m., at the Technical School, Suffolk-street, Birmingham, the President (Mr. H. L. Reason) will deliver an address.

THE JUNIOR INSTITUTION OF ENGINEERS.—Monday, October 30, at 7 p.m., at the Institution of Electrical Engineers, Victoria Embankment. Annual general meeting, followed by annual general meeting of the benevolent fund contributors; and at 8 p.m., paper on "Notes on Design and Construction in Gas Works," by Mr. George Evetts, Assoc. M. Inst. C.E. (Member). Saturday, November 4, at 7 p.m., reception by the President, Sir J. J. Thomson, F.R.S., and Lady Thomson, at the Caxton Hall, Westminster.

ENGINEERING.

FRIDAY, OCTOBER 27, 1911.

RAILWAY CONCILIATION AND ARBITRATION.

THE view that arbitration is only acceptable to British workmen when the decision is favourable to them would seem to be once more established by the reception afforded to the report of the Committee appointed to investigate the working of the railway conciliation and arbitration scheme of 1907; but we doubt not that with reflection there will come a calmer recognition of the only logical and inevitable result. The reference to the five Commissioners was most definite, and limited the subject of investigation to the complaints made and the means for overcoming defects in the machinery of the scheme named, and yet there seems now to have been an impression that the Commission was going to create a new heaven and a new earth. The desire for this millennium appears to have been at the root of all the trouble in connection with railway labour. The unions, in 1906, formulated what has since been termed the "national all-grades programme," and although they had to defer the demands made by this programme when the conciliation scheme was originated four years ago, leaving to elected boards the settlement of many issues on the different railway lines, the railway trade unions continued their agitation for the extraordinary demands of the programme, with the result that the concessions made, falling far short of the aims of the union leaders, gave rise to discontent. Of course, the agitators were only pursuing their usual tactics, as the future of all such protagonists depends on recognition by the men of their earnestness in the *rôle* of saviours of society. One of the valuable features of the report now issued is the clear perspective in which events, opinions, and demands are set out for the edification of the general public. On this question of the national programme it is important to note that the Commissioners have come to the unanimous conclusion that the men would not have regarded the proposals as feasible had they been in possession of adequate information as to the financial and other difficulties involved in the acceptance of that programme on the part of the various railway companies. This view was officially recognised also by the Board of Trade when they evolved the agreement of 1907, and here again there is no mistaking the view of the Commissioners, who state that, "bearing in mind the circumstances of the situation, the agreement, as an entire departure, cannot be regarded otherwise than as a promising solution of a question pregnant with difficulties."

The Commission's report, which is unanimous, notwithstanding the known opposing predilections of the members of the Commission, will be accepted by the general public as a common-sense and impartial solution of the existing difficulties; and particularly so because of the simplicity in the details in the machinery by which the original agreement is modified. The report is essentially in the form of a compromise. Briefly stated, the Commissioners recommend a fuller and freer interchange of information between employers and workmen, the encouragement of deputations chosen by, and consisting exclusively of, a company's workers to the directors and managers on all questions affecting not only wages and hours of labour, but conditions of service. There is also to be publicly announced a frank exposition of the latter. Should these meetings between deputations and the managements of railways fail, the points at issue are to be brought before Sectional Boards, or Conciliation Boards, as they are named in the report, constituted on similar lines to those instituted in 1907—but sufficiently comprehensive to include all grades—which are to be classified under eight sections; differences of opinion between the workers and the company in respect of the grading are to be settled by the Board of Trade. Each board is to meet normally at intervals of six months, fourteen days' notice of the agenda being given; but special meetings may be called on the requisition of either side, with fourteen days' notice. The first meeting of the board is to be without a chairman, and, failing agreement, a second meeting is to be called, with an interval of fourteen days, at which a chairman will preside. Such chairman is to be chosen from a panel to be prepared by the Board of Trade. As far as possible, the same chairman will act for all the Sectional Boards on a company's system, during the entire period of office of those boards. He is to be selected by the Sectional Boards from the panel, and, failing this, by the Board of Trade. Objections as to the legitimacy of the questions on the agenda paper are to be decided by the chairman, whose decision shall be final. The settlement made by the Sectional Boards is to be final, and is to continue in force for twelve months, and to be held to be continued thereafter until amended, superseded, or nullified by agreement of a board or decision of a chairman.

Existing awards are to remain in force until July 1, 1912. Thus eight months are allowed for the constitution of the new boards, and the setting in working order of the modified machinery. The new scheme is to continue in force until 1914, being subject to revision or determination, as regards any given company, by twelve months' notice by the company, or by a majority of the aggregate representatives of employees. The men may elect as the secretary of each Sectional Board, and as advocate at all meetings of the board, a representative from their trade union, who need not be an employee. The men's secretaries, while acting in discharge of their secretarial duties, are to be offered the privilege of free travelling over the company's system, and the members of the board are to have a like privilege on producing a summons to attend the meeting. This overcomes the objection on the score of expense of the numerous boards, and it is puerile for unionists to object to this system.

The report is judicial in its tone and in its review of the difficulties and shortcomings of the procedure under the 1907 scheme. Reference is made to the lapses of railway management, which are due probably to over-zealous foremen and assistants, rather than to the directorate and general management. It is pointed out, however, that the examples of re-grading, the establishment of trip rates, and other methods of management, by which the men were alleged to have been deprived of the beneficial effects of awards, are not numerous. Some of the companies did take such action, but, assuming that in doing so they acted in good faith, and were within their rights, "the carrying out of the economies at the very time the awards came into operation was, in the opinion of the Commissioners, unfortunate, and calculated to excite feelings of irritation." Such an expression of opinion will, no doubt, be duly respected by the railway companies, and will awaken the directors and managers to the importance of greater caution in the future, in order to obviate any possibility of new procedure, while ostensibly fair and conducive to economy, being suspected of concealing ulterior motives. In all such affairs it is incumbent upon those responsible for the management to recognise the inherent suspicion of the ill-trained mind. Many disputes have been developed owing to this characteristic, fanned in some cases by professional agitators, eager to grasp any incident which assists to foment discontent.

In respect of the delays, which constitute another important grievance of the men, the companies themselves recognise that there were delays, but they established the fact that these were in large measure due to the complication of the machinery of the scheme of 1907, to the unnecessary multiplication of stages in the process of arbitration, and to the avowed inability of the men to depart from the terms of the "national programme." As will

be seen presently, all of these objections will be removed by the amendments made, and generally it is to be hoped that in the future the inherent difficulties in all such conciliation schemes will be minimised by a fuller exposition and exchange of views between the parties.

The Commission refer repeatedly in their report to the fact that the men often do not understand, even if they hear, what can be said from the point of view of the railway companies, or of the financial consequences of the demands they make. The Commission state that "the men no doubt received important and valuable concessions, but, notwithstanding this, the results of the arbitrations were at the time, and have since remained, a keen disappointment." For this the national programme is largely to blame, as well as the biassed view placed before the men by the professional agitators. One more point in the guidance offered to the managements has reference to the offences against discipline. It has been urged that men have been discharged for misconduct, neglect of duty, or other breaches of discipline, without having a full opportunity for explanation or for stating any extenuating circumstances before they were punished. It is true that appeal may be made, but the Commission consider that the men charged with such offences should be permitted to state their defence, to call witnesses, and to advance extenuating circumstances, before their officers, prior to a final decision being arrived at. Where doubt arises, or where the results are serious to the men, the case should, in the view of the Commissioners, be placed before the higher officials of the company. This will undoubtedly remove one source of complaint, because it must be admitted that appeals after punishment are difficult, and that the necessity for such appeals should be avoided as far as possible.

The amendments made to the conciliation scheme ought to satisfy the workmen, because in practically every instance the objections urged before the Commission by the 43 workmen witnesses, representing unionists and non-unionists, have been met. These may be taken *seriatim*. Recognition of the union is probably the most important, because it bulked most largely in the demands of the men. In the first place, it is recalled that the 1907 negotiations were conducted through intermediaries; "there were no direct negotiations between the companies and the men." But the Commissioners point out that they have no evidence before them to enable them to say that the men understood it to be an essential condition of the agreement that the question of recognition should not be raised during its term. The contentions of employer and employed in this matter generally are well known. The Commission came to the conclusion that there was difference of opinion even amongst unionists as to the necessity for the presence of a trade-union official to help the men in advocating their cause before the officers of the company or the directors. Under the existing conditions trade-union officials are permitted to plead before the arbitrator, and the Commission have made a compromise which ought to satisfy the unionists

In the amended scheme the Central Board is abolished; the Sectional Boards are, as we have explained, to attempt a final settlement by conciliation, if possible without a chairman; but, at a second meeting, if such is necessary, with a chairman. Such a board, with a chairman, practically takes the place of the final arbitration proceedings under the 1907 scheme; and at all meetings of the Sectional Board the men are to be free, if they think proper, to combine in the same person the duties of secretary and advocate; he need not be an employee of the company, but he will not have power to vote unless he has been duly elected a member. This secretary, or advocate, is to be appointed by the representatives of the men on the Sectional Boards. Obviously, if trade unionists are in the majority in any group of workers on any railway, they can secure recognition for their union, so that the democratic conception that the majority must rule has full play. This applies equally in the event of non-unionists predominating. It should be understood, however, that in the preliminary procedure, which, we are glad to note, is being extended as well as simplified, the negotiations are to be between employers and their own workmen only. This is a commendable course, as it must conduce to amicable relations between the men and their employers. The freer the interchange of opinions, the greater will be the sympathy between the parties, and the fuller will be the knowledge of the related responsibilities of capital and labour. Moreover, as it is the aim of professional trade-unionists to justify their services and develop their unions, by a demonstration of the extent of their work, their tendency is to create discontent rather than to be satisfied to serve as the medium for redress of real and pressing grievances. Economic injustice in all cases asserts itself, and the men, by calm and firm protestation to their employers, will be met with ready and generous consideration. Temperate action by the men, too, will strengthen their case in subsequent proceedings at the Sectional Boards, and will win public sympathy, which in all such matters is spontaneously given, and effective in its result.

The Commission further point out that, with their great responsibilities to the public, the companies cannot, and should not be expected, to permit any intervention between them and their own men on the subjects of discipline and management. It is being urged that this conflicts with the decision that "terms of service" should be subject for consideration of the Sectional Boards; but we are glad to note that Mr. Barnes, who is well entitled to speak on conciliation procedure, in view of his long connection with it, urges the railway men not to interpret "terms of service" in a small way as applying to detail. The whole case demands, alike on the part of employers and employed, dispassionate tolerance and earnest desire to interpret liberally the main proposals of the scheme.

The abolition of the Central Board is a wise proceeding, because in all negotiations the multiplication of appeal courts tends to the prolongation of disputes. Neither side is willing to concede anything so long as there is a higher court, where further concessions may be demanded. Moreover, the delay involved has a disturbing effect upon industry. The decisions of the Conciliation Board, formerly the Sectional Board, are to be final. It will be remembered that the 1907 scheme provided for a suspensory period within which the companies or the men had the option of rejection. This suspensory period is no longer to exist, and here again there is wisdom in the decision, because it is as important that a decision should be final as that it should be arrived at in the most direct and speedy way Only one of the four railwaymen's unions was in favour of the retention of the Central Board, while others were desirous of having in its stead a National Board. The aim, as we have time and again pointed out, is to centralise union methods in order to make it easier to declare general strikes, in accordance with the new gospel of syndicalism. But as such movements are inimical to national interests, involving the stoppage of practically all industries, and ultimately reducing the people to starvation, the State must exert every influence and enforce every deterrent to defeat such action.

The exchange of office just made by the Home Secretary and the First Lord of the Admiralty may possibly be a portent of a change in the attitude of the Government. Mr. Winston Churchill in the recent crisis showed the true statesman spirit not only by his vigorous action in defending the people against the trend towards anarchy, but in his defence of such action, and in his grave warning to those who, in the cause of "the solidarity of labour," were really warring against the State. To permit him to give effect to his warnings would have been a wise procedure, and therefore his transference to the Admiralty at this juncture cannot be commended, even if it has been suggested by party expediency to smooth down the annoyance of some Government supporters. At the same time Mr. McKenna's satisfactory control of Admiralty administration should not have been disturbed. The Commissioners' recommendations, however, tend to defeat the general strike movement. The Sectional Boards are supreme. This is as it should be. The work and terms of service of different grades of workers on railways differ so materially as to call for separate treatment. The locomotive driver has no association with the station porter; the signalman has no connection with the sweeper of railway carriages. As the secretary of the General Railway Workers' Union said on Saturday last, "We have always contended that our members were under a great disadvantage when their grievances were discussed by a board consisting chiefly of representatives of grades who receive less wages." The same argument holds good of a central board or a national council. The conditions which affect the economy of work and of living on a purely London railway contrast greatly with those on the Highland, or, say, the Cambrian railway, and thus separate treatment for each company must be agreed upon. If the men seek for redress of grievances and for prosperous conditions generally for themselves, the most direct method of redress must be more efficacious. It ensures, too, readier recognition of individual merit. Difficulties are simplified by the narrowing of issues, and therefore the sectional boards will enable settlements to be more speedily evolved.

The enforcement of a settlement is quite another story; this, indeed, has been one of the great difficulties in connection with arbitration in trade disputes. In other trades, notably shipbuilding and engineering and in the case of the boot and shoe operatives, provision has been made against the non-fulfilment of agreements, but in these industries the workmen who are unionists are in a great majority, whereas in the case of the railway workers barely one-third are unionists. The machinery of the unions cannot therefore be utilised to enforce an agreement. Public opinion, however, can do much, and in view of the composition of the Commission and the high reputation of the representatives of labour upon that Commission, railway workers, unionists as well as non-unionists, and all railway directors and managers, will do well to recognise that public interests are too deeply involved in the maintenance of transport facilities to permit of any indecision in the fulfilment of this scheme of conciliation The Commissioners point out that to make such a scheme effective "there should be no organised stoppage of work until the conciliation machinery has been exhausted." Obviously this rests with the trade unions, because they alone can organise opposition to conformity with the system now proposed. It is therefore left with the Government, who are responsible for the appointment of the Commission, to devise means whereby such encouragement or assistance to break the agreement by arbitrary and violent means shall be illegal. The Commission plead for "full and ample protection" to those who desire to observe the new schemes, and say that it is not for them to prescribe how adherence to contracts can be encouraged, or how the breach of them can be penalised. Men have a right to terminate their engagement by giving lawful notice, but in the exercise of their freedom in this respect they should not, in the opinion of the Commission, be permitted to excite, or coerce by threats or by any form of intimidation, men who desire to give their labour. No stronger injunction to the Government could be made in favour of a radical amendment of the Trade Disputes Act. Moreover, the Commission point out that strikes have taken place under circumstances which had no connection with the contract for hours, wages, or general conditions of service, nor, indeed, with the concerns of either the strikers or their employers; and here again firm action is demanded on the part of the Government. Finally, the Commission refer to the great traditions and high ideals upon which our unexcelled railway service has been built, and to the participation in this work of railway men of all grades, and urge upon all railway men, alike in the directorate, management, and in every department, their duty so to act in the future that the public will continue to regard the railway system with pride and confidence.

THE DIRECTOR OF NAVAL CONSTRUCTION AT THE ADMIRALTY.

The appointment of Sir William E. Smith, C.B., the Superintendent of Construction Accounts and Contract Work, to succeed Sir Philip Watts, K.C.B., as Director of Naval Construction at the Admiralty, now officially announced, will be approved by all interested in the Navy. When Sir Philip's resignation was foreshadowed a few months ago, we expressed the view that the claims of members of the Royal Corps of Naval Constructors should have first and earnest consideration; and we stated indisputable reasons for this contention. The splendid training—theoretical and practical—which the members of this corps undergo, the standard of ability which they have to attain, the arduous work they have to perform, in view especially of the paucity of their numbers when compared with the increasing volume of work and of responsibility involved, and the general success of their designs and

supervision, warrant confidence and recognition on the part of the Board of Admiralty. Moreover, it is doubtful if the scale of remuneration is adequate, or the available rate of promotion commensurate, owing to the unduly limited number of officers occupying the higher ranks. If to this state of the case, the accuracy of which is widely acknowledged, there had now been added such lack of recognition as would have been established by the ignoring of the claims of the Royal Corps to provide a chief of the staff, and by the appointment of a naval architect from the outside, the spirit of emulation might have been damped, although the *esprit de corps* is so important a factor in the efficiency of this department of the Service. One must not ignore, too, the national disappointment which would have been possible in the event of it having been found impracticable to choose a chief from among the members of the corps. May we assume that the choice of Sir William Smith is indicative of a more liberal spirit on the part of the authorities towards the claims of the Royal Corps for fuller acknowledgment of the services they render to the State ?

Apart altogether from his position in the Royal Corps, however, Sir William Smith merits the honour of his preferment by his professional ability, tact, and administrative capacity, which have been well proved in the important office he has filled during the past nine years. In him is combined in an eminent degree the combination of practical and theoretical knowledge essential to the work of design. He has sound engineering instincts ; he entered the industry through the "hawse-pipe," to use a naval simile, and after an all-round practical training, achieved high distinction during his diligent pursuit of scientific knowledge. He has a high repute as a practical mathematician. Moreover, he has spent all his life in the Service, for he began when eleven years of age, and the only regret is that he cannot long give the Navy the benefit of his work in the highest post the Service can bestow on a naval architect, since he is now in his sixty-second year. After being a boy in the rope-house at Portsmouth Dockyard, he served four years' apprenticeship as a shipwright—one year, 1865, at Woolwich, and three years at Portsmouth—joining, in 1869, the South Kensington School of Naval Architecture. There he finished his course in 1873, being one of the last to complete the full term before the transfer of the school to Greenwich. He graduated with the high distinction of a first-class professional certificate, and was immediately appointed to the Admiralty staff. His immediate predecessors in the directorate of naval construction passed out of the school before him, and all three were at the Admiralty together. He was at once engaged upon the design work in connection with the battleships of the 'seventies, when great developments had to be made owing to the improvement in armour and propelling machinery. He succeeded Sir William White in the early 'eighties as instructor in naval architecture at Greenwich College, and won special distinction, during the controversy on partial and complete armour belts, by a series of lectures on "Armour," delivered at the college, and issued by the Admiralty for the information of all officers in the Service. In 1887 he became Inspector of Contract Work, and thus early was brought into close contact with the shipbuilding establishments throughout the country, which must have afforded a splendid means of training for a future Director of Naval Construction. He returned to the Admiralty later as a chief constructor, and was occupied on the design of some of the vessels of the Naval Defence Act, and of the more important ships built later for the Navy. In 1902 he was appointed Superintendent of Construction Accounts and Contract Work, an office which afforded him further opportunities for acquiring experience. At the same time he succeeded in extending amicable relationships between the Admiralty and the contracting firms, so that, alike for his personal as well as for his professional qualities, his appointment now is welcomed by all naval architects, whether associated with the Navy or in private service. He was made a C.B. in 1903 and a knight in July last.

The further announcement is made officially that, "at the request of the Lords Commissioners of the Admiralty, Sir Philip Watts will still be available as adviser to the Admiralty." This is a recognition of splendid service rendered to the Navy and practical shipbuilding generally — a service which we reviewed some time ago when his resignation was first intimated (see page 73 *ante*). Moreover, it is no disparagement to Sir William Smith to say that in an advisory capacity Sir Philip can render useful service to the Navy. These two distinguished naval architects have been closely associated for many years ; they differ in characteristics, are close friends, and the arrangement now made will in, their case, be of distinct benefit. From all points of view, therefore, the Admiralty have, in their arrangement in connection with the Directorate of Naval Construction, succeeded in winning the approval of all who seek for progress in warship building.

THE ROAD BOARD.

The Road Board has just issued its first report, which is mainly devoted to a discussion of questions of policy. These required much consideration. The income of the Board is estimated at 600,000*l* per annum, but the proposals to which it was asked to give financial support would have required an expenditure of no less than 7,870,459*l*. The difficulty of apportioning the funds was enhanced by the claims made by the different nationalities and counties for preferential treatment, Ireland, in particular, being very insistent on getting a larger share of the grant than the Road Board have deemed just. Irish roads, so far, have suffered relatively little from motor traffic, and the actual amount contributed by that country to the funds of the Board is so small that any division on an equitable basis would have made impossible any early improvement in the Irish highways. Hence the Board have determined to apportion, between the nationalities concerned, the funds at their disposal on a basis of population rather than to adopt the plan of equitably returning to each country, as grants in aid, the amount it has contributed to the finances of the Board. This in effect amounts to England and Wales contributing a substantial subsidy to the improvement of the Irish roads ; but, in spite of this, claims for a still larger one were vehemently pressed on the Board by the Irish County Councils. In the general scramble for aid, the Metropolitan district, as usual, comes off somewhat badly. This area contributes a very large proportion of the total revenue of the Board, and improvements in the approaches to the Metropolis are urgently required. Since, however, this area is proportionately much unrepresented in Parliament, the Road Board would undoubtedly have been subjected to insupportable political pressure had they adopted the plan of distributing their funds *pro rata* amongst the contributory areas, and, as a consequence, London is to pay heavily in other areas for road improvements which are not more urgently required than others of immediate concern to herself.

The Board have adopted the wise resolution not to bear the whole cost of improvements, but to compel the local authorities to share in the expense. In general, the Board will contribute 75 per cent. of the cost ; but where the bad state of the road is due to past neglect, they reduce this proportion accordingly. Had they agreed to carry the whole cost of the proposed improvements, they would have required an enormous staff to ensure against waste and needless expense ; but when a substantial fraction of the total is contributed by the local authorities, the latter have every inducement to avoid unnecessary expenditure.

The arguments advanced by some of the local authorities, who demanded that the Board should bear the whole cost of improvements, were often not a little curious. They took the line that in asking the highway authority to bear a fraction of the cost, the Board were, in fact, imposing additional expenditure on them. They claimed that many of the works, for which applications were made, had no interest to the local residents. If so, however, as Sir George Gibb remarked, why make an application ? It is the business of the local authority to attend to local needs, and if these do not demand any improvement in the roadways, there is no reason why either the Road Board or the highway authority should spend money on what is not required.

The Board have decided for the present to make no new roads, nor, indeed, to ameliorate bad corners. There are, they state, many such in urgent need of improvement, but such a condition is not general, whereas the troubles which have arisen from the defective character of the road crusts are widely prevalent, and it is on the improvement of these that the Board propose in the first instance to concentrate their efforts. With a properly made road, they state, motor traffic "probably causes less wear and tear than is caused by horse-drawn traffic." With the latter, however, a "water-bound" road will more or less do, but a motor requires the use of a bituminous binder. When this is properly applied, however, it appears that the cost of road maintenance can be remarkably reduced, and the main difficulty arises on the score of initial cost, though there is in some cases a minor one from the incompetence of some road surveyors. An interesting instance of the advantages of motor traffic in reducing wear is afforded by the recent decision to repave Piccadilly-circus with wood in place of granite sets previously used. This has been rendered financially possible by the recent great reduction in the horse-drawn traffic, and we may add that the improvement of the Kingston-road through Wandsworth, fitting it to carry heavy motor traffic, has led to a remarkable saving in the cost of maintenance.

The Board issued, in the first instance, a provisional scheme for their proposed improvements, on which they asked the criticism of the local authorities, as the result of which a number of emendations have been made. As a matter of policy they have further decided for the present not to make grants in aid of street-widenings in populous areas. There the traffic which is congested is largely of local origin, and the relief should, they consider, be afforded by the local authorities. On the other hand, in many villages the existing roads are quite inadequate to accommodate the great growth of through traffic, and here the Board will, as circumstances permit, give assistance.

One of the most interesting announcements made in the report is to the effect that the Board have decided to continue and extend the valuable researches on road materials, commenced some years since by Mr. E J. Lovegrove, of Hackney, in conjunction with Mr. J. A. Howe and Dr. Flet, of the Geological Survey. The work will be carried out in the main at the National Physical Laboratory, where a complete testing plant is to be installed at a cost of about 1850*l*. The Geological Survey has also agreed to assist, and will report upon the petrological character of the materials tested, and store specimens for future reference.

JET PROPULSION.

It is probable that there are many engineers who would be somewhat startled by the assertion that jet propulsion is the most efficient method yet devised of propelling any type of vessel ; and yet, if attention is directed solely to the jet itself, the statement is strictly and indisputably true. If, for instance, a vessel could, whilst standing still, pump into large air vessels enough water to carry her through to her destination, propulsive efficiencies of the order of 80 per cent. or more would be readily realisable. The whole trouble arises from the fact that the boat must pick up water as she moves. The drawbacks to this are both theoretical and practical. Thus theory shows that in the case of a tank propelled by the reaction of a jet issuing from an orifice at its rear, the efficiency of the jet would be unity when the speed of motion was half the speed of flow. If, however, the tank has to pick up its water as it goes, the efficiency will, at most, be only two-thirds when the travelling speed is half the speed of issue. The latter is, no doubt, a reasonably high value, considerably in excess of that of the ordinary screw propeller, but in the case of the latter the efficiency is an over-all one, whilst in the case of the jet, to its own losses must be added those involved in the means employed to capture the water, increase its velocity or pressure by pumps, and to deliver it finally to the jet. These losses have commonly been very large, and there seems little prospect of any serious improvement being effected. In fact, the difficulty in some respects resembles that which arises in coupling a steam-turbine to a screw-propeller. To be efficient the power-generating machine should handle a small quantity of water at a very high pressure, which means a high velocity of discharge. This was realised some twenty years or so ago by an American inventor, who installed, on a launch, pumping machinery designed to produce a jet to be delivered under a head of over 3000 ft. This portion of his plant was no doubt extremely efficient, and its designer had the most sanguine

expectations as to effecting a revolution in methods of ship propulsion. Being, moreover, unacquainted with mathematical principles, demonstrations thereby of the utter futility of his ideas failed to discourage him, and the experiment was accordingly tried on a very liberal scale. The result, of course, was a foregone conclusion, the efficiency of his pumping plant being wholly obliterated by the pitiful inefficiency of the jet produced. What is needed to solve the problem of jet propulsion is some means of handling the water on board ship in small volume, and at a correspondingly high pressure, and of then transferring the energy of this mass to a larger body of water, which should form the actual jet. An obvious proposal is to use something of the nature of an ejector, but it is easy to show that in this case the thrust of the large mass sent astern is at the best no greater than that of the original high velocity jet, so that the arrangement is in actual fact considerably worse than would be the direct application of the latter. Another suggestion, plausible at first sight, is to pump the water at a high velocity, and hence through pipes of moderate diameter, and then discharge it astern through a divergent nozzle, thus getting the desiderated low velocity of discharge. The trouble with this plan lies in the fact that the pressure of the jet at the discharge end of the nozzle must be that of the atmosphere (assuming the discharge takes place above water-level), and therefore the pressure at the throat must be less than this. What is required to secure compact pumping machinery is, on the contrary, a high-water pressure, since the energy is proportional to the product of the pressure and the volume, and it is the latter which is the governing factor in the cost and weight of the machinery employed.

We are not therefore sanguine that it will prove feasible to apply successfully any known form of pump to ship-propulsion on the water-jet system. Should, therefore, the Humphrey internal-combustion pump prove as economical for large outputs as it has already done in the smaller sizes, it seems probable that any attempt to adapt it to ship-propulsion will take the form of using the discharge from the pump to drive a turbine, and let the latter drive an old-fashioned screw. The advantage of such a method lies in the fact that the volume of water on board, at any time, might be very moderate in quantity. The losses in getting it on board, which are a large proportion of the head corresponding to the ship's speed, are thus minimised, and a compact and relatively efficient plant should result.

It may be objected that this system is complicated, but occasionally the "longest way round" is really the "shortest cut." An internal-combustion pump will not be applied to marine propulsion unless its own efficiency is so high that a substantial saving of coal can be effected. The problem to be solved is, in fact, twofold. In the first place, it is necessary to have an efficient means of producing power, and, in the second, an efficient method of utilising it. With jet propulsion pure and simple the two elements of the problem make incompatible claims. Owing to considerations of cost and weight, an efficient pump means in practice an inefficient jet, and *vice versa*. If, however, a high-pressure Humphrey pump can be designed which will yield 1 horse-power at, say, 25 per cent. less fuel cost than a good marine engine requires to develop 1 shaft horse-power, the combination of turbine and screw becomes a commercial proposition, and the plan of effecting the ultimate propulsion by a jet can be dismissed.

In a paper read on the 13th inst. before the Manchester Association of Engineers, Mr. Rankin Kennedy advocates another solution of the problem. His proposal is to use centrifugal pumps of a modern design, for which he anticipates over 80 per cent. efficiency. We do not know of any low-lift centrifugal pump with such an efficiency as this, and a low-lift pump would be required in practice. Possibly 75 per cent. might be reached with very careful design, but it would mean an enormous pump with large diffusion chambers. Mr. Kennedy suggests that a centrifugal pump is "essentially a pressure pump, in which the velocity of the fluid is low, whatever the head pumped against." This statement, we think, is calculated to convey a wrong impression, since, as Rankine pointed out years ago, half the energy of the fluid in a forced vortex is pressure energy, and the other half kinetic, so that the velocity is $\frac{7}{10}$ths of that due to the maximum head.

If the water taken into the vessel is brought to rest relatively to the vessel, a velocity head equal to $\frac{s^2}{2g}$ (s being the speed of the vessel in feet per second) must either be destroyed or converted into pressure head. This conversion Mr. Kennedy proposes to effect by letting the water enter the centrifugal through a divergent nozzle. The latter is, however, likely to prove a very inefficient device. Unless the taper is kept below about 1 in 10, the losses become enormous, and we hope shortly to publish a description of a very important and careful series of experiments, by Professor Gibson, which showed that unless this limit was adhered to, the loss was actually greater than when the whole of the reduction of velocity was effected by a sudden enlargement of the pipe.

There remains one other possible plan of operation —viz., not to bring the water to rest in the vessel, but to let it enter the impeller of the pump with its initial relative velocity. This, Mr. Rankin Kennedy claims, is an inefficient method of operation, and this is, perhaps, true. The method, however, is exactly that on which the ordinary screw-propeller operates. The latter, it is known, has no appreciable centrifugal action. It takes in the water (apart from the wake correction) at the speed of the ship, accelerates it, and discharges it astern; working very much in the same way as if completely cased in.

THE MINERAL WEALTH OF KATANGA.

Katanga is situated at a considerable height above the level of the sea (4260 ft. to 4920 ft.) and forms the watershed between the Zambesi and the Congo —that is, between the Atlantic and the Indian Ocean. Forming the southern portion of the Congo State, it adjoins, to the south and east, Rhodesia. The ore deposits go from east to west over a distance of some 220 miles, with a breadth of as much as 280 miles, the district of Kambove being considered their centre. The southern extension, which penetrates a long way into Rhodesia, is also remarkable for its wealth of minerals. It is more especially Katanga's fabulous wealth in copper which makes it of such importance internationally. As long as six years ago the copper ore deposits of some 120 findings were estimated to contain 15,000,000 tons, and since then it has become manifest that this figure is much too low. It has even been asserted that Katanga single-handed could supply the world's aggregate requirements of copper for a period of a hundred years. Gold, too, is found in large quantities (estimated in value at 200,000,000*l*.), also platinum, silver, and zinc.

The immense mineral wealth of the Katanga soon attracted the attention of capitalists, but so far with no favourable financial results, the reason being due to the difficult position of Katanga as regards the export of metals or ore. The country is located almost in the centre of Southern Africa, and the shortest distance to the coast is some 1130 miles. The construction of a railway to some port on the east or west coast would be attended by almost insurmountable difficulties, as the line would have to be taken through unexplored districts, peopled by hostile natives, and through States where there was no available railway connection. There being no chance of an outlet either to the east or the west, the Cape - Cairo Railway, almost unexpectedly, brought the wished-for relief. Since December 12, 1909, the most southern part of Katanga, by a branch line, has been connected with this railway; and as this line already a year and a half ago reached Elizabethville, the road to the sea is now open. In some two years the railway is expected to reach Kambove, the heart of Katanga. Cape Town is out of the question as a shipping port for Katanga minerals, &c., the distance between Kambove and Cape Town being some 2200 miles, and in the meantime the first transports of Katanga ore will take place by way of Bulawayo, on the Bulawayo-Beira Railway, to the latter (Portuguese) port on the Indian Ocean. This distance, however, is also formidable, being 1740 miles, and in order to reach Europe or America the ore has to pass through the Suez Canal, or go round by the Cape, so export can only take place as far as particularly valuable ores are concerned. It is believed that ore containing 25 per cent. of copper can with advantage be shipped by this route. The percentage of copper in the Katanga ore varies from 7 to 30 per cent., averaging some 12 to 15 per cent. This, compared with copper ore from other countries, is a very high percentage (the Spanish ore, for instance, only contains 2½ per cent.), yet it is insufficient to make export of the ore remunerative.

The projected extension of the Benguella-Angola Railway eastwards, so as to bring about a connection with the Cape-Cairo Railway or the Katanga branch line will, however, improve matters, inasmuch as the distance from the Kambove copper ore deposits to the sea will be reduced to 1130 miles, and that of the Etoile du Congo Mine to 1200 miles. This, too, is a substantial distance, but then the cheaper and shorter waterway to Europe and America comes into consideration, and will probably make it possible to export also ores with a medium percentage of copper. The inferior ores must then be dealt with on the spot; Katanga does not herself possess any coal deposits, the nearest deposits being those of German East Africa, a distance of 440 to 500 miles. There is, however, no railway connection, and the Wankie coal deposits in Rhodesia are some 930 miles distant.

We learn, however, from a German report by Dr. Hennig that the possibility of establishing an export route from Katanga by means of the Lulua and the Kassai, auxiliaries of the Congo, has of late been under contemplation; this would be in connection with the railway from Stanley Pool to the port of Matadi. The distance, Lusambo-Leopoldville, about 625 miles, is already navigable.

THE AUSTRALIAN NAVY.

The flagship of the Australian Navy, appropriately named the Australia, was launched on Wednesday of this week from the Clydebank Shipbuilding Yard of Messrs. John Brown and Co., Limited. The occasion was quite justifiably celebrated as a great Colonial event, and Sir George Reid, the High Commissioner for the Commonwealth, with many Colonial and Admiralty officials, attended, the honours of the day being performed by Lady Reid, who is an Australian, although her husband is a Scotchman. The ship, with three second-class cruisers of 25 knots speed, six destroyers and three submarine boats, will form one of three units of a Pacific squadron, the other units, of corresponding composition, being provided by New Zealand and the home country, the latter unit to be identified with India. The Australian and New Zealand ships, designed by Sir Philip Watts, K.C.B., are being built under Admiralty supervision, but will be paid for by the Colonies, and will be utilised primarily for the defence of the island continents of the Pacific, but doubtless will conform to any scheme of strategy which may be deemed prudent when Imperial supremacy is challenged. In the policy pursued the Australians have adopted quite different procedure from that preferred in Canada, where up till the present there has been a preference for the construction of a fleet within the Dominion in order to develop the shipbuilding resources. Much can be adduced in favour of this idea; and even Australia aims at the foundation of shipbuilding, or at least ship-repairing, resources, so that although two of the destroyers have been built in this country from designs by Professor Biles—one by the Fairfield Company and the other by Messrs. Denny, of Dumbarton (see Engineering, vol. xc., page 404)—the third has been sent in pieces to Australia, there to be put together, a process which will educate Colonial workers. The same procedure will be adopted with one of the smaller cruisers; the others are being built—the Sydney by the London and Glasgow Company, on the Clyde, and the Melbourne by Messrs. Cammell Laird and Co., at Birkenhead.

The cost of the fleet will not fall far short of four millions sterling, while the expenses of maintenance will be about 750,000*l*. per annum; and Lord Aberconway, the chairman of Messrs. John Brown and Co., Limited, in referring to the patriotic munificence of the Australian Colonies, found satisfaction in the fact that although the population of the Commonwealth was less than that of London, they were readily bearing this burden in addition to the normal calls of Government—a sacrifice which he felt would not be made by the Metropolis. He found two-fold reason for the organisation of this fleet in the desire of the colonists to defend their territory against attack and to support the rest of the Empire's naval forces. This was in conformity with Imperial policy, which included —(1) the maintenance of a fleet unsurpassed,

THE AUSTRALIAN CRUISER "AUSTRALIA."

CONSTRUCTED BY MESSRS. JOHN BROWN AND CO., LIMITED, CLYDEBANK, N.B.

Fig. 3.

unequalled, unconquerable—more than sufficient to meet any combination of armed Powers that could reasonably be supposed to come together to attack our Imperial interests; and (2) the ensurance of absolute autonomy in every component part of the Empire. Sir George Reid went further, and sought to disarm foreign suspicion by pointing out that, although Australia was thousands of miles from any probable war centre, the colonists recognised their obligations to the Empire, and were eager to maintain the flag of the mother-land. Indeed, throughout the speeches appropriate to the occasion there was as the dominant note the truism "to maintain peace, prepare for war," quoted by Lord Aberconway. Thus it was further recognised that this part of the Australian navy was but a beginning of that large scheme sketched by Admiral Reginald Henderson, who was present, involving the creation within twenty-two years of a fleet of eight armoured ships, ten protected cruisers, eighteen destroyers, and twelve submarine-boats, at a total first cost of 23 millions, a *personnel* of 15,000 men, and a maintenance charge of 1,226,000*l*. per annum.

Australia has begun well, because the flagship launched this week, as illustrated on page 566 and this page, will prove a most useful ship. Like the New Zealand and the Indefatigable, which latter will most likely form part of the Pacific Squadron, the Australia has a length over all of 590 ft., between perpendiculars of 555 ft., and a beam of 81 ft. 6 in. The displacement tonnage is 18,800 tons at 26 ft. 6 in. draught. These dimensions are less than those of the Lion, which was ordered earlier than the colonial ships, but was designed for other contingencies. The armament is equal almost to that of a Dreadnought battleship, there being eight 12-in. 50-calibre guns and sixteen 4-in. quick-firing guns, with two submerged torpedo-tubes. The eight big guns can be fired on either broadside, and six ahead or astern. The midship guns are mounted on the beam, but *en echelon*. This is the principle adopted in the three first cruisers of the type and known as Invincibles. But a greater distance separates the guns in the longitudinal line in the newer vessel, and hence the length of the hull has been increased by 25 ft. and the displacement by 1550 tons. The Parsons turbines for driving four shafts, each with three-bladed propellers, as shown in Fig. 2, have been increased in size and power to 44,000 shaft horse-power in order to ensure the same high speed, and although the vessel is of 25 knots legend speed, a rate of 26 to 27 knots is anticipated. Thus the Colonials may accept the view that their ships will be equal to the best that the money provided can secure.

The launch was in every way successful; that is only to be expected, from the experience and traditions of the Clydebank yard. Although none of the armour is in position, several of the boilers, which are of the Babcock and Wilcox type, are on board, and the vessel generally is in such a state of advancement that no difficulty should be experienced in completing it within the contract time, which does not expire until a year hence. The tonnage at the time of the launch was about 7000 tons. The vessel was cradled in the usual manner on 6-ft. ways (Fig. 3, above). This width of ways was used as a matter of convenience, and not from the necessities of the case, because, as is well known, ships can be, and are, successfully launched with pressures upon the ways up to 3 tons per sq. ft., whereas in this case the figure was less than half that amount. The declivity of the ways averaged $\frac{39}{64}$ in. per foot. The releasing gear was of the usual forged steel pivoted-lever type, actuated by an electromagnet. The time occupied in launching from start to flotation was 72 seconds, quite a substantial proportion of which time was taken in moving the first foot, and in tripping the blocks left under the keels. Four drags of piled-up cables were used on each side of the ship, making up 480 tons, and these brought the ship to rest with the bow at 100 ft. from the end of the ways. Subsequently the ship was towed into the fitting-out basin, there to be completed.

NOTES.

The Marine Oil-Engine.

The application of the internal-combustion engine for the propulsion of ships is making progress, steady, if slow, and it is noted in the annual report of Lloyd's Register that there are now being built twelve merchant ships fitted with oil-engines. The largest for registry with this society is to be of 8000 tons gross, and five others are to be of 4500 tons gross register and upwards, so that in a year or so much important data will be available regarding the reliability and economy of such engines in long over-sea voyages. It should be added also that several vessels are being built under the supervision of other registry societies. So far two oil-engine-propelled ships have made over-sea voyages—the Toiler to Canada and the Vulcanus from Rotterdam to the Black Sea and back, and promising results have been got. As to the design of engines there is wide divergence, although practically all are on the Diesel principle. A double-acting two-stroke-cycle engine for one of the largest ships referred to has been erected, and is undergoing shop trials before being fitted on board; but most of the other engines are of the single-acting type, adapted for the two or the four-stroke cycle. The double-acting engine has attractions; but it remains to be seen how the difficulties, notably of the stuffing-box, are overcome. Certainly many shipowners, and still more marine-engine constructing firms, are watching developments, ready to take definite action provided encouragement is afforded by the results. It is gratifying also to find that Lloyd's and other registry societies are alive to the importance of the subject, and distinctly sympathetic in their attitude. This is most desirable, especially in the case of Lloyd's, in view of their great influence, which is clearly established by some of the facts in the annual report. For instance, the tonnage registered by this society alone totals 21,060,070 tons, representing 10,400 ships, over 95 per cent. of the tonnage being steel steamers. The number registered during the year was 616, and the tonnage 1,098,476 tons, and of these five were over 10,000 tons, ranging up to the Cunard liner Franconia, of 18,150 tons, while at present there are being built the Cunard liner Aquitania, of 45,000 tons gross, and ten others ranging from 18,000 to 10,000 tons. Another interesting fact is that now 1013 vessels registered by Lloyd's are fitted with wireless telegraphic apparatus, and 566 with submarine signalling apparatus.

The Mid-Scotland Ship-Canal Scheme.

The proposal to construct a ship-canal between the Forth and the Clyde sufficient in dimensions to pass the largest of warships has advanced a stage, the Glasgow Corporation, at their meeting on the 19th inst., having appointed a committee to consider and report as to the steps that should be taken in the matter in the interests of the city. This step is absolutely non-committal, but it will at least assist towards the accumulation of data and the preparation of accurate estimates of cost, of possible strategical value, and of probable revenue. Whether the Government will be influenced is quite another matter. The Royal Commission on Canals and Waterways, it may be remembered, indicated that the canal was desirable, but were not disposed to advise the Government to proceed with the scheme, unless financial support could be obtained from Glasgow and other towns on the route. Such towns have supported the scheme by resolution, which is a long way from financial commitment, and it remains to be seen now whether the city of Glasgow will follow the example of the city of Manchester. In the latter case municipal support was given, under preferential conditions, after the Canal Company had done all that could reasonably be expected of private enterprise, and to avoid a commercial catastrophe. With the Scotch scheme the Corporation will act initiatively. One point which simplifies the decision of the municipality is the recent agreement between the advocates of the rival routes. Formerly there were competing schemes, one *via* the Forth Valley to Loch Lomond and thence through a cutting to Loch Long and to the estuary of the Clyde, the other by direct route to

the river near Glasgow. This latter route naturally commended itself to the citizens, and now all promoters are uniting their forces, under the direction of the Mid-Scotland Ship-Canal Association, while the engineers of the respective schemes, Mr. Stevenson, of Edinburgh, and Mr. C. P. Hogg, of Glasgow, are together working out the details for borings along the direct route with a view to estimating the cost. The engineers are considering whether the canal should be at the level of the Forth at high water or at a slightly lower level, which would involve deeper cuttings, but would simplify the terminal and locking arrangements. The route is largely along the Kelvin Valley, terminating in the Clyde about four miles below Glasgow, where there would be canting basins opening up, as well as down, the river. The arguments in favour of both schemes and the general advantages of the canal have already been discussed in Engineering (vol. lxxxvii., page 564, and vol. lxxxix., page 115), so that it need only here be added that the estimates are now being prepared for a canal having a floor width of 138 ft. and a depth of 36 ft.—dimensions which it has been ascertained would satisfy the Admiralty.

The South Manchurian Railways and the Chinese East Railway.

According to an official report the aggregate length of the South Manchurian Railway system amounts to 1136 km. (706 miles). This system comprises the south-north line Dairen (formerly Dalny)-Mukden-Kuangtschengtse, the branch lines to Port Arthur, to the commercial port of Inkou, and to the frontier of Korea at Antung. Prior to the Russo-Japanese war, the south-north line, with the Port Arthur branch line, was Russian property, and these lines were single, and for the broad Russian gauge. The Japanese, however, have transformed the lines which came into their possession to ordinary gauge, and with double roads. The railway from Mukden to Antung was, in the first instance, only temporarily rebuilt to serve military purposes and establish a connection with the mother-country, but it has since been completed and opened for general traffic. The South Manchurian railways are being managed by the South Manchurian Railway Company, which has a capital of 200,000,000 yen, or close upon 21,000,000*l.*, of which the greater portion is held by the Japanese State. Already, in the financial year of 1908, and prior to the Mukden-Antung Railway being opened for traffic, the company had net profits amounting to about 400,000*l.*; the passenger traffic then amounted to some 1,500,000 passengers, and the goods traffic to 1,500,000 tons, which figures rose in the following year to respectively 1,868,640 passengers and 2,629,815 tons, the receipts amounting to 15,537,142 yen, or about 1,310,000*l*, and the expenditure to 5,161,408 yen, or about 540,000*l.*, the net profits being 7,375,734 yen, or about 770,000*l.*, averaging 678*l.* per kilometre. The aggregate length of the system of the Chinese East Railway is 1717 km., of which 1480 km. are in the west-east line Manchuria-Harbin-Prograniitschuaja and 237 km. on the south line Harbin-Kuangtschengtse. The Chinese East Railway has been built by Russian engineers and is managed by the Chinese East Railway Company, in which only Russians and Chinese are interested, the majority of the technical officials of the railway being Russians. The Chinese Government has the option of buying the railway in the year 1932, and in the year 1976 the railway will in any case pass into the possession of the Chinese. Since the southern portion of the Chinese East Railway from Kuangtschengtse has become Japanese the company has had to contend against more or less serious financial difficulties. In the year 1906 the goods traffic on the Chinese East Railway amounted to 428,793 tons, in 1907 to 445,681 tons, in 1908 to 549,507 tons, and in 1909 to 655,200 tons, exclusive of the military traffic. These figures do not compare favourably with those of the South Manchurian Railway. In 1904-5 the Chinese East Railway was almost entirely taken up with war traffic, and in 1906 came the return traffic of soldiers and war material, during its first half almost without interruptions, and afterwards with some breaks, so it was not till 1907 that more normal conditions by degrees were brought about. The increase in the goods traffic on the Chinese East Railway is closely connected with the growing activity of the port of Vladivostock and the increased export of grain from Southern Manchuria *via* this port. In addition, it is also influenced by various new developments in Northern Manchuria, in Trans-Baikal, and in the province of Usuri.

ARGENTINE RAILWAY AFFAIRS.

The Buenos Aires Western Railway, Limited, had a good time in its financial year ending June 30, the gross revenue collected having been 2,634,186*l.*, as compared with 2,300,510*l.* in 1909-10. The working expenses increased to 1,392,318*l.*, as compared with 1,300,317*l.*; but the twelve months representing 1910-11 produced a net revenue of 1,241,868*l.*, as compared with 1,000,193*l.* After full provision had been made for the fixed charges of 1910-11, a balance of 737,154*l.* remained available for dividend. Out of this balance the ordinary stock will receive 7½ per cent. for 1910-11, 120,000*l.* being carried to the general reserve fund, 15,000*l.* being allocated for philanthropic purposes, and 189,098*l* being carried to the credit of 1911-12. It is right to remark that the system was extended to 1586 miles in 1910-11, as against 1365 miles in 1909-10. In 1901-2 the company had only 628 miles in operation, so that the expansion of the undertaking during the last ten years has been great and continuous. The new lines brought into working have not only produced a considerable revenue by themselves, but they have also increased the earning power of the old lines, the receipts per mile in working having grown from 1493*l.* in 1901-2 to 1661*l.* in 1910-11. The ratio of the working expenses to the traffic receipts has been kept well under control, having only advanced from 48.52 per cent. in 1901-2 to 52.86 per cent. in 1910-11. The yearly ratio since 1906-7 inclusive has been :—1906-7, 56.25 per cent.; 1907-8, 55.08 per cent.; 1908-9, 55.28 per cent.; 1909-10, 58.52 per cent.; and 1910-11, 52.86 per cent. An advance of the balance available for dividend upon the ordinary stock from 357,934*l.* in 1901-2 to 1,029,583*l.* in 1910-11 shows that the large expenditure of capital made during the last ten years has been judicious and profitable. Every effort appears to have been made to work the system as economically as possible, the large amount of additional revenue acquired in 1910-11 having been obtained with only two additional engines, the locomotive stock having been carried from 310 at the close of June, 1910, to 312 at the close of June, 1911. It may be interesting to note that the 312 locomotives upon the system at the close of June this year were of the following designs :—Local tanks, 42; four-wheeled coupled, with tenders, 43; mixed six-wheeled coupled, 71; goods six-wheeled coupled, 84; goods eight-wheeled coupled, 40; shunting, 32. The working expenses were increased to the extent of 10,149*l.* in 1910-11 by torrential rains, which caused overflows of the Las Conchas and Riachuelo in April and May. The extensions which the company has in hand are making good progress, but they do not present any very special feature. As regards the existing lines of the undertaking, hard-wood way beams upon eighteen small culverts have been replaced with iron troughs. About 20 miles of single track have been relaid with 85-lb. rails and new hard-wood sleepers; half a mile of sidings at Lujan has been renewed with 70-lb. rails; about 3½ miles of line at nine stations have been renewed with 80-lb. rails; and 4½ miles of single-track near Olascoaga have been ballasted with burnt city refuse. Seven miles of single track on the Carhué branch have been re-ballasted with black earth; about 3½ miles of single track between Bragado and Olascoaga, and 65 miles between Timote and Pico have been strengthened by the addition of two extra hard-wood sleepers per rail length; and a mile of single track between Metileo and Trenel has been strengthened by the addition of two extra steel sleepers per rail length.

The Buenos Aires Great Southern Railway also made a good year's work of it in 1910-11, the revenue collected having been 4,988,380*l.*, as compared with 4,601,924*l.* in 1909-10. While there was an increase of 386,456*l.* in the receipts, the working expenses only advanced from 2,516,752*l.* to 2,694,027*l.* The net revenue was, accordingly, larger by 209,181*l.*, coming out as it did at 2,294,353*l.*, as compared with 2,085,172*l.* The ratio of the working expenses to the traffic receipts declined last year to 54.01 per cent., as compared with 54.69 per cent. in 1909-10. The ratio attained its highest point in 1906-7, when it stood at 57.58 per cent.; in 1901-2 it was only 46.25 per cent. As in the case of the Buenos Aires Western Railway, the Buenos Aires Great Southern Railway owed, no doubt, something of its very appreciable revenue increase to the opening in the course of last year of fourteen extensions, representing altogether 356 miles of line. At the same time there is little doubt that the older lines are growing in productibility, the revenue of the undertaking having expanded from 2,373,569*l.* in 1901-2 to 4,988,380*l.* in 1910-11. The average length of line open last year, including lines worked under agreements, was 3044 miles, as compared with 2770 miles. The number of locomotives upon the system showed no change last year, remaining, as it did, at 546. This total, it may be added, was made up as follows :—Tank passenger-engines, 46; simple express, 5; compound six-wheeled coupled, 41; six-wheeled coupled compound mixed, 142; four-wheeled coupled simple, 43; four-wheeled simple mixed, 43; four-wheeled coupled compound mixed, 49; eight-wheeled coupled compound goods, 70; six-wheeled coupled simple goods, 28; six-wheeled coupled compound goods, 47; and shunting, 75. That an average of 270 more miles of line was worked in 1910-11, with no addition to the locomotive stock, shows that every effort was made to get the utmost possible amount of work out of every engine. The quantity of coal consumed per engine-mile run in 1910-11 was 40 24 lb., as compared with 39.43 lb. in 1909-10; the increase observable was due to heavier trains having been run. Practically the whole of an extension programme authorised by the proprietors in October, 1908, has now been completed, with the exception of a line from Neuquen to Chili, surveys for which are still being proceeded with, as the line will have to cross the Andes. In addition to lines constructed under the original extension programme, other short branches from Saladillo to the south-west, and from Dorrego to the east, have been built. Altogether 603 miles of new line have been completed and brought into operation since the authority of the shareholders was obtained in October, 1908. During the past year bridges and spans were renewed on the Chascomus and Maipu and the Lobos and Saladillo sections; a timber viaduct over the flood opening in the Neuquen valley also received important repairs. Work is proceeding on a transporter bridge over the Riachuelo, and the sinking of the cylinders is now well in hand. An installation for discharging coal from steamers, consisting of two Temperley transporters, and a bunker with a capacity of 10,000 tons, has been completed. The remaining portions of light permanent way between Las Flores and Tandil are being renewed with heavy rails on steel sleepers. The general results worked out are certainly highly satisfactory.

Compulsory Fitting of Rubber Tyres on Commercial Motor Vehicles. — A rumour having been current that an Act of Parliament was to come into force on January 1 next to compel owners of commercial motor vehicles to fit solid rubber tyres to their vehicles now running on steel wheels, a letter was addressed by the Motor Users' Association to the Local Government Board on the subject, the reply being that the Board knew nothing of such an intended Act, nor had any such Act been contemplated.

Guide to Patents, &c.—Messrs. J. S. Withers and Spooner, chartered patent agents, of 323, High Holborn, W.C., have sent us a copy of the fifth edition of their guide to patents, trade-marks, and designs. The book contains thirty-three pages, bound in limp cloth covers, and its object is to explain briefly the necessary steps to be taken for the protection of inventions and the registration of trade-marks and designs. The fees charged for obtaining British and foreign patents are stated, and much other information likely to be of assistance to inventors is included in this little book.

The Willans-Diesel Engine.—On Monday last Messrs. Willans and Robinson, Limited, of Rugby, invited a number of guests to view one of two sets of Diesel engines, recently built by them for despatch to the Argentine, where they will be installed at the works of the Alianza Company, Limited, Bellavista. The engines are direct-coupled to alternators supplied by Messrs. Siemens Brothers, of Stafford, rated at 175 K.V.A. Under normal conditions of working the engines are capable of developing 335 brake horse-power when running at 220 revolutions per minute, and will carry an overload of 10 per cent. for a period of two hours. The contract requirements, however, called for a speed of 187 revolutions per minute, at which the normal full load of the engine is 280 brake horse-power. At Bellavista, where the engines are to be erected, the output will be less than this, since the power-house is situated at a height of 3200 ft. above sea-level. The air being correspondingly less dense, the weight drawn into the cylinder on each suction stroke is correspondingly diminished, so that the normal output here will be about 200 brake horse-power. Each engine is of the vertical type with four cylinders 15 in. in diameter by 22 in. stroke. It is single-acting and operates on the four-cycle principle. The cam-shaft operating the valves is supported on brackets from the cylinder covers, and is driven by spiral gearing from a vertical shaft, which, in its turn, is similarly geared to the crank-shaft. The latter is fitted with ring lubrication throughout, and the crank-pins are also provided with continuous lubrication. The governing of the engine is effected by holding open for a longer or shorter time the suction valve to the fuel pump. The consulting engineers for the purchasers of the plant were Messrs. Strain and Robertson, of Glasgow, and under their auspices continuous 29-hours' trials of the engines have been run before shipment, highly satisfactory results being obtained. The guaranteed consumptions were :

15 per cent. overload	..	0.44 lb. of oil per B.H.-P. hour.
Full load	..	0.44 lb. " "
¾ load	..	0.46 lb. " "
½ load	..	0.52 lb. " "
¼ load	..	0.72 lb. " "

We hope in a future issue to publish a fully illustrated description of the engines, and reserve further details till then.

"MOTION STUDY."

To the Editor of Engineering.

Sir,—Your issue of September 15, 1911, has duly reached me, and I have read with much interest, and have to thank you for, your long editorial on my book, "Motion Study."

With your kind permission, I will now endeavour to reply to your criticism of the same. I may say that I have been favoured with dozens of reviews of my book, but yours is only the second more or less hostile opinion of its teachings I have seen.

If I occasionally use the plural hereafter, please understand that I refer to the group to which I have the honour to belong—viz., the exponents of the new science of "scientific management." Some call us "efficiency engineers," whilst others dub our methods "applied common-sense." Fortunately, your criticism is not well grounded, and after careful reading it seems to be you have adopted the mental attitude of the scoffer, which would not have been the case had your writer known more of his subject, and especially if he had seen some of the tremendous and surprising outputs that have been obtained by the study of motions.

Statements may be facts, even though we may not put them into operation, due to the opposition of those who do not know, but still oppose.

Your points are similar to those Mr. F. W. Taylor has spoken of in his remarkable paper entitled "A Piece-Rate System," and also in his other paper, "Shop Management," in which he states that neither the workman himself nor anybody else will believe the remarkable things that can be obtained by scientific management, or even by motion study, although the latter term was not invented when the books in question were written.

It is therefore not surprising, seeing Mr. F. W. Taylor recognised as long ago as 1895 that neither the workman himself, nor his employer, nor the manager, could realise the tremendous savings and tremendous increases in output that could be obtained by his methods, that you also should be a scoffer; but I think your criticism nevertheless is extremely intelligent, and that we should treat it that way. I personally am much pleased with it. We ought not to find any fault with your criticism for the reason that (1) we are right, and (2) we can back up what we have said at any time that we are called upon to do it. Now while I do not make it a practice to undertake the work as an efficiency engineer, because I devote all of my time and ability to the systematising of my business, which is the most rapid construction of large undertakings that ingenuity and practice can accomplish; yet, rather than submit to the criticism such as has appeared in this foremost of engineering papers, I would be perfectly willing personally to undertake the systematising of any big plant in England, America, or any other place within one week's travelling time of New York City, on a contingent fee that I be paid one half the saving that I can make; it being understood, however, that I am not prepared to undertake a job that is not big enough to furnish sufficient saving for me to neglect my regular business long enough to make the demonstration.

It certainly is not very encouraging to receive such criticism as is in Engineering when one considers that we are giving to the world the best secrets that we have, in the hope that the world may have the benefit of our unusual experience. As far as possible we are all trying to follow Mr. Taylor. He, by the way, works for no wages whatever, and gives his entire time to the public in the hope that he may raise the pay of the working men and increase the profits of the employers, and in this manner get the industrial peace which all countries need so much at the present time.

Your writer seems to have the idea that bricklaying is the only trade where this motion study has been applied. As a matter of fact, bricklaying has been used as a medium of illustration for the reason that it is so obvious that anybody can understand it; in fact, everybody thinks they know all about bricklaying, and consequently an illustration drawn from this simple trade, which is thousands of years old, and which up to the advent of "motion study" has been less "improved" than any other known operation, was thought to be less capable of misunderstanding than a more complex industry.

Professor Ira O. Baker, the best-known authority on masonry in the United States, whose book on "Masonry" is used as a text-book in English-speaking colleges throughout the world, states that the only improvements in masonry, as such, have been invented in the last year or two, and they are: the fountain-trowel, the packet for brick or stone, and the non-stooping scaffold, although he has not been generous enough to mention my name as the inventor when he makes this remarkable statement; but perhaps he thought the fact so well known as to be not worth mentioning in connection with these admitted improvements.

Bricklaying is by no means the only trade where motion study has been applied with such marvellous results (my men now lay 3500 bricks a day in less time and with much less fatigue than they formerly laid 1000, they work 7½ hours daily, and are paid 3s. 1½d. per hour), but similar successful results have been achieved, and quite as remarkably, in concrete work, concrete-form work, derrick and crane work, rigging, hoisting, carting, handling of heavy weights, and in many other operations, such as the working of steam-shovels, excavators, rock-drilling, &c.

It is quite the practice to-day for American manufacturers to hire motion-study experts to examine their hoisting devices and other large heavy machinery with the idea of rearranging the handles to the levers, throttles, brakes, ratchets, dogs, and other slewing and controlling devices, that they may have the benefits of the last suggestion of economy of motions.

You stated that these two matters are confused in my book; to quote accurately, you wrote:—"This being so, it is of much importance to note that two entirely different matters are confused throughout the book." Now, as a matter of fact, the two matters are not confused, although I see perfectly the writer's standpoint and viewpoints. He loses sight of the fact that the presentation of the two points—namely, (1) study and regulation of the actual motions, (2) the use of suitable tools and labour-saving appliances—are purposely presented in this manner so that the student may see that motion study will invariably predict inventions that will tend to make motion economy. In the case of the packet, the fountain-trowel and the patent scaffold cited in this article, it is of tremendous importance that motion study predicted the possibility of making this motion economy long before we were able to devise the tool, or device, or apparatus that would enable us to take advantage of the saving that was prophesied by the data taken by motion-study observations. I cannot conceive how any one can decide that the devices, such as the packet, the fountain-trowel, and non-stooping scaffold, should not be used to cite great economies that are possible as the result of motion-study when they were prophesied, predicted, and invented specially as a result of the data that was obtained by motion study. It does show, however, that the gentleman who wrote this editorial has been reading closely much of the literature. Mr. F. W. Taylor, at the Convention at Birmingham last year, called particular attention to the fact that very often people mistook the devices, and the economy resulting therefrom, as the cause of the economy under scientific management. He called particular attention to the fact that this must not be confused with the enlarged and increased output that comes as a direct result from methods of scientific management themselves. In this case my critic has entirely lost sight of the fact that in motion study there have been no devices cited, from one end of the book to the other, that have not been the direct result of motion-study data. Re-reading the book will show this most clearly, if the thought is in mind at the time of reading. Therefore these inventions are not "examples of a class of improvement which is being carried out every day all over the world by people who have never even heard of motion study."

This fact is recognised in a vague way in the next paragraph, which says:—

"In a sense, of course, all new appliances designed to save trouble and to enable operations to be carried out more quickly are developments due to motion study; but to refer to them under that name in view of the special meaning which it has come to have is simply to confuse the issues." That is not the point at all. There are a great many inventions that have been made that save motions that never were the result of definite motion study, where the type and style of the invention was predicted by the data of the motion study. I object most seriously to that statement where it says:—"He must be treated like a machine." That is misleading, unless it refers to the fact that the motions made should be made as nearly accurate as they would be made by a machine.

Let us take a very simple example of a case where the motions are not made like a machine, and let us take a flight of stairs, which nearly every body has encountered at some time during their life, where all the steps are of a different height and a different width of tread, and then attempt to go up and down easily, quickly, or both easily and quickly, and see where you land—probably on your hands and knees if you have good luck. It is not possible for any man to go up or down this flight of stairs like a machine unless they present an opportunity which will permit him to make motions like a machine, with the accuracy of the piston-rod of an engine, each time that he raises his foot or knee.

Let us take another case cited:—"If he is picking up a brick, he must do it with a certain hand in a certain way. He must be told where to put his thumb and where to put his fingers." Now, motion study shows which is the right way to pick up a brick with the thumb and fingers in the ideal position. It immediately prophesies that in some way or other the brick must be presented to that bricklayer so that he can always pick up that brick in that position, and consequently we find that under each end of the brick is the only place where it can be supported in that way; and this and a few more similar conclusions prophesy the shape of the packet as well as the fact that the bricks must be handled in a unit which is the most convenient unit and economical unit from a carrying standpoint—that is to say, a transporting standpoint, and not a standpoint of the most economical sized unit from a baking, or coal, or from a conductivity of heat standpoint at the time the brick is made.

Again: "The failure to differentiate between the saving which has resulted from motion duty and the saving which has resulted from the introduction of improved appliances greatly lessens the value of the results of his method which are given in Mr. Gilbreth's book." How would it be possible for the savings recommended as a result of motion study, as the phrase is used in this criticism, to be obtained unless that device that was shown necessary by motion study were furnished to enable the bricklayer to find the brick in that position whereby he could use the prescribed motions. This is very similar to giving the small boy a jack-knife with the proviso that he shall never open it.

The case of the pneumatic riveter herein cited is not a parallel case in any way, as it is a clever, well-thought out mechanical device which in no way has been prophesied by motion study; and it is a well-known fact that the knowledge of the most expert riveters as to where to place their feet and their hands, and the motions that they use to operate the riveter, is the cause of some riveters being able to make a very much larger output than the others, and the young learners are invariably taught exactly these motions, except with less exactness than a motion expert would advise, and thus the younger men are given the experience of the best and oldest workers, in so far as the old ones are willing or mentally able to pass on that information.

Again: "The truth of the matter as to the value of motion study, as with many other matters, probably lies in a compromise between the complete acceptance and the complete rejection." This, unfortunately, has been the mental attitude of many people since the beginning of our Courts of Justice; anyone following the verdicts of juries that do not understand the evidence will notice that there is a tremendous tendency for them to hit upon a compromised verdict, giving the plaintiff about one-half or thereabouts of what he claims, on the theory that probably he is partly right and the other side is partly right, and therefore if they cut the verdict in halves it will be about fair to both sides.

We do not ask anyone to believe what we say or to give us the benefit of any approval whatever on a compromised basis. What we demand is to be given exactly what we prove, and no more, "and if the results of such study are used in a moderate way and as an aid to suggestions, &c.," shows that the critic in this case misses entirely the scheme of motion economy. We do not want to use anything in a moderate way: it is either right or wrong, and we desire to use it in the right way whether it is moderate or not. "We doubt their efficacy, however, if they are to be used as the foundations of a cast-iron code, which is to instruct the workman as to what he is to do in every detail." The point that we desire to make is, that it must instruct the workman in the greatest possible details.

Does not the writer of the article agree with me that the correct motions must be used at *first* when one is learning the game of golf, cricket, fencing, boxing, &c.; and yet he would lay down the dictum that to teach a workman how he should make proper movements with his body or his tools, to obtain the best results, is to make him a machine. Can he explain why? Look at the hundreds of illustrated books in existence to teach learners the correct attitudes at all games, and then ask where is there similar literature for the would-be proficient workman to study. Is it not time that England should wake up?

Again, "Mr. Gilbreth mentions military training as an example of what can be accomplished by means of motion study." I did not mean "military training." I meant the motion-study training of the sabre exercise and the bayonet drill, and for anyone who doubts the efficacy of the bayonet drill I would suggest that he send three or four men with bayonets against one soldier who is thoroughly trained with bayonet exercise, and see exactly where they would land. I do not refer to military training in general. Military training does not lead to a better class of workers, and I did not intend to suggest that; but the more elastic methods of the workshop would never do in the case of the bayonet fighter against a mob.

Again: "We cannot believe ultimate good can come from codifying every movement that is to be made in the operation of one [a capstan lathe], so that the man and machine together become a sort of an automatic tool." Sight seems to have been lost of the fact that we desire to have the man taught so that he and the machine will become a sort of an automatic tool for their first lessons, and after that, we are pleased to have them deviate, in so far as such deviations will show by actual records that better methods can be determined; but it is not possible to get the same results with a man who is not trained and prepared by data to pick out the best way, and we therefore want the man to do the best way; that is to say, our standard way first until he learns it and it becomes automatic with him, and then we will pay large prizes for any improvements or suggestions that he can make.

Again: "But he will certainly tend to arouse opposition and alienate sympathy." This is unfortunate only for the other man; it in no way will oppose or stop me from continuing with what I believe to be my duty to put this information before the world, and it has nothing to do with the case whether or not "if men could but be got to adopt and live up to this theory or that, all the ills of life would disappear—no doubt they would;" this in no way interferes with the truth of the statement that if all the savings that are possible were carried out, that half of the workers of the country could be benefited.

Again: "The quite visionary nature of Mr. Gilbreth's ideas is perhaps best illustrated by the fact that one of the foremost of them is the reclassification of all the trades." This is now being done by some of the trades.

Again: "This book is, of course, concerned in American conditions, and his idea is that the United States Government should investigate motions made by working men in all trades, and should investigate the ground of the various trades, &c." This is by no means an idle dream, for the United States Department of Agriculture, Office of Experiment Station, has published Bulletin No. 208, entitled "The Influence of Muscular and Mental Work on the Metabolism and the Efficiency of the Human Body as a Machine," by Francis G. Benedict, Ph.D., and Thorne M. Carpenter, D.Sc.

This shows that the United States Government is already doing the very work predicted by me; but I want them to go still further, and get all English-speaking countries to come together for an interchange of data on motion study, for the day will surely come when the English speaking people will have to do this, or, when the Japanese and Chinese have learned how to do it, there is no doubt in the world that they will take our markets away from us.

I expect to find all kinds of difficulties from the working men who believe "that restriction of output does not increase employment."

Again: "Although one having any knowledge of the

mental attitude of labour in this country would have no difficulty in anticipating its general attitude towards Mr. Gilbreth's ideas, it is none the less interesting to have an official or semi-official pronouncement on the subject," &c. The same might be quoted to-day regarding the opposition of labour people in certain sections against machinery, but it in no way interferes with the facts of the case.

Your article, on the whole, is one of the best reviews I have seen. It has the peculiar feature, however, that it is exactly what was expected, and that the review could have been written by me before I read it; and it is exactly the conditions that confront the employer, as stated in this review, that we expect, and that we are trying to overcome in the introducing of these new methods, which the more they are discussed and criticised, and adopted, the better for all concerned.

In the last two weeks, in the face of exactly such opposition as here mentioned, in Canada I overcame the objections and the prejudices, and increased about ten men's wages from 1½ dols. to 2 dols. 30 cents per day, where the ruling wages for that class of labour were 1.50 dols., and I increased their output from 6 to 23, and, incidentally, had to overcome every one of the objections cited in your leader, and many more besides; in fact, the working-men were so suspicious from having received unfair treatment in the past, that as fast as they achieved their task of an output of 23 units they left their job, believing that there was some hidden trick to be played upon them, and it was with great difficulty that they could be persuaded to stay long enough to see that it was the economy of the motion study that enabled me to pay the additional wages for the larger output which I received *without speeding up the men*, but simply from greater economy from the motions.

If you will read "Shop Management" carefully, you will find time and time again where Mr. Taylor prophesies that the owner and the average man—in, fact, the working man himself—believes exactly as does the writer of your article.

With best wishes,

I remain yours very truly,

FRANK B. GILBRETH.

60, Broadway, New York, September 27, 1911.

[It is difficult to reply to Mr. Gilbreth's letter in moderate compass, and to attempt to deal with it in detail would involve an article as long as our original leader. As we propose, however, to return to this subject at a later date, it will be sufficient if, for the moment, we confine ourselves to the more important points which are raised. The main line of our criticism was that two radically different matters were confused throughout the book, and, while this is clearly recognised in the above letter, we cannot admit that Mr. Gilbreth has succeeded in destroying our case. We have no wish to dispute about words or phrases, and if Mr. Gilbreth contends that "motion study" means the studying of a workman's motions with the idea both of improving the appliances he uses, and of laying down a code of motions to which he and others are to conform in the future, we have no objection to adopting the same definition. This, however, does not alter the fact that savings due to improved appliances, and savings due to organised and formularised motions, are absolutely independent things. And it does not alter the fact that it is impossible to learn from Mr. Gilbreth's book how much of the saving he claims was due to improved appliances and how much to organised motions. That the study of a man's motions, with whatever object, may well lead to improvement in the appliances he uses we admit—indeed, we said as much in our article—but this does not render savings due to such improved appliances comparable in any proper sense with savings due to the organising and codifying of his motions.

The other point raised in Mr. Gilbreth's letter, which appears to demand a reply, has reference to the fact that beginners at games—golf, cricket, &c.—must be taught the correct motions at the outset. This is, of course, true, but, so far from destroying the general attitude taken up in our article, the example appears to reinforce and underprop our position. Motion study at golf or any other game is used only in the moderate way for which we pleaded and which Mr. Gilbreth repudiates altogether in the paragraph immediately preceding that which raises the question of games. It is common knowledge that golf-players of any ability have all quite different styles and motions one from another, and that, than their practice, nothing could be further from adherence to a cast-iron code. The same applies to lawn tennis and all other games. If motion study is merely to mean that when starting an absolutely new process, or game, a man is to be told how to do it, or play it, it is difficult to see that there is anything new in the matter at all. It is many years now since we first started in the shops, but one of our experiences was being taught how to hold a hammer and chisel when chipping at a vice.—ED. E.]

NEW ZEALAND HEMP.

To the Editor of Engineering.

SIR,—For many years past the people of New Zealand have been looking forward to a better system, mechanical or chemical, for the dressing and preparation of their native hemp, known as *Phormium tenax*.

As Trade Commissioner in 1897-8, I personally made widely known throughout Great Britain, America, Canada, and other countries the many benefits that would accrue to the fortunate inventor who could reduce the cost of dressing the green blade, improve the quality of the fibre, and save the enormous waste now occurring under the present crude method of disintegration. To encourage engineers, mechanics, and chemists throughout the world to turn their attention to this valuable product, the Seddon Government offered 2000*l.* as a prize to the successful competitor, free of any other conditions as to the ultimate sale of the patent.

It is instructive to note that New Zealand hemp is indigenous to the soil of the Dominion, grows in every part of the country, without special cultivation, and the land in many places has produced crops upwards of 40 tons to the acre, or an average of about 5 to 5½ tons of dressed fibre. This makes the cheapest cordage and is specially suitable for binder twine for harvesting operations, for which there is an increasing demand throughout the grain-producing countries of the world. If by any improved process a saving could be effected of even 5*l.* per ton, this would mean 150,000*l.* per annum on the present output from New Zealand, and I see no reason why the Dominion could not profitably export 100,000 tons yearly.

As one of the results of my investigation of the fibre markets in many countries, the Government, upon my strong recommendation, adopted a compulsory grading system, which, I pointed out, would protect the honest miller, correct the carelessness of others, and, above all, secure the confidence of oversea buyers—the latter a desideratum of the greatest importance to any country desiring to extend and improve its export trade. From that time forward prices began to rise from the low level of 10*l.* per ton to 30*l.* per ton, with a corresponding development in the annual exports, which gradually increased from 1800 tons in 1896 to 30,000 tons in 1906, the best argument in favour of the Government grading system.

The Department of Agriculture, recognising the value of the hemp industry, offered on February 13, 1899, two bonuses of 1750*l.* and 250*l* respectively, some particulars of which are appended hereunder. These amounts have not been paid over, and although the time limit has expired, I feel persuaded the Government would willingly restore the bonuses to encourage *bonâ fide* efforts in the direction referred to.

Bonus No. 1.

A bonus of 1750*l.* is offered for a machine or process for dressing New Zealand hemp (*Phormium tenax*) which shall be an improvement on the machines or processes now in use, and which shall, after trial, be found materially to reduce the cost of production, improve the product, or increase the quantity of dressed fibre.

The following are the conditions:—

1. All applications for the bonus must be addressed to the Hon. the Minister for Agriculture, Wellington, and must reach him not later than March 31, 1900. Each application must be accompanied by a description of the machine or process, particularly stating improvements on present machines or processes, and also the cost at which the machine or process can be supplied.

2. The applicants must be prepared to submit their machines or processes to examination at such time and place as the Government may direct.

3. The Government shall appoint a committee of three or more experts, to whom all applications shall be submitted. Such committee shall, after perusal, state what machines or processes they deem worthy of consideration, and may inspect the same at any place within the colony; and, having so inspected the whole or any of them, may direct that the whole or any of them be brought for further trial to such place as they may think fit.

Then follow particulars of the tests, &c., and the criteria of efficiency.

Bonus No. 2.

A bonus of 250*l.* is offered for a process of utilising the waste products of the hemp.

The first three conditions of bonus No. 1 to apply to this also.

The committee shall supply a sufficient and equal quantity of the waste products to each process as a test.

On completion of the tests the committee shall report to the Minister, and shall give the following particulars of each process:—(*a*) The nature of the article made. (*b*) The quantity produced, and the cost of production. (*c*) The value of the product. (*d*) Whether any of the processes are of sufficient importance to warrant the Minister in giving (1) the whole, or (2) any part, of the bonus; (3) if a part only, how much.

I hope the foregoing information will lead to more active operation by your numerous clients throughout the United Kingdom.

Yours faithfully,

JOHN HOLMES.

Tavistock House, 19, Upper Woburn-place,
London, W.C., October 24, 1911.

MOULDING-MACHINES.

To the Editor of Engineering.

SIR,—I feel considerable reluctance in trespassing further upon your valuable space, but I am glad that my letter has brought a distinct denial from Mr. Horner to any claim on Mr. Pridmore's behalf of "originating" the "Die" moulding-machine; but it is still vague to my dull perception as to what he does claim Mr. Pridmore "originated and developed," unless it be some small mechanical details, in his various descriptions of Pridmore's machines, not embodied in earlier types. I am inclined to think that the "essential" feature in this type of "Die" moulding-machine, which Mr. Horner is describing, is the "Die," and not various small mechanical details embodied in its manifold variety of designs.

The illustration I sent you of Messrs. Howard's machine will, I think, have convinced you, Sir, that the so-called "essentials," named by Mr. Horner, of "the main frame;" the "movable, or yoke frame," with its upper and lower guides; and "the hand-lever and crank-shaft," or their mechanical equivalents, are practically existent in this machine, as they are in several machines in daily use in our foundry, and have been for over twenty years, the only addition, practically, in Mr. Pridmore's, being a counterbalancing spring, or weight, for heavy patterns.

I have referred to Mr. Horner's article, No. XXXII., again, in which he commences by stating "an extensive series of moulding-machines is manufactured by Mr. Pridmore;" then goes on to say that "these were originated and developed by the same gentleman (for a specific reason)," after which he proceeds to describe these machines.

I can only read this article as being a claim for "originating and developing" a machine which he proceeds, a few lines further down, to describe; and in the description of this machine I maintain there is nothing, practically, of an original character beyond Howard's machine, unless it be in a few minor details, but, at the same time, I fully admit a small "development" of mechanical points.

I must now leave your readers to draw their own conclusion as to whether my criticism has been without a basis, or whether this conclusion is one that is singular to Mr. Horner, and I do not intend to trespass any further upon your valuable space.

Yours faithfully,

ERNEST SAMUELSON.

Britannia Works, Banbury, October 24, 1911.

THE NEW INDIAN PATENTS ACT.

To the Editor of Engineering.

SIR,—May I through the columns of your paper bring to the notice of such of your readers as are interested in Indian patents the fact that a new Act comes into force in India on January 1, 1912, which will alter the conditions under which valid patents are obtainable? The particular point to which I should like to draw attention is, that, under the new Act, valid Letters Patent cannot be obtained for an invention which has been previously used or published (as by the printed British specification) in India. Under the present Act, however, it is allowable to file an application at any time within one year of the filing of the British application, or of the actual sealing of the British Letters Patent. Therefore, any intending applicants for Indian patents of which the corresponding British specifications are now published, or will be published by December 31 next, should take care to have their applications filed before that date.

Yours faithfully,

CHAS. B. KETLEY.

128, Colmore-row (opposite Eden-place), Birmingham,
October 24, 1911.

STEAM TRIALS OF H.M.S. "SANDFLY."—The torpedo-boat destroyer Sandfly, built for the British Navy by Messrs. Swan, Hunter, and Wigham Richardson, Limited, Newcastle-on-Tyne, and fitted with her machinery by the Wallsend Slipway and Engineering Company, Limited, Wallsend-on-Tyne, completed on Monday, the 23rd inst., her official 8 hours' steam trials, when she attained a speed of 27.7 knots with the turbines running at a mean of 741 revolutions and developing 15,700 shaft horse-power. The designed speed was 27 knots. On her 24 hours' fuel-consumption trial on the preceding Wednesday the oil used was about 1 lb. per shaft horse-power per hour. The Sandfly is 240 ft. long, 25 ft. 9 in. beam, and at 7 ft. 10 in. draught displaces 780 tons. She is armed with two 4-in. quick-firing and two 12-pounder guns.

ECONOMY IN STEEL MANUFACTURE.—Mr. Walter Dixon, in his presidential address at the West of Scotland Iron and Steel Institute, on the 20th inst., pleaded for a fuller application of electricity in iron and steel works. With one or two exceptions it had not, he said, been applied to reversing rolling-mills, notwithstanding its extensive and largely extending adoption on the Continent, and the fact that there were no adequate grounds for supposing that the maintenance and work of a properly designed electrical equipment would not compare favourably with steam driving. As early as 1896 blast-furnace gas was utilised in Scotland in gas-engines; but difficulties were assumed in the profitable and economical disposal of the energy, in view of the favour with which existing steam plant was viewed. With the undoubted efficiency of electricity gas could now be used; and even if the supply of gas were deficient, a small number of blast-furnaces could be united to supply adjoining works. The building of producers using coal was justified by the economy realisable, particularly as the residual products were so valuable. The second part of the address was devoted to a plea for more liberal legislative treatment of industries.

CONTRACTS.—Messrs. Ed. Bennis and Co., Limited, Little Hulton, Bolton, and 28, Victoria-street, S.W., have recently received orders for forty-six stokers and self-cleaning compressed-air furnaces. The great bulk of these orders are from firms who already have such furnaces in use.—The Midland Railway Company has extended its contract with the Pearlite Steel Company (1910), Limited, Royds Mill-street, Sheffield, for a further two years, until December 31, 1913, for their pearlite hardening only chisel steel.—Messrs. George Fletcher and Co., Limited, Masson Works, Derby, are about to send out to the island of St. Croix a complete five-roller sugar-cane grinding plant with hydraulic attachment, steel gearing, and heavy horizontal engine. This plant is the third sent out to this island to the same firm during the last few years.—We are informed by the British Westinghouse Electric and Manufacturing Company, Limited, Trafford Park, Manchester, that they have, among other orders, recently received the following:—From Sir Wm. Arrol and Co., Limited, one 60, two 50, six 35, two 12, five 10, and four 2½-horse-power 220-volt motors and spares. From Messrs. Hulse and Co., Limited, for Japan, various types "G." motors and panels. From Messrs. Strakers and Love one 174-horse-power slip-ring motor and liquid starter. From the Linde British Refrigeration Company, for Bristol Dock, Avonmouth, two 45, two 7½, and three 7½-horse-power 500-volt "G." motors; and for Messrs. Stothert and Pitt, Limited, for Bristol Docks, equipment for nine 2-ton electric cranes for Avonmouth, nine 40, nine 12, and nine 6-horse-power 500-volt motors, control-gear, and spares.

THE ENDURANCE OF METALS.

*Experiments on Rotating Beams at University College, London.**

By E. M. EDEN, of the Armstrong College, Newcastle-on-Tyne, W. N. ROSE, and F. L. CUNNINGHAM, Graduate, of London.

WHEN a piece of metal is subjected to alternating or intermittent stress, the metal may fracture after a large number of alternations or repetitions of stress, although the maximum stress applied is considerably less than would be required to fracture the material with a single application. As in the large majority of cases, metals used by engineers are subjected to varying stresses, and as failure, when it does occur, usually happens after a large number of repetitions of stress, the importance of tests on alternating stresses is very great. It is doubtful if a direct tensile test of a piece of steel gives any very definite information of its capacity to resist alternating stresses. The hard brittle-looking fracture of steel broken under repeated repetitions of stress is entirely different from the fracture caused by the single application of a larger stress in a testing-machine, and the hard-looking fracture of a broken piston-rod or crank-shaft is often taken as a proof that the material is, or has, grown too brittle for such service. The appearance of the fracture in such cases is probably responsible for the common idea that a soft ductile material is most suitable for withstanding alternating stresses.

The classical researches of Wöhler included experiments on repeated tensions varying from 0 to a maximum, repeated torsion, and on revolving bars subjected to a bending moment while revolving; in this last case the stress in the outside fibres varies from a maximum tension to a maximum compression, and the range of stress is twice the maximum imposed stress. In every case the number of repetitions to cause fracture increases as the stress diminishes. If a number of experiments with different maximum stresses applied are considered, and the applied stress is plotted against the number of repetitions to cause fracture, the points are found to lie more or less on a curve, which appears to become nearly horizontal after a few million repetitions. The stress where the curve is horizontal is the limiting stress which can cause fracture after an indefinite number of repetitions. The exact form of this curve is difficult to obtain, and repeated bending and repeated tensile tests by various experimenters with different types of testing-machines give results differing considerably in their general character.

Fig. 1. METHOD OF LOADING THE TEST SPECIMEN.

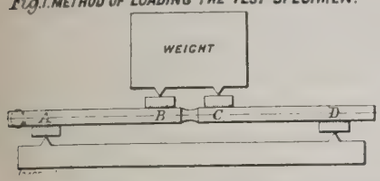
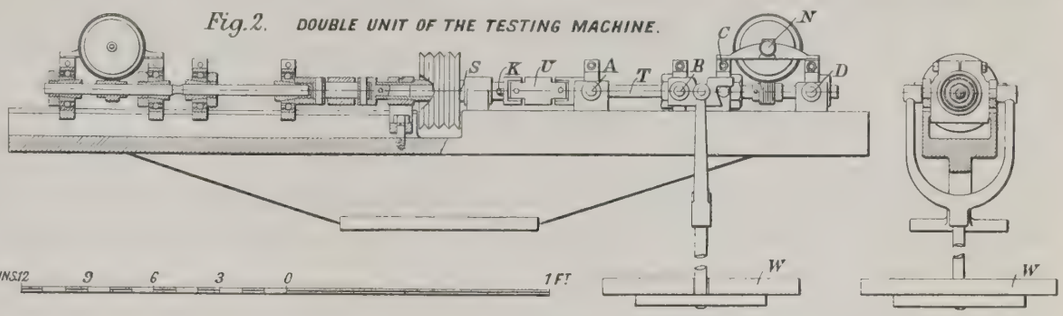


Fig. 2. DOUBLE UNIT OF THE TESTING MACHINE.



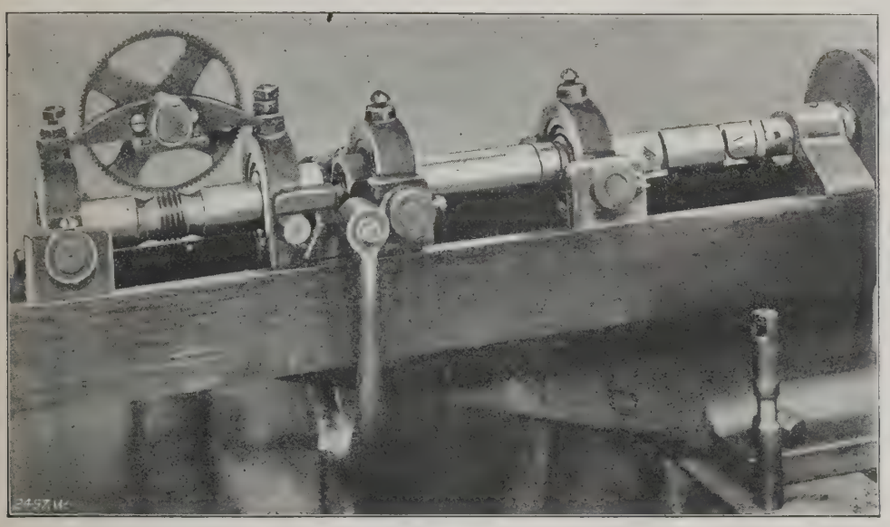


FIG. 3. UNIT OF TESTING-MACHINE.

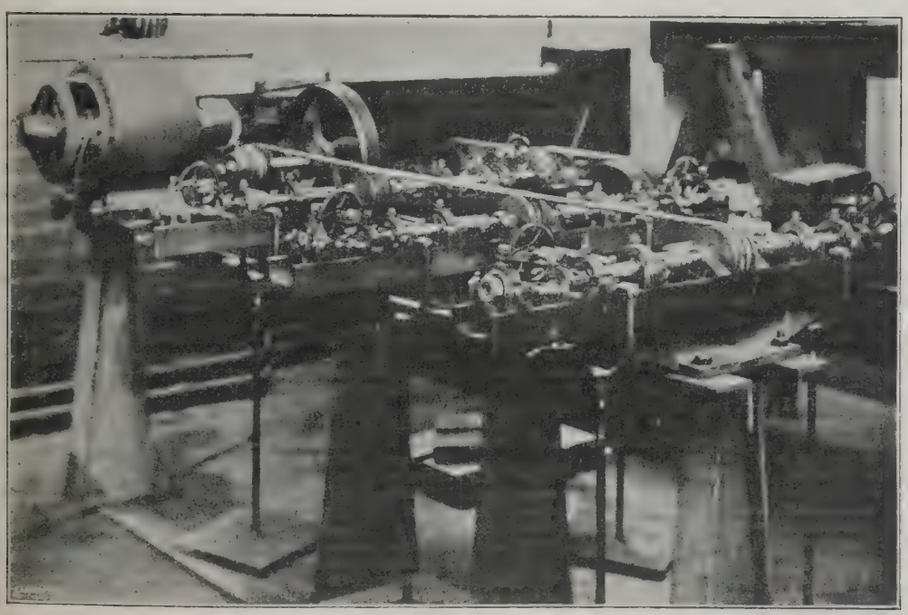


FIG. 4. COMPLETE TESTING-MACHINE.

The tests described in this paper were undertaken with a view to finding, if possible, the form of the stress-repetitions curve for any one material, and to determine the effect of speed or rate of alternation of stress on the stress-repetitions curve and on the limiting resistance for an indefinite number of repetitions. The testing-machine was specially designed and built with these objects in view, but the tests deal also with the comparative endurance of various materials and with the effect of rests, vibration, surface and form of test-piece, and annealing on endurance.

Description of Testing-Machine used in the Experiments.—The testing-machine is of the revolving-beam type, in which the test specimens are subjected to a uniform bending moment while revolving on their own axes. The method of loading the test specimen is shown diagrammatically in Fig. 1.* The test-piece, ½ in. in diameter and 12 in. long, is supported on swivelling bearings at A and D and loaded at B and C. The distance between A and B and between C and D is 4 in. The central portion of the test specimen is reduced in diameter, and the bending moment is uniform over the reduced portion and numerically equal to 2 W inch-lb., where W is the total load on B and C in pounds.

The maximum stress on the test-piece is calculated from the formula

$$f = \frac{M}{\frac{\pi}{32} d^3},$$

where f is the maximum stress, M the bending-moment, and d the diameter of the reduced portion.

A double unit of the machine is shown in Fig. 2 (above); and Fig. 3 (annexed) shows a single unit. To prevent possible torsional stresses in the test specimen due to accidental seizing of the bearings, and also to prevent heating, ball-bearings are used at A, B, C, and D, Fig. 2.

The test-piece T is driven by means of a double universal joint U and a clutch K from the spindle S, and is supported on the two swivelling ball-bearings A and D. The load W is supported by means of the cross-bars on the two swivelling ball-bearings B and C. The clutch K was added so that any specimen could be withdrawn after fracture, and a new specimen inserted, without stopping any other specimen. The revolution counter N is driven by worm and wheel from the test specimen; it stops automatically when fracture occurs, and the outer end of the specimen is thrown clear of the revolving part by suitable inclined slopes on the cross-bars.

The complete machine, Fig. 4, annexed, and Fig. 6 (page 576), consists of three double units on an angle-iron frame; the three spindles S being driven by belt and cords and a counter-shaft from the motor. The speed at which the spindles and test-specimens revolve can be varied by using different belt-pulleys on the motor and counter-shaft. The spindles S were originally driven from the counter-shaft by a chain, but as this was too noisy, the leather-cord drive shown was substituted.

Fig. 2 shows the machine as at first arranged, using 12-in. specimens; these are shown to a larger scale at B, Fig. 5, and *d*, Fig. 7 (page 576). The 12-in. specimens were used in the series of tests numbered XVI. to XX. In the earlier series of tests, Nos. I. to XV., short test-specimens and holders, shown at A, Fig. 5, were used, and C and D, Fig. 5, show the modified holders used in the series of tests XXI. to XXVII. and XXVIII. to XXXVII.

The use of holders was a very great convenience, as the test-specimen could be slipped into place quickly, and the short specimens that could be used with the holders were much easier to prepare than the long 12-in. specimens, and enabled a much larger number of test-pieces to be made from a bar of material. For these reasons holders and short test-pieces were used in the majority of the tests. The corrosion and wear of the holders was, however, an objection to their use, and on this account the original

* Paper read before the Institution of Mechanical Engineers on October 20.

* A revolving-beam testing-machine of the type shown in Fig. 1 was used by the late Professor Sondericker at the Massachusetts Institute of Technology, U.S.A. See "Technology Quarterly" of 1892 and 1899.

long test-pieces without holders were reverted to in the series of tests XVI. to XX.

Rests.—For various reasons the tests were not all run continuously without a stop. In diagrams, Figs. 8 to 31 (pages 577 to 580), the number of *r*'s marked on the observation points shows the number of times that the test was stopped before fracture. The symbol R refers to an overnight rest of several hours, and *r* refers to a shorter rest. The unmarked tests were run continuously without a stop. During the rests the load remained on the test-piece. It does not appear that these rests have any appreciable effect on the total number of revolutions up to fracture.

Vibration.—With truly turned test-pieces and holders the machine runs quietly, and with very little vibration at all speeds used, only a slight tremor being felt when the hand is placed on the central ball-bearings, and this tremor does not reach the scale-pan and weights. In some of the tests, after the holders had worn and corroded, there was, however, considerable vibration, and in some cases the weights were rattled about on the scale-pans, making a considerable noise, the noise increasing to a maximum, and then quietening down a number of times during the test. This vigorous vibration and noise would be naturally expected to cause fracture sooner, but it will be noticed that in many cases tests which showed considerable vibration gave as good results as others. It, nevertheless, seems to be of great importance that the test specimens should run truly.

In diagrams, Figs. 8 to 31 (pages 577 to 580), tests which were noticed as showing vibration are indicated by the symbol *v*; *v* meaning slight vibration, *vv* considerable vibration, and *vvv* excessive vibration.

Tests Made on the Machine.—Diagrams, Figs. 8 to 31.—With the exception of a few series of tests in which the number of tests in the series is too few to be of any value, all the tests made on the machine are shown by observation points on Figs. 8 to 31. The tests were all carried out between June, 1906, and December, 1908, and the series numbers are in chronological order. The letters in brackets after the series numbers refer to the form of test-piece and holder, shown in Figs. 7 and 5 respectively. The bar numbers refer to the various bars of metal from which the test-pieces were cut. Every bar of metal is given a separate bar number with the exception of bars numbers 9, 10, 19, 20, and 24. Bar No. 9 refers to a number of short-turned bars of oil-tempered type A vanadium steel, and bar No. 10 to a number of short-turned bars of annealed type A vanadium steel, all of which were supplied by Messrs. Willans and Robinson. The whole of these short bars were made from a single length of vanadium steel, the only difference between 9 and 10 being in the heat treatment. Bars Nos 19 and 20 refer to a number of 12-in. turned bars supplied by Messrs. Willans and Robinson. Each bar was cut up into three short test-pieces, and no record was taken from which bar they were made.

Bar No. 24 refers to a number of short lengths of trolley-wire which were in stock. They are believed to be all cut from a single length.

Two qualities of $\frac{1}{2}$-in. bright drawn mild steel were used in the tests; they are distinguished as quality A and quality B, and the letters C and D are used to distinguish between two qualities of blued rolled Bessemer steel.

Description of Tests.

Following is a short account of the tests; the object aimed at throughout was to find a material and form of test-piece which should give a perfectly definite stress-repetitions curve, and to find the effect of speed or rate of alternation of stress on this curve.

Series I. (*a* A).—Five tests of $\frac{9}{16}$-in. blued rolled Bessemer steel quality C, untreated, at a speed of 1100 revolutions per minute.

Series II. (*a* A).—Sixteen tests of the same material, but annealed. The plotted results of these two series are shown on diagram, Fig. 8 (page 577). In both cases the points lie irregularly, but the effect of the annealing is quite marked.

Series III. (*a* A).—Thirteen tests of $\frac{9}{16}$-in. blued rolled Bessemer steel (C), turned and annealed. Speed, 600 revolutions per minute. The results of this series, diagram, Fig. 9 (page 577), give a fairly definite curve with the exception of three tests which are apparently weaker than the others.

Series IV. (*a* A).—Eleven tests of the same material also annealed, but the turned-down portion was carefully polished with the finest emery cloth and oil. Speed, 600 revolutions per minute. The curve shows more irregularities than Series III., but the effect of polishing is very marked. Diagram, Fig. 9.

Series V. (*a* A).—Nine tests of $\frac{1}{2}$-in. bright-drawn mild steel, quality A, polished, at 600 revolutions per minute. This material appears to give more uniform results. Diagram, Fig. 10 (page 577).

As previous tests had shown that polishing the surfaces of test-pieces had a considerable effect on the resistance of the steel, it was thought that the variations from a smooth curve might be caused by small surface scratches which were not always removed by polishing.

Series VI. (*a* A) gives the results of ten tests of the same material (bright-drawn mild steel) turned and polished, and scratched all over with sewing-needles. This shows no improvement in uniformity of results, but the reduction in the resistance of the material due to scratches is clearly shown. Diagram, Fig. 10.

Series VII. (*b* A).—Seven tests of the same material, the specimens being turned with a sharp V groove, Fig. 7*b* (above); the points lie very irregularly, one being almost on the Series VI. curve.

Series VIII. (*b* A).—Exactly the same as Series VII., but all six specimens were run together at the same time, and all were subjected to the same bending moment. The variation in stress is caused by variation in diameter from 0.35 in. to 0.42 in. The variation from a smooth curve is rather greater than before.

These two Series VII. and VIII. are shown together on diagram, Fig. 10; the great irregularity is partly due to inaccurate measurement of the diameter at the bottom of the V groove, which was measured after fracture with a scale to the nearest $\frac{1}{100}$ in. only. An error of $\frac{1}{100}$ in. diameter corresponds to about 8 per cent. error in the calculated stress. The effect of the sudden change of section is clearly shown.

Series IX. (*a* A).—Six tests of the $\frac{1}{2}$-in. bright-drawn mild steel, quality A, run concurrently with the same bending moment on all the specimens, which were plain turned. Owing to small variations in diameter, the stress is not quite the same for all.

The maximum variation in endurance is large, one specimen running four times as long as another before fracture (Diagram, Fig. 11, page 577).

Series X. (*a* A).—Exactly the same as Series IX., but the specimens were polished; there is no improvement in uniformity, but the effect of the polishing is shown. Diagram, Fig. 11.

It was thought that a ground surface might give more uniform results. To facilitate the grinding, and also because a larger radius was thought to be desirable,* the form of test-piece was altered to that shown at *c*, Fig. 7 (below). The grinding was done dry with a rather coarse carborundum wheel, and the surface, after grinding, was rough in appearance. The same grinding-wheel was used for all the test-pieces which are described as "ground" to size.

Series XI. (*c* A).—Eight tests of $\frac{1}{2}$-in. bright-drawn mild steel, quality B, ground to $\frac{3}{8}$ in. in diameter. This is the first test of this material, and shows very irregular results. Diagram, Fig. 11.

Series XII. (*c* A).—Five tests of cast-iron specimens. With one exception these either broke within two minutes of the application of the load or were unbroken. The figures are given on diagram, Fig. 11.

Series XIII. (*c* A).—Eleven tests of $\frac{1}{2}$-in. bright-drawn mild steel, quality A, ground, at 600 revolutions per minute. The results are very irregular and are shown on diagram, Fig. 22 (page 579), the lower curve. The remarkable symmetry of the tensile fractures of some vanadium steel tested at University College at this time suggested this material as likely to give consistent results in repeated-loads tests. Some preliminary tests appearing to bear out this idea, Messrs. Willans and Robinson kindly supplied a large number of test-pieces for more extended tests.

Series XIV. (*c* A) gives the results of eleven tests of oil-tempered vanadium steel. While the results are an improvement on Series XIII., there is still considerable variation from a smooth curve. Diagram, Fig. 12 (page 577).

Series XV. (*c* A).—Eleven tests of annealed vanadium steel. These results are extremely irregular; this is believed to have been caused by some of the test-pieces being a loose fit in the holders. Diagram, Fig. 12.

The holders shown at A, Fig. 5 (above), were by this time considerably bell-mouthed, and it was thought best to give up their use and use 12-in. specimens, as shown at B, Fig. 5. This was the form originally intended to be used when the machine was built, but the great convenience of using specimens only $3\frac{3}{4}$ in. long, which could be easily slipped into position, had caused the adoption of the holders.

Series XVI. (*d* B).—Fifteen tests of $\frac{1}{2}$-in. bright-drawn mild steel, quality A, test-pieces 12-in. long, turned and ground, 600 revolutions per minute. This series shows a great improvement on XV., and gives a fairly definite curve. Diagram, Fig. 13 (page 577).

Series XVII. (*d* B).—Fourteen tests of 12-in. test-pieces of the same material, but at a much lower speed, 300 revolutions per minute. This gives a still more uniform curve. Diagram, Fig. 14 (page 577).

Series XVIII. (*d* B).—Thirteen tests of 12-in. test-pieces of the same material, but at 1300 revolutions per minute. This curve is not quite so good as XVII., but, if anything, shows less variation than XVI. Diagram, Fig. 15 (page 578).

Series XIX. (*d* B).—Eleven tests of bright-drawn wrought-iron rod, test-pieces 12 in. long, 1300 revolutions per minute.

The wrought-iron rod was not quite straight, so that these test-pieces did not run truly. Two of the test-pieces were straightened before testing. Diagram, Fig. 16 (page 578).

Series XX. (*d* B).—Twelve tests of the same material at 600 revolutions per minute. All specimens carefully

* Several of the earlier test-pieces shown at *a*, Fig. 7, broke high up on the radius, and not at the smallest diameter.

Fig. 5. HOLDERS WITH TEST-PIECES.

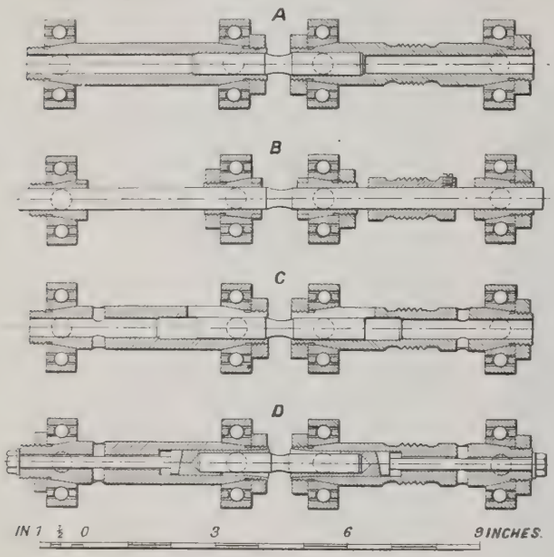


Fig. 6. COMPLETE TESTING MACHINE.

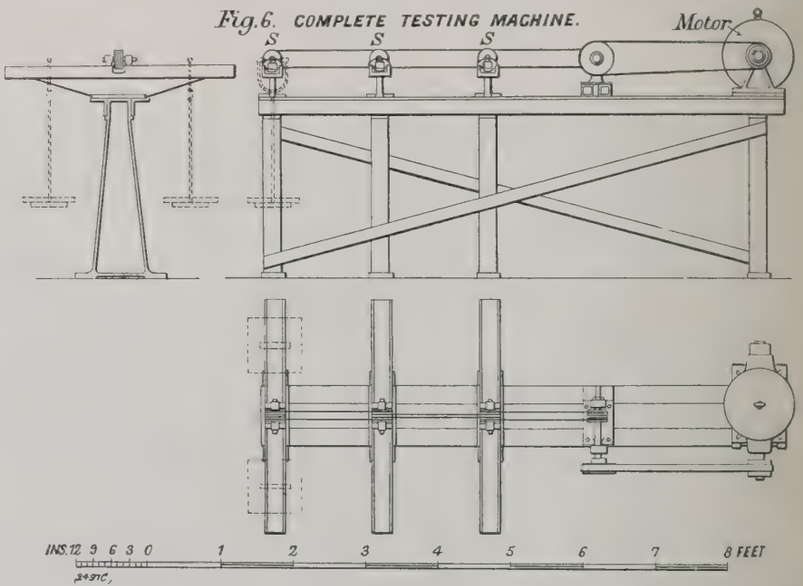
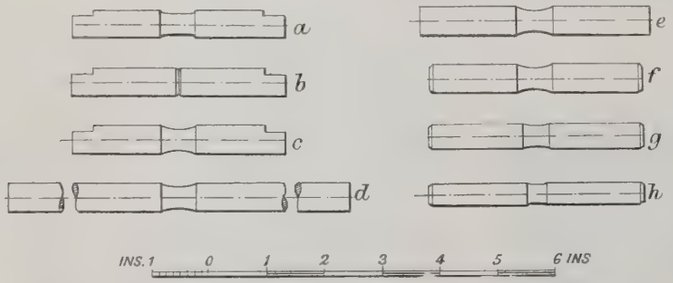


Fig. 7. TEST-PIECES.



THE ENDURANCE OF METALS.

Fig. 8 { SERIES I (a A). ⅜" diam. Blued Rolled. Bessemer Steel C. Bar No. 1. Untreated, turned. Speed 1,100 r. per m.
" II " " " " " Annealed, " " "
Fig. 9 { " III " " " " " 2. " " " 560–600 "
" IV " " " " " {Annealed, turned and polished.} " " "

Fig. 9.

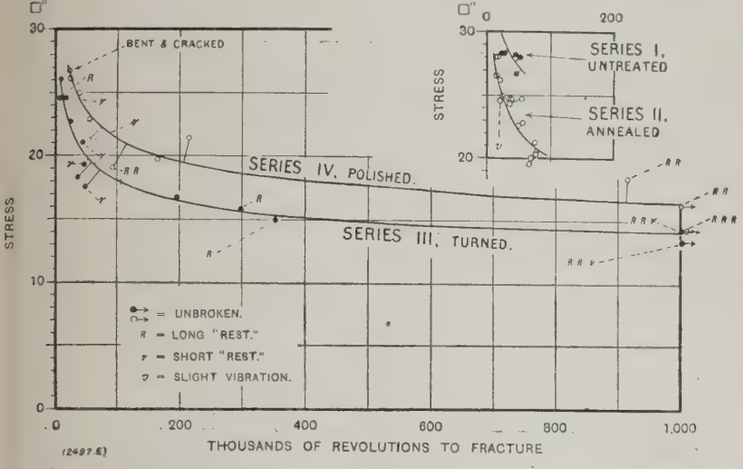
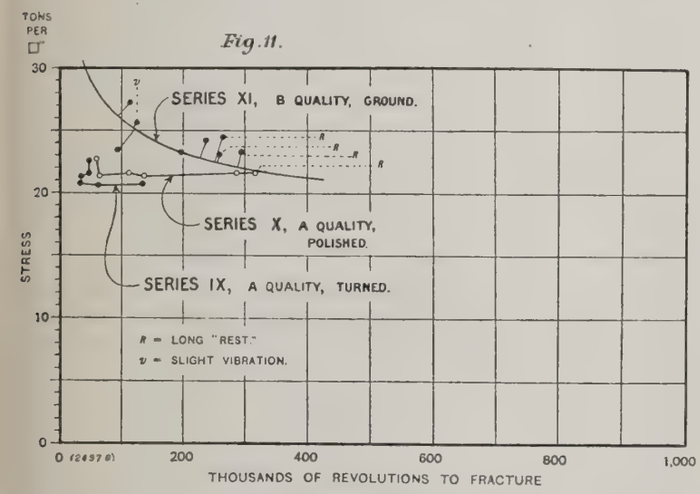


Fig. 8.

NOTE.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 and Fig. 5

SERIES IX (a A). ¼" diam. bright drawn Mild Steel A. Bar No. 4. Untreated, turned. Speed 560–600 r. per m.
" X " " bright drawn Mild Steel A. Bar No. 4. Untreated, turned and polished. Speed 560–600 r. per m.
" XI (c A). " bright drawn Mild Steel B. Bar No. 5. Untreated, ground. Speed 560–600 r. per m.
" XII " 1" " cast-iron bar. Bar Nos. 6 and 7. Untreated, ground. Speed 560–600 r. per m.

Fig. 11.

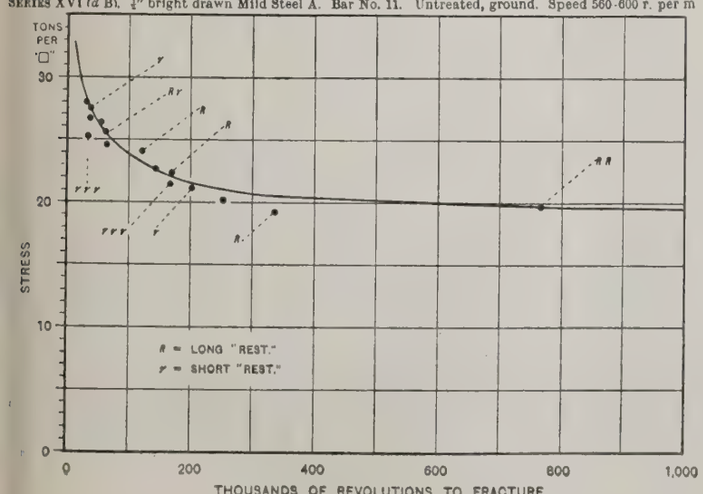

TONS PER □"
SERIES XI, B QUALITY, GROUND.
SERIES X, A QUALITY, POLISHED.
SERIES IX, A QUALITY, TURNED.
R = LONG "REST."
v = SLIGHT VIBRATION.
STRESS
THOUSANDS OF REVOLUTIONS TO FRACTURE

SERIES XII.

Bar No.	Stress, tons per sq. in.	Total Revolutions before Fracture.	Remarks.
7	12.6	300	—
7	11.7	1,200	—
7	11.1	400	—
6	9.8	622,000	R R
6	8.9	830,000	R R R unbroken

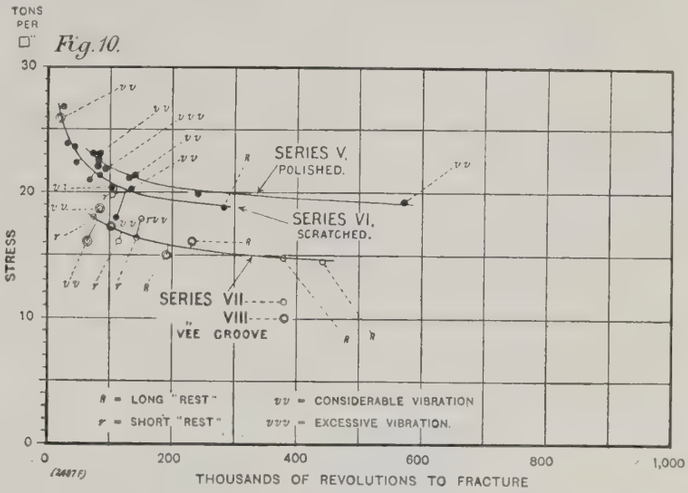
Fig. 13.

SERIES XVI (d B). ¼" bright drawn Mild Steel A. Bar No. 11. Untreated, ground. Speed 560–600 r. per m



SERIES V (a A). ¼" diam. bright drawn Mild Steel A. Bar No. 3. Untreated, turned and polished. Speed 560–600 r. per m.
" VI " " bright drawn Mild Steel A. Bar No. 3. Untreated, turned, polished and scratched. Speed 560–600 r. per m.
" VII (b A). " bright drawn Mild Steel A. Bar No. 4. Untreated, turned vee groove. Speed 560–600 r. per m.
" VIII " " bright drawn Mild Steel A. Bar No. 4. Untreated, turned vee groove. Speed 560–600 r. per m.

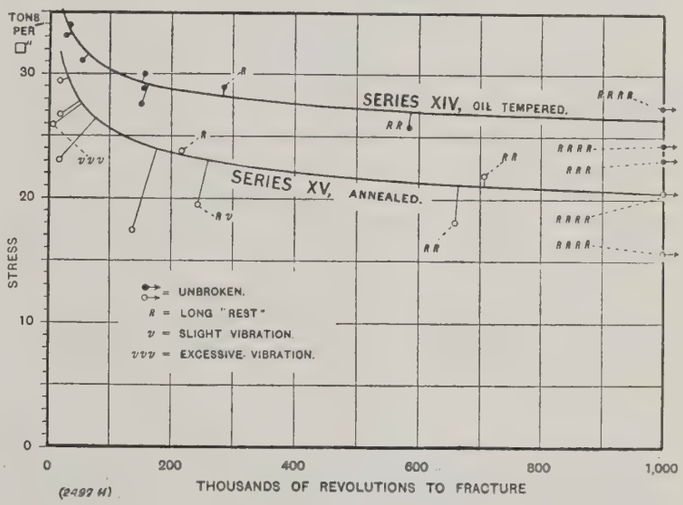
Fig. 10.



NOTE.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 and Fig. 5

Fig. 12.

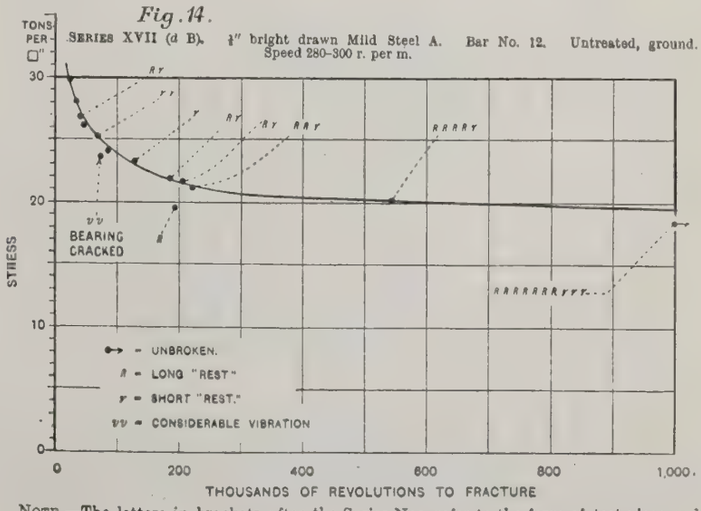
SERIES XIV (c A). Vanadium Steel Type A. Bar No. 9. Oil Tempered, ground. Speed, 560–600 r. per m.
" XV " " " " 10. Annealed, " " "



NOTE.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 and Fig. 5.

Fig. 14.

SERIES XVII (d B). ¼" bright drawn Mild Steel A. Bar No. 12. Untreated, ground. Speed 280–300 r. per m.



NOTE.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 and Fig. 5

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Fig. 15.

SERIES XVIII (*d* B). ¼" bright drawn Mild Steel A. Bar No. 13. Untreated, ground. Speed 1,230-1,300 r. per m.

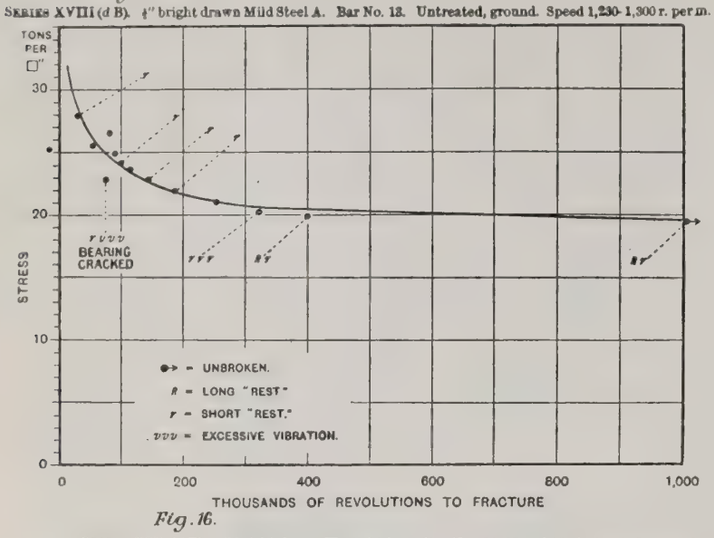
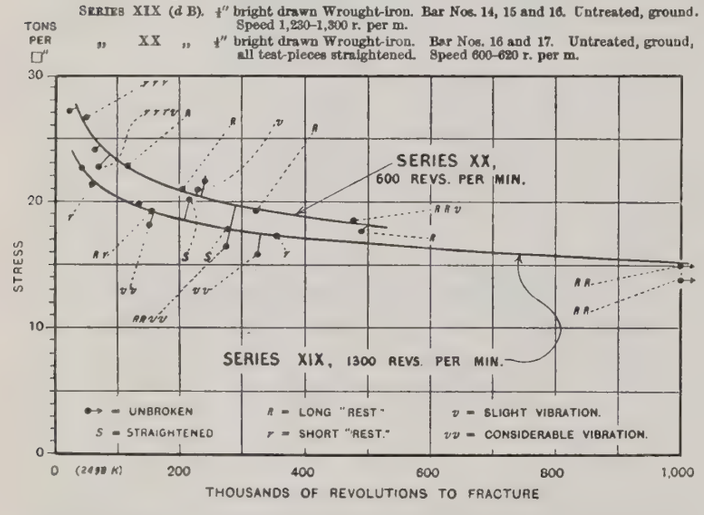


Fig. 16.

SERIES XIX (*d* B). ¼" bright drawn Wrought-iron. Bar Nos. 14, 15 and 16. Untreated, ground. Speed 1,230–1,300 r. per m.
SERIES XX (*d* B). ¼" bright drawn Wrought-iron. Bar Nos. 16 and 17. Untreated, ground, all test-pieces straightened. Speed 600–620 r. per m.



NOTE.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 . and Fig. 5 .

Fig. 17.

SERIES XXI (*e* C). ¼" bright drawn Wrought-iron. Bar No. 18. Untreated, turned and polished. Speed 600 r. per m.

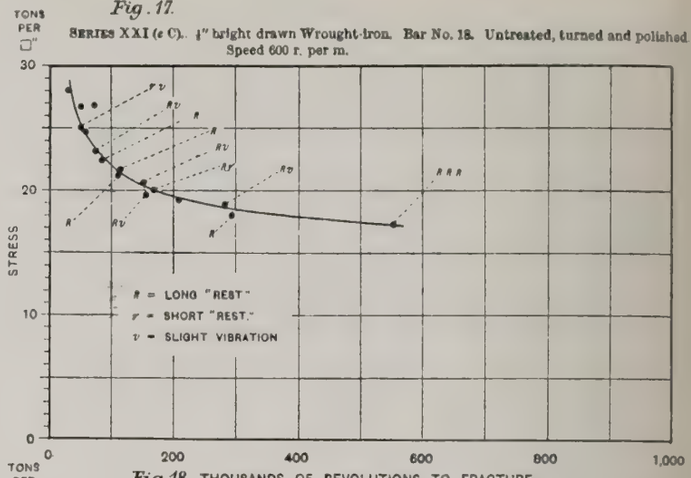
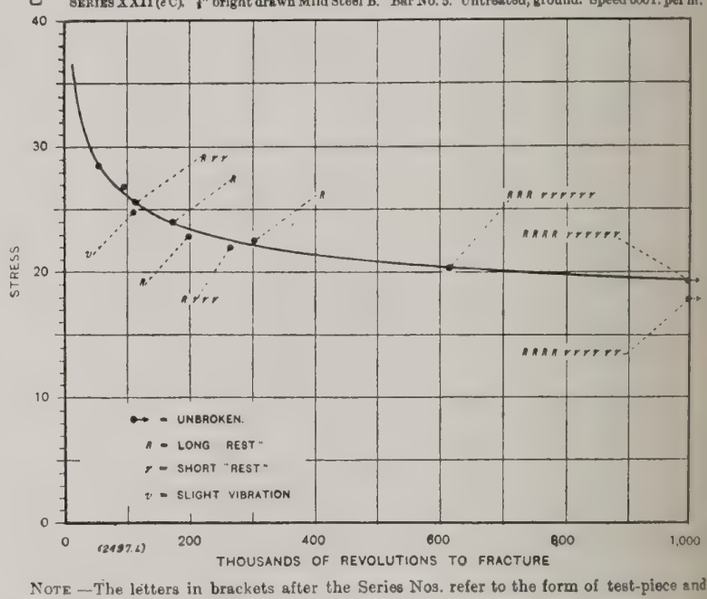


Fig. 18.

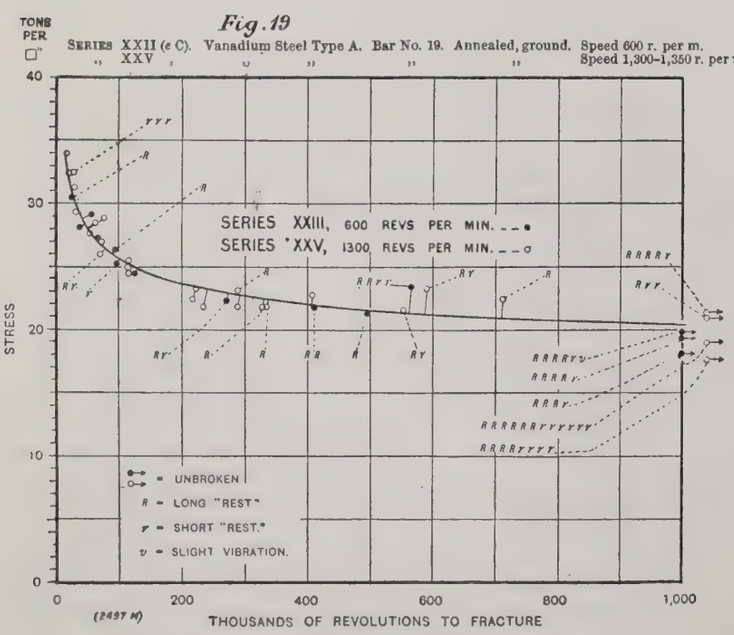
SERIES XXII (*e* C). ¼" bright drawn Mild Steel B. Bar No. 5. Untreated, ground. Speed 600 r. per m.



NOTE.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 and Fig. 5

Fig. 19.

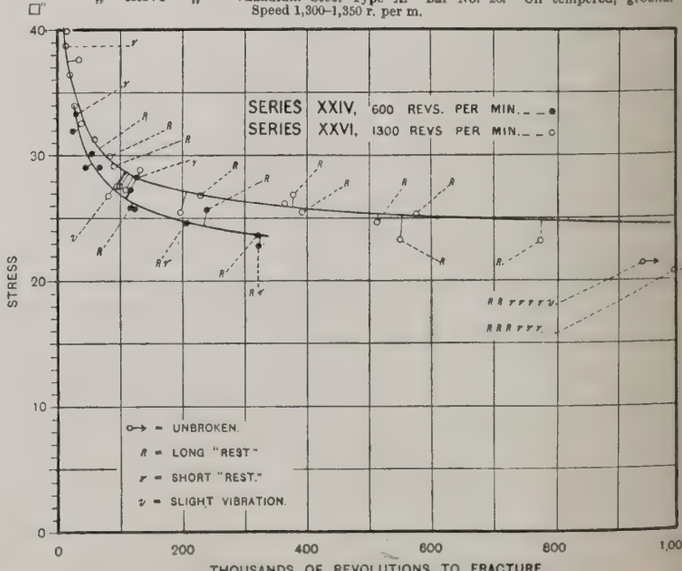
SERIES XXII (*e* C). Vanadium Steel Type A. Bar No. 19. Annealed, ground. Speed 600 r. per m.
SERIES XXV (*e* C). Vanadium Steel Type A. Bar No. 19. Annealed, ground. Speed 1,300–1,350 r. per m.



NOTE.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 and Fig. 5

Fig. 20.

SERIES XXIV (*e* C). Vanadium Steel Type A. Bar No. 20. Oil tempered, ground. Speed 600 r. per m.
SERIES XXVI (*e* C). Vanadium Steel Type A. Bar No. 20. Oil tempered, ground. Speed 1,300–1,350 r. per m.


TONS PER □"
STRESS
SERIES XXIV, 600 REVS. PER MIN.
SERIES XXVI, 1300 REVS PER MIN.
● = UNBROKEN.
R = LONG "REST"
r = SHORT "REST."
v = SLIGHT VIBRATION.
THOUSANDS OF REVOLUTIONS TO FRACTURE

NOTE.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 and Fig. 5

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Fig. 21.

SERIES XXV (*e* C). Vanadium Steel Type A. Bar No. 19. Annealed, ground. Speed 1,300–1,350 r. per m.

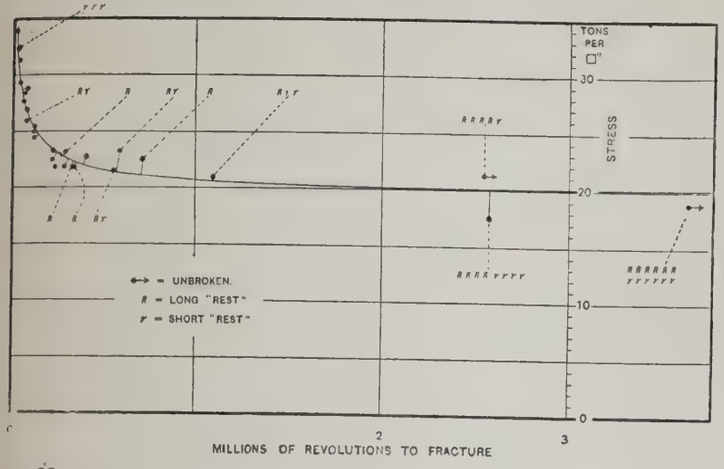
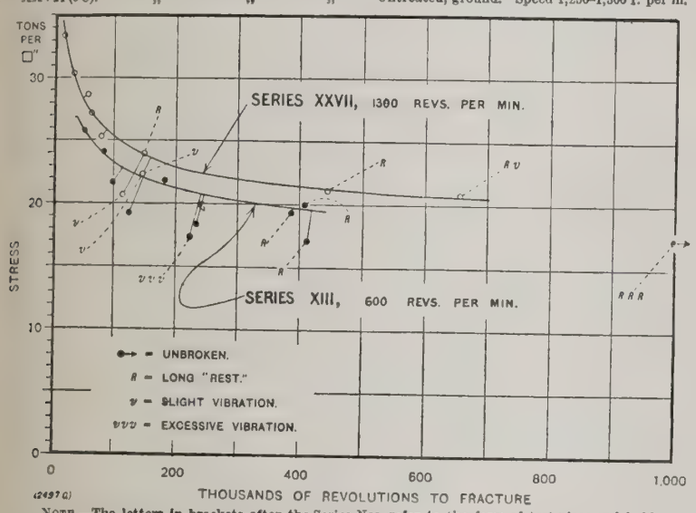


Fig. 22.

SERIES XIII (*c* A). ¼" bright drawn Mild Steel A. Bar No. 8. Untreated, turned and ground. Speed 560–600 r. per m
" XXVII (*e* C). " " " Untreated, ground. Speed 1,250–1,300 r. per m.



NOTE.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7. and Fig. 5

Fig. 23.

SERIES XXVIII (*f* D). ¼" bright drawn Mild Steel A. Bar No. 21. Untreated, ground. Speed 1,250–1,300 r. per m.

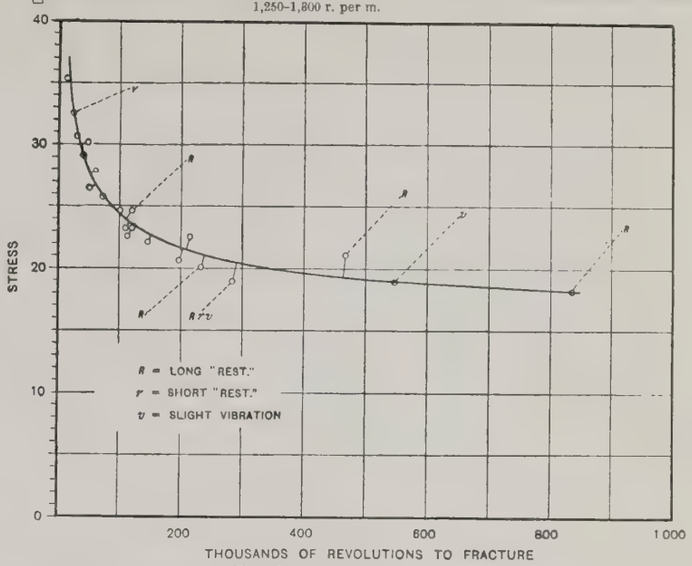
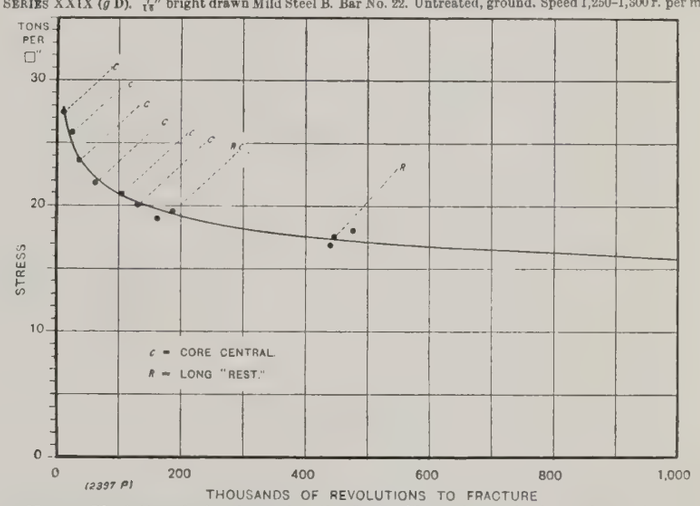


Fig. 24.

SERIES XXIX (*g* D). $\frac{7}{16}$" bright drawn Mild Steel B. Bar No. 22. Untreated, ground. Speed 1,250–1,300 r. per m



NOTE.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 and Fig. 5

Fig. 25.

SERIES XXX (*g* D). $\frac{7}{16}$" bright drawn Mild Steel B. Bar No. 22. Untreated, ground. Speed 560–600 r. per m.

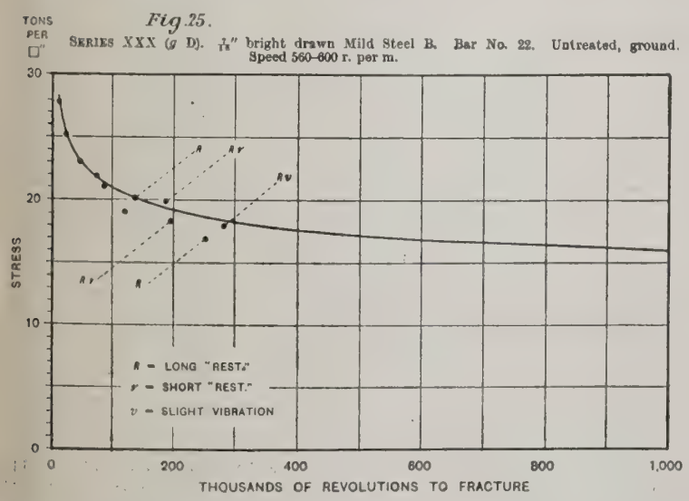
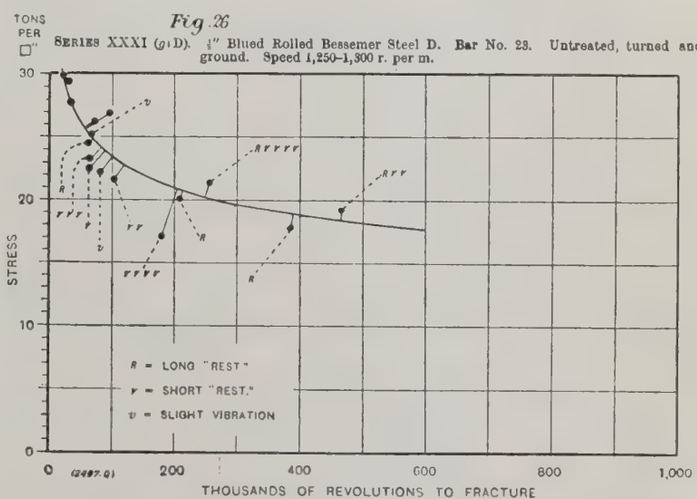


Fig. 26.

SERIES XXXI (*g* D). ¼" Blued Rolled Bessemer Steel D. Bar No. 23. Untreated, turned and ground. Speed 1,250–1,300 r. per m.



NOTE.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 and Fig. 5

straightened before testing. The curve, which is rather higher than XIX., is irregular. Diagram, Fig. 16.

In the following tests split-holders which clamped the test-pieces were used as shown at C and D, Fig. 5 (page 576), the last form D being found the most satisfactory.

SERIES XXI. (*e* C).—Sixteen tests of bright-drawn wrought iron, turned and polished, 600 revolutions per minute.

These tests ran with less vibration than XIX. and XX. The curve is quite definite. Diagram, Fig. 17 (page 578).

SERIES XXII. (*e* C).—Eleven tests of bright-drawn mild steel, quality B, at 600 revolutions per minute.

The test-pieces were made from the same bar as Series XI.; the variations from a smooth curve is much less than in the earlier series. Diagram, Fig. 18 (page 578).

SERIES XXIII. (*e* C).—Fourteen tests of annealed vanadium steel at 600 revolutions per minute. With the exception of two points these tests all lie well on a curve. Diagram, Fig. 19 (page 578), black circles.

SERIES XXIV. (*e* C).—Thirteen tests of oil-tempered vanadium steel at 600 revolutions. The results are rather irregular. Diagram, Fig. 20 (page 578), black circles.

SERIES XXV. (*e* C).—Twenty-eight tests of annealed vanadium steel at 1300 revolutions per minute. In this series one test-piece was run up to $3\frac{1}{2}$ million revolutions without fracture, and two fractures were obtained after

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Fig. 27.

Series XXXII (*h* D). Copper (Trolley Wire) hard drawn diam. 0·402″ Bar No. 24. Untreated, turned. Speed 1,250–1,300 r. per m.

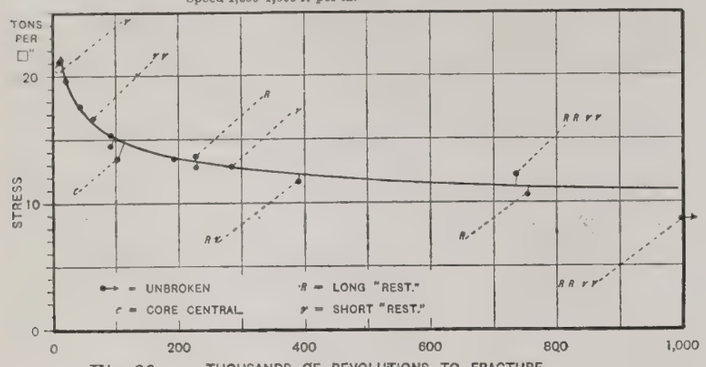
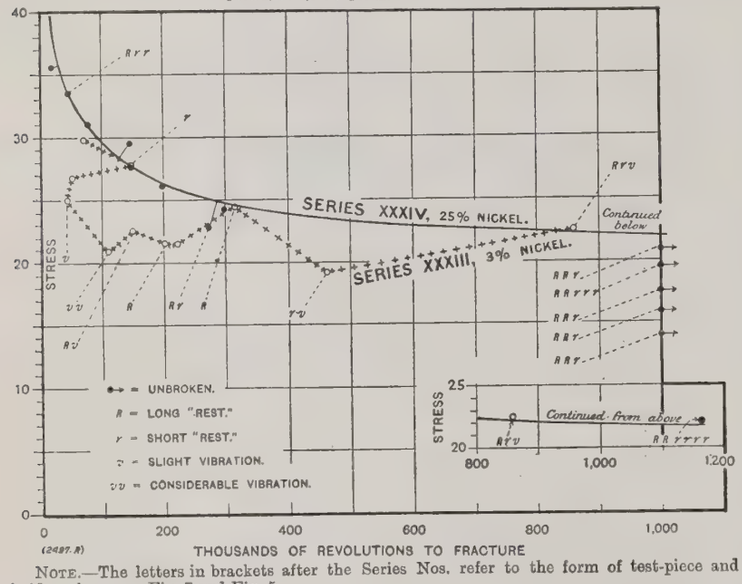


Fig. 28.

Series XXXIII (*g* D). Crossed line 3 per cent. Nickel Steel. Bar No. 25. Untreated, turned and ground. Speed 1,250–1,300 r. per m.

Series XXXIV Full line 25 per cent. Nickel Steel. Bar No. 26. Untreated, turned and ground. Speed 1,250–1,300 r. per m.



Note.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 and Fig. 5

about 2½ million revolutions. The majority of the tests fall fairly well on a smooth curve, but there are many outside points, and the three tests that passed the million revolutions limit differ widely. In this series the vibration was very small. Diagram, Fig. 19 (page 578), white circles, and Fig. 21 (page 579).

Series XXVI. (*e* C).—Twenty-five tests of oil-tempered vanadium steel at 1300 revolutions per minute. The vibration in these tests was greater than in previous cases. The holders did not grip sufficiently, and the specimens, being of a tough material, held on by a small core previous to breaking, causing considerable vibration until fracture occurred. Diagram, Fig. 20, white circles.

Series XXVII. (*e* C).—Ten tests of bright-drawn mild steel, quality A, at 1300 revolutions per minute. The specimens were made from the same bar as Series XIII. The test-pieces were slightly bent, and the points do not plot very well. Diagram, Fig. 22 (page 579), white ciroles.

Series XXVIII. (*f* D).—Twenty-one tests of bright-drawn mild steel, quality A, at 1300 revolutions per minute. New clamping-holders were used as shown at D, Fig. 5 (page 576). The curve is shown on diagram, Fig. 23 (page 579). In this series the draw-in chucks in some of the holders broke. New and thicker chucks were made to take $\frac{7}{16}$-in. round test-pieces, instead of the ½-in. test-pieces previously used.

Series XXIX. (*g* D).—Eleven tests of $\frac{7}{16}$-in. bright-drawn mild steel, quality B, at 1300 revolutions per min. The points plot well. Diagram, Fig. 24 (page 579).

The fractured test-pieces always show a "core" differing in appearance from the portions outside. The core is often round or oval, but is not usually exactly central. Most of the test-pieces in this series exhibited a central circular core; these are marked *c* on the diagram.

Series XXX. (*g* D).—Eleven tests from the same bar as Series XXIX., but at 600 revolutions per minute. The variation from a smooth curve is rather greater than Series XXIX. Diagram, Fig. 25 (page 579).

Series XXXI. (*g* D).—Sixteen tests of ½-in. blued rolled Bessemer steel, quality D, turned down to $\frac{7}{16}$ in. to fit the holders. The variations from a smooth curve in this case are so great that the material was thought to be unsuitable for obtaining a definite stress repetition curve, and no more tests were made from it. The vibration was very slight. Diagram, Fig. 26 (page 579).

Series XXXII. (*h* D).—Sixteen tests of hard-drawn copper trolley-wire at 1300 revolutions per minute. The form of the test-pieces is shown at *h*, Fig. 7 (page 576). The same holders were used with bushes inserted to take the smaller test-pieces. The points lie fairly well on a smooth curve. Diagram, Fig. 27 (above).

Series XXXIII. (*g* D).—Eleven tests of 3 per cent. nickel steel at 1300 revolutions per minute. Some of the tests show a very high resistance, but the points plot very irregularly, and no attempt has been made to indicate a smoothed curve. The vibration in these tests was very slight. Diagram, Fig. 28 (above), white circles.

Series XXXIV. (*g* D).—Fourteen tests of 25 per cent. special nickel steel at 1300 revolutions per minute. The resistance is much higher than was expected, and the stress applied in the first tests was too low, so that five specimens remained unbroken after a million revolutions.

With two exceptions, the points lie well on a curve. Diagram, Fig. 28, black circles.

Series XXXV. (*g* D).—Twelve tests of ½-in. bright-drawn wrought iron, at 1300 revolutions per minute. Diagram, Fig. 29 (above).

Series XXXVI. (*g* D).—Fourteen tests of the same material at 600 revolutions per minute. Diagram, Fig. 30 (above).

Series XXXVII. (*g* D).—Fourteen tests of the same material at 250 revolutions per minute. Diagram, Fig. 31 (above).

(To be continued.)

Fig. 29

Series XXXV (*g* D). ½″ bright drawn Wrought-iron. Bar No. 27. Untreated, turned and ground. Speed 1,300 r. per m.

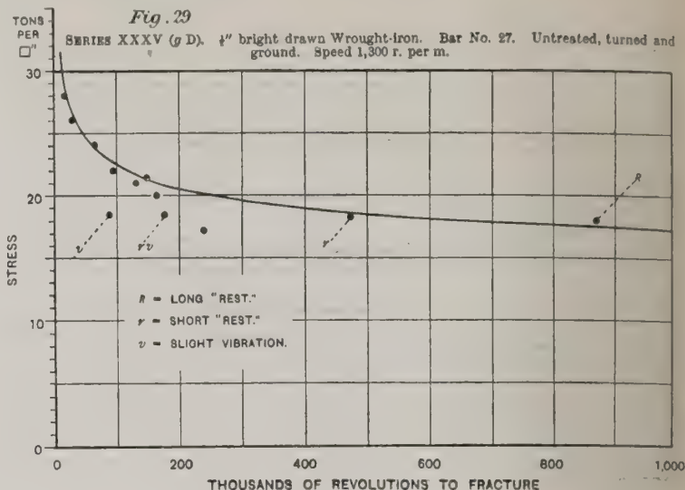
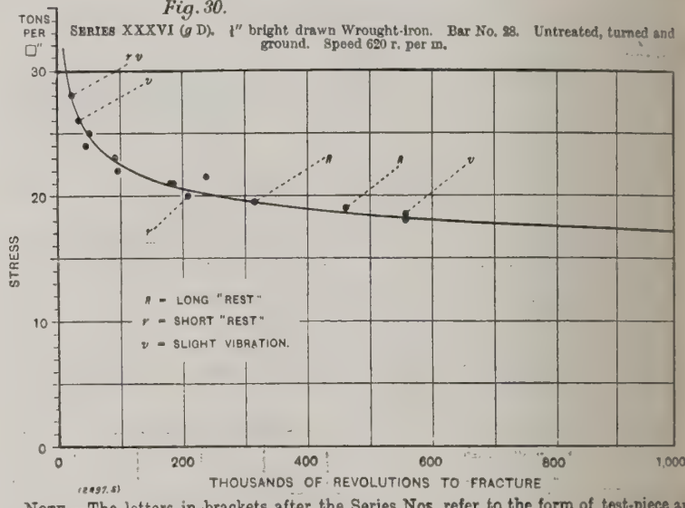


Fig. 30.

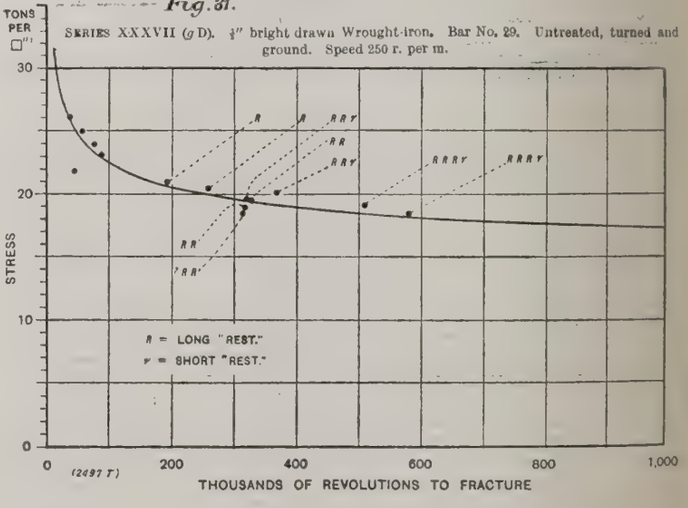
Series XXXVI (*g* D). ½″ bright drawn Wrought-iron. Bar No. 28. Untreated, turned and ground. Speed 620 r. per m.



Note.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 and Fig. 5

Fig. 31.

Series XXXVII (*g* D). ½″ bright drawn Wrought-iron. Bar No. 29. Untreated, turned and ground. Speed 250 r. per m.



Note.—The letters in brackets after the Series Nos. refer to the form of test-piece and holder, shown on Fig. 7 and Fig. 5.

The Copper Market.—According to the mid-monthly report of Messrs. James Lewis and Sons, Standard copper fell from 55*l.* per ton for cash on October 2 to 54*l.* 6s. 3d. on the 11th inst., 55*l.* 2s. 6d. being accepted for three months prompt, the small American exports for the month of September, and increase of 3428 tons in the stocks advised on the 10th inst., creating an unfavourable impression. With the improved political outlook, and large exports of Standard copper to Italy, materially reducing the stocks held in England, there has since been an advance to 55*l.* 5s. for cash and 56*l.* for three months, the closing values on the 16th inst. The lower prices at which some of the American producers offered electrolytic copper, down to 56*l.* 15s. c.i.f. for wire bars, have induced both American and European consumers to replenish their stocks, considerable sales resulting. Sulphate of copper continues in good demand.

FOREIGN ENGINEERING PROJECTS.

We give below a list of foreign engineering projects, for some of which tenders are asked. Further information concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Bolivia: H.M. Legation at La Paz have furnished the following particulars, taken from a presidential message to the Bolivian Congress, regarding railway construction in the Republic:—The construction work in the hands of the Bolivian Railway Company is proceeding with despatch. The line from Rio Mulato to Potosi is already in operation for the first 80 km., and 93 km. of track-levelling work have been completed. It is stated that the whole line will be in operation by the month of February, 1912. This line will give a great stimulus to the tin industry in and around Potosi. The line under construction from Oruro to Cochabamba has been in operation for the first 62 km. of the total distance of 210 km. since August, 1910. The Bolivian Railway Company is also proceeding with the construction of a line from Viacha to La Paz. When this line is finished it is proposed to build an extension therefrom to the Yungas Provinces of the Department of La Paz, and the necessary surveys have been made already for the first 67 kilometres of this proposed extension. The President recommended to the favourable consideration of Congress the proposal of the Bolivian Railway Company for the construction of the suggested railway line from La Quiaca to Tupiza. The railway from Arica (Chili) to La Paz will be opened to traffic in June, 1912, according to present estimates. Preliminary surveys will shortly be made of the projected line from Potosi to Sucre, with a view to its construction as soon as the present line under construction from Rio Mulato to Potosi is finished. Work on the Madeira-Mamoré railway is proceeding rapidly. Already the rails are laid up to the town of Villa Murtinho, opposite Villa Bella, and the traffic was to be inaugurated to kilometre 220, near the mouth of the River Abuna, by September. It is expected that this line will be completed by the end of the year 1912.

Mexico: H.M. Legation at Mexico City report that a contract has been made between the Mexican Government and the Compañía Agricola Tepiqueña for the irrigation of lands owned by the company in the district of Santiago Ixcuintla, Territory of Tepec. The company undertakes to carry out the hydraulic works necessary for the irrigation of 24,000 hectares (about 59,000 acres) of land, and in return the Government undertake to pay a subsidy of 25 pesos per hectare (about 1*l.* per acre). Plans of the works are to be submitted within a year from the date of the contract, and work begun within six months after the approval of the plans. Materials and plant required will be admitted free of duty for ten years from the beginning of the works. The *Diario Oficial* of September 21 notifies that a concession has been granted to Señora Josefa Llano, in conjunction with others, to construct from the River Turibo, in the State of Guanajuato, a feeding channel and two canals, designed to distribute water for hydraulic purposes in the districts of Piedra Gorda and Purísima del Rincon. The concessionnaires will be entitled to exemption from Customs duties in respect of machinery, &c., which it may be necessary to import for carrying out the work.

Argentina: The *Bulletin Commercial* (Brussels) of October 14 notifies, on the authority of the Belgian Vice-Consul at Mendoza, that a Bill has been submitted to the Legislative Chambers of the Province of Mendoza, with a view to obtaining authorisation for the issue of a loan of 10,000,000 pesos (about 875,000*l.*). This amount is to be utilised for the establishment of a sewerage system at Mendoza, for the extension of the water-works in the same town, and for the carrying out of kindred works in other towns of the Province.

Netherlands: The *Bulletin Commercial* (Brussels) of October 14 notifies, on the authority of the Belgian Legation at The Hague, that a Bill has been submitted asking for Parliamentary sanction for the construction of a railway from Burgh to Brouwershaven (Zeeland), and also for permission to relay and improve a section of the existing line from Brouwershaven to Steenbergen.

Norway: According to a recent report to his Government by the United States Consul-General at Christiania, the Kristiania Elektriske Sporvei, Valkyriegade No. 21, Christiania, propose to make a tunnel to enable the street tramways of the town to reach eventually a neighbouring amusement resort on a hill 3 miles away.

Russia: The *Journal de St. Pétersbourg* of October 8 announces that the special conference which has been held at Tiflis to discuss the question of the construction of the Arkhot tunnel through the main range of the Caucasus mountains, concluded its deliberations on September 18. The conference pronounced emphatically in favour of the project. The tunnel will be about 14 miles long. The cost of the work is estimated at about 100,000,000 roubles (about 10,500,000*l.*), and it will take eight or nine years to complete. It is stated that sufficient water power has been found in the vicinity of the proposed tunnel to supply electrical energy for carrying out the undertaking.

Projected New Mountain Railway in Norway.—The Norwegian Railway Department has been making surveys for a new mountain railway, which is to proceed from the Myrdal station, one of the most elevated points on the Bergen-Christiania Railway, through the picturesque Flaamsdal, to a point on one of the inlets of the Sognefjord. The new railway, which it is proposed to work by means of electric current from one of the State waterfalls, will, over certain portions, have to be constructed on the rack-rail system.

CATALOGUES.

New and Second-Hand Machine-Tools.—The Machine-Tool Company, Limited, Northern Works, London-road, Nottingham, have issued a catalogue giving prices and brief particulars of a great variety of new and second-hand machine-tools they have in stock. Some hydraulic plant, cranes, fans, engines, pumps, and miscellaneous machinery are also included in the list. Each item is assigned a code word to facilitate telegraphic inquiries.

Gas-Purifiers and Valves.—We have received from Messrs. C. and W. Walker, Limited, Midland Iron Works, Donnington, near Newport, Shropshire, a catalogue illustrating and describing Milbourne's patent luteless purifiers and purifier-valves, of which they are the sole makers. In these purifiers the cover-joint is made by means of a strip of rubber, semicircular in cross-section, secured to the cover without the aid of cement. The catalogue contains a list of users, and also illustrates several installations. A number of small plans, showing various arrangements of valves and piping for purifiers, are also included.

Grinding-Machines.—Messrs. Charles Churchill and Co., Limited, 9 to 15, Leonard-street, E.C., have issued a descriptive catalogue relating to their plain and universal grinding-machines, internal grinders, and also ring-grinders, tool-grinders, &c. The leading features of the various designs are fully described, and many illustrations of details are given. The machines, which are all of entirely British manufacture, are made at the works of the Churchill Machine-Tool Company, Limited, Manchester, an affiliated company. The descriptive matter deals fully with the range of work suitable for the machines described, and gives many practical hints as to the methods of setting down the machines and their care. The importance of cleanliness and attention to details is also pointed out, and information concerning the methods of carrying out work of an accurate description is also included. Suggestions as to the choice of suitable wheels are also given, together with data as to the correct speeds for the work, feed, and wheels for different classes of work.

Friction Metal Saws.—We have received from Messrs. E. G. Appleby and Co., 10, Victoria-street, Westminster, S.W., a pamphlet relating to Marston's patent high-speed friction saws, for cutting all kinds of rolled iron and steel sections cold. The saws can also be employed for cutting glass-hard high-speed tool steel. The saw consists of a plain steel disc, without teeth, driven by means of a belt, and carried in a saddle situated vertically over a slotted bed on which the bars are placed. The saw is fed downwards by two hydraulic cylinders, a third cylinder being provided to raise the saddle when the cut is completed. Although more burr is produced in cutting soft material by this method than by ordinary saws, the makers claim that, after making due allowance for this, the total cost of cutting is only one-third to one-sixth as great as with the older methods. It is stated that a 15-in. by 6-in. steel joist, or a 110-lb. girder tramway rail, can be cut through in one minute in ordinary working, and that much time is saved by the circumstance that it is unnecessary to clamp any but round sections. It is also mentioned that these saws are well adapted for hot sawing if a toothed blade be substituted for the plain disc.

Incandescent Oil-Lighting System.—A pamphlet relating to their well-known lighting system, in which ordinary petroleum is used in conjunction with an incandescent mantle, has reached us from the Kitson-Empire Lighting Company, Limited, of Stamford, Lincolnshire. The system is suitable for both interior and exterior lighting, and is largely used in factories and workshops, railway stations and sidings, wharves, docks, lighthouses, &c., as well as for street and shop-lighting. Several different patterns of lamps, ranging from 250 to 1500 candle-power, are illustrated, some of them being combined with an oil reservoir, and therefore self-contained, while others are fed with oil under pressure through a small pipe from a tank, which may be placed in any convenient position. An improvement, which has recently been adopted, will greatly facilitate the lighting of these lamps. It consists of an automatic thermostatic valve designed automatically to turn on the supply of oil to the vaporising tubes as soon as they are properly heated. This arrangement not only saves the time which would otherwise be occupied in waiting for the tubes to get hot, but prevents the burner from being flooded and the mantle blackened by the oil being turned on too soon. The device can be fitted to any existing pattern of Kitson lamp.

Centrifugal Friction-Clutches.—Messrs. Thomas Broadbent and Sons, Limited, of Central Iron Works, Huddersfield, have sent us a pamphlet illustrating and describing their automatic centrifugal friction clutches. These clutches have been designed to allow an electric motor to start up light, and to pick up its load gradually as the speed increases. They are thus particularly useful in connection with alternating-current motors of the squirrel-cage type, and other machines giving a poor starting torque. Briefly, the clutch consists of a boss keyed to the armature shaft and carrying four radial arms, in each of which slides a friction shoe or slipper. As the speed of the shaft increases, these shoes slide along the arms until they come in contact with the inside of the rim of the clutch pulley, which is keyed on to the shaft to be driven. The latter is thus started gradually by the friction between the shoes and the rim. If desired, the slippers can be arranged to move against the action of springs, so that no load comes on the motor until it has attained a suitable speed. The clutches also act as flexible couplings protecting the motor from shocks or suddenly applied loads; they can also be designed to slip at any desired overload. Among the other advantages claimed for these clutches it is mentioned that their use enables a considerable saving to be effected in the cost of the motor and switch-gear. The pamphlet illustrates a few of the many possible applications of the clutches, and gives prices and particulars of thirteen standard sizes, the largest of which has an outside diameter of 35 in., and is suitable for a load of 280 horse-power at 500 revolutions per minute.

Self-Discharging Railway Wagons.—A catalogue dealing with steel self-discharging hopper wagons for the transport of coal, ore, ballast, &c., has been issued by the Leeds Forge Company, Limited, of Leeds. The catalogue first deals with coal wagons, having capacities up to 40 tons, fitted with central-discharge doors. One wagon illustrated in this section is provided with both central and end-discharge doors, this arrangement enabling much of the space that would otherwise be wasted by the inclined surfaces at the ends of the wagon, to be usefully employed. The catalogue next illustrates and describes a new type of ballast-wagon arranged so that its load can be discharged between the rails, or on either, or both, sides of the track. The central and side openings are quite independent of each other, so that the discharge in any direction can be reduced or stopped as desired. Another recently introduced type of wagon is a composite flat-bottomed self-discharging wagon, intended for use on railways having a different class of traffic in opposite directions. This wagon is made flat-bottomed so as to be suitable for carrying general merchandise, timber, rails, &c., and the flat bottom is provided with doors through which coal or other minerals can be rapidly discharged. The doors cover the greater part of the bottom surface of the wagon, so that, when opened, about 90 per cent. of the load (when this consists of minerals) is discharged through the doors, which are arranged so as to deliver the material on both sides. The remaining material must, of course, be shovelled out. Any type or arrangement of doors can be adopted for the sides, or, if desired, the whole, or any part, of the sides can be made to open down to the floor-level of the wagon. These wagons can thus be utilised for several different classes of traffic, and are, therefore, not so likely to lie idle as those suitable for one kind of load only.

Rubber and Balloon Fabrics.—In the technical testing of rubber and balloon fabrics in the Königliches Materialprüfungsamt zu Gross Lichterfelde (West) the loss on washing of raw rubber samples is determined by washing on small rollers. The tensile strength and elasticity tests are made on the Schopper-Dalén machine, preferably with a ring-shaped test-piece. Many experiments were made with strips, both uniform in width throughout their length, and also with enlarged ends, but the results showed that breaking nearly always occurred between the jaws of the grips in the case of very soft samples. The rings used had a cross-section of 6.6 sq. mm. and an internal diameter of 44.6 mm., and were punched from sheet with a circular punch. As in the case of metals, the final extension under a given load can only be read off after the lapse of a certain time, and a further test is therefore applied in which strips or rings are suspended under a given load, and the extension observed when it has attained a constant value. The load is then removed and the contraction of the test-piece followed, and recorded. The behaviour of the sample under this test depends largely on the degree of vulcanisation. Further valuable information as to the durability of the sample is obtained by exposing it, in a stretched condition, to various external influences, such as an elevated temperature. To this end rings are stretched side by side on sheets of glass, this arrangement being a suitable one for observation, whether visual or with the aid of the camera. The behaviour of the test-piece when repeatedly stretched is ascertained with the aid of a machine by Schopper capable of testing four rings at a time. A bending or folding test is also applied by means of an apparatus similar to that used for paper testing. For abrasion or wear tests, balls of rubber 30 mm. in diameter are caused to run round a V groove under a heavy load. The nature and extent of the abrasion is very characteristic for a given mixing. In a second apparatus rubber rings are caused to run between two rollers. For testing rubber rollers for typewriters a small electro-magnetic hammer is employed. In the case of balloon fabrics the tests applied are as follow:—1. For tensile strength strips 50 mm. wide cut in two or four principal directions are tested. 2. For resistance to bursting pressure. A piece of the fabric is clamped between iron rings, the following diameters being recommended:—113, 160, 196, 252, 357, 505, and 618 mm., corresponding to areas of 0.01, 0.02, 0.03, 0.05, 0.1, and 0.3 sq. m. Air pressure is then applied from a bottle, or direct from an air-pump, until the fabric gives way. The bursting pressure is, of course, dependent upon the size of ring employed. 3. For gas-tightness—(*a*) Air is forced under a definite pressure through a circular disc of the fabric, the quantity being measured by means of a gas-meter; (*b*) for measuring the diffusion of hydrogen through the material, a sample is stretched between two funnel-shaped vessels, into one of which a mixture of air and hydrogen is passed, whilst air passing through the second vessel carries away the diffused hydrogen, which is estimated by combustion in presence of palladiumised asbestos. Tests made after exposure to wind and weather for a long time give an indication of the durability of the material. 4. Heat conductivity is determined by means of Bauer's apparatus, consisting of four opaque cylindrical vessels, across which samples of four materials to be compared may be stretched. The radiation passing through them from various sources is measured by means of thermo-couples placed behind the samples.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

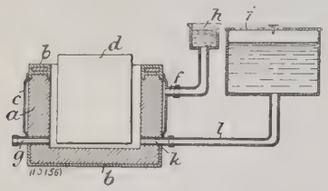
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

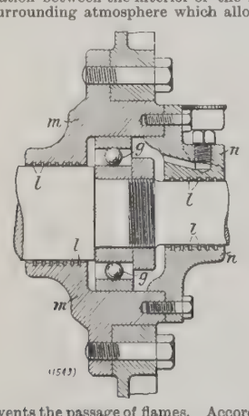
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

10,156 11. S. Benko, Budapest, Hungary. Voltaic Cells. [2 *Figs.*] April 26, 1911.—In voltaic cells, in which an exciting electrolyte is caused to pass through the porous wall of the negative electrode to the soluble or positive electrode, complete utilisation of the liquid can be attained if the depolarising and exciting liquid be not sent in dilute solution through the negative electrode to the positive electrode, but the exciting electrolyte be produced in the cell itself by the meeting of two liquids. For this purpose, according to this invention, the pores of the negative electrode are impregnated with a liquid which may or may not be under pressure, and which contains the exciting and depolarising electrolyte in a highly concentrated state, and water, which also may or may not be under pressure, is admitted into the chamber of the cell which contains the soluble or positive electrode. The concentrated electrolyte saturates the pores of the negative electrode so that the water in contact with the wall thereof dissolves the exciting electrolyte from such wall by osmotic action. *a* is the negative electrode and *d* the positive or soluble electrode. The negative electrode *a* is provided at top and bottom with terminal pieces *b*, to which is connected a casing *c*, which surrounds the electrode and forms th-rewith a chamber. The electrode *d* is arranged in the carbon chamber. In cases where the electrolyte is introduced into the chamber for the negative electrode the positive electrode may be placed outside the negative electrode. The electrolyte is introduced into the chamber formed by, and between, the casing *c* and the electrode *a* through a pipe *f*, and carried away from the carbon chamber through a pipe *g*. The highly concentrated exciting and depolarising electrolyte is poured into a vessel *h*, with which the pipe *f* communicates, and from which the liquid penetrates into the pores of the negative electrode when the vessel *h* is on a level with the cell—that is to say, when no pressure is employed, which is not the case in the example illustrated. Water is supplied to a vessel *i*, which by a pipe *l* communicates with a passage *k* formed in the electrode *a*. In the vessel *i*, or in the pipe *l*, may be arranged any suitable controlling and regulating device. From the vessel *i* the water flows in a regulatable stream into the carbon chamber. By regulating the supply from the vessel *i* the concentration of the exciting liquid may be controlled as desired. (*Accepted August* 23, 1911.)

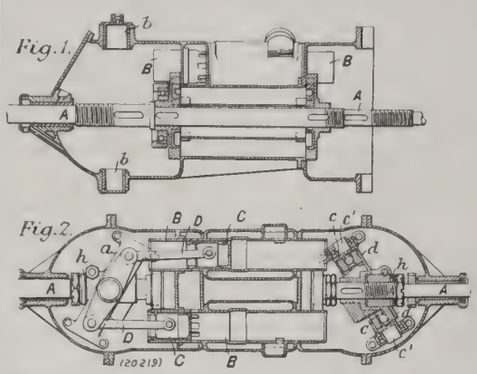


1543/11. J. C. Crawshaw, Dewsbury, and the Phœnix Dynamo Manufacturing Company, Limited, Bradford. Electric Motors. [2 *Figs.*] January 20, 1911.—This invention relates to electric motors particularly adapted for use where accumulations of explosive gases are liable to occur. The object of the invention is to construct a motor so that sparks in the interior of its casing will not ignite explosive mixture around the exterior thereof, without, at the same time, preventing egress of explosive gases which may enter the casing and be ignited inside. In other words, the invention provides a means of communication between the interior of the motor casing and the outside surrounding atmosphere which allows the passage of gases but prevents the passage of flames. According to the invention, means are provided for establishing such a communication in the case of motors fitted with ball or roller bearings. At the points where the shaft passes through the casing of the motor, a ring is bolted to the latter, and is made of such a form as to closely surround the shaft. This ring has the same effect as long journal bearings in allowing the passage of gas, and, at the same time, presents a sufficiently large cooling surface to any flame, to prevent the flame from passing through. *g* are the main ball-bearings of the motor. An internal ring *m* corrugated at *l* is bolted to the inside of the motor casing, and a subsidiary ring *n* of the same form is bolted to the ring *m*. (*Accepted August* 30, 1911.)

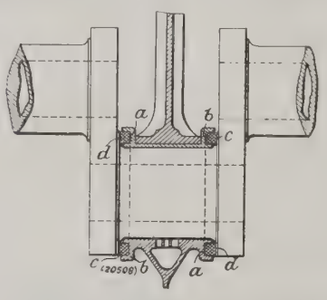


GAS ENGINES, PRODUCERS, HOLDERS, &c.

20,219/10. F. Lamplough, Willesden. Internal-Combustion Engines. [11 *Figs.*] August 30, 1910.—The invention relates to an improved internal-combustion engine. According to this invention, a pair of fixed parallel firing cylinders B is employed. The cylinders are open at both ends, and each is fitted with a pair of pistons C (only one of which latter is shown in each cylinder), which pistons alternately approach towards and recede from each other. These pistons, by connecting-rods D, are connected to means for oscillating inclined discs, one towards each end of the engine shaft, and thereby give rotary motion to said shaft. The following is the arrangement it is preferred to use in combination with the above-described parts for communicating motion from the connecting-rods D to the inclined discs *d*. At each end of the shaft A is a ring or gimbal *a*, oscillating in fixed bearings *b*. On a diameter at right angles to one passing through the trunnions, the gimbal *a* is provided with ball-bearings to receive the trunnions c^1 of a cup-shaped ring *c*. The inclined discs *d* are suitably balanced and keyed on the shaft A with capability of sliding longitudinally thereon for adjustment. The inclined discs *d* are each formed with a boss fitting the shaft A, and with a split socket to receive an adjusting sleeve screwing on to a screw-threaded part of the shaft A. When the inclined disc *d* is properly adjusted, the lugs of the split socket are drawn towards each other by a bolt, thereby locking such parts together. The inclined disc *d* and its adjusting sleeve are locked on the shaft A by a locking-ring *h*. As the pistons C fly out each way, the inlet ports near one end of each cylinder B are uncovered; the charge enters the cylinders and drives out the exhaust through the exhaust openings near the other end. (*Accepted August* 30, 1911.)

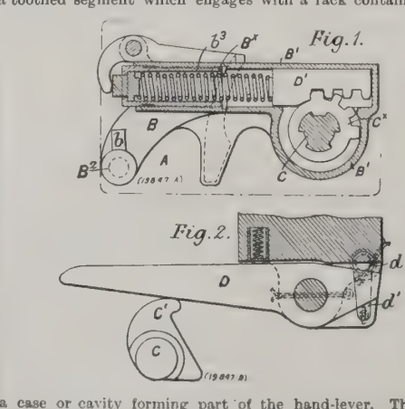


20,508/10. C. Y. Knight, Coventry. Internal-Combustion Engines. [1 *Fig.*] September 2, 1910.—In high-speed internal-combustion engines, more particularly in petrol-motors, it is found that considerable noise and vibration are produced by the relative motion between the big end of the connecting-rod and the webs of the crank. This invention consists in interposing between the big end of the connecting-rod and the webs of the crank-shaft a face of some soft material which will serve as a bearing. In carrying the invention into effect, according to the form illustrated, a groove *a* is cut in the bearing metal *b* at the big end of the connecting-rod, and in this groove are fitted rings or strips of fibre *c*, the fibre projecting laterally from the grooves so as to form a bearing against the webs *d* of the crank-shaft. (*Accepted September* 6, 1911.)

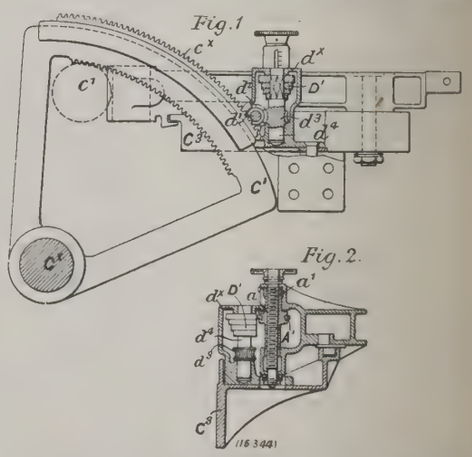


GUNS AND EXPLOSIVES.

19,847/10. Sir A. T. Dawson and G. T. Buckham, London. Breech-Block Gear. [10 *Figs.*] August 25, 1910.—This invention relates to breech-block actuating-gear for guns of the semi-automatic type that can be readily converted into quick-firing guns. According to this invention, the actuating-spindle is provided at its end adjacent to the hand-lever with a toothed segment which engages with a rack contained within a case or cavity forming part of the hand-lever. The rack is under the influence of a spring which is preferably of the helical type, and bears at one end against the rack and at the other end against an adjustable plug or sleeve screwed into the outer end of the case. The end of the actuating-spindle remote from that carrying the toothed segment is provided with the cam for co-operating with the hinged pawl in the usual manner. A is the breech end of the gun, B the breech-actuating hand-lever, B^1 the spring case containing the actuating spring B^*, C the block-actuating spindle, C^* the toothed segment, C^1 the cam, and D the hinged pawl adapted to engage therewith. The spring case B^1 is made integral with the hand-lever B, the handle of the latter being provided with a spring catch *b* adapted to engage with a part of the gun when the hand-lever is in the breech closed or closing position, the hand-lever being thereby restrained from moving until the catch is released by grasping the handle of the hand lever, as is well understood. The upper end of the spindle C carries the toothed segment C^*, which engages with the short rack D^1, which is slidably mounted in the case B^1. The helical spring B^* bears at one end against the rack, and at the other against the end of the adjustable screwed plug b^3. When the gun is to work semi-automatically, the pawl D operates upon the cam C^1 on the actuating spindle C in the usual manner, and as the hand-lever B is restrained from moving by the catch *b*, the actuating spindle C will revolve, and, through the intervention of the toothed segment C^*, will move the rack D^1 in a direction to compress the spring B^* within the case B^1 that forms part of the hand-lever B, as the block assumes the open position. The return movement of the block is effected by the reaction of the spring B^* on the actuating spindle C through the rack D^1 and the toothed segment C^*. For the first round the mechanism is operated by hand, the hand-lever B being then returned to its closed position, in which the catch *b* engages with its pocket in the gun A. As the block is now held open by the extractors, the spring B^* is fully compressed ready to close the breech when the extractors are released by the action of loading. When the gun is to work as a quick-firer, the said pawl D is set into its inoperative position relatively to the cam C^1 by any suitable means, such as a change-over switch comprising a transversely slotted rotary pin *d* having an operating arm d^1 at one end. When this rotary pin is turned into a position in which the solid or unslotted portion lies against the pawl D, the latter will be retained in a position in which it will not operatively engage with the cam C^1. The breech-block can then be moved into its open position by the hand-lever B, and the connection existing between it and the actuating spindle C, through the spring case B^1, the rack D^1, and the toothed segment C^*, the said rack occupying a position with its outer end abutting against the case B^1. During the closing of the breech the pressure of the spring B^* maintains the rack D^1 in its relationship to the pinion C^*, and is of sufficient strength to rotate the spindle C and close the breech. (*Accepted August* 30, 1911.)



19,344/10. Sir A. T. Dawson and G. T. Buckham, London. Sighting Apparatus. [6 *Figs.*] August 17, 1910.—This invention has particular reference to sighting apparatus of the kind in which, when the sight is elevated, the necessary correction for drift is imparted thereto by means of a cam working in connection with the sight-elevating mechanism and co-operating with a member carrying the sight. In sighting apparatus for howitzers, it has been proposed to employ a series of cam surfaces (corresponding to the deflection required to be imparted to the sight for the various charges used) formed on independent non-rotary cams or on a single non-rotary cam carried by the sight-holder and adapted to co-operate with a roller on a fixed part of the apparatus, the roller being adjustable so that it can be brought into contact with any one or other of the cam surfaces. It has also been proposed in rocking-bar sights to employ a series of cam surfaces formed on a single rotary cam carried by the sight-bar and working in conjunction with an adjustable roller on the sight-holder for the purpose of deflecting the line of sight for relative speed of ship and target. According to the present invention, the cam surfaces for imparting the necessary deflection to the sight corresponding to the different charges used, are formed on independent rotary cams (or on a single rotary cam) carried by a part of the apparatus that moves with the sight when the latter is elevated, and the roller co-operating with the cam surface is mounted on a member which carries the sight, and which is angularly displaceable about a vertical pivot. The elevating quadrant C^1 is rotatably mounted at C^* in a casing attached to one of the gun trunnions. The quadrant C^1 is formed with teeth on its inner periphery, with which a pinion c^1 of the usual worm and worm-wheel sight-elevating gear engages. The quadrant has a lateral platform C^3, constituting the sight-carrier, on which the sight-bar is pivotally mounted in such a manner that it can move laterally, to compensate for drift. A rack member c^* is connected to the aforesaid casing, with which member a pinion carried by the sight-carrier C^3 engages. The pinion is mounted on a horizontal spindle d^1, carried in a casing d^* attached to the carrier. The spindle carries a worm, which gears with a worm-wheel d^3 on a vertical spindle d^4, carrying the cams D^1, which, in the example shown, are four in number, corresponding to the number of powder-charge divisions on the range-drum. The roller A^1 that co-operates with the cams is carried by a sleeve *a* mounted in the sight-bar, and screw-threaded internally to receive a screwed spindle a^1, the rotation of which causes the sleeve *a* and its roller A^1 to move axially. A spring, one end of which is fixed to the sight-bar and the other to the sight-carrier C^3, causes the roller A^1 and its co-operating cam surface to remain in contact with each other. When the sight is elevated by the rotation of the pinion c^1, the sight as a whole is angularly displaced about the axis C^*. Consequently the rack member c^* causes the pinion engaging therewith to be rotated, and the cams D^1 thereby revolved through the worm gearing d^3, d^4. The roller A^1 has previously been adjusted so that it is in engagement with the cam corresponding to the charge employed in the gun. As the cams D^1 are mounted on the sight-carrier C^3, and the roller A^1 on the sight-bar, the rotary movement of the said cams causes the sight-bar to be deflected about its pivot. (*Accepted August* 23, 1911.)



OERLIKON ELECTROLYSERS AT THE ARMY AIRCRAFT FACTORY.

By G. Wüthrich.

The Gordon-Bennett races of spherical balloons, starting from Berlin on October 11, 1908, from Zurich on October 3, 1909, from St. Louis on October 8, 1910, and other events of a kindred nature, as well as the feats of the French Army dirigibles, and of the German Zeppelins and Percivals, together with the excellent performances of the British ships Beta and Gamma, and the trip of the French dirigible Lebaudy in 1910 from Paris to Farnborough, have demonstrated clearly that very great progress has been made by the lighter-than-air machine. For some time past, most Continental armies have had dirigibles attached to them as regular operation units. The British Army Aircraft Factory at South Farnborough, by its ceaseless and extensive work, affords a proof that the importance of aerial navigation has been recognised in this country also. Figs. 1 to 4, subjoined, show respectively the British airship Beta ready to start, the Gamma in full flight, and views of the sheds and aircraft factory at Farnborough. Both the Beta and Gamma are inflated by hydrogen generated by the Oerlikon type of electrolysers described further on. Since the advent of the airship motor and air-propeller the design of dirigibles has made great strides, and the balloon, once the plaything of a few enthusiastic sportsmen, occasionally also used by scientists, has become a serious means of aerial locomotion and transport; to act in the service of pleasure and science, and also for war purposes. The large number of airships already built and those now under construction, together with the increase in size and lifting capacity of the new types, have made it very necessary to give particular attention to the economic, commercial, and safe manufacture of pure hydrogen in large quantities.

It would lead us too far to describe here, even in a condensed form, the various processes made use of in the production of hydrogen. The best known processes are undoubtedly those based on the principle of decomposing water—1 lb. of water gives roughly 0.11 lb. of hydrogen and 0.89 lb. of oxygen. This principle of making hydrogen may be divided into two distinct methods—one depending on the absorption of energy solely, the other on the use of metals, &c., binding the oxygen. In the first case the gases, according to the system of operation adopted, are more or less pure, but ready for immediate use. In the second case it is necessary mechanically to separate the oxidation product from the hydrogen. The decomposition by means of heated metals, or carbon, or acids, &c., belongs to the latter class. Hydrogen manufactured by dissolving iron in diluted sulphuric acid is still used for inflating balloons. By far the most effective and best-known principle, and probably the only one of any real future value, is that of decomposing the water electrolytically. In making this pronouncement, the writer has in mind the cheap electricity now-a-days generated, particularly in countries favoured with Nature's most precious gifts—viz., coal-fields and waterfalls.

The commercial aspect of producing hydrogen (and oxygen) by decomposing water electrolytically becomes especially interesting when it is shown that this process may be used as an effective means of improving the relatively low load-factors under which many lighting stations are labouring. The surplus energy of these lighting stations may be transformed, by means of the electrolytic process, into hydrogen and oxygen, which may be led into gasometers, or compressed into steel bottles, for future use.

General.—Dr. Schmidt's system of apparatus, as manufactured by the Maschinenfabrik Oerlikon in Switzerland, has been greatly developed of recent

Fig. 1. Airship "Beta" Ready to Start.

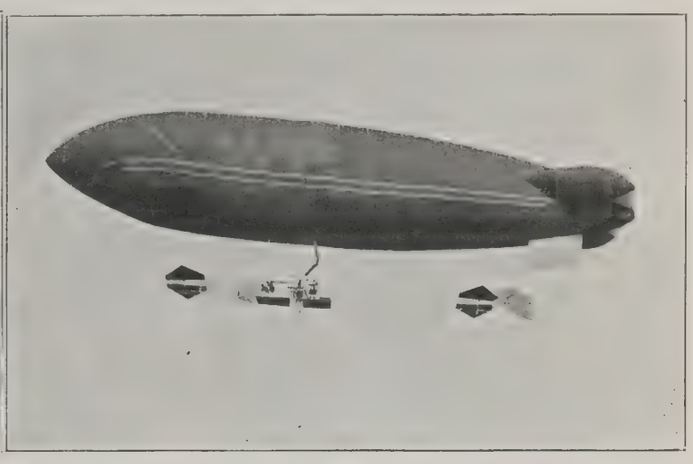


Fig. 2. Airship "Gamma" in Flight.

Fig. 3. The Airship Sheds at Farnborough.

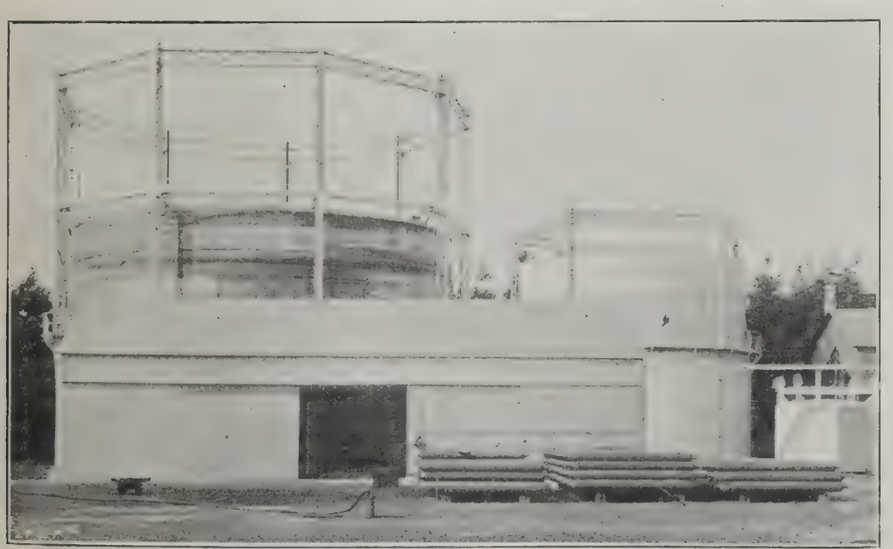


Fig. 4. The Aircraft Factory at Farnborough.

years, and the wide experience gained during well over a decade has resulted in the design of a complete series of fully-tried electrolysers, with their accessories. They have been standardised in twelve distinct units, as under :—

Type.	Amperes.	Volts.	Kilowatts.	Number of Cells.	Production of Gas per Hour in Cubic Feet.		Working Solution in Gallons.
					Hydrogen.	Oxygen.	
A	20	30	65	1.95	28	11.30	5.65	8.83
A	40	60	65	3.90	28	22.70	11.35	15.45
A	75	105	65	6.80	28	39.50	19.75	41.80
A	125	175	65	11.40	28	66.50	33.25	66.20
B	20	30	110	1.30	48	19.20	9.60	13.25
B	40	60	110	6.60	48	38.50	19.25	22.1
B	75	105	110	11.60	48	67.50	33.75	66.20
B	125	175	110	19.30	48	112.10	56.05	110.00
C	20	30	220	6.60	96	38.50	19.25	24.25
C	40	60	220	13.20	96	77.00	38.50	44.20
C	75	105	220	23.20	96	135.00	67.50	128.00
C	125	175	220	38.50	96	225.00	112.50	199 00

The maximum voltage and the number of cells for which the standard types of electrolysers are used are the following :—

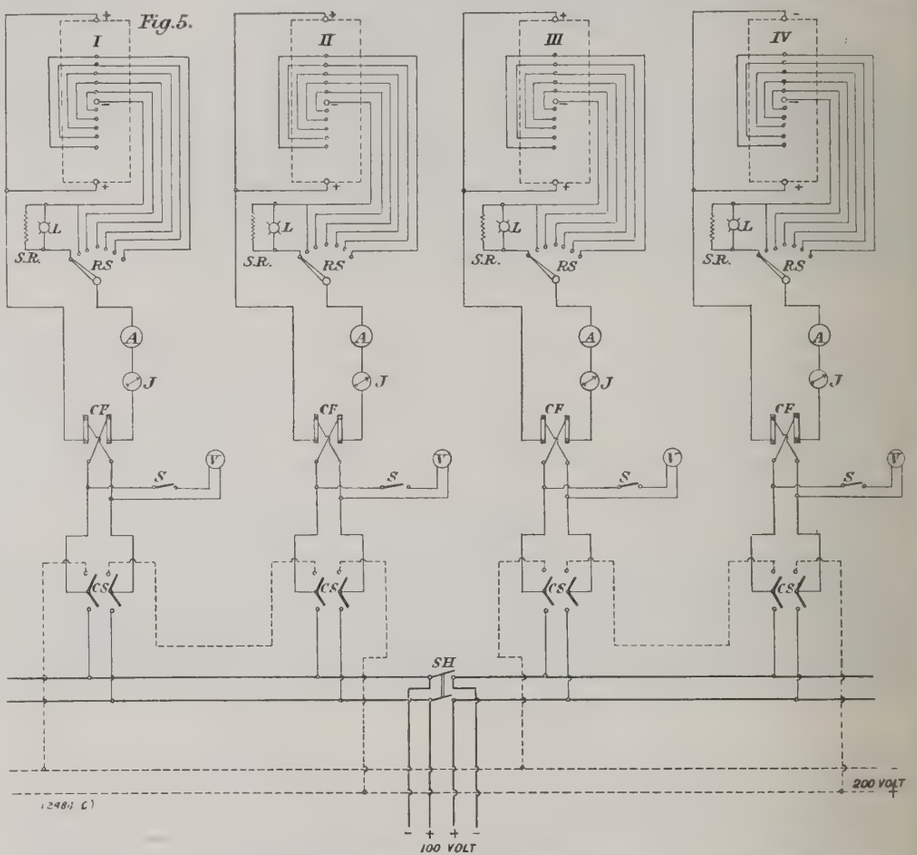
Type A ... ... 70 volts with 30 cells.
,, B ... ... 120 ,, 52 ,,
,, C ... ... 250 ,, 109 ,,

Other sizes are, of course, designed and constructed to meet special requirements, and the electrolysers can be combined in parallel and series banks or batteries as desired.

In the spring of 1910, the British War Office authorities, acting upon the specification issued by Mr. Mervyn O'Gorman, consulting engineer and superintendent of the Army Aircraft Factory, gave the Oerlikon Company the order for four plants for the production of hydrogen and oxygen by the electrolysis of water, and these plants have since been erected at the Army Aircraft Factory, Farnborough. A great resource of practically cost-less power will, in the future, be derived from the test-beds and laboratories at Farnborough, where the tests of aeroplane and dirigible engines are carried out. An essential condition for these engines is that they should run with absolute reliability over a very lengthy period; they are therefore thoroughly tested on *terra firma* before they are fixed into their respective places on the aeroplanes and dirigibles. In order, however, that the power generated during these trials may not be wasted, the dynamo coupled to the engines on the test-beds for the loading up of the machines generates electric energy—*i.e.*, direct current of 100 or 200 volts, the voltage depending on the speed at which these long-period trial-runs are carried out. The diagram of electric connections, Fig. 5, annexed, illustrates the flexible use to which the electrolysers can be put by generating the current either at 200 or 100 volts respectively. The general arrangement of the installation is shown in Figs. 6 to 8, on page 585, and Figs. 9 and 10, on page 586. The run of gas-tubes is shown in Fig. 11. It will be seen from the illustrations that there are two groups of electrolysers; each group is built for a current of 500 amperes, and consists of two electrolysers, type C. 125, the two connected in parallel.

The Oerlikon electrolysers consist mainly of a number of decomposition chambers or cells, connected in series, and provided with an automatically operated circulation arrangement for the solution and the gases, which arrangement keeps the chambers always properly filled, and simultaneously leads the gases by the quickest route to the gas-separators. The electrodes and diaphragms follow alternatively, and are carried on two carefully-insulated carrier-spindles; they are pressed together by means of a heavy screw and headstock-plates, filter-press fashion (Figs. 9 and 10). The electrodes are of special cast-iron, separated from each other by diaphragms made of specially prepared asbestos, provided with a rubber bordering about 30 mm. (1.18 in.) in width. The diaphragms serve both as an installation and a packing medium; they also keep the gases separate. The collection of gases inside the chambers, and the formation of a mixture of gases, is totally excluded. The electrodes are ruffled (Fig. 13), and subjected on the anode side to a secret process, in order to suppress all polarisation troubles and to prevent the formation of deposits, and the oxidation of the electrodes themselves. This special preparation, in addition to the very great care given to the manufacture of every part of the electrolysers by the Oerlikon Company, is eminently successful, and not only increases very considerably the life of the diaphragms and the period during which the plant remains in perfect working order, but the conductivity of the apparatus is also greatly improved, increasing the voltage efficiency of the whole electrolyser appreciably. The space between two electrodes and one diaphragm represents a chamber element or cell, and the number of chambers required is, of course, a direct function of the voltage of the electric circuit. The electrolyser used in conjunction with the Farnborough installation is of the so-called double type, equipped with a monopole centre-plate, on both sides of which the rest of the electrodes are arranged mirror-like. The design of the electrolyser is such that the distance between the individual electrodes is a minimum, and the quantity of the solution to be decomposed exceptionally small. The current (positive pole) is connected to the centre monopole-plate, from which it passes through both sides of the electrolyser to the end electrodes. These latter are electrically interconnected and form together the negative pole. The electrodes used for the regulation are grouped round the positive centre-plate. This type of electrolyser is diagrammatically illustrated in Fig. 12.

Fig.5.



A. Ammeter.
V. Voltmeter.
J Current-indicator.
S. Voltmeter switch.
CF. Change-over fuses.
CS. Change-over main switch.
BB. Main bus-bars.
bb. Auxiliary bus-bars for series connection.
RS. Cell regulating-switch.
SR. Starting resistance.
L. Signal-lamps.
SH. Switch.

The ruffling on the electrode surface above referred to not only increases the effective surface very considerably, but also forms a large number of small vertical channels, through which the liquid and gases are kept in constant motion by the rising bubbles. This brings about a very effective renewal of the liquid on the electrode surface, and prevents any possibility of back-pressure arising. It also makes it possible to run the electrolysers with a very high current density. Fig. 13 shows that the plates are made with circular holes on the left and right-hand side top corners, and with one in the centre at the bottom. These holes, when the plates are compressed on the carrier spindles, form circular tubes or passages for the gases. The passages are connected to the inner side of the cells by means of slots cast into the electrodes. The two main gas-passages formed by the holes in the top of the electrodes serve the purpose of leading away the oxygen and hydrogen, whilst the bottom passage represents the main for the electrolyte.

Solution.—The liquid used in the apparatus is, as a rule, a 10 per cent. solution of the purest refined potash in distilled water, having a maximum specific gravity of 1.10. The solution must show no trace of any mineral or chloric acid.

Efficiency.—As the heat of combination of water is 68,400 calories, and as 1 coulomb $= 4.18 \times 10^7$ erg $= 0.2394$ calories, the electrolysis of a gramme-molecule of water requires

$$\frac{68,400}{0.2394} = 285,714 \text{ volt-coulombs.}$$

Technically this pressure could be reached very closely if the decomposition of water were taking place according to the formula

$$H_2O = H + O.$$

The reaction is, however, more complicated, owing to the probable formation of primary O H and to the fact that a part of the energy is lost, due to the re-formation of water from 2 molecules O H.

As with the decomposition of 1 gramme-molecule of water, 2 gramme equivalents of hydrogen become free on the cathode side of the electrode, requiring, on the basis of Faraday's law, $2 \times 96,540$ coulombs, the theoretical decomposition pressure is

$$\frac{285,714 \text{ volt-coulombs}}{2 \times 96,540 \text{-coulombs}} = 1.48 \text{ volts.}$$

The practical decomposition pressure of the Oerlikon electrolyser at normal load and temperature (40 deg. to 50 deg. Cent.) is 2.2 to 2.4 volts—sometimes even lower—and therefore considerably lower than required in connection with other electrolysers. In practice, under normal working conditions, with the electrolyte properly warmed up, the current efficiency is on an average approximately 93 per cent., when 1 kilowatt-hour generates 5.9 cub. ft. to 6 cub. ft. of hydrogen and about 3 cub. ft. of oxygen. With the especially treated electrodes, this figure has been known to range approximately 5 per cent. higher.

The trials carried out at Farnborough have confirmed the figures above given.

Gas-Pressure.—The standard apparatus can be used for pressures up to 2.5 metres of water column, equal to about $\frac{1}{4}$ atmosphere, or 3.7 lb. per sq. in.; and by designing certain parts rather stronger than usual, the gas may be generated at a pressure of even 2 atmospheres (29.4 lb. per sq. in.) if required. The Farnborough installation produces gas at a pressure of about 6 in. to 7 in. of water column, which is led into the gasometers, where-

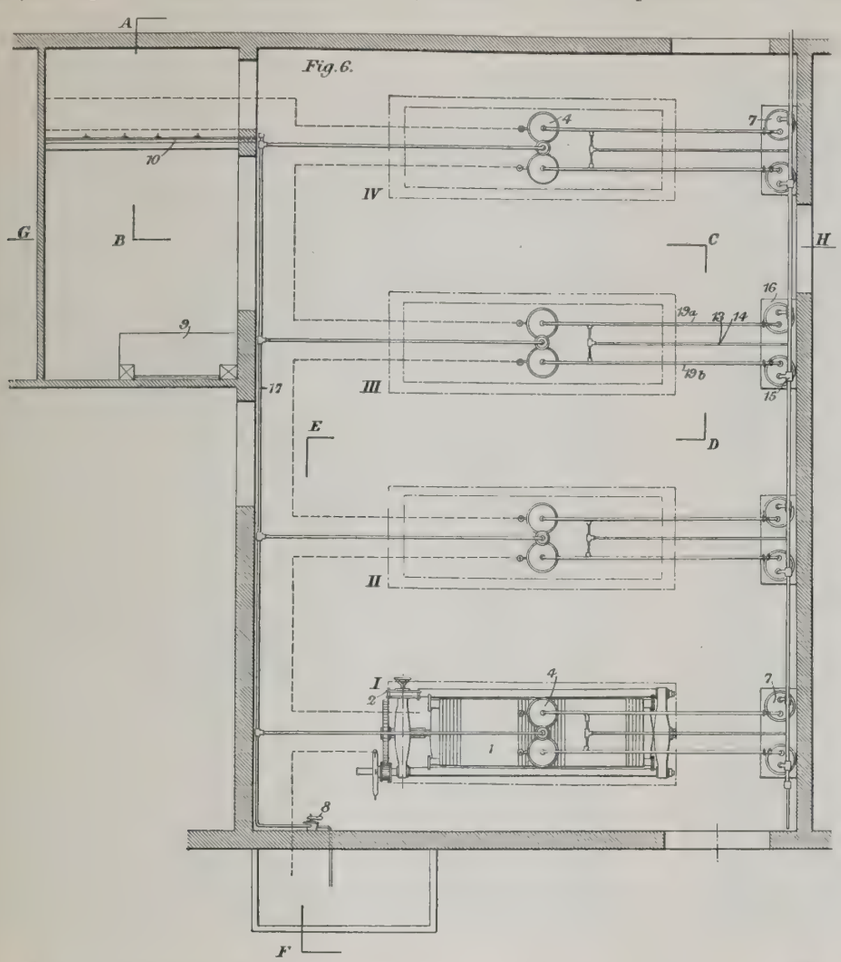
from it may either be used direct for the inflating of dirigibles, or compressed to about 120 atmospheres (1764 lb. per sq. in.) and stored in steel bottles (see Fig. 4, showing gasometers, compressor shed, and steel bottles immediately in front). The passages for the solution and the gases, going right through the electrolyser, result in quite a negligible loss of current and an infinitesimal mixing of gases, roughly in the proportion of the sections of these passages, to the total effective surface of the electrodes; electric resistances and back-pressures make themselves only felt when the plant is run with a very small current input, a condition which never arises in practice.

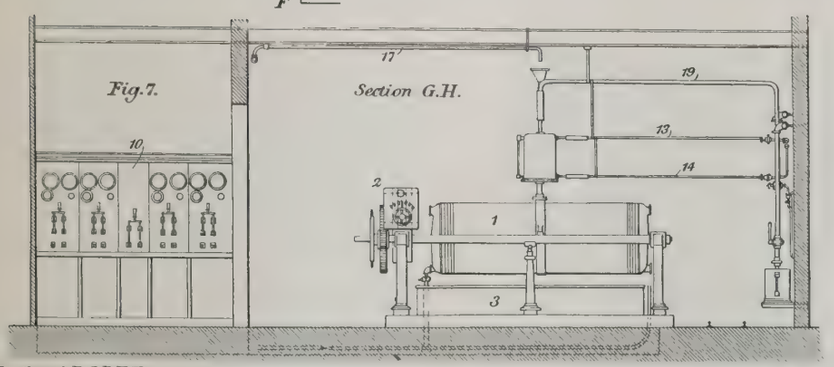
Purity of Gases.—Under normal load conditions the hydrogen generated does not contain more than 1 per cent. oxygen, and the oxygen not more than $2\frac{1}{2}$ per cent. hydrogen. The Farnborough plant, even under a continuous overload of approximately 35 per cent., generated at the trials hydrogen containing not more than 0.6 per cent. oxygen, whilst the oxygen registered about 1.8 per cent. hydrogen.

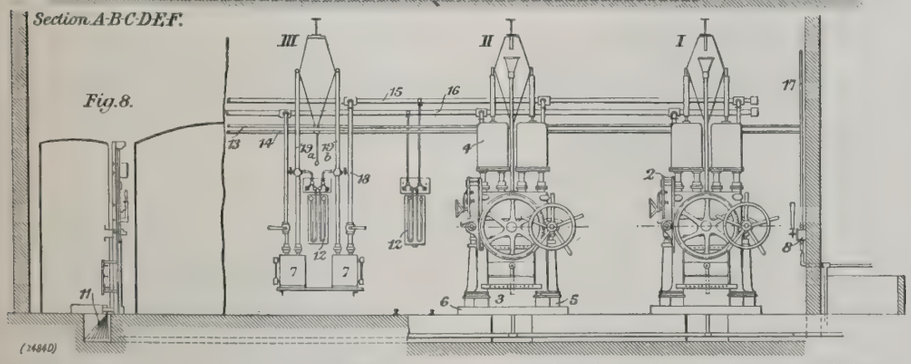
Overload Capacity.—The Oerlikon electrolysers easily stand an overload of 20 per cent., and sometimes more, provided that the cooling of the solution by means of cooling-spirals in the gas-separators be sufficiently complete. This facility of considerably overloading the plant, and of generating a proportionally increased quantity of hydrogen, is of the greatest importance, particularly in connection with military aerial navigation, since dirigibles may not receive a longer notice for sailing than any other army or naval unit.

Oerlikon Electrolysers.—These electrolysers can be connected either directly to an ordinary direct-current supply system or fed by a special dynamo. Under normal load conditions the decomposition voltage per cell is only 2.2 to 2.4 volts instead of 3 volts and more, as is the case with many other types of apparatus. The electric connections and the system of gas-tubing are extremely simple. The insulation and packing difficulties are reduced to a minimum, and the cost of maintenance is said to be very small.

Assuming continuous running and normal load conditions day and night, the Oerlikon electrolysers need not be overhauled and cleaned for some five to six months,* and then the whole operation should not occupy longer than, say, four hours, if properly prepared for beforehand. As already stated, the electrolysers allow the gases to be generated up to a pressure of about 2 atmospheres (29.7 lb. per square inch), securing the additional advantage that they may also be used for soldering and welding purposes, which is of particular value where large flames are necessary. Small pressure fluctuations have no detrimental influence.







1. Electrolyser unit.
2. Starting resistance with regulating switch (cell type).
3. Electrolyte tanks.
4. Gas-separators with cooling-water pipe.
5. Porcelain feet.
6. Concrete foundations.
7. Water seals.
8. Hand-feed pumps.
9. Testing-board and space attendant's desk.
10. Main switchboard.
11. Duct for electrolyser cables and drain-piping.
12. Gas pressure meters.
13. } Cooling-water piping.
14. }
15. } Main gas-pipes going to
16. } gasometers.
17. Electrolyser feed piping.
18. Gas-cocks.
19. } Gas-pipes connecting up
19a. } the gas-separators (8
19b. } in number) with the mains.

THE TWO-STROKE CYCLE ENGINE.

By R. G. Wells.

Nearly every internal-combustion engineer has had at some period of his career what might be termed an attack of "two-stroke;" indeed, such an experience is almost a part of his training, and may well be a not unimportant part. But the majority of inventors appear to be so taken up with the possibilities of the cycle that they rather ignore the impossibilities, whereas it is the latter that demand the greater attention. Therefore the present article aims at a critical analysis of some of the mechanical difficulties presented by the cycle, with a view to their possible elimination or modification, and that more particularly with reference to engines suitable for automobile and similar work. In dealing with these points it has to be borne in mind that the various functions and features, being largely dependent upon one another, can only be dealt with separately to a limited extent, and should always be considered in the light of their interconnection as a whole.

From the increasing number of "two-stroke" engines now being made, it would appear that the border-line between present practice and complete practical success must be a thin one; but while it may be thin, it is none the less marked in most cases. Reasons for this are not only the inherent difficulties of the cycle, but also a lack of working experience, for though the cycle calls for as much, or more, working experience as the "four-stroke," it has not yet had a tithe. The cycle received its share of attention up to the time of the lapsing of Crossley's Otto patents in 1890, when a four-stroke cycle of such well-proved merits becoming generally available, the still struggling "two-stroke" engine was quietly discarded by practically all the makers. While the lapsing of the Otto-Crossley patents was a sad blow to the advancement of the "two-stroke" engine, it should not be overlooked that, at the time, it was largely Crossley's success, combined with their monopoly, that spurred the early inventors on, and so helped to lay the foundation from which the cycle is now being advanced; this, largely by the elimination of numerous ingenious designs, the study of which

* Oerlikon electrolysers have been at work for as long as twelve months without requiring to be overhauled and cleaned.

OERLIKON ELECTROLYSERS AT THE ARMY AIRSHIP FACTORY, FARNBOROUGH.

CONSTRUCTED BY THE MASCHINENFABRIK OERLIKON, ENGINEERS, OERLIKON, SWITZERLAND.

(*For Description, see Page* 583)

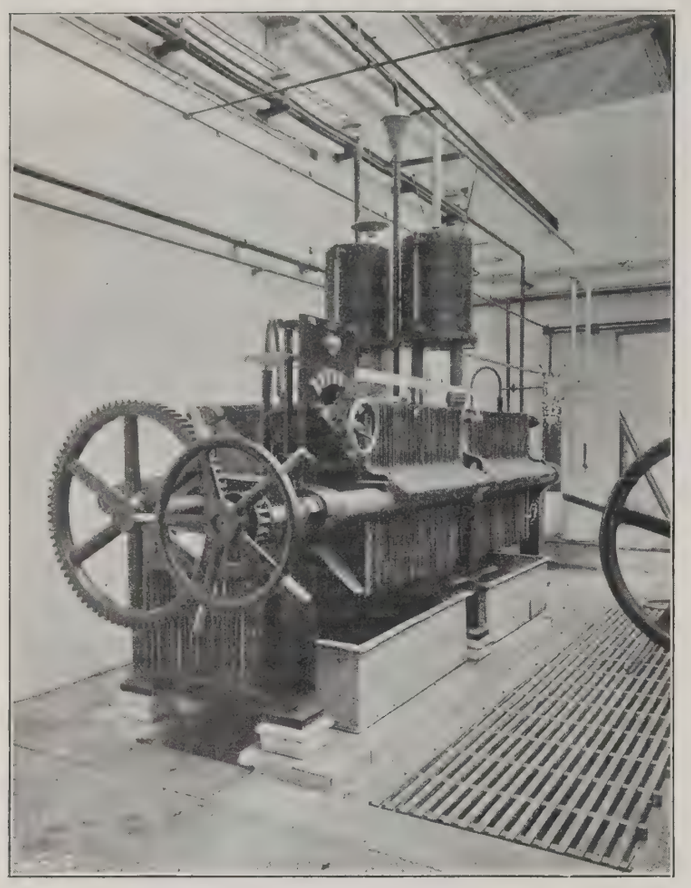


FIG. 9. VIEW OF ELECTROLYSER.

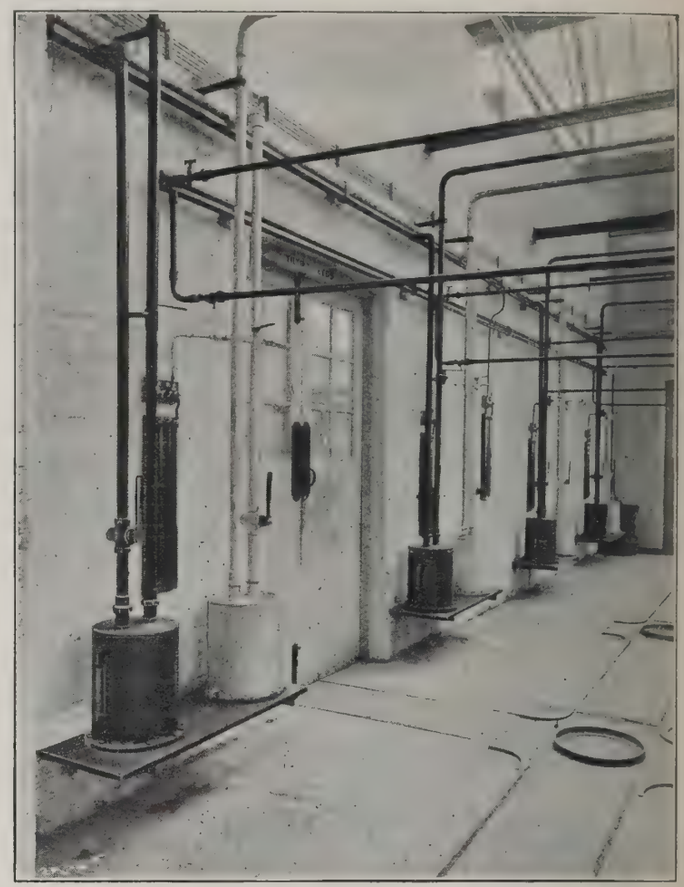


FIG. 11. VIEW SHOWING THE GAS-TUBE ARRANGEMENT.

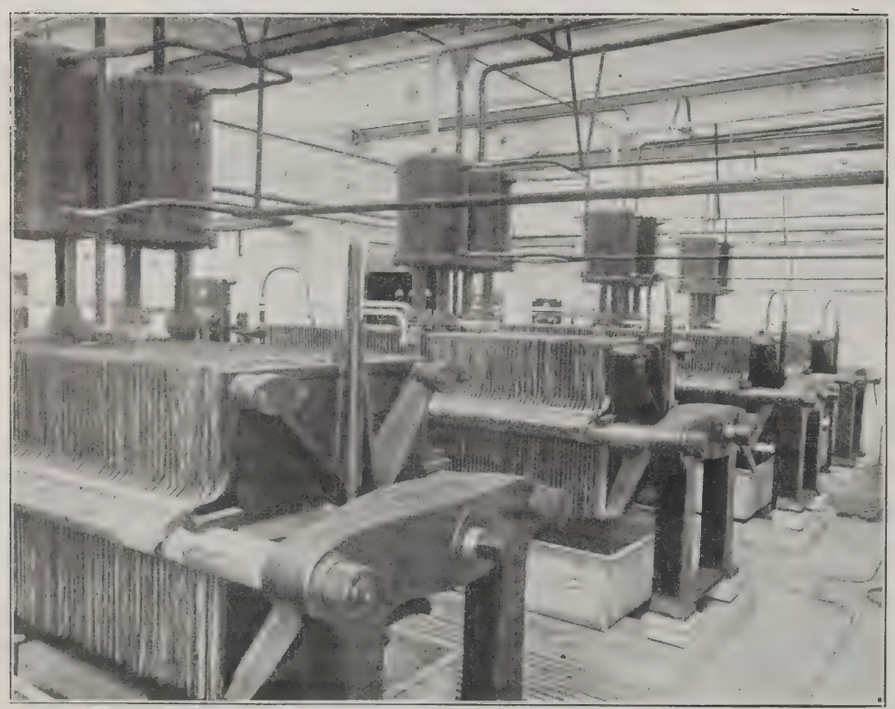


FIG. 10. VIEW SHOWING THE GROUPS OF ELECTROLYSERS.

Fig. 12.

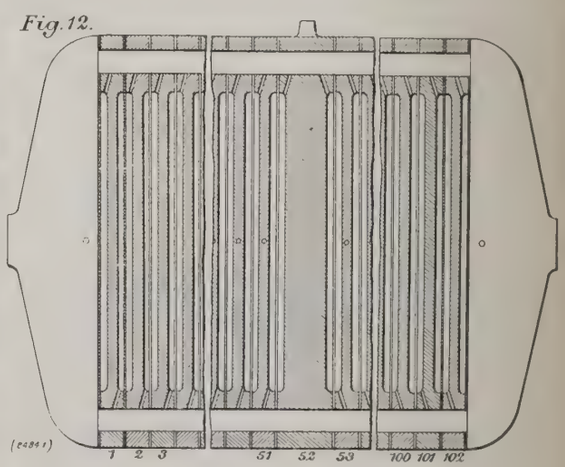


FIG. 12. DIAGRAM OF ELECTROLYSER.

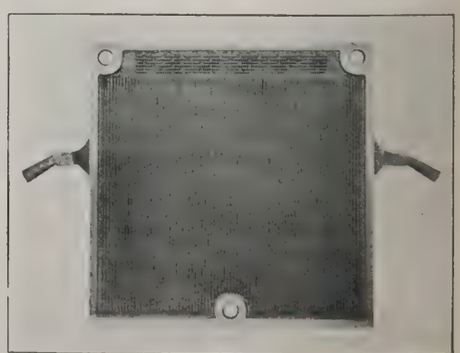


FIG. 13. VIEW OF AN ELECTRODE.

may still afford considerable instruction to the modern designer. In connection with the inventors of these early days, Dugald Clerk is one whose name should be mentioned as being closely associated with the pioneer work of the two-stroke engine.

In studying the cycle under review it is well not to under-estimate the excellent features of the four-stroke cycle, and going into the *pros* and *cons* of the former tends to a fuller appreciation of the latter. Theoretically, almost the only flaw in the four-stroke engine is the lack of complete scavenging, otherwise the Beau de Rochas cycle is nearly

ideally fulfilled. A deficiency that might be laid to its charge is that of the absence of expansive working, with consequent loss on the high exhaust pressure. The four-stroke cycle certainly does not include any really "idle stroke," often depreciatingly referred to; and in any case this so-called idle stroke is but transferred to the pump or its equivalent in the "two-stroke" engine. At the same time it is well to bear in mind that the classical compression cycle of Beau de Rochas did not necessarily imply four strokes as essential to the cycle; and to carry out the pump functions in the working cylinder, while being simple, is not ideal. Combustion entails requirements that are not necessary for the process of exhausting, charging, and compression, and it should be more efficient to provide separate cylinders, or their equivalent, adapted to the special requirements of the process carried out therein. Against this separation, however, must be set the slight loss incurred in transferring the charge from the pump to the working cylinder. As regards the matter of comparative thermal loss, this is somewhat swallowed up in the necessary waste by cylinder-cooling, but is in favour of the two-stroke cycle.

Fig. 1.

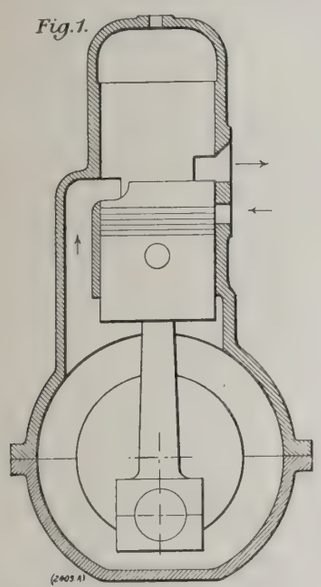


Fig. 2.

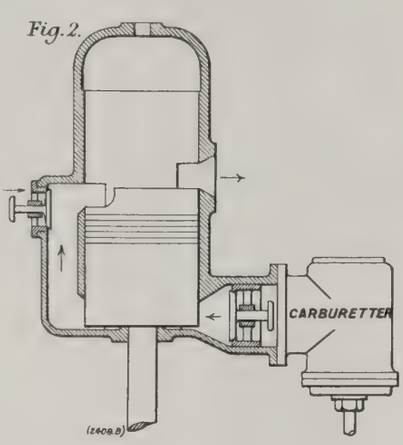


Fig. 3.

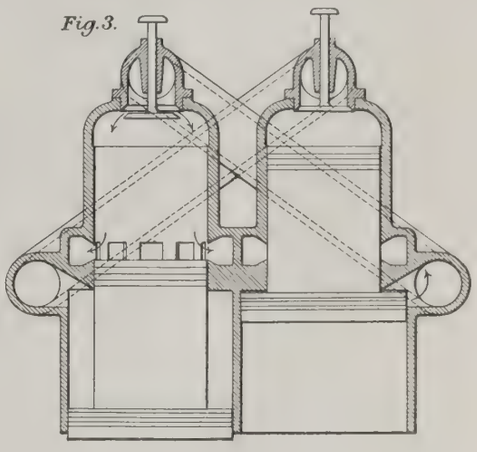


Fig. 4.

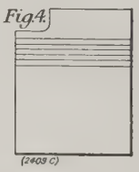
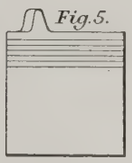


Fig. 5.

In designing a two-stroke cycle engine, many points peculiar to the cycle, and of the greatest importance to its success in practice, present themselves for determination, and yet about which there are, so far, but scanty data for our guidance. Thus the ports call for serious calculation as to their area, position, mode of operation, and timing; while such matters as method of control, fuel supply, and type of air-pump all require careful weighing. It is, indeed, largely from the lack of essential data of this description that the "two-stroke" engine suffers; and therefore instructive research-work, such as that carried out by Dr. Watson and Mr. Fenning, should prove of real value.

Ports.—A fundamental point for early consideration in design is that of the inlet and exhaust-ports, their size, position, and control. Both sets of ports should be of ample area; the inlet so that the fresh charge sweeps in in large volume and does not tend to mingle with the old charge so much as it would if forced in jet-fashion through confined ports; the exhaust should be of large area to allow of easy scavenging, with the minimum of back pressure, in the short time available. With reference to position, the simplest and most usual method is to place the two sets of ports opposite one another at the outer end of the cylinder, to be uncovered by the piston towards the end of its working stroke, for a period between one-fifth and one-quarter of the stroke (Figs. 1, 2, and 11). This arrangement must be carefully carried out with respect to exhausting and charging from the one end of the cylinder, with which in view, it would seem better to make the stroke the same as, or not much greater than, the cylinder bore. With the ports thus opposite one another it is necessary to provide a baffle on the piston-head to deflect the incoming charge to scavenge the cylinder-head, and to keep the charge from blowing straight across out through the exhaust-ports. For this purpose a stepped piston (Fig. 4) is preferable to the more usual piston-deflecting plate (Fig. 5), as the latter may have a tendency at times to become unduly hot, whereas a stepped piston, offering less area, has not this objection. In either case the baffle should be of ample proportions to ensure good deflection of the incoming charge. With the stepped type of piston the long side of the latter should preferably be arranged to take the connecting-rod power-stroke thrust. In its simplest form this disposition of ports entails the exhaust-ports remaining open longer than necessary on the inward stroke; this being due to the exhaust-ports requiring a lead in opening to allow the cylinder pressure to drop as low as that of the incoming charge before the inlet is uncovered; and as, in the ordinary way, the ports to be first uncovered will be the last covered, the exhaust remains open after the inlet. Placing a non-return valve close to the inlet ports would allow of them being uncovered at the same time as the exhaust, but such a valve, or valves, would have to be large to afford free way for the incoming gases. Placing both sets of ports at the outer end of the cylinder allows of a simple cylinder casting, with the advantage of a valveless head, and with an interposed charge of air—a point dealt with later—a thorough scavenge can be effected from the one end without loss of mixture: thus this arrangement has much in its favour.

The possible difficulties of exhausting and charging from the same end of the cylinder have led to the adoption of other port positions. A well-known alternative is that of having but one set of ports controlled by the piston, preferably for the exhaust, while the charge is admitted through a large poppet, or other valve, in the cylinder head (Fig. 3). This affords larger port area, with an end-to-end sweep for scavenging, and automatically gives correct timing of the inlet relative to the exhaust, but sacrifices the advantages of a plain combustion head. The Dolphin automobile engine was an example of this construction; while the Körting gas-engine, made by Mather and Platt, exemplifies it successfully applied for large powers.

A method of port control which has at least one notable exponent is that of utilising two pistons in a common cylinder open at both ends, the compression and explosion taking place between the opposed pistons, there being thus no cylinder head; while the inlet ports are at one end and the exhaust at the other end. Such is the system of the Oechelhauser gas-engine, built for large-power units by Messrs. Beardmore, of Glasgow. While this arrangement affords an ideal through way from the inlet to the exhaust port for scavenging, and incidentally relieves the main bearings of thrust, it is at the heavy cost of doubling the piston, with its connections and crank-throw. A modification of the double-pistoned Gobron-Brillie automobile engine might give a successful two-stroke engine on this principle (Fig. 6, page 588), but the same number of crank-throws would be required for each two-stroke cylinder as for two four-stroke cylinders, thus entailing some sacrifice in comparative simplicity.

This double-piston system is carried further in the dual-cylinder type of engine, in which a pair of parallel cylinders open into a common combustion-head. It may be roughly likened to the foregoing bent double in the middle (Figs. 7, 8, and 9). Here the inlet-ports are in one cylinder and the exhaust-ports in the other, each set controlled by its own piston, while the wall between the cylinders acts as a directing baffle, the scavenging flow being up one cylinder, across the combustion-head, and down the other cylinder. The dual cylinders may be set either one behind the other in line with the crank-shaft, with the connecting-rods operating from a common crank-throw (Fig. 7), or side by side across the crank-shaft, when the connecting-rods may work from a crank-throw set between the cylinders (Fig. 8), or from separate cranks geared together to revolve in opposite directions (Fig. 9). The first-noted arrangement is the simplest, and was adopted in the early Lamplugh design. The present Lamplugh engine, however, has the cylinders set side by side, with the two connecting-rods working on a single crank-throw set between the cylinders, as shown by Fig. 8, in such a manner that the piston controlling the inlet ports finishes its stroke a little behind the piston controlling the exhaust, thus giving the necessary lead to the exhaust-ports without the usual undesirable lag of closing behind the inlets, as indicated in Fig. 12. With this arrangement allowance should be made for the fact that the extended connecting-rod angle entailed by the off-setting effect of such crank position increases the piston side-thrust. The last-named dual-cylinder arrangement, employing independent cranks, is well exemplified in the Lucas engines, where advantage is taken of the two crank-shafts to effect a balance of impulse reactions by having a fly-wheel on each shaft, the shafts being geared together to revolve in opposite directions, on the same principle as the original Lanchester engine. It has occurred to the writer that a dual-piston engine might be made with the crank connected to the piston controlling the exhaust-ports set a few degrees in advance of its fellow-crank, as indicated applied to this latter principle by Fig. 9, so that the exhaust-ports would not remain open after the inlet, while opening earlier as usual, giving the cycle, Fig. 13, page 589. This differential setting would also put the exhaust-piston in a better position to receive the impulse at the time of firing. The gain of such a setting should more than compensate for any slight effect on balance.

The great weakness of the dual-cylinder arrangement is very evident by noting that the same impulses are obtained from a similar number of cylinders working on the four-stroke cycle. Moreover, the double set of pistons and rods does not afford any better balance than a single set; though, as noted in the Lucas engine, advantage is taken to balance impulses, but at the additional expense of gearing. Thus it is largely a matter of paying in primary parts for a gain of simplicity in secondary parts.

A somewhat untried method of end-to-end scavenging is that of having a tubular tail-rod extension from the top of the piston, which tail-rod works in a sleeve extension on the cylinder-head (Fig. 10). As the piston uncovers exhaust-ports in the cylinder walls, this extension, drawn out with it,

leaves the cylinder-head at the time of inlet, whereupon the fresh charge is forced up the tubular extension into the cylinder-head, and drives the spent gases out through the cylinder ports. On the return stroke the extension enters the sleeve portion of the cylinder-head and so closes the inlet, the exhaust ports being covered by the piston. This tubular extension may be longer than the stroke, so that it does not leave the cylinder-head sleeve, in which case it has ports through its upper end. The double-acting Enderly-Johnson engine, with its hollow through piston-rod, embodies this principle. To give a good passage for the incoming charge the tubular rod should be of sufficient diameter to afford an area of at least quarter the cylinder-bore area, which means both reduced working area and increased cylinder-wall area; and the packing round the neck of the cylinder-head extension is a matter that might give trouble in withstanding the working heat and pressure.

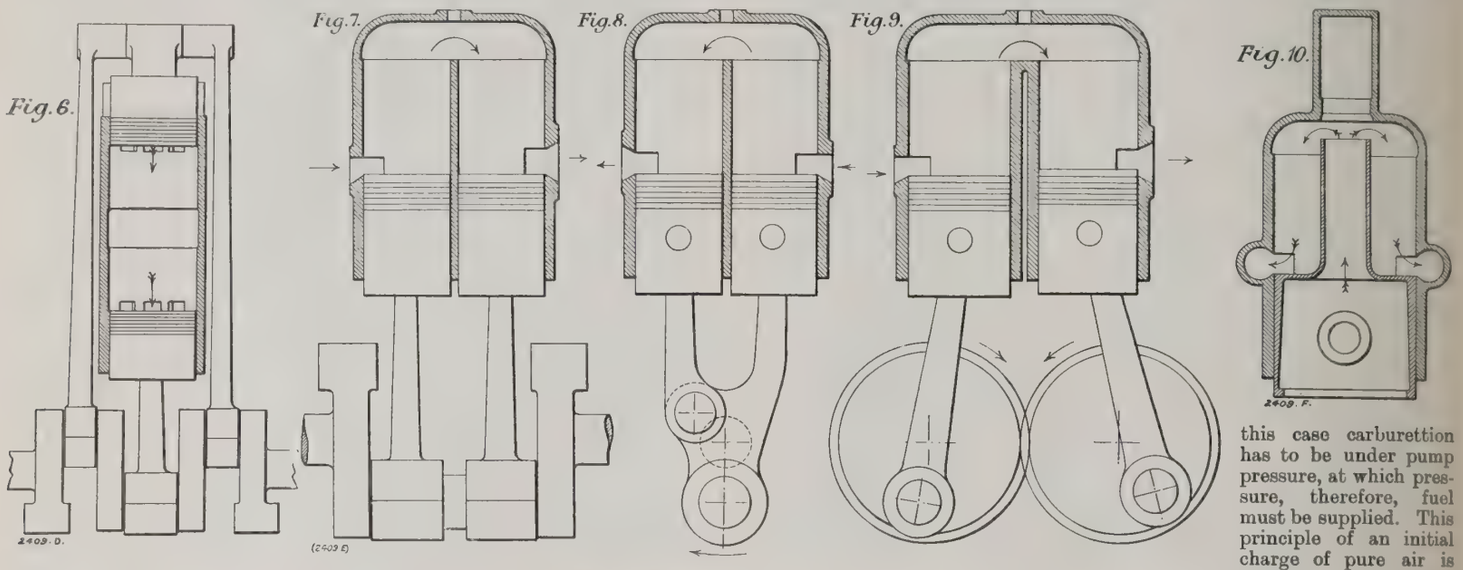
A recent idea for obtaining an end-to-end flow between ports is that of having the ports in an internal reciprocating sleeve situate between the piston and cylinder, similar to the Knight sleeve-valve. The inlet ports are in one end of the sleeve and the exhaust in the other end, those at the inner end sliding behind an inverted cylinder head, while those at the outer end are covered by the piston in the usual manner. Messrs. Willans and Robinson have patented, and commenced building, Diesel engines on this principle, in which the pump piston is made round the lower part of the sleeve, the pump-chamber being annular. To gain the required opening in the small portion of crank revolution available—55 deg. to 65 deg. either side of the dead centre (Fig. 14)—the travel of such a sleeve has to be considerable, approximating half the piston stroke; but as the sleeve reciprocates in phase with the piston, the frictional aspect of this length of travel is not serious. Ports so controlled are slow opening and closing, and it should be observed that the sleeve is solely on account of the ports at the cylinder head end; indeed, the opening and closing of the outer end ports is adversely affected thereby, as the sleeve moving with the piston partially negatives the piston's motion over the ports in the sleeve.

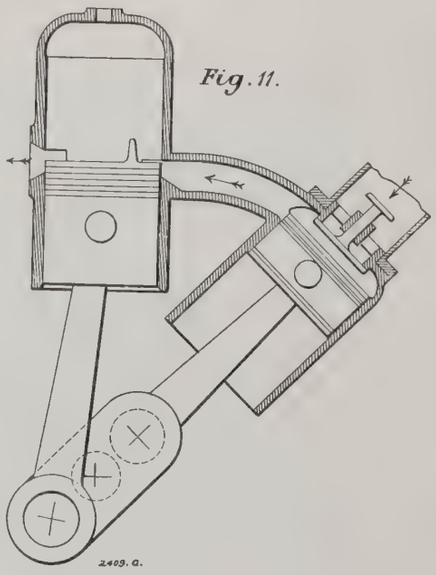
A revolving or oscillating sleeve has also been proposed for a similar purpose; but the possible area of ports so controlled is limited by the fact that the bars between ports must be the width of the ports plus coverance, thus leaving at most a total circumferential port width of but a third the cylinder circumference. Further, a revolving cylindrical member does not offer the same facility as a sliding one for being kept pressure-tight.

When double sets of ports are provided, as in the latter examples (Figs. 6, 7, 8, and 9), or a poppet or other valve in conjunction with a set of piston-controlled ports (Fig. 3); then, assuming that the total port area is thereby increased, the period of port opening may be less, and the working stroke proportionately slightly longer. But this reduction of time allowance for port opening cannot be carried far, as the minimum of time for efficient scavenging is irrespective of port area beyond certain limits.

While there are other possible port arrangements, such as piston valve and similar combinations, the foregoing can be said to cover the lines of present alternatives. Thus it will be seen that the position and control of the inlet and exhaust is a matter of several *pros* and *cons*; and while simplicity is in itself a most desirable feature, it should not be retained at undue expense of efficiency: a valve system partly independent of the working piston may justify its employment by the efficient engine working it ensures.

Fuel Feed.—In dealing with the usual shortcomings of the two-stroke engine, a leading point is that of economy, in which is involved the matter of fuel supply. An ordinary method of supply for small engines is for the pump to draw in its charge through the carburettor, the mixture thus obtained being duly transferred to the cylinder (Fig. 1); but in its simplest form this method entails serious





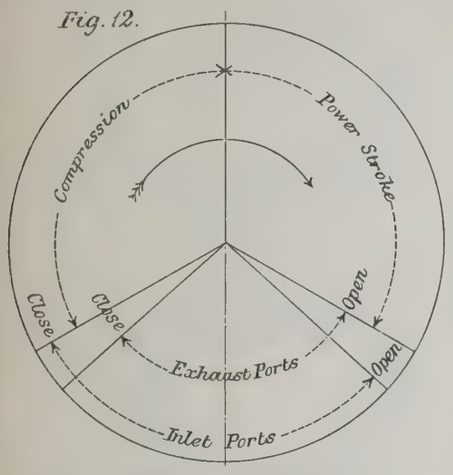
lack of economy, from two causes: either in ensuring complete scavenge, part of the fresh charge is lost with the exhaust, or, on the other hand, the exhaust is not completely expelled, and a portion remaining in the cylinder weakens the fresh charge; in variable running both these effects may occur. Then there is danger of the incoming charge being ignited by the hot, possibly still burning, gases in the cylinder, with a resultant back-fire. These difficulties may be largely overcome by an interposed air scavenge—that is, admitting pure air alone before the mixture. This may be arranged in several ways: a simple method is for the pump to draw in through two inlets, one which admits mixture direct into the main pump body, while the other admits pure air into an intermediate chamber between pump and cylinder (Fig. 2). This intermediate chamber being adjacent to the inlet ports, the pure air therein enters the cylinder first, driven by the mixture following it. While a certain amount of intermingling of scavenging air and mixture inevitably takes place, such a scavenge is a marked advance. The Ajax engine made at Stockport is a good example of this method under Bamford's patent. A method often adopted for large engines is that of having separate pumps for scavenging and charging; the Mort engine, with its divided rotary blower, is a successful example of this principle for light engines. While this duplicating of the pump is effective, it is at the cost of additional working parts, which, however, need not be prohibitive in a multi-cylindered engine. By effecting carburettion between the pump and the cylinder, part of the air may be diverted and admitted direct for scavenging; this allows of a good separation of scavenging air and mixture if ports can be arranged to deal with the separate charges in proper sequence. In this case carburettion has to be under pump pressure, at which pressure, therefore, fuel must be supplied. This principle of an initial charge of pure air is practically essential for efficient working. In its best form the scavenging volume should be variable for control purposes, and as less mixture is required proportionately more scavenging air should be supplied to ensure thorough sweeping out of the burnt gases, and to keep compression constant; though as regards this latter point a variable compression offers advantages for flexibility. Such scavenging should not be carried to an extent that unduly weakens the mixture by the inevitable intermingling.

Going a step further, there is what may be termed the full scavenge principle with separate fuel admittance under pressure, either before firing or on the Diesel system. In the Diesel type "two-stroke" engine scavenging and charging is by air alone, and fuel is injected under pressure direct into the cylinder after compression is completed, being ignited as it enters by the temperature induced by exceptionally high compression pressure, upwards of 500 lb. There is no explosion as usually understood, the fuel, which may be crude oil, being fed in gradually during the initial part of the working stroke, so that combustion is continuous; a very efficient control is afforded by having this fuel feed variable. The principle of fuel injection during or after compression lends itself peculiarly well to the "two-stroke" cycle; there is no possibility of loss of fuel by scavenging through the exhaust ports, and scavenging may therefore be thorough, and, with the exception of the fuel-feed valve, the cylinder head is clear of valves, which valves require a good deal of keeping up to their work against the high pressure entailed. While many such engines are running, it seems strange that the "two-stroke" type of Diesel engine is not more in evidence. It may be noted that the first Diesel engine built in England, by Scott and Hodgson, of Hyde, was on this cycle. Owing to the high pressure involved, with resultant working strains, the Diesel system does not lend itself well for comparatively light engines at present, though the near future may see its evolution for heavy automobile and similar work; in fact, experimental work has been in progress for some time with this end in view, and single-

cylindered Diesel engines of 5 horse-power were running at the Brussels Exhibition.

There are a number of successful two-stroke engines made for running on heavy oil in which the fuel is similarly injected after compression, but which, having a more normal working pressure, do not rely for ignition on compression heat alone.

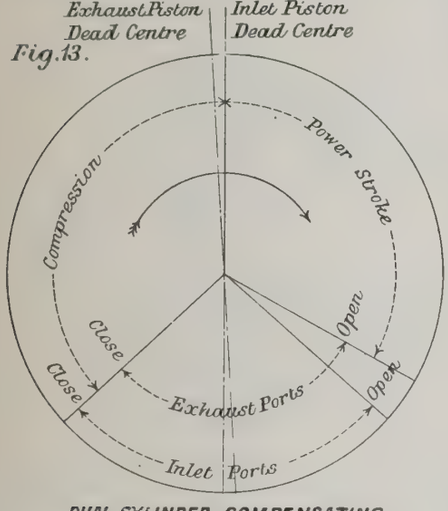
Fig. 12.



DUAL CYLINDER LAMPLUGH TYPE PORT SETTING.

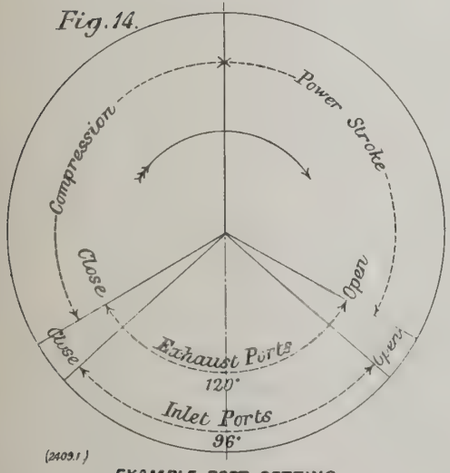
(2402.H)

Fig. 13.



DUAL CYLINDER COMPENSATING PORT SETTING.

Fig. 14.



(2403.I)

EXAMPLE PORT SETTING

These are started by aid of an external heating lamp until the cylinder gets hot enough by running for self-firing. A good example of such is the Marmot engine, made by Messrs. Sharer and Young, of Alloa, while on the Continent there are the Bolinders, the "Primus," and others. A compromise, retaining the chief advantage of this fuel-injection system, but of lighter construction, might be evolved by an engine made to run on the usual light motor-spirit. A simple electric ignition could be used for starting-up, to be switched off when the cylinder got sufficiently hot for auto-ignition, to which end a throttle inserted in the cooling-water circulation system would be an aid to letting the cylinder retain its initial heat. Such an engine might be made to run on ordinary paraffin oil after having been got well going on the lighter fuel, and should find ample scope for commercial-vehicle work; but the scheme is not as feasible as it is ideal.

(To be continued.)

BOOKS RECEIVED.

Natural Stability and the Parachute Principle in Aeroplanes. (*The S. and C. Series, No.* 39.) By W. Lemaitre. London: E. and F. N. Spon; New York: Spon and Chamberlain. [Price 1s. 6d. net.]

Electrical Mining Installations. By P. W. Freudemacher, A.M.I.E.E. London: Constable and Co. [Price 2s. net.]

Mill and Factory Wiring. By R. Geo. Devey, A.M.I.E.E. London: Constable and Co. [Price 2s. net.]

Projective Geometry for Use in Colleges and Schools. By William P. Milne, M.A., D.Sc. London: Macmillan and Co., Limited. [Price 2s 6d.]

A Treatise on Dynamics, with Examples and Exercises. By Andrew Gray, LL.D., F.R.S., and James Gordon Gray, D.Sc. London: Macmillan and Co., Limited. [Price 10s. net.]

Reinforced-Concrete Design Simplified. Diagrams, Tables, and other Data for Designing and Checking Accurately and Speedily. By John C. Gammon. With an Introduction by H. Kempton Dyson. London: Crosby Lockwood and Son. [Price 10s. 6d. net.]

The Post Office and Its Story. By Edward Bennett. London: Seeley, Service, and Co., Limited, 38, Great Russell-street. [Price 5s. net.]

Electric Cranes: Their Design, Construction, and Application. Being Vol. I. of a Complete Manual on Lifting and Hauling Machinery. By H. H. Broughton. London: *The Electrician* Printing and Publishing Company, Limited. [Price 25s. net.]

A Treatise on Hydraulics. By Hector J. Hughes, A.B., S.B., and Arthur T. Safford, A.M. New York: The Macmillan Company. [Price 16s. net.]

United States Department of Commerce and Labour. Bulletins of the Bureau of Labour. No. 93. *Wholesale Prices* 1890 *to* 1910. *Cost of Living in Great Britain, Germany, France, Belgium, and the United States.* No. 94. *Fourth Report on Hawaii.* Washington: Government Printing Office.

Boilers and Boiler Control: A Hand-Book for Firemen and Boiler Engineers. By John B. C. Kershaw. London: Davis Brothers. [Price 1s. net.]

Marine Engineering Estimates and Costs. For those engaged in the Technical and Commercial Sides of Engineering and Shipbuilding. By C. R. Bruce. Glasgow: Fraser, Asher, and Co., Limited, 164, Howard-street. [Price 4s. 6d.]

Smoke-Prevention and Fuel Economy (*Based on the German Work of E. Schmatolla*). By W. H. Booth, F.G.S., M. Am. Soc. C.E., and John B. C. Kershaw, F.I.C. Second Edition, revised and enlarged. London: Constable and Co., Limited. [Price 6s. net.]

Trempe, Recuit, Cémentation, et Conditions d'emploi des Aciers. Par L. Grenet. Paris: Ch. Beranger. [Price 16 francs.]

The Basic Open-Hearth Steel Process. By Carl Dichmann. Translated and edited by Alleyne Reynolds. London: Constable and Co., Limited. [Price 10s. 6d. net.]

Structural Engineering. By Joseph Husband and William Harby. London, New York, Bombay, and Calcutta: Longmans, Green, and Co. [Price 7s. 6d. net.]

The Testing of Motive-Power Engines, including Steam-Engines and Turbines, Locomotives, Boilers, Condensers, Internal-Combustion Engines, Gas-Producers, Refrigerators, Air-Compressors, Fans, Pumps, &c. By R. Royds, M.Sc. London, New York, Bombay, and Calcutta: Longmans, Green, and Co. [Price 9s. net.]

Le Chômage et son Remède. Par Daniel Bellet, Secretaire Perpétual de la Société d'Economie Politique. Preface de M. Paul Leroy-Beaulieu de l'Institut. Paris: Felix Alcan, 108, Boulevard St. Germain. [Price 3.50 francs.]

Multiplex Telephony and Telegraphy by Means of Electric Waves. By George O. Squier. A paper presented at the Twenty-Eighth Annual Convention of the American Institute of Electrical Engineers, Chicago, Ill., U.S.A., June 28, 1911.

Theorie und Konstruktion der Kolben- und Turbo-Kompressoren. Von P. Ostertag. Berlin: Julius Springer. [Price 11 marks.]

Plain-Language Extra-European Telegrams at Half Rates.—A scheme has been suggested by the Government of Australia, and elaborated by the Pacific Cable Board, by which the existing rates for extra-European telegrams may be reduced in the interests of those who only use the telegraph occasionally, chiefly for social and minor business affairs, and who cannot take advantage of the use of codes. The proposal, which is supported by the Governments of Canada and New Zealand, and has been accepted by the British and American cable companies, is that telegrams of the less urgent nature, which can, if necessary, be held back for not more than twenty-four hours in favour of fully-paid traffic, shall be sent at half the present rates.

THE SKEFKO SELF-ALIGNING BALL-BEARING.

Among the exhibits at the recent Electrical Exhibition at Olympia there was a very striking and novel ball-bearing, which we were only able to refer to briefly when dealing with the show as a whole. We now propose, however, to describe it in detail, as its special features render it of singular interest to all concerned with ball-bearing applications. The bearing is of Swedish origin, but is manufactured in this country by the Skefko Ball-Bearing Company, Limited, of Carlton House, Regent-street, London, S.W., who have works at Luton, in Bedfordshire. The commercial application of the bearing dates only from 1907, but its use has increased so rapidly that the Swedish works have been repeatedly extended, and now have a capacity of over 5000 bearings a day. The English works are also now being extended, although they were only completed in the early part of this year. The success which has attended the introduction of the Skefko bearing is witness to its practical value, and to the adequacy, in service, of its special features.

Although the bearing is very novel in its design, it is, none the less, so simple that the whole of its features may be appreciated after a few minutes' inspection of a sample, and there will be no difficulty in understanding its construction from the illustrations on page 590. Fig. 1 is a perspective view of a Skefko radial bearing of ordinary type; Fig. 2 a perspective view of a Skefko thrust-bearing, partly disassembled; Fig. 3 a cross-section through half of the radial bearing; and Fig. 4 a section through a combination thrust and radial bearing fitting. Confining our attention for the moment to the ordinary radial Skefko bearing, as shown in Figs. 1 and 3, it will be seen that the arrangement consists of a ridged inner race carrying two rows of balls which work against an outer race, the surface of which forms part of a sphere. The balls are held in position and their pitch is maintained by a solid metal cage, which can be very clearly seen in Fig. 1, and is shown in cross-section in Fig. 3.

The first main idea underlying the design of the bearing has reference to the fact that the spherical outer race allows the inner race and balls to swivel out of their plane of rotation, so that they are capable of adjusting themselves to any out-of-alignment of the shaft owing to bending or bad erection. The value of this feature is recognised in ordinary ball-bearings, which are so frequently mounted in swivelling housings, but the advantage of having the feature inherent in the bearings themselves is obvious, more especially as the swivelling, of course, takes place on balls instead of on a solid bearing, so that even in extreme conditions, with a badly bent shaft, or one somewhat light for the work in hand, the loss in friction due to the swivelling is extremely small. The second idea underlying the design is that, owing to the two rows of balls, the load is, at any instant, taken on three balls, situated at the apices of a triangle instead of on a single ball, as in an ordinary bearing. This feature greatly increases the capacity of the Skefko bearing, and renders it capable of dealing successfully with very heavy loads. A third feature of the bearing which should be mentioned, and which also has relation to the heavy loads which it can carry, turns on the areas of contact between the balls and the races. In an ordinary ball-bearing the areas of contact between the balls and the outer race are greater than those between the balls and the inner race. This is due to the fact that in the plane of rotation the outer race is concave towards the balls in contact with it, but the inner race is at the same time convex. The effect of the unequal contact areas is that undue wear takes place on the inner race, and at the same time unequal strains are set up in the balls, leading sometimes to fracture. In the Skefko bearing, however, these unequal areas do not exist, since the radii of curvature of the ridged inner race are taken so that the contact areas with the two races are the same. The radii of the inner race are a little greater than the radii of the balls, although this is not shown very well in Fig. 3.

It is probably hardly necessary to refer in further detail to the main features of the bearing, although it is perhaps well to point out that any load on the bearing must be taken equally by the three top balls, as they are at the corners of an equilateral triangle. Also that any such load is transmitted through the centre of the balls directly to the centre of the bearing, since the radius of the outer race is struck from this centre of the bearing. The tangents at the points of contact of any ball with the races are always at right angles to the line joining the centre of the ball to the centre of the bearing, so that there is at no time any outward thrust on the balls due to the load. At the same time, however, the bearing is capable of taking a certain amount of end-thrust, owing to the ridged inner race and the spherical outer one. The inner race and balls are capable of slewing completely round in the outer race, and at the same time maintaining proper contact with it. The example illus-

THE SKEFKO SELF-ALIGNING BALL-BEARING.

CONSTRUCTED BY THE SKEFKO BALL-BEARING COMPANY, LIMITED, ENGINEERS, LUTON.

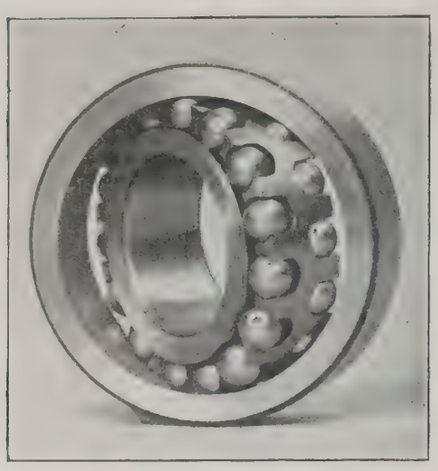


FIG. 1.

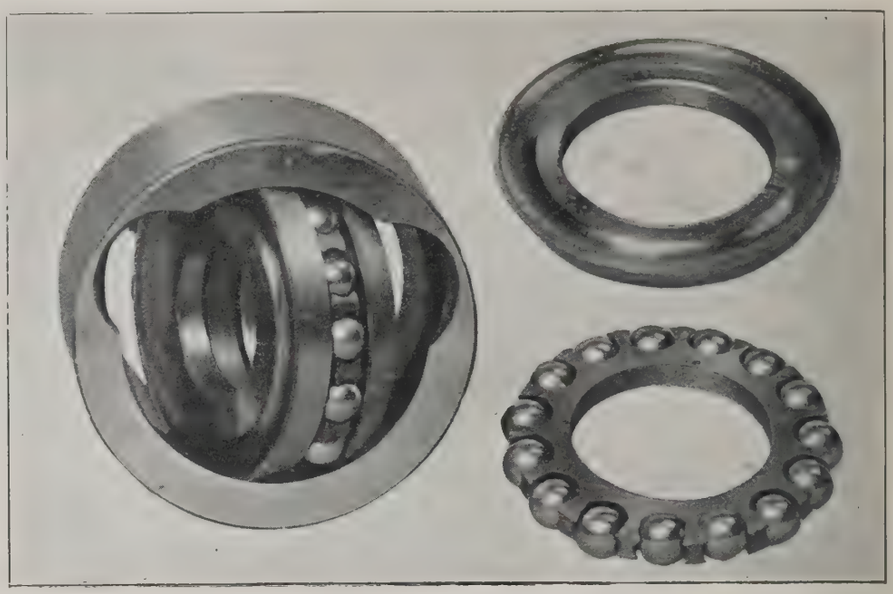


FIG. 2.

trated in Fig. 1 is shown with the balls and inner race moved round through a large angle.

It is claimed by the makers that Skefko ball-bearings are not only capable of performing very heavy duty as a result of their design, but also in virtue of the material of which they are made and the accuracy of their construction. Both balls and races are made of Swedish charcoal crucible cast steel, the balls being formed by a die-forging process, instead of being turned from a bar, so that they receive much working in course of manufacture and are of quite exceptional strength when completed. The races are turned from bar and hammered blanks, and are hardened and tempered in a special plant before grinding. The grinding is, of course, one of the most important operations in the manufacture of the races. It is done on machines specially designed for the operation, and carrying rotating carborundum wheels at the ends of oscillating arms. The pockets in the cages are proportioned to hold the balls quite loosely, but, at the same time, prevent them falling out by their own weight. A race with its balls may be handled as a complete unit, without fear of losing the balls, and, at the same time, any ball may easily be sprung out of place by prising it from behind, if it is desired.

We may say that we had an opportunity of inspecting the works of the Skefko Company at Luton on a recent date, and found them excellently equipped for the manufacture of the speciality to which they are exclusively devoted. The machine plant consists of automatic, semi-automatic, and engine lathes, grinding-machines, a special gas-heated oil-hardening plant, &c. The works also contain the usual tool-room, in which are made the working jigs and gauges to which the bearings are manufactured. The limit system is used throughout, and a very high degree of accuracy is obtained, the working gauges being founded on a set of Johansson gauges, which form the standard of the works. A very complete system of inspection at all stages is a feature of the manufacture, while all complete races are subjected to a Brinell hardness test. An interesting feature of the system is that the selling organisation of the firm has an inspector who is quite independent of the works side, and whose duty it is to inspect every complete bearing before it finally leaves the factory.

In conclusion we must mention the thrust bearing, shown in Figs. 2 and 4, which, although not the main feature of this notice, is of much interest in itself. The bearing shown has a double row of balls, but both double and single-row thrust-bearings are manufactured. The balls are carried in a phosphor-bronze cage, and the races and housing are turned from crucible cast steel and ground. The three races making up the bearing are turned so that their outer surface forms part of a sphere, which is capable of rotating in any direction in the housing to allow for lack of alignment. The disassembling of the bearing is allowed for by two slots made in the housing, which can be seen in Fig. 2. By swinging the races with their balls out of their plane of rotation until one of the end races comes opposite these slots it is possible to remove this race, and after it the first set of balls with their cage. The bearing is shown with these two parts removed in Fig. 2. The remaining parts may, of course, be removed in the same way, while individual balls may be sprung out of their cage exactly as in the ordinary bearing previously described.

Fig. 3.

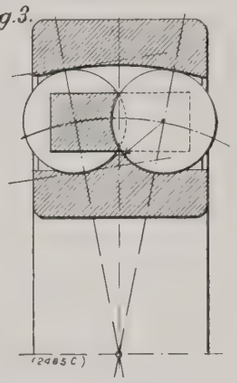
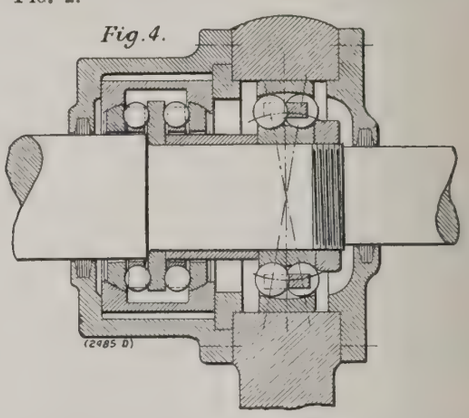


Fig. 4.



THE ARGYLL SINGLE SLEEVE-VALVE PETROL-ENGINE.

A NOVEL departure from the conventional design of valve-gear has been made in the petrol-motor now being put on the market by Messrs. Argylls, Limited, of Alexandria, near Glasgow. In this engine the usual tappet-valves are replaced by a single sleeve-valve, provided with suitably spaced exhaust and inlet ports, which, by means of an oscillatory rotation combined with a linear reciprocation, alternately uncover the exhaust and inlet ports in the cylinder. The general design of the engine, as will be seen from the drawings reproduced on the opposite page, follows the firm's usual practice, and we will therefore confine ourselves more particularly to a description of the valve-gear which has been designed by Mr. Peter Burt.

Referring to Figs. 1, 2, and 3, which give respectively an end view, a longitudinal section, and a cross-section of a 25-horse-power engine, it will be seen that the cylinders are fitted with loose liners or sleeves A in which the pistons work. In the cylinders two sets of ports are formed at the upper end, there being three ports for inlet and three for exhaust on opposite sides of the cylinder, whilst in the valve-sleeves five ports are provided, of which one is alternately used for exhaust and inlet. In Fig. 4 we reproduce photographs of a pair of cylinders, cut in sections in order to show the arrangement of the water-jackets which entirely surround the ports; the upper view shows the cylinders cut through at the port level, and the port will be cut between the water spaces shown. The cylinder-heads B, which are also water-jacketed, project into the cylinders and form pistons, which serve to close the upper ends of the valve-sleeves. The arrangement of these heads will be seen from Figs. 2 and 3, whilst Fig. 5 further shows the manner in which the water-jackets are connected up to the corresponding spaces in the cylinders.

As already mentioned, the valve-sleeve receives a combined reciprocating and oscillating motion, which is obtained as follows:—Referring to Figs. 2 and 3, it will be seen that at the lower end of the sleeve a forked lug (clearly shown in Fig. 6) is formed, into which is fitted a crank-pin D, held in place by a hinge-pin E, which allows the crank-pin to move in the horizontal plane. The crank-pin D works in an eccentric hole in the crank-bush F, which is rotated at half engine-speed from the lay-shaft C by means of skew gearing. It will thus be seen that the valve-sleeve travels in a vertical direction equal to the throw of the crank-pin D. Owing, however, to the hinge-pin E being at a greater distance from the axis of the sleeve than the port-faces, the length of arc travelled in a rotary direction by the ports is less than the throw of the crank. It will thus be seen that the motion imparted to any point in the sleeve is an ellipse, having its longer diameter vertical, and therefore the ports in the sleeve have an elliptical motion with regard to the fixed ports in the cylinder, as indicated in the diagrams on Fig. 7, page 592. In this figure the forms of the two sets of ports are shown, and their relative positions at six different positions of the engine cycle are also indicated, whilst diagrams are also given showing the relative positions of the crank and sleeve-valve for a complete cycle of the engine.

From the diagrams it will be seen that the ports are opened during the lower portion of the sleeve motion, inlet occurring on the upward, and exhaust on the downward portion of the stroke. During the upper part of its travel, corresponding to the compression and working strokes of the engine, the ports in the sleeve are covered by the fixed piston, already mentioned, and are thus entirely protected from the action of the burning gases; another and more important function of this piston is that of relieving the ports of the necessity of withstanding the high pressures due to compression and explosion of the charge.

Referring to the diagrams, Figs. 7 and 8, page 592, it will be seen that at the time of opening the inlet ports the sleeve is passing across the lower end of its elliptical path, where its rotary motion will be relatively rapid with regard to that of the engine piston, and further, that the direction of motion is such as to give a rapid opening of the ports. Continuing its motion around its

25-HORSE-POWER ARGYLL SINGLE SLEEVE-VALVE PETROL-ENGINE.

CONSTRUCTED BY ARGYLLS, LIMITED, ENGINEERS, ALEXANDRIA, N.B.

Fig. 1.

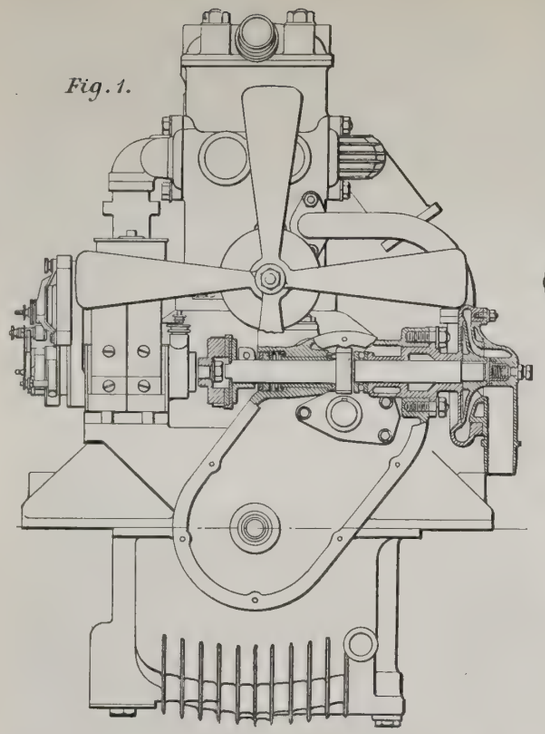


Fig. 2.

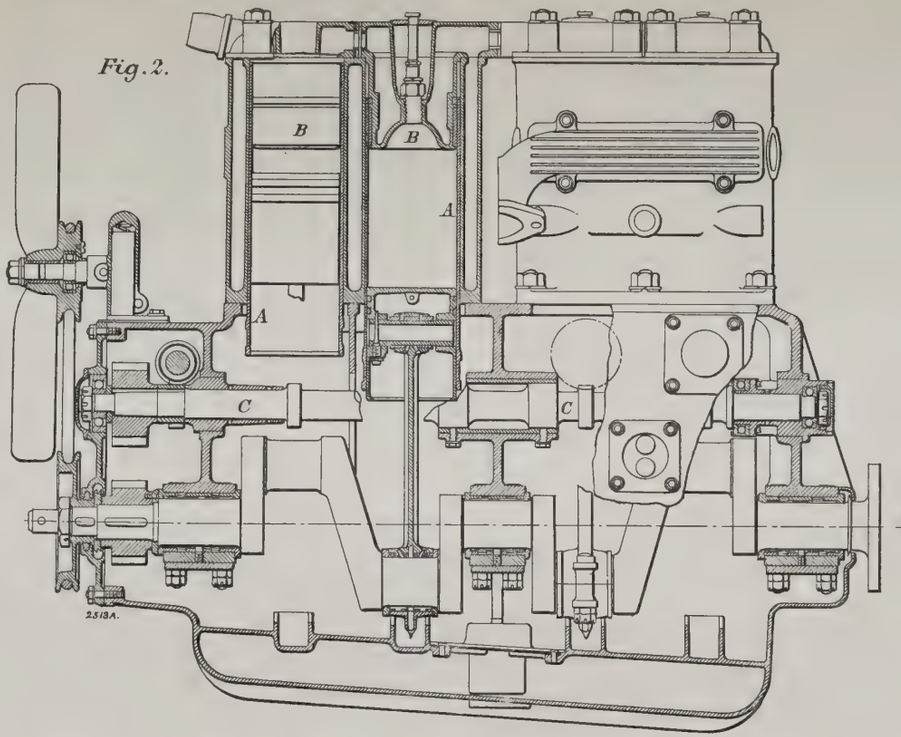
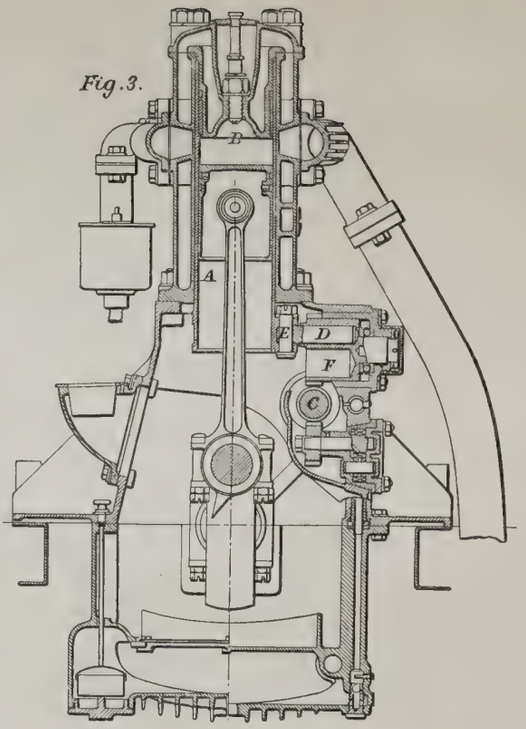


Fig. 3.



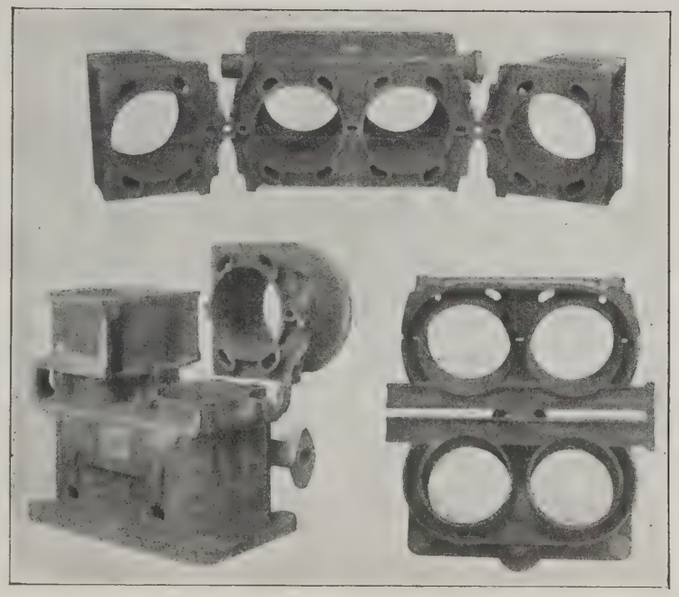


Fig. 4.

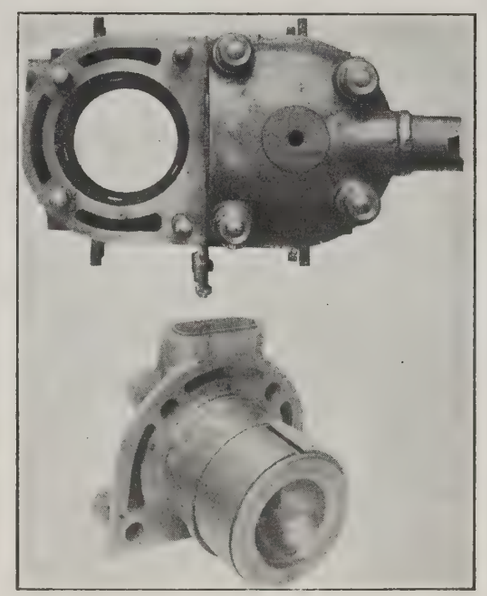


Fig. 5.

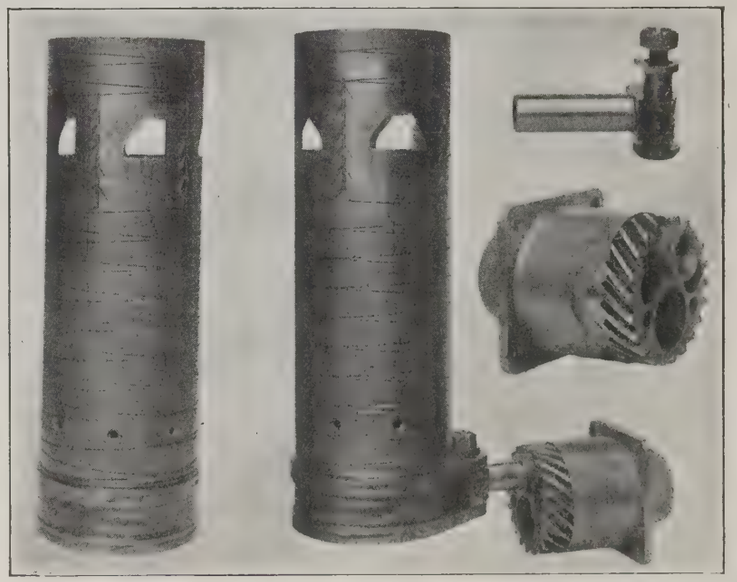


Fig. 6.

elliptical path, the motion of the sleeve becomes relatively small compared to that of the piston during the time that the port opening is at a maximum. On reaching the point of closing the sleeve motion is again rapid as compared to the piston movement, whilst its direction is also such as to result in rapid closing of the ports. A similar set of conditions also obtains in the case of the opening and closing of the exhaust ports, and this rapid operation combined with a comparatively long duration of full port opening is a noteworthy feature of the engine. In Fig. 8 the relative areas of the port openings are shown in dotted

Fig. 7.

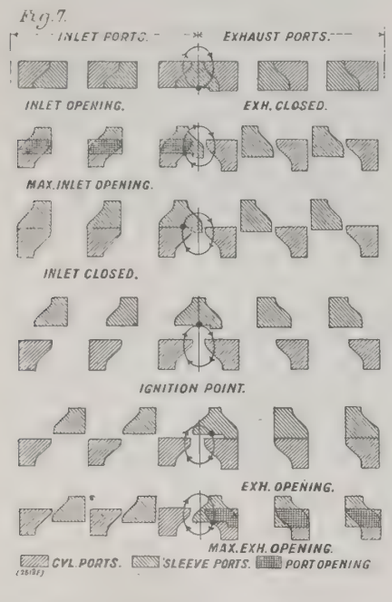
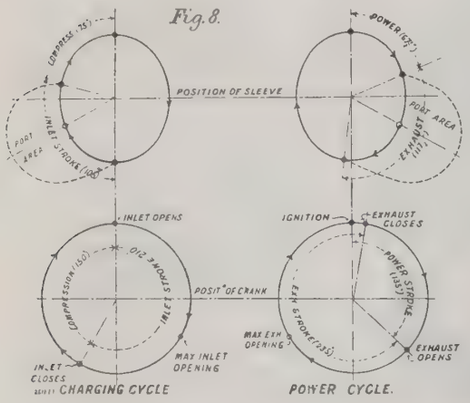


Fig. 8.



lines for the two sets of ports, the areas being plotted radially to the ellipse corresponding to the valve path.

It will also be seen from the diagram that slight modifications in the position of opening the ports can be effected by removing a portion of the leading edge of the sleeve ports, whilst a later closing is effected by removing some of the "trailing" edge.

In order to simplify the replacing of the valve-sleeves in their correct positions after overhauling the engine, the fly-wheel is marked to correspond to the lowest position of the sleeve, and it is only necessary to set the mark at its bottom position to ensure the correct setting of the valve.

A feature of the valve-gear that is worthy of mention is the fact that the motion given to the sleeve ensures a very efficient lubrication being effected. It is also claimed that the engine is practically free from vibration at all speeds, whilst the employment of a single sleeve considerably simplifies the construction and renders the cooling effect of the water-jacket more efficient than in the case of engines having two sleeves.

The engine, which has undergone a series of practical tests during the past two years, will be exhibited at the Exhibition which opens at Olympia to-day, and will, no doubt, be examined with interest by all concerned with internal-combustion engines.

CANADIAN RAILWAY PROGRESS.

We recently analysed the position of the Canadian Pacific Railway, and we propose now to review the older, but less successful, undertaking known as the Grand Trunk Railway of Canada. This well-known railway has been combating since 1860 what have sometimes appeared to be almost hopeless difficulties. This is due largely to the fact that the Grand Trunk Company has not received anything like such substantial aid and encouragement from the Canadian Government as has been accorded to the Canadian Pacific Railway. The Grand Trunk Railway received, in its early stages, Government advances to the extent of 3,111,500*l.*, and then the Canadian Treasury was closed against it for many years. In comparatively recent times, however, the Canadian Government has shown some disposition to assist the Grand Trunk in its efforts to reach the Pacific.

The company has, during the last decade, deemed it well to form a new company for linking the original Grand Trunk Railway undertaking with the Pacific Coast. This railway got to Winnipeg long since, and now it has practically reached the Rocky Mountains. Here great constructive difficulties have, of course, to be encountered: but when these have been overcome it will be a comparatively easy matter to reach the Pacific Coast at Prince Rupert, which has been selected as the terminal point. The company has had to create everything in connection with its Pacific Coast development; even Prince Rupert has had to be called into existence, and built from beginning to end.

The amount of the ordinary stock in circulation is 22,475,993*l.*, and as most of it was created fifty, forty, or thirty years ago, it is high time that its holders should be obtaining some return upon their capital. In the six months ending June 30, this year, the receipts increased by 239,546*l.*, but the working expenses were larger by 172,140*l.*, so that the additional net profit acquired was only 67,406*l.* Still it is certainly satisfactory to find that the revenue acquired in the first half of this year was 3,561,182*l.*, as compared with 3,321,636*l.* in the corresponding period of 1910, and when the large extent of new line now in course of construction has been brought into complete operation, there can scarcely fail to be a further growth of business and revenue. On the other hand, the fact cannot be overlooked that the ratio of the working expenses to the traffic receipts was still as high as 73.81 per cent. in the first half of this year, which was slightly less than the corresponding ratio for the first half of 1910, when it was as high as 73.94 per cent.

We must, however, give the Grand Trunk directors credit for endeavouring to develop the undertaking with true British perseverance. Notwithstanding the disheartening position of the ordinary stock, the company had raised capital in one way or another to the close of June, 1911, to the extent of 76,283,582*l.* An addition of 341,328*l.* was made to the expenditure on capital account during the first half of this year, 112,705*l.* being laid out for new works and sidings, 205,683*l.* for 1000 steel coal-cars, and 2829*l.* for further double tracking. As regards the Grand Trunk Pacific Railway extension, track has now been laid to Fitzhugh, a distance of 111 miles from Wolf Creek (the end of the Prairie section), and 1027 miles from Winnipeg. This new track is not at present in complete working, but it will assist the harvesting of a considerable extent of new country in the summer and the early autumn of 1912. Even if the Grand Trunk Pacific Railway were not completed, the extension of the Grand Trunk system 1027 miles further into Western Canada must necessarily assist greatly the development of the country, and bring considerable additional revenue into the Grand Trunk Railway exchequer. There is no reason, however, to suppose that the Grand Trunk Pacific Railway will not be completed, although it will not be in full operation, before 1913 or 1914. Construction has been commenced at the Prince Rupert end, and grading has been completed 185 miles to Hazelton.

In the course of the six months ended June 30 maintenance of way and works cost the Grand Trunk 395,714*l.*, as compared with 365,487*l.* in the corresponding period of 1910; maintenance of equipment, 600,415*l.*, as compared with 638,696*l.*; traffic charges, 114,947*l.*, as compared with 107,374*l.*; conducting transportation, 1,373,042*l.*, as compared with 1,204,624*l.*; and general charges, 96,524*l.*, as compared with 93,507*l.* The item "conducting transportation" comprised locomotive power, signalling, working station yards, &c. The aggregate distance run by trains in the first half of this year was 10,381,006 miles, as compared with 9,548,039 miles in the first half of 1910. These details show that the company is progressing, and give encouragement to those responsible for the management. The hopes of the Grand Trunk Railway rest, of course, upon the great Canadian future.

The Institution of Civil Engineers: Awards for Papers.—The council of the Institution of Civil Engineers have made the following awards in respect of papers published in Section II. of the proceedings for the session 1910-11:—Telford Premiums to Messrs. S. M. Dixon, M.A., B.A.I., Birmingham; H. J. F. Gourley, B.Eng., London; J. Holden, London; A. Rogers, Horsell; A. E. Griffin, Hong Kong; and F. C. Lea, D.Sc., Birmingham; and a Crampton Prize to Professor W. E. Dalby, M.A., B.Sc., London. They have also awarded the Indian Premium for 1911 to C. E. Capito, Ahwaz, Persia, and the Webb Prize to F. W. Bach, London.

NOTES FROM THE UNITED STATES.

Philadelphia, October 25.

The possibility of a reduction in the price of ore and a reduction in freight rates on ore has precipitated a possibility that is encouraging to the steel industry. The United States Steel Corporation has been threatened by the Federal Government with prosecution for violation of the Sherman law. To avert this contingency it is rumoured that this Corporation will give up its lease on the ore properties leased from the Great Northern Railroad Companies, and that freight rates will be also reduced on ore from that region to the Lake ports. This will throw open a great deal of ore to the iron and steel makers at large, which in turn will give room for further reductions in pig iron and to possible shadings in their products. Last week pig iron dropped an additional 0.25 dols. per ton. The great producers have not yet opened their books for 1912 orders on a large scale.

The past week or two has developed a demand for crude steel. Tin-plate has been shaded 4 dols. per ton. This means 3.40 dols. a box. Large tin-plate contracts will soon be placed, and the above price will likely be permanent. Heavy contracts have just been placed for structural steel throughout the east. Contracts for 75,000 tons in all will result from the present activity. The New York Central has placed a small order for 1500 tons. The boat builders along the Atlantic coast are having an unusual amount of work. Agitation is progressing, looking to the construction of a canal along the coast from Boston to the Gulf. This enterprise has been agitated for years, and powerful commercial and manufacturing interests are being brought to bear on Congress to enter upon the work, which involves for its completion an outlay roughly estimated at 80,000,000 dols. The promoters are arguing that if the Government can afford to put 400,000,000 dols. in the Panama Canal it ought to be able and willing to put 80,000,000 dols. into a canal that would affect the interests of some 25,000,000 of people.

In many respects the steel industry is showing decided improvement, though all orders and purchases are based upon present and urgent necessities. There is a prevailing disposition to accept present extremely low prices on business for delivery far into next year, but with one-fourth of productive capacity idle the manufacturing interests will hardly be able to hold out for higher prices.

The Association of Engineers-in-Charge.—The first "social" meeting, or "Ladies' Night," of this Association for the current session took place on Saturday evening last, the 28th ult., at the Liverpool-Street Station Hotel, and took the form of a dinner and concert, at which Mr. Alfred E. Penn, the Chairman of the Association, presided. The gathering was made the occasion of the presentation of a testimonial to Mr. Henry Capsey on his retirement from the position of honorary secretary, an office which he had held for seven and a half years. Mr. Capsey joined the Association in 1899, became a member of council in 1900, was elected vice-chairman of the council in 1903, and succeeded Mr. Davey as honorary secretary early in 1904. The testimonial took the form of an illuminated address, accompanied by a suitably engraved gold watch and chain, for Mr. Capsey; a purse containing the unexpended balance of the sum subscribed, for Mrs. Capsey; and a gold bracelet for Miss Capsey. In making the presentation the President for the current session, Mr. William H. Maw, expressed the indebtedness of the members of the Association to Mr. Capsey for the admirable way in which he had discharged his duties as honorary secretary, and referred to the material aid he had received from Mrs. and Miss Capsey during his long period of office. The meeting was exceedingly well attended, a large number of ladies being present, and a very pleasant evening was spent.

The Institute of Chemistry.—The Council of the Institute of Chemistry have inaugurated a series of lectures, the first of which was delivered by Mr. Bertram Blount, F.I.C., at King's College on Thursday, October 26. In the unavoidable absence of the President, Dr. Beilby, the chair was taken by Professor J. Millar Thomson, LL.D., F.R.S., who opened the proceedings with a reference to the scheme of lectures which, he said, was an extension of the work of the Institute on lines mainly directed to benefit advanced students of chemistry. Its aim would be to indicate the scope and object of the work actually carried out in various branches of professional chemical practice, as distinct from academic training; while occasionally the lectures would deal with matters of forensic and ethical interest. Mr. Blount's lecture was the first of two on "Cement." He limited his discourse to the consideration of calcareous cements as being of predominant importance, and more particularly to the Portland cement industry, the size of which might be judged by the fact that the world's production was estimated at 25,000,000 tons per annum, valued roughly at 35,000,000*l.* The industry is essentially a chemical one, and, in the interests of both manufacturer and consumer, was, and should be, controlled by the chemist. In the next lecture, to be given in the latter part of November, the chemistry, properly so-called, and testing of cement will be dealt with. The lectures will be published.

PASSENGER LOCOMOTIVE (4-6-2 TYPE) FOR THE BELGIAN STATE RAILWAYS.

CONSTRUCTED TO THE DESIGNS OF MR. J. B. FLAMME, ENGINEER-IN-CHIEF OF THE BELGIAN STATE RAILWAYS, BY THE SOCIÉTÉ JOHN COCKERILL, SERAING.

(*For Description, see Page* 593.)

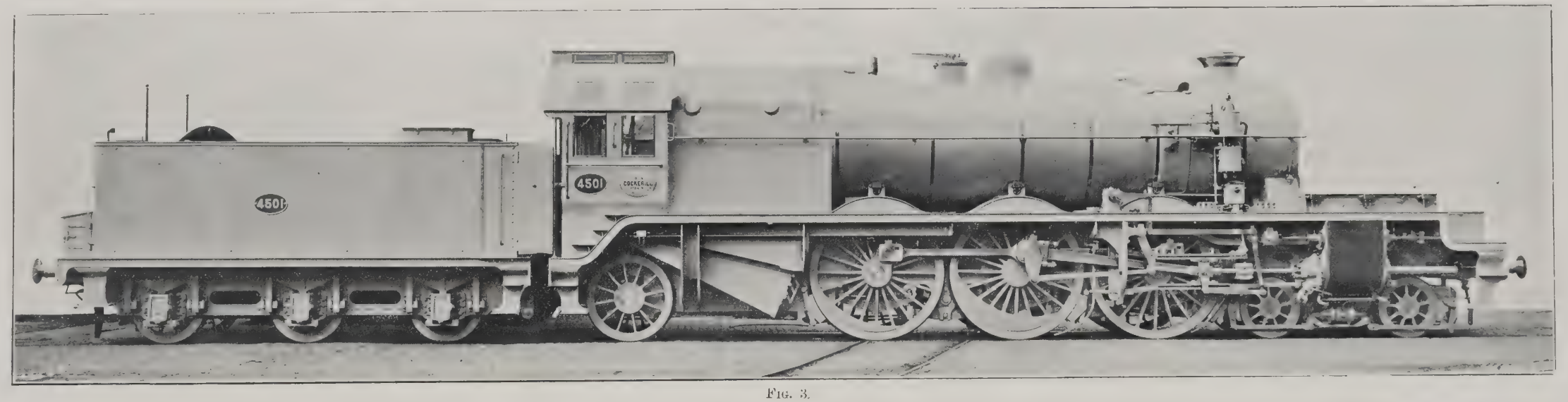
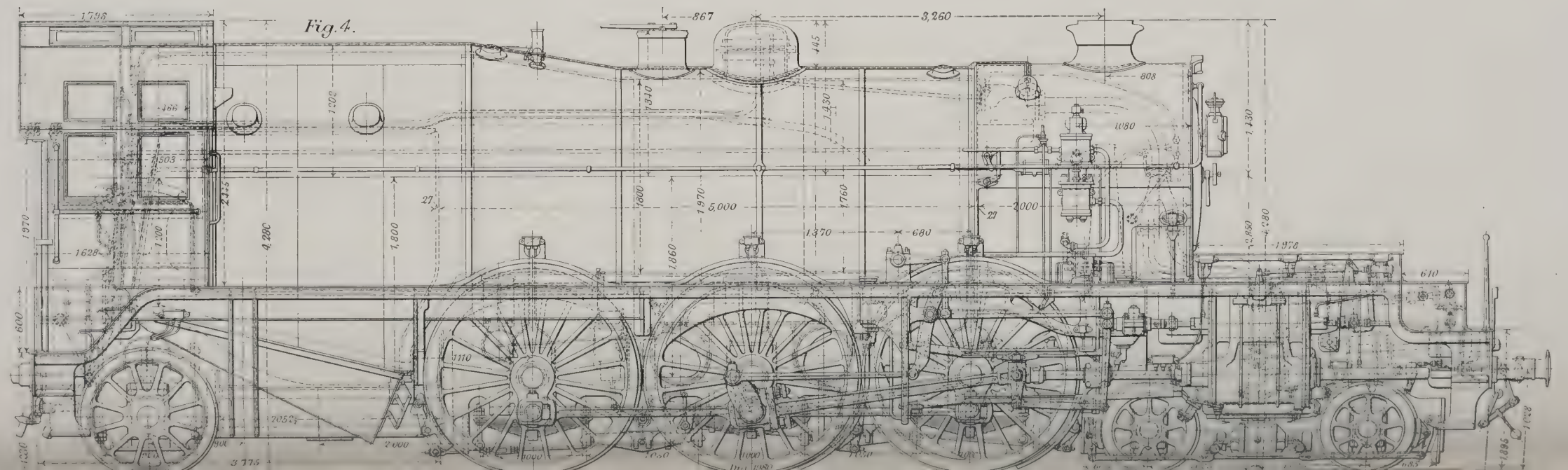


Fig. 3.



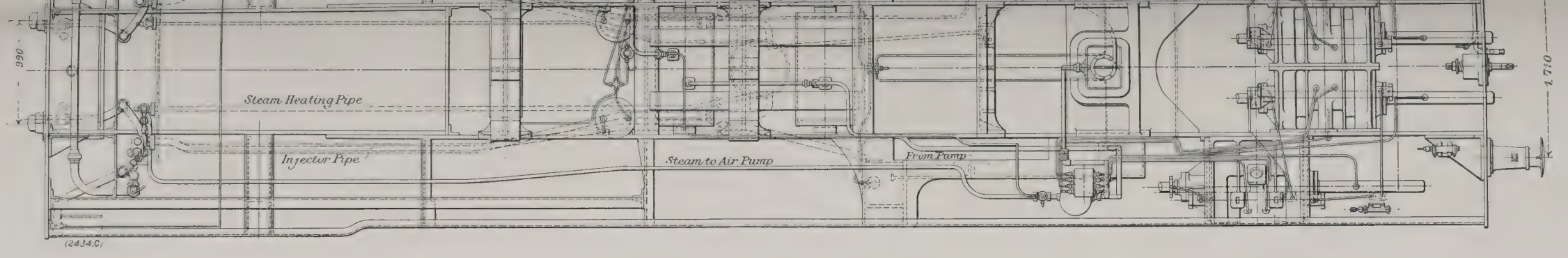


Fig. 6.

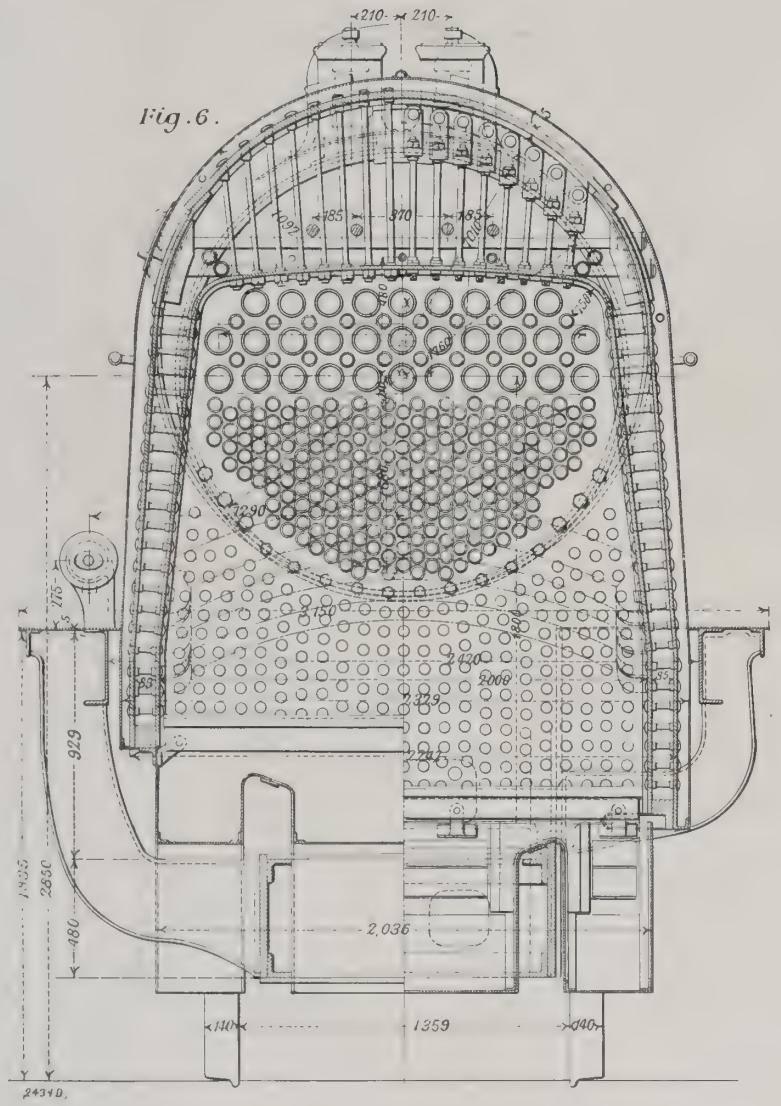


Fig. 7.

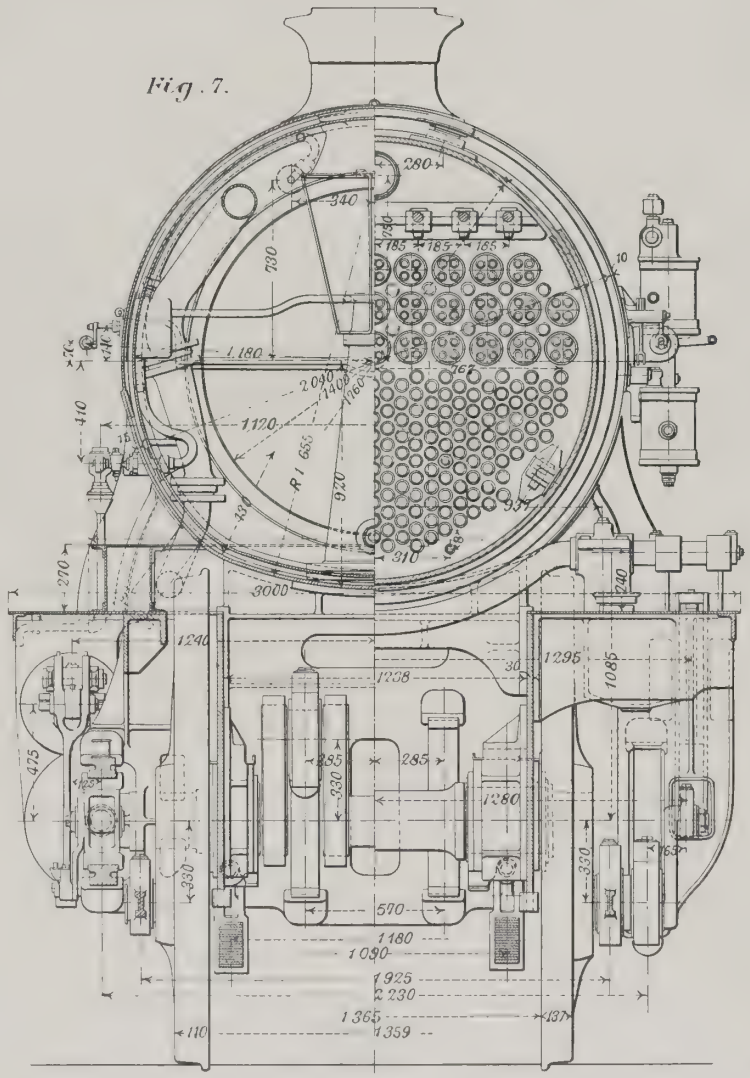
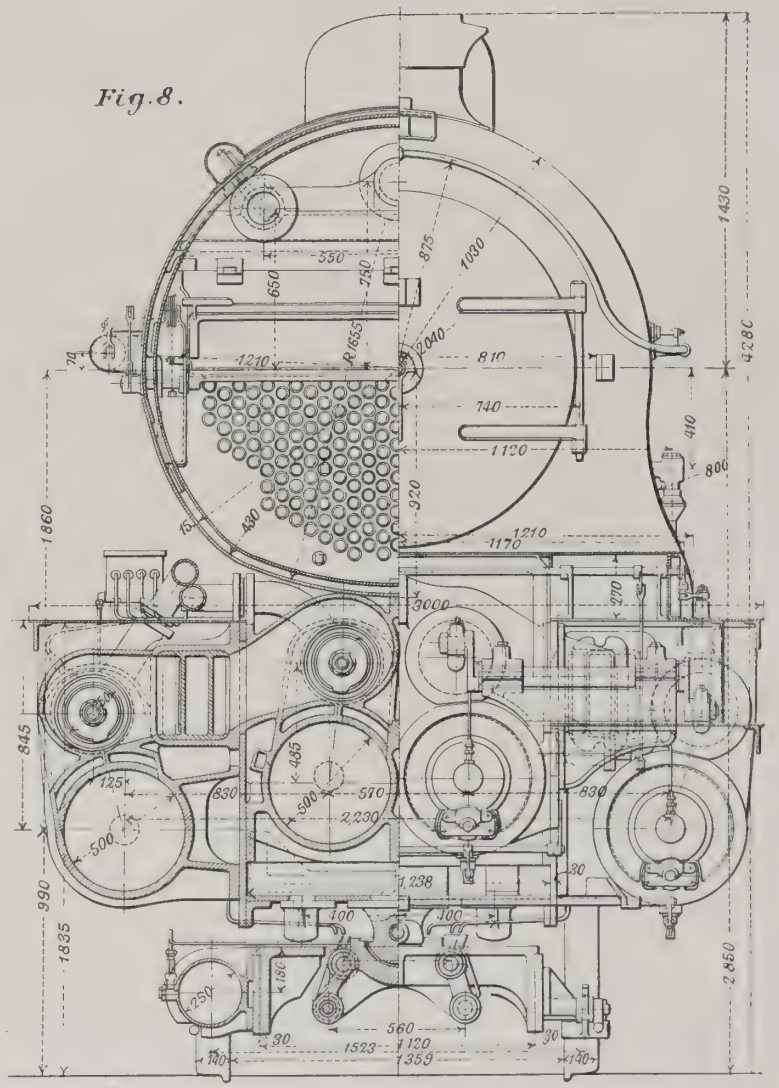


Fig. 8.



ASSENGER LOCOMOTIVE (4—6—2 TYPE) FOR THE BELGIAN STATE RAILWAYS.

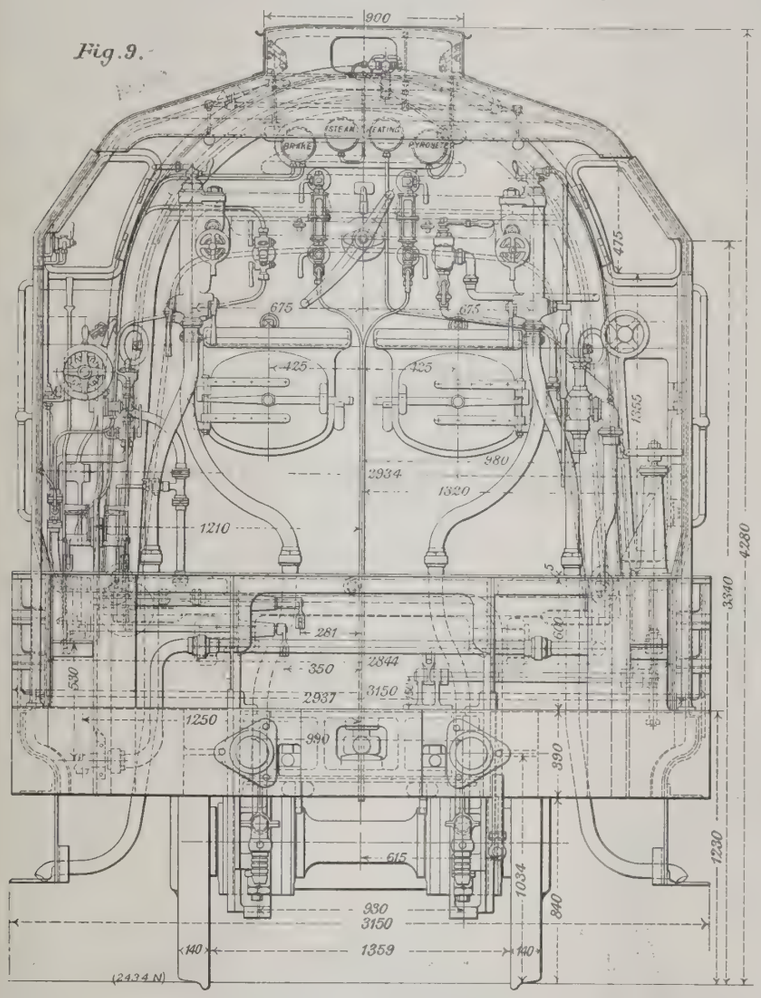
We gave in Figs. 1 and 2, on our two-page plate, o. LII., with our issue of October 20, two general ews of a passenger locomotive of the 4-6-2 type, signed by Mr. J. B. Flamme, chief engineer for the elgian State Railways. As stated in our notice on age 525 *ante*, there are two engines of this type, own as "Type 10," at the Turin Exhibition, one ilt by the Société Anonyme de St. Léonard, Liége, d the other by the Cockerill Company, Seraing.

The passenger engine, "Type 10," of which we give rther engravings in Figs. 3 to 8, on Plate LIV., blished with the present issue, and Figs. 9 to 36, on e present page and pages 594, 595, and 598, is an provement upon the preceding "Type 9." It has ur equal cylinders and six coupled wheels, the latter 980 m. (6 ft. 6 in.) in diameter. In the locomotive Type 9," the first axle alone was the driving axle. It as an oblique crank-axle fitted with outside crank-

Total heating surface "S" ..	240 sq. m. (2583.38 sq. ft.)
Superheating surface "S_1" ..	62 sq. m. (667.39 sq. ft.)
Ratio : $\frac{S_1}{S}$	0.257
Length of grate	2.5 m. (8 ft. 3 in.)
Width of grate	2 m. (6 ft. 6¼ in.)
Grate area	5 sq. m. (53.82 sq. ft.)
Diameter of driving-wheels "D"	1.980 m. (6 ft. 6 in.)
Diameter of trailing-wheels	1.262 m. (4 ft. 1⅜ in.)
Diameter of bogie wheels ..	0.900 m. (2 ft. 11⅜ in.)
Weight in working order on each bogie axle	14,000 kg. (13 tons 15 cwt. 2 qr.)
Weight in working order on each coupled axle ..	19,000 kg. (18 tons 14 cwt.)
Weight in working order on trailing axle	17,000 kg. (16 tons 14 cwt. 2 qr.)
Total weight in working order	102,000 kg. (100 tons 7 cwt. 2 qr.)
Weight, empty	92,000 kg. (90 tons 11 cwt. 1 qr.)
Weight available for adhesion	57,000 kg. (56 tons 2 cwt.)
Draw-bar pull $\frac{2 \times 0.65\ p\ d^2\ l}{D}$	15,166 kg. (33,370 lb.)

The engine has been designed with a view to hauling the heavy passenger trains which hitherto have required two engines of the ordinary type

Fig. 9.



ns keyed at 180 deg. as regards the cranks on the axle ody. In the locomotive "Type 10," which we illusate, a much more powerful engine than the preceding ne, the leading driving axle is a crank-axle, with cirlar webs, driven by the inside cylinders, the outside linders being connected to crank-pins on the second upled axle.

The piston-rods of the outside cylinders are made to ide in a special guide, owing to their greater length, is arrangement having made it possible to reduce e length of the outside connecting-rods. The steam stribution mechanism of the inside cylinders is iven by a rocking shaft; in this, the newer type of gine, it was not possible, owing to the position of e cylinders, to make use of a horizontal rocking-ver, as was the case in the engine "Type 9."

The principal dimensions are the following :—

ameter of the four cylinders "*d*"	500 mm. (19.69 in.)	
roke "*l*"	660 mm. (25.98 in.)	
iler pressure "*p*"	14 kg. per sq. cm. (205 lb. per sq. in.)	
side diameter of boiler barrel	1.800 m. (5 ft. 11 in.)	
stance between tube-plates	5 m (16 ft. 5 in.)	
ickness of barrel-plates ..	20 mm. (0.79 in.)	
ight of boiler centre above rail level	2.850 m. (9 ft. 4 in.)	
iler tubes { Number	230	31
iler tubes { Outside diameter ..	50 mm. (1.97 in.)	127 mm (5 in.)
iler tubes { Thickness ..	2.5 mm. (0.098 in.)	4.5 mm. (0.176 in.)
eating surface of fire-box ..	20 sq. m. (215.28 sq. ft.)	
eating surface of tubes ..	220 sq. m. (2368.10 sq. ft.)	

over the heavy gradients. The Belgian lines, as is well known, form a most intricate system, and to the east of Brussels, especially in the vicinity of Liége, the gradients are at places particularly difficult. For example, the line from Liége to Ans has gradients of 31 mm. per metre (1 in 32.3); the lines serving the table-lands of Herve, Pepinster-Gouvy, Verviers-Aachen, Liége-Vivegnis-Liers, have long continuous gradients of 16 mm. to 25 mm. per metre (1 in 62.5 to 1 in 40). These difficulties, combined with the fact that Belgium is on the route taken by a large proportion of the travelling public from this country and from Holland, have compelled the Belgian State Railways gradually to increase the power of their engines so as to enable them to cope with the increasing weight of passenger-trains running at the high speeds which now generally obtain. The latest type of Belgian engine to meet these conditions for passenger traffic is the "Type 10," which we illustrate.

Mr. Flamme states that, for dealing with traffic in Belgium, special types of engines are required, and he gives as an illustration the following instance :—Between Paris and the Belgian frontier, the Paris-Cologne trains, which are hauled as far as Liége by the magnificent du Bousquet engines of the Northern Railway Company of France, run at an average speed of 95 km. (58.5 miles) per hour. On Belgian territory, between Erquelinnes and Liége, their speed is 65 km. (40.5 miles) per hour between Erquelinnes and Charleroi, 57 km. (35.5 miles) between Charleroi and Namur, and 63 km. (39.3 miles) between Namur and Liége. It should be noted, however, that the intricacy of the Belgian railway system alluded to above, especially in the industrial districts of Charleroi and the Lower Sambre, where the junctions and branch lines are very numerous, frequently makes it difficult to exceed a speed of 70 km. (43.5 miles) per hour.

The Belgian State Railways used coke on their locomotives until 1853, when firing with coal and briquettes became the practice. In 1856 and 1857 briquettes formed one-third of the fuel used on the Belgian locomotives, a proportion which increased to half in 1858, and to three-quarters in 1859. The change of fuel was accompanied by no change of practice as regards fire-box design, as low-grade slack coal, which was available in abundance, and at a comparatively low cost in the country, was being used in large quantities for raising steam in stationary engines, the possibility of utilising it in locomotives also was then considered. As a result, in 1860, Belpaire, a Belgian engineer, designed his well-known locomotive fire-box for the purpose. On the locomotives gradually increasing in power, the fire-box for burning slack coal exclusively gradually increased in size and ultimately reached large proportions. This led the Belgian State Railways to fit their engines with the Flamme type of boiler, in which slack, nut coal, and briquettes can be burnt separately or together.

The Flamme boiler is characterised by a round-topped fire-box casing, strengthened by transversal ties and T-bars riveted to the sides. The fire-box, the width of which, as above stated, is 2 m. (6 ft. 6⅛ in.), is placed, as shown in Figs. 4 and 6, Plate LIV., above the wheels, and is provided with two doors. The cylindrical ring of the boiler-barrel is followed by a taper course, the object of which is to reduce the height of the boiler in front, so as to bring the steam-dome and the chimney within the limits of the loading gauge. The four safety-valves have been reduced in height, and have been placed in pairs side by side.

The barrel is built up of three steel-plate rings, 20 mm. (0.79 in.) in thickness, lap-riveted together. The top part of the fire-box shell is 30 mm. (1.18 in.) thick, and is directly connected to the crown by vertical stays. The two rows of stays in the vicinity of the tube-plate are arranged to allow for expansion. The connections of the crown to the sides are on a large radius, thus making it possible to decrease the height of the upper row of stays which are specially exposed to fracture. The lower portion of the fire-box tube-plate and of the throat-plate below the arch has been made slanting, as shown in Fig. 4, Plate LIV., and Fig. 1, Plate LII. *ante*, to clear the trailing coupled wheels. The fire-box tube-plate is stiffened by four longitudinal stays connecting it to the smoke-box tube-plate.

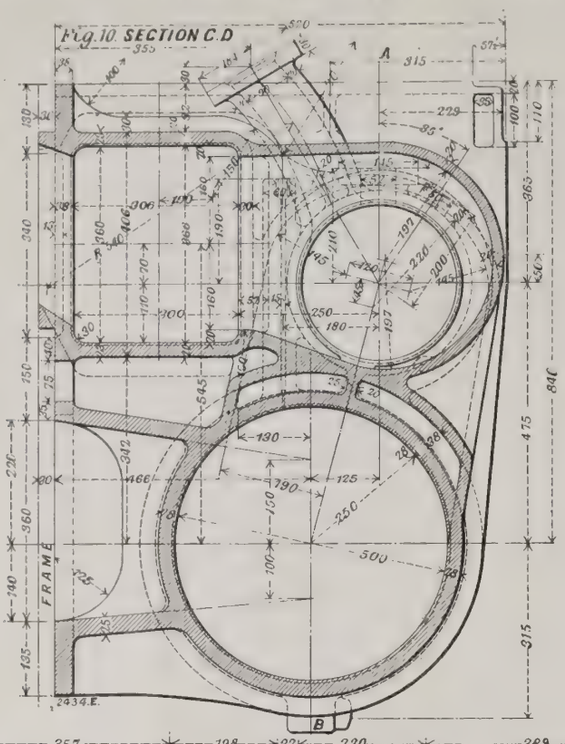
The frame-plates are inside the wheels; they are of steel, 30 mm. (1.18 in.) in thickness. Owing to their dimensions, they are made in two parts, lap-jointed together. The boiler is fixed at the smoke-box, and rests on expansion-brackets on the underframe under the barrel and at the fire-box. The Schmidt superheater consists of 124 superheating tubes, which are contained in the thirty-one large smoke-tubes. Each one of the latter contains two loops, the superheating tubes being joined together at the fire-box end by steel bends, in which they are screwed. Each loop thus formed establishes communication between the two compartments of the steam-collector placed in the upper part of the smoke-box. As in the usual practice, the first compartment receives the saturated steam coming from the regulator, and from the other superheated steam is supplied to the steam-pipes leading to the cylinders.

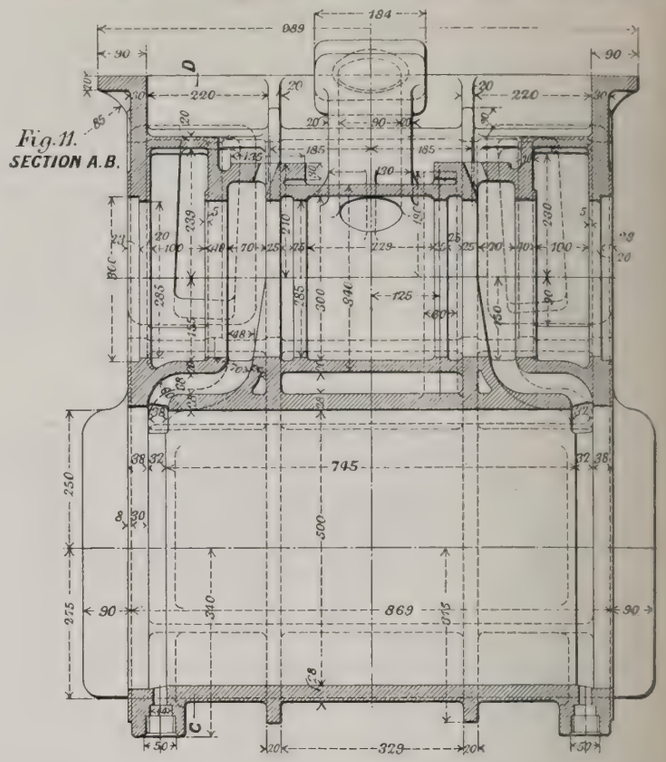
As already pointed out, this locomotive has four cylinders, two outside the frames and two in. They are carried far forward over the bogie. On page 594, in Figs. 10 and 11, are given drawings of the outside cylinders, and in Figs. 12 and 13 drawings of the inside pair, the latter being cast separately. Details of the pistons are given in Figs. 14 to 17. They are steel castings, and are fitted with three packing rings. The latter are grooved in the middle of their outer surface, and are drilled with holes 3 mm. (0.118 in.) in diameter, which run through their whole thickness from the bottom of the groove, to allow the steam to exert a pressure at the back of the rings to cause them to press against the cylinder walls. The rings do not serve to support the pistons; these are carried in the rear by the cross-head, and in front by tail-rods. Each tail-rod runs in a cast-iron liner made with lubricating grooves, enclosed in a cast-iron casing bolted to the front cover of the cylinder. The casing is closed in front; it is provided with a lubricator. In order to prevent compression of the steam which might leak along the tail-rod, a hole 3 mm. (0.118 in.) in diameter establishes a communication between the cylinder and the annular space round the liner and the tail-rod end.

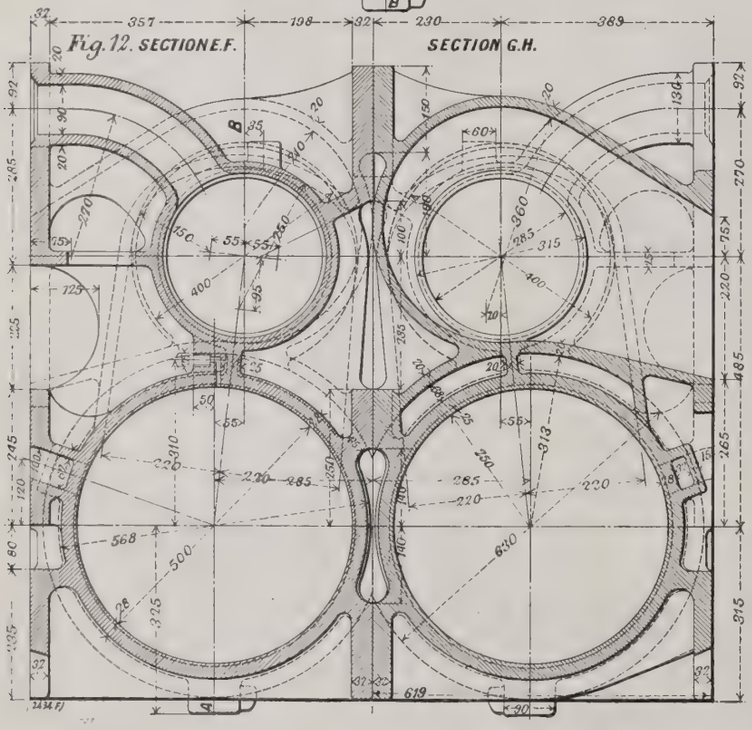
Steam distribution is by piston valves, with inside admission. Drawings of the valve and valve bushings or liners are given in Figs. 18 to 22, page 595. Figs. 19

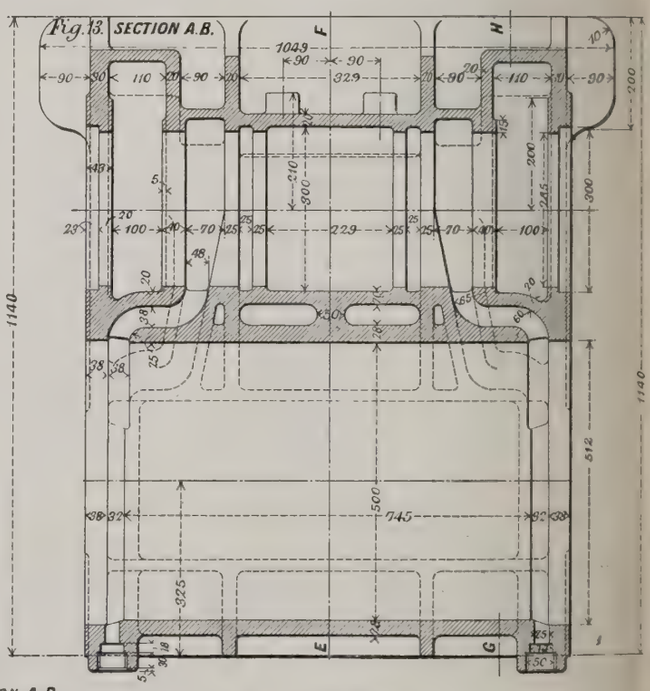
PASSENGER LOCOMOTIVE (4-6-2 TYPE); BELGIAN STATE RAILWAYS.

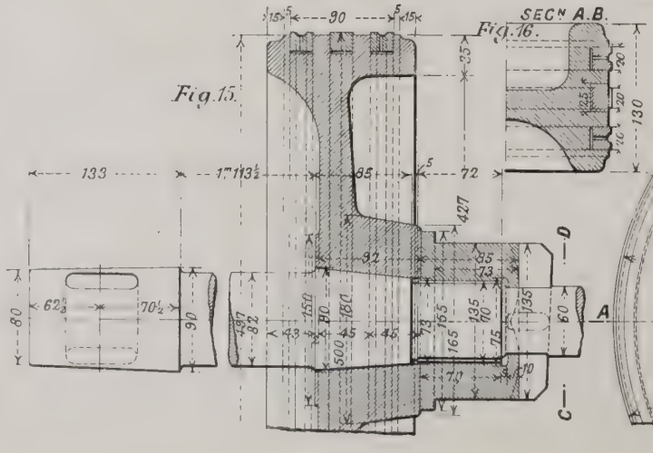
CONSTRUCTED TO THE DESIGNS OF MR J. B. FLAMME, ENGINEER-IN-CHIEF, BY THE SOCIÉTÉ JOHN COCKERILL, SERAING.

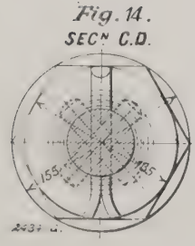


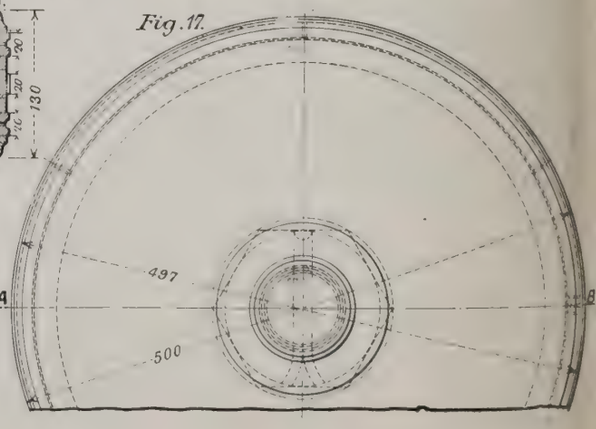












PASSENGER LOCOMOTIVE (4–6–2 TYPE); BELGIAN STATE RAILWAYS; DETAILS OF VALVES.

CONSTRUCTED TO THE DESIGNS OF MR. J. B. FLAMME, ENGINEER-IN-CHIEF, BY THE SOCIÉTÉ JOHN COCKERILL, SERAING.

Fig. 18.

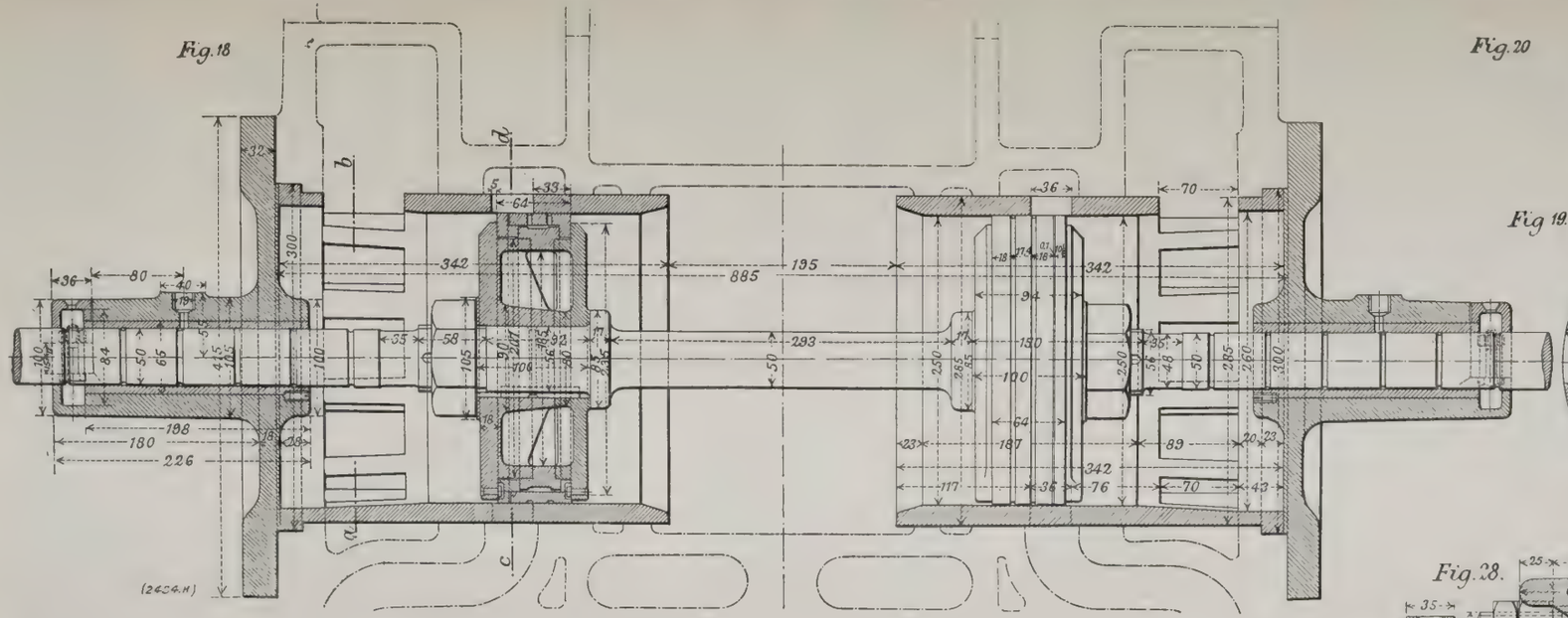


Fig. 20.

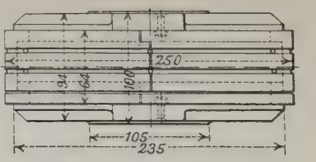


Fig. 19.

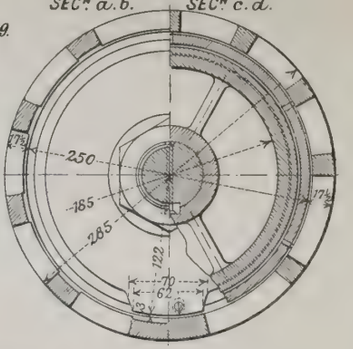


Fig. 21. DEVELOPMENT OF INLET PORTS

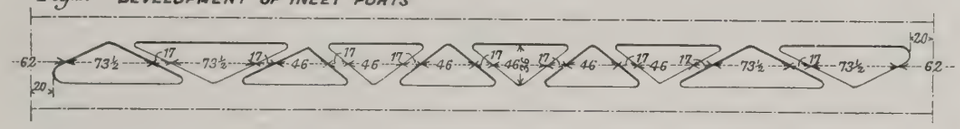


Fig. 22.

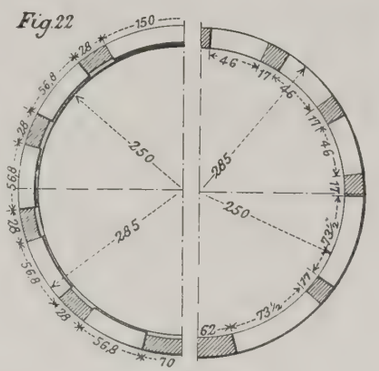


Fig. 23.

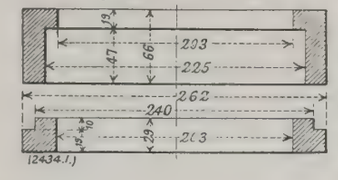


Fig. 24.

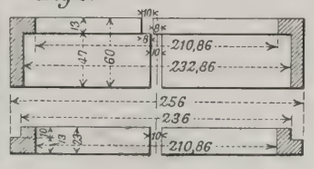


Fig. 25.

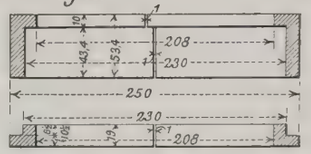


Fig. 26. FOR OUTSIDE CYLINDER

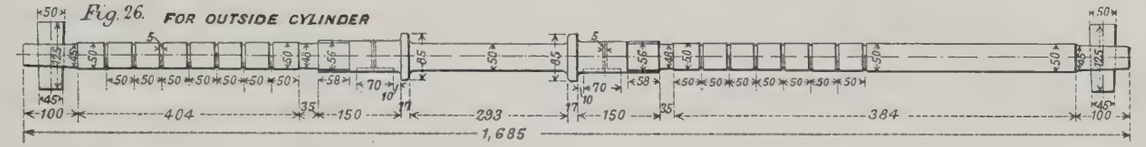


Fig. 27. FOR INSIDE CYLINDER

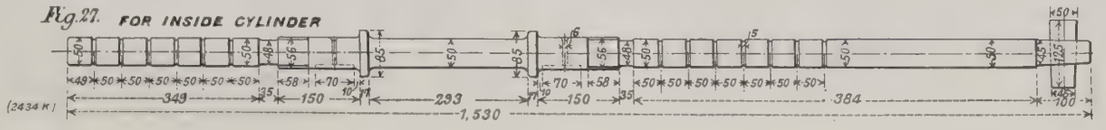


Fig. 28.

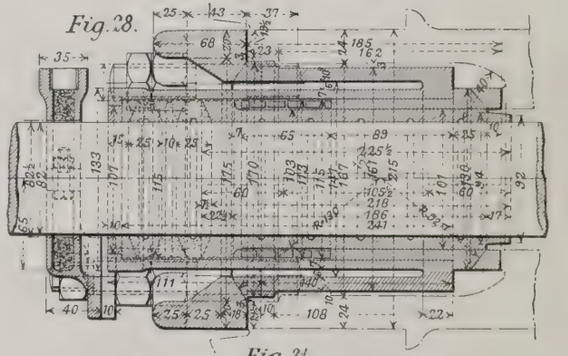


Fig. 29.

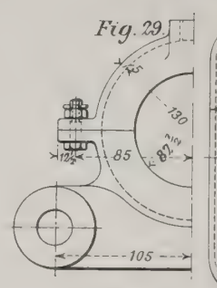


Fig. 31.

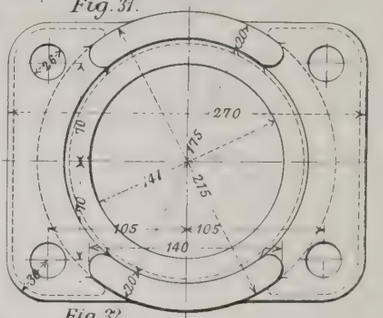


Fig. 30.

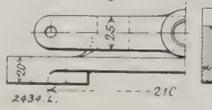
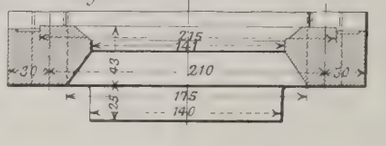


Fig. 32.



and 20 show the valve piston. Fig. 21 shows the steam-port openings developed, and Fig. 22 sections through the steam and exhaust ports. Figs. 23 to 25 show the piston-valve rings in three stages of finish, Fig. 25 representing their final form. With inside admission it has been found possible to dispense with metallic packing for the valve spindles, which are simply provided with oil grooves. The valve spindles are shown in Figs. 26 and 27, Fig. 26 showing the spindle for the outside cylinders, and Fig. 27 the spindle for the inside cylinders, operated by rockers at the front. The valve gear is of the Walschaert type. The cylinders are fitted with relief valves, 100 mm. (3.94 in.) in diameter, and a by-pass valve operated from the foot-plate by compressed air. Figs. 28 to 32 show the piston-rod packing of metallic rings, fitted with spring neck-rings carried in a box. Figs. 31 and 32 show the gland, and Figs. 29 and 30 the oiler fixed to the gland studs, and shown in section in Fig. 28.

The reversing-gear consists of a small steam cylinder, the piston of which is connected on one side to the weigh-bar, and on the other to the reversing lever. Lubrication of the valve casings, cylinders, and piston counter-rods is ensured by two eight-way distributing boxes, operated by the link-motion gear. The flow of each of the eight pipes is made adjustable.

The engine is coupled to a six-wheel tender which has a capacity for 24,000 litres (5280 gallons) of water and 7 tons of coal.

The bogie is of the Flamme type with lateral play. It is illustrated in Figs. 33 to 36 on page 598. It has a spherical centre bearing which rests in a centre casting suspended by four inclined swing-links. The bogie centre is a steel casting made with stiffening ribs. The bogie frame-plates, 26 mm. (1 in.) in thickness, are inside the wheels, and are further connected together by two headstocks of plates and angles. The load is transmitted by four independent supporting springs. The spherical centre pivot is fixed to a horizontal plate fitted to the locomotive underframe, and which bears against the inside cylinders. A horizontal bar fixed to two lugs, cast in one piece with the bogie centre, holds the bogie to the engine. Check-clamps prevent the side play exceeding 65 mm. (2.56 in.) towards either side. The bogie is fitted with the Westinghouse brake, since it carries a high proportion (28 tons) of the total weight of the engine. The Belgian railways were the first to extend the continuous brake to the bogie. In the case of the engine "Type 10," the bogie is provided with a separate brake mechanism and cylinders connected to a separate triple valve and receiver. The bogie, therefore, in regard to braking, forms, as it were, a distinct vehicle.

The running on curves is also facilitated by a 50-mm. (1.97-in.) play, provided between the guides and the axle-boxes of the trailing axle, controlled by wedge blocks above the axle-boxes.

The engine is provided with the Westinghouse brake, which acts on all the wheels, the bogie-wheels being also braked as above stated.

The late Mr. William C. Martin.—We regret to have to record the death, at an early age, of Mr. William C. Martin, of the firm of Messrs. W. C. Martin and Co., of Glasgow. Mr. Martin, who was born in 1862, was well-known in electrical and shipbuilding circles, his firm having made a speciality of electrical ship work for many years. They were responsible for the electrical installation on the Cunard liner Mauretania. Mr. Martin, who, in earlier years, was connected with the Telephone Company, of London, and the British Electric Light and Power Company, of Scotland, was a member of the Institution of Engineers and Shipbuilders of Scotland, of the Institution of Electrical Engineers, and of the Incorporation of Hammermen, of Glasgow. He had been a member of the Glasgow Town Council since 1908.

Personal.—The office of the Patents Secretary (Mr. H. G. Graves) under the Inventions and Designs Act, which is now a branch of the Department of Commerce and Industry, Government of India, has been removed from 2, Bankshall-street, Calcutta, to 1, Council House-street, Calcutta.—Messrs. Cutbill, King, and Co., of 26, Nicholas-lane, Lombard-street, E.C., have been appointed sole agents in Great Britain for the De Laval Steam-Turbine Company, Limited, of Stockholm.—Mr. Rowland C. Feilding has ceased to be a member of Messrs. Hooper, Speak, and Feilding, mining engineers and managers, of 3, London Wall Buildings, E.C., and his business address now is 18, St. Swithin's-lane, London, E.C. Mr. Edward Hooper and Mr. S. J. Speak will remain in partnership, and will continue to carry on their business under the style of Hooper, Speak, and Co.—Mr. J. R. Garner, for eight years works manager of the Electric and Ordnance Accessories Company, Limited, Aston, Birmingham, has resigned in order to take up a similar position with the Lancashire Dynamo and Motor Company, Limited, Manchester.—Mr. William C. Mountain, M.I. Mech. E., M.I. Min. E., M.I.E.E., is retiring from the firm of Messrs. Ernest Scott and Mountain, Limited, and proposes to devote his whole time and attention to consulting work, and has taken offices in Sun-buildings, Newcastle-on-Tyne. He has been appointed arbitrator by the coal trade to represent a number of the principal counties of England in connection with the use of electricity in mines.

"JET PROPULSION."

To the Editor of Engineering.

Sir,—With reference to the interesting article on "Jet Propulsion," which appeared in last week's Engineering, we are in entire agreement with the opening paragraph, in which the efficiency of jet propulsion is insisted upon. Our experience, moreover, goes to show that whatever may be the obstacles to the adoption of jet propulsion on an extensive scale, it is undoubtedly extremely useful in many special cases. One of these special cases is in relation to fire-floats stationed in canals, harbours, or other situations where the frontage to be protected is small, and where, consequently, any desired position can be reached in a sufficiently short time at a moderate speed.

We have frequently utilised the pumping plant of such a fire-float to effect its propulsion with very gratifying results. In one recent case a boat 50 ft. long, with a relatively small pumping outfit—1000 gallons per minute only—was fitted with two 1½ in. nozzles fore and aft, and attained a speed in still water of 5 miles per hour, with the jets discharging into the atmosphere just above water-level. This, of course, is only a sharp walking pace, but serves its special purpose admirably, with a minimum of initial outlay and expenses of upkeep. This method of propulsion is also extremely handy for manœuvring purposes, as the vessel can be readily steered or reversed by the simple operation of two valves.

With regard to the type of pump proposed in the article referred to above, though no doubt a centrifugal pump would be necessary to deliver the enormous volume of water required for jet propulsion on a large scale, for the small quantities which we have employed for this purpose we have invariably used reciprocating pumps. Our experience shows that with the relatively small quantity and high pressure necessary for this class of work a considerable improvement in efficiency is obtained with reciprocating pumps as compared with pumps of the centrifugal type.

In conclusion, we would say that, though water-jet propulsion may never reach an efficiency high enough to warrant its general adoption, it still possesses features which, perhaps, merit more consideration than they commonly receive.

We are, Sir, yours faithfully,

Merryweather and Sons, Limited.

Greenwich-road, London, S.E., November 1, 1911.

Jet Propulsion: Erratum.—By a slip of the pen, in our article on page 569 of our last issue, the efficiency of a jet propelling a tank which moves at half the speed of the jet was said to be unity. It should, of course, have been 75 per cent.

City of Bradford Technical College.—We have received from the City of Bradford Education Committee a copy of the Calendar for the thirtieth session, 1911-1912, of the City of Bradford Technical College, which gives complete information in all the various courses. These cover the textile industries, chemistry and dyeing, and engineering.

The London Chamber of Commerce (Incorporated).—Members desirous of being included in the engineering and allied trades sub-section are requested to forward, for registration, the name of the person whom they may wish to depute to represent them at meetings. The engineering section is divided into (*a*) consulting engineers, or those who have more or less the same interests as professional engineers; and (*b*) manufacturing companies, firms, and individuals interested in or concerned with engineering.

Lloyd's Record of Shipwrecks.—A gratifying condition is reflected in the quarterly report of shipwrecks just issued by Lloyd's, which indicates continuous improvement in ship construction, because it establishes a decreasing rate of loss, the total number of vessels removed from the Register from all causes during the quarter being 112, and the tonnage 129,211. This, as will be seen, is equal to only about half a million tons per year. Of the total, 52, of 97,645 tons, were steamships, and 60 vessels, of 31,566 tons, sailing ships. In view of the enormous preponderance of steamships in Lloyd's Register the number of sailing vessels seems great, but against this it has to be noted that the average age is considerably higher. Wrecks, as usual, account for the greater number of losses — practically two-thirds — namely, 55 vessels, of 79,085 tons, of which 20,716 tons were of sailing ships. Collisions account for the second largest number, 28 vessels, of 28,858 tons; and here naturally steamers preponderate, sixteen steamships owing their loss to this cause, the tonnage in this case being 25,770 tons. The number of ships reported missing is four, of 7441 tons, including a sailing ship of 146 tons. The other causes of loss are—ships foundered, eight, of 4480 tons; ships abandoned at sea, four, of 3094 tons; ships destroyed by fire, four, of 2412 tons; and ships lost from other causes, five, of 2204 tons. In the case of four vessels, of 1637 tons, the explanation is that they were broken up or abandoned. The British ships again establish a satisfactorily low rate of loss per 100 tons owned, the percentage being only 0.29; but for no country is the rate more than 0.66 per cent., the ratio applicable to Italy; next comes Spain, with 0.51 per cent.; Norway, 0.45 per cent.; the United States of America, 0.41 per cent.; the British Colonies, 0.40 per cent.; France, 0.30 per cent.; Germany, 0.21 per cent.; Denmark, 0.19 per cent.; Russia, 0.17 per cent.; Sweden, 0.14 per cent.; and Austria-Hungary, 0.02 per cent. All of these rates, it must be admitted, are most satisfactory.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning there was little doing in the pig-iron market, and the dealing consisted of only one lot of Cleveland warrants at 46s. 5d. cash, with sellers over at that figure and at 46s. 9d. one month, and 47s. 4d. three months. Cash buyers of hematite offered 60s. 9d., but sellers wanted 61s. 3d. In the afternoon Cleveland warrants were the turn firmer, but business was confined to 3000 tons at from 46s. 5d. to 46s. 5½d. cash, and at 47s. 4½d. three months. Closing sellers quoted 46s. 6d. cash, 46s. 9½d. one month, and 47s. 5d. three months. Hematite was unchanged at 60s. 9d. cash buyers. On Friday morning quietness again prevailed, and only one lot of Cleveland warrants was done at 46s. 4½d. cash. The closing quotations were called at 46s. 5d. cash, 46s. 9d. one month, and 47s. 4d. three months sellers. The afternoon session was a complete blank as regards business, and sellers of Cleveland warrants quoted easier at 46s. 4½d. cash, 46s. 8d. one month, and 47s. 3½d. three months. On Monday morning Cleveland warrants were again in small demand, and prices were weak. The turnover consisted of 1500 tons at 46s. 3d. cash, 46s. 6½d. one month, and 47s. 1½d. three months, with sellers over at these quotations. One lot of hematite changed hands at 62s. 1½d. three months, with sellers over. In the afternoon the market was the turn firmer, and 1500 tons of Cleveland warrants were dealt in at 46s. 4d. cash, and 47s. 1½d. and 47s. 2d. three months. Closing sellers quoted 46s. 4d. cash, 46s. 7½d. one month, and 47s. 2½d. three months. Hematite was quoted at 61s. cash sellers, with buyers at 3d. less. On Tuesday morning the tone was steady, but business was limited to one Cleveland warrant at 46s. 3½d. cash, and there were sellers at the close at 46s. 4d. cash, 46s. 7½d. one month, and 47s. 2½d. three months. The afternoon session was a repetition of its predecessor, and only one Cleveland warrant changed hands at 47s. 1½d. three months. Closing quotations were easier, with sellers at 46s. 3½d. cash, 46s. 7d. one month, and 47s. 1½d. three months. When the market opened to-day (Wednesday) business was quiet, and only two lots of Cleveland warrants were done at 47s. 1½d. three months. At the close prices were the turn firmer at 46s. 4d. cash, 46s. 7½d. one month, and 47s. 2d. three months sellers. Buyers of hematite offered 60s. 6½d. cash, but there were no sellers. The afternoon session was also quiet, and dealings were limited to 1500 tons of Cleveland warrants at 46s. 7d. one month, and 47s. 1½d. three months. Closing quotations were unchanged at 46s. 4d. cash, 46s. 7½d. one month, and 47s. 2d. three months sellers. The following are the market quotations for makers' (No. 1) iron:—Clyde, 61s. 6d.; Calder, 61s. 6d.; Gartsherrie, 62s.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 63s. 6d.; Shotts (at Leith), 62s. 6d.; and Carron (at Grangemouth), 63s. 6d.

Sulphate of Ammonia.—A good demand for sulphate of ammonia is general, and the forward inquiry is also of a satisfactory nature. The current price is firm at 14*l.* 5s. per ton for prompt lots, Glasgow or Leith. The amount shipped from Leith Harbour last week was 1555 tons.

Scotch Steel Trade.—Scotch steel-makers report no scarcity in specifications for ship-plates and heavy material generally, with the result that the various works are all very well employed. Old contracts are, of course, responsible for the present activity, but new home business is still exceedingly quiet. For the latter, producers must now quote the official selling prices, although export orders do not come under the category of the new rebate scheme, particulars of which are given on page 597. A fair amount of business has lately been put through on shipping account, India, Australia, and Japan all having fixed lots of ship-plates and angles for early dispatch. The demand for angles and boiler-plates is rather better, but there is not quite so much doing in structural sections generally. No falling-off is reported by makers in the demand for black sheets, and consumers at home and abroad are pressing for delivery.

Malleable-Iron Trade.—Producers of malleable iron in the West of Scotland are much better off for work at present, and most of the plant is fully employed. Inquiries for lots for home consumption have improved, but the prices on offer are still very low.

Shipbuilding.—The shipbuilding industry in Scotland is at present in a very healthy condition, and the majority of the yards are well off for work. New orders have been fixed up with some regularity during recent months, and a number of important contracts were also booked during October. With regard to output, the past month stands out well, and the Clyde total alone creates a record for the month of October. The district figures are:—

	Vessels.	Tons.
The Clyde	24	58,186
The Forth	1	60
The Tay	1	1,250
The Dee	2	700
Total	28	60,286

As is only to be expected, the output from the yards on the Clyde is a long way ahead and is the third highest month's total for the year, and it also makes the year's total to date the third highest on record. The figures for the past ten months now amount to 219 vessels, of 491,404 tons, as against 509,823 tons for 1907, and 509,862 tons for 1906, so that there is quite a possibility of the year 1911 creating a new record in output.

Scotch Pig-Iron Trade.—Some improvement falls to be noted this week in the local inquiry for the ordinary qualities of Scotch pig iron, and a fair amount of business has resulted. The export trade continues satisfactory, and from the South the inquiries have been on a larger scale. The output over all is again most encouraging, as buyers have been taking delivery of fairly large quantities. The hematite position shows little change, and although some new forward business has just been arranged, the current price is still 64s. per ton.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Steam coal has shown a marked strengthening on the week. The explanation is to be found in the rush of orders coinciding with the bringing to a close of the shipping season proper. Contract deliveries from many of the collieries are considerably in arrear, and merchants have been pressing for supplies. The hard-coal position is still further improved by the fact that manufacturers are still taking large quantities. Considering the manner in which they have been stocking for several weeks past, the large works, in the event of a recrudescence of the railway labour troubles, ought to be better able to face the situation, provided such a stoppage is not of long duration. The railway companies, too, are in the market for odd lots. Most of this class of coal, however, is fetching high prices, since outputs are practically swallowed up by contracts already in hand. Prices are firmer all round, and there are rumours of increases running up to 1s. a ton having been obtained in respect of coal to be delivered next year. Business in gas coals is still vigorous, and in this branch also there are arrears on contracts. Slacks are easier, in consequence of the present large productions, and supplies have been offered at slight reductions. Coking smalls show a similar tendency, and are in good supply. A marked contrast is afforded in the house-coal market. Here orders are coming in in driblits. What little business is done is mostly in the open market, and many merchants are very slack. There are still a good number of orders on hand at pits for best grades, but these are a diminishing quantity, and the cheaper qualities are in very little request. Prices have not altered materially, but the trend is downwards, and merchants are awaiting reductions. Week-end quotations on 'Change were:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. 6d. to 13s. 6d.; Silkstone, 11s. 6d. to 12s. 6d.; Derbyshire brights, 12s. 6d. to 13s.; Derbyshire house, 10s. to 11s.; large nuts, 10s. to 11s.; small nuts, 6s. 6d. to 8s.; Yorkshire hards, 9s. 3d. to 10s. 3d.; Derbyshire hards, 9s. to 10s.; washed nuts, 8s. 6d. to 9s. 6d.; rough slacks, 5s. 6d. to 7s. 6d.; seconds, 4s. 6d. to 5s. 6d.; smalls, 2s. to 3s.

Iron and Steel.—Hematites still remain on the weak side so far as prices are concerned, and the market has remained steady during the past week. The Lincolnshire and Derbyshire makers keep up quotations, and are doing well in forge irons. There is a considerable demand for the best basic material. Scrap continues to be depressed. The present price-list is as follows:—Hematites—West Coast, 75s. to 77s.; East Coast, 68s. to 70s.; Lincolnshire No. 3, 50s. 6d.; forge, 49s. 6d.; Derbyshire No. 3, 51s. 6d.; forge, 49s. 6d.; bars, 7*l.*; sheets, 9*l.* The finished iron industry has shown an improvement recently owing to a quantity of iron being used, principally in railway wagon work, in place of steel. Whilst benefiting the finished-iron makers, these orders are not of sufficient moment to have any real adverse effect upon the steel manufacturers, who have been, and still are, receiving a very large quantity of work. The steel trades generally seem in no danger of slack time during the winter, and there is just now a little more confidence in the labour outlook, tending towards increased activity in the placing of orders. Outside the armament departments, and excluding certain special branches of local industry, a good deal of the existing prosperity is attributed to a big volume of work given out by railway companies, who have been compelled materially to increase their rolling-stocks, and to the improvement in general engineering.

CONTRACTS.—The Mawchi Tin and Wolfram Mines, Limited, have recently placed an order with the British Humboldt Engineering Company, Limited, of Dixon's House, Lloyd's-avenue, E.C., for the supply of a complete magnetic separating plant for the Mawchi Company's mines in India. The plant is complete, including the crushers, screens, shafting, Humboldt's Wetherill separator, &c.

MANCHESTER TUBE RAILWAYS.—A definite scheme has been matured for tube railways for Manchester, and a syndicate of Manchester men has been formed to promote a Bill upon the subject next session. The system proposed is about 4¼ miles long, and a capital of 1,000,000*l.* is suggested. Mr. J. Webb, a Manchester engineer, has prepared plans and estimates.

ZOELLY TURBINES.—Following the torpedo-boat destroyers Warrington and Mayrant, both fitted with Zoelly turbines of 13,000 shaft-horse-power, and built at Messrs. Wm. Cramp and Sons' yard in Philadelphia for the United States Navy, the latter have placed an order with the same firm for other four torpedo-boats fitted with Zoelly turbines. The turbines of each vessel are designed for 16,000 shaft-horse-power. Messrs. Wm. Cramp and Sons are the licensees of Messrs. Escher Wyss and Co., in Zürich, for the construction of Zoelly marine turbines.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Little new of moment can be reported concerning the pig-iron trade. Buyers continue to act with extreme caution, and as a rule confine operations to the purchase of small lots to meet early requirements. At the same time, however, there are occasional inquiries for forward business, and it is gratifying to learn, as indicating that confidence in the future has not altogether disappeared, that rather higher rates are demanded on forward account than those ruling for early delivery. Producers of Cleveland pig iron are well sold, and they have practically no stocks, but a much less satisfactory state of affairs exists so far as hematite iron is concerned. Makers of hematite pig are said to have rather heavy, and still accumulating stocks, and sales are very slow. It is understood that some merchants are prepared to sell No. 3 g.m.b. Cleveland pig at 46s. 6d. f.o.b., but the general market quotation is 46s. 7½d.; whilst No. 1, which is still rather scarce, is 50s. 6d.; No. 4 foundry, 46s. 3d.; No. 4 forge, 46s.; mottled and white iron, each 45s. 9d.; and mixed numbers of East Coast hematite pig iron, 60s. 6d.—all for early delivery. Foreign ore shows a marked upward movement. Sellers take a very firm stand, and market rates are now based on fully 20s. ex-ship Tees for best Rubio. Coke continues in good request, and prices are firm. Local consumption is heavy, and medium blast-furnace kinds realise 15s. delivered here. Foundry coke for shipment is fairly well taken up, and the quotation is in the neighbourhood of 17s. 6d. f.o.b.

Manufactured Iron and Steel.—There is great activity in practically all branches of the manufactured iron and steel industries. Several firms have contracts made that will keep them busily employed over the whole of next year, and, in addition to this favourable state of affairs, there are quite a number of inquiries in the market. Under such circumstances values naturally tend upwards, and for some descriptions advances may be announced at any time. Up to the present, however, no quotable changes have been made. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron girder-plates, 6*l.* 17s. 6d.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 7s. 6d. to 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 11*l.* 5s.—sheets less 4 per cent. f.o.b., railway material net, and all other descriptions less 2½ per cent.

Iron and Steel Shipments.—For the month of October shipments fully realised expectations. Those of pig iron averaged 4423 tons per working-day, the total despatches being returned at 115,003 tons, as compared with 106,693 tons, or a daily average of 4103 tons for the previous month, and a total clearance of 111,374 tons, or an average of 4283 tons per working-day for the month of October, last year. Of the pig iron loaded during the past month 105,858 tons went from Middlesbrough and 9145 tons from Skinningrove, the whole of the latter going to Scotland. Of the Middlesbrough clearances, 70,439 tons went to foreign ports, and 35,419 tons to coastwise customers. Once more Scotland was the largest buyer, receiving 24,809 tons; whilst Japan took 13,160 tons; Russia, 8540 tons; Germany, 8015 tons; Canada, 7410 tons; Sweden, 6302 tons; and Holland, 4100 tons. Of 12,674 tons of manufactured iron shipped at Middlesbrough last month, 4602 tons went abroad and 8072 tons coastwise; and of 133,125 tons of steel despatched, 27,574 tons went to foreign buyers and 5551 tons coastwise. Again India was the largest importer of both manufactured iron and steel, taking 3521 tons of the former and 9671 tons of the latter. Other importers of steel were:—West Australia, 4352 tons; the Argentine, 2448 tons; Canada, 2215 tons; Japan, 2144 tons; and Portuguese East Africa, 1914 tons.

THE JOHN COCKERILL COMPANY.—The past financial year has been one of the best ever enjoyed by this company, the metallurgical orders received having footed up to 1,357,648*l.*, and the mechanical and construction orders to 729,252*l.* The rough profits of the year were 240,214*l.*, of which 94,600*l.* was available for distribution in dividends and statutory allocations. A dividend of 3*l.* 12s. per 20*l.* is accordingly announced for payment November 2. The amount paid in wages during the year by the company was 539,103*l.* The production of pig for the twelve months in the company's seven blast-furnaces was 250,000 tons. The company is building a Diesel motor-boat for the Congo.

THE LATE MR. BENJAMIN HARLOW.—We regret to have to announce the sudden death of Mr. Benjamin Harlow, which took place at Macclesfield, at the age of eighty-two. The deceased was a member of the firm of B. Harlow and Son, heating engineers and iron-founders, King Edward-street, Macclesfield, which was established by his father in 1836. The firm had a wide reputation for their steam-heating process, chiefly owing to the inventive genius of Mr. B. Harlow, who, in the North of England, was one of the pioneers of the low-pressure system of hot-water heating. Mr. Harlow retired from active participation in the business about twenty-five years ago. The business is now carried on by Mr. Charles Harlow, his son.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has been quiet, tonnage arrivals having been checked by stormy weather. Colliery-owners in many cases have orders which will carry them to the end of November, but they are less favourably circumstanced as regards transport facilities. Holders of best Admiralty steam-coal have shown unwillingness to make concessions, but other descriptions have been obtainable upon rather easier terms. The best large steam-coal has made 16s. 9d. to 17s. per ton; secondary qualities have ranged between 15s. and 16s. 6d.; best ordinary bunker smalls between 7s. 3d. and 7s. 6d.; and cargo smalls between 6s. and 6s. 9d. per ton. House-coal has shown a firm tone; the best ordinary qualities have made 14s. 6d. to 16s. 6d.; No. 3 Rhondda large, 17s. to 17s. 6d.; and smalls, 10s. 3d. to 10s. 6d. per ton. No. 2 Rhondda large has been quoted at 11s. 9d. to 12s. 3d.; and smalls at 6s. 3d. to 6s. 9d. per ton. Foundry coke has realised 18s. to 20s. 6d.; and furnace ditto, 16s. to 17s. per ton. As regards iron ore, Rubio has made 18s. 6d. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Dowlais.—The works are well supplied with orders, and the blast-furnaces, as well as the Siemens and Bessemer plants, have been actively employed. The Goat Mill has been turning out tin bars, steel rails, and steel sleepers, while the Big Mill has been engaged on small and light rails, fish-plates, curves, angles, &c.

More Welsh Coal.—Another seam of coal has been struck at Bedwas, where the Bedwas Navigation Colliery Company is sinking new pits. The seam is 3 ft. 3 in. in thickness, and it was reached at a depth of 730 yards. This is the third seam of workable coal struck in the district this year.

Welsh Coal for Belgium.—The administration of the Belgian State Railways has placed orders for four lots of Welsh small coal, amounting to about 18,000 tons. Of these, two lots, or 9000 tons, were secured by Messrs. Morgan, Wakley, and Co., Limited, at 11s. 9d. per ton; and two lots by Messrs. G. H. J. Davey and Co.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—The graduates of the Institution of Automobile Engineers paid a visit on October 28 to the works of Messrs. J. Tylor and Sons, Limited, King's Cross, where they were conducted over the motor-construction department by the manager, Mr. W. F. Drayson, M.I.A.E. One of the chief points of interest was the large marine motors constructed by the firm for the National Lifeboat Institution. These engines presented an example of the use of low-tension ignition, which is preferred for this class of work, owing to the damp conditions under which the motor has to work. They are also required to continue working until the boat heels to an angle of 45 deg., when an automatic ball-valve breaks the ignition circuit. The arrangement of the water-pipes is very neat, consisting of small inverted U castings connecting the cylinders together, the water entering at one end and flowing to the cylinders consecutively, with a difference of temperature between the first and last cylinders of only some 9 deg. Forced lubrication to all the parts is supplied, which can be immediately replaced in cases of failure by splash. The upper part of the crank-chamber is made of the firm's special bronze, under the name of "Rolyt metal," which has a tensile strength of 20 tons, and makes an excellent substitute for aluminium for marine work, both from the view of strength, lightness, and absence of corrosion. Motors of very similar design are also made for omnibuses and commercial purposes generally, and altogether the visit provided a very interesting study in manufacturing methods and in the design of motors for special purposes, which the graduates have all too few opportunities of examining.

STEEL PRODUCERS' REBATES TO CUSTOMERS.—A circular, signed by twenty-three of the leading steel-makers of Great Britain, has been issued to consumers of plates, angles, bars, &c., intimating that, from October 13 last, they will, under certain conditions, grant a rebate of 5s. per ton on certain classes of specified material delivered direct from the makers' works to, and used by, the consumers, against sales made by the makers or through merchants since October 13. This rebate becomes due on the fourth month following delivery, and is to be paid each month thereafter on the material paid for within the previous month. In order to secure the rebate, the consumer is required to lodge a statement of claim for rebate (signed by the principals only) on a form which includes a declaration to the effect that he has not purchased or received any of the specified materials which have been manufactured by other firms than those granting the rebate, except, of course, against contracts made prior to the issuing of the circular. In other words, those accepting the agreement and rebate of the steel producers undertake not to accept any steel material of the form specified—plates, angles, bars, &c.—from other British or foreign makers who are not parties to the producers' agreement; failing this, no rebate is given. Should the consumer at any time desire to withdraw from the arrangement, he is required to give twelve months' notice, and the rebates will continue until the termination of such notice; but no consumer can give notice of termination until after the expiry of six months from entering into the agreement. The responsibility of any maker for the payment of rebate does not extend beyond deliveries under sale made by himself. The arrangement does not apply to any of the specified materials which may be sold for export.

PASSENGER LOCOMOTIVE (4-6-2 TYPE); BELGIAN STATE RAILWAYS.

CONSTRUCTED TO THE DESIGNS OF MR. J. B. FLAMME, ENGINEER-IN-CHIEF, BY THE SOCIÉTÉ JOHN COCKERILL, SERAING.

(*For Description, see Page* 593.)

Fig. 33.

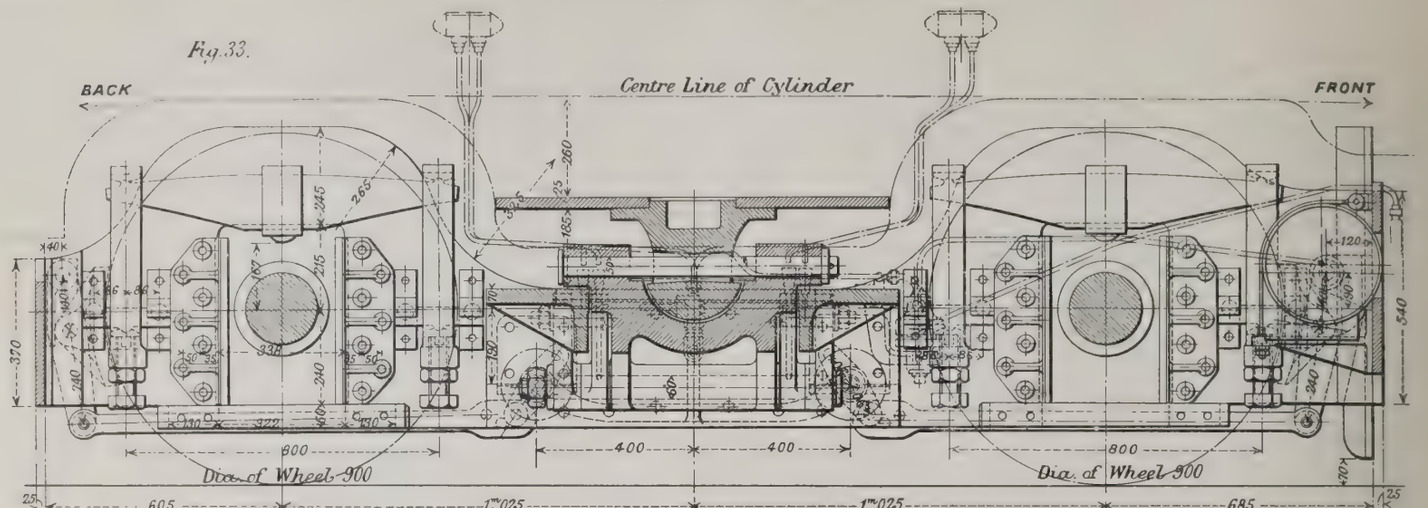


Fig. 34.

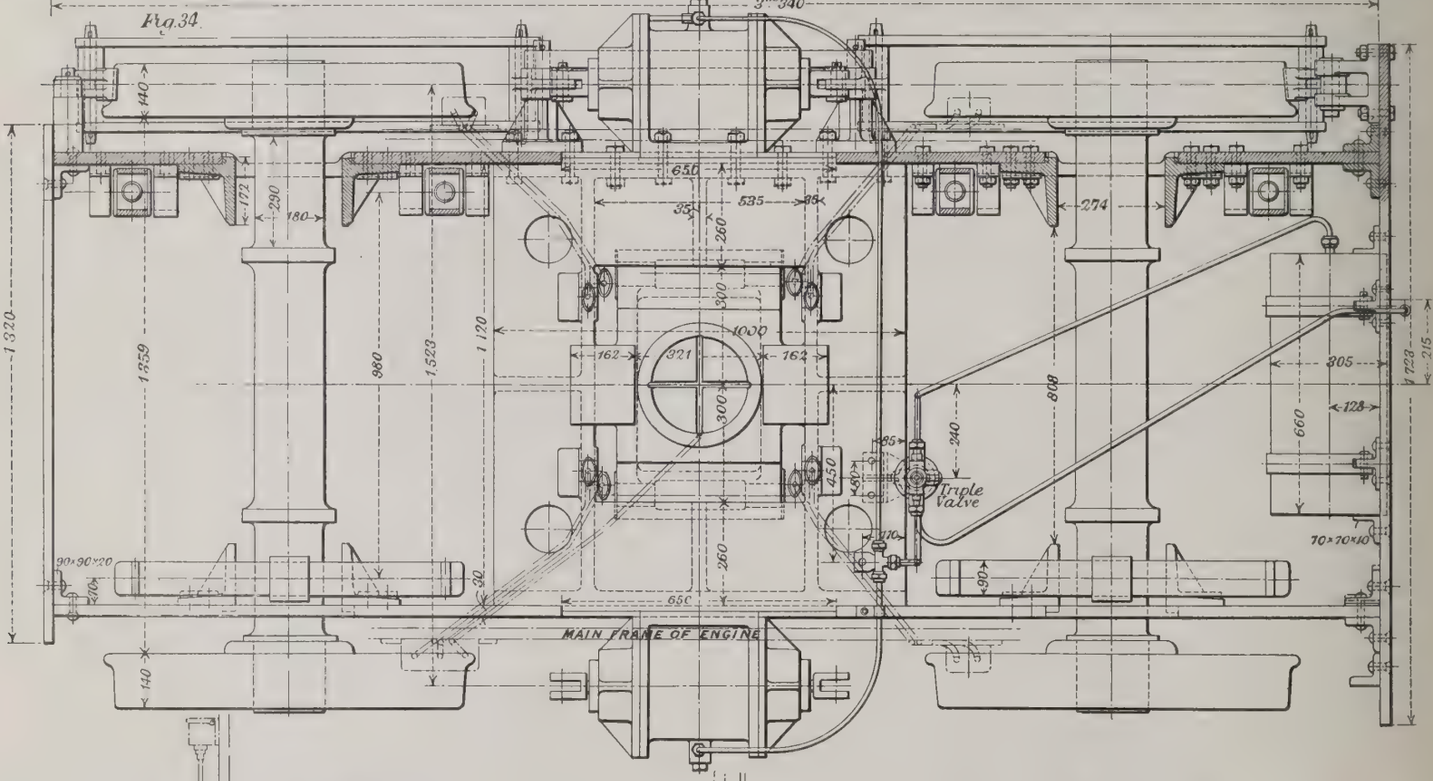


Fig. 35.

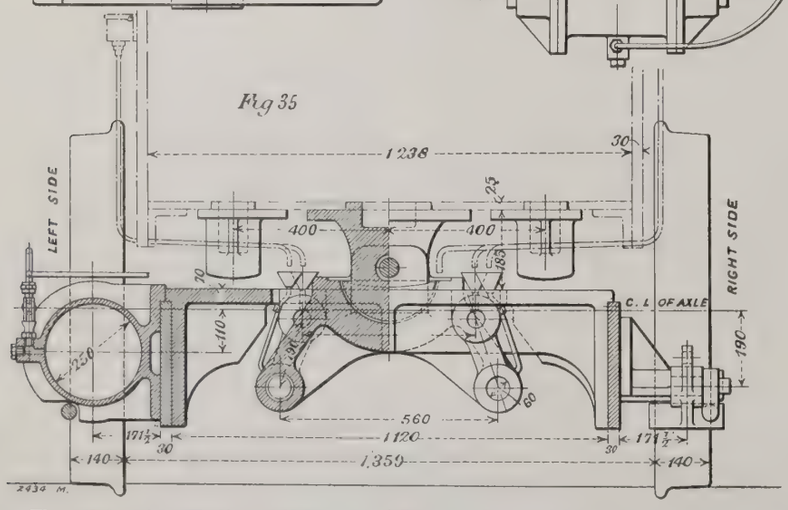
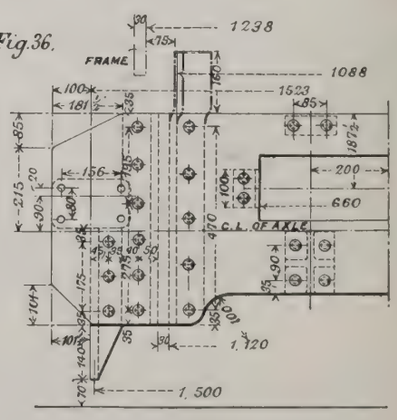


Fig. 36.



SELENIUM.—The results of interesting researches on selenium and its sensitiveness to light have been published by Christian Ries in the programme of the Theresien-Gymnasium of Munich, and have also appeared in the *Physikalische Zeitschrift*, 1911, pages 480 and 522. Ries finds that the light does not affect the volume of selenium, and that there is no special modification of a sensitised, less dense selenium. In normal selenium cells the current intensity increases under illumination. In abnormal selenium the current intensity decreases when the cell is illuminated. The chief source of this anomaly, Ries ascertains, is the moisture of the atmosphere, which also influences the resistance of the selenium in the dark. Selenium cells should therefore be kept in a vacuum. The sensitiveness to light of selenium seems to be a resonance phenomenon. Light, particularly of a certain wave-length, causes the electrons in selenium to oscillate. The translatory movement imparted to them is not of sufficient intensity, however, to allow them to escape, but they increase the number of electrons available for conducting the current, and thus improve the conductivity.

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NOTICES OF MEETINGS.

THE NORTHAMPTON INSTITUTE ENGINEERING SOCIETY.—Friday, November 3, at 5.45 p.m., when Mr. T. R. Houston and Mr. F. G. Parnell will read a paper on "Diesel Engines."

THE GEOLOGISTS' ASSOCIATION, LONDON.—Friday, November 3, at 8 p.m. A conversazione will be held in the library of University College, Gower-street, W.C. Morning dress.

THE INSTITUTE OF MARINE ENGINEERS.—Monday, November 6, at 8 p.m. Paper on "Notes on Two-Cycle Oil-Engines," by Mr. F. Duncanson, B.Sc. (Substituted in place of Mr. W. Veysey Lang's paper, "Specification of the Engines of a Tramp Steamer," the reading of which has been postponed.)

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, November 6, at 7.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. A paper will be read on "Two-Cycle Engines," by Mr. Robert W. A. Brewer, A.M. Inst. C.E., A.M.I. Mech. E., M.I.A.E. (Fellow).

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 7, at 8 p.m. Address by Dr. W. C. Unwin, F.R.S., the President, and presentation of medals and prizes awarded by the Council. Reception by the President in the library after the meeting.

THE RÖNTGEN SOCIETY.—Tuesday, November 7, at 8.15 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. The President, Mr. Alan A. Campbell Swinton, M. Inst. C.E., M.I.E.E., will deliver his address.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, November 8, at 8 p.m., at the Institution of Mechanical Engineers, Storey's-gate, S.W. A paper on "Chassis Design" will be read by Mr. Howard Coffin (Past-President of the American Society of Automobile Engineers), and a number of members of the American Society who will be visiting this country are expected to be present. A representative programme of visits to works in this country has been arranged for the visiting Society, concluding with a dinner at the Trocadero, given by the Institution of Automobile Engineers on November 11.

THE FARADAY SOCIETY.—Wednesday, November 8, at 8 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C., when Dr. Edward G. Acheson, of Niagara Falls, will give an account of his researches to the members of the Society. The address will be accompanied by experiments. Non-Members will be admitted by tickets to be obtained on application to the secretary, 82, Victoria-street, S.W.

THE CONCRETE INSTITUTE.—Thursday, November 9, at 8 p.m., at Denison House, 296, Vauxhall Bridge-road (close to Victoria Station), Westminster, S.W., when a Presidential Address will be given by Sir Henry Tanner, C.B.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 9, at 8 p.m., when the premiums awarded for papers read or published during the Session 1910-1911 will be presented, and a paper by Mr. W. T. Taylor (Member), entitled "Modern High-Voltage Power Transformers in Practice, with Special Reference to a T Three-Unit System," will be read and discussed. In the author's absence in Brazil, the paper will be read on his behalf by Mr. J. F. C. Snell, Vice-President.

THE PHYSICAL SOCIETY OF LONDON.—Friday, November 10, at 5 p.m. (and not at 8 p.m. as announced in the time-table already circulated), at the Finsbury Technical College. Agenda: 1. "Reflecting Polariscopes for the Study of Optical Stress in Materials," by Professor Silvanus Thompson and Professor E. G. Coker. 2. "The Effects of Holes and Semicircular Notches in the Distribution of Stress in Tension Members" (demonstrated by polarised light), by Professor E. G. Coker. 3. (*a*) "A Surface-Tension Phenomenon;" (*b*) "Temperature Rise in Drops as they Part;" (*c*) "Temperatures of Equidensity of Liquids," by Mr. C. R. Darling. 4. (*a*) "Exhibition of a Large Harmonograph;" (*b*) "Physiological Effect of an Alternating Magnetic Field;" (*c*) "Demonstrations of Acoustical Experiments, New and Old," by Professor S. P. Thompson.

ENGINEERING.

FRIDAY, NOVEMBER 3, 1911.

THE UNEMPLOYMENT INSURANCE BILL.

THE second part of the Government scheme for insurance against ill-health, unemployment, &c., has been remitted to the Grand Committee, which began its consideration of details yesterday, while the House of Commons in Committee are simultaneously considering the first part of the scheme, dealing with ill-health and other causes of invalidity. The consideration of such Bills by the Grand Committee can be commended, because the procedure may, perhaps, be more businesslike, owing to the comparative smallness of the Committee, and to the less tendency to "talk to the gallery." There are, however, grave objections; the Committee may not be thoroughly representative, so that discussion on the subsequent report stage has to be extensive. Again, many members of Parliament on the Grand Committee are intensely interested in the invalidity insurance section of the Bill, and have therefore to attend also the House of Commons. A great tax is thus placed on their time and on their capacity for careful consideration of important details. Such great pressure on members has arisen because of the determination on the part of the Government to pass the Bill this year, and to carry out the original intention of bringing it into operation on May 1 next. Such haste is not fully justified, because a further prolongation of the present condition of affairs for a year would not have involved great hardship; moreover, the result would probably have been such a perfecting of the details of the measure as to obviate the need for later amendment in Parliament and to avoid the possibility of serious disputes in the application of the scheme. That there is room for thorough consideration of the details is established by the many amendments which have been made even by those who have drafted the Bill, while the acceptance by the Government of amendments suggested by those having experience of industry further goes to show that a fuller exchange of opinion between the drafters and the representatives of all interests involved would have ensured a greater measure of permanent success for the project. Hasty legislation is never satisfactory, because the saving of time at the outset is more than counterbalanced by the waste of time occupied in the subsequent process of amendment, and because of the difficulty of interpreting ill-expressed and immature ideas in the clauses.

For the present we confine ourselves to the scheme for insurance against unemployment. In view of modern altruistic tendencies by those in authority, there is little need to enter into the principle of the Bill; moreover, that was done when the Bill was introduced. (See ENGINEERING, vol. xci., pages 623 and 727.) Again, it would probably be futile to point to the objections to the compulsory character of the scheme. Another subject on which there is sharp and justifiable difference of opinion is as to the trades embraced by the unemployment scheme. So far as it affects ill-health and invalidity generally the Bill is all-embracing, but in respect of unemployment it only extends to the industries connected with shipbuilding, engineering, and building. Now iron-founding is added, a change which we contended for in our previous article, because many engineering factories include foundries. The argument in favour of such limitation carries considerable weight, the view being that, as legislation in this direction is to a large extent experimental, it was desirable to confine the experiment within well-defined limits and to those trades where the organisation of labour made the administration fairly easy. We attach no importance to the further view that the industries scheduled include those most affected by alternating periods of activity and depression, because the same can be said of most industries, and, moreover, the effect of such alternations in the industries included affect many other trades. As we have said, however, the general idea of a legislative experiment in insurance against unemployment is accepted, although perhaps unwillingly by many who are involved, and the only alternative left for those interested, not only in the branches affected, but in commercial prosperity generally, is to do everything that is reasonably possible so to amend the details as to involve the least permanent injury to commercial prosperity. That there will be injury is widely agreed, because the cost of providing for the recurrent periods of depression in a scheme which involves 2½ million workmen must be considerable, and the provision made must be directly charged against the productions of the works embraced.

We admit, however, that indirect advantage may accrue. One effect will undoubtedly be to bring employers and the labour exchanges into closer contact. Under Clause 73 provision is made whereby the labour exchanges may be largely utilised in connection with the collection by each employer who provides 2½d. per week for each workman, and a corresponding amount collected from each employee, in addition to the State contribution of 1⅔d.—equivalent to one-third of the worker's and employer's contribution. The weekly payments may be handed over to a labour exchange in a lump sum, to be credited by the authorities at the exchange to each workman's card. At the same time the exchange is to be utilised for the purpose of paying the out-of-work benefit to such men as are not connected with a friendly society or trade union approved under the Bill. It will be the duty also of the labour exchange to find work for those who may seek relief under the scheme; and, as we shall presently show, a most satisfactory amendment has now been agreed to by the Board of Trade as to the conditions under which workmen may refuse to accept employment. The tendency, therefore, will be to sift out the man "seeking work while trusting to God that he won't find it." There is the further advantage that from each worker's card the employer can learn much as to the constancy or otherwise of the applicant for work, and generally as to his record of service. Such evidence possessed initially by the Labour Exchange Commissioner will help him in establishing the credit of the exchange in meeting efficiently the requisition of employers for capable and "steady" men worthy of appointments. While

employers may thus be able to improve the standard of the workmen within their establishments, the State may suffer, as the number of permanent unemployables may be increased. Claims under the poor law may thus ultimately grow, since it is provided in the Bill that payment of out-of-work benefit must terminate at the end of fifteen weeks in any one year. A workman, too, can only secure payment after he has been one week idle, and can only get one week's benefit for each five weeks of employment and, therefore, of contribution to the funds. While expenditure is thus limited, it is still liberal, and we can only hope that in the presence of the process of elimination possible under the Bill all workmen will awaken to the fact that the State demands such steady service and application to work as merit continuous employment.

We have referred to the proposed amendment in reference to the terms of employment to which a man seeking work is entitled to object. This is one of the most important points in the scheme, and we think that Mr. Buxton, in the amendment of which he has given notice, is acting wisely. The clause in question (62) provides that an unemployed workman will still be eligible for unemployment benefit although he refuses to undertake work in a situation vacant in consequence of "a strike or lock-out." This phrase has now been amended, so that the last words read "a stoppage of work." This is more or less a euphemism. The real amendment affects the second part of the clause, under which the workman is justified in refusing to undertake work "at a rate of wage lower than the rate which he habitually earns when in employment, or, in the case of the offer of employment in a district other than that in which he resides, at a rate of wage lower than the rate current in the district in which the employment is offered." There was room here for very serious dispute. The question as to what was the "rate" which a man habitually earned in any employment would have been most difficult to interpret. The use of the word "earns" in conjunction with "rate" is incompatible. A man does not earn a rate; he is paid according to a rate. A difficulty might arise, for instance, in the case of a piece-worker who is supposed to earn, say, 25 per cent. above time rates. Is he to be allowed to refuse a time-rate job simply because he was habitually earning 25 per cent. more than the time-rate when on piece-work? Other difficulties of the same nature will suggest themselves. A solution has now been found by the adoption of practically the terms of the "fair wage resolution" of the House of Commons. The new words are that the "workman shall not be deemed to have failed to fulfil the statutory conditions by reason only that he has declined an offer of employment in the district where he was last ordinarily employed at a rate of wage lower, or with conditions less favourable, than those which he habitually obtained when in employment or would have obtained had he continued to be employed, or an offer of employment in other districts at a rate of wage lower or under conditions less favourable than those observed in such district by agreement between associations of employers or workmen, or, failing any such agreement, other than those generally recognised in such districts by good employers."

It may be remembered that in our previous articles we took exception also to the terms of the concession which Mr. Lloyd George made to employers provided they were prepared to pay in advance a lump sum for the year's contributions for any workman. This lump sum was to be 15s. per annum, and was to cover the weekly charge of 2½d. from the workman and 2½d. from the employer. But, as we pointed out, it was difficult for the employer to say that "John Smith" would be engaged by the firm for the whole of the calendar year, and yet in the event of "John Smith" resigning, and "John Brown" taking his place at any time, the weekly contributions for "John Brown" would require to be met in addition to the lump sum paid for "John Smith." Everyone acquainted with industrial conditions knows that there are many and frequent changes in the *personnel* of all large establishments. The Board of Trade, therefore, have drafted a new clause, which is much more acceptable, and confers benefit from compounding. This new clause practically gives a discount on the completion of the calendar year for each workman who has been continuously paid for each week by the employer. This ensures the incentive to continuous employment aimed at in the original clause. The new clause states that "the Board of Trade shall, on the application of any employer, made within one month after the termination of any calendar year, or other prescribed period of twelve months, refund to such employer, out of the unemployment fund, a sum equal to one-third of the contributions (exclusive of any contributions refunded to him under any other provisions of this part of the Act) paid by him on his own behalf during that period in respect of any workman who has been continuously employed by him throughout the period, and in respect of whom not less than forty-five contributions have been paid during that period."

Another amendment officially proposed removes, in part, a hardship which the casual worker would have laboured under. According to the eighth schedule of the Bill, the intention originally was that such a workman, even if he were only employed by one employer for one day in a week, must pay 2½d., while the employer paid 2½d. An extreme case would be a man engaged on six successive days by six different employers, in which case he would have had to pay a total of 1s. 3d., while the six employers collectively would pay a corresponding amount. This provision has now been modified. If a man is employed for one day, or less, he pays a penny, and so does the employer; if he is engaged for more than one day, 2d. is paid by each. Thus, a man employed for two days successively by three separate employers during one week will pay 6d. Here we have another indication of the looseness with which the project was prepared, and of the great difficulties and occasional injustice which may result from the scheme.

Another point which must sooner or later involve difficulty has reference to the workmen who may be employed part of their time within the industries embraced by the scheme, and partly in works which have no connection with the new law. One can conceive, for instance, of a labourer being employed in the building trade for part of the year, and being compelled, during succeeding months, to seek other outlets for his energy—for instance, in dock labouring. He would only be contributing to the unemployed insurance fund while engaged in the building trade, while his term of unemployment might arise after he was engaged as a dock labourer. If he belonged to a trade union, or other society approved under the Act, there would be difficulty in connection with his contribution, and perhaps also with his benefit payment, unless the trade union ensured that, when not employed in an industry scheduled under the Bill, he would pay 5d. a week to the trade-union fund for unemployment benefit in addition to other union demands. Where the payment is made to the unemployed worker from the labour exchange, his payment-card will clearly show how much he is entitled to—namely, one week's benefit for each five weeks' contributions. Here one finds justification for the general contention that difficulties would have been minimised had the Government made up their minds to utilise the labour exchanges exclusively for the receipt of workmen's and employers' contributions, and for the payment of the 7s. per week of benefit money, instead of relying on the media of approved societies, whether friendly societies or trade unions. In connection with the amount of the benefit, it is provided that if experience shows that the rate cannot be maintained, it may be reduced to 5s. per week. Meanwhile the Treasury is to advance three millions sterling to launch the scheme, and reserves the right not only to reduce the benefit, but to increase the contributions by 1d. per week per workman. Benefit payment will not begin until six months after the beginning of contributions. A man "who loses employment through misconduct, or who voluntarily leaves his employment without just cause," or who has been sent to prison, will not get benefit until six weeks have elapsed. No benefit may be paid where unemployment is due to trade disputes. Every applicant must prove that he has been at work and contributing for twenty-six weeks; that he is willing, but unable, to find employment; that he has not previously had fifteen weeks' benefit for each year the scheme has been in operation; and that all contributions on his behalf have been paid. Workmen at the age of sixty years who have paid 500 weeks' contributions may secure refundment of money which they have not had occasion to demand in the way of benefits.

It is possible that the difficulties which threaten to involve complications will be removed by the regulations which the Board of Trade propose to make. These will no doubt settle also the allowances to be paid to the friendly societies and trade unions for the administration of the funds; but in the latter cases such allowances will assist in maintaining sinews of such industrial warfare as is, under present-day militant unionism, more and more becoming the chief function of these combinations of workers.

THE "LIBERTÉ" DISASTER INQUIRY REPORT.

The report of the Commission appointed to inquire into the cause of the Liberté explosion has now been made public, and it is impossible to help being struck with the baldness of the conclusions arrived at, and with the inadequacy of the recommendations made to avoid a repetition of this appalling disaster. Briefly put, the Commission find:—1. That it was not due to an act of malevolence. 2. That it was not due to a fire having occurred in any of the spaces adjoining the magazines. 3. That it was due to the inflammation of a cartridge of service powder in one or other of the forward starboard magazines, and almost certainly in the upper magazine containing only powder from one lot—namely, lot $B\,M_{13}\,A\,M_8$ 2.06 P.B.—*i.e.*, the second lot of powder manufactured in 1906 at the Government powder factory of Pont-de-Buis. The Commission hesitate to attribute the cause to "spontaneous combustion" of the powder for reasons which are not only extremely hypothetical, as they admit, but also because "the powder being enclosed in soldered cases, we are not able to go further than the outside of the cases themselves in discriminating as to the causes of the inflammation of the powder." The report then continues in the following words: "The task of the Commission appointed to investigate the causes of the catastrophe is finished." It is difficult to imagine a report which is more unsatisfactory in its conclusions or one which, in its subsequent recommendations, will inspire less confidence in the minds of those who have to serve aboard French war vessels.

The recommendations are as follow, to quote, in translation as nearly as possible, the actual words: "But it goes without saying that the members of the Commission could not help exchanging amongst themselves their views as to the progress which should be realised in the storage and conservation of the powders on board, as well as in the guarantees of security against fire and malevolence. They are of opinion that certain improvements in the actual installations, not necessitating any great modifications, could, from henceforward, be undertaken in all vessels in service. A study of this special question calling attention to the competency of the military and technical services will no doubt shortly be made. As regards the guarantees of safety against the instability of "B" powder, the recent order lowering to *four* years the limit of age allowed for powders stored on board will be without doubt, *for a long time yet*, one of the most efficacious. Foreign navies have preceded us in this direction, and, according to certain documents, their limit of age is even lower." (The italics are our own.)

Could futility go further? It may be remarked that the final recommendation is not even based upon fact, at any rate so far as Britain is concerned, for the latest regulations on the subject, July, 1911, state as follows:—"Every lot of cordite on board His Majesty's ships and in store is to be tested as soon as possible after it becomes eight years old;" and though periodical examination of all cordite is made also twice a year, no matter of what age, it is clear that our powder, at any rate, is expected to last at least eight years without any difficulty. Nor can the Liberté Disaster Commission have studied the conditions in Germany or Italy, both of which countries use nitro-glycerine powders for their navies, which, so far as is known, have been immune from trouble as regards powder. But possibly the United States regulations have been referred to by the Commission, and this is probably so, since the United States Navy use a nitro-cellulose powder—*i.e.*, the same type as the French Navy.

All this would appear to furnish confirmatory evidence from an official and responsible source as to the correctness of the views we have always held to the effect that, for naval purposes, the nitro-

cellulose type of propellant powder is vastly inferior, both chemically and ballistically, as compared to the nitro-glycerine type. We dealt with this question in our leading article of October 6 (page 463 *ante*), and though that was written previous to the publication of the Commission's report, there is nothing in that report which causes us to modify our views in the smallest degree; on the contrary, a close study of the body of the report confirms the views we put forward as to the probable causes of the disaster.

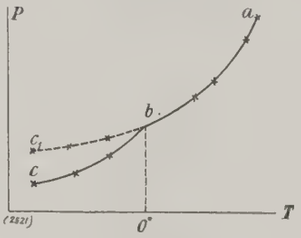
It is a matter of astonishment that the recommendations, instead of making an attempt to eradicate the seat of the disease, which will always be liable to break out, merely suggest mild palliatives, which are based not only upon inaccurate information, but actually upon a wrong diagnosis. The disease itself is the persistence with which the French authorities adhere to the use of a nitro-cellulose powder for their navy; and if the signs are not wrong, we fear that one day the United States navy may have to deplore a similar disaster, as they have lately adopted the course of "reworking" their "old" powders, some of them only a couple or so of years old, with so-called "stabilizers." These latter have their uses when added to newly-made powders, but to add them to powders which have already shown themselves to be unstable, from the fact that they are sentenced to be re-worked, is a dangerous expedient, which no economic consideration can excuse.

ALLOTROPY AND THE TIN PEST.

The adoption of a designation like "tin pest" seems to suggest that metals, like living beings, may be subject to infective diseases. That will appear absurdly fanciful to those who believe in a definite boundary-line between the living and the non-living, and may not be approved of by others, who feel less sure of the existence of such a boundary, but who would not compare a living organism built up of many compounds, constantly undergoing changes, with a metal or other elementary substance, which is uniform in its mass and endowed with certain permanent qualities. Yet Professor Ernest Cohen, of Utrecht, did not act without reason when he designated the peculiar decay of tin—which probably does not stand alone in this respect—by the name of a plague or pest. He has carefully investigated the phenomenon, and he has succeeded in demonstrating that the decay of tin can be prevented and cured. Tin should not be exposed to cold, to put the matter briefly. The subject is of considerable interest to engineers, and for this reason Professor Cohen's discourse on "The Allotropy of Metals," delivered last summer at the Faraday Society, deserves attention.

The main facts of the decay of tin were recognised forty or fifty years ago. O. L. Erdmann noticed in 1851 that some organ pipes in the castle church of Zeitz (Prussian Saxony) were decaying; he thought that the concussions to which the pipes were subject might under certain conditions cause a mechanical disintegration. When Fritzsche was consulted upon some peculiar Banca tin in February, 1868, by a St. Petersburg firm, Erdmann's observation had been forgotten. Some blocks of the bright white Banca tin—a very pure material—which had been kept in the customs-house sheds during the winter, had turned into a dull grey powder, and had begun to crumble. It was ascertained that the case was not isolated; tin buttons for military uniforms had changed into shapeless lumps, for instance. Fritzsche suspected the cold of the severe winter, and experiments convinced him of the correctness of his assumption; the storekeepers in a drug firm, he found out subsequently, had long known that tin should not be exposed to the cold. When Fritzsche heated the grains of his grey tin in hot water, it became bright again, and contracted at the same time; whether the heat was dry or wet did not matter. On the other hand, white tin, cooled artificially, became brittle and grey, expanding at the same time. When the grey tin was fused it changed into ordinary white tin again, and the transformation could be repeated. Fritzsche thus proved that decayed tin is not bad tin; yet, after the organ-pipes of a church in Ohlau, Silesia, which had been restored in 1837, were found badly corroded and full of holes in 1884, organ-builders did not consider such tin a suitable raw material for making new pipes, and the manufacturers of art objects shared this prejudice.

Professor Cohen's attention was first drawn to the matter when a badly-corroded 25-kg. block of tin was returned by a Moscow firm to Rotterdam because an adulteration was suspected. The tin was found to be very pure, containing not more than 0.05 per cent. of impurities. Experimenting with it, Professor Cohen confirmed and extended the observations of Fritzsche, and he demonstrated that the case of white and grey tin is entirely analogous to that of ice and undercooled water. Below its normal freezing-point water can exist in two modifications—the stable modification, or ice, and the metastable condition of carefully undercooled water. When water contained in a closed vessel is cooled, and the vapour pressure plotted as ordinate against temperature as abscissa, the curve will be somewhat like the curve a, b in the annexed diagram; at the freezing point the slope will become steeper, and the vapour tension, or, more correctly, the sublimation pressure of ice, will take the trend b, c. But when water is undercooled, the vapour tension curve of the liquid water will take the continuous course a, b, c_1. When a small crystal of ice, *i.e.*, of the solid phase of water which is stable at tem-



peratures below the freezing-point, is introduced into the undercooled metastable water, the whole bulk will freeze in an instant. With regard to the reversible transformation which water undergoes at 0 deg. Cent., this temperature, at which the two phases of ice and of undercooled water can co-exist, is called the transformation or transition point, and the reversible process is expressed, after Van't Hoff's manner, by: ice $\overset{0^\circ}{\rightleftharpoons}$ water.

With the aid of his transition cell, Professor Cohen has proved that the transition temperature of tin is 18 deg. Cent. The transition cell is a glass vessel of H form. A few grammes of grey tin are brought into each limb, a solution of pink salt is poured over the tin, and platinum wires in glass capillaries are inserted into the limbs. When the one limb is heated by being dipped into warm water, while the other limb is kept cold, the grey tin in the warm limb turns into white tin. The whole cell is then slowly heated up in a water bath to 5 deg., 10 deg., and 15 . . . deg. Cent.; there is a potential difference between the grey tin and the white tin, which is measured by the Poggendorff potentiometer method. When the temperature has come up to 18 deg. Cent., the potential difference vanishes, showing that the grey tin (left in the formerly cold limb) has also been converted into white tin at that temperature. The reversible change may hence be expressed: grey tin $\overset{18^\circ}{\rightleftharpoons}$ white tin. The addition of the pink salt accelerates the change in both directions; this can be explained, but Professor Cohen did not enter into this explanation during his discourse.

In order to measure the volume change accompanying the transition, Professor Cohen connected a cylindrical glass vessel, charged with about 70 grammes of grey tin and water, with a U-tube filled with mercury; on the mercury floated a piece of iron which was suspended by a thread from a pulley, and a long pointer was attached to this pulley. When the cylinder was lowered into warm water the grey tin changed into white tin, and the resulting diminution of the volume was indicated by a sinking of the mercury level and a rise of the pointer. In this way Professor Cohen demonstrated that the volume change at the transformation amounted to as much as 30 per cent., and this was confirmed by determining the densities of the two modifications, white tin having the density 7.28, and grey tin the density 5.70. This enormous increase in the volume leads to the disintegration of the white tin when passing into the grey modification; warts begin to appear on the surface, the tin swells, and the warts afterwards crumble into a grey powder.

Since the transition temperature of 18 deg. Cent. (64.4 deg. Fahr.) is so low, it might be objected that white tin should practically be unknown. But the change is very slow, and we know from the analogy of water that undercooling is possible. Yet if the theory be correct, all tin should turn grey as soon as the temperature falls below 64 deg. Fahr., and Professor Cohen found that this was so. He examined the tin coins and art objects of museums, and made inquiries of dealers in tin ware, and he was able to show photographs of some very badly corroded objects, coins, a coffee-pot, organ-pipes &c., which were covered with warts and holes. At ordinary temperatures, as just stated, the change proceeds very slowly. At lower temperatures the change takes place more rapidly; at −48 deg. Cent. it is very rapid, and Professor Cohen has hastened the change by bringing the white tin in contact with some grey tin. When a block of good Banca tin was brought in contact with grey tin at −5 deg. Cent., the change was very marked in a few weeks, while a block kept at + 15 deg. Cent. was not badly corroded after eight years. The decay or transformation starts from the particle of grey tin, as a small crystal of ice, a germ of ice, dropped into the undercooled water becomes the centre of a crystallisation. In a similar way every particle of grey tin becomes a centre for the formation of more grey tin; the transformation advances very slowly in the dense metal, but the particle of grey tin acts like the germ of a disease, and in this sense it may be said that the tin is infected, and that all tin is liable to infection with the tin disease or tin pest. In the cold galleries of museums the danger of the tin infection is particularly great, and this museum disease is very prevalent. It can be prevented by keeping the temperature above 18 deg. Cent.

Technically the tin pest is not so serious, fortunately, because it does not appear to affect the alloyed tin. In what way the presence of other metals exercises a retarding effect does not seem to be well understood. Professor Cohen did not refer to this side of the problem; but it was pointed out during the discussion, by Mr. J. W. Hinchley, that terne plates (whose coating consisted of a tin-lead alloy) made good moulds for refrigerating plant, while tin plates always failed. Whether or not lead is subject to a similar disease as tin is doubtful. Professor T. Turner mentioned that Canadian architects distrust roofs built up of iron and glass and lead, because the cold is believed to affect the lead. Professor Cohen had so far been unable to decide whether or not lead was liable to suffer from the cold. Cases of failure in the lead walls of sulphuric-acid chambers, which he had examined, and in which chemical corrosion seemed to be out of the question, rather suggested to him a different phenomenon, a strain disease, to which most metals were subject. To avoid confusion, he had not referred to this disease, of which Professor Ewing and Dr. Rosenhain spoke after his lecture. When crystals of metals are broken up by severe straining, they begin to recrystallise; that, in Professor Cohen's opinion, would be a re-arrangement, not a transformation of state, and an irreversible, but also infective, process. On the other hand, Professor Cohen emphasised that the tin pest was characteristic of the pure metal, and he felt sure—though he was, of course, anxious to investigate the point—that some exceptionally pure tin, which Mr. G. T. Holloway had obtained from Nigeria, would also be liable to the pest; the natives run this tin into straws or reeds, and it does not appear to contain any impurities except traces of iron. That the grey tin always contains some oxide does not disprove Professor Cohen's assumption. For the fine grey powder would naturally oxidise more readily than the compact white tin. This oxidation may prevent the ready re-conversion by heat of the grey tin into ordinary white tin; but re-fusion of the grey tin with the addition of some carbon to reduce the oxide always yields good white tin again.

In his discourse Professor Cohen also dealt with another type of dynamic allotropy—that of the so-called explosive antimony. It is a less simple type than that of tin, and might rather be thought to indicate that some supposed allotropies might, after all, be due to impurities. The late Dr. George Gore, of Birmingham, observed in 1885 that when a solution of antimony chloride in hydrochloric acid was electrolysed, the antimony was deposited in a peculiar state. Scratching sufficed to make the antimony "explode" with the evolution of white

vapours. It is not a violent explosion—rather a puffing. Professor Cohen has studied this explosion phenomenon for some years, in conjunction with his pupils. He deposits the metal on a platinum wire; a rod of antimony is then obtained, which explodes when slightly scratched with a glass rod. When the antimony was deposited on the bulb of a mercury thermometer, the thermometer rose, in a demonstration, to 310 deg. Cent. during the explosion; it should really rise higher—to about 390 deg. Cent. —as Professor Cohen has established by careful calorimetric experiments. For 1 gramme of explosive antimony liberates 19.6 gramme-calories during the explosion, and the specific heat of antimony is approximately 0.05. The heat generation is hence stupendous.

Antimony, Professor Cohen has proved, can also be deposited in its explosive modification from its tribromide or tri-iodide, but not from the trifluoride. In each case the deposit includes mechanically a little (a few tenths of a per cent. only) of the electrolyte. Some more of the electrolyte enters into a solid solution with the antimony. When the explosive antimony is cooled down to − 80 deg. Cent., it can be powdered without exploding; but the trichloride in it cannot be extracted by means of alcohol and ether. When the explosive antimony is slowly heated, however, the trichloride oozes out. This trichloride (or tribromide, &c.) accounts for the white vapours—which consist of this compound —and the exploded antimony, *i.e.*, the metal left behind after the explosion, is nothing but ordinary antimony. Originally it had been assumed that there were three modifications: ordinary antimony, explosive α antimony, and exploded β antimony. That Professor Cohen seems to have disproved by his very careful calorimetric researches and in other ways. Yet one is a little inclined to regard the phenomenon as due to impurities rather than to allotropic modifications. We can, of course, not account for the striking differences between the allotropic modifications of carbon—diamond, graphite, charcoal—by suggesting impurities, and there are other cases of undoubted allotropy. On the other hand, every chemist knows that the appearance of apparently pure crystals, their melting-points, &c., may, to an extraordinary degree, be influenced by the presence of impurities, and that repeated re-crystallisation will yield the substance in the previously observed normal condition. But the meaning of the term "allotropy" is fairly well understood, and the term will conveniently be retained.

FRENCH RAILWAY ECONOMICS.

Veiled conflicts have been going on for years past between the French Parliament and the French railway companies; that Parliament evinces a most supreme disregard of the rights of capital and capitalists, and has never for one moment given the least consideration to the services which these render to the whole community. At the present time, the situation has become more acute than ever owing to the more active interference—a most arbitrary proceeding at all times—of Parliament with the contracts signed between the companies and the State. For example, Parliament has taken upon itself to modify the conditions under which the railway employees are pensioned off by the funds belonging to the companies; it has increased the rates of the pensions; it has decided that its new measures shall be retroactive and shall apply to the older employees already in receipt of a pension; it wants, further, to compel the companies to take back those of their employees who go out on strike, and who thus deliberately and of their own free will cancel the contract which unites them to the companies. This untoward action on the part of Parliament is fraught with great danger to the whole community; it is unjust; it leads to an increase in the companies' expenditure, to a corresponding decrease in their net receipts and in the return they are able to afford the shareholders, and also—according to the terms of their agreement with the State—in the payments they have to make to the Treasury. It has led the general public to question whether the situation is not such as to cause the greatest alarm, for it should be remembered that the measures put forward by Parliament have for their only purpose the benefit of the railway employees, who form but a fraction of the labouring class of the country. Serious, however, as the situation certainly is at the present time, it will require deeper intervention still on the part of Parliament to impair the safety of railway debentures. The same cannot be said in regard to the railway shares; an evidence of the evil effects which the parliamentary measures have upon the share values is afforded by the fluctuations in the latter, fluctuations which began as soon as Parliament commenced, without any just cause whatever, to meddle with controlling the working of the railways. Parliamentary interference of a similar nature is, unfortunately, becoming very general; other countries are feeling the effects of it. One of its results is to compel the French railway companies to show, occasionally it may be with the aid of the State Budget, special generosity towards railway men.

In order to ascertain the actual situation of the French railway companies from the financial and economical standpoints, it is necessary to look into more than one of their balance-sheets. We shall consider their working during 1909, and shall compare this with that for 1910, a comparatively easy matter, since the balance-sheet for the latter year has been put before the shareholders at recent meetings. In the matter of gross receipts, the situation for 1909 was a satisfactory one. These receipts amounted, for the whole of the large companies, to a total of 1,671,000,000 francs (66,840,000*l.*); we include in this the Western Railway of France, which has been taken over by the State, and is subjected to the same parliamentary measures in regard to labour legislation. The corresponding figure for 1908 had been 1,636,000,000 francs (65,440,000*l.*), and that for 1907, 1,607,000,000 francs (64,280,000*l.*). In the total for 1909, the receipts of the Paris-Lyons-Mediterranean system entered for 524,000,000 francs (20,960,000*l.*); then came the Paris-Orleans system, with 281,000,000 francs (11,240,000*l.*); the Northern of France, with 280,000,000 francs (11,200,000*l.*); the Eastern of France, with 243,000,000 francs (9,720,000*l.*); the Southern of France, with 127,000,000 francs (5,080,000*l.*); and the Western of France, now worked by the State, with 215,000,000 francs (8,600,000*l.*). The average gross receipts per kilometre for all the railways amounted, in 1909, to 47,000 francs (3020*l.* per mile). They were 74,000 francs (4760*l.* per mile) on the Northern; 55,000 francs (3535*l.* per mile) on the Paris-Lyons-Mediterranean; 49,000 francs (3150*l.* per mile) on the Eastern; 36,000 francs (2315*l.* per mile) on the Paris-Orleans; 37,000 francs (2380*l.* per mile) on the Western; and 33,000 francs (2120*l.* per mile) on the Southern.

These figures, considered alone, are sufficiently satisfactory; it should be noted also that they are produced by tariffs which are comparatively low, both for passenger and for goods traffic. On the Northern of France Railway, for example, the complete tariff for passengers is 5.48 centimes per kilometre (0.88d. per mile) on an average; for return tickets it is only 4.27 centimes (0.68d. per mile); for excursions, only 2.9 centimes (0.46d. per mile); while the rate for season-tickets is only 1.54 centimes (0.24d. per mile); and that for clerks' and workmen's tickets only 0.95 centime (0.15d. per mile). The special concessions for clerks and workmen have been granted at the request of Parliament; they lead to a loss for the companies, as is the case on the railways in every other country. There is but a very small proportion of tickets issued at the full rate; almost half the passengers pay at the rate of 3 centimes (0.48d. per mile) only. The rate for goods is satisfactory. In this conjunction it should be borne in mind that heavy goods of comparatively low value are carried in less quantity in France than in most other countries. The average rate varies between 3.59 centimes per ton-kilometre (0.57d. per ton-mile) on the Northern of France Railway, and 4.55 centimes (0.73d. per ton-mile) on the Paris-Orléans system.

When comparing the gross receipts for 1909 with those for 1908, both of which include the Western of France Railway, taken over by the State, we find the difference in excess for 1909 to amount to 35,000,000 francs (1,400,000*l.*); by leaving out of both accounts the Western of France system, the difference in excess for 1909 would be slightly greater, a fact which shows that even for the early days of State ownership there has occurred a falling-off in the receipts. Expenditure for 1909 compared with that for 1908, and leaving out the Western of France Railway under State ownership, showed an increase of 24,000,000 francs (960,000*l.*). This was not as bad as it might have been, since in 1908 expenditure had showed an increase of 44,000,000 francs (1,760,000*l.*) over 1907, while the receipts had only increased by 29,000,000 francs (1,160,000*l.*) over those for the same year. Matters were more unfavourable still as between 1907 and 1906. The law of March, 1905, was then commencing to show its effects. This law compels the railway companies to bear the full weight of responsibility arising from damage caused to the goods carried, and from loss of goods, whatever be the special advantages in the shape of reduced tariffs granted by the companies to the senders. At that same time, and in reply to claims put forward by their employees, the companies were also making increased grants to their pension funds, which they had started of their own free will, for the benefit of the whole of their staff. In 1905, the Northern of France Company added 6,000,000 francs (240,000*l.*) to the 55,000,000 francs (2,200,000*l.*) they had already paid to their pension fund; the Paris-Lyons-Mediterranean Company paid in 8,000,000 francs (320,000*l.*), in addition to a former sum of 48,000,000 francs (1,920,000*l.*). The effects of the law of March, 1905—called the Rabier law, from the Member of Parliament who put it forward —were heavily felt in the course of the year 1910, owing to a very great increase in goods traffic. The law which provides a day of rest per week also resulted in a large increase in expenditure.

When viewing the situation of the French railways, the fact should be borne in mind that they have to face financial expenses which are constantly on the increase; they have to issue loans for the cost of the work they have to undertake on their permanent way, and for increase of their rolling-stock, and matters are rendered for them more complicated still year by year, owing to the gradual decrease in the time at their disposal for redeeming their new issues, which time is limited by the terms of their contracts with the State. This means that they have to borrow at increasing rates of interest. The increase in receipts for 1909 was to a large extent absorbed by the higher financial charges, as was the case also in former years; this increase has not benefited the shareholders.

If now we turn to the balance-sheets for 1910, we find that in the case of the Northern of France system the gross receipts have increased by 13,500,000 francs (540,000*l.*) over the corresponding figure for 1909—a fact which gives evidence of favourable conditions and good management. Expenditure on the same system has increased by 9,350,000 francs (374,000*l.*) over the figure for 1909, which amounted to 161,800,000 francs (6,472,000*l.*); expenditure, therefore, has increased in a greater proportion than receipts, and the percentage has risen from 57.75 to 58.29 per cent. The greatest portion of the increase is in expenditure for the staff. At the close of 1910 the Northern Railway Company had a reserve of over 113,000,000 francs (4,520,000*l.*) in the pension fund; this sum became insufficient from the commencement of 1911, owing to the new law dealing with the increase in pensions, and the company will be obliged to set apart 1,500,000 francs (60,000*l.*) of the profits of the present year, and to continue on the same lines for meeting the increase in the charges for pensions. In 1910 the general working expenses had to be increased by 1,700,000 francs (68,000*l.*), as compared with 1909, owing to an increase in the salaries and wages; the increase in the rolling-stock department for the same purpose amounted to over 1,750,000 francs (70,000*l.*).

For 1910 the gross receipts of the Paris-Lyons-Mediterranean Railway Company amounted to 536,000,000 francs (21,440,000*l.*), as against 524,000,000 francs (20,960,000*l.*) for 1909; but the expenditure increased from 279,000,000 francs (11,160,000*l.*) to 289,000,000 francs (11,560,000*l.*), showing for the latter a much greater percentage difference than for the gross receipts. In the case of this company also the increase in expenditure is mainly to the profit of the staff; in the course of 1910 it spent large sums for improving the condition of its employees in a great number of ways, and 8,000,000 francs (320,000*l.*) were added to the pension fund.

The year 1910 was one of difficulty for the Eastern of France Railway Company, and, notwithstanding this, it will have to pay back to the State 18,000,000 francs (720,000*l.*) on account of the loans made to it by the latter in the shape of guarantee of interest. Gross receipts in 1910 amounted to 256,500,000 francs (10,260,000*l.*), or 13,500,000 francs (540,000*l.*) more than for the

preceding year. Fortunately, in the case of this company there occurred a lower proportional increase of expenditure in 1910 than has been noted for the two former companies, but, in this increase, such as it stands, expenditure for the staff takes by far the larger amount. It is too early to speak of the working during the present year; the Eastern Company, however, estimates that its wages bill this year will be 4,000,000 francs (160,000*l.*) higher than that of 1910, without counting the increase for rise in pensions.

The gross receipts of the Paris-Orléans system in 1910 amounted to less than 282,000,000 francs (11,280,000*l.*), showing an increase over 1909 of 700,000 francs (28,000*l.*). The expenditure for 1910 exceeded that for 1909 by 5,800,000 francs (232,000*l.*). The net receipts, therefore, decreased by over 5,000,000 francs (200,000*l.*), and the working expenses exceeded 55.5 per cent., as against 53.60 in 1909. The unfavourable conditions for 1910 are due, in part, to the inundations at the commencement of the year, and also, in part, to the programme which the company has instituted for improving the status of its staff. In 1910 it added large sums to its wages bill.

The gross receipts of the Southern of France Railway in 1910 amounted to 128,500,000 francs (5,140,000*l.*), equal to 1,500,000 francs (60,000*l.*) in excess of the total for 1909, whilst the expenditure for 1910 was over 2,000,000 francs (80,000*l.*) in excess of the total for 1909. The bad harvests in 1910 were specially felt by this company, but apart from this fact, the increase in wages and pensions due to Parliamentary intervention are also largely responsible for the increase in expenditure.

This increase in expenditure which the companies are made to bear naturally leads to a decrease in their net receipts, and reacts upon the return which the shareholders expect from the companies. In a former article (see ENGINEERING, vol. lxxxv., page 756) we explained the working of the guarantee of interest between the State and the railway companies. The constant intervention on the part of Parliament in the inner working conditions of the railway companies, made in favour of the railway staffs, reacts upon the whole French budget, and thereby upon every French citizen, by reason of this same guarantee of interest. Up to comparatively recently it was possible to calculate pretty closely the date on which the railway companies would be able to reimburse the totality of the sums which had been advanced to them in the shape of the said guarantee. This is now most difficult, and as an instance we may state that the Paris-Orléans Company, which had paid back into the Treasury as much as 40,000,000 francs (1,600,000*l.*), has been compelled lately to borrow back 6,000,000 francs (240,000*l.*) as advance money, a sum to which every French tax-payer has to contribute. Had it not been for this same Parliamentary meddlesomeness in matters which concern the railway companies alone, and which they were in every way capable of conducting satisfactorily to all parties concerned, the French Treasury, and every French tax-payer, would have already commenced to reap the advantages of a division of profits in the case of several of the French railway systems.

NOTES.

Enlargement of the Bradford Technical College.

BRADFORD, it is claimed, was one of the first towns in the United Kingdom to provide technical education for the working classes; but we gather from the proceedings which took place at the opening of the new Textile Building at the Technical College on the 25th ult., that the education authorities there would now find themselves in agreement with the Llama's aphorism on the value of education as set forth in Kipling's "Kim": "Education is greatest blessing if of best sorts. Otherwise no earthly use." The technical education needed by workmen is best secured in the factory. At the Leicester meeting of the British Association the extraordinary manual dexterity of young people of both sexes was noted by several speakers in the Engineering Section, and the future workman had far better be making the most of this period of unstiffened fingers and muscles at learning his trade than in getting a misleading smattering of theoretical principles. The elementary technical school has, of course, its uses, but the most important of these is that it affords a means of selecting those to whom it is worth while giving the Llama's "education of best sorts." This fact is now becoming more generally recognised. The new buildings at Bradford are, we gather, intended for advanced work, and only in so far as they are confined to this are they likely to prove of much benefit to the textile industries. The usefulness of such an institution should be reckoned not by the number of pupils, but by the value of the work done. One of the difficulties met with, however, is that employers who take technical-school graduates are generally indisposed to make their service attractive enough to secure and retain the ablest, who can commonly get a better immediate return in other than technical work. The buildings for the new department have, we learn, been erected at a cost of 20,000*l.*, and are equipped with plant for studying every department of the textile industries for which Bradford is specially noted. The policy of the Education Committee is now one of concentration of a few branches of study, and this, we think, is eminently wise.

Employers' Liability for Excessive Sickness.

Next week the House of Commons will reach the consideration of Clause 46 of the Insurance Bill, and as this clause, like some others, may involve serious consequences for employers, it is important that definite action should be taken in order to have amendments made which, while fair to the workers, will not involve injustice to the employers. The clause in question empowers approved societies and local health committees to demand inquiry into cases of "excessive sickness," which is defined to mean 10 per cent. above the average "expectation of sickness." In the event of it being found that such excess is due to any industry, the extra expenditure involved must be met by the employers In other words, should an "approved society" find that, in any particular district, their funds are being depleted at an exceptional rate, such an inquiry would at once be demanded. There is room here for serious injustice. In the first place the inquiry, which is to be conducted by one official, opens up possibilities of great difference of opinion as to what constitutes unhealthy conditions of employment, due either to collateral causes or to the nature of the work carried on. At present, under the Factory and Workshop Acts and the Public Health Acts, employers are required to maintain their workshops and factories in a satisfactory condition, in order to comply with the requirements of those Acts, and it would seem that such a provision, if satisfactorily enforced, should meet the case without any need for special inquiry or further penalty. If the conditions are not met, then the factory inspectors are not performing their duties efficiently. Presuming even that such inquiry is justified under the insurance scheme, it would seem that a more representative board of inquiry should be instituted, particularly as the clause also makes the owners of property responsible for "excessive sickness" which may be attributed to the unsanitary condition of property. The inquiry in all cases of excessive sickness, provided it is justified, ought, therefore, to be more comprehensive, as it should be determined whether the excess is due directly to "the conditions or nature of employment," or to the sanitary state of the habitations of the workers. The board of inquiry ought to include a certifying surgeon under the Factory Act and a factory inspector, with a barrister of standing as president. Again, as the Bill now stands the decision of the one official is to be final. Even were a board of inquiry instituted, appeal ought to be permitted, first to the county court and subsequently to the High Court, since the consequence to employers of an adverse decision might be serious from the commercial point of view.

The New Allan Canadian Liners.

One of the most important shipbuilding orders placed recently is that for the construction of two high-speed Allan liners for the Liverpool-Canadian service, one of which will be built and engined by Messrs. William Beardmore and Co., Limited, Dalmuir, and the other by the Fairfield Shipbuilding and Engineering Company, Limited, Glasgow. The ships, which are expected to steam 20 knots, will be the fastest in the Canadian service, but apart from this, Mr. Hugh A. Allan, the chairman of the line, and the management generally, aim rather at providing special comforts which involve weight and space, than the achievement of very high speeds. As the two new ships will take 200 first-class, 500 second-class, and 1000 third-class passengers, all in state-rooms, and will carry 3000 tons dead-weight of cargo, it will be recognised that a sound compromise has been made from the dividend-earning point of view. In the arrangement of cabins several interesting features are to be introduced. For instance, bath-rooms will be arranged with direct access from practically every first-class state-room. In some cases a bath-room will be located between two state-rooms, with doors from each; in others the bath-room will be exclusively for the use of those in an adjacent state-room. There will be, of course, suites of rooms, and a large number of single-berth cabins. The rooms, too, are to be of larger cubical capacity than is the general practice; the first-class accommodation will be heated by steam, by the thermo-tank system and by electricity, the second-class passengers' quarters by steam and the thermo-tank system, and the third-class rooms, &c., by the thermo-tank system. There will be the usual public rooms, which include verandah cafés, gymnasium, &c., and, in addition, a separate card-room, where "silence" is often more desired than even in the reading and writing-rooms. The length of each ship is to be 570 ft., the beam 72 ft., and the depth moulded 45 ft. 6 in., and the gross tonnage expected will be about 18,000 tons, while the displacement in service will be about 25,000 tons. These dimensions are the largest yet adopted for a vessel for the St. Lawrence trade. One interesting feature is that the stern will be designed on the lines of a cruiser, which not only gives a smart appearance, but lengthens the waterline, and enables the steering gear to be placed under the water-line. This will make the ships specially adaptable as unarmoured cruisers, particularly as they are well subdivided by bulkheads, the doors of which are operated by the Stone-Lloyd hydraulic system, and as the coal-bunkers are being arranged to add to protection. Another feature is that the Frahm anti-rolling tank system will be adopted. There are to be four screw-shafts arranged in three engine-rooms, and the shafts are to be driven by turbines of the Parsons type, consisting of one high-pressure ahead, one intermediate-pressure ahead, and two low-pressure ahead turbines, and two astern turbines. The two astern turbines are to be incorporated with the low-pressure ahead turbines, and will be on the inner lines of shafting. The power is to be divided as nearly as possible over the four shafts, and each shaft will be fitted to work independently of the others by a suitable arrangement of pipes and valves. The total power is to be 19,000 shaft horse-power. The boilers are to be worked under Howden's forced-draught system, and to be arranged so that oil fuel may be used, if it is found economically possible to do so. There will be six double-ended and four single-ended boilers, the former being 16 ft. 9 in. in diameter by 22 ft. long. For the carriage of provisions refrigerating machinery and cold stores with a capacity of 70,000 cub. ft. are arranged for. It will thus be recognised that the two ships, which are to be classed under the British Corporation for the Survey and Registry of Shipping, promise to be thoroughly adapted for the Canadian service, alike in speed, comfort, and cargo capacity.

COLLIERY EXHIBITION.—At a meeting of the sub-committee of the Northern Mining Industries Exhibitors' Committee, held at the Midland Hotel, on Tuesday, October 17, it was decided to recommend the committee to hold the next Colliery Exhibition in the North in 1914. Among those present were:—Messrs. A. E. L. Chorlton (Messrs. Mather and Platt, Limited); A. E. Mathewson (Tilghman's Sand-Blast Company, Limited); F. Steel (Messrs. A. Steel and Sons); G. E. Rowland (Rossendale Belting Company, Limited); and Mr. Callender (representing Mr. Maurice Gibb, of the Central Marine Engine Works), &c.

BRENTWOOD SEWAGE DISPOSAL WORKS.—A meeting of the members of the Institution of Municipal Engineers was held at Brentwood, on Saturday, October 28, for the purpose of inspecting the sewage disposal works there, which are now nearing completion. The scheme comprises the construction of the main outfall sewer and a complete installation of bacteria beds, on the most modern lines, for dealing with the sewage of the joint drainage area, having a population of 12,000, including detritus and screening chambers, sedimentation tanks, colloidal tanks, high and low-level filters, humus-tanks, sludge lagoons, together with irrigation area for dealing with the supernatant water and drainage from the sludge lagoons.

INDUSTRIAL NOTES.

A REVISED edition of the National Programme for railway workers has been issued; but the demands made show such a lack of appreciation of the economic conditions obtaining in the railway service that the programme does not merit serious consideration. Many of the demands made are most extravagant, indefensible, and impracticable. One or two instances may suffice as proof of this. Lads, on joining the service, irrespective of the kind of employment they are engaged in, are to be paid, between the ages of fourteen and sixteen, 15s. per week (with 2s. extra if in London), and at higher rates according to age, with two weeks' annual holidays, during which they are to be paid, and for which they are to have two free passes. Again, in all sections "length of service is to have primary consideration in all cases of promotion." Length of service should only be regarded in so far as it confers greater experience, superior knowledge, and increased reliability. Again, it is stated that "where it can be shown that the cost of living at country stations is 5s. per week less than the standard rates of pay, it shall be competent for the company and the men's representatives to tabulate such stations, and, if mutually agreed to, the standard rates of pay may be reduced by not more than 5s. per week." What is the "cost of living"? Who is to set the standard? Workmen know that the cost is in most cases dependent on housewifely management, and thus the idea is to penalise the thrifty household. Finally, future alterations in rates of pay are to be "governed automatically by the rise in the cost of living." There is no need for comment.

Several of the leading railway companies have given most practical evidence of their desire to deal fairly by their employees. The Great Western Railway Company announced at the end of last week that they were arranging for revision of the scale of wages in order to give increases in wages, particularly to workers in the lower grades. This will represent in the first year an addition to the total wages bill of 53,000*l.*, rising to 83,000*l.* in four years, excluding the advances to the locomotive department. Including the latter, the ultimate addition to expenditure, due to present concessions alone, will be 100,000*l.* per annum. Like action has been taken also by nearly all the other important lines. In the case of the London and North-Western Company the concessions now made total 80,000*l.* per annum. The Midland and other lines have been equally liberal, and the total result for all railways must be very considerable.

Whether this proof of the conciliatory attitude on the part of practically all companies will appease the restlessness of the men remains to be seen. There are strong indications, however, that all matters hold a minor place with the unionist leaders to that of "recognition," for which they have a great longing. But it is almost impossible to believe that the men will be so misguided as to commence the war again, for in the face of the unanimous and generally fair finding of the Royal Commission any such action must have but one ending—disaster to the men. Workers may rest assured that there will be no further Government interference to help them out of their difficulties, and public opinion will be even more against them than it was during the late trouble. Meanwhile the executive councils of the unions concerned with railway workers are considering in conference the situation, with particular reference to the report of the Commission, but at the time of writing the decision has not been announced.

A discouraging feature of the situation is that the men are now stating that they were not a party to the Royal Commission, a position which it seems rather late to take up now. Mr. J. H. Thomas, M.P., speaking at Crewe on Sunday last, said that there had been no breaking of their word by the men's representatives, for they were never asked whether they would accept the findings of the Commission, and they never said they would. The only people who did say so were the companies, and they said it in writing. By no stretch of imagination could it be said that the men's representatives gave a pledge to accept the findings of the Commission. They could not, and would not, accept the Commission's recommendation that, before any programme could be considered, 25 per cent. of the men must sign a petition.

The general impression by the public at the time the Commission was called was, however, that the leaders and the men hailed it with joy; at any rate, so far as we know, no statements to the contrary were made. No doubt the men then felt sure of getting a decision much in their favour, and therefore the matter of signing was omitted. But it was undoubtedly a mistake, for both sides ought to have agreed in writing to submit to the finding of the Commission. Had things turned out more to the satisfaction of the men it is probable that we should have heard nothing about the men's representatives not having stated in writing their intention of abiding by any decision that might be arrived at. There is, however, hope that better counsels will prevail. Mr. A. Henderson, M.P., speaking last week at Haworth in support of the Labour candidate for the Keighley Division, said that he had met a body of railway workers in Keighley, and discussed with them the report of the Commission, and he thought he had convinced them all that, by means of the machinery provided by the Commission, if that machinery were properly used, and if the recognition recommended were granted, they would secure before long a vast improvement in the condition of the railway workers of the land.

According to the monthly report of the National Union of Boot and Shoe Operatives for October we find that employment continued moderate, but was slightly better than a year ago. Returns from firms employing 65,252 workpeople in the week ending September 23 showed an increase of 0.2 per cent. in the number employed, and of 0.8 per cent. in the amount of wages paid, compared with a month ago. Compared with a year ago, there was an increase of 0.9 per cent. in the number employed, and of 2.7 per cent. in the amount of wages paid. At Leicester employment was moderate, and slightly worse than a month ago; it was better than a year ago, but much short time was reported. At Northampton employment showed little change compared with a month ago, but was better than a year ago. At Kettering trade continued fair, but with army bootmakers in Northamptonshire it was still slack. At Norwich it was good in some branches, but bad in others, while at Bristol and Kingswood it showed an improvement. At Leeds trade was moderate, but better than a month ago and a year ago. In Scotland it continued fair, and was better than a year ago.

The oil-millers at Hull struck work last week, and on Friday about twenty mills in the Stoneferry and Sculcoates districts were idle. The transport workers have mixed themselves up with the agitation, for at a mass meeting held on Sunday they unanimously agreed to a motion pledging themselves to refuse to handle goods going to or from the mills affected.

The annual Congress of the National Free-Labour Association commenced its sittings on Monday last at the Memorial Hall, Farringdon-street, E.C. A resolution was unanimously adopted urging the establishment of boards of conciliation and arbitration throughout the country upon which free labour should be fully represented. The Congress condemned the growing tendency of employers to enter into "closed shop" agreements with trade unions, and called upon employers to stand up for the right to engage a man according to his ability and irrespective of his membership of any trade union or other society. The repeal of the mischievous Trade Disputes Act was also strongly advocated.

Trouble has arisen at Messrs. Mark Brown's wharf, Tooley-street, owing to a dispute with the shipowners as to rates of pay for unloading, and some fifty or sixty stevedores are on strike. As usual, the Board of Trade was at once turned to by the representatives of the men, and the position was laid before Sir George Askwith. The demand made by the men is for 8d. per hour for day-work and 1s. an hour for overtime, as against 7d. and 9d. now paid. As the owners refuse to pay the increased amount, there is at present a deadlock.

It must cause a feeling of satisfaction to all true lovers of freedom to know that an association of London manufacturers and employers of labour for the purpose of taking such action as may be necessary for the protection of free labour and the prevention of unfair picketing is to be formed, though not until a meeting has been held to consider the details of the scheme, probably about the end of November. It is not at present known what the liability of the members will be, but the promoters intend to confine themselves to purely defensive action in the matter of labour troubles, and for the protection of non-union labour, so that large contributions from individual firms will probably not be necessary. It is not proposed that there should be any interference with the right of any members of the Federation personally to settle disputes with their workmen. In case questions of general interest should, however, arise, reference would be made to the Council. It is suggested that the Federation should form sectional committees, which would consider the questions submitted to them with full knowledge of the circumstances and conditions of the particular case, in order that the varied interests affected might be adequately dealt with. It is not intended in any way to supersede the many associations of employers which already exist in particular industries, but to co-operate with them in questions common to all. Employers in other places are carefully watching this London movement, and if the scheme proves successful it will probably be followed by similar movements in other cities.

The strike at the Douglas Bank Collieries, in the Wigan coalfield, has now been settled, after lasting twenty-three weeks. The dispute arose over "abnormal places," and affected 1200 men. By this settlement miners in abnormal places are guaranteed 7s. 6d. a day for a fortnight after work is begun until the new system of dealing with abnormal places becomes operative. A local committee, consisting of two representatives of the men and two of the masters, is to inspect abnormal places, and if the management and the men cannot agree as to payment, the committee will consider the question. If no agreement is arrived at by the committee, an outside arbitrator is to decide the point.

On Thursday last week a strike of two hours' duration occurred among the shunters on the Great Western at Llanelly. As a result of a conference between the men's representatives and the divisional superintendent, the men were granted eight-hour shifts and certain increases of wages varying according to circumstances.

An alleged act of injustice in the matter of "extras" has been the cause of another strike, some hundreds of taxi-cab drivers of the National Motor-Car Company having stopped work yesterday on account of it. The cause of the trouble appears to be that a driver who had been watched by an inspector ought, it was said, to have paid 4d. as an extra; but did not pay this in on Tuesday morning, and it was (less 25 per cent., his due) deducted from him. The driver denied having had the "extra" given to him and refused to pay it, and was therefore told that he would not be allowed to take out a cab until he did. The men therefore went out in sympathy. The men's executive held a meeting yesterday to discuss the situation, but at the time of going to press the result was not announced. Yesterday there were said to be 6000 men out.

The statistics of German labour conflicts during the first half of the present year were as under, the figures for the corresponding half-year of 1910 being given for comparison's sake:—

		1911.	1910.
Number of strikes		1,259	865
,, lock-outs		90	789
		1,349	1,654
Number of concerns affected:			
By strikes		4,579	3,106
,, lock-outs		923	7,703
		5,502	10,809
Of these there were brought to a complete cessation of work:			
By strikes		1,462	765
,, lock-outs		366	2,490
		1,828	3,255
Number of hands affected:			
By strikes	striking 88,433; compulsory idle 10,562	98,995	55,871
By lock-outs	locked-out 31,477; compulsory idle 7,786	39,263	150,101
		138,258	205,972
Victory for the hands by strikes:			
Complete	in cases	228	176
Partly	in cases	609	327
None	in cases	422	362
Victory for the employers by lock-outs:			
Complete	in cases	33	64
Partly	in cases	54	695
None	in cases	3	30

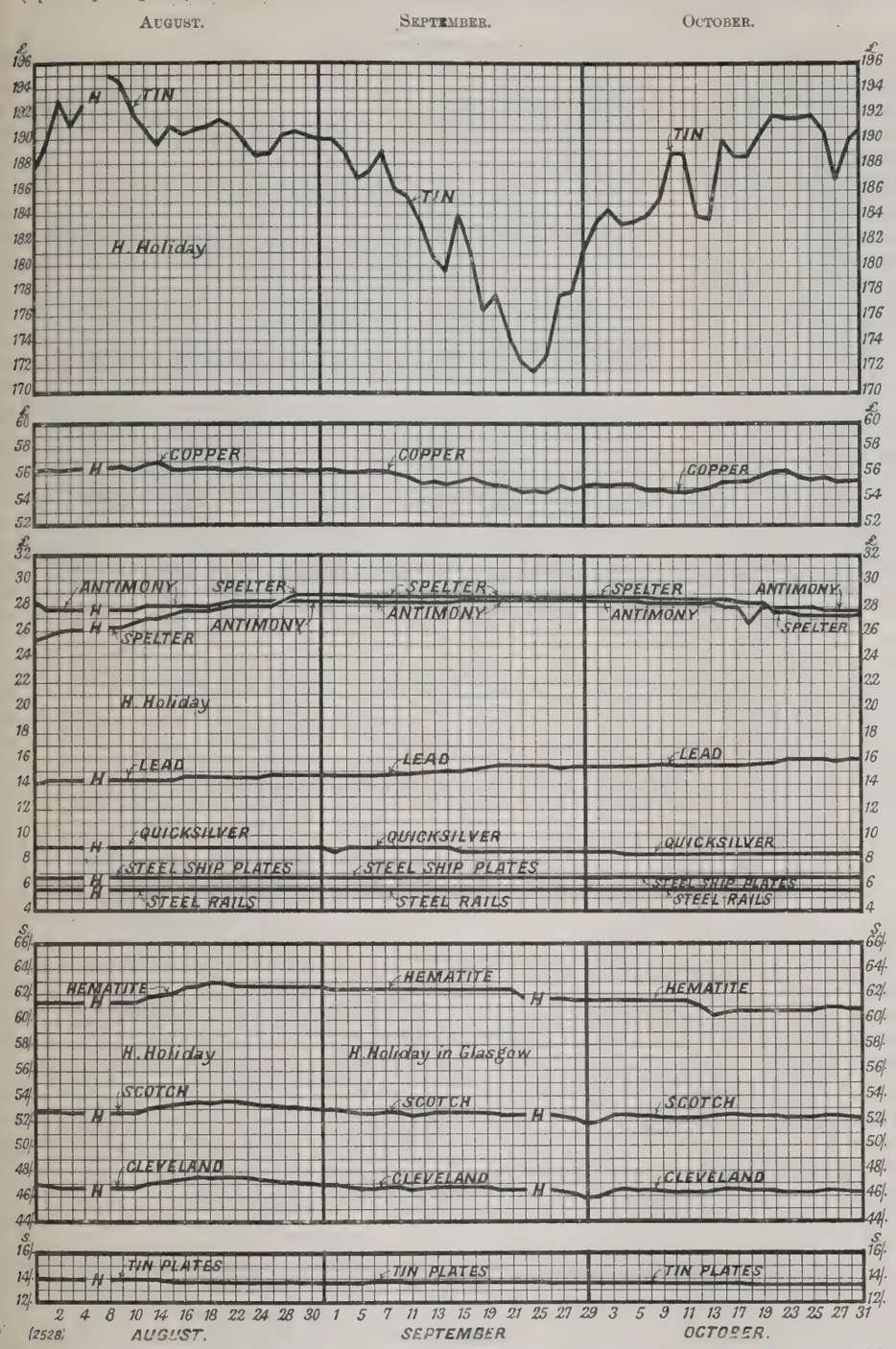
The general strike in Sweden in the year 1909 seems to have had some very serious and, it would appear, lasting effects upon the Swedish labour organisations. In the year of the great strike the number of members of the all-Sweden labour organisation went down from 169,776 to 108,079, and in the course of the same year the members of the Social-Democratic Party were reduced to 60,813 from 112,693—a decrease of 46 per cent. This retrogressive movement was continued during 1910, the party experiencing a further reduction to 55,248 members. The all-Sweden labourers' organisation fared still worse, the number of members sinking to 85,176—a reduction of 21 per cent. That the Social-Democratic Party shows a somewhat smaller decline is no doubt attributable to new bodies having joined. The all-Sweden organisation of trade unions has during the last three years lost considerably more than half their members, the figures being:—

	Members.
January 1, 1908	186,236
January 1, 1909	169,776
January 1, 1910	108,079
January 1, 1911	85,176

Insurance against unemployment is at present attracting considerable attention in Germany, and at a recent representative congress of delegates, held at Düsseldorf, more especially for the smaller industries, very pronounced opinions were expressed. The leading principle set forth, amongst others, by an Augsburg organisation was to the effect that all insurance against unemployment must be based upon self-help; any other principle must be denounced as reprehensible, and the application of common funds to such purposes must be termed an injustice. Even a parliamentary regulation of the question was objected to, as was

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



(2528)

In the accompanying diagrams each vertical line represents a market day, and each horizontal line represents 1s. in the case of tin-plates, hematite, Scotch and Cleveland iron, and 1*l.* in all other cases. The price of quicksilver is per bottle, the contents of which vary in weight from 70 lb. to 80 lb. The metal prices are per ton. Heavy steel rails are to Middlesbrough quotations. Tin-plates are per box of I.C. cokes.

the plan of laying the burden of such insurance on the community, which, through recent social politics, had already been called upon to serve as a maid-of-all-work or an all-round nurse. The representative of a Cologne institution urged that insurance against unemployment was only acceptable when it rested on the basis of self-help, and on the expenditure being in no way levied upon the employers, &c.

Petrol-Engines.—A special course of five lectures on "Petrol-Engines" will be given at the City and Guilds Technical College, Finsbury, Leonard-street, City-road, E.C., by Professor W. Watson, D.Sc., F.R.S., on Tuesday evenings, at 8 p.m., commencing on November 7. The fee for the course will be 5s.

The Junior Institution of Engineers.—At the reception of the Junior Institution of Engineers by the President, Sir J. J. Thomson, F.R.S., and Lady Thomson, taking place on Saturday evening, November 4, at Caxton Hall, Westminster, a feature of the evening will be an illustrated lecture entitled "Some Physical Experiments," to be given at 7.30 p.m. by Sir J. J. Thomson.

Association of Teachers in Technical Institutions.—The annual meeting of the Association of Teachers in Technical Institutions will be held at the Borough Polytechnic, Borough-road, S.E., on Saturday, November 4; the President, Mr. Barker North, will occupy the chair. The annual report of the Council, which will be considered at this meeting, deals with the large increase in the membership of the Association in the past year. Branches have been formed in Ireland and Wales, so that the activities of the Association are now spread over the whole kingdom. After the consideration of the report a discussion will be initiated, at 4 p.m., on the Board of Education Examinations in Science, by Mr. C. F. Smith, Manchester School of Technology, and Mr. J. Wilson, Battersea Polytechnic. To this discussion visitors are invited. Particulars can be obtained from the hon. secretary, Mr. P. Abbott, the Polytechnic, Regent-street, W.

JOHNSON'S DIRECT-READING TORSION-METER.

The instrument which we illustrate on page 606 is the invention of Mr. Charles H. Johnson, assistant works manager to Messrs. Kelvin and James White, Limited, of Glasgow, who are noted throughout the world as nautical instrument makers and electrical engineers, and are the sole makers of this apparatus. This system has proved most successful in the ships in which it has been fitted, having been manufactured during the past eighteen months by the firm, so that the details we are enabled to publish will be studied with interest, particularly as, with the increasing use of the marine turbine, a means of accurately determining the power developed is desiderated. Mr. Johnson, it may be noted also, has a wide and varied experience of torsion-meter design and application, and his first instrument, designed while he was associated with Messrs. William Denny and Brothers, the well-known firm of shipbuilders in Dumbarton, and described in these pages in April 7, 1905 (vol. lxxix., page 441), is known and used all over the world. Figs. 1 and 2 are perspective views of the new direct-reading torsion-meter, while the important details of the mechanism are shown in Figs. 3 to 6.

On the shaft, the torsion of which it is desired to measure, is fixed a split-metal sleeve (Fig. 3), provided at one end with two projecting arms. The other end of the sleeve is fixed to the shaft by means of pinching-screws, and arranged so that its free end—*i. e.*, the end with the arms—can rotate about a collar on a metal resting-piece, which is also provided with projecting arms similar to those on the sleeve, and fixed to the shaft by means of pinching-screws. It is evident that when the shaft twists, due to its transmitting power, the arms on the sleeve and resting-piece respectively will move circumferentially relatively to one another, and that the movement will be a measure of the torsion of the length of shafting situated between the pinching-screws. It is necessary to measure accurately this movement of the arms, and the following means are employed to do this.

On one arm of the resting-piece is fixed a short strip of very high resistance material—an alloy of platinum iridium of extreme hardness and quite non-corrosive—the ends of which are connected to two slip-rings (shown in Figs. 1, 3 to 6), so that a current of electricity may be passed along the resistance strip (which in future we will term the shunt), the current being led to and from the slip-rings by means of brushes and cables (Fig. 4). A small 4-volt storage battery supplies the necessary current, and included, in circuit with the battery and each shunt, is a regulator (Fig. 4), by means of which the current flowing through the shunt may be adjusted at will. On the corresponding arm of the sleeve is fixed a bracket carrying a spring contact-piece, which bears on the shunt, and makes contact with it. The contact-maker is also connected to a slip-ring, and thence to a brush, and by means of a suitable conductor to a torque-meter, which is practically a voltmeter, measuring the potential along the shunt when current is passed along it. It will be seen that as the contact-maker moves along the shunt in one direction or the other, depending on whether the vessel is going ahead or astern, the contact-maker, and hence the torque-meter, will be subjected to a higher or lower potential, and the instrument will read directly in proportion to this rise or fall, and therefore to the distance travelled by the contact-maker—*i. e.*, to the relative displacement of the arms of the sleeve and resting-piece. This is a measure of the torsion of the shaft.

The torque-meter is calibrated in units of shunt-length instead of potential, and the full scale-length represents the total length of the shunt. The position of the contact-maker when the shaft is transmitting no power is exactly at the middle of the shunt, and the pointer of the torque-meter consequently also at the centre of its scale. This centre point is made the 0 of the torque-meter, and the pointer rises or falls from this point, depending, as previously explained, on the direction of travel of the contact-maker on the shunt. The torque-meter scales are divided into tenths, one-hundredths, and one-thousandths of an inch, and, as the smallest divisions can easily be subdivided by the eye into two or more parts, the error of observation may be said to be nil. As it is somewhat difficult to set the contact-maker exactly to the middle point of the shunt, and consequently the pointer of the torque-meter also exactly to 0, the scales of the torque-meters are made movable, so that the 0 point of the scale can be adjusted to correspond exactly with the position of the pointer. This arrangement makes the setting of the zero a very simple operation.

A very important feature is the two-way switch for the torque-meter (Fig. 4) and its connections. Before taking a reading of torsion, this switch is put in the "test" position; this connects the torque-meter directly across the ends of the shunt. The regulator is then adjusted until the pointer of the meter comes to the extreme end of its scale. It is then definitely known that the necessary strength of current is flow-

JOHNSON'S DIRECT-READING TORSION-METER.

CONSTRUCTED BY MESSRS. KELVIN AND JAMES WHITE, LIMITED, ENGINEERS, GLASGOW.

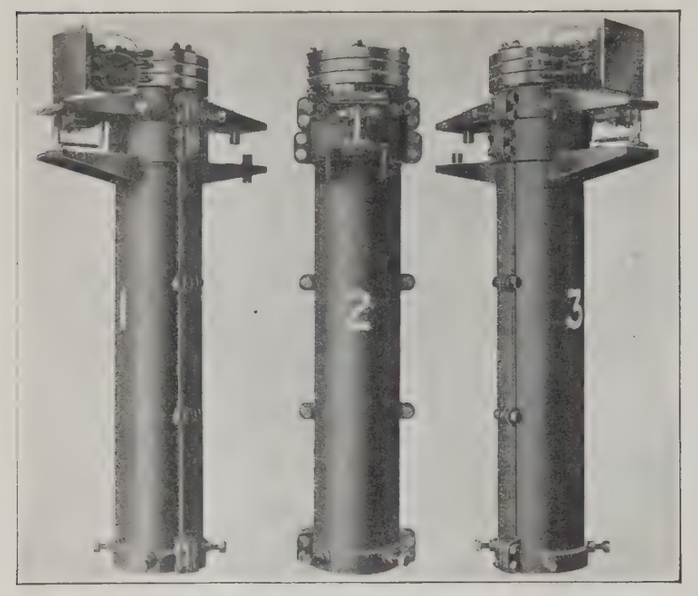


FIG. 1.

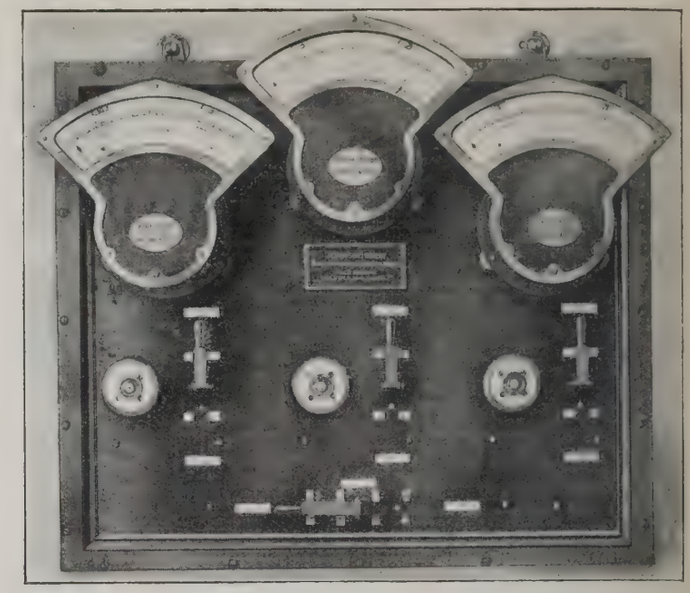


FIG. 2.

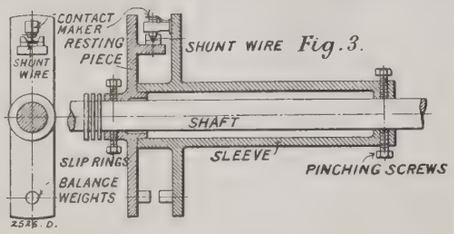


Fig. 3.

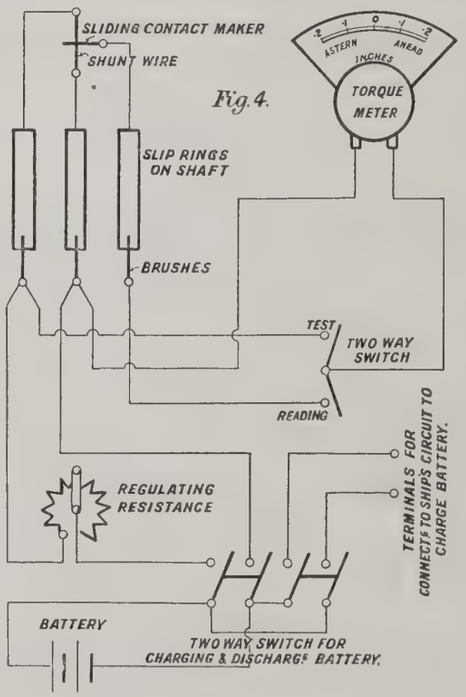


Fig. 4.

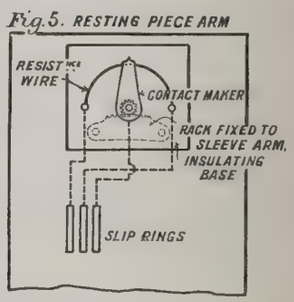


Fig. 5. RESTING PIECE ARM

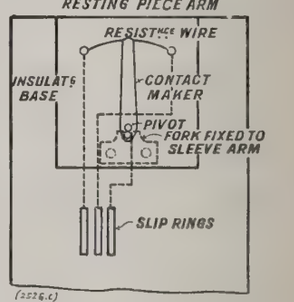


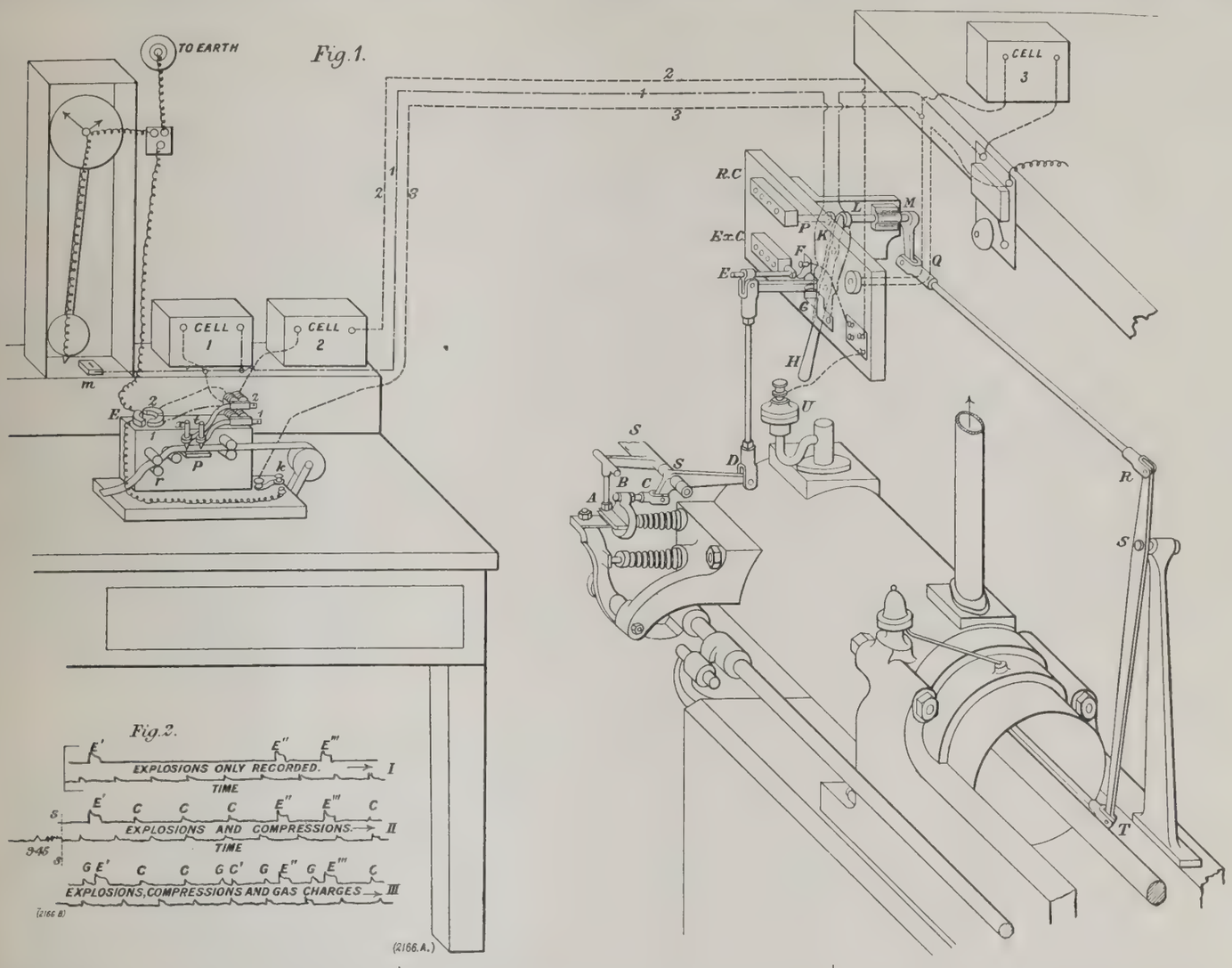
Fig. 6.
RESTING PIECE ARM

ing in the shunt to give a difference of potential between its ends corresponding to the full scale length of the torque-meter. The two-way switch is then placed in the "reading" position connecting the torque-meter between the contact-maker and one end of the shunt, and the torsion read off. If desired (by means of a special arrangement of the switch), the torque-meter can also be connected between the contact-maker and the other end of the shunt. The two readings thus obtained should be exactly equal, and this provides a simple and very definite check on the accuracy of the readings obtained. This special arrangement is not shown in the diagram of connections, as it is only fitted where specially desired. It will be seen that the two-way switch enables the torque-meter to be instantly checked with its shunt, and it is not necessary to ascertain what the voltage of the battery may be, nor what the strength of the current flowing in the shunt is. It may be mentioned here that the contact-maker could, of course, be "earthed" to the sleeve—*i.e.*, connected directly to it—and the circuit completed through the shaft and bearings and hull of the ship, and the third slip-ring dispensed with. This, however, is not good practice, as with the two-way switch in the "test" position, two slip-rings would be included in the circuit, and when the switch was in the "reading" position only one ring would be in the circuit. With a third slip-ring, however, there are always two slip-rings in circuit in either the "test" or "reading" position, and any slight resistance there may be at the slip-rings is constant, and affects both circuits equally. The two-way battery switch (Fig. 4) is for enabling the battery to be charged when desired direct from the ship's electric circuit. When in the "charge" position it is connected to the ship's circuit, and when in the "discharge" position it is connected to the torsion-meter.

Various forms of shunts and contact-makers were tried. The first form, which is shown in Fig. 5, consisted of a semi-circular resistance wire mounted on an insulating base, and a contact-maker bearing upon it and carried by the base, the whole arrangement being carried by the resting-piece arm. A pinion fixed to the spindle of the contact-maker engages with a rack fixed to the sleeve-arm. The relative displacement of the arms was multiplied considerably by the gearing thus introduced, and a large travel of the contact-maker on the shunt obtained. It was considered, however, that the advantage of the larger movement of the contact-arm, and consequently the greater potential difference obtained for small movements of the arms, was negatived by the backlash and uncertainty of the rack and pinion gearing, and the present arrangement, giving a direct motion without the use of multiplying gear or any secondary motion, was adopted as the standard method in all cases where a length of 4 ft. or 5 ft. was obtainable for measurement. In extreme cases, however, where only about 2 ft. is available for measurement, a multiplying attachment becomes desirable, and the method ultimately adopted for such cases is shown in Fig. 6. An insulating base carrying a semi-circular resistance wire is fixed to the arm of the resting-piece, and a contact-maker, pivoted as shown, bears upon it. The end of the contact-maker arm is made, as shown, in the form of a steel roller which engages with a steel fork attached to the sleeve-arm. The movements of the sleeve and resting-piece arms are, of course, multiplied considerably by this arrangement, and a large travel of the contact-maker obtained. This method gives all the advantages of the previous arrangement, with the minimum of backlash.

Fig. 1 is from a photograph of a three-shaft torsion-meter, and shows the three sleeves and resting-pieces, with their slip-rings, brushes, shunts, and contact-makers. Fig. 2 is from a photograph of the same set, and shows the "indicating-board," on which are grouped the torque-meters, regulators, switches, &c. This board may, of course, be placed in any desired part of the vessel, and the readings of all three shafts be taken practically instantaneously by one observer. This is an important feature, as it is, of course, very desirable to obtain the readings of all the shafts in the vessel at the same moment, and also to limit the personal error to one man. The average length of sleeve is about 5 ft. between the pinching-screws, and the radius of the arms is so proportioned as to give a movement of about $\frac{1}{10}$ in. at full power. This gives a deflection of 3 in. "ahead" and 3 in. "astern" on the torque-meter, so that a very wide open scale is obtained. A particular advantage of this torsion-meter is that it is quite independent of any displacement or distortion of any part of the hull of the vessel, such as may occur in destroyers and other light high-powered vessels. It has also the advantage of being an integrating meter, and therefore gives the true mean torque. Another advantage lies in the fact that the torsion of stationary shafts can be measured by means of it, so that the shafts can be calibrated with their own torsion-meter before being placed on board. The means of calculating the horse-power from the torsion readings obtained is so well known that it is not proposed to make any reference to it here.

MECHANICAL COUNTER & ELECTRICAL RECORDER FOR GAS-ENGINE EXPERIMENTS.



MECHANICAL COUNTER AND ELECTRICAL RECORDER FOR USE IN GAS-ENGINE EXPERIMENTS.

By Professor JOHN EUSTICE, B.Sc., A.M. Inst. C.E.

A FEW years ago the writer commenced some investigations in connection with internal-combustion engines in which it was necessary to obtain a correct record of the explosions, the difficulty of counting the explosions was overcome by employing a device which has since been in constant use, the arrangement is shown in the sketch, Fig. 1.

The controlling lever and striker for the ordinary hit-and-miss gas control is shown at A, an adjustable rod is connected at B to the gas-valve spindle, and at C to the bell-crank lever C S D; this lever is pivoted on a fixed spindle S S, which also carries the gas-controlling lever of the governor; when the gas-valve is opened the rod D E gives motion to E F; if E is in the position shown—that is, at the end of the rod E F—the angular movement of E F is insufficient to actuate the counting mechanism in the gas admissions counter Ex. C.

To throw the counter into action it is necessary to bring the point E nearer to F; this is done as follows:—A slider at E is connected by means of a link to a lever H K L, pivoted at K; by moving the handle H in the right-hand direction, E is brought closer to F, and the angular movement of E F is sufficient to actuate the counter. The motion of the handle H to the right moves the spindle M L P to the left, and a clutch at P throws the revolution counter R C into gear, a linkage M Q R connects the spindle M L P to the lever R S T, which is the lever used for obtaining a reduced motion of the piston for taking indicator diagrams. When the handle H is in the position shown in the sketch, both counters are out of action; when H is moved to the extreme right of its swing, both the gas-admissions counter and the revolutions counter commence to register.

This mechanical counter gave accurately the number of revolutions and the number of times the gas valve opened during a test, but it afforded no means of determining the number of misfires. The writer has used a Mathot recorder, which gives a valuable record of the explosions, but it does not give a record of the opening of the gas valve, nor of the number of charges which have been received into the engine, and which have not been exploded, nor does it lend itself to a test which extends over a long period.

In order to obtain a complete and permanent record of the number of strokes of the engine, as well as the number of charges of gas and air, and at the same time to ascertain if there have been any unexploded charges, an electrical attachment has been made to the counter. The arrangement adopted is as follows:—A steel diaphragm, fixed as in the Schäffer pressure gauge, is connected to the junction-piece between the indicator and the cylinder by a small U-pipe, as shown at U, in Fig. 1. The space between the diaphragm and the junction-pipe is filled with glycerine, which prevents the hot gases coming into contact with the diaphragm; at the same time it lessens the volume of gases passing through the indicator connection. The U-pipe is kept cold by surrounding it with water.

The cover of the diaphragm case is fitted with a screw insulated from the casing; the end of the screw may be adjusted to the pulsations of the diaphragm; the screw is in electrical connection with the coils of a tape chronograph, as shown by the dotted lines in the circuit numbered 2 and marked thus - - - - - .

The diaphragm responds to the variations in pressure in the cylinder if the contact-screw is adjusted so as to make contact when the pressure in the cylinder is just above that of the ordinary compression pressure of the charge. The record consists of the parts E′ E″ E‴, &c., only (see Fig. 2, I.). If, however, the screw is adjusted so as to make contact when the pressure is just below that of compression the record has the additional ridges C C C, Fig. 2, II. This record gives the number of cycles and the number of explosions.

E, Explosions.
C, Compressions.
G, Gas-charges.
C′, Compression, no explosion after gas-charge—*i.e.*, misfire.
ss, Start.

To indicate a misfire the recorder is arranged with an electrical contact-piece, which is placed either in connection with the gas inlet-valve, or as shown at F, in the sketch (Fig. 1). The record then contains the additional ridges G G G, &c., Fig. 2, III. If an explosion follows the opening of the gas inlet-valve, the ridge G is immediately followed by an elongated ridge, as at E′ E″ E‴, &c. If there is a misfire, two short ridges are marked close together, as shown at G C′, in Fig. 3; in the tape record these misfires can be clearly distinguished.

As at first arranged the recorder was fitted so as to give the revolutions of the cam-shaft; but it was found that the record of the compressions, obtained by adjusting the contact-screw, gave the number of complete cycles, and hence the revolutions of the engine could be counted. There is necessarily a slight falling-off in the speed of the engine between the completion of a working stroke and the commencement of the next working stroke; by careful measurement it is possible, by means of the recorder, to measure the variation in speed between the explosions.

The chronograph used consists of the clockwork of a Morse tape-machine, but the Morse inker is replaced by fine tubular glass pens attached to the armature of an electro magnet, as in the ordinary tape-chronograph. The writer designed a tape-recorder to be driven by the cam-shaft of the engine, but on account of the limited space around the engine when several persons are engaged in a test, it has been found convenient to keep the recorder at some distance from the engine, communication being kept up between the instrument and the engine by electric signals.

The rollers at r draw the tape along a flat plate p, over which are the pens x and t, the pen x is in the circuit 2, and when the diaphragm in U makes contact with the screw an earth circuit is completed, the armature and pen x then make a movement which is recorded on the tape as shown at C, Fig. 2. The contact-piece F completes the same circuit when the gas-valve is opened, and this produces the ridges G, G in Fig. 2, III.

The time record is obtained from the circuit 1 (shown

by the lines — . — . —) which is completed at the bottom of each swing of the clock pendulum, contact being made by a piece of thin copper, at the end of the pendulum, touching the mercury in the grooved receptacle *m*, shown underneath the pendulum ; the same circuit is continued to a contact-piece on the starting-handle H, which gives the record shown by the small ridges *s s* on the left-hand side of Fig. 2.

The dotted circuit 3 is for transmitting signals from the key *k* on the recording instrument to the bell which is fixed over the gas-engine.

The person conducting the test starts the revolution counter on the engine by pushing in the handle H, at the same time electrical contact is made at G by the link E G, an electric bell is rung, and the start is recorded on the time-line in the tape by a series of small ridges as at *s s* (Fig. 2), the approximate time of start being written on the tape by the observer in charge of the instrument ; at the close of the test a similar record is made by pulling out the handle H, the approximate time of finish being written on the tape ; lines are drawn on the tape at the exact time of the commencement and finish of the test, and the chronographic record is checked by means of a stop-watch.

The recorder has been a useful auxiliary in experiments which the writer is carrying out at the Hartley University College, Southampton, in conjunction with one of his colleagues, on the "distribution of heat energy in internal-combustion engines," and in other experiments on the fluctuations in speed of the engine between explosions.

The Ural Coal-Mining Industry.—This industry continues unsatisfactorily, and the output for the earlier portion of the present year compares unfavourably with the corresponding figures for the two last years, being only about two-thirds of the corresponding output for 1909. Several mines have discontinued work. The greatest output, at least in the earlier part of the year, was from the Kiselowski mines of Prime Abamelek-Lasaren.

The German Fuel Industry.—The production of coal in Germany in July was 13,611,845 tons, as compared with 13,031,280 tons in July, 1910. The output of lignites was 5,611,596 tons, as compared with 5,666,355 tons ; of coke, 2,058,619 tons, as compared with 1,975,107 tons ; and of briquettes, 1,804,433 tons, as compared with 1,671,442 tons. The production of coal in the Zollverein to July 31, this year, was 92,278,434 tons, as compared with 88,360,970 tons in the corresponding period of 1910 ; of lignites, 39,818,351 tons, as compared with 38,027,891 tons ; of coke, 14,580,632 tons, as compared with 13,388,070 tons ; of coal briquettes, 2,835,533 tons, as compared with 2,471,358 tons ; and of lignite briquettes, 9,261,206 tons, as compared with 8,355,414 tons. In this year's output of coal Prussia figured for 86,933,523 tons, Bavaria for 446,779 tons, Saxony for 3,124,409 tons, Alsace and Lorraine for 1,762,457 tons, and other districts for 11,266 tons. To the coal production of Prussia to July 31, this year, the Breslau group contributed 24,046,823 tons, the Halle district 4188 tons, the Clausthal district 513,174 tons, the Dortmund district 52,583,338 tons, and the Bonn district 9,786,000 tons.

Impermeable Fabrics for Balloon Envelopes.—H. Hoernes, in the *Gumme-Zeit*, of 1911, discusses the relative values of the materials used in making balloon envelopes, and in producing impermeability. Ponghee silk has an advantage over other fabrics in that it has great tensile strength combined with lightness. Its disadvantages are its high cost, its electrical properties, and its marked tendency to become brittle. Cottons, such as perkal or calico, possess the advantage over silk of greater stability towards atmospheric influences, but they are much heavier and less strong. They are generally employed in the form of a double layer of the fabric, with the threads either parallel or at an angle of 45 deg. to one another, united by an intermediate layer of india-rubber. Fine linen is almost as costly as silk, without the advantage of lightness in weight, and therefore is not recommended. Gold-beater's skin is very costly, difficult to repair, and very sensitive regarding atmospheric influences. Its comparatively high tensile strength per unit of weight and its low porosity are advantages. Aluminium is used in the form of strips of sheet about 0.2 mm. thick, riveted or welded together. It is not advisable, however, to make the entire envelope of sheet aluminium on account of the great risk of damage. The materials used for securing impermeability to gases are :—Linseed oil varnish, which has the advantage of low cost and ease of application, together with great efficiency in rendering the fabric gas-tight. The disadvantages attending its use are the need of constant attention during storage, the risk of spontaneous inflammation of the freshly varnished fabric, in the absence of a sufficient supply of air, the slowness of the repairing process, and tackiness, especially at an elevated temperature. India-rubber, in the form of a layer of vulcanized rubber, between the layers of fabric. With this repairs are easily effected, the fabric always remains supple, and there is no tackiness at high temperatures. The disadvantages are the high price of rubber, the possibility of electric discharges, its great weight, and its susceptibility to the action of the violet and ultra-violet rays of light. The other gas-tight materials referred to are "Ballonin," a solution of gutta-percha in benzol; "Konjaku," a Japanese vegetable product, which is placed on the market in the form of a white powder, soluble in warm water; bichromated gelatin, and "Pegamoid."

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a list of colonial and foreign engineering projects, for some of which tenders are asked. Further information concerning them can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Argentina: The *Boletin Oficial* of September 14 contains the following notices and decrees, &c. :—(1) A notice authorising the Dirección General de Obras Hidráulicas, Buenos Aires, to proceed departmentally with the erection of sheds and workshops at the harbour of Concepción del Uruguay, the cost of which is estimated at 136,500 pesos currency (about 12,000*l.*). Tenders will be invited publicly or privately for the supply of boilers, machinery, and other accessories required for one of the works which is designed to supply electric light and also power for working machinery, cranes, &c. (3) The text of a Bill, together with a contract, under the terms of which the Entre Rios Railways Company engages to take over and assume financial responsibility for the construction of the railway from Hasenkamp to Curuzú Cuatiá, in respect of which the Argentine Government in 1909 granted a subsidy of 5,500,000 pesos gold (1,100,000*l.*) to the above-mentioned company. In connection with this undertaking a sum of 4,247,500 pesos currency (about 372,000*l.*) has already been expended, and this amount the Entre Rios Railways Company agrees to reimburse to the Argentine Government. Four years are allowed for the completion of the line. (4) A decree approving the plans submitted by the General Directorate of Railways for the construction of the second portion of the Quimilí section of the Central Northern Railway—viz., from Quimilí to Barranqueras al Oeste, a distance of 56 miles. (5) A decree authorising the Dirección General de Obras Hidráulicas to proceed departmentally with the carrying out of breakwater and dredging works on the River Gualeguaychú. The cost of the operations is estimated at 200,000 pesos currency (about 17,500*l.*).

Brazil : The *Diario Official* of September 30 publishes a decree (No. 8989) granting, in favour of the Ministry of Communications and Public Works, a credit of 1,500,000 milreis (about 100,000*l.*) to meet the expenses in connection with the surveying operations and construction of the so-called "Fluminense" system of railways.

Italy: With reference to the notice on page 516 of the *Board of Trade Journal* of September 14, relative to the carrying out of harbour works in the Port of Ortona, the *Gazzetta Ufficiale* (Rome) of October 16 notifies that, as no award has been made in respect of this contract, tenders are again invited, and will be opened on November 14 at the offices of the Ministero dei Lavori Pubblici, Rome. The upset price is put at 2,700,000 lire (108,000*l.*). Although the foregoing contract will doubtless be awarded to an Italian firm, nevertheless the carrying out of the works may involve the purchase of some materials out of Italy.

Mexico: Adverting to the notice on page 115 of the *Board of Trade Journal* of January 20, 1910, relative to the construction of a dam on the River Conchos, State of Chihuahua, to store the flood waters of the river up to 1,019,000,000 cub. m., for the generation of electrical energy, the *Mexican Herald* of September 20 states that more than 1000 men are at work on the dam and reservoir, which, it is announced, will be completed by June, 1913. The power generated will be transmitted to the Parral, Naica, Santa Barbara, Santa Eulalia, and other mining districts of Chihuahua. Water will be stored along the course of the Conchos for a distance of 30 miles, the reservoir varying in width from 4 to 5 miles. The total cost of the work is estimated at 15,000,000 pesos (about 1,530,000*l.*). The undertaking is being carried out by the Mexican Northern Power Company, a Canadian company. The *Diario Oficial* of the 3rd ult. announces that a concession has been granted to Mr. William T. Leek for the utilisation of 500 litres per second of water from the River Humaya, for the purpose of carrying out irrigation works on the concessionnaire's property entitled Yetato. Exemption from customs duties will be granted in respect of any machinery, &c., which it may be necessary to import for carrying out the work.

Russian Far East : The following information is from the report by H.M. Consul at Vladivostock (Mr. R. M. Hodgson) on the trade of that district in 1910, which will shortly be issued :—Wire nails are imported from Germany or Belgium. For private buildings and for general purposes a very thin nail is required, the principal users being Chinese. Government building contracts require large quantities of nails. American nails come in occasionally, and this being so, there seems to be no good reason why British manufacturers should not compete, having a great advantage in freights (which are 2*l.* 12s. or thereabouts from New York, as against 1*l.* to 1*l.* 5s. from Europe). C.i.f. prices for Belgian and German nails are from 1 rouble 46 kopecks to 1 rouble 50 kopecks per pood (9s. 7d. to 9s. 11d. per cwt.). They would require to be packed in 5 lb. (Russian) [= 4½ lb. avoirdupois] packages. Locks, door and window fittings, stoves, and builders' accessories generally are of Russian and German manufacture, and of the poor quality which this market demands. American locks, butts, and hinges find a good sale. British locks should be saleable in small quantities on account of their high quality. Window glass is imported almost entirely from Belgium, and is of what is known as the "china" quality. Higher grade glass is very little in demand ; the consumption of window glass is largely on the increase. It has been decided to effect important improvements in the accommodation and equipment of the port of Vladivostock. The work, which is to be completed in three periods of construction, is being begun this year (1911), but the whole scheme of the modifications is not yet fixed (see also *Board of Trade Journal* of September 28, page 640). The question of water works and a sewerage system for Vladivostock remains in abeyance. The former would certainly seem to be one of urgency, for the town continues to increase, and the supply of water available to become more polluted and more inadequate. The deep-bore wells sunk by private landowners give poorer results than formerly, and a miserable stream called Pervaya Ryetchka, which is an important source of supply, runs close to a large flour-mill recently built, and to the new railway goods station now in course of construction. A new town council was elected in the early summer of 1910, but the elections have recently been cancelled by the Senate for certain irregularities. It is conceivable that the body which will be returned in the autumn of 1911, in the room of the one displaced, may again take the matter of the water-works in hand.

South Africa: H.M. Trade Commissioner for South Africa (Mr. R. Sothern Holland) writes that, according to the report for 1910 of the general manager of the South African Railways, provision is made in the 1910-12 capital estimates for the installation of improved signalling arrangements on the South African Railways. The work is to be spread over a number of years, beginning with the stations most urgently needing improved signalling arrangements.

Switzerland: With reference to the notice on page 656 of the *Board of Trade Journal* of June 29 relative to the construction of a tunnel, 8135 m. in length, between Tecknau and Olten, the *Feuille Fédérale Suisse* of October 18 notifies that, as no award was made in respect of this contract, tenders are again invited, and will be received up to November 11 at the offices of the Direction Générale des Chemins de Fer Fédéraux, Berne.

Spain: H.M. Consul at Bilbao (Lord H. Hervey) reports that tenders are invited for the carrying out of the filtration and sterilisation of the water supply of that town. Tenders will be received at the Secretaria del Excmo. Ayuntamiento, Bilbao, up to noon on December 1. A statement of the conditions governing the contract (in Spanish) may be seen by British firms at the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C.

Venezuela: The *Gaceta Oficial* of September 29 publishes a notice, issued by the Ministry of Public Works, approving the plans and estimates for the extension of the water main and water-works generally in the town of Táriba, State of Táchira.

The Coal Industry of the Hennegan District.—In the year 1829 the output of coal in the Hennegan district amounted to the modest aggregate of 1,760,000 tons, whilst the present output is 16,000,000 to 17,000,000 tons, and in the meantime the number of pits has been reduced from 274 to 181. The number of hands employed has risen from 19,600 in 1829 to 101,700 in 1909. The wages have risen from an average of 1.56 francs per day in 1848 to 5 francs per day in 1907. Fatal accidents averaged in 1852 5.45 per mille and in 1907 0.94 per mille.

Launch from the Middleton Shipyard.—The Middleton yard of Messrs. Irvine's Shipbuilding and Dry Docks Company, Limited, West Hartlepool, on Monday, the 23rd inst., launched the El Paraguayo, the first of the twin-screw insulated steamers built to the order of Messrs. Birt, Potter, and Hughes, Limited, which is intended to take her place in the new fortnightly express service of steamers between the River Plate and Liverpool, shortly to be inaugurated jointly by Messrs. Birt, Potter, and Hughes, Limited, and Messrs. Furness, Withy, and Co., Limited. This vessel is the largest meat-carrier yet constructed, having an insulated capacity of over 405,000 cub. ft , and the whole of this space is fitted for the carriage both of chilled and frozen meat. She has been constructed to the plans and specifications of Messrs. William Esplen, Son, and Swainston, Limited. The dimensions of the vessel are 456 ft. 6 in. in length by 59 ft. beam by 38 ft. 1 in. depth moulded, and she is fitted with four complete decks, all fore and aft. The various decks are supported by three rows of stanchions, all fore and aft; there being about 900 stanchions in all. The vessel has nine steel transverse bulkheads, seven extend to the shelter-deck, which, with the various decks, divide the vessel into twenty-six compartments, twenty of these being insulated throughout. Accommodation for a limited number of first-class passengers is provided in a deck-house on the fore end of the bridge-deck, and accommodation for about 400 emigrants is fitted under the bridge-deck. An installation of refrigerating machinery is being fitted by the Haslam Foundry and Engineering Company, Limited, of Derby, consisting of two horizontal combined surface-condensing duplex refrigerating-machines of the carbonic anhydride type, with brine circulation. Two large carbonic anhydride condensers with copper coils are fitted, together with four brass-lined brine-circulating pumps and a large duplex water-circulating pump for circulating through the condensers. The insulated chambers throughout are cooled by brine-circulation with flows and returns in sections, and the various insulated compartments can be regulated to a temperature suitable for frozen or chilled meat, the entire control of the brine system being centred in the refrigerating engine-room. This installation includes the supplying and fitting of 45,000 meat-hooks. For ascertaining the temperature of the insulated spaces 108 thermometer-tubes are fitted to the various compartments. The machinery, which has been constructed by Messrs. Richardsons, Westgarth, and Co., Limited, Hartlepool, consists of twin-screw triple-expansion engines, with cylinders 25 in., 41½ in., and 70 in., by 48 in. stroke, with six large boilers working under forced draught at a pressure of 200 lb. per sq. in.

VOLUME CHANGES IN THE ALLOYS OF COPPER WITH TIN.*

By J. L. Haughton, M.Sc., and Professor T. Turner, M.Sc. (University of Birmingham).

INTRODUCTION.

By Professor Turner.

The work which has been done by Mr. Haughton during the past session may be regarded as a continuation of previous researches on the changes in length which occur in a cast bar during and after solidification. To these investigations Picken, Simpson, Murray, Hague, Ewen, and Coe have contributed. The method employed has been that of applying an extensometer to one end of a cast bar while the other end was kept fixed. With a single substance, such as a pure metal or a definite compound, the extensometer does not appear to act until

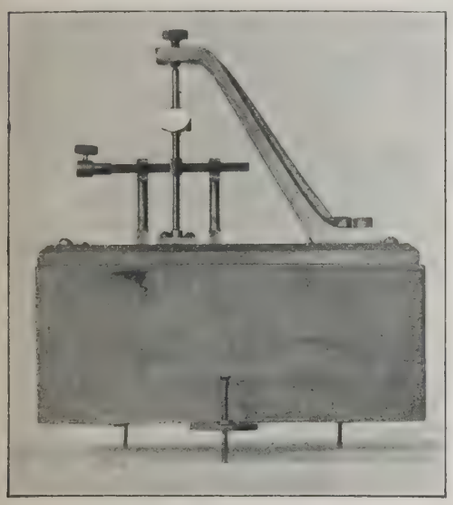


Fig. 1. The Extensometer.

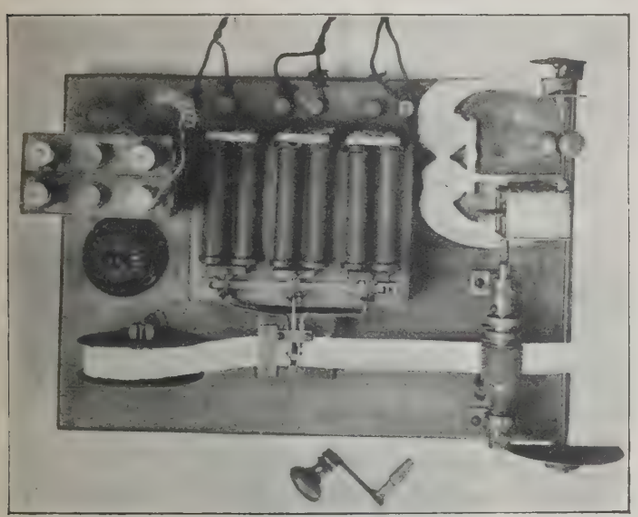


Fig. 2. The Chronograph.

immediately after solidification has occurred, and contraction thereafter proceeds regularly. But where internal changes take place, due to such causes as the separation of a constituent, or of an eutectic, from the solid matrix, such changes are indicated by changes in length of the bar. The separation of a constituent is generally accompanied by an expansion, while if the interval between the solidus and the liquidus is considerable, the expansion of the cast bar is also generally large, and it extends over a considerable interval of time.

The apparatus employed has been modified in an ingenious manner by Mr. Haughton in order to allow a single operator to observe both pyrometer and extensometer readings at the same instant, and to record these results by means of a chronograph on a paper tape. In a few cases tin-copper alloys have been already examined by Ewen and by Wüst, and it is satisfactory to find that the agreement between Haughton and these previous workers is generally quite satisfactory.

From an examination of Fig. 6 it will be seen that there are four maxima in the expansion curve, and that three of these, with about 10, 46, and 65 per cent. of tin respectively, agree with the "crystallisation interval" as determined from the accepted equilibrium diagrams. The maximum observed at 30 per cent. of tin is not easy to explain, though it may be pointed out that the equilibrium diagram at this point is exceptionally complicated, and that perhaps the "crystallisation interval" should extend down to 500 deg. Cent., in which case the maximum would fall into proper order.

It is interesting also to note that the hardness tests do not agree with what might be expected from the equilibrium diagram if viewed in the light of the theory of Kurnakow and Shemtschunsy, nor is there any obvious connection between density determinations and composition. These facts also depend upon the complicated nature of the changes which occur in this series of alloys, and in certain parts of the diagram there are evidently obscurities which have yet to be made clear.

Mr. Haughton records the fact that certain of the intermediate alloys of the series are remarkably insoluble in acids and ordinary solvents. Hence the analysis presented unexpected difficulties. These were overcome by the use of bromine, and this simple method of solution may be of use to other investigators of the tin-copper series.

* Paper read before the Institute of Metals at Newcastle.

VOLUME CHANGES IN THE ALLOYS OF COPPER WITH TIN.

By J. L. Haughton, M.Sc. (Birmingham).

1. Historical and Introductory Remarks.

The following research is a continuation of the work on volume changes, commenced in 1904 by Professor Turner [1]* on cast iron, and continued by Turner and Murray [2] on copper-zinc alloys; Turner and Ewen [3] on antimony-lead and on aluminium-zinc alloys; Turner and Hague [4] on silicon-carbon-iron alloys; and Coe [5] on manganese-carbon-iron alloys. While the methods employed have been, in the main, the same as those described in the papers mentioned above, a few minor alterations have been made which will be referred to as occasion demands.

The copper-tin alloys form a very interesting and important series, both from a practical and theoretical point of view. The fact that they include the "bronzes" makes them of such practical value that they can only be said to be exceeded in this respect by the iron-carbon and the copper-zinc series, while in theoretical interest they are of the first rank.

The equilibrium diagrams of these alloys have been worked out by many careful investigators — notably Heycock and Neville [6], whose results were embodied in the now classical paper read before the Royal Society. Shepherd and Blough [7], as well as Giolitti and Tavanti [8], have also published diagrams for the series. Mention must also be made of Roche [9], Behrens [10], and Roberts-Austen [11] as workers who, though they did not attempt to find the whole of the equilibrium diagram, nevertheless did useful work in breaking the ground for the later investigators. In spite of all this work, however, the diagram can only be said to be somewhat imperfectly known, as the agreement in the results is not good in certain places, especially near the tin-rich end.

Much work on the expansion during solidification of these alloys has been done by Wüst [12], Ewen [3], and others, but up to the present the volume changes of the whole series have not been systematically investigated.

2. Materials Used.

The materials used consisted of very pure electrolytic copper and the purest obtainable tin. Analysis showed the copper to contain only 0.004 per cent. of lead and 0.023 per cent. of iron. Tin, antimony, and sulphur could not be detected, and arsenic and bismuth were only present to the extent of a minute trace. The tin contained at least 99.9 per cent. tin. The materials were melted in a covered fireclay pot in a coke-fired wind furnace, and were cast at a temperature sufficiently above the melting-point to enable the mould to be completely filled before any solidification commenced. The bars were cast in two series, their composition being shown in Table I.

* The numbers in brackets refer to the Bibliography given at the end of the paper.

Table I.—*Bars Cast.*

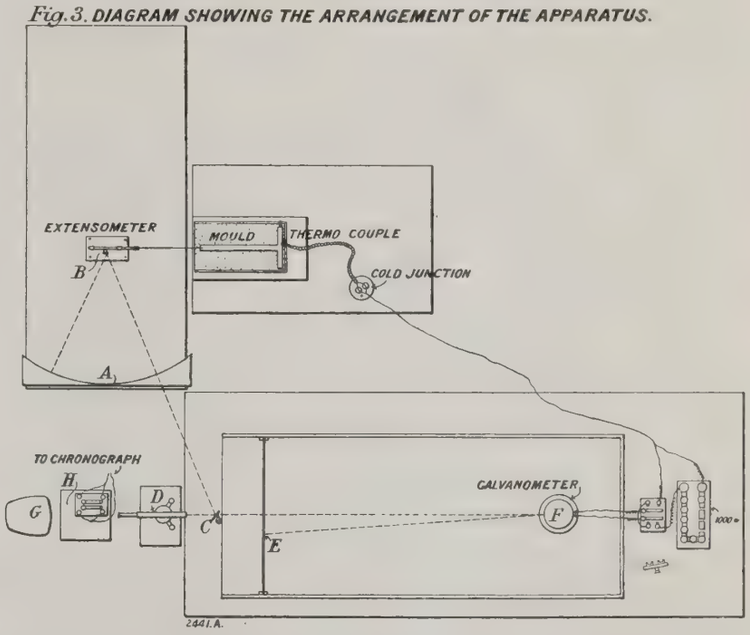
First Series.		Second Series.	
Number.	Tin per Cent.	Number.	Tin per Cent.
1	10.4	21	32.0
2	31.0	22	37.4
3	49.4	23	69.0
4	60.2	24	52.5
5	80.7	25	55.0
6	100.0	26	65.0
7	19.6	27	66.0
8	0.0	28	59.0
9	90.6	29	15.0
10	39.3	30	27.3
11	70.6	31	30.0
12	55.2	32	31.2
13	76.0		
14	34.3		
15	4.5	A.	11.0
16	25.0	B.	22.0
17	65.3	C.	32.0
18	42.8		
19	86.2	Bars A, B, and C, were cast by Mr. D. Ewen in 1910.	
20	96.0		

3. Apparatus Employed.

(A) *The Mould and Bar.*—The mould, made with common "moulding sand," was prepared in the usual way in two cast-iron boxes. The bar, cast in the now well-known T-shape, which has been used in all these researches, was held by a pin passing through the head of the T and clamped to the moulding-box. A second pin, of $\frac{3}{16}$-in wire, penetrated for about 1 in. into the other end of the mould, and was clamped to the extensometer.

The bars were made $\frac{3}{4}$ in. square, in the hope that, owing to the slower cooling obtainable with this cross-section over what was obtained with the standard $\frac{1}{2}$-in. bars, it might be possible to detect some of the changes occurring below the solidus. Results have amply justified this supposition. After cooling, samples for analysis were taken by drilling right through the bar in two places, and a piece for microscopic examination was taken about 3 in. from the T-piece. Another piece about 6 in. long was preserved for future experiments, and the rest remelted to make up new bars.

Fig. 3. DIAGRAM SHOWING THE ARRANGEMENT OF THE APPARATUS.



(B) *The Extensometer.*—The instrument used was the mirror extensometer designed by Murray, and employed by Ewen in his researches on the antimony-lead alloys (*q.v.*). It consists of a rack carried in guides, which is clamped to the pin from the cast bar. This rack engages with a pinion, which forms part of a vertical rod turning in cone-shaped bearings, the upper one of which is made adjustable so as to enable any trace of "play" to be removed without making the bearings tight. A small mirror is carried on this rod, and in the mirror the reflected image of a scale can be viewed by means of a telescope. The whole is mounted on an iron plate, which is fixed to a wooden block provided with levelling-screws (Fig. 1, above). As it was found that the contraction of some of the bars was so great as to cause the extensometer mirror to move right off the scale while the metal was still very hot, an adjustable clamp was fitted between the pin and the extensometer, which enabled the latter to be brought back whenever this was necessary.

(C) *The Pyrometer.*—The pyrometer consisted of a platinum and platinum-rhodium thermo-couple, connected through a 1000-ohm resistance and a mercury switch to a galvanometer. This latter was housed in a large box, painted dead black inside, and containing a semi-transparent scale illuminated by an electric lamp, the image of the scale reflected from the mirror of the galvanometer being viewed through a telescope. The cold junction was kept at a constant temperature by immersion in a water-bath; the reading of the thermometer in this water

was only taken just before casting the bar, as it was found that the variation of temperature during one experiment never exceeded 0.5 deg. Cent.

(D) *The Chronograph.*—In all previous researches on the volume changes in alloys three people have been necessary to carry on the work. One poured the metal, one read the extensometer, while the third read the pyrometer. To obviate this necessity the author designed, and with the assistance of Mr. Ward, the University steel-melter, made a chronograph, by means of which one observer was enabled to record the readings of both instruments. The chronograph consisted of a centrifugally-governed driving clock, which drew a strip of paper beneath three vertical pencils fastened to the armatures of three electro-magnets that, when energised, gave a lateral motion to the pencils. A clock transmitted a current to one of the magnets every second, and the other two were actuated by means of a pair of tapping keys. Fig. 2, page 609, is a photograph of the chronograph. The arrangement of the whole apparatus is shown in Fig. 3, where A is the scale whose reflection in the mirror B of the extensometer is directed by the mirror C into the telescope D. This telescope is provided with cross wires in the focus of the object glass.

Similarly, the reflection of the scale E in the galvanometer mirror F passes below the reflector C into the telescope. In this way the observer, seated at G, sees both scales simultaneously. As each division of either scale "transits" the cross wire of the telescope he presses one or other of the tapping keys (H), thus actuating one or other of the pencils on the chronograph. In this way a simultaneous record of the temperature and expansion is obtained, the exact position of any halt or maximum point on the curve being noted down, as it is not shown by the chronograph record unless it should happen to coincide with a whole division of the scale. (This obviously applies to any method of recording in which time is the variable function.)

4. Volume Changes.

The bars that were cast ranged from pure copper to pure tin in steps of 5 per cent., except in a few cases where it seemed desirable to cast intermediate ones. These, together with certain bars which were cast twice, brought the total number up to thirty-eight. The curves of volume change and of temperature are shown in Fig. 4, above. It will be noticed that, in addition to the expansion during solidification, most of the bars show marked changes in the rate of contraction, many of which appear to correspond with phase changes as shown by the equilibrium diagram. These changes in the solid alloys will be dealt with in a later part of the paper.

Considering first the volume changes occurring during solidification: The expansion curve for the whole series is shown in Fig. 5, below, and is repeated in Fig. 6, together with the crystallisation interval according to Heycock and Neville, to Shepherd and Blough, and to Giolitti and Tavanti. (The equilibrium diagrams of these workers are reproduced in Figs. 7, 8, and 9.) The object of this is to investigate whether the remarkable agreement between these two phenomena (expansion and crystallisation interval), which was found by Murray for the brasses, exists in this series also. Murray pointed out that, in the copper-zinc alloys, the expansion during solidification was directly proportional to the distance between the liquidus and the solidus, and suggested that the extensometer might be used to plot the latter. Ewen showed that, while there was some relationship in the case of the aluminium-zinc alloys, it was not nearly so pronounced as in the copper-zinc series, and that there was no such relationship in the antimony-lead alloys. It will be observed that in the series at present under discussion the expansion curve corresponds with the crystallisation interval of Shepherd and Blough from 0 per cent. to about 23 per cent. of tin, and from 40 per cent. to 65 per cent. of tin, while it agrees with that of Giolitti and Tavanti from 15 per cent. to 25 per cent. of tin, and from 35 per cent. to 60 per cent. of tin. The agreement with Heycock and Neville is only pronounced between 40 per cent. and 65 per cent. of tin, where it is very good indeed. As a first approximation it may be said that the general form of the expansion curve is the same as the curve of crystallisation interval in alloys of tin content ranging

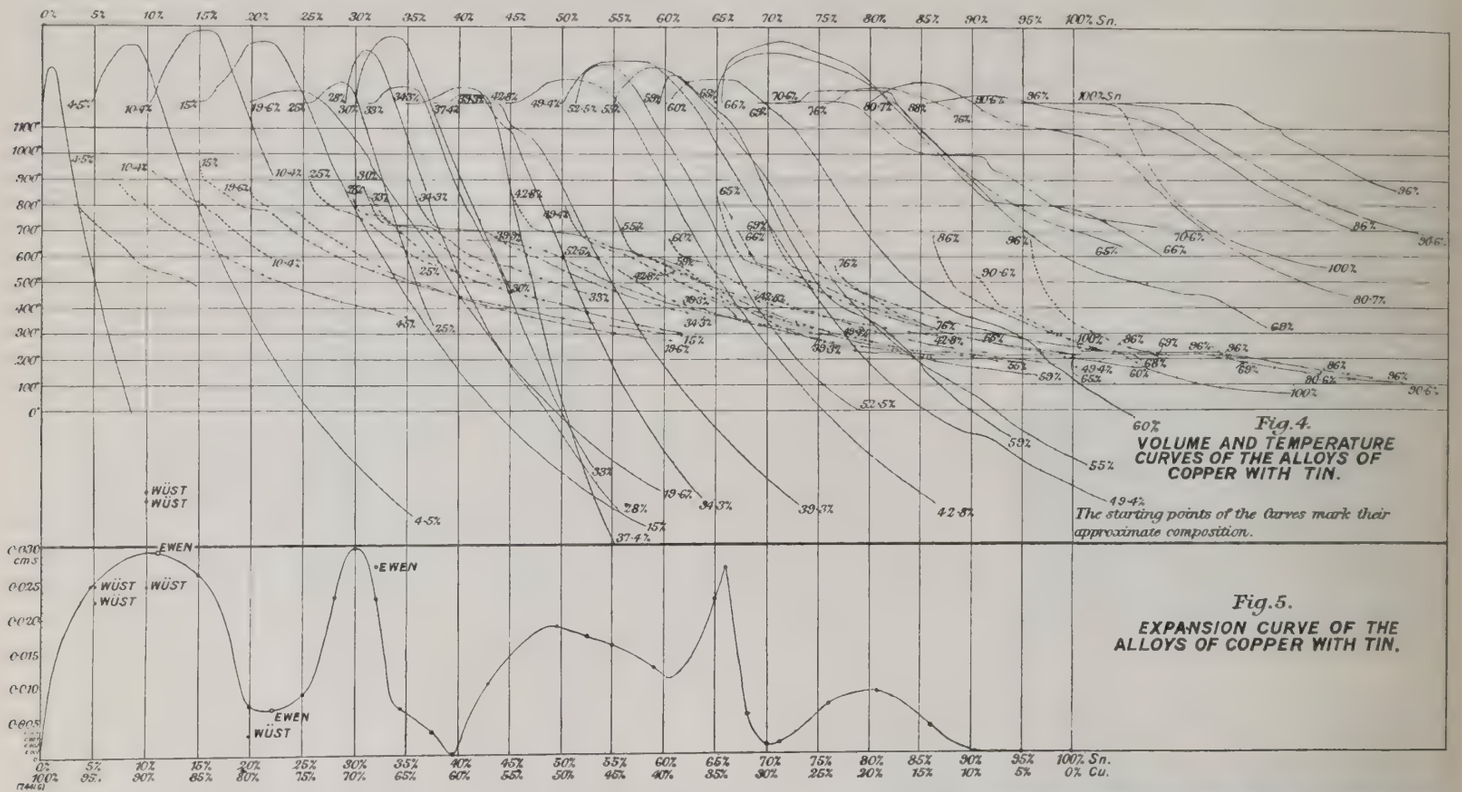


Fig. 4.
VOLUME AND TEMPERATURE CURVES OF THE ALLOYS OF COPPER WITH TIN.
The starting points of the curves mark their approximate composition.

Fig. 5.
EXPANSION CURVE OF THE ALLOYS OF COPPER WITH TIN.

Fig. 6. EXPANSION CURVE AND CRYSTALLISAT^N INTERVAL.

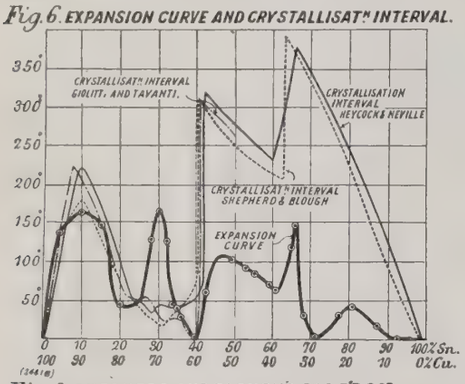


Fig. 7. HEYCOCK AND NEVILLE'S DIAGRAM.

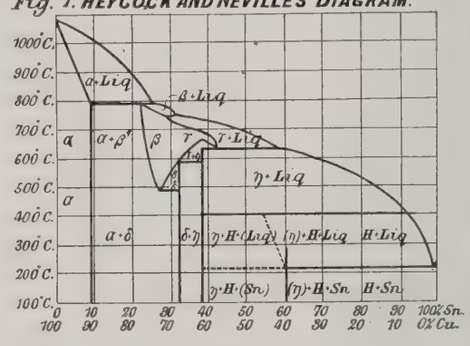


Fig. 8. SHEPHERD AND BLOUGH'S DIAGRAM.

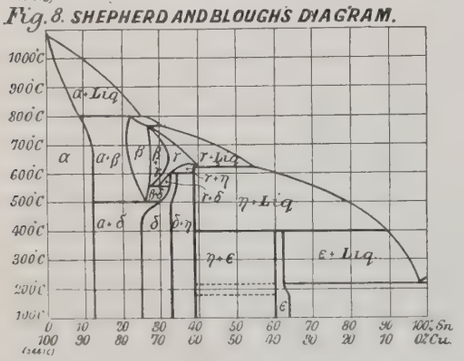
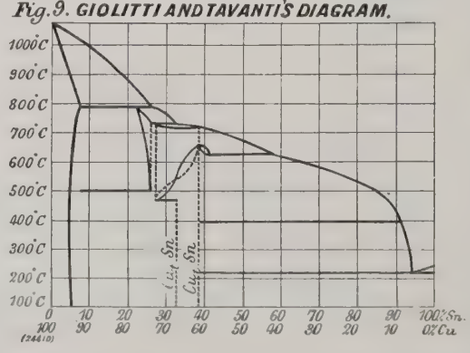


Fig. 9. GIOLITTI AND TAVANTI'S DIAGRAM.



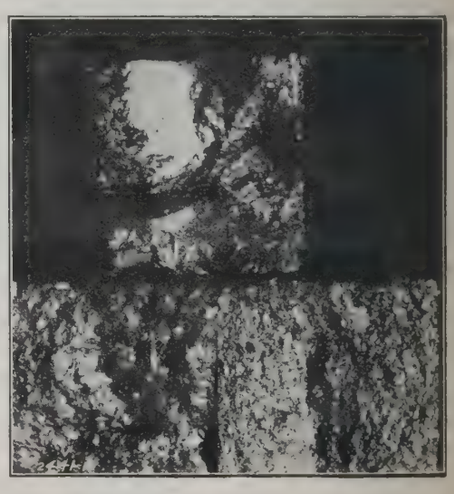


FIG. 10. FRACTURES SHOWING DIFFERENT CRYSTAL SIZE IN DIFFERENT PARTS OF THE SAME BAR.

from 0 per cent. to 25 per cent. and from 35 per cent. to 65 per cent. Beyond this last point the uncertainty of the equilibrium diagram makes it impossible to draw any definite conclusion, though the author believes that the extensometer records show some slight evidence of a horizontal line at about 500 deg. Cent., or a little lower. This can hardly be seen on the curves as plotted in Fig. 4, page 610; but if the alteration in length for a given number of degrees be plotted against the mean temperature at which that alteration takes place, a change in the direction of the curve in the neighbourhood of 500 deg. Cent. is noticeable in many cases.

While aware that the evidence is at present utterly inadequate for drawing any definite conclusion, the author would hazard a tentative guess that either the line separating the $\alpha + \beta$ region from the $\alpha + \delta$ region, or that separating $\beta + \delta$ from $\alpha + \delta$ (Heycock and Neville), should be continued right across the diagram towards the tin end. Two causes combine to give rise to this uncertainty. In the first place, the alloys are cooled so rapidly that they are a very long way from being in equilibrium; and secondly, the cooling conditions are such that the temperature of one part of the bar may differ from that of another part; and, while the pyrometer is registering the temperature of the metal in its immediate vicinity, the extensometer is registering the contraction or expansion of the bar as a whole at a mean temperature which may differ somewhat from that indicated by the pyrometer. The author is convinced that valuable light might be thrown on the composition of these alloys by taking extensometer readings on a bar heated or cooled very slowly—say in an electric furnace—and with this in view he has designed a much more sensitive form of extensometer.

The other part of the expansion curve which exhibits a marked divergence from the crystallisation interval curve is that lying between 25 per cent. and 35 per cent. of tin.

This expansion is a very remarkable one, the curve rising rapidly to a maximum at about 30 per cent., and falling away even more rapidly. It is confirmed by an observation of Ewen's mentioned at the end of his paper referred to above (3), and he seems inclined to attribute it to the existence of the compound Cu_3Sn. In this connection it is interesting to note that the peak at 66 per cent. tin, which shares, with the 30 per cent. maximum, the characteristic of very great changes of expansion for very small differences in composition, corresponds closely with the possible compound CuSn; on the other hand, a glance at Fig. 6 will show that this part of the expansion curve corresponds very well with the solidus-liquidus distance according to Heycock and Neville, and this explanation of the peak seems more probable than the alternative one, that it is caused by a very doubtful compound, inasmuch as there is no *a priori* reason why a compound should expand more than a solid solution; indeed, one would rather suppose the reverse to be the case, a supposition which is borne out by the fact that the compound Cu_3Sn—the only one whose existence is fully proved—falls very near the minimum at 40 per cent. tin. This is also the case in the copper-zinc series, where Murray has shown that the compound Cu_2Zn_3 practically corresponds with the minimum at 60 per cent. zinc.

In discussing these facts, however, it must be noted that, with the possible exception of Cu_3Sn (Giolitti and Tavanti), none of the copper-tin compounds or pseudo-compounds separate out from the liquid, but are all formed in the solidified alloy; and as the expansions under consideration appear to take place during solidification, the presence or absence of a compound at a temperature below that of the solidus can hardly be expected to have any effect on them. (The question as to whether or not the expansions observed are really volume changes during solidification will be discussed in a later part of the paper.)

While, therefore, the author is unable to accept the existence of a compound at about 30 per cent. tin as being the cause of this very remarkable expansion, yet he must admit that he can, at present, offer no other explanation for it. In passing it may be noticed that the hardness curve exhibits a maximum at this same point.

Turning now to the volume changes in the solid alloys, it will be found that there are many and of great interest The most pronounced is that which occurs in the tin-rich end of the series, at about 220 deg. Cent., and which is obviously caused by the separation of the eutectic. It is noticeable for the first time in the bar containing 50 per cent. tin, which was the earliest one taken to a low enough temperature to show the change, and it appears in every succeeding bar that was cooled far enough down. The temperature curve also gives marked evidence of this change from 55 per cent. tin onwards. Heycock and Neville only mark this line in full from 65 per cent. tin, dotting that part which lies between 38 per cent. and 66 per cent. tin. Shepherd and Blough do likewise. Giolitti and Tavanti, on the other hand, show the line in full the whole way. Unfortunately, very little can be deduced from the present results, as the alloys are not in equilibrium.

It will be noticed that in many, though not in all, cases this arrest is followed by a second retardation in the rate of contraction, of which no sign is given by the temperature curve; the reason for this is not clear, and the matter is by no means simplified by the fact that the arrest does not occur invariably. It may, however, be pointed out that Shepherd and Blough have on their diagram a dotted line at 180 deg. Cent. between 38 and 60 per cent. tin. If this line were continued right across the diagram, it would explain the occurrence of this peculiar change, but not the fact that certain bars show no sign of it.

Much more light might be thrown on this and other interesting points by measuring the expansion of the alloys on slow heating.

(To be continued.)

THE RESIDUARY RESISTANCE OF VESSELS.

*The Relationship Between Residuary Resistance Horse-Power and Forms of Vessels.**

By Ernest Saxton White, B.Sc.

So much has been said and written by eminent authorities of this and other institutions on subjects akin to the heading of this paper, that it is with some degree of hesitation the writer has approached the study of this interesting problem.

In estimating the indicated horse-power necessary to drive a given vessel at a particular speed, the designer may adopt several methods more or less accurate, such as the Admiralty coefficient, the extended law of comparison, the use of standard curves, the model-tank experimental and the independent estimate methods.

It is not the purpose of this paper to discuss the relative values of the methods mentioned; but, failing actual tank experiments, a careful analysis of trial-trip results, in conjunction with the independent estimate method, gives a good indication of the power necessary to drive any particular ship at a given speed. As you are aware, in this latter method the horse-power necessary to overcome the skin resistance is determined by using the following formula:—

$E_s = 0.0030707\, f\, S\, V^{n+1}$.

E_s = skin resistance power,

f = a coefficient of friction depending on the nature of the surface; average value being 0.00907.

S = the wetted surface in square feet

n = index of friction; average value being 1.83.

To obtain the horse-power required to overcome residuary resistance—*i.e.*, the combined resistance of wave and eddy—suitable coefficients are used which can be derived from carefully analysed speed trials of similar vessels. The addition of the skin resistance horse-power to the residuary resistance horse-power gives the effective horse-power, and from this the indicated horse-power may be determined by the use of suitable propulsive coefficients obtained from the results of progressive speed trials.

An analysis of the results of a very large number of speed trials of various types of vessels, with the object of obtaining suitable coefficients for this residuary horse-power, showed that a close relationship existed between the form of the vessel and the residuary resistance at the maximum speed for which the various vessels had been designed.

The system of comparison pursued was to bring all vessels to a standard displacement of 10,000 tons to obtain in the usual manner the corresponding maximum speeds and indicated horse-powers at this displacement. The effective horse-power was then ascertained as previously mentioned.

In the case of vessels, say, under 3000 tons displacement on trial, it would be advisable to bring these results to a less standard than 10,000—say 5000—and work out an exponent value x in the same manner as hereafter described. In this way any small discrepancy in the results is not so magnified as it would otherwise be if brought to the larger displacement.

If the skin resistance horse power be deducted from the effective horse-power for each vessel at its designed maximum speed, the remainder naturally gives the residuary horse-power.

In order to arrive at the relation which exists between the forms of the various ships and the residuary horse-power three factors were taken into account:—

1. The relation of beam to draught.
2. The midship section area coefficient.
3. The form of the ends.

These factors were combined in the formula, and the results obtained corresponded to a definite exponent of the speed, which is practically constant for all designed maximum speeds. No claim is made that this result is arrived at from any scientific basis; in fact, when certain theoretical principles are applied to it, the fault is apparent. Yet the fact remains that the results obtained are extremely interesting and particularly constant.

If this paper is the means of inducing some of the scientific members of this Institution to give their consideration to the matter from a theoretical standpoint, it will have served the purpose for which it has been written. It cannot be too strongly emphasised also that the results obtained should not be applied to find the residuary horse-power of any one ship at several speeds, but only at the maximum speed for which the form of the vessel has been designed; for instance, if a vessel has been given a form suitable for 20 knots maximum speed, one cannot obtain by this method the residuary horse-power for the same vessel at a speed of 12 knots, and *vice versâ*, as this would imply that the residuary horse-power varied as the speed raised to a constant exponent for all speeds for the same vessel, which is, of course, entirely erroneous. The factors used in the analysis of the form are as previously stated:—

(1) *Relation of Beam to Draught.*—It is well known that with a constant beam and varying draught the residuary horse-power increases as the draught decreases, which for analysis is written $\frac{B}{D}$, but in order to bring the result to an exponent approaching constancy for various types of form this has been reversed and called $\frac{D}{B}$.

2. *Midship Section Area Coefficient.*—This is taken as the measure of the fulness of the midship body.

3. *Form of Ends.*—For this a fair representation may be said to be (1- prismatic or cylindrical coefficient) × $\frac{L}{B}$, called in practice the "ends in terms of beams." In other words, it is the end coefficient multiplied by the number of beams in the length. For low speeds this factor, which may be called y, is generally much lower than for high speeds, varying from about 1 at 8 knots to about 3.5 for 26 knots. By combining these factors it will be admitted that the principal items in the form of the vessel affecting residuary resistance are included, and by treating these as follows as coefficient K is obtained:—

$$\frac{D}{B} \times a \times y = K,$$

where

D = draught in feet, excluding hanging keel.

B = breadth over shell-plating.

a = midship section coefficient.

y = form of ends in terms of beams.

Results of Speed Trials, showing Residuary Power.

Type of Ship.	Length on Water Line.	Beam over Shell.	Draught Ex. Hanging Keel.	Block Coefficient.	Midship Area Coefficient.	Form of Ends.	Results of Actual Speed Trials. Maximum Speeds.	I.H.-P.	Propulsive Coefficient.	E.H.-P.	Skin Resistance H.-P.	Residuary Resistance H.-P.	Coefficient of Form K	Residuary H.-P. by Formula K × V^2.7.
	ft.	ft.	ft.											
S.S.	374	49.5	24 0	0.794	0.977	1 43	11.2	2,620	0.47	1,231	785	446	0.67	455
S.S.	4 0	55.0	19.78	0.797	0.973	1.540	12.54	3,530	0.47	1,660	1140	520	0.54	560
T.S.S.	449	55.1	20.25	0.7 2	0.965	2.12	16.0	7,290	0 51	3,720	2357	1363	0 752	1341
T.S.S.	428	55.0	24.2	0.623	0.92	2.20	17.05	9,600	0.5	4,940	2760	2180	1.018	2155
T.S.S.	481	56 6	21.7	0.602	0 932	2.575	19.9	14,900	0.536	7 988	4528	3460	1.075	3480
T.S.S.	432	66.0	23.3	0.537	0.91	2.88	22.1	19,050	0.5	9,525	5760	3765	0 8 3	3680
T.S.S.	500	62.2	23.3	0.488	0.877	3.43	26.1	34,600	0 52	17,970	9990	7980	1 171	7825
T.S.S.	506	60.3	23.3	0.5	0.88	3.40	25.92	32,300	0.5 5	17,910	9 92	8118	1 261	8275
T.S.S.	485	63.15	23.4	0.49	0.884	3.37	25.7	32,600	0.52	16,950	955)	7400	1.122	7194

If V = speed in knots, x the exponent of this speed, then this coefficient K × V^x is used to arrive at the residuary power for the designed maximum speed of the vessel.

An analysis of the results of speed trials of some hundreds of vessels gave this exponent x a value of about 2.7, so that residuary horse-power for the maximum speed for which the form was designed would be obtained thus:—

$$\text{Residuary horse-power} = \frac{D}{B} \times a \times y \times V^{2.7}.$$

A tabulated list of some results taken at random from a large number of speed trials is given in the table above, the skin horse-power being deducted from the effective horse-power to give the residuary power.

The indicated horse-power given is that actually developed on the speed trials, and the figures obtained by the above formula for residuary power are practically identical with those obtained from the results of the speed trial.

No claim is made that this exponent of the speed is a fixture, and it would be well if each designer worked out his own value of x from the particulars which he has at his disposal. In the analysis normal trials have only been taken, and specially good results, never likely to be repeated, have been eliminated, as were also poor results, which were clearly no indication of what the vessel was able to do. Hump and hollow speeds were also neglected. In the above table there is a range of speeds from 11 to 26 knots, and the results will no doubt speak for themselves.

A comparison of the figures for residuary resistance horse-power obtained from trial results with those obtained from the formula show that the latter has an over-estimate of about 1 per cent. in the indicated horse-power for the 10,000-ton vessel at low speeds, and an under-estimate of 1 to 1½ per cent. at high speeds, while at medium speeds the results are practically identical.

Before finishing, I must express my thanks, first to Mr. Frank Hope for his invaluable assistance in the preparation of this paper, and, secondly, to the members of this Institution who most kindly gave me particulars of trials which they had at their disposal.

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders, Friday, October 27, 1911.

New Union-Castle Liner.—The T.-S.S. Galway Castle, built by Messrs. Harland and Wolff, Limited, Belfast, for the Union-Castle Line, left Belfast, on the 9th inst., and, after very satisfactory trials on the Clyde, proceeded to Hamburg. The new steamer is 452 ft. long between perpendiculars, by 56 ft. beam and 33 ft. 9 in. deep, with a gross tonnage of about 8000, and is intended for the company's intermediate service to South Africa.

THE ENDURANCE OF METALS.

*Experiments on Rotating Beams at University College, London.**

By E. M. Eden, of the Armstrong College, Newcastle-on-Tyne, W. N. Rose, and F. L. Cunningham, Graduate, of London.

(*Concluded from page* 580.)

Tensile Tests of Materials.—The results of tensile tests of test-pieces cut from some of the bars of metal used for the endurance tests are shown in Table I. All the tensile tests were made on the full-size bar, and extensometer readings were taken on a 10-in. length.

Table I.—*Tensile Tests of some of the Metals used in the Endurance Experiments.*

Bar No.	Material.	Limit of Elasticity.	Tenacity.
		tons p. sq. in.	tons p. sq. in.
5	½-in. bright-drawn mild-steel rod, quality B	28.8	40.0
8	Ditto Ditto A	25.0	35.7
9	Vanadium steel-type A, oil-tempered ..	46.5	57.2
10	Ditto A, annealed.. ..	26.8	38.4
23	½-in. blued rolled Bessemer steel, quality D	35.7	49.3
25	3 per cent. nickel steel	44.6	57.0
26	25 per cent. special nickel steel	24.1	48.8
27	½-in. bright-drawn wrought-iron rod ..	25.9	33.3
28	Ditto Ditto ..	26.8	34.0
29	Ditto Ditto ..	26.8	34.1

The limit of elasticity was obtained from extensometer readings, and is the limit of the straight portion of the stress-strain curve. Both the limit and tenacity are expressed in tons per square inch of original area.

The Form of the Stress-Revolutions Curve, and the Limiting Stress causing Fracture after an Indefinite Number of Revolutions.—The series of experiments in which there is least variation from a smooth curve appear to be XVII., XXI., XXII., XXIX., XXXII., XXXVI., shown in Figs. 14, 17, 18, 24, 27, and 30, pages 577 to 580 *ante*. The same curves are repeated, plotted on logarithmic scales in Figs. 32 to 37, annexed. The curves are all of similar form.

It is generally assumed that the stress-revolutions curve becomes horizontal after a sufficiently large number of repetitions of stress, and the ordinate of the curve where it is horizontal is the limiting stress causing fracture after an indefinite number of alternations or repetitions of stress. An examination of the curves shows that this limiting stress is not reached with one million revolutions: this is seen most clearly in the logarithmic curves (Figs. 32 to 37), where, as in the case of the other curves, the limiting stress is the ordinate of the curve when it becomes horizontal. In spite of the irregularities in the position of the points, it seems to be certain that the curves have not become horizontal after one million revolutions.

The actual existence of a limiting stress, at any rate for revolving beam tests, appears to be doubtful; the logarithmic curve for Series XXIX., Fig. 35, herewith, has been smoothed by a straight line from 10,000 to 400,000 revolutions; the equation to this line is $\log N = 15.7 - 8.1 \log f$, where N = the number of revolutions up to fracture, and f = the applied stress. It is unlikely that this curve remains indefinitely straight if continued to the right; but even taking this extreme assumption, the number of revolutions required to cause fracture with low applied stresses is very large, a continuous run of the machine at 1300 revolutions per minute for about 3½ years would be required to cause fracture with an applied stress of 6 tons per sq. in., and about 100 years' run would be required if the applied stress were 4 tons per sq. in.

For the sake of comparison, Wöhler's rotating-beam experiments on wrought iron are shown in Fig. 38, page 613. These are by far the most definite curves obtained by Wöhler, and it is remarkable that in the case of the "Phœnix" iron the limiting stress is not reached with 19,000,000 revolutions.

The Effect of Speed on the Stress-Revolutions Curve.

Mild Steel, Quality A.—A comparison of Figs. 13, 14, and 15, pages 577 and 578 *ante*, shows that in the case of this material a variation in speed from 250 to 1300 revolutions has no appreciable effect on the curve. In all three diagrams the smoothed curve is identical, and it will be seen how closely the observed points from all the series of tests follow the same curve. In order to show all the available evidence of the effect of speed, Series XIII. and XXVII. are shown together in Fig. 22, page 579 *ante*. Both series were made with test-pieces cut from the same bar, but the two series were made at different times and with different holders. The earlier series at 600 revolutions per minute is very irregular, and it seems probable that the higher and more consistent figures obtained at 1300 revolutions per minute are due to the improved form of holders used, and not to the increased speed.†

Mild Steel, Quality B.—Figs. 24 and 25, page 579 *ante*, show mild steel, quality B, at 1300 and 600 revolutions per minute; the same smooth curve is drawn on both diagrams. The evidence is not, perhaps, so conclusive as for the A quality mild steel, but there appears to be no speed effect.

Vanadium Steel.—Two series of tests on annealed vanadium steel at 600 and 1300 revolutions per minute are shown in Fig. 19, page 578 *ante*; in this case also speed appears to have no effect on the curve. The results for oil-tempered vanadium steel are not so conclusive. Fig. 20, page 578 *ante*, shows the comparison. The points lie rather irregularly, but on the whole the lower speed tests gave lower values.

Wrought Iron.—Fig. 16, page 578 *ante*, compares two series of tests on wrought iron at 600 and 1300 revolutions per minute. Neither of the curves is very definite, but on the whole the series at 1300 revolutions per minute gives lower results than the series at 600 revolutions per minute. The drawn bars from which the test-pieces were cut were not quite straight; in Series XIX., at 1300 revolutions per minute, only two of the test-pieces were straightened before testing, whereas in Series XX. all the test-pieces were carefully straightened before testing. One of the two straightened test-pieces of Series XIX., tested at 1300 revolutions, lies well on the curve drawn for Series XX., at 600 revolutions.

As it seemed probable that the lower values obtained at the higher speed were caused by want of straightness in the test-pieces, Series XXXV., XXXVI., and XXXVII. were carried out at 1300, 620, and 250 revolutions per minute. In these series particular care was taken in preparing the test-pieces which were turned and fitted to clamping holders. The results are shown in Figs. 29, 30, and 31, page 580 *ante*; the same smooth curve is drawn for each diagram. The points lie rather irregularly, particularly in the case of the high-speed tests, but, as in the case of the steels, speed appears to have no effect.

A careful examination of the evidence of the various curves referred to proves that in the testing-machine used a variation of speed from 250 to 1300 revolutions per minute has no appreciable effect on the stress-revolutions curve, and that for any one material the stress to cause fracture depends on the number of repetitions or alternations, and not on the rate of alternations.

Effect of Surface and Form of Test-Piece.—The increased resistance of a polished specimen compared with one that is plain turned is shown in Fig. 9 and in Fig. 11, page 577 *ante*. The curves are too irregular to obtain any numerical results.

The reduction resistance caused by scratching a polished test-piece is shown in Fig. 10, page 577 *ante*, and also the still greater reduction on resistance caused by a V groove. The majority of the test-pieces used were ground to size, but no direct comparison was made of the resistance of ground as compared with polished or turned test-pieces.

Effect of Annealing.—Annealed and "as rolled" tests for Bessemer steel are shown in Fig. 8, page 577 *ante*, and annealed and oil-tempered vanadium steel in Fig. 12, page 577 *ante*, and also in Figs. 19 and 20, page 578 *ante*. In all cases the annealed material shows a lower resistance.

Range of Stress Required to Cause Fracture after a Million Alternations.—The range of stress in these tests is double the applied stress, as the stress alternates between equal positive and negative values. The range of stress causing fracture after a million alternations is twice the ordinate of the stress-revolutions curve at a million revolutions. Table II. gives the values of this range of stress for some of the more important series of tests and also the limit of elasticity and tenacity obtained from tensile tests of the materials. The endurance of the various materials, as shown by the range of stress figures, appears to depend more on the tenacity than on the limit of

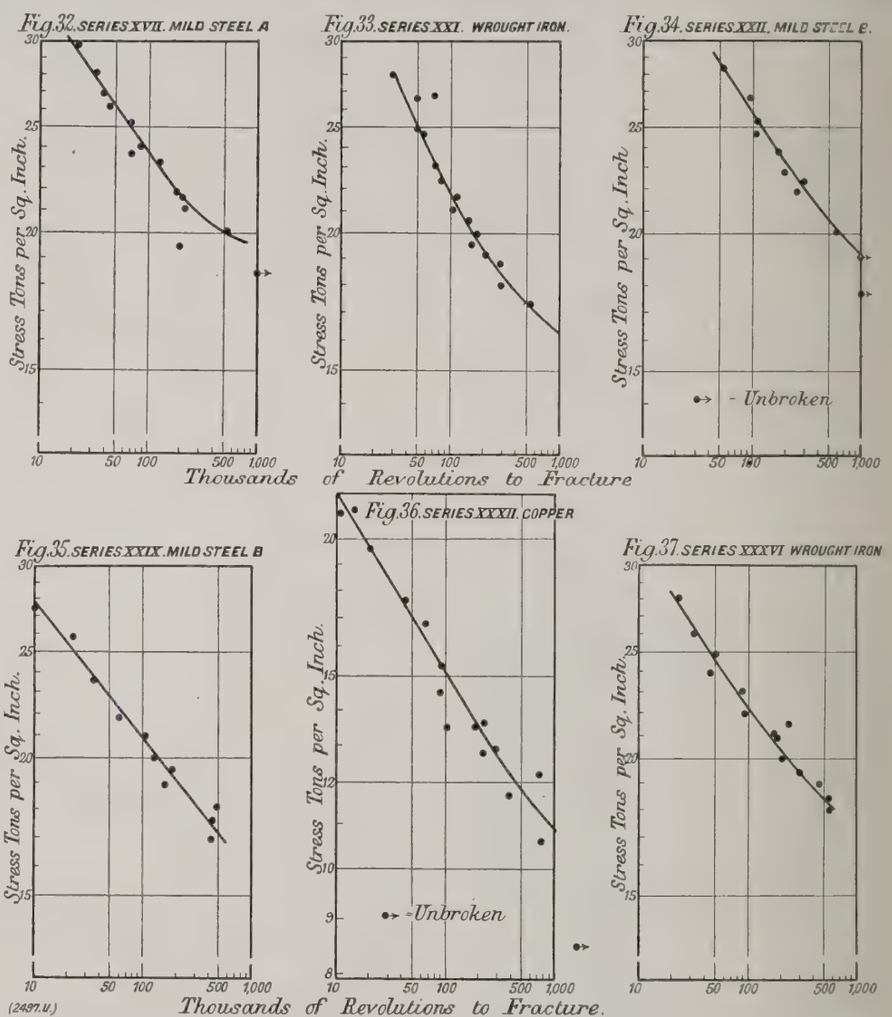


Fig.32. SERIES XVII. MILD STEEL A
Fig.33. SERIES XXI. WROUGHT IRON.
Fig.34. SERIES XXII. MILD STEEL B.
Stress Tons per Sq. Inch.
Unbroken
Thousands of Revolutions to Fracture
Fig.35. SERIES XXIX. MILD STEEL B
Fig.36. SERIES XXXII. COPPER
Fig.37. SERIES XXXVI WROUGHT IRON
(2497.u.)
Thousands of Revolutions to Fracture.

Table II.

Material.	Tensile Tests. Tenacity. Tons per Square Inch.	Tensile Tests. Limit of Elasticity. Tons per Square Inch.	Endurance Tests. Speed, Revolutions, or Alternations of Stress per Minute.	Endurance Tests. Range of Stress Causing Fracture after 10^6 Revolutions.	Endurance Tests. Ratio $\frac{\text{Range}}{\text{Tenacity}}$.	Endurance Tests. Ratio $\frac{\text{Range}}{\text{Limit}}$.
⅞ in. bright-drawn mild-steel rod, quality B	..	..	600 1300	31.6	—	—
½-in. bright-drawn wrought-iron rod	33.8	26.5	250 620 1300	34.6	1.02	1.3
½-in. bright-drawn mild-steel rod, quality A	35.7	25	300 600 1300	39	1.09	1.56
Vanadium steel, annealed	38.4	26.8	600 1300	41	1.07	1.53
25 per cent. nickel steel	48.8	24.1	1300	44.2	0.90	1.83
Vanadium steel, oil-tempered	57.2	46.5	1300	49	0.86	1.05
Copper trolley-wire, hard-drawn	..	..	1300	22	—	—

* Paper read before the Institution of Mechanical Engineers on October 20.

† That a change in the holders can affect the results is shown from a comparison of Series XI. (Fig. 11, page 577 *ante*), and Series XXII. (Fig. 18, page 578 *ante*); the test-pieces for both these series were made from the same bar of steel, and both series were at the same speed.

elasticity, the material with higher tenacity always showing greater resistance to alternating stresses. The high values of the elastic limit and tenacity in the case of the wrought iron and mild steel A are due to the material being in the form of drawn rod.

The ratios: $\frac{\text{range of stress}}{\text{limit of elasticity}}$ and $\frac{\text{range of stress}}{\text{tenacity}}$

are also shown. It is remarkable that the drawn mild steel rod and the annealed vanadium steel give nearly the same values for these ratios.

Corrosion of Test-Pieces and Holders.—A good deal of trouble was caused by corrosion where the test specimen fits into its holders. The rusting at this point was so great in the case of heavily loaded tests lasting for several days that it was often difficult to remove the broken specimen from the holder. The same trouble was experienced in an earlier repeated-loads testing-machine at University College. This machine was of the Wöhler rotating cantilever type, with round test specimens 1 in. in diameter, fitted into conical holes in the testing-machine spindle. In this machine red rust was produced in considerable quantity. There seems to be no doubt that this corrosion is due to the varying stress between the test specimen and its holder, and the authors believe that the rust often found between a wheel and its shaft or a key and key-way, and the corrosion of ball-bearings, is usually due to a similar action, and not only to the presence of moisture. After the first few trials the specimens were well oiled before being put in place, but this was only partially effective. The specimens were somewhat easier to withdraw, but rust was still produced.

Comparison of these Tests with other Alternating Stress Tests.—A few values for the range of stress causing fracture after 10^6 alternations of stress by various experimenters are quoted in Table III., given below. The Wöhler, Baker, Rogers, and University College (London) tests were all on rotating beams; the first three being rotating cantilever tests, while the University College tests were on rotating beams supported at each end and loaded at two points. In the testing-machine used by Mr. Turner the free end of a fixed cantilever is made to move in a circular path, thus giving what may be described as a rotating deflection. The machine is an alternating strain-testing machine, and the stress is calculated from the load required to cause the strain used in the test. The Reynolds and Smith* and Stanton and Bairstow† tests were direct tension and compression tests produced by the inertia of a reciprocating weight.

Referring to Tables II. and III., the range of stress figures in the University College tests are seen to be higher than those obtained by other experimenters with the exception of the Turner tests. The ratios $\frac{\text{range of stress}}{\text{tenacity}}$ agree with Rogers's and some of Turner's tests, but are higher than any other results quoted for material of similar tenacity. Turner's value for the ratio for mild steel is still higher.

The University College tests confirm the increased endurance of high-tenacity steels, shown by Wöhler, Baker, Rogers, Stanton and Bairstow, and by Turner, and the reduced ratio $\frac{\text{range of stress}}{\text{tenacity}}$ as the tenacity increases shown by Wöhler, Baker, Rogers, and Stanton and Bairstow. In the Reynolds and Smith tests annealed cast steel showed rather less endurance than annealed mild steel, in spite of the much greater tenacity of the cast steel.

The reduced endurance caused by annealing in the University College tests is in accordance with Professor Osborne Reynolds's suggestion and with Rogers's results.

The weakening effect of a V groove agrees with Wöhler's tests on specimens with a sudden change of section and with Stanton and Bairstow's results on screwed specimens.

The form of the stress-revolutions curve in the University College tests agrees as well as can be expected with other tests. A comparison with the two wrought-iron tests of Wöhler has been referred to, and is seen from a comparison of diagrams, Figs. 33, 37 (page 612), and 38 (annexed).

The stress-revolutions curves in the University College tests are not horizontal at a million revolutions, and the limiting stress causing fracture after an indefinite number of alternations of stress is not reached in these tests. This is the case also in the Wöhler and Rogers tests. The Reynolds and Smith and Stanton and Bairstow curves are said to be about horizontal at 10^6 alternations, but the evidence in favour of this statement is not very conclusive. This limiting stress, the ordinate of the stress-revolutions curve where it becomes horizontal, does not appear to have been reached with any certainty in any endurance tests. Wöhler's estimated values for the limiting stress are quoted in Professor Unwin's "Materials of Construction," but it is not clear how the figures are arrived at.

The most remarkable point shown in the University College tests is the absence of all speed effect between 250 and 1300 alternations per minute. In the experiments of Reynolds and Smith a very large and perfectly definite speed effect was found for speeds between 1300 and 2000 alternations per minute. The figures are quoted on Table III. The entirely different results of the University College tests must be due to the different form of test and testing machine.

In the report of the National Physical Laboratory for 1908 Dr. Stanton stated that tests on a special ring machine, giving a combination of alternating stress with rolling abrasion, did not confirm the Reynolds and Smith speed effect, and in the report for 1910 he states that later tests on a rotating cantilever machine at 100, 200, and 2200 reversals of stress per minute show no evidence of a reduction in the fatigue strength due to the rapidity of the alternations. This is in agreement with the University College tests.

The endurance figures of the Reynolds and Smith tests were compared with the Wöhler and Baker tests of steels of similar tenacity, and it was suggested that the lower endurance figures of the Reynolds and Smith tests were due to the increased speed, the speed of the Wöhler tests being only 60 to 80 alternations per minute.

Stanton and Bairstow's tests at 800 alternations per minute showed endurance figures more nearly agreeing with the Wöhler tests at 60 to 80 alternations per minute than with the Reynolds and Smith tests at 1300 to 2000 alternations per minute, and this agreement has been explained on the assumption that change of speed from 60 to 800 alternations of stress per minute does not affect endurance, but that change from 800 to 1300 alternations per minute does do so.

In view of the great difficulty of obtaining endurance figures which agree with each other from endurance tests on one machine, under apparently identical conditions, and the difficulty of obtaining a perfectly definite stress-revolutions curve, it seems unwise to draw conclusions as to the effect of speed from a comparison of endurance tests made on machines so different as the rotating cantilever machine of Wöhler and the reciprocating weight direct tension and compression machines of Reynolds and Smith, and of Stanton and Bairstow, particularly when the tests are on different materials.

The thanks of the authors are due to Professor J. D. Cormack, member, in whose laboratory the tests were carried out, to Messrs. Willans and Robinson, who supplied the vanadium-steel test-specimens, and to Mr. C. G. Eden, who carried out the three last series of tests on wrought iron and assisted in the preparation of some of the diagrams.

Fig. 38. WÖHLER'S WROUGHT-IRON TESTS.

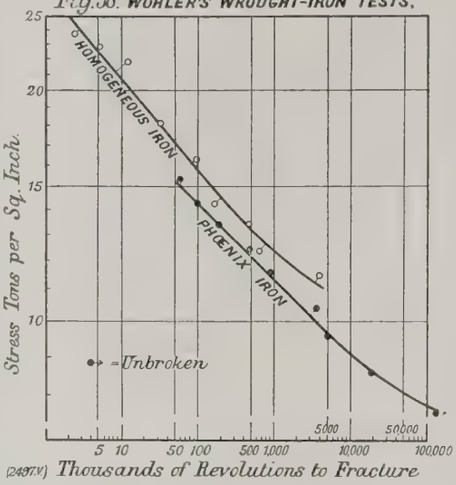


TABLE III.—ENDURANCE UNDER ALTERNATING STRESSES.

Experimenter.	Type of Endurance Test.	Material.	Tensile Test Figures. Tenacity.	Tensile Test Figures. Limit of Elasticity.	Endurance Test Figures. Speed. Alternations of Stress per Minute.	Endurance Test Figures. Range of Stress Causing Fracture after 10^6 Alternations.	Ratio: Range of Stress / Tenacity	Ratio: Range of Stress. / Limit of Elasticity
			tons per sq. in.	tons per sq. in.		tons per sq. in.		
Wöhler*	Rotating cantilever	Phœnix iron	21.3	..	60—80	22.8	1.07	—
		Homogeneous iron	28.1	..	60—80	24.5	0.87	—
		Vickers' steel axles	27.7	..	60—80	24.0	0.87	—
		Firth's tool steel	55.0	..	60—80	30.9	0.56	—
Baker*	Ditto	Soft steel	27.7	..	50—60	25.0	0.90	—
		Fine drift steel	54.0	..	50—60	27.5	0.51	—
Rogers†	Ditto	Steel C (0.32 per cent. C.) as rolled	29.3	16.7	400	32.0	1.09	1.92
		Steel C annealed	26.5	7.1	400	27.7	1.05	3.9
U.C.L.‡	Rotating beam, uniform bending-moment	½-in. bright-drawn wrought-iron bar	33.8	26.5	250 620 1300	34.6	1.02	1.3
		½-in. bright-drawn mild-steel rod A	35.7	25.0	300 600 1300	39.0	1.09	1.56
Turner§	Fixed cantilever	Mild steel	27.3	18.8	250	35.6	1.3	1.9
	Rotating deflection	Nickel steel	48.0	36.1	250	52.5	1.1	1.46
Stanton and Bairstow‖	Reciprocating weight, direct tension and compression. Ratio: Tension / Compression = 1.4	Wrought-iron No. 2	25.6	13.4	800	19.2	0.75	1.43
		piston-rod steel	43.8	19.6	800	28.3	0.65	1.44
Reynolds and Smith¶	Reciprocating weight, direct tension and compression. Ratio: Tension / Compression = 1.15	Mild steel annealed	25.8	..	1337 1428 1516 1656 1744 1917	20.9 20.1 19.2 18.1 15.2 12.4	0.81 0.78 0.75 0.70 0.59 0.48	— — — — — —
		Cast steel annealed	48.0	..	1320 1660 1820 1990	20.1 18.3 16.8 13.1	0.42 0.38 0.35 0.27	— — — —

NOTE.—The values for "range of stress" causing fracture after 10^6 alternations of stress in this table are copied from the published accounts of the experiments of Turner, Reynolds and Smith, and of Stanton and Bairstow. The corresponding figures for the tests of Wöhler, Baker, and Rogers have been estimated from stress revolution diagrams plotted from the various published results. The tenacity figures for the Reynolds and Smith tests are for short test-pieces two diameters long.

* "The Testing of Materials of Construction." Unwin.

† "Heat-Treatment and Fatigue of Iron and Steel." Rogers. Journal of the Iron and Steel Institute, No. 1, 1905.

‡ For other metals see Table II. (page 612), also Proceedings of the University of Durham, Phil. Soc., vol. iii., page 251.

§ "The Strength of Steels in Compound Stress, and Endurance under Repetitions of Stress." L. B. Turner. (See pages 115, 183, and 247 *ante*)

‖ "On the Resistance of Iron and Steel to Reversals of Direct Stress." Stanton and Bairstow. Proceedings of the Institution of Civil Engineers, 1906, vol. clxvi.

¶ "On a Throw Testing-Machine for Reversals of Mean Stress." Professor Osborne Reynolds and J. H. Smith. Phil. Trans. of the Royal Society, 1902.

* See ENGINEERING, vol. lxxiii., page 504.

† *Ibid.*, vol. lxxxv., page 697.

CEMENTATION OF NICKEL STEEL: GASES IN STEEL.—F. Giolitti and F. Carnevalli continue in the Arts Reale Accademica Torino, 1911, page 407, their studies of the cementation of steel containing from 2 to 30 per cent. of nickel, by the action of carbon monoxide and ethylene gases. The presence of nickel, especially if exceeding 5 per cent., diminishes the maximum content of carbon in the cementation zone. In successive layers of this zone the carbon content varies much more regularly when nickel is present than in ordinary carbon steel. In further experiments on the liberation of gases from steels at a temperature of 950 deg. Cent. in a vacuum furnace, G. Charpy and S. Bonnerot (*Comptes Rendus*, vol. cli., page 1247) find that the generation of gas appeared to stop very nearly, after five days' heating, and that the critical points of hard and soft steels were not altered by this treatment.

FAILURES OF OPEN-HEARTH AND BESSEMER RAILS IN THE UNITED STATES.—A report covering 11,759,000 tons of rails has lately been issued in the United States by the Committee on Rails of the American Railway Association, and shows a noticeable difference between the number of failures of open-hearth and of Bessemer rails. The failures for the year ending October 31, 1910, were 11.5 per 10,000 tons for open-hearth material, and 33 per 10,000 tons for Bessemer. It may, however, be pointed out that whereas the open-hearth material has mostly been introduced during and since the recent rail agitation in the United States, and the failures cover, therefore material on which considerable care was expended in manufacture, the influence of methods till recently in vogue in connection with the manufacture of Bessemer rails is probably still felt with resulting heavy failures. The failures are classified as 29¼ per cent. breaks, 55¼ per cent. head failures, 7 per cent. web failures, and 8½ per cent. base failures. In 1909 the head failures amounted to 66½ per cent., so that this part of the rail is apparently still unable to stand up to the heavy loads common on American roads.

FATAL STEAM-PIPE EXPLOSION FROM WATER-HAMMER.

A FORMAL investigation under the provisions of the Boiler Explosions Act, 1882, has been conducted by the Board of Trade at the Town Hall, Stratford, E., into the cause and circumstances attending a steam-pipe explosion which occurred on October 31, 1910, at the Electricity Works, Marshgate-lane, Stratford, belonging to the Charing Cross, West End, and City Electricity Supply Company, Limited.

The investigation was conducted by Mr. A. A. Hudson, K.C., and Mr. G. Fullerton Bell, consulting engineer. Mr. George C. Vaux appeared for the Board of Trade, Mr. Lane for the owners of the works, and Mr. Percy Gibbs for George Town, one of the men injured by the explosion.

Mr. Vaux, in opening the proceedings, stated that at the end of October a new range of steam-pipes, including two stop-valves, was fixed up at the Bow works to carry steam to some new engines. The steam-valves were made in 1889, and were originally used at the Lambeth works at a pressure of 165 lb. per sq. in. From October, 1909, to March, 1910, they remained unused, and were then fixed at the Bow works for a pressure of 180 lb. per sq. in. In September, before being fixed, the valves were stripped entirely and examined by Mr. Ernest Coates, the company's superintendent engineer, and Mr. J. W. Kingston, works foreman, who was subsequently killed by the explosion. The work of erection was supervised by Mr. Coates, who was assisted by Mr. Kingston. Orders were given that the work must be completed without delay, and steam was not to be admitted into the new pipes until all was in working order. A steam-trap was fitted, and steam was admitted into the new range by Wilson, one of the foremen, at 3.30 p.m on October 30. One of the steam-valves, A, was gradually closed until the full pressure was on the new pipes, but half-an-hour later it was slightly open, and water and steam issued from it. At 7.30 the next morning the valve was again seen, and water and steam appeared to be coming from it. Shortly afterwards, when the valve B was still shut, orders were given that it should be opened very gradually. An assistant named Blyth commenced to turn the wheel gently, acting on signals from the foreman, until he was requested to stop. Almost immediately a knocking sound was heard in the pipes, and this was followed by a violent explosion. Both valves were completely fractured, and the room was filled with steam. The valve admitting the steam to the new pipes was shut off as quickly as possible, and it was then found that Mr. Kingston, the foreman, was killed, and that a fitter named Henry Hands was so severely injured that he died shortly afterwards. Three other men were also injured, but fortunately recovered. Mr. Vaux stated that the pressure in the pipes at the time of the explosion appeared to have been 175 lb. He thought it would be found, from the evidence to be given, that no question would arise as to the fitness either of the valves or of the pipes for their intended purpose. What would have to be considered was whether there were proper means for draining the pipes, and at this point he might say that there seemed to have been an unfortunate mistake on the part of the deceased foreman in the carrying out of his instructions.

Mr. Walter Henry Kingston, chief engineer to the Electricity Supply Company, said he designed the whole of the plant for the works in 1901, and remained in charge till 1906, when he was appointed engineer-in-chief. Mr. Coates was appointed superintendent of the Bow Works, and the late Mr. J. W. Kingston was foreman. In 1910 witness designed a new length of steam-piping and two steam-valves to meet certain demands of steam. The valves were in perfectly good condition, and witness saw them before they were fitted, and was satisfied that they were fit for the pressure for which they were intended. Three lengths of 5½-in. piping were used, and these were in accordance with his designs.

In reply to Mr. Vaux witness stated that he anticipated that when the length of pipe was energised the valve A would be closed, but to his knowledge there were no special directions on that point. On Monday, October 31, he received a telephonic communication, and on going to the works found that the three 5½-in. pipes had been detached from their position, and that both valves had burst, with the serious consequences that had been mentioned.

In answer to Mr. Vaux, witness said that the cause of the explosion was water-hammer. Although two steam-traps had been connected to the new range of piping with the object of sufficiently draining it, and although the foreman remained until late on the Saturday night to complete his work, valve B was closed, and so put both steam-traps out of operation. The result was that when steam was admitted into the range on the afternoon of Sunday, it condensed in the three lengths of pipes, and a quantity of water collected there. This was perfectly harmless had it been allowed to remain without being moved, but on the Monday morning valve B was opened, allowing part of the water which had collected to be discharged into the water-separator attached to the engine. This would cause a part vacuum, and send the water in motion. In consequence of this, the water would pass through valve A and then rebound with considerable velocity, which would be checked by the two valves, resulting in this rupture. Witness went on to say that on the Sunday following the accident, he replaced the two injured valves with new ones, and also replaced the steam-trap; valve A was closed and valve B was opened; steam was then turned into the pipes, and no trouble whatever was experienced. The pipes had been in working order since that time without trouble of any kind.

Mr. Ernest Coates, superintendent engineer to the Electricity Supply Company, gave evidence of a similar nature, and said that there were two knocks followed by an explosion. The explosion was undoubtedly due to water-hammer action.

In reply to Mr. Lane, witness said that the energising of the new pipes was not a difficult undertaking; it only required a little ordinary care, and the deceased foreman was a competent man. If valve B had been left open there would have been no trouble. He could give no other explanation for the mistake beyond some mental lapse or some misjudgment on the part of the deceased.

James Wilson, boiler-house foreman, was the next witness, and in answer to Mr. Lane, said the late Mr. Kingston, told him particularly not to open valve B. He thought himself competent to undertake the work entrusted to him, and it was quite an ordinary proceeding for him to put on and take off the steam. Possibly it would have been better had he taken orders from Mr. Coates instead of the late foreman.

David Baxter, engine-fitter, said the deceased foreman also told him to make sure that valve B was closed, but for what reason he did not say. Witness was instructed to drain the pipes dry, and this having been done, steam was turned on gradually. He noticed valve A leaking, and it continued to do so until the Monday morning. Valve B had been kept shut all the time, and to his knowledge it was never opened. Witness heard the knocking in the pipes, and ran to tell the foreman, who made no reply, and a second later the explosion occurred. Witness crawled on the floor and escaped without injury.

After further evidence by two of the workmen, Mr. William George Coomber, engineer-surveyor to the Board of Trade, said he made an examination after the explosion, and found that the end of valve A had been blown a distance of 24 ft., and the other valve was cracked. He came to the conclusion that the explosion was due to water-hammer. He thought that if valve B had been open the steam-traps would have taken off the water rapidly enough to avoid the accident. The reason was that both the valves were erected in a horizontal position, and witness thought there should have been a drain in the lowest part of the pipes to have taken off the water. He was of opinion that the valves should not have been fixed horizontally, but vertically, because when they were in the former position it was quite impossible to drain the pipes. A steam-trap should have been fixed at the lowest portion of the pipes, so that the water would gravitate there and drain off. Witness also took exception to the level of the pipes, &c. The lowest point was near valve A, and, owing to the vertical position of the valve, a considerable portion of the water would always remain in the pipes.

Mr. Kingston said he would like here to point out that the valves were not put in for drainage purposes, but only for shutting off the range when necessity occurred.

At the conclusion of the evidence the presiding Commissioner, Mr. Hudson, delivered judgment, reviewing at some length the events which led up to the explosion, dealing fully with the arrangement of the pipes and valves, and also with the cause of the explosion, which, he stated, was simply water-hammer. Dealing with the question of the responsibility of the different persons who had been made by the Board of Trade parties to the inquiry, the Commissioner said that with regard to Mr. Kingston, the superintendent engineer to the Electric Supply Company, the Court considered that the design of the new range of steam-piping without some method of drainage was defective. It mattered not whether the drainage was by means of traps or some other effective method. In the second place, knowing that it was dangerous to admit steam with valve B closed, he gave no explicit instructions on the subject. Mr. Kingston had told the Court that the valves were never intended for drainage, and no doubt this was correct; but valve A had to be used for drainage, and in the condition the pipes were in at the time when steam was let in, the valve was not an effective means to this end. In the third place, a system was in operation at the works by which the foreman of one department could give an order to another foreman without any communication with Mr. Coates or anyone else in authority. Mr. Coates had a good deal to answer for, but he was not responsible for the order to the works foreman to close the valve B. With regard to Mr. Coates, the presiding Commissioner said there were many matters to which reference might be made. Mr. Coates's chief responsibility lay in the fact that when he was in charge of the works on the morning of the explosion he failed to satisfy himself that the pipes were free of water. Further than this, Mr. Coates had said that he knew it was very dangerous to open the valve, but he was present when it was opened, and made no objection. He left the operation to a subordinate, a person who had apparently had nothing to do with pipes charged with steam. With regard to the question of the blame which attached to the Electricity Supply Company, it was scarcely conceivable, the President said, that the owners of a works of this magnitude should be so reckless as to place an engineer in charge who at the time had apparently only served an apprenticeship with regard to steam. He might be, and no doubt was, highly competent to look after an electricity plant, but, in the judgment of the Court, he had not had sufficient experience to look after the steam plant, and the company ought to have known it.

On this finding of the Court, Mr. Vaux made application for costs against the parties found to blame.

The Commissioners then retired to consider the question of costs, and, on returning to the Court, the presiding Commissioner stated that they had taken into consideration the question of the amount which, in their opinion, they should order to be paid to the Board of Trade as costs. In view of the fair way in which both Mr. Coates, the superintendent engineer, and Mr. Kingston, the engineer-in-chief, had given their evidence, and having regard to the distress which any criticism of their conduct professionally must cause them, the Commissioners had decided to make no order for costs against those gentlemen. With regard to the Charing Cross, West End, and City Electricity Supply Company, Limited, the Court held that they were to blame, and therefore ordered them to pay the sum of 100*l.* towards the costs of the investigation.

COAL-MINING IN JAPAN.

WHEN the subject of the future of our coal supply is being discussed in this country, it is interesting to note how things are shaping in Japan. While the quantity of coal produced is increasing slowly, the prices obtained are going down rapidly, as is shown by the following statistics for the past five years:—

	Quantity. Metric Tons.	Value. Yen.
1906	12,980,103	63,144,000
1907	13,803,969	59,961,264
1908	14,835,363	63,622 773
1909	15,048,113	58,213,680
1910	15,681,324	49,379,308

The consequence of the falling prices has been that many colliery-owners have been compelled to abandon business; with the exception of the Mitsui, Mitsui Bishi and some other large mine-owners, most of the collieries have discontinued working, and are waiting for brighter prospects. The main cause of this depression in the coal trade is very interesting, as it is said to be mainly attributed to the remarkable decrease of demand consequent on the recent development of the hydraulic electric industry, aided, no doubt, by the general industrial depression. The downward tendency of the market price has been remarkable during the past year, when the price went down to 3.10 yen a ton, against 4.50 yen or so in 1909 (the yen is approximately 2s.). Should the depreciation continue for some time, it is feared that there will be a panic in the coal market. In these circumstances some of the colliery-owners of smaller means are gloomy over the prospects of the industry, and are thinking of disposing of their mining properties, which are thus likely to fall into the hands of the larger colliery-owners, at prices much below what they cost a few years ago.

We mention these facts as bearing on the industrial evolution of Japan, and its relation to competition in several departments with the countries of the West in which the price of coal is rising. Japan is specially favoured in the matter of water-power, and during the past few years remarkable progress has been made in its utilisation, and the Government is doing all in its power to favour this development. Some time ago it appointed a Commission for the purpose of examining and making a record of the water-power resources of the country, in the hope of assisting in the development of the use of water-power, and at the same time to guard against the granting of water-power concessions to persons seeking to obtain them for speculative purposes. The water-power for which charters have been granted is estimated at some 592,000 kw. In addition to the use of hydro-electric power for lighting and traction purposes there is undoubtedly a great future for it in supplying the requirements of factories and mines of all kinds. Besides the power-stations already erected, a large number are in contemplation or in course of erection. This action on the part of the Japanese proves (as many other things have done) that they take long views of the work they undertake, and not only conserve their coal supply, but as far as possible make themselves independent of it for industrial purposes. We wish we could feel that we, in this country, had always been as far-seeing.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—A number of gentlemen interested in the automobile industry met at the Albion Hotel, Manchester, on Wednesday night, October 25, at the invitation of Mr. Edgar Stafford, to discuss the feasibility of the formation of a north provincial branch of the Institution of Automobile Engineers. Mr. Stafford was voted into the chair, and the meeting was addressed by the secretary of the Institution, and a resolution was unanimously passed that the Council of the Institution should be requested to permit the formation of a branch. Some thirty-five of those present, from Lancashire, Yorkshire, and Cheshire, expressed their desire to join, in addition to the forty-two gentlemen in those counties who are already members of the Institution.

PRIZE COMPETITION OF THE VEREINS DEUTSCHER GIESSEREIFACHLEUTE.—The Vereins Deutscher Giessereifachleute offers three prizes, of the value of 1000, 500, and 300 marks respectively, for the best three essays on whether any practical progress has been made during the last twenty years in cupola furnace construction. With regard to the handling of this question, special value will be placed on information relating to advances in economy and in improvement of the quality of the molten material. The hygienic side of furnace working should also be dealt with. A committee of the following gentlemen has been formed to judge the essays:—Geh. Regierungsrat Professor Dr.-Ing. F. Wüst, Aachen; Kais. Regierungsrat W. Schlenker, Berlin; Professor Dr.-Ing. A. Nachtweh, Hanover; Direktor C. Gilles, Berlin; Direktor F. Meyer, Winterthur; Direktor C. Henning, Mannheim; Dipl.-Ing. H. Adämmer, Hengelo; Ober-Ingenieur C. Humperdinck, Durlach; Direktor H. Dahl, Berlin; Giesserei-Ingenieur F. Bock, Berlin. Detailed conditions can be obtained from the Geschäftstelle des Vereins Deutscher Giessereifachleute, Berlin - Charlottenburg Sybelstr. 60.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

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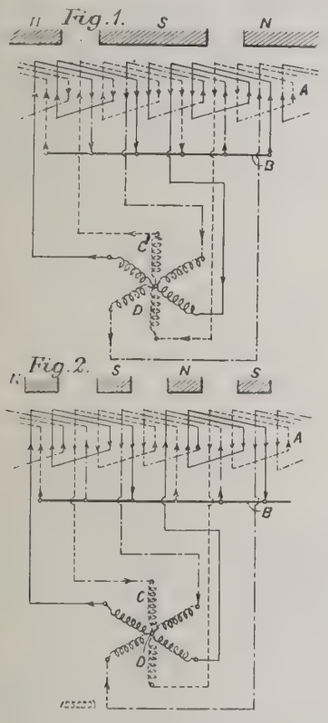
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

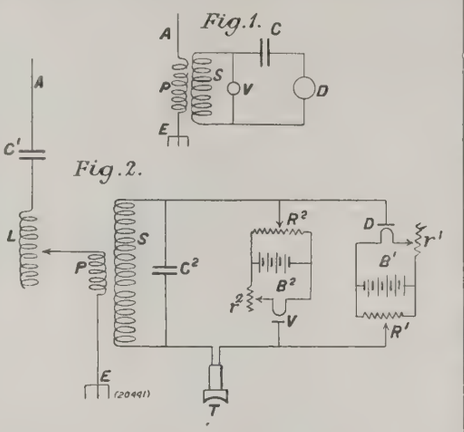
ELECTRICAL APPARATUS.

25,683/10. The British Thomson-Houston Company, Limited, London, and J. Martin, Rugby. Alternating-Current Induction Motors. [2 *Figs.*] November 4, 1910.—An alternating-current induction motor, according to this invention, has a primary member wound so as to produce a variable number of poles in the ratio of 2 to 1 and a secondary member having a star connected six-phase winding, the latter operating inductively as a single-winding for one number of poles of the primary member or as two windings of half the number of phases for the other pole member. The stator of an asynchronous motor has a three-phase winding adapted to be connected so as to produce either two poles, as in Fig. 1, or four poles, as in Fig. 2. The rotor is fitted with a six-phase diametrical



winding A, with its neutral or crossing points permanently connected together by the conductor B and its free ends connected to slip-rings, between which are connected an adjustable six-phase resistance C having a common neutral point D. When the stator winding is excited as a two-pole winding, as in Fig. 1, the rotor winding responds as a six-phase winding, and the motor runs at a speed corresponding to the two-pole connection of its stator winding, which speed may be varied by controlling the resistances connected to the slip-rings. When the stator is connected for double the number of poles, or four poles, as in Fig. 2, the rotor winding responds as two distinct three-phase windings, and the speed of the motor in this connection may again be controlled by variation of the rotor resistances. (*Accepted September* 6, 1911.)

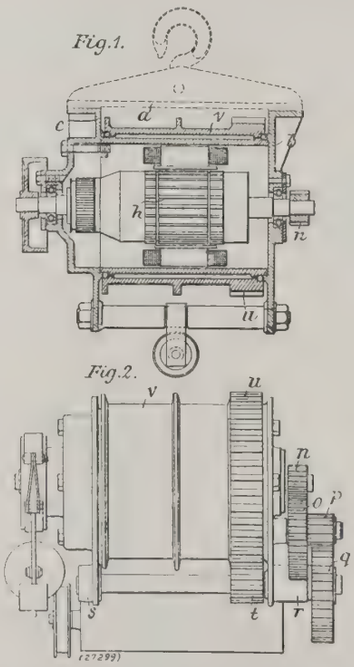
20,441/10. Marconi's Wireless Telegraph Company, Limited, and H. J. Round, London. Wireless Telegraphy. [4 *Figs.*] September 1, 1910.—According to this invention, the effects produced by powerful atmospheric discharges are reduced or eliminated, and for this purpose a path which is normally a bad conductor, but which, when acted upon by powerful oscillations, becomes a relatively good conductor, is provided in the receiving circuit. The path is so arranged that it annuls the effect of the current in the receiver circuit when it is a good conductor, but does not materially affect the signals when it is a bad conductor. The applicants employ for this purpose unidirectional conductors of the type specified, and have found that mercury-vapour valves, crystal detectors, and Fleming valves are suitable. In Fig. 1, the aerial A is connected to earth E through the primary P of an oscillation transformer. The secondary S is connected through the condenser C to the receiver D. The variable conductor V is connected across the secondary S. When the circuits are in tune, signals can be received if they are not sufficiently strong to affect the variable conductor V; but if a powerful atmospheric discharge occurs, the variable conductor V will become a shunt to the secondary S, and very little effect will be produced in the receiver. The variable conductor V is of the unidirectional type, and two such conductors are employed connected in parallel and in opposition as shunts across the secondary. Only one such conductor may be employed when a receiver which is also of the unidirectional type is used. Fig. 2 shows such an arrangement. The aerial A is connected to earth E through the condenser C^1, inductance L, and primary P. The secondary S is connected to the condenser C^2, and across this are the valve-receiver D and telephone T, the latter being connected either direct to the circuit as shown, or through a transformer. The variable conductor V is connected in parallel with the receiver D, which, in this case, is a similar Fleming valve connected in opposition. The filaments of the valves D and V are rendered incandescent by the current from the batteries B^1 and B^2 passing through the adjustable resistances r^1 and r^2 respectively, and R^1 and R^2 are potentiometers for varying the voltages across the valves. When the circuits are in tune, signals can be received in the telephone T if they are not sufficiently strong to affect the variable conductor V; but if a powerful atmospheric discharge occurs, the valves D and V become almost equally operative, and, being in opposition, no rectification takes place, and no sound is produced in the telephone T. It will be seen that the variable conductor V must not be sufficiently sensitive to be affected by the received signals, and as the strength of the received signals may vary considerably, it is



necessary either to adjust their effect upon the variable conductor V, or to vary the sensitiveness of the latter. For example, if the signals are so strong as to affect the variable conductor V, the coupling between the primary P and secondary S may be weakened by moving them apart until the variable conductor V is no longer affected by the signals. But it is preferable to adjust the sensitiveness of the variable conductor, and since its resistance varies with the voltage across it, this can conveniently be done by applying an adjustable voltage to the variable conductor. Thus, in Fig. 2, the potentiometers R^1 and R^2 may be adjusted to give such a voltage across the valves D and V that the additional voltage due to the signals is sufficient to render the valve D operative, but insufficient to appreciably affect the valve V, while the additional voltage due to a powerful atmospheric discharge is sufficient to render both valves operative. (*Accepted September* 6, 1911.)

LIFTING AND HAULING APPLIANCES.

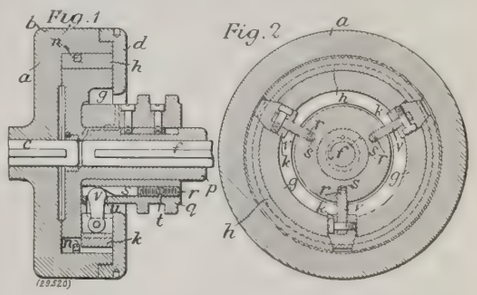
27,299/10. Adamson, Ramsbottom, and Co., Limited, and H. Ramsbottom, Birkenhead. Hoists. [3 *Figs.*] November 23, 1910.—In an electric hoisting apparatus which may be hung from a fixed support, or may form part of a travelling carriage, according to this invention, the supporting member has end plates upon it carrying between them the stationary carcase of the motor with the fixed field portion thereof, while the armature is revolubly supported in the end plates and is suitably geared to the hoisting drum, which is supported on bearings around the stationary carcase of the motor. The top piece *a* of



the frame has two side pieces *b* and *c*, carrying between them the carcase of an electric motor. The carcase carries the field portion of the motor, and the armature *h* is supported in bearings in the end pieces *b* and *c*. On one end of the armature shaft *h* is fixed a pinion *n* which gears with and drives a toothed wheel *o* on a countershaft, and a pinion *p* attached to the wheel *o* serves to drive in turn a toothed wheel *q* on the end of a shaft supported in brackets *r*, *s*. This shaft carries a pinion *t* which drives a toothed wheel *u* on the pulley-drum *v* mounted around the carcase of the motor. (*Accepted September* 6, 1911.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

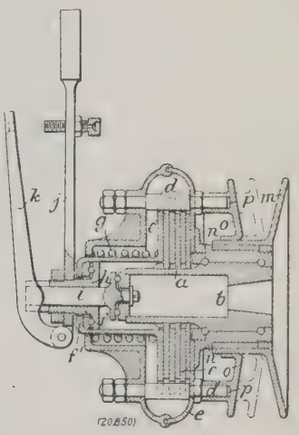
29,520/10. G. H. Broadbent, Hyde. Friction-Clutch. [2 *Figs.*] December 20, 1910.—This invention has particular reference to that type of clutch in which the two main elements consist of a flanged disc and segmental plates forced into contact with the inner surface of the flange by various mechanical means so as to obtain sufficient friction to turn the shafts which are coupled together by means of the clutch, the aforesaid mechanical means also being employed to disengage the disc and plates, being aided in such operation by a spring or springs. A friction-clutch of the type described, according to this invention, comprises a flanged disc fixed on one shaft having an inwardly-projecting removable flange at its open end, a second flanged disc on the other shaft located between the removable flange and the flanged disc, adapted to carry radially movable wedge-blocks mounted in holes formed in the latter, two or more segmental blocks arranged between the periphery of the second flanged disc and the inner face of the first disc, with the ends of which the wedge-blocks engage, a slidable sleeve mounted on the boss of the second disc carrying adjustable wedges supported in holes parallel to the clutch-shafts, and adapted to engage with the inner ends of links pivoted to the radially movable wedge-blocks, and a circumferential spring or springs located in circumferential grooves in the segments. A disc *a*, flanged at *b*, is secured to the shaft *c*. The open end of this flanged disc has secured to it a removable flange *d*, arranged parallel with the main disc *a*. On the shaft *f* is fixed another flanged disc *g*, the diameter of which is somewhat less than the



inner diameter of the flange *b*. In the space so left are arranged two or more loose and unpivoted segmental plates *h*, the ends of which are bevelled off and located a little distance apart from each other. In the spaces between the ends of the segments *h*, and sliding in radial holes in the flange *g*, are wedge-shaped blocks *k* adapted to force the segments *h* apart, and cause them to grip the inner face of the flange *b*. The segments are moved together when the wedges are withdrawn by one or more circumferential springs *n* located in grooves formed in the segments. For the purpose of engaging or disengaging the segments *h*, there is mounted on the boss *p* of the flanged disc *g* a grooved operating sleeve *q* which can be actuated by a forked lever. This sleeve is provided with holes *r* parallel to its axis, in each of which is located a hardened steel wedge *s* adjustable in an axial direction by means of screws *t*. Communicating with each hole *r* at a point near the inner end of the sleeve *q* is a slot *u*, through which one end of a pivoted lever *v* passes, each lever being arranged radially. The other end of each lever is coupled to one of the wedge-shaped blocks *k*. To operate the clutch, the slidable sleeve *q* is moved forward so that the hardened wedges *s* bear on the inner ends of the radial levers *v* and force the wedge-shaped blocks *k* between the bevelled ends of the segments *h*, so causing the latter to engage with and grip the inner face of the flanged disc *a*. This operation is carried on against the action of the springs *n*. When the slidable sleeve is moved in the opposite direction the springs *n* contract the segmental blocks *h*, thus forcing the wedges *k* towards the shaft and allowing the segments to become disengaged. (*Accepted August* 23, 1911.)

MOTOR ROAD VEHICLES.

20,850/10. East London Rubber Company, London, and E. A. Baines, Gainsborough. Motor Cycles. [1 *Fig.*] September 7, 1910.—This invention relates to clutches especially applicable for use with motor-bicycles, which clutches consist of two series of plates held in contact by a spring, the plate with which the spring engages being formed with a tubular projection, around which the spring circles. According to this invention, the spring is compressed by a sleeve caused to slide on a stud attached to the engine-shaft by a lever, whose fulcrum is the stud. *a* are plates attached to, but free to slide on, the



engine shaft *b*, whilst *c* are plates attached to, but free to slide upon, two rods *d*, *d* secured to the clutch-casing *e*. On one end-plate *c* is a tubular projection *f*, around which the spring *g* is coiled. Engaging with the flange *f*¹ on the projection *f* is a sleeve *h*, free to slide on a stud *i* attached to, but not capable of revolving with, the engine shaft *b*. To the sleeve *h* is secured a bar *j*, pivoted to which is a lever *k*. On pressure being applied to the end of the lever *k* in any convenient way, the sleeve *h* slides on the stud *i*, moves the outer end-plate *c* mentioned, compresses the spring *g*, and leaves the plates *a* and *c* free to revolve in

relation to one another. The wheel with which the driving-band engages is made in two parts; one part m is secured to a ring n secured to the casing e, whilst on the other part o are sockets p of varying depth, into which enter the rods d. The position of the part o when the depth of the socket is small is shown in dotted lines. By these means the wheel may be easily adjusted for use with bands of different widths. (*Accepted August* 16, 1911.)

PRINTING AND ALLIED MACHINERY.

21,537/10. H. B. Croker, London. Die-Printing Presses. [4 *Figs.*] September 16, 1910.—In a die-printing press having a reciprocating die-carrier and die, and, according to this invention, the die-carrier is connected with the driving means through a connecting-rod formed of two parts so arranged that relative motion therebetween takes place when the die-carrier and die-plate arrive at the printing point, and remain stationary while the impression plunger is moved in relation to the face of the die, the carrier and die remaining stationary all the time during which relative motion of the parts of the connecting-rod takes place. The main driving shaft 7 is mounted in bearings in the main frames 1, 2. 13 is a second-motion shaft driven from the shaft 7, and also mounted in the main frames 1, 2. On one end of the shaft 13 is a pinion 15 which meshes with a spur-wheel 16 on one end of a third-motion shaft 17 carried in the main frames 1, 2. 18 is a crank-wheel mounted on the shaft 17. The third-motion shaft imparts movement to the die-carrier and die, and also actuates the impression plunger. The crank-wheel 18 is connected through a connecting-rod 27 to an arm 28 fixed to a spindle 29 mounted in the main frames 1, 2. On the spindle 29 is mounted a lever 47 connected with one end of a connecting-rod 48, the other end of which is connected at 61 with the die-carrier 21. When the shaft 17 is rotated, the arm 28 and lever 47 are rocked and the die-carrier 21 is reciprocated. The angle through which the

Fig. 1.

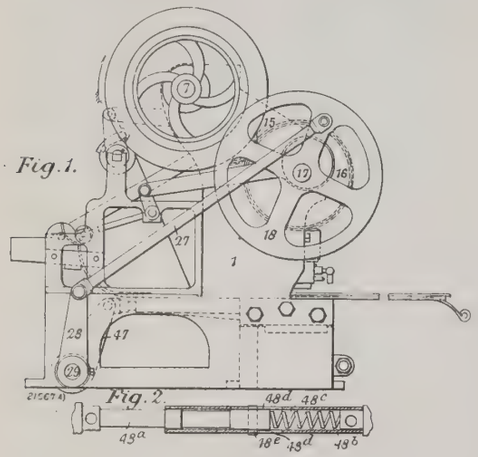
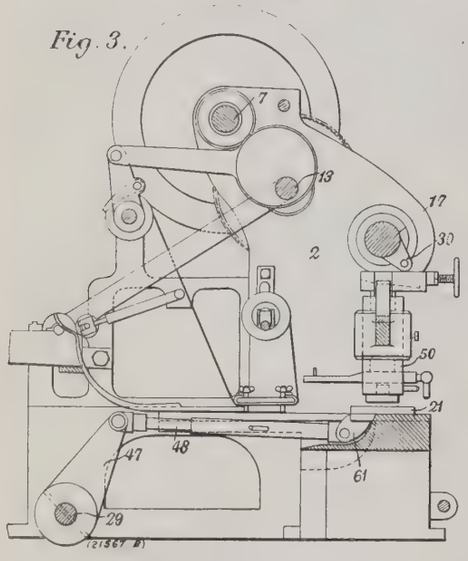


Fig. 2.

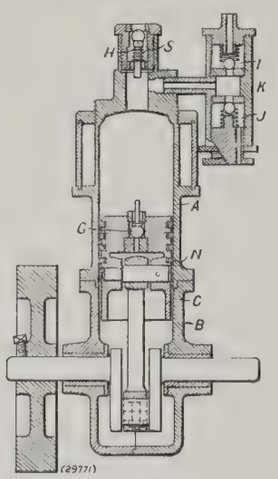
Fig. 3.



lever 47 rocks is greater than that necessary to reciprocate the die-carrier between the limits of its motion. To allow of this greater movement it will be understood that some means must be provided to permit of relative motion on the line joining the pins connecting the connecting-rod with the lever 47 and lug 61. This relative motion is allowed for by the connecting-rod 48, which is telescopic, and comprises a solid part 48*a* and a hollow part 48*b*, within which the part 48*a* can slide. 48*c* is a spring placed within the part 48*b* between the closed end thereof and the end of the solid part 48*a* contained therein. 48*d* is a slot cut in the part 48*b* longitudinally thereof, and 48*e* is a pin carried by the part 48*a* and engaging the slot 48*d*. The slot 48*d* and pin 48*e* limit the relative movements of the parts 48*a* and 48*b*. As before stated, the die-carrier has not a movement equal to the angular movement of the lever 47; the shortening of its stroke is effected by means of stops mounted on the machine frame. When the die-carrier is moved towards or from the front end of the press, its resistance to motion is not sufficient to alter the stress on the spring 48*c*. The stress is, however, altered as soon as the die-carrier in its movement towards the front end of the press comes into contact with, and is stopped by, the stops; relative motion in one direction is set up between the parts 48*a*, 48*b*, and the die-carrier remains stationary until the end of the lever 47 has moved through a distance in one direction equal to the length of the slot 48*d* and in the reverse direction to a similar amount. The contact between the end of the slot 48*d* and the pin 48*a* prevents further relative motion between the parts 48*a*, 48*b*, and the die-carrier is accordingly again set in motion and moved towards the rear of the press. 30 is a projection mounted on the shaft 17. The arm 30 forms the impression-depressing means. The pad or "force" is carried on the lower end of the impression plunger 50, normally maintained in a raised position by a spring, against the action of which it is depressed by the arm 30 so as to bring the pad or "force" on to the paper and press the same into contact with the face of the die on the die-carrier 21. (*Accepted September* 6, 1911.)

PUMPS.

29,771/10. W. Evans and Brecknell, Munro, and Rogers, Limited, Bristol. Air-Compressors. [2 *Figs.*] December 22, 1910.—This invention relates to air-compressors, and consists in the combination of a cylinder having a crank-chamber attached thereto, and an automatic admission valve for preventing the creation of a vacuum therein, of a tightly-fitting piston having an automatic admission valve therein, and a receiving chamber attached to the cylinder and fitted with an outlet-valve and an adjustable relief-valve. A is the cylinder to which is attached the crank-case B. C is a piston having a tight fit in the cylinder; G is a snifting valve in the piston, and which automatically regulates the admission of air to the cylinder for compression. The air flows in from the exterior of the cylinder through a perforation N and passes through the piston by valve G.



At the top of the cylinder is placed an inlet-valve H, having a regulating spring S for the purpose of allowing the entrance into the cylinder of sufficient air to prevent a vacuum during the down stroke of the piston. Attached to the head of the cylinder and at right angles thereto is a receiving chamber K, having at the top thereof a spring-controlled outlet-valve I, and at the bottom a spring-controlled and adjustable relief-valve J. The compressor operates in the following manner:—On the down-stroke of the piston sufficient air is allowed to enter the cylinder by the action of the automatic valve H to prevent a vacuum therein; air also enters through the perforation N in the cylinder and passes the automatic valve G, and is compressed on the up-stroke, and passes into the receiving chamber K, and from thence to its required destination through valve I, the pressure being controlled and adjusted by relief-valve J. (*Accepted August* 30, 1911.)

SHIPS AND NAUTICAL APPLIANCES.

19,626/10. J. Stone and Co., Limited, Deptford, and W. S. Parsons, Ladywell. Ash-Ejectors. [5 *Figs.*] August 22, 1910.—This invention relates to apparatus for discharging ashes from ships, the apparatus being of the type comprising a hopper, in which is deposited the material to be expelled,

Fig. 1.

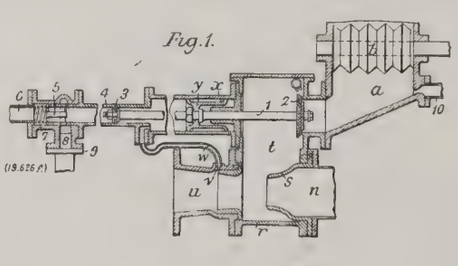
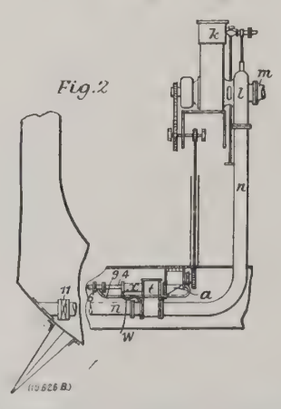


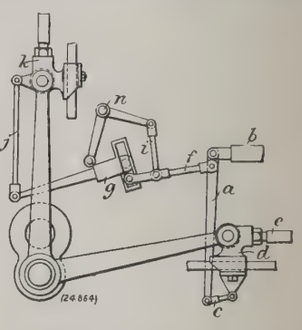
Fig. 2.



and a water circulatory system, comprising the discharge-pipe, to which system the ashes are admitted from the hopper, and are discharged by the stream of water. The invention consists in the combination of a contracted or coned water-jet nozzle and a flared or reversely-coned delivery-pipe connection in such operative relation with the nozzle that the ashes are sucked into the stream. The hopper a is provided with crushing rollers b, geared together and driven from the engine k, which also drives a centrifugal pump l provided with a suction-pipe m and a delivery-pipe n. The delivery-pipe n is connected to a casing r, and has a nozzle s delivering into a chamber or space t below and to one side of the hopper a. The other end of the casing r is provided with a nozzle u of opposite taper, and the pipe n is continued, and ultimately passes through the side of the ship. The nozzle u is provided with a cone or cones, leaving an annular space v communicating by a pipe w with a cylinder x, in which slides a piston y. One end of the piston-rod 1 carries a valve 2 for opening and closing the discharge orifice from the hopper a, while the other end of the rod 1 has mounted thereon a piston 3 working in a cylinder 4 open on one side to the low-pressure end of the cylinder x, and on the other side through a hollow piston-valve 5 to a pipe 6 in communication with the sea. This valve 5 is provided with a spring 7, which tends to keep it closed. A port 8 connects by a pipe 9 with the water inlet 10 of the hopper a, the valve 5 being opened by the end of the piston-rod 1, when the latter is moved owing to the partial vacuum set up in one end of the cylinder x by the suction action of the jet passing by the annular space v. The discharge pipe is provided with a gate valve 11. In operation, as long as the jet is powerful enough to effect the discharge of the ashes, there will be sufficient suction through the pipe w owing to the action of the stream flowing past the space v, to reduce the pressure on one side of the piston y so as to allow the atmospheric pressure acting upon the other side to force back the piston to open the valve 2 against the action of the head of water upon the small piston 3. As soon, however, as the jet diminishes or ceases, owing to a stoppage of the engine, or other breakdown, the pressure in the pipe w will rise, so that the pressures upon both sides of the piston y will be equalised, or nearly so, and the pressure upon the piston 3 will at once effect the closing of the valve 2. Therefore it is not essential that the gate valve be closed immediately a breakdown occurs or the jet ceases, as the automatic closing of the valve 2, the opening of which depends upon the sufficiency of the suction set up by the jet, ensures safety against flooding due to back-flow of the sea. (*Accepted August* 23, 1911.)

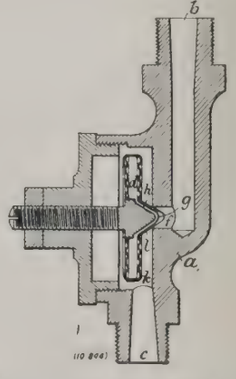
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

24,864/10. A. Robertson, Fleetwood. Valve-Operating Gear. [2 *Figs.*] October 26, 1910.—The invention relates to valve-operating gear for steam-engines, and particularly for steam-engines in which the high and low-pressure cylinders are set at right angles to one another. One end of a rocking lever a is pivotally attached to the low pressure valve-spindle b, the other end of the lever being secured by a link c to the crosshead d of the piston-rod e of the low-pressure engine. To the rocking lever a, and adjacent to the low-pressure valve-spindle, one end of a link or connecting-rod f is secured, the other end of



the link or connecting-rod working in a slotted T lever g fulcrummed about the centre of its slot. The link or connecting-rod f is also connected to a radius-rod i attached to the reversing lever n. The free end of the slotted T lever is pivotally attached by means of a connecting-rod j to the crosshead k of the piston-rod of the high-pressure engine. A similar arrangement of links and rods is employed for actuating the high-pressure valve-spindle, the one reversing shaft or spindle n acting by means of a bell crank lever and radius-rods upon both valve-gears. (*Accepted August* 23, 1911.)

10,844/11. W. M. Still and Sons, Limited, E. H. Still, and A. G. Adamson, London. Steam-Traps. [*Fig.* 1.] May 4, 1911.—In steam-traps of the kind in which the discharge of water and steam is controlled by the contraction and expansion of fluid contained in a capsule or chamber, the capsule or chamber has fixed to it a jacket which shields that part of its front wall that serves as the valve, an air or other fluid-containing space preferably being provided between the valve part and jacket. a is the casing, b the inlet thereto, c the outlet therefrom, d the fluid-containing capsule, e the adjusting screw, and f the

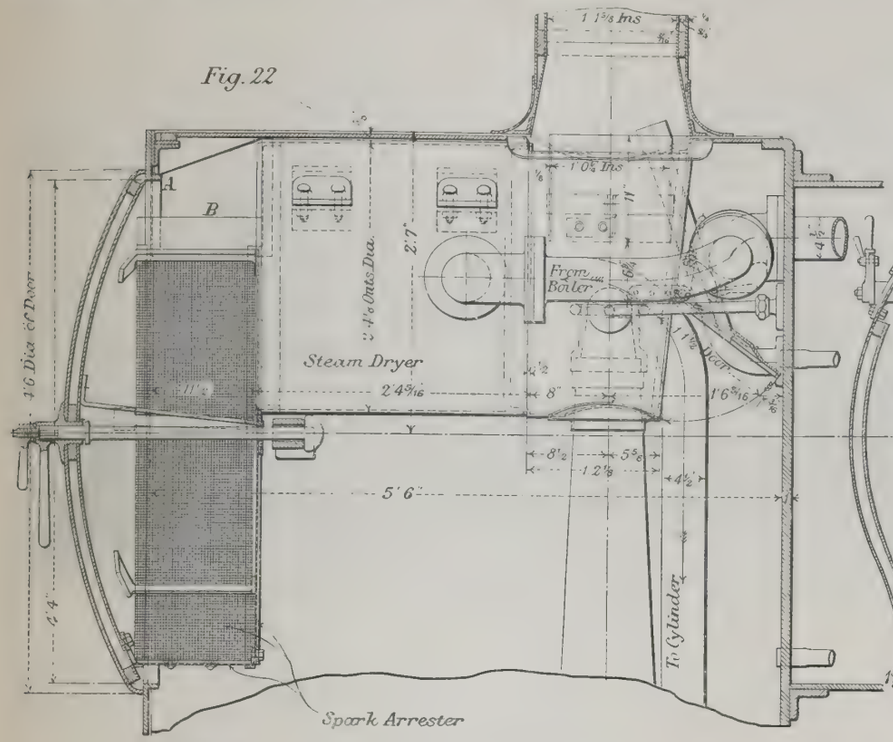


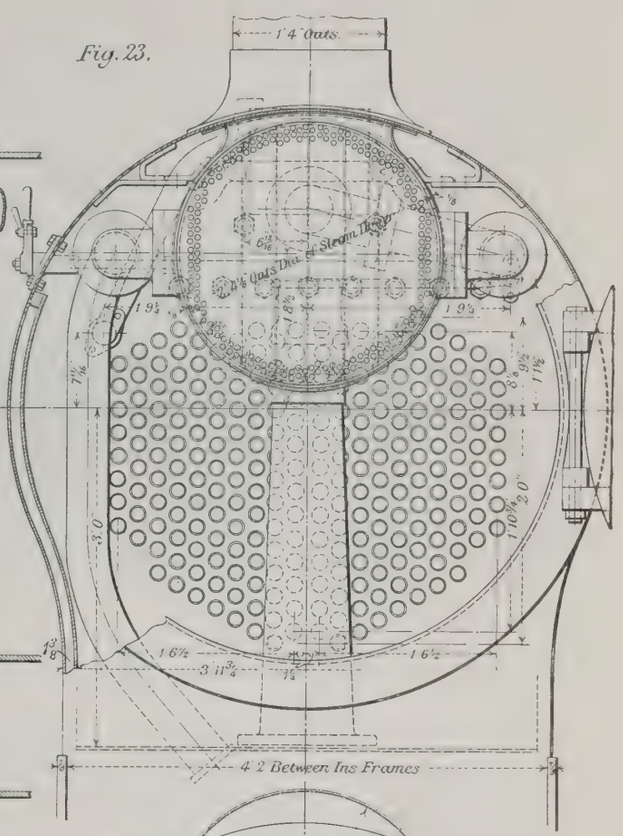
orifice to be closed. The front and rear walls of the capsule d are formed of concentrically corrugated diaphragms, the front wall being fashioned with a cone g to which the expansible fluid has access, and the rear wall with a similar but inward depression h adapted to receive the end of the screw e. k is the jacket which is similarly shaped to the front wall of the capsule d, but has a hollow conical valve-piece l, so shaped as to leave an air space between it and the cone g which delays the exchange of heat between the fluid in the capsule and that at the mouth of the orifice f, so that an intermittent action is obtained. (*Accepted September* 6, 1911.)

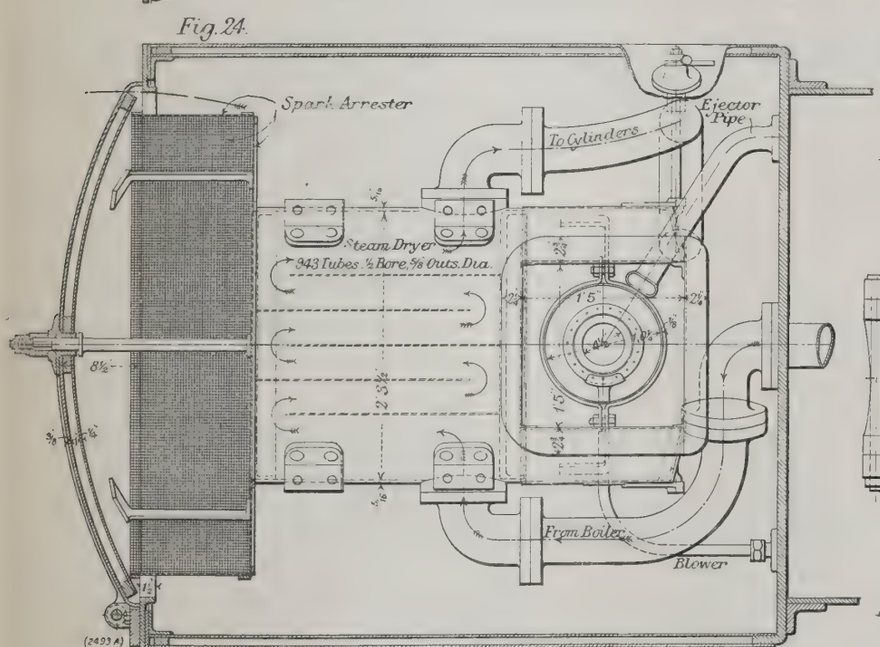
FEED-WATER HEATING AND SUPER-HEATING ON LOCOMOTIVES.—No. VI.

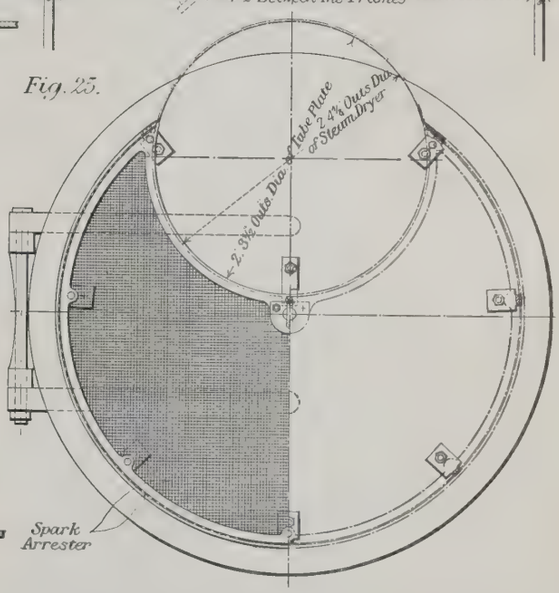
Comparative Trials of the Trevithick Combination System and the High-Degree Superheater System.

As a result of the trials, described in our last article,* on the Upper Egypt division of the Egyptian State Railways, between engines fitted with the Trevithick combination system of feed-water heating and moderate superheating, and ordinary engines of the same class, experiments were continued with a view to seeing whether improvement was attainable with other proportions for the smoke-box heater. Engines of the "695—725" class were used in connection with this further work. The class has already been described in Engineering† in connection with feed-water heating trials, in which No. 711 (heater engine) competed with No. 695 (non-heater). These engines are rather more powerful than the 612 class, and they are used for express working in Lower Egypt, where the line is more exposed and wind has a very great effect on train-working. The chief Lower Egypt train services are run between Cairo and Alexandria, and Cairo and Port Said, the former being the best as regards timing, and especially suitable for test purposes, owing to the comparative regularity of the loading of the trains, and the ease with which checking at either end can be carried out. For convenience the chief particulars of the two classes of engine are shown side by side in the statement subjoined.









* See page 517 *ante*.
† See vol. xci., page 271.

		"612" Class.	"695" Class.
Cylinders	.. .. in.	18×24	18×26
Driving-wheels, diameter	.. ..	6 ft. 3 in.	6 ft. 3 in.
Heating surface, tubes	.. .. sq. ft.	1108.4	1108.4
,, ,, fire-box	.. .. ,,	126.6	141.1
,, ,, total	.. .. ,,	1235·0	1249.5
Grate area	.. .. ,,	21.35	23.74
Working pressure	.. lb. per sq. in.	160	180
		tons cwt.	tons cwt.
Weight of engine and tender	.. ..	77 9	87 5

On account of its simplicity, the experiments were continued with the single-drum type of smoke-box heater, the proportions being altered in the direction of providing greater heating surface and more ample flue area. This step was taken as a result of experience with the "612" class, and it proved of considerable benefit. Such experience had suggested that more liberal provision in these directions would result in freer working, and an increase was therefore made over and above that considered to be necessary with the larger grate area and higher working pressure. In Table IX., subjoined, are given particulars of the two more important forms of heater tried, together with data concerning those applied to the Upper Egypt engines, for comparison.

The results obtained with engines 706 and 709, and with other modifications tried on other locomotives of the same type, were such as to lead to the conclusion that the best all-round arrangement was most certainly that of the type fitted to 706. With this, steam temperatures of between 80 deg. and 90 deg. Fahr. are obtained when the regulator

Table IX.—*Particulars of Single-Drum Smoke-Box Heaters.*

Engine	"612" Class	"706" Class	"709" Class
Smoke-box heater, inside diameter in.	25⅝	27½	30½
Smoke-box heater, length between tube-plates .. .. .. in.	24¾	24¾	36
Tubes, number	792	943	1169
,, size, inside diameter in.	½	½	½
Heating surface, total .. sq. ft.	270	322	574
Flue area .. .. ..sq. in.	156	186	229

is full open, calculated on the temperature equivalent to the boiler pressure. The point at which the temperature is recorded is near the entrance to the steam-chest, so that, if the practically unavoidable drop of pressure between the boiler and this point be taken into consideration, the actual superheat would most likely be somewhat in excess of the figure calculated on boiler pressure. This heater proved of convenient size in every way. It did not obstruct the smoke-box interior, and it gave a very free-running engine. While the heater fitted to engine No. 709 gave rather higher superheat—between 90 deg. and 100 deg. Fahr., calculated on boiler pressure—its size was rather against it. Its introduction rendered necessary the extension of the smoke-box, while the extra resistance to the flow of the gases, due to the greater length of tubes, did not give quite such a free engine, with the result that the advantage of the extra 10 or more degrees of superheat was in this way counteracted, and proved to be of little real benefit.

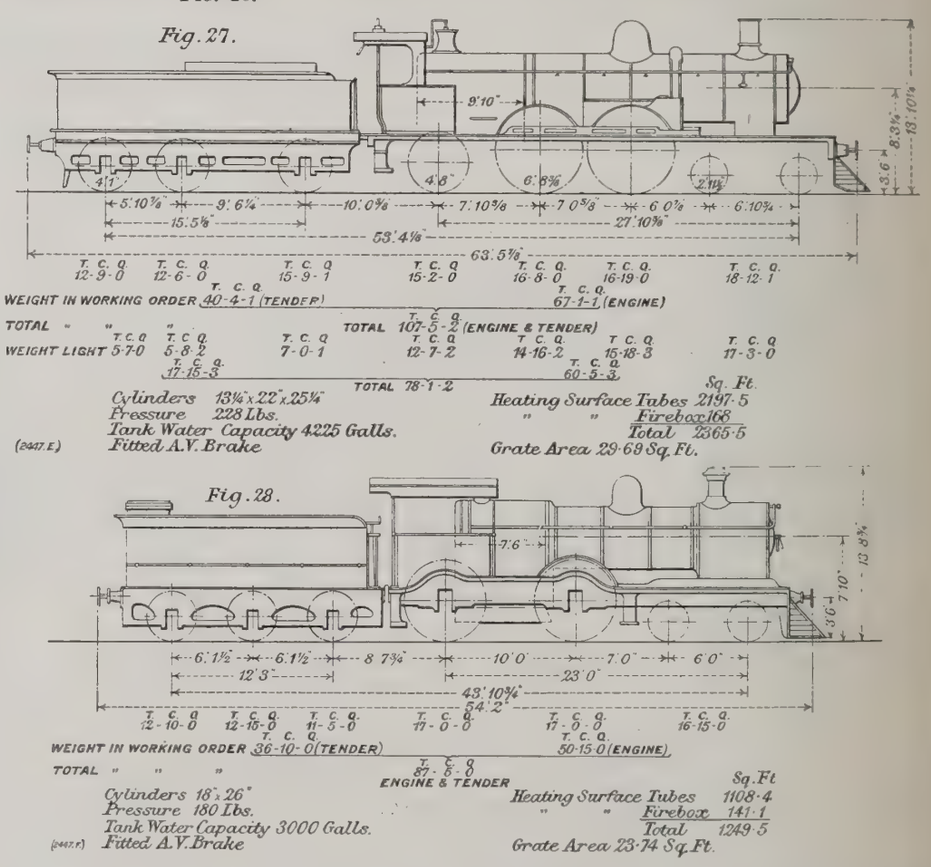
In Figs. 22 to 25, page 617, are given views of the smoke-box of engine 706. Fig. 22 shows the heater and the blast-chamber fitted at the back with the hinged door. This door can be opened and closed from the outside by means of the spindle and hand-lever shown in Fig. 23. The door is kept open while raising steam, and with this arrangement it can be shut without opening the smoke-box. The spark-arrester in this final arrangement is fixed wholly to the door. The horizontal netting is abolished and the arrester takes the form of a sieve with sides of mesh. It is cut away in the upper part so as not to cover the heater tube-plate, the enclosure being completed by a plate fixed inside the smoke-box. The smoke-box door and spark-arrester are shown in Fig. 25. On opening the door the whole smoke-box is thus left free of netting, a great convenience when any work has to be done in it.

In the spring of this year, soon after engine 706 had left the shops, trials were arranged between this engine and one of the same class, which had been converted to a high-degree superheater locomotive. In order that full justice might be done to the latter system, the matter of the conversion was entrusted to the Schmidt Company, Wilhelmshöhe, and at their direction Messrs. Henschel and Sohn, of Cassel, the original builders of the engine to be taken in hand, submitted an offer to the Egyptian State Railways for the supply of the necessary material. The work was stinted in no way. A free hand was given as regards proposals, and these the railways accepted without modification. The work of installing was, of course, done at the Egyptian State Railways' Works, Boulac, and involved practically the reconstruction of the engine, for, although it is known that slide-valves, provided with special lubrication, have been successfully used with high degrees of superheat, it was proposed to the railways that cylinders with piston-valves should be substituted for those with slide-valves of the standard Egyptian State Railway pattern. Everything, in fact, was done to put one direction, this loss was probably much more than compensated for by the advantages piston-valves possess over slide-valves as regards leakage, resistance, &c. In these matters engine 712 undoubtedly possessed a considerable advantage over the other engines of the same class engaged in the trial. The modification of the boiler was carried out in such a way that the total heating surface was increased from 1249 sq. ft. to about 1277 sq. ft., of which latter figure some 216 sq. ft. represented superheater tube surface, part of which, however, is, of course, in the smoke-box.

The General Manager delegated the supervision of the trials to Mr. H. W. Davis, M.I. Mech. E., of his office, now outdoor superintendent of the locomotive department. The test extended from the beginning of April to the beginning of May. This happens to be about the least favourable period of the year in Egypt for such a test, as the weather is then subject to violent disturbances, from which the climate of that country is, as a rule, free. The ordinary workings were therefore modified, each engine doing one single trip between Cairo and Alexandria each day, a distance of 130 miles. Each in this way completed fifteen double trips of 260 train-miles. The coaling and other arrangements were carried out as in the Upper Egypt trials considered in a previous article, all coaling being done at Cairo, and the engines carrying their coal in sealed bags, the weight of which was constantly checked.

In order to provide a basis of comparison, five ordinary engines of the same class were included in the same link working, and the best engine of a class of De Glehn compounds, with independent

Fig. 26.



FOUNDRY PLANT AND MACHINERY.

(*For Description, see Page* 621.)

Fig. 552.

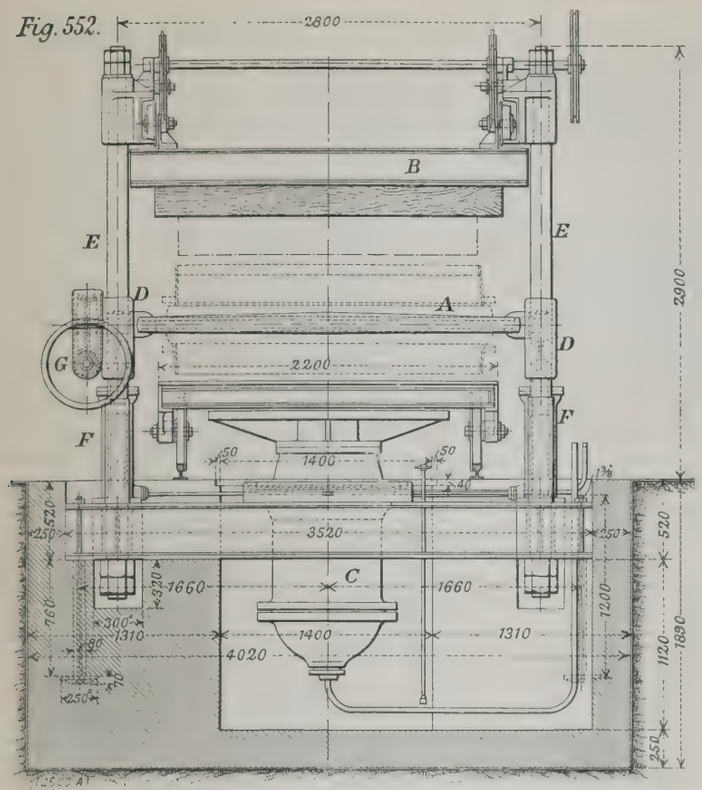
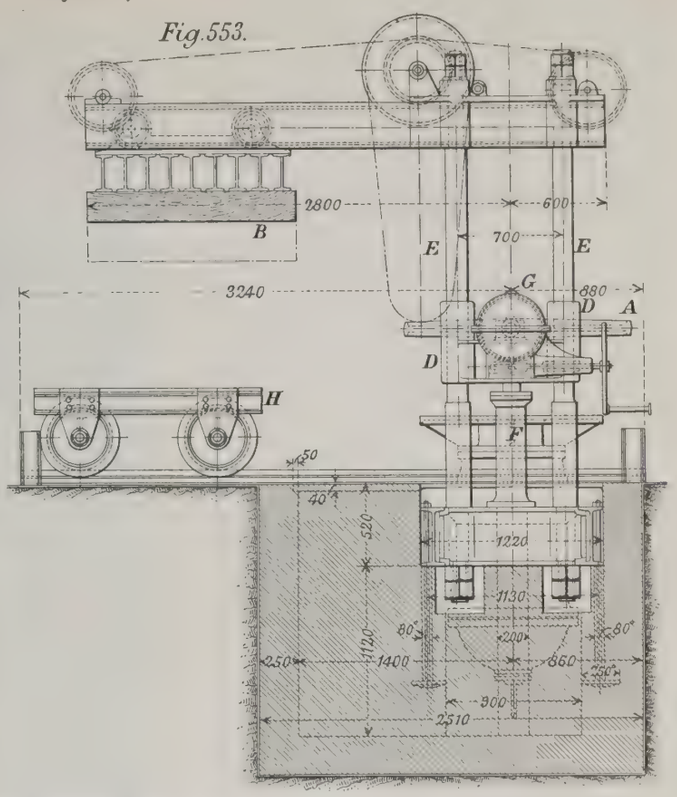


Fig. 553.



Figs. 552 and 553. Hydraulic Moulding-Machine; Messrs. Bopp and Reuther, Mannheim.

Fig. 554.

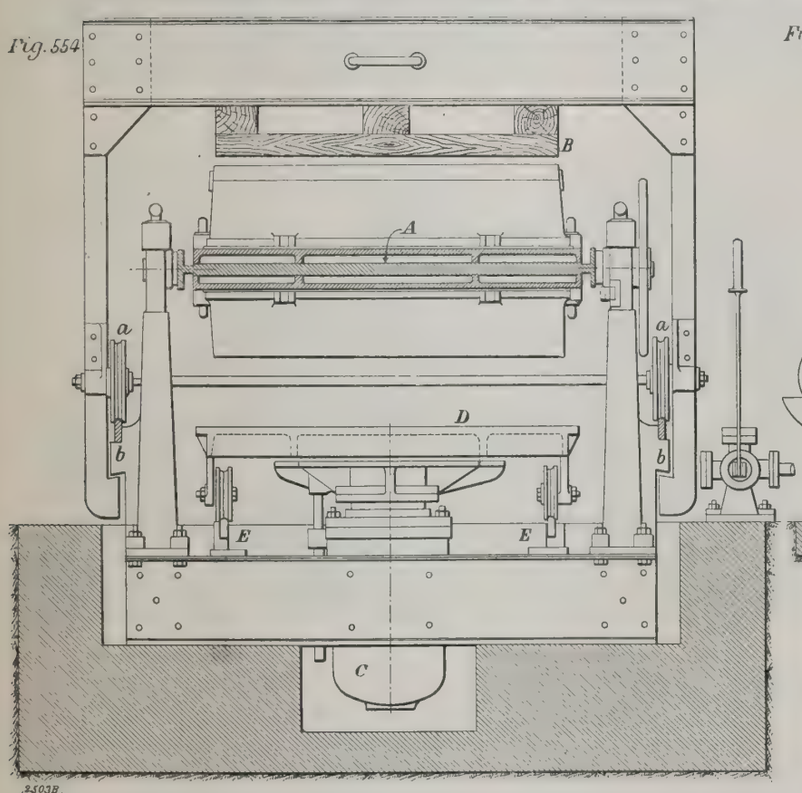
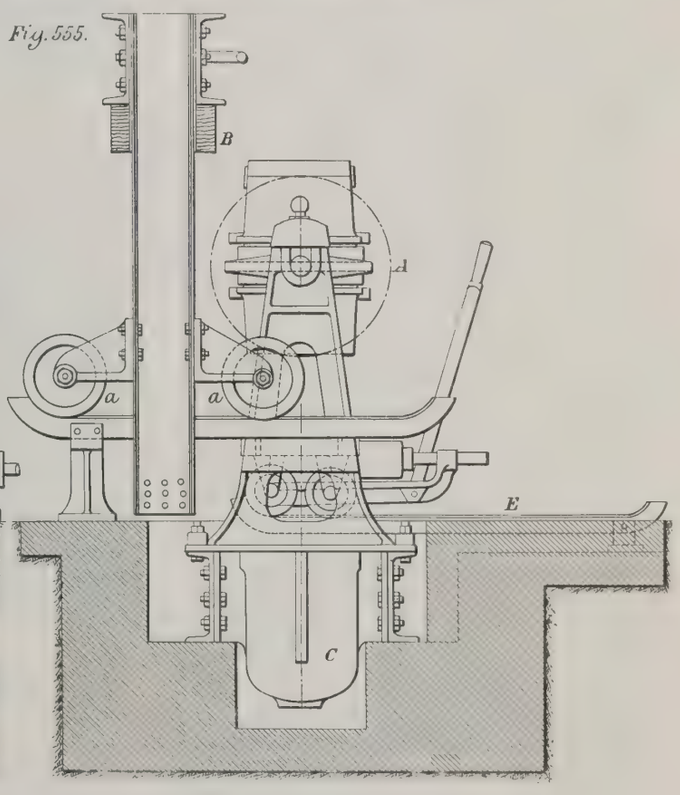


Fig. 555.



Figs. 554 and 555. Hydraulic Moulding-Machine; The Badische Maschinenfabrik und Eisengiesserei, Durlach.

cut-off to the high and low-pressure cylinders, was also run on measured coal over the same period and on the same trains. Two other De Glehn engines of the same class were also introduced into the trial at a later stage, but they were run on trains of rather a slower timing, so that their results are not quite comparable with those of the other engines, though the difference in conditions is slight. An external view of one of these compounds is given in Fig. 26, page 618, while Fig. 27 is a diagram showing the chief particulars of engines of this class. The diagram, Fig. 28, gives particulars of the class to which the four-coupled non-heater engines belonged, as also the engine 706, fitted up on the Trevithick system, and 712, fitted with a high-degree superheater. A class of large six-coupled passenger engines were also tried on the same schedules, against the heater engines and compounds, but the results were so unsatisfactory that their consumption is not recorded here. The trains selected for trial purposes were two daily expresses from Cairo to Alexandria, timed at mean speeds, omitting stops, of 42.6 and 43.3 miles per hour, and two daily from Alexandria to Cairo, at speeds of 42.4 and 43.1 miles per hour. The records for this test give the results shown in Table X., on the next page, these figures being quoted from Mr. Davis's report.

From these figures the savings recorded in Table XI. following are found to result, when engines on the Trevithick combined system, the

Table X.—*Coal Consumption of Trevithick, Schmidt, De Glehn, and Ordinary Locomotives, Egyptian State Railways.*

Engine Nos.	697, 713, 717, 720, 721	706	712	669, 674, 675
System	Ordinary.	Trevithick.	Schmidt.	De Glehn.
Average load, tare behind tender tons	328.65	336.14	332.83	333.53
Coal Consumption.				
Average per mile lb.	47.766	33.8	33.971	42.061
Average per ton-mile .. lb.	0.14534	0.10055	0.10207	0.12611

high-degree superheat system, and the De Glehn system of compounding, are compared with ordinary engines.

Table XI.—*Savings Realised with the Trevithick and Schmidt Heater Systems and the De Glehn System of Compounding.*

—	Trevithick System.	Schmidt System.	De Glehn Compound.
Saving on the pound per mile basis .. .. p.c.	29.24	28.88	11.94
Saving on the pound per ton-mile basis .. p.c.	30.82	29.77	13.29

So far as these trials were concerned, therefore, the Trevithick combined system and the high-degree superheater system gave results which were extraordinary for their similarity. A very slight advantage was recorded throughout for the Trevithick system, but the difference was scarcely material, except at the heavier loads, when engine 706 showed up very well. At the conclusion of his report Mr. Davis states: "I found that both engines Nos. 706 and 712 were stronger than the non-heater engines of the same class, and were able to deal successfully with heavier loads. Under heavy stress engine 706 steamed remarkably well, and had a good reserve of steam when it was necessary to let the engine out."

The heaviest trains in the trial were taken by engine No. 706, which showed so large an economy. The De Glehn engines were expressly introduced on to the system some years ago, before, of course, the heater systems had been brought to their present state of reliability and economy, in order to deal with heavy loads, but their usual train-loads do not exceed by much, if at all, the figure of 336 tons behind tender, which was the average hauled in these trials by engine No. 706. Their economy amounts to less than half the saving realised by the heater engine on either system. The non-heater engines took the lighter trains only, and even with these lost a great deal of time. Time was also lost to a varying extent with the other types of engines. The most important cases occurring to engine No. 706 were one loss of 17 minutes and another of 11 minutes, besides other smaller delays. The worst case of No. 712 was a loss of 10 minutes. All but one small loss occurred in the case of engine No. 706 within one week, and the runs on which engine No. 712 lost time also fall within this week. The engines of the other types included in the trial likewise lost time on these days, including even the powerful compounds, which suggests that this was a period of exceptionally heavy weather, such as is sometimes experienced at the time of year at which the trials were run. The report, however, does not enter into this point, neither do the figures for total coal consumed afford any correct indications with regard to this, since the coal is recorded for the double or round trip. A heavy run against a head wind might, of course, be followed by an easy return trip with a strong wind. The total coal consumption would then appear no different than for two average runs. Only when two heavy workings come together do the coal records reveal anything in the way of exceptional figures. The road worked over is very exposed; the line is raised above the surrounding flat Delta country, and the trains feel the full force of the wind, which is often very strong indeed.

The savings thus shown for the two heater systems are larger than those arrived at in previous articles, either in connection with the theoretical consideration of the two systems, or with the application of the combined system of feed-heating and moderate superheating on the Upper Egypt Division of the system. Some explanation for the difference between theoretical and practical results has already been given in Article V., while extended experience with engine No. 706 and other engines has confirmed the impression that the fullest benefit was not derived from the system as actually applied in the "612" class, owing to the waste gases not being able to pass sufficiently freely to the chimney, which necessitated, in that class, a smaller blast-pipe top than the system would otherwise have permitted. This having been rectified in the later arrangement, a blast-pipe top $4\frac{3}{4}$ in. in diameter is found suitable, compared with $4\frac{1}{2}$ in. for ordinary engines of the same class, the virtual increase in size being, as previously pointed out, for engines using exhaust-steam heating, very much larger than the actual increase. On the other hand, the high-degree superheater engine, No. 712, would only steam properly when the blast-pipe was reduced from $4\frac{1}{2}$ in. to $4\frac{3}{8}$ in. A similar change has been recorded as necessary in connection with the Purdue trials, but no explanation for this is offered in the reports on these tests. It appears probable, however, that this reduction is a necessary accompaniment of the reduced volume of steam consumed, which, with the standard top, would give too low a vacuum. The top has therefore to be reduced to some extent, though, on account of the reflex influence of the demand for less steam, the reduction need not be quite in proportion to the smaller volume. In the Trevithick system the demand for steam is also reduced to some extent, but not, of course, to the

FOUNDRY PLANT AND MACHINERY.

(*For Description, see opposite Page.*)

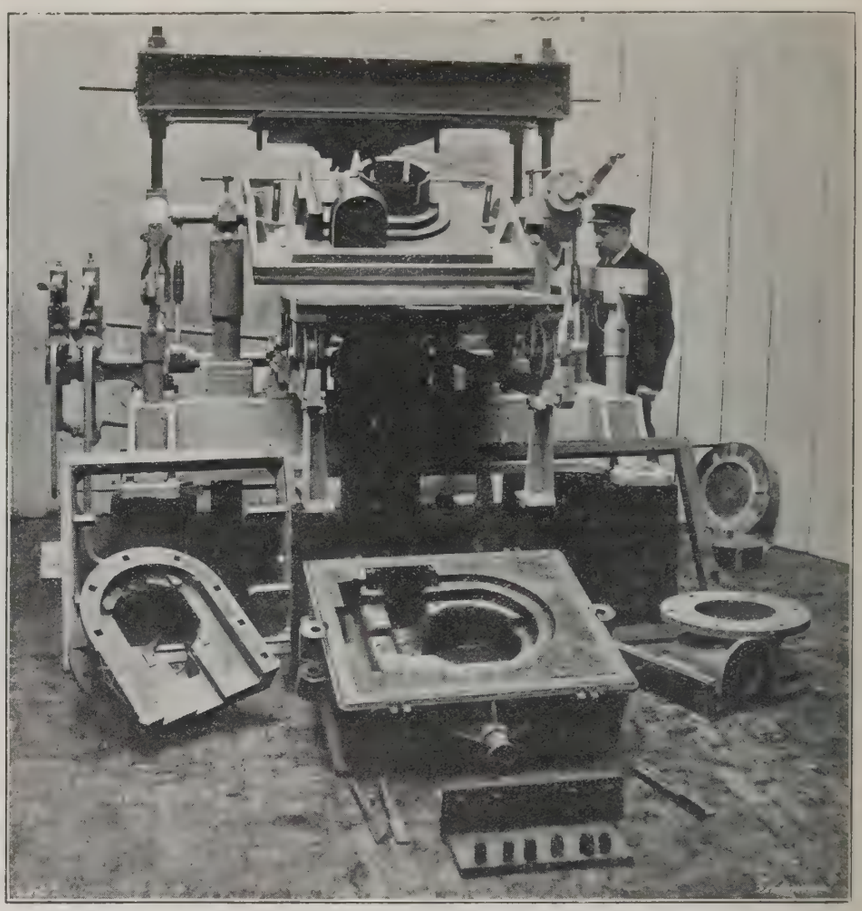


Fig. 556.

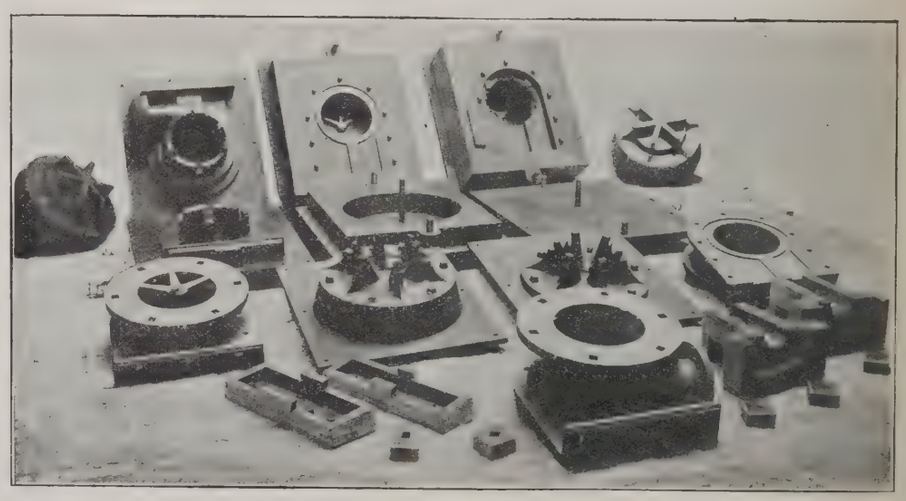
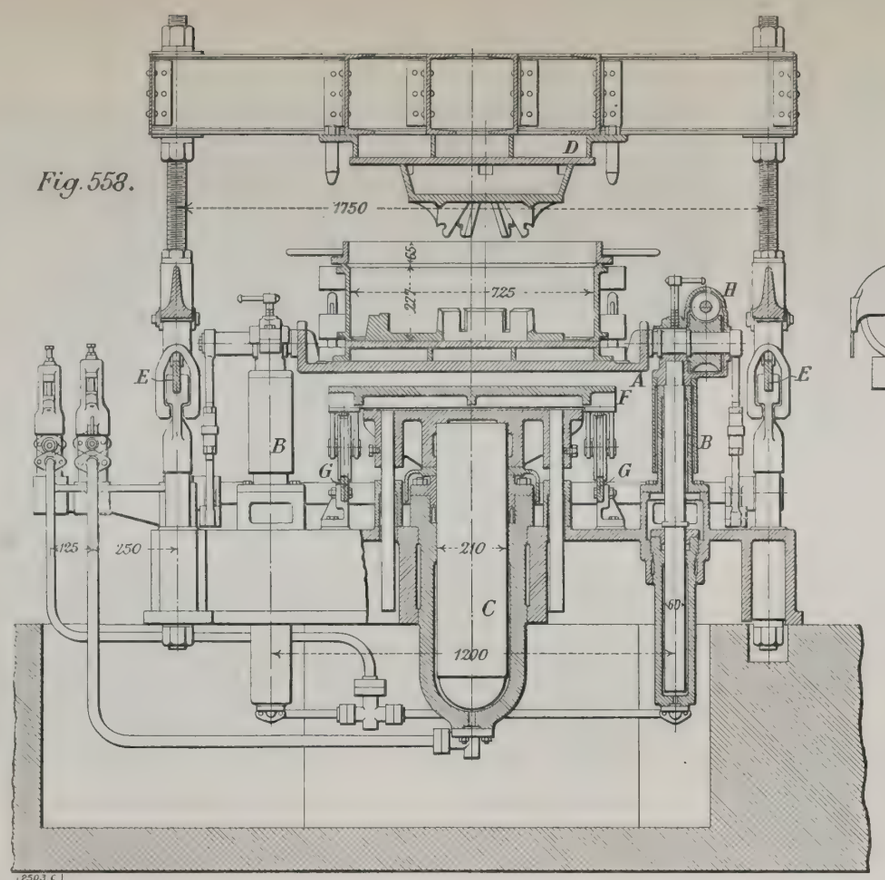
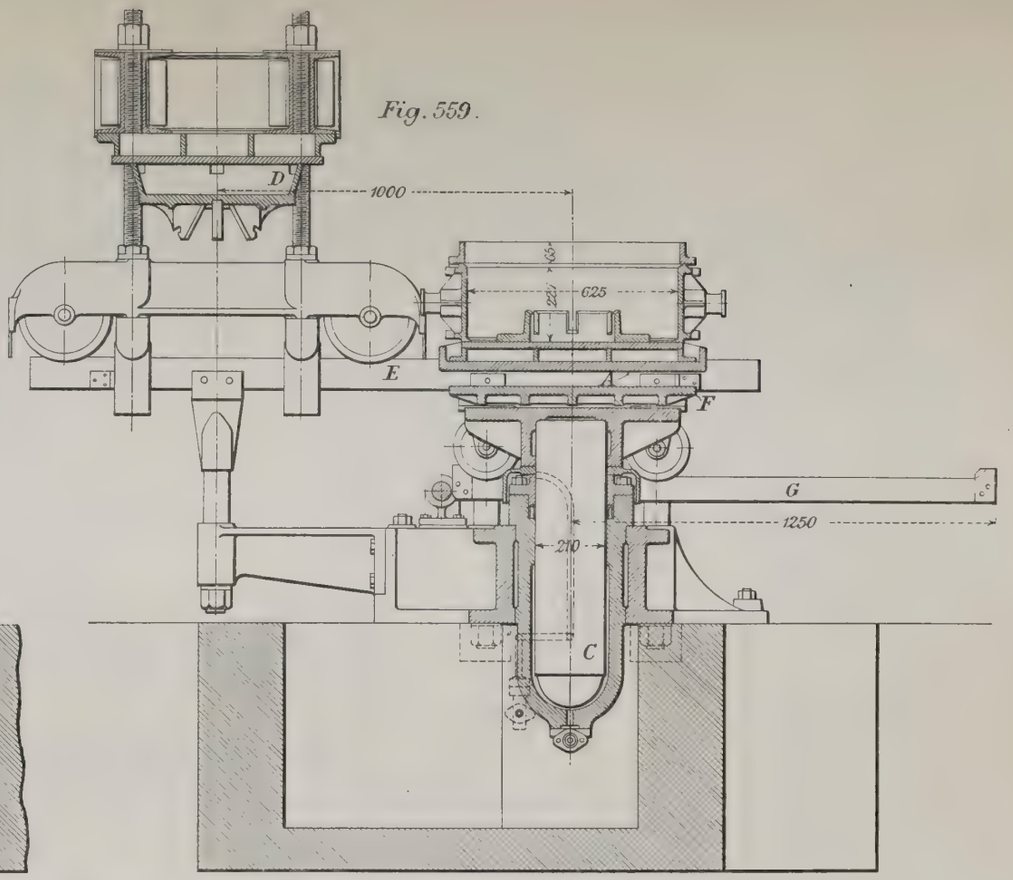


Fig. 557.

Figs. 556 and 557. Hydraulic Moulding-Machine; The London Emery Works Company, Tottenham, London, N.





FIGS. 558 AND 559. HYDRAULIC MOULDING-MACHINE; THE LONDON EMERY WORKS COMPANY, TOTTENHAM, LONDON, N.

same degree. All chance of a smaller blast-pipe top being required to meet this change is, however, more than counteracted by the relief afforded to the boiler by the hot feed. If, in the application of the combined feed-heating and moderate superheating system, no additional resistance to flow of the gases of combustion had to be overcome, it would be possible to use a still larger top.

The trials fully establish the economy of the two heater systems, the commercial advantage of which will be dealt with in the next article.

FOUNDRY PLANT AND MACHINERY.
No. XXXIV.

By JOSEPH HORNER.

WE now give a selection of heavy hydraulic machines for general work, constructed on models which are peculiar to German practice. Almost invariably power machines in that country are built of hydraulic type, dividing favour with the hand-machines. Some of these are of enormous dimensions.

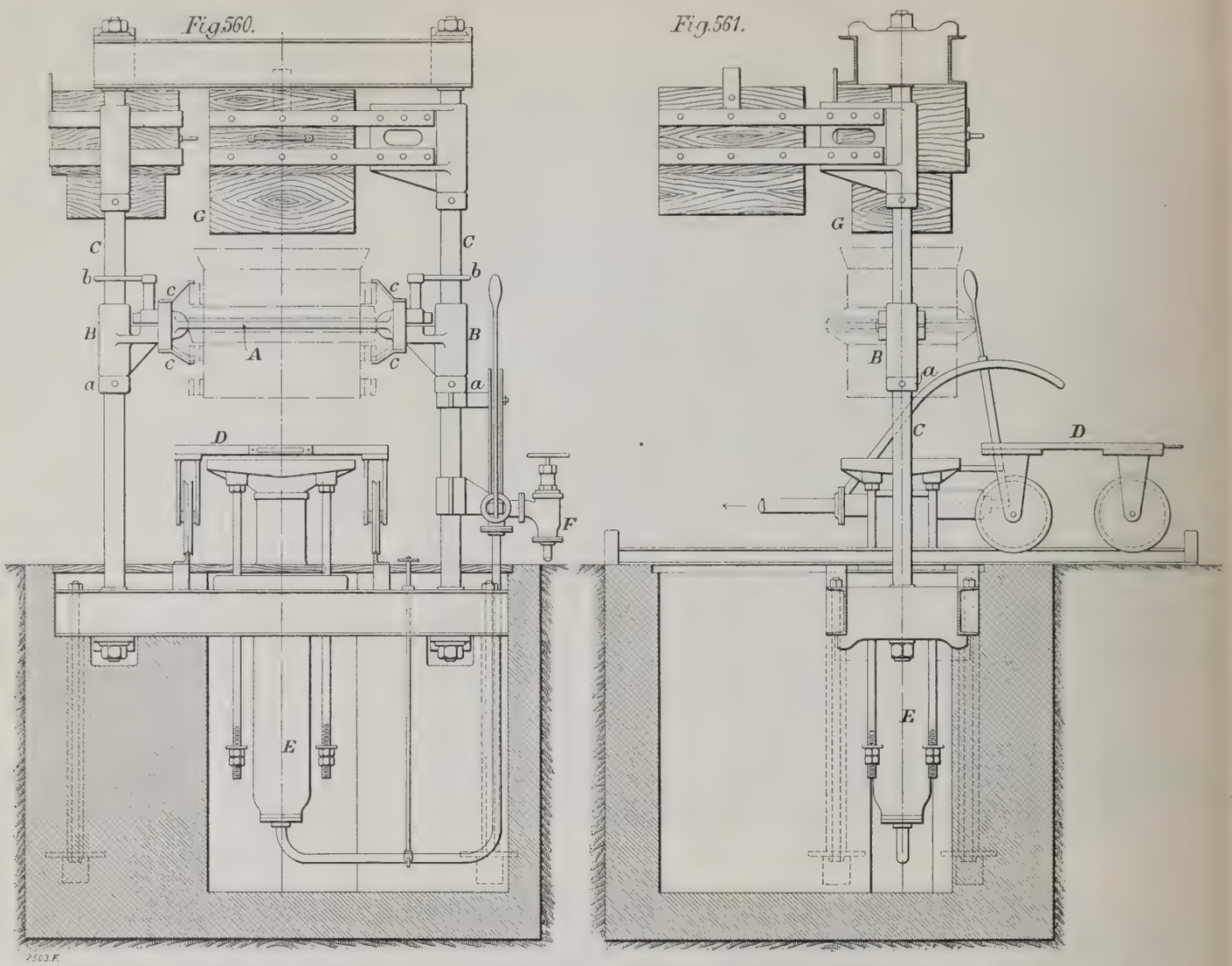
As machines increase in size, the throw-back design of presser-head is abandoned for one the uprights of which are maintained rigidly vertical. The presser-head is then usually ran to and fro along horizontal tracks. There are many examples of this design. A machine of the kind is shown in Figs. 552 and 553, page 619. A is the turn-over table, moved up against the presser-head B by the central ram C. It is carried by the sockets D, D, which slide on the columns E, E, E, E. The sockets are actuated by the withdrawing cylinders F, F. The table is turned over by worm-gear, indicated at G. The tracks which carry the trolley H for the moulding-box are on a level with the floor. The presser-head B, travelling to and fro along the lower flanges of the overhead girders, is operated by an endless chain. In moulding, one half-box is set on the turn-over table, the other half on the trolley. The upper box is then filled with sand, brought up to the presser-head by the side rams, and squeezed by the main ram. The table is then lowered and turned over, bringing the rammed box on the trolley, and the empty box uppermost, which is then rammed similarly to the other. The table being lowered, the part first rammed is ran away on the trolley, so completing the cycle. This machine is by Messrs. Bopp and Reuther, of Mannheim.

A machine type which includes numerous varieties is shown in Figs. 554 and 555, page 919, as constructed by the Badische Maschinenfabrik und Eisengiesserei, of Durlach. It has a turn-over table A and a presser-head B, which is carried to and fro horizontally by trolley wheels a, a on tracks below. The resistance to pressing is taken by the bevelled shoulders b, b, formed at the sides of the uprights which carry the trunnions of the pattern-table. The machine is shown fitted up with pattern-plates—the function of which has been explained in a previous article—on opposite sides of the turn-over table, and they are covered with top and bottom box parts. The cope part is seen covered with a sand-pressing frame.

In working, an empty box part is placed on top of the turn-over table A, while to the bottom of the table a box which has been already pressed with sand is attached. The presser-head B is ran away, and the top box and the sand-frame filled with sand. The head is brought along over it, and the sand squeezed by opening the hydraulic valve.

Next the wedges of the bottom flask will be released, and the valve opened, so that the ram lowers, with its pressure-plate, the trolley D and the bottom flask with the turn-over table, until the last-named rests on the two side-standards, while the ram with its pressure-plate, the trolley, and bottom flask goes further down, and withdraws the bottom flask from the pattern-plates. The trolley, which rests on the rails E, is ran away with the bottom moulding-flask, and transferred to the casting-place. The sand-frame is removed from the top flask, the sand strickled level with the edge, and the turn-over table revolved so that the top flask will be placed upside down. Next the movable trolley will be ran again over the ram and pressure-plate, and

FOUNDRY PLANT AND MACHINERY.



Figs. 560 and 561. Hydraulic Moulding-Machine; Messrs. Bopp and Reuther, Mannheim.

on the turn-over table, now empty on top, an empty moulding-box and sand-frame is placed, filled with sand, and squeezed as described above.

Figs. 556 to 559, pages 620 and 621, illustrate an hydraulic machine, by the London Emery Works Company, moulding gas and water-valves of the rack-and-pinion type. A photograph of the machine in operation, Fig. 556, will assist to the better understanding of the design and the moulding, while the photograph, Fig. 557, shows the pattern and core-box work very clearly.

In this design the table A—of the turn-over type—is raised and lowered by the side-rams B, B, which are connected to one supply-pipe, seen below. These rams withdraw the pattern, while the main one C performs the work of pressing. The presser-head D is brought forward for pressing, or is run back during filling, along the bar-rails E, E, which are supported on brackets from the massive foundation casting which is seen in section in Figs. 558 and 559. It is bolted down over a pit, into which a portion of the hydraulic cylinder descends. The pressing takes place between the moulding-box when the table is supported on the trolley truck F carried on rails G, and the presser-head D. The table is turned over by the hand worm gear at H to lay the rammed box on the trolley table F to be ran away. The numerous details of the machine do not call for special observation, as they are shown clearly by our engravings. The piece of work being done on the machine, as shown in Fig. 556, is the middle section or cheek of the casing of the valve. The mould is seen in front of the photograph in Fig. 556, flanked by castings, and the pattern work in Fig. 557.

An hydraulic machine, with rigid uprights for the presser-head, which is hinged, to be thrown aside,

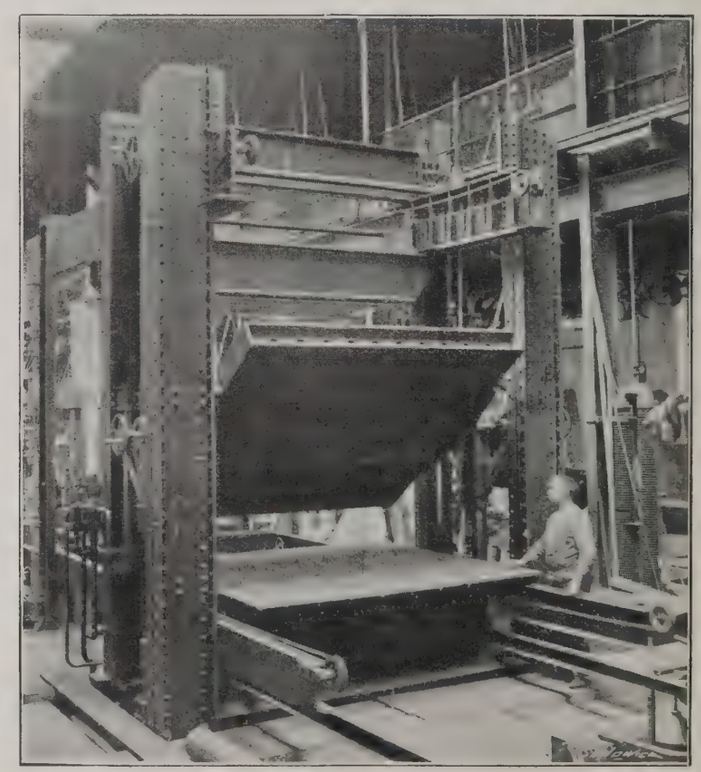
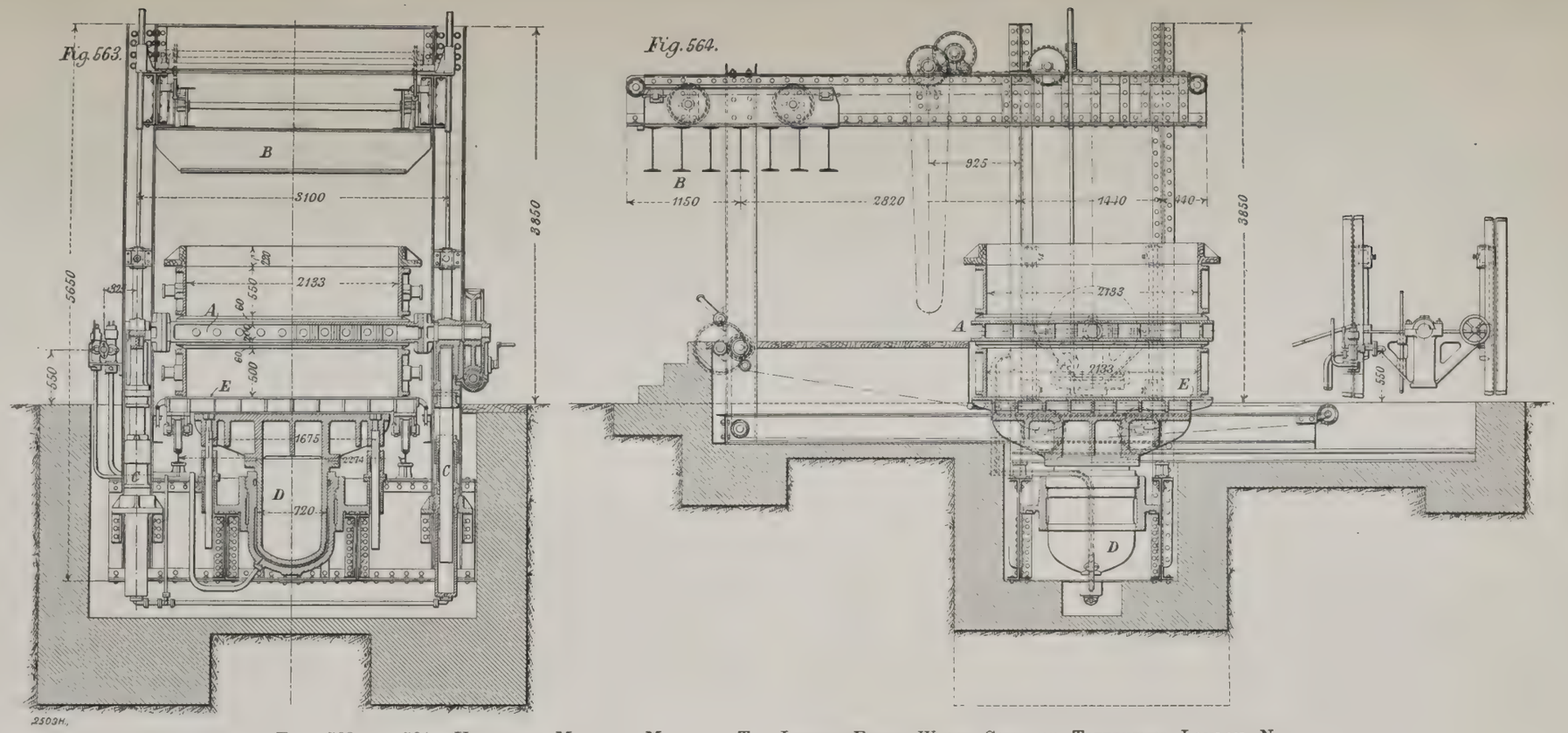


Fig. 562. Hydraulic Moulding-Machine; The London Emery Works Company, Tottenham, London, N.



FIGS. 563 AND 564. HYDRAULIC MOULDING-MACHINE; THE LONDON EMERY WORKS COMPANY, TOTTENHAM, LONDON, N.

and a work carriage running on rails, is shown by Figs. 560 and 561, page 622. It is by Messrs. Bopp and Reuther, of Mannheim. The table A is of the turn-over type. Its height is adjusted by means of sleeves B, B, which are carried on the upright pillars C, C. Set collars *a*, *a* on the pillars locate the range of downward movement of the table. The handles *b*, *b* are for clamping the table. It is shown as carrying, in dotted outline, cope and drag flask parts, and a sand frame on the former. D is the carriage which receives the moulds.

In working, the box parts being clamped, the bottom one is lowered on the carriage D, and the upper box with its frame is filled with sand, and the ram enclosed in E is moved upwards by the opening of the valve F, thrusting and compressing the sand against the presser-head G. This is hinged, to be thrown aside when sand is being shovelled in the box, and brought forward over it for pressing. The boxes being secured by the clamps *c*, *c*, the pressure is taken off, and the ram lowers and the table also until the latter rests on the collars *a*, *a*. The table is next turned over, bringing the empty box part uppermost to be rammed into. The clamps are released and the box part ran away on the trolley.

Fig. 562, page 622, and Figs. 563 and 564, above, illustrate a massive moulding-machine, with turn-over table by the London Emery Works Company. It takes boxes measuring 2133 mm. (7 ft.) square by 500 mm. (1 ft. $7\frac{1}{16}$ in.) deep. The main frame is a plated structure, within which the working mechanism, built of castings, is bolted. The turn-over table A is a boxed structure. The presser-head B is travelled along overhead beams by means of an endless chain over sprocket wheels. The pattern is lifted from the mould by special hydraulic rams C, C at the sides distinct from the main central ram D, which is used for pressing only. The machine is shown with top and bottom boxes attached to the table, and a sand frame over the top box. The trolley E which receives the mould is travelled by endless chains over sprocket wheels, Fig. 564; seen better in the photograph, Fig. 562.

The machine is also constructed for the backward and forward movement of the presser-head and trolley to be actuated by hydraulic rams. A large portion of the machine is sunk into a deep pit, which is boarded over where the operator has to work.

THE TWO-STROKE CYCLE ENGINE.

By R. G. WELLS.

(*Concluded from page* 589.)

Control.—Closely allied to the matter of economy and fuel supply is the question of control, embracing torque and speed range. That the large majority of two-stroke engines have comparatively narrow speed limits is an unfortunate fact, and one that is mainly due to two causes—one affecting the low-speed limit, and the other the high-speed limit. The limit of slow speed is reached when speed is reduced by throttling the ingoing charge, which is therefore not of sufficient volume thoroughly to scavenge out the spent gases, part of which latter, remaining in the cylinder, adulterate the fresh charge, and so make it liable to misfire. This difficulty might be overcome to a considerable extent by the adoption of a variable scavenge of pure air to precede the admittance of mixture, as already dealt with, the volume of such scavenge charge to be increased as the volume of mixture was decreased. But as such scavenging air inevitably weakens the firing strength of the mixture, this system has its limits, and may not allow of particularly low speeds. The importance of this question of low-speed limit is enhanced by the fact that one of the main theoretical advantages of the cycle is that, owing to the double number of impulses, lower speeds should be obtained, whereas in practice the average two-stroke engine cannot be run as slowly as the modern four-stroke type.

The limit at high speed is reached when, owing to the speed, there is insufficient time for the function of scavenging and charging to be performed thoroughly. When it is borne in mind that the ports are not opened until over three-quarters of the out-stroke, and closed correspondingly early (Fig. 14, page 589 *ante*), this point may be easily appreciated at speeds ranging above 1000 revolutions per minute. Indeed, if it were not for the inherent feature of gradual reversal of the reciprocating ports giving a comparatively long period at the end of the piston's travel, there could hardly be a two-stroke cycle. This matter of time for complete scavenging and charging at high speeds is not an easy one to deal with, as, should the ports open

early in the piston's travel, to allow of high speed, then the power stroke is unduly shortened.

Bearing the foregoing in mind, it will be seen that if the ports were independently controlled to remain open a relatively longer period on the inward stroke, then the power stroke could be kept normal, or might well be longer than usual, approximating that of a "four-stroke" engine. Fig. 15, annexed, gives an indication of such a division of the cycle. While this timing would diminish the volume of compression charge (but not compression pressure), the subsequent slight decrease of power would be more than compensated for by increased working efficiency; for this port timing would also give, in a simple manner, expansion of the charge to a sufficient extent to obtain full practical advantage of expansive working, that is exhausting at about 15 lb. above atmosphere. As, at a low estimate, some 25 per cent. of the total thermal efficiency of an internal-combustion engine is, in the usual way, lost by the exhaust, this matter of low exhaust pressure is of considerable consequence. It is important to note that such expansive working on the two-stroke cycle would afford other advantages in addition to that of economy; thus, the expanded charge, being reduced in pressure at the time of emission, would be more easily scavenged, the exhaust ports would not require much lead on the inlet ports, and the exhaust emission would be less noisy. An engine working on this desirable cycle, the "Utilité," was brought out about 1893 by Mr. Atkinson, and gave very economical running, but was not made in numbers. The short life of this engine was largely due to commercial reasons, and possibly also partly due to the fact that the ports were controlled by a piston-valve; while such a valve might afford a larger area than could be conveniently obtained by a poppet-valve, it could not well give the same clear way that is obtained by the usual ports in the cylinder wall controlled by the main piston; and ample port area having clear way is essential for the higher speeds on a two-stroke engine.

Going further into the question of speed range, it will be seen that with embryo "two-stroke" engines, having the time of port opening and closing arbitrarily set, such setting can only allow of efficient running at one certain speed, above or below which speed the setting is not correct. If, however, the timing of the ports be made variable, a greater proportion of stroke could be allowed for scavenging and charging at high speeds than at low, and *vice versâ*. Thus, as engine speed fell, the cycle duration of port opening could be decreased, when the time duration would remain constant or be extended but slightly. Variable port opening of this description would allow full benefit to be taken of the increased time allowance at low speeds to get in a longer power stroke and larger charge, thus tending to keep torque up as speed fell, and so afford to some extent that valuable but elusive quality of flexibility in the true sense of the word. It must not be overlooked that this variable timing would have its effect on the compression; as the period of port opening was shortened, and the compression portion of the stroke proportionately lengthened, the volume for compression being thus increased, the compression pressure would be raised likewise. By fixing the minimum compression pressure at the maximum cycle period of port opening, the compression, and consequently the torque, could be increased as the engine speed fell.

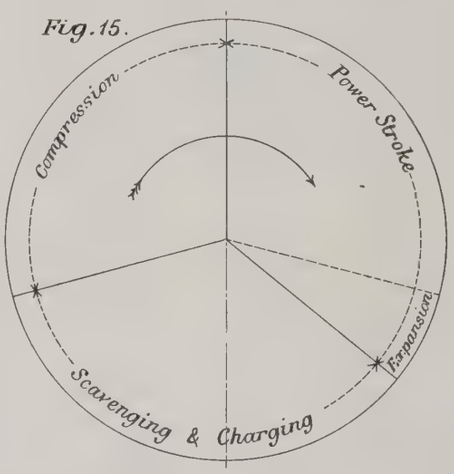
Such variable timing might well be combined with expansive working previously outlined, when the ratio of expansion would be also variable; then, indeed, both speed range and economy would be much more ideal. Further, with variable expansion action such an engine while working expansively for normal load could be run at its greatest power, irrespective of expansion economy, when required for abnormal load; such working further tending to flexibility, in a manner similar to the running of a steam-engine.

The crux of the question of torque and speed-range of the two-stroke cycle-engine would seem to lie largely in this matter of time of port opening and closing, in fact, almost as largely as it does with the steam-engine. Thus variable port-timing giving expansive working is an interesting proposition, promising, as it does, some real approach to ideal working; and more than one patent has been taken out with something of this end in view. Dr. Watson's and Mr. Fenning's investigations showed that with a Day type of two-stroke engine the loss of fresh charge with the exhaust was much greater at low than high speeds, varying from 33 per cent. at 600 revolutions per minute to only 7 per cent. at 1500 revolutions per minute; thus to some extent indicating that at low speeds the ports were uncovered for an unnecessarily long period, even when due allowance has been made for the fact that loss of fresh charge through the exhaust of this simple type of engine does not altogether imply that scavenging has been completed.

Before leaving the subject of control it may be just noted that a delightfully simple system is that effected by varying the time of ignition. It is hardly necessary to say that the range of speed variation obtained by such a crude control is low, and economy likewise; also with the spark retarded for slow speeds the late firing endangers pre-ignition of the incoming charge. Some launch-engines on the market are so equipped, but with regard to these it is only fair to note that for small inexacting boat-work this simple system may come well under the head of good enough. Crude as this control is, it should be observed that the function of scavenging is not impaired thereby at low speeds as it is when control is effected by throttling the ingoing charge.

Pump Action.—Another cause of inefficiency is that due to the power absorbed in what is descriptively known as "pump losses." This should be a minor cause, but is not as negligible a matter as many designs might lead one to suppose. Its importance increases with the size of engine, and in large gas-power plants, such as the Körting and Oechelhauser, a saving in pump efficiency of 2 or 3 per cent. is a consideration. It may be remarked that the "four-stroke" engine is not by any means free from this loss, the power absorbed in the scavenging and induction strokes being "pump losses" pure and simple; while the time taken, 50 per cent., for the performance of them must also be charged to the same cause. The compression stroke in both cycles also comes under this division of "pump losses." In dealing with the pump question it should be noted that no great pressure is necessary or, indeed, advisable, for, besides absorbing power, if the pressure of the incoming charge be over high it has a tendency to blow through the spent charge instead of sweeping it out. A pressure of about 5 lb. to 7 lb. is mostly ample; but if high pressure is not required, large volume is very desirable; the volume for scavenging should be greater than the cylinder working capacity. It is practically impossible to time it so accurately that while no fresh charge is lost no burnt gas is left in; so that, to ensure the scavenge being thorough, provision should be made for allowing a small quantity of the new charge of air being lost with the exhaust. Desirable as a large scavenging volume thus is, it is a point in which many engines are deficient.

Fig. 15.



DIVISION OF CYCLE FOR EXPANSIVE WORKING.

The operation of replacing the burnt gases with a fresh charge by the necessary pump action may be arranged for in several combinations. The most common and the simplest method for medium-size engines is that of utilising the open end of the cylinder in conjunction with a closed crank-case (Fig. 1, page 587 *ante*). All doors, &c., have, of course, to be an air-tight fit; and in multi-cylindered engines the crank-case must be so divided as to make a separate housing for each throw. A point requiring attention is the prevention of lubricating oil in the crank-case from being forced out by the internal pressure through the end-bearings; and this does not appear such a difficult problem but that it should be met better than it often is. The efficiency of this method is impaired by the fact that when the piston is fully out there still remains the crank-case area in which air is compressed but not expelled from; therefore this area should be kept as small as possible, to which end disc crank-webs are an aid. The defects of this system may be largely mitigated by careful design; and for engines where simplicity is the keynote, a pump action is thus afforded practically without additional parts, excepting the air-valves.

The utilisation of the other side of the piston, with the inner end of the cylinder closed, gives high pump efficiency (Fig. 2, page 587 *ante*). The consequent crosshead construction adds to the height of the engine if vertical, and entails increased weight of reciprocating parts, which latter, however, need not be a serious matter with the lower speed of the two-stroke engine, and is but following sound steam practice. Moreover, such construction relieves the piston from side thrust. With this combination the pump volume is greater than that of the cylinder area to be filled, for while the volume given by the full length of the stroke is available for pump action, less the area of piston rod, the volume of cylinder area to be filled for compression is less than this by the length of stroke devoted to scavenging. This construction, therefore, practically affords the maximum of pump efficiency with the minimum of extra parts and friction.

Another method of attaining the desired end is that of having a piston of two diameters, the larger diameter working in a similarly enlarged extension of the cylinder forming an annular pump (Fig. 3, page 587 *ante*). This type is best suited for a two or three-cylinder engine with cross-transfer passages from the outlet of one pump to the inlet of the adjacent cylinder, as the air-pressure is obtained simultaneously with compression in the working cylinder, from which it may be noted that instead of the air-pressure tending to slightly balance the working stroke, as in the previous systems, it augments it. A three-cylinder engine with cranks at 120 deg. lends itself to an arrangement of transfer passages affording excellent pump delivery efficiency. This construction permits of ample pump capacity and allows the engine being kept low, assuming it to be vertical, though, on the other hand, the distance between cylinder centres is increased somewhat. For all-round efficiency with simplicity this method affords a good alternative to the one just dealt with.

In the foregoing systems, where one piston is common to both working cylinder and pump, the pump stroke is necessarily completed with the piston stroke, and therefore pump delivery finishes and suction commences before the cylinder inlet ports are closed, so that the pressure behind the incoming charge drops rapidly before the main cylinder is fully charged. Thus an intermediate reservoir would seem desirable to conserve the pump pressure and utilise it to fuller advantage, but such a reservoir entails a certain amount of waste compression for a similar reason to that noted with crank-case compression. With an engine of three or more cylinders, however, high efficiency should be obtained by arranging an intermediate passage of minimum area common to all pump outlets and cylinder inlet ports, so that there would thus be no pump action against closed outlets, and an even pressure would be maintained.

Then there is the alternative of arranging the pump as a more or less separate unit (Fig. 11, page 588). In this case, by having the pump stroke set before that of the working piston by about 130 deg. on the crank, the completion of its stroke coincides with the closing of the cylinder inlet ports, so ensuring delivery of the full pump charge. This entails either a separate crank-throw for the pump, or if set to work off the main throw the pump has to be set at an angle. For a small engine such a separate pump means a somewhat serious addition and sacrifice of simplicity, though the Lamplugh and Dolphin engines are neat exponents of it. But there is more to be gained for large engines by thus partially separating the engine components, and practically all large power engines have separate pump cylinders. An interesting type of separate pump is found on the producer-gas marine engine designed by Mr. C. H. F. Alston, for the trial boat Progress. This is a double-acting "two-stroke" engine, and the pumps, which are also double-acting, are situated where the usual steam-

condenser pumps are found, being similarly worked by bell-crank rocking-levers from the cross-heads. For big plants of a number of engines, such as at an electric station, the separation might be carried still further, and an independent blowing unit for the whole station, supplying air pressure for all engines, much as a boiler battery does steam, might well afford good working efficiency.

A suggestion with possibilities for large power plants is that of a "two-stroke" turbine combination, the reciprocating unit of the plant to exhaust—comparatively early—direct into the turbine unit. Such a combination would allow of ample time for scavenging and charging with low-exhaust waste, and the turbine would not be subjected to the initial heat of combustion. The turbine could be direct-coupled to a rotary scavenging blower; or be utilised for power purposes, in which case the reciprocating and turbine units would preferably drive separate loads. A successful lead in a similar direction has already been given by steam.

Still another method of raising the wind is the adoption of a rotary blower, and the low pressure required can well enough be obtained by this means with fair efficiency; a good Root's blower, for instance, should have an efficiency of about 70 per cent. This method possesses the advantage of simplicity as a pump unit, there being an entire absence of valves and reciprocating parts in most designs. Yet a small engine incorporating such a blower may not be so simple, on the whole, as an engine combining one of the outlined reciprocating pump actions, insomuch as, with the latter, fundamental parts of the engine may be utilised, additional parts being thus few. Further, crank-shaft speed being rather low for the full efficiency of the usual rotary blower, a geared drive is called for. It will be readily understood that such a blower, with its constant delivery, cannot be as suited for a single as a multi-cylindered engine. The Mort engine is a good example of the successful adaptation of such a scavenge.

A rather different system of scavenging and charging is one in which the burnt gases are partially expelled by the piston through an exhaust-valve in the cylinder-head, while at the same time a fresh charge is compressed in a separate chamber, which compressed charge is admitted into the cylinder near the end of the inward stroke, and sweeps out the residue of burnt gases, when the charge may be still further compressed by the main piston for the completion of its stroke. The old Trent gas-engine worked on this principle, having a double diameter piston, the outer diameter compressing the charge, which was admitted to the main cylinder through a valve in the piston. In practice great difficulty was found in timing the valves sufficiently closely to deal with the high-pressure final scavenge by the compressed charge without loss.

Yet another method of scavenging is found in the adoption of a suction-pump that forms a partial vacuum to draw the burnt gases out and the fresh charge in after them. Theoretically this should be efficient, as less energy is required to fill a chamber (the cylinder in this case) by suction than by pressure. But the size of suction cylinder to adequately withdraw the expanded gases is so large as to render the idea unwieldy. Should a rotary suction-pump be adopted for the same end, it also will have to be of large size to deal with the exhaust in the short time allowance.

While the foregoing may be said to constitute the sum of ordinary pump arrangements, other combinations will suggest themselves, especially in connection with unorthodox designs: the pump is such a salient feature of the engine that its form must be largely a matter of general design of the complete unit. But while the matter is capable of a number of solutions, there are not many affording that fewness and simplicity of parts desirable for small engines. The suction and delivery ports may be controlled by piston covered ports (Fig. 1), automatic valves (Fig. 2), or mechanical valves. The first arrangement is inefficient, owing to the resultant waste partial vacuum; the second is the most common, and is very sound; while the third may be good in special cases if the valve mechanism be of simple construction.

By a suitable combination of two separate and differently timed pump actions super-compression may be applied to the two-stroke cycle. The first operation of scavenging is performed by an air-pump whose stroke finishes with the outward stroke of the piston, or the closing of the exhaust ports; this scavenging air being admitted through ports in the manner described, common to the majority of engines, or through the same valve as the mixture, which valve opens into the cylinder-head. The mixture pump forces its charge into the cylinder during compression stroke, where it is super-compressed with that portion of the scavenging air trapped in the usual manner; the mixture having to be rich enough to stand this dilution. Thus a charge of larger volume than the cylinder working area is finally compressed and fired; the amount of super-compression depending upon the capacity of the mixture-pump, which might with advantage be made variable for control purposes. Various modifications can be worked out in this combination: the scavenging air might well be compressed in the crank-case, or supplied by a simple rotary blower; but the mixture charge must be injected by a pump to deliver at a pressure of some 50 lb. per square inch and upwards. While there is much in super-compression that is in the right direction, presenting possibilities of good scavenge and high power per working-cylinder capacity, the system entails serious problems. The exhaust is very heavy to clear out, and therefore scavenging calls for a larger portion of the stroke than for normal working; the increased pressure of the exhaust is so much increased loss, while economy is also sacrificed in no small measure by the more than double "pump losses." Owing to the pressure in the mixture-pump having to be equal to the compression pressure to effect late entry into the cylinder, care must be exercised in the design to ensure that the charge cannot fire back into the mixture-pump. Generally, the design must be heavy to withstand the strains resultant from the high-pressures, and complicated in pump action.

The importance attached to silent running for automobile engines raises a minor issue in the point that the exhaust of a two-stroke engine is more noisy than that of a four-stroke, this being due to the longer period—more than half a revolution—allowed for emission with the latter type. While, of course, a generously-designed silencer mitigates this evil, it would be better met by the expansion cycle outlined, in which more work is taken out of the gases, so that they are liberated at a lower pressure, and a longer period may be allowed for exhausting without curtailing the working stroke.

The question of balancing multi-cylindered engines is affected by the cycle. A three-cylindered "two-stroke" engine, with cranks at 120 deg., gives practically all that is required with the minimum of parts—that is, evenly-spaced impulses affording a constant, *i.e.*, overlapped, torque, and an excellent all-round balance of reciprocating parts, with a constant sum of piston speed, only the couple being unbalanced. A four-cylinder unit does not give any further advantage worth the complication of the added cylinder, for if the couple be balanced, as with the usual "four-stroke" practice, by having the two outer or inner pistons descending at the same time, then two of the impulses occur together, and the torque is no better than that of a "four-stroke" engine. It may also be noted that while this four-cylinder type gives a balanced couple, the piston speed is periodic, all four pistons reversing motion simultaneously. On the other hand, if the impulses are evenly spaced by setting the cranks at 90 deg., then the balance is no better than with three cylinders; in fact, the unbalanced couple is more pronounced. These remarks do not apply to setting the cylinders in pairs V position at 90 deg., as with the Mort engine, a form which affords an excellent balance, but may not be the most convenient disposition of cylinders.

Although the subject of lubrication is one of importance, it does not offer any special difficulties peculiar to the cycle in general. When the outer side of the piston is utilised as the pump piston, provision has to be made for its proper lubrication, but no great difficulty is entailed thereby. Engines incorporating peculiar construction will have to be dealt with by provision to meet the special requirement; and it is important to keep this matter of lubrication in view in working out a design that departs from known practice.

Adapting the two-stroke cycle to the double-acting type of engine somewhat modifies the conditions of design. The pump may be arranged tandom fashion, but otherwise cannot well be incorporated in the engine itself, especially as the pump has to be double-acting, or, in any case, equal to feeding both ends of the cylinder. One set of ports round the centre of the cylinder may be made to serve for both ends, as is done with the exhaust in the Körting engine before referred to. Such an engine has fewer parts for the turning movement afforded, which is, of course, equal to that of the usual steam-engine. The greatest problem presented by double-acting internal-combustion engines is that of keeping the piston cool and lubricated, the difficulty of dealing with which increases inversely to the size of cylinder. Mr. Alton's marine design, already mentioned, is an excellent example of a double-acting two-stroke engine of moderate dimensions; it develops 100 horse-power from three cylinders, each having poppet inlet-valves, and a single set of piston-controlled exhaust-ports.

While there are other matters of interest which might be touched upon, the foregoing may be said to constitute the chief mechanical features requiring the consideration of the designer. None of the problems are altogether insurmountable; indeed, many have been well met in recent practice, while the future promises further advance. As the engineer well knows, it is not a matter of striving for an ideal design, in which all theoretical faults are eliminated, but evolving one which will afford a practical working compromise without any outstanding fault, functional or mechanical. Apart from the theory of design, the financial aspect is one of great importance. Other things being equal, it is easier to market an engine the design of which lends itself well to cheap shop production, than one which may be a little more efficient, but is expensive to put through the shops. The inventor and designer have to exercise care in their calculations to see that the term "I.H.P." is not used to the entire exclusion of £ s. d.

It is not sufficient for a two-stroke engine to be an interesting mechanical success, it must possess advantages in some, if not all, of such points as simplicity, economy, flexibility, weight, and size. While this is obvious, it is surprising to note the number of two-stroke designs that are more complicated than that of a four-stroke engine giving similar, or better, results; the natural advantages of the cycle being in many examples practically nullified by the mechanism entailed to ensure them. While the simplest two-stroke engine is not as efficient as the more complicated and refined four-stroke engine, its very simplicity entitles it to a certain freedom from comparison. This primitive simplicity has to be abandoned if fuller efficiency is to be obtained; but it is undesirable to go to the other extreme of obtaining a theoretically satisfactory cycle of operations at the expense of considerable auxiliary complications, such as an inspection of the patent records only too fully exemplifies. It is comparatively easy to work out a feasible two-stroke engine by incorporating without limit pumps, mechanical valves, &c. But while such a design might include nothing but sound engineering practice in all its components and motions, and make quite a workable engine, the number of its parts at once puts it right out in competition with a four-stroke engine giving the same number of impulses. Or it is possible to obtain an ideal sequence of operations—at least on paper—by aid of giant cams, toggles, or other abominations; but an engine depending upon such mechanism having irregular motion, especially if entailing an extremely high speed or quick reversal of some important part of one period, stands no chance of ever being more than interesting. At the same time, in dealing with small engines for special work, it is well to bear in mind that size modifies design, and some mechanical arrangements, which would not be desirable for a large engine, might well be quite legitimate and advantageous in a small type. With the foregoing in view, a designer might start with the simple primary type as a base to build up on with additions and modifications for overcoming its initial deficiencies; or, conversely, take a theoretically perfect but complex type, and modify it by elimination so that without undue complication the advantages of the cycle are given full scope. The fact that many poorly designed and cheaply-made engines work as well as they do on this cycle is encouraging to the designer with a well-equipped works behind him.

Much of the antipathy of engineers against the two-stroke cycle is due to so many of the smaller engines of this cycle on the market being sadly behind in finish, both as regards design and workmanship; and too often most exaggerated claims,

based on the cycle, are put forward for these very engines—an exaggeration quite uncalled for, as the cycle offers sufficient legitimate claims Referring to the more sweeping claim so often put forward, of double power to the four-stroke cycle, in the ordinary way it is impossible to obtain full double the power of a four-stroke engine of equal cylinder capacity, and there is no reason why such should be expected. Of course, increased power can be obtained by additional components, as in super-compression, but at the expense of complication and consequent losses; and, in the matter of comparison, super compression is also applicable to the four-stroke engine.

As initially intimated, this *résumé* may to some extent be regarded as a pessimistic view of the matter, in which the advantages of the cycle have not been emphasised; but when the deficiencies touched upon are overcome totally, or in part, the legitimate claims of this cycle will place it as a strong competitor of the once nearly universal four-stroke cycle. With such advantages of better torque, greater speed range, more even stresses, less weight, and absence of half-speed shaft, and perhaps gearing, there is indeed much worth striving for. And once the cycle obtains a sound commercial footing, it may be relied on to advance towards practical idealism by that gradual but sure evolution of constant refinement brought about by practice, and by practice only.

OLYMPIA MOTOR EXHIBITION.

The tenth annual show promoted by the Society of Motor Manufacturers and Traders opened at Olympia on Friday, the 3rd inst., and will remain open until to-morrow. The chief features of the Show are :—

First, the extending use of sleeve or rotary valves.

Second, the increased number of cheap American cars exhibited, and the attempts of the European makers to meet the competition thus established.

With regard to the first feature, it is obviously the result of the success of the Knight engine, introduced some years ago by the Daimler Company. It still, of course, remains to be seen whether any form of sliding or rotary valve will supersede the ordinary beat-valve, but there can be no doubt whatever that it has had a very considerable success in the form designed by Mr. Knight. It is, however, obvious that the essential point on which this depends is the ability of a piston-valve to keep tight. Granted that it can do this, there are undoubtedly innumerable ways in which either ordinary piston-valves or sleeves can be arranged. It seems likely, however, that sliding-valves of all types will find a formidable rival in the rotary valves. These have the very great advantage that they have no reciprocating parts at all, and therefore, if they can be made tight, should work with less noise and vibration than the slide-valves. Silently as the latter work, there must be a certain amount of wear in the various brasses, and therefore a liability to knock, which will be quite absent in the rotary valve. The question of balancing is also of some importance.

The ordinary four-cylinder engine is perfectly balanced as regards the inertia of the pistons, &c., except for the error due to the angle of the connecting-rods, and even this can be eliminated in the double opposed horizontal type. As the slide-valves work at half the speed of the engine, however, their motions do not balance each other in the same manner; and as they are a great deal heavier than the ordinary beat-valve, and have a much longer travel, the question of vibration at high speeds becomes of importance. The rotary valve is, of course, entirely free from vibration. Further, the rotary valve should be a very cheap design to make if well carried out, especially as it is quite possible to arrange that one valve shall serve for two or more cylinders. Meanwhile the beat-valve is still in a very large majority, and with careful design of cams there is no difficulty in making it work extremely quietly.

The question of American competition may be serious for the European car-maker. It is perfectly well known that the price at which such articles as motor-cars can be produced depends largely on the number which can be put in hand at a time, and this, of course, depends entirely on the number which can be sold. The American manufacturer has for his cars a huge market protected from foreign competition by a heavy import duty, and can therefore be sure of selling far greater numbers than would be possible in this country, more especially as he has the whole of the English market open to him on the same terms as our own manufacturers. He can therefore economise labour in their manufacture to an extent quite impossible here. The result is that even after paying freight, and a European agent's commission, American cars are being offered here at prices very much below what a corresponding article of home manufacture can be got at. Whether this will result in the American cars being widely used in this country remains to be seen, and probably depends very largely on whether or not the American manufacturers think it really worth while to make an endeavour to sell them here, as they do in the case of such articles as typewriters. At present most American manufacturers appear to be able to sell pretty nearly all the cars they can make at home, and therefore many of their best cars are either not represented at all here, or not pushed with any energy.

Further, the American and English manufacturers are attacking the problem of the cheap car in very different ways. In engine construction the American makes a light engine with fairly large cylinders, and runs it comparatively slowly, whereas the English maker uses very small cylinders, but runs them very fast, making the engine heavy enough to stand the high speed. The American, in spite of his larger engine, often makes both his engine and car lighter than the English car per horse-power, and with the large engine and light car finds three speeds ample, and often only uses two. The English car, with its small engine and heavy weight, on the other hand, must have three speeds, and often has four. Further, as bevels, with a great reduction, are difficult to make to run quietly at high speeds, the English maker often uses a worm on the back axle in place of a bevel.

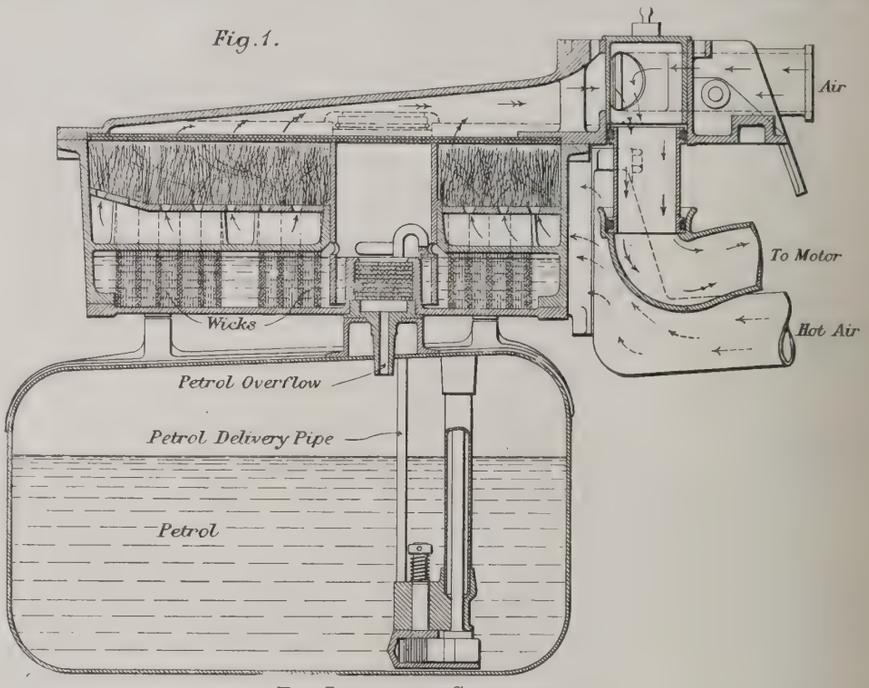
As it is hardly likely that it will suit the American manufacturer to build cars especially for the English market, their sale here will probably depend on whether English people will take up the slow-running engine, &c. There is much to be said in its favour, and we shall refer to the matter again. The use of the worm drive is extending, though it has become by no means universal, even for small cars. It appears curious that there should be no serious attempt to apply it to the larger type of car, for the only objection to it is the lower efficiency, and this would be less important in the large car than the small one, owing to the greater engine-power available. One reason for the retention of the bevel-gear in the larger car is, perhaps, that the ratio of reduction in the back axle does not need to be so great as in the small one, and therefore there is less trouble in making the gear run quietly. Cost may also have a good deal to do with the matter, as in the cheap car it is impossible to spend money in tuning up the bevel-gear as can be done in the more expensive car.

Chains are now being extensively employed for driving the cam-shaft and magneto in the engine. The main object for this no doubt is silence, the noise of the timing wheels being one of the many difficulties of the excessively high-speed engine. The use of chains is, however, a very great convenience to the designer, as the height of the various spindles can be fixed without any reference to the diameters of the gear-wheels.

It is noticeable that there is a great tendency to substitute roller bearings for balls, the claims of the makers for durability on the part of the latter not having been apparently borne out in practice.

In the matter of lubrication there is not a great deal of change. Forced lubrication is gaining ground, while the simple splash is being abandoned. This is undoubtedly an improvement, as although the splash has worked on the whole very well, it is by no means an ideal form, as it is impossible to supply the bearings with as much oil as is desirable without throwing so much on to the cylinder walls that smoke is produced. In some cases oil is only forced to the main bearings, and not the crank-pins, the latter being lubricated by scoops on the big ends, which dip into troughs in which the oil is kept at a constant level. This is undoubtedly a great improvement on the simple splash, as the amount of lubrication is a perfectly constant quantity, but it is open to the same objection as the splash, though in a smaller degree. The whole problem of lubrication in the ordinary type of petrol-engine is to supply the maximum possible amount of oil to the bearings without getting too much on the cylinder walls. Obviously the right way to do this is to pass the whole of the oil through the bearings before any of it is thrown into the cylinder, and the only system which does this is the forced feed. The trough system is, however, probably cheaper, as it avoids drilling the crank-shaft. It is possible that in the sleeve-valve engines the above arguments may not apply, and that more lubrication to the sleeve is necessary.

Fig. 1.



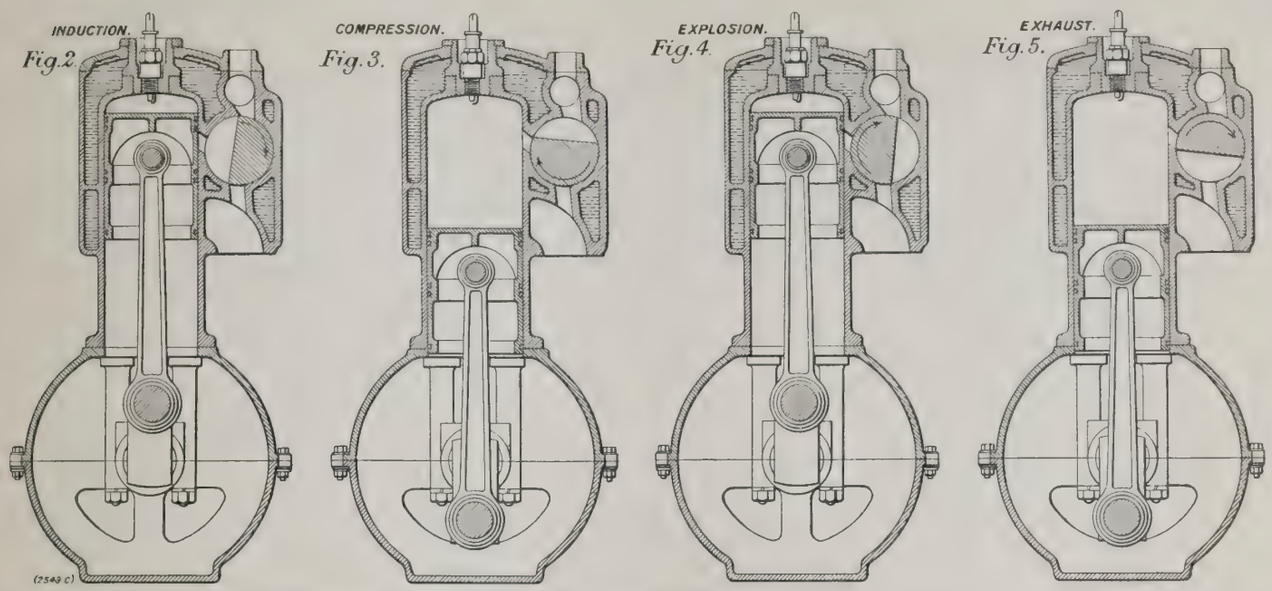
The Lanchester Carburettor.

In the matter of placing the worm above or below the axle there is still great diversity of opinion. Many makers—*e.g.*, the Rover, N.E.C., Maudslay, Thornycroft, and Wolseley—follow the lead of Lanchester, and place the worm below the axle, where it runs covered in oil. Others—*e.g*, Argyll, Darracq, "Standard," B.S.A. "Vulcan," and Dennis—have it above, while one firm—Messrs. Humber, Limited—show one car with the worm placed above, and another with it placed below. The worm above the axle undoubtedly makes the neater arrangement, and gives considerably more clearance from the ground. On the other hand, it raises the floor at the back of the car, and it is dependent for its lubrication on the oil carried up by the worm-wheel.

There is a strong tendency to dispense with torque-rods and radius-rods to the back axle, and

MOTOR-CAR ENGINE WITH ROTATING VALVE AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. A. DARRACQ AND CO. (1905), LIMITED, LONDON.



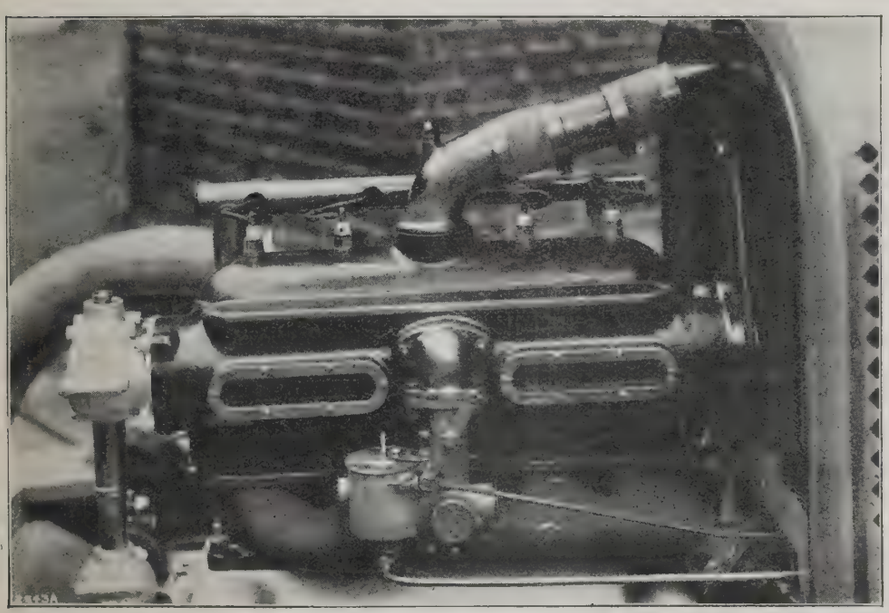


Fig. 6.

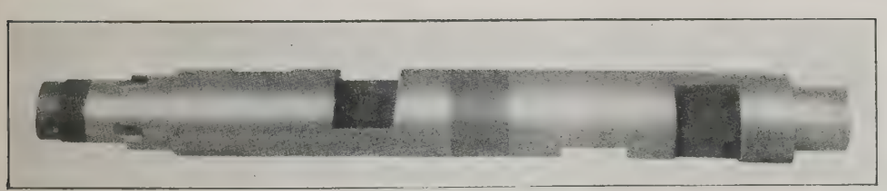


Fig. 7.

to allow the back springs to take the torque as well as to hold the axle in position.

In springing the half elliptical front springs are almost universal, while the three-quarter elliptical back springs are in a very large majority. It is becoming increasingly common to fit some form of supplementary spring, such as a spiral spring interposed between the two after parts of the three-quarter elliptic back springs.

It is interesting to note that while the petrol-car of the ordinary pattern is nearly universal, it is not quite so, and there are several variations of it still in the market. One or two of these are freaks, of no commercial or practical value, but some are well tried machines, which still have a substantial sale. It is well that this should be so, for however well the ordinary type of petrol-car may answer its purpose, it is too early yet to say that we have evolved the permanent future type, and it is as well that there should be some successful cars of special design to remind us that the petrol-car, with the engine in front, usual change-speed gear, &c., is not the only possible type.

The Lanchester, for instance, is a car which still retains its popularity, in spite of its very special design. In the pattern shown by the Lanchester Motor Company, Limited, Armourer Mills, Birmingham, the modifications from previous patterns are principally in matters of detail. The stroke of both the four and six-cylinder models has been increased from 3 in. to 4 in., the cylinder diameter remaining 4 in. One of the most interesting features of the Lanchester car is the wick carburettor, it being probably the only car in the Show not fitted with a carburettor of the float-feed spray type.

We illustrate this carburettor in Fig. 1, on the opposite page, from which it will be seen that it consists of a number of wicks dipping into a chamber in which petrol is kept at a constant level. The upper part of these wicks projects into an evaporating chamber, through which warm air is drawn. This passes through a mixing-valve, where it is diluted with pure air, so as to make a suitable explosive mixture for the engine. The carburettor proper is placed immediately above the petrol-tank, which is built into the frame; in fact, forms a part of it. The petrol is continuously pumped up by a small pump of the oscillating-cylinder type, driven by a shaft passing down from the top of the tank. An overflow pipe is fitted to the carburettor, through which the excess of petrol returns to the tank, the level in the carburettor being thus kept constant. This system is stated to be an improvement on the pressure feed and float regulation previously employed.

There are still two types of steam-car exhibited. The Stanley, shown by the Stanley Steam-Car, Limited, 13, West Cambridge-circus, London, W., is a representative of the type having a shell boiler and simple two-cylinder engine, while the White, shown by the White Company, Carlow-street, Camden Town, London, N.W., has a flash boiler and compound engine.

Among the petrol-cars the N.E.C., shown by the New Engine (Motor) Company, Limited, of Grafton-street, Bond-street, London, W., is almost, if not quite, the only car in the Show which retains the horizontal engine. This is of the double opposed type, and is therefore very much better balanced than the ordinary vertical engine, as the error due to the angle of the connecting-rods is eliminated. The engine is placed in the centre of the car, and as the dashboard is done away with, the whole body can be got between the axles.

Among the substitutes for the ordinary poppet valve is one shown by Messrs. A. Darracq and Co. (1905), Limited, Walnut Tree Walk, Kennington, London, S.E. In this engine, the principle of which we illustrate in Figs. 2 to 5, on the present page, a long parallel cock (see also Figs. 6 and 7) lies alongside the cylinders near the top, and is driven by suitable skew gear at half engine speed. Ports communicate from the top of each cylinder to the cock, and the plug of the latter has suitable

ilats in it for the control of the inlet and exhaust gases. There are no means of packing the plug, which is simply a mechanical fit.

So far the arrangement differs little from other arrangements of parallel cock valves, the difficulty of which has always been to keep them tight under wear, a difficulty which is increased by the fact that at the moment of explosion the plug of the cock is subject to a side pressure from the gases in the cylinder. In the Darracq engine, however, this is avoided by making the piston over-run the port from the cock to the cylinder, thus isolating the plug for the end of the compression stroke and commencement of the working stroke. The arrangement forms in many ways a new departure in the distribution of gases in internal-combustion engines, and it will be interesting to see how it works in practice. It is obvious that as the piston overruns the port to the valve, the port will be closed on the exhaust stroke before the piston gets to the end of its travel, and that a very much larger amount of exhaust gases will be retained in the cylinder than is usually the case. For the same reason the inlet passage cannot open till the piston is some way down the stroke. This will probably mean that a larger cylinder will be required for a given power, but as nothing need be increased except the diameter of the cylinder, this need not add materially to the weight. The question will probably be rather whether the large increase in the proportion of exhaust gases will affect the flexibility of the engine. The design should be very cheap to build, makes a very neat engine, and is very simple.

The example shown is a 20-horse-power engine having four cylinders 95 mm. by 140 mm. ($3\frac{3}{4}$ in. by $5\frac{1}{2}$ in.), and the valve is driven by skew-gear from a vertical shaft. This is the only size to be put on the market at present. The radiator in this engine is behind the bonnet. Final transmission is by a worm-drive, with the worm above the axle, and the propeller-shaft runs in a tube forming a torque-rod. A 15-horse-power chassis is also shown with a similar final transmission.

A car embodying many original features, and in some ways recalling American practice, is shown by the Birmingham Small Arms Company, Limited, Sparkbrook, Birmingham. The frame, which we illustrate by Figs. 8 and 9, annexed, is a very simple one, consisting of two straight longitudinals upswept at the back with three cross-pieces, one at each end, and one just behind the engine, which is carried on the cross-pieces by a three-point suspension. The engine is of the Knight pattern, and has cylinders 75 mm. and 114 mm. (3 in. and $4\frac{1}{2}$ in.). The clutch is of the leather-faced conical pattern, and from it the power is transmitted through a universal joint to a propeller-shaft running in a tubular torque-rod. A three-speed gear-box with gate change is used, but this is placed on the back axle in place of the frame, as usual. Final transmission is by worm and wheel. The springing is peculiar, the back axle being carried by a single very deeply curved cross-spring, the front axle being on very short and broad semi-elliptical springs having only four leaves. The steering-gear is bolted to the front cross-member of the frame just above the front axle, and the worm and wheel are placed transversely in place of longitudinally, the steering-rod working therefore across the car. Both brakes are hand-brakes on back hubs. An excellent feature of this car is that the track is 4 ft. $8\frac{1}{2}$ in., and it therefore fits the usual cart tracks of the country.

The Maudslay Motor Company, Limited, Parkside, Coventry, and 60, Piccadilly, London, W., show a chassis with a completely new transmission gear. We illustrate the change-speed gear-box in Fig. 10, on page 634. In place of the transmission being by gears it is by chains. Four speeds and a reverse are provided, and the drive is from shaft to shaft in all cases, no direct drive being used. The change is made by clutches operated by a gate change of the usual type.

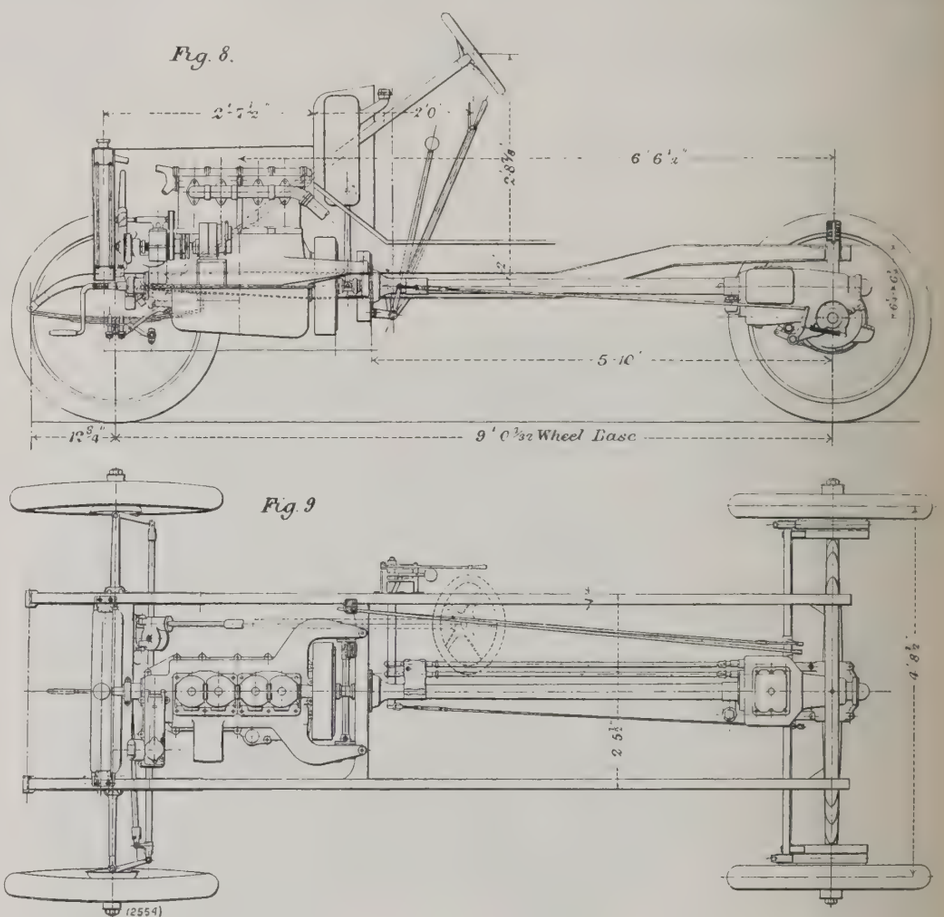
It will be seen that the clutches for the third and fourth speeds are on the driving shafts, while those for the first and second are on the driven shafts. The ratios of speed between the driving and driven shafts are 0.518, 0.800, 1.25, and 1.93, giving gear ratios of 1.0, 1.6, 2.5, and 3.8. When the first or second speed is used, the reverse pinion slides with the reverse wheel, which is part of the first and second speed clutch; but when the reverse is used, the clutch with the wheel is held still, and the pinion slid into gear with it. The wheels and chains of the first and fourth speeds are interchangeable, and also those of the second and third. Many advantages are claimed for this type of gear-box. The chains are said to run absolutely silently, and this being so, the necessity of a direct drive is largely done away with. The direct drive involves driving through two sets of gear on the lower speeds, and, therefore, although the loss through gear friction is eliminated in the direct drive, it is doubled on the lower speeds. It is in these that efficiency is really of the most importance, for any reasonably powerful car is amply fast enough on the flat, and where additional speed is required is on the hills. By gearing up the counter-shaft the worm and wheel can have a greater reduction, and therefore be of suitable proportions, while a large ratio can be got between the top and bottom speed without having very large ratios between any pair of chain wheels. The arrangement of the clutches not only allows of the chain wheels being manufactured in double the quantities they could be if both were on one shaft, but keeps the relative motions of the idle wheel and shaft low.

An incidental advantage of doing away with the direct drive and placing the driven shaft below the driving one is that it is possible to get a straight drive through the universal joints of the propeller shaft with a worm drive below the axle without inclining the engine. The final drive is by worm and wheel. The steel forging forming the axle and centre piece of the differential casing, which has been the distinctive feature of the Maudslay car, is retained, but is turned on its side and a worm and wheel is placed below it. The worm and wheel are of the Lanchester pattern. The ratio on the back axle is usually from 5 to 1 to 6 to 1.

A distinct feature of the Show is the very largely increased number of really small cars shown. A year or two ago hardly any maker appeared to think it worth while to make a chassis below the size suitable for carrying a fairly heavy landaulet body. Hence if one wanted a two-seated car of good make, it was practically necessary to have a chassis weighing some 17 cwt., which is obviously quite unnecessary for carrying two people. There are now quite a number of really small and medium-size cars specially built to cope with this demand. The smaller ones are intended solely for a two-seated body, while the larger are, in many cases, really fit to take a three or four-seated one. In the case of the four-cylinder cars the diameter of the cylinders is often kept down to 69 mm., to keep the car within the three-guinea tax. The reintroduction of the light car is probably largely due to the fact that the Americans are producing numbers of cars whose weight is little more than half even the lighter European cars of a couple of years ago.

The De Dion, Austin, Waverley, Star, Belsize, Turner, and 11-horse-power Humber, described below, will show the tendencies of manufacturers of the lighter types of cars.

Messrs. T. B. Andre and Co., 8, Great Marlborough-street, London, W., are showing an improved form of their "Waverley" voiturette. We illustrated this car in its 1911 form in our issue of November 11, 1910, page 663. The general features remain very much the same, but the two-speed gear



Figs. 8 and 9. Chassis by the Birmingham Small Arms Co., Ltd., Sparkbrook, Birmingham.

on the back axle has been replaced by a three-speed gear-box in the ordinary place, with a gate change. The lubrication is now by mechanical pump through a sight-feed to a splash lubrication. The circulation is now by thermosyphon and the special springing of the back axle, with "costermonger" type springs, is retained, but the front axle is carried on ordinary half elliptic springs. The wheel-base has been lengthened from 8 ft. to 9 ft., and the wheels increased in diameter from 700 mm. to 750 mm.; the weight complete is about 12 cwt. The engine has four cylinders 65 mm. by 110 mm. ($2\frac{1}{2}$ in. by $4\frac{3}{8}$ in.), cast *en bloc*, with the inlets over the exhausts worked by rocking levers and a two-bearing crank-shaft, as last year.

Messrs. Turner's Motor Manufacturing Company, Limited, Wulfruna Works, Lever-street, Greenlane, Wolverhampton, show two light cars, the larger of which is fitted with a four-cylinder engine having the cylinders cast *en bloc*, a two-bearing crank-shaft, and all valves on one side, the cylinders being 60 mm. by 100 mm. ($2\frac{3}{8}$ in. by 4 in.). Two speeds and a reverse are provided, the gears being always in mesh, and the change-speed being by expanding clutches. Both speeds are shaft to-shaft drives. The final transmission is by worm drive on a live back axle. A reverse actuated by a friction-clutch and foot-pedal is provided, and this can be used as a brake if necessary. The other

foot-pedal works a brake on the back hubs. The front springs are of the ordinary semi-elliptical type, and the back of the "costermonger" type. The weight of the car complete is 10½ cwt. A smaller car, having two cylinders 90 mm. by 90 mm. (3½ in. by 3½ in.), placed diagonally, is also shown.

An interesting example of the small car is shown by the Austin Motor Company, Limited, Longbridge Works, Northfield. This car is rated at 10 horse-power, and in most of its details follows far more the features usual in large cars than small. The engine has four cylinders, 2½ in. diameter by 3½ in. stroke, giving 10 horse-power at 1000 revolutions. The cylinders, contrary to the usual practice in small engines, are cast separately, and the crank-shaft is provided with five bearings, while the valves are placed on opposite sides of the cylinders, and are driven by two cam-shafts. Water circulation is by centrifugal pump. A leather-faced cone-clutch drives a three-speed gear-box having gate change, universal joints being provided between the clutch and gear-box. In place of the usual ball-bearings the shafts in the gear-box, which are hardened and ground, run in long bearings of cast iron. As usual in Austin cars, the engine and gear-box are carried on an underframe. The live back-axle has no torque-rod, the front arm of the three-quarter elliptical spring serving this purpose. The petrol-tank is built into the dashboard, and gravity feed can therefore be used without any possibility of the petrol failing to get to the carburettor on a steep hill. The engine lubrication is by pump circulating the oil to the bearings in proper quantities. The wheel-base is 8 ft., and the weight of chassis is about 10 cwt. The front wheels run in plain bronze bushes carried on hardened and ground spindles.

Altogether this is a most interesting departure in the matter of small cars, being, in fact, a large car in miniature, and it will be interesting to watch its progress as compared with the more ordinary type of small car. The workmanship appears to be excellent, and the car should appeal to those who want a really small car, but to whom price is not the most serious consideration.

Another new car of the really small two-seated type is the 7-horse-power De Dion, shown by Messrs. De Dion Bouton (1907), Limited, 10, Great Marlborough-street, London, W. This car is in many ways a very great departure from Messrs. De Dion Bouton's previous practice, as the distinctive axle, with its special change-speed gear, &c., is abandoned. The engine has two cylinders, 66 mm. by 120 mm. (2½ in. by 4¾ in.), having thermo-syphon circulation, forced lubrication, and ignition by high-tension magneto mounted direct on the end of the cam-shaft. This makes a very simple and neat engine. A three-speed gear-box is used of the run-through type, with a direct drive on the top speed. The bottom half of the crank-chamber and gear-box are bolted rigidly together so as to form one unit, on which are carried the brake and clutch-pedals. The back axle is of the ordinary bevel-geared pattern, the propeller-shaft running in a tube torque-rod. The clutch is of the three-plate pattern, leather faced; three-quarter elliptic back springs are provided. The wheel-base of this car is 6 ft. 5 in., and it is therefore quite of the small two-seated type.

It is interesting to note that Messrs. De Dion are again making a single-cylinder car, the general features of which are much like the above, except that the engine is single-cylindered, 84 mm. by 130 mm. ($3\frac{5}{16}$ in. by 5⅛ in.), and is rated at 6 horse-power.

Messrs. Humber, Limited, Stoke, Coventry, show two chassis having some features of interest: a 20-horse-power and an 11-horse-power. The larger has cylinders 90 by 120 mm. (3½ in. by 4¾ in.), cast in pairs, while the smaller has cylinders 68 by 120 mm. (2.7 in. by 4.7 in.), cast *en bloc*. The construction of the latter engine is interesting, as the crank-shaft is of the two-bearing type; but instead of the cylinders being all placed as close together as possible, a passage is cast between the centre pair of cylinders for the inlet from the carburettor. This necessarily slightly lengthens the distance between the bearings, but makes a very neat engine, as the carburettor can be placed on the opposite side of the engine to the exhaust-valves without any complicated pipes being needed. Thermosyphon circulation and forced lubrication are used in both cars. The clutches in both cases are leather cone-clutches, running in oil. The larger car has four speeds, and the smaller three, gate change being used in both cases. Contrary to the practice of many makers, who use worm drives for their small cars and bevels for their larger ones, the smaller car has a bevel drive, while the larger has a worm. There is a great deal to be said for this, as the efficiency of the worm is probably less than that of the bevel, especially on steep hills, where the pressure on the teeth is so high that the oil is liable to be largely squeezed from between the surfaces. This is a matter of less importance with a large car having a reserve of power and four speeds than in a small one which has very little reserve. The 11-horse-power car has no torque-rod, the front half of the spring performing this function, while the 20-horse-power car has a tube torque-rod surrounding the propeller-shaft.

Messrs. S. F. Bennett, Limited, 219 to 229, Shaftesbury-avenue, London, W.C., show the 30-horse-power Cadillac. In general design this car is not materially altered since we described it last year, but it is now provided with an electrical equipment of special design. The essential feature of this system is that a dynamo is used which can be used as a motor if required, and it is so used for starting the engine, the usual starting-handle being therefore suppressed. The system of operation is as follows:—In normal running the dynamo furnishes current to a storage battery of 80 ampere-hours capacity, and this battery furnishes current for the ignition, which is by single-contact coil and high-tension distributor, and also for the side and tail lamps and the head lamps. The dynamo automatically cuts out when the revolutions fall below those necessary to give the required voltage, and cuts in again when the speed rises. The dynamo will give a potential sufficient to charge the accumulators at about 300 revolutions of the engine, and in order to prevent its furnishing too much current as the speed rises it is regulated by short-circuiting some of the field-magnet coils. The accumulators are arranged in four sets, giving six volts for ordinary purposes, and are all connected in parallel. In order to start the engine the spark is fully retarded and the clutch-pedal fully depressed. The effect of this is, firstly, to couple the accumulators in series, so that the dynamo is supplied with current at 24 volts; secondly, to connect it to the engine by a suitable reducing gear to give it power to turn it round. It is stated that the batteries are of enough capacity to keep the engine turning for twenty minutes, though, of course, it usually starts in the first few turns. When the engine starts the reducing gear is automatically thrown out and locked, so that it cannot be put in till the engine stops.

Whether this system will be successful in practice remains to be seen. It is an undoubted convenience, and using the dynamo for the lighting and ignition as well as starting is a simplification of many systems. A starting-handle is provided in case of emergency, and a completely separate ignition with dry batteries.

An interesting example of *en bloc* construction is the new 10-horse-power car, shown by Belsize Motors, Limited, Clayton, Manchester, and Dean's-yard, Cavendish-square, London, W. This car has a four-cylinder engine, having cylinders 69 mm. by 130 mm. ($2\frac{11}{16}$ in. by 5⅛ in.), cast *en bloc*, with all the valves at one side. The crank-shaft is of the three-bearing type, and lubrication is forced, the pump being placed at the bottom of the crank-chamber, and a float provided to show the oil level in the sump. The connection between the engine and gear-box is peculiar. A large unsplit aluminium casting bolts up to the after end of the crank-case, and is bored out to take a casting, which slides into it from the after end, carrying the gear-shafts and the brake. The lay-shaft is below the driving-shaft. This inside casing has a spigoted oil-tight joint at the front end, and a flange joint at the after end. Doors are provided in the outside casing for access to the clutch and gears. This unit is carried on short lengths of tube fitting into sockets in the castings of the engine and gear-box. The clutch is of the internal leather-cone type. The back axle is of the worm-drive type, with the worm at the top. A tubular torque-rod is provided, placed alongside the propeller-shaft, and the back axle is carried on semi-elliptical springs, with subsidiary spiral springs at the back. The wheel-base of this car is 8 ft.; track, 4 ft. 3 in.

A new design embodying several interesting features is the 10-horse-power car exhibited by the Star Engineering Co., Limited, Wolverhampton. This car, which we illustrate by Figs. 11 and 12, page 634, has a four-cylinder engine, the cylinders being 68 mm. by 120 mm. ($2\frac{11}{16}$ in. by 4¾ in.). The engine is of the two-bearing type, having all the cylinders cast *en bloc*, with all the valves on one side. The "bloc" system is also employed for the crank-case and gear-box, these being bolted up in one piece by means of an extension of the bottom half of the gear-box. The whole is carried by two very substantial cross-arms near the front of the crank-case and a single bolt attached to the middle of a cross-piece immediately behind the gear-box. Forced lubrication is employed for the engine, the crank-shaft being drilled for the lubrication of the crank-pins. Circulation is by thermo-syphon. The clutch is of the metal to metal cone type, and the gear-box has three speeds, operated by a gate change. The pedals are carried on the casting of the gear-box, making their erection a bench job. The back axle is of the bevel type, and the back springs are three-fourths elliptic. The track is 4 ft. 3 in., wheel-base 8 ft. 2 in., and weight of chassis about 12 cwt.

(To be continued.)

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We note below a number of colonial and foreign engineering projects, for several of which tenders are asked. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

New Zealand: The Imperial Trade Correspondent at Dunedin reports that the New Zealand Government propose to proceed with the extension of two or three lines of railway, which will open up a large area of agricultural and pastoral land. Where other modes of traction are not available it is proposed to employ the Renard road-train as a means of bringing produce to the rail-head. The system of irrigation which has been successfully tried on a small scale in North Otago is also to be extended.

Norway: With reference to the report by the United States Consul-General at Christiania, that the Kristiania Elektriske Sporvei Company propose to make a tunnel to enable the street tramways of Christiania to reach a neighbouring amusement resort, H.M. Consul there states that the company above-mentioned is not promoting the scheme, but another company, which is already in touch with firms with a view to the supply of such plant as is required.

Australia: A recent report by the Queensland Engineer for Harbours and Rivers recommends, in view of the rapid growth of trade at Brisbane, the expenditure of a sum of about 809,000*l.* for improving the accommodation for shipping in the Hamilton Basin at that port. The proposed works involve the dredging of the basin to a depth of 26 ft., the construction of reinforced-concrete quays, the laying of railway lines, the installation of lighting systems, the construction of sheds, and the installation of a 40-ton floating crane. The *Age*, Melbourne, states that the Melbourne Harbour Trust contemplate the carrying out of various important works at a total estimated cost of 990,530*l.* The following is a list of works contemplated and authorised, including some under execution:—

	£
Dredging 6½ miles of river and bay channels, also the swinging basin and Victoria Dock to 30 ft. at low water (work now being carried out)	175,000
Plant, two dredgers and three steam hopper barges	93,240
Rock excavation in upper and lower river (work now proceeding)	15,000
Victoria Dock pier, 1800 ft. in length and 240 ft. in breadth	216,000
Widening Victoria Dock wharf from 40 ft. to 100 ft. on north-east and north-west sides	135,000
Setting back the south wharf and widening the swinging basin; also erecting a new wharf 6600 ft. by 50 ft.	165,000
Removing old wharf one mile	26,000
Widening the north wharf at Nos. 17 and 27 sheds, and between 6 and 8 Victoria Dock, and erecting the shed thereon (expenditure authorised in July last)	17,000
Sheds on reconstructed north wharf (the contract for which has been let)	5,490
Wet shed for bulk spirit (acceptance of tender authorised)	12,100
Sheds around Victoria Dock and on proposed pier, 25 in number	70,000
Cutting off angle at entrance to Victoria Dock (expenditure authorised in March last)	10,000
Widening Victoria Dock 10 ft.	20,000
Widening sheds along the Victoria Dock by 20 ft.	20,000
New launch (expenditure authorised in May last)	5,000

H.M. Trade Commissioner for Australia has forwarded a copy of the progress report of the Royal Commission on Northern Railways appointed by the South Australian Government in 1910, in which the construction is recommended of a railway from Wirrabara, *via* Melrose, to Wilmington, a distance of 31 miles, and of another line from Booleroo Centre to Willowie township, a distance of 10 miles.

Italy: The *Gazzetta Ufficiale* announces that tenders will be opened on November 15 at the offices of the Comando degli Stabilimenti Militari di Pena, Gaeta, for the supply of a large quantity of machine and hand-made paper, parchment, and ink, during 1912, 1913, and 1914. The total upset price is put at 945,000 lire (37,800*l.*). The *Gazzetta* also states that, as no award has been made in respect of the contract for the carrying out of harbour works at Viareggio, tenders are again invited and will be opened on November 22, at the offices of the Direzione General delle Opere Marittime, Ministero dei Lavori,

Pubblici, Rome. Although the two foregoing contracts will doubtless be awarded to Italian firms, nevertheless the carrying out of the contracts may necessitate the purchase of some materials out of Italy.

Turkey: His Majesty's Consul at Trebizond reports that the municipal authorities of that place invite tenders for the preparation of (1) a plan of the town; (2) a project for a water supply system, the water to be brought by an aqueduct 22 km. long from the Gallian-Dere River; and (3) a project for the drainage of the town. No final date has yet been fixed for the receipt of tenders.

Morocco: His Majesty's Consul-General at Tangier reports that tenders are invited by the Special Committee of Public Works for the construction of a road, 389.5 metres long, from the "Grand Sokko" gate to the British Legation at that city. The estimated value of the contract is placed at 37,468 francs (about 1500*l.*); a deposit of 500 francs (20*l.*) is required with each tender, to be increased by the successful tenderer to 2000 francs (80*l.*). Tenders will be received by M. le Président du Comité Spécial des Travaux Publics, Dar en Niaba, Tangier, up to 10 a.m. on December 21. The contractor must elect domicile in the neighbourhood of the works.

Brazil: The *Diario Official* publishes a decree (No. 9006) approving the plans and specifications which have been prepared in connection with the construction by the Companhia Mogyana de Estradas de Ferro e Navegação of the line from Igarapava to Uberaba. The line will be 31 miles long, and the cost is estimated at 4,166,000 milreis (280,000*l.*).

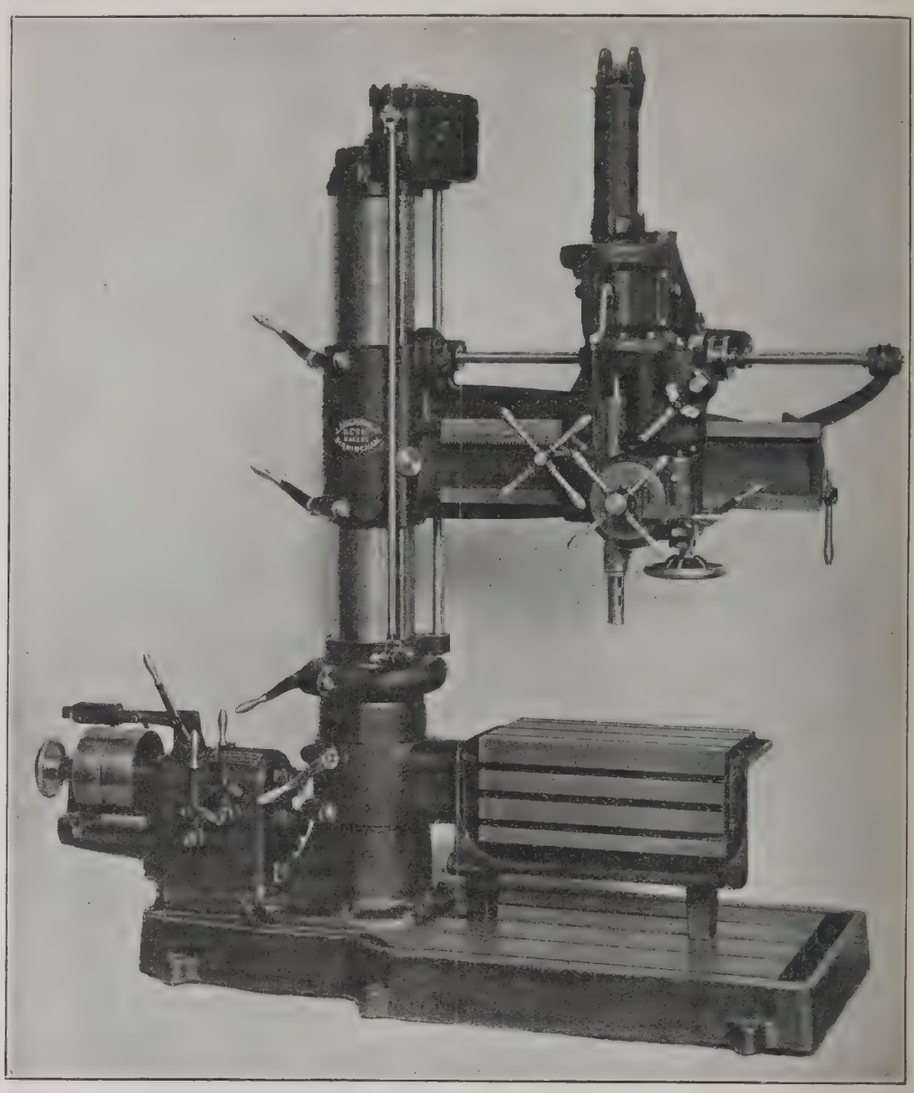
Argentina: The *Boletin Oficial* contains the text of a contract under the terms of which Mr. Abel J. Pagnard engages to construct and work during sixty years a commercial port at the mouth of the River Pareja, near Puerto Belgrano, Bahia Blanca. The harbour will have a depth of 30 ft. at low tide. The works will comprise docks and wharves having a total frontage of 5000 m. (5450 yards), railway lines, grain-elevators, and other harbour equipment, such as cranes, gantries, &c., sufficient to deal with 500 tons of goods per lineal metre of wharf per annum. The work will be divided into five sections, the first of which will comprise the establishment and equipment of 1000 metres of wharves; as soon as the tonnage dealt with aggregates 500,000 tons per annum for two consecutive years, the second section must be commenced; and so on with respect to the remaining sections. Exemption from customs duties will be granted in respect of any materials which it may be necessary to import from abroad. The official decree approving the foregoing contract *ad referendum* provides for the transference of all the rights and obligations assumed by Mr. Pagnard to the Sociedad Administradora General de Ferrocarriles y Obras Públicas. The *Boletin* also publishes the text of a decree (No. 8157) under the terms of which a concession is granted to Messrs. Francisco Doll and Co. for the construction and working of the following railways:—Between General Acha, in the Pampa territory, and the port of San Antonio, in the Río Negro territory; between Carhué and San Antonio; between General Acha and Bahia Blanca; a line to link up the General Acha-San Antonio section with the General Acha-Bahia Blanca section; a branch from a point near the fifth meridian to the Bay of San Blas. Within two years from the promulgation of this law the concessionnaire must submit complete plans and specifications of the projected lines, and constructional work must be completed within seven years after the approval of the plans. The *Boletin* further publishes a decree (No. 8203) issued by the Ministry of Public Works, under the terms of which the executive authorities are empowered to proceed with the construction of the railway from Tinogasta to the Chilian frontier *via* Paso de San Francisco, in accordance with the plans submitted. The amount to be expended for this purpose is put at 8,122,000 pesos gold (1,624,400*l.*).

Personal.—Messrs. Watts, Fincham, and Co., Billiter Buildings, E.C., have completed arrangements with the Halesowen Steel Company, Limited, Halesowen, Worcestershire, for the sole selling rights in London and district, including fifteen counties, of their English and American qualities of bright-drawn steel, for use in automatic machines.—Messrs. Richardsons, of Billiter-square Buildings, London, E.C., have just been appointed London representatives of Messrs. Tait and Co., Kobe, Japan, who are opening an engineering department.—The Lilleshall Company, Limited, are removing their London office to Billiter Buildings, 22, Billiter-street, E.C.

The Institution of Electrical Engineers.—At the opening meeting of the session of the Institution of Civil Engineers, last Tuesday evening, a deputation consisting of Mr. S. Z. de Ferranti, President of the Institution of Electrical Engineers, Mr. R. K. Gray, Past-President, Messrs. W. Duddell, F.R.S., W. H. Patchell, J. F. C. Snell, and Major W. A. J. O'Meara, C.M.G., Vice-Presidents, Mr. Robert Hammond, Hon. Treasurer, and Mr. P. F. Rowell, Secretary, presented to the Council and members of the Institution of Civil Engineers an illuminated address of thanks, as follows, on behalf of the Institution of Electrical Engineers:—"We, the President, Council, and members of the Institution of Electrical Engineers, desire hereby to express to the Institution of Civil Engineers our deep sense of gratitude for the privilege so generously granted to us from February, 1872, to April, 1910, of holding the ordinary meetings of this Institution, more than 500 in number, in the hall of the Institution of Civil Engineers. The hospitality extended to us during this long period of thirty-eight years has conferred a material and lasting benefit on the development of the electrical profession, and will always be held in our memories with sincere appreciation and thankfulness."

HIGH-SPEED RADIAL DRILL.

CONSTRUCTED BY MESSRS. JAMES ARCHDALE & CO., LTD., ENGINEERS, BIRMINGHAM.



We illustrate above a radial drilling-machine, built by Messrs. James Archdale and Co., Limited, Ledsam-street, Birmingham, for drilling at high speed holes up to 2 in. in diameter. The rapidity of drilling by using high-speed steel twist drills calls for a corresponding rapidity and ease of movement to enable the operator to position the drill for the next hole. The machine illustrated has been so designed as to enable all movements of spindle and saddle to be made by handles and levers carried on the saddle and within easy reach. As will be seen, the machine has a centre standard, which is bolted down upon a ⊥-slotted base-plate. The radial arm, of extra deep-box section, with square edges, is adjusted vertically by power on a rotating sleeve which encircles the centre standard, the adjusting mechanism being operated by lever through friction-clutch and gearing. It is then clamped firmly at the height desired, the sleeve being also clamped to the standard where required. Ball-bearings and vertical anti-friction bearings are provided for the various movements. The saddle is carried by rollers on the upper edge of the radial arm; it is exceedingly easy to traverse, and is provided with an improved locking-gear by lever and taper wedge. An additional spindle can be fitted to the saddle for tapping and studding. The drilling-spindle is driven by gearing through a strong friction-clutch, which can be engaged at any speed, and can be instantly reversed for tapping. It is carried as close to the arm as possible in order to reduce twist; it extends in one piece through the upper and lower guides, and runs in a sleeve with hardened-steel ball thrusts. It is counterbalanced by a spring having a compensating device, and is fitted with quick withdraw motion graduated in sixteenths of an inch, and bored to No. 4 Morse taper, also arranged with automatic stop motion. The double gear, which is carried on the saddle, can also be engaged by a lever while running. The spindle can be raised or lowered, started, stopped, reversed, the feed can be altered, the double gear engaged or disengaged, and the saddle can be moved along the arm by levers and handles on the saddle, while running at the highest speeds.

The machine is provided with a positive gear-driven feed-motion, with four feeds, which can instantly be changed by lever; the feed-motion is driven through an improved friction-clutch, which can be instantly engaged or disengaged by lever. The machine as illustrated is driven by a constant-speed belt through a change-speed box and gearing. The change-speed box is of the sliding-wheel type giving nine speeds; the double gearing gives a total of eighteen speeds. The machine can also be driven by an electric motor.

The machine is specially suited for work requiring extra height between the spindle and the base-plate; it is fitted with a box-table which can be swung round completely clear of the base-plate. The box-table requires no setting; being supported, it is comparable to a fixed table. It can be made to swivel round its horizontal axis for angular drilling.

All the main bearings are provided with ring lubrication and oil reservoirs. All the gear-teeth are machine-cut, and all bevel-wheels and wheels in the change-speed and feed-boxes are of steel.

Cutting Glass, Porcelain, and Quartz Tubes.—A neat way of cutting the glass and quartz tubes of delicate apparatus by means of etching with hydrofluoric acid is described by Jaroslaw Milbauer in the *Chemiker Zeitung*, 1911, page 669. The tube is rested horizontally in a fork, and a wet string is tied round in a single knot. One end of the string is placed in a vessel containing hydrofluoric acid mixed with one-third of its volume of hydrochloric acid; this vessels stands above the tube. The other end is dipped into a vessel filled with water, at a lower level. The string is tightened as the etching proceeds, and the tube turned and the knot shifted. When the etching has proceeded to a sufficient depth, the tube is wrapped with a cloth and broken.

THE ELLIOTT FLANGE-LUBRICATOR.

Fig. 1.

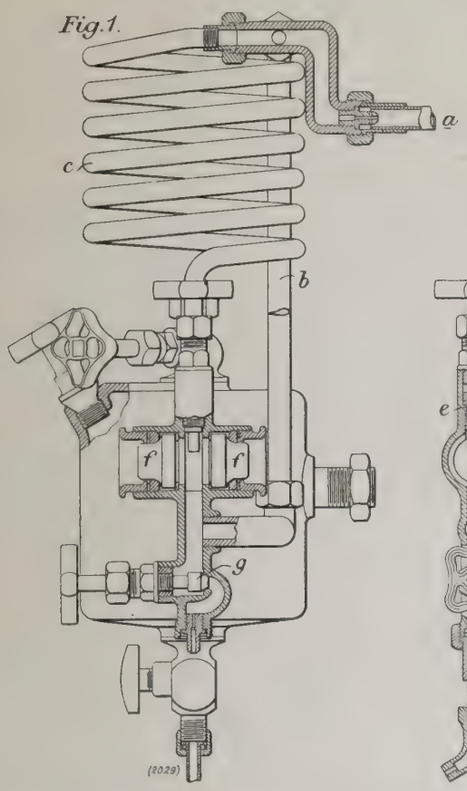
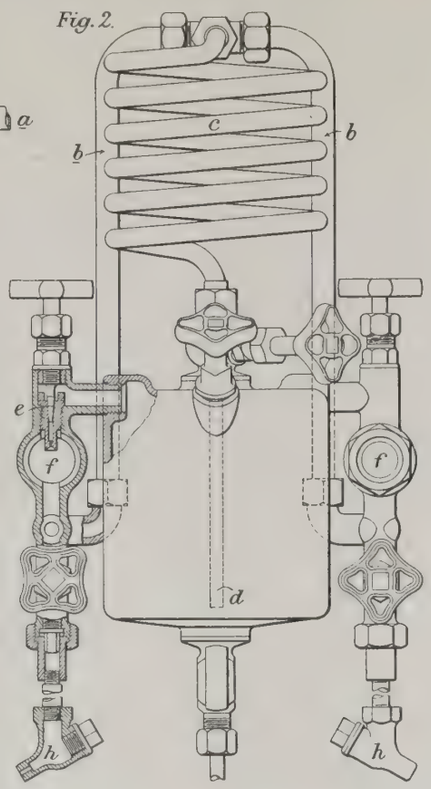


Fig. 2.



In another column we draw attention to the favourable report recently presented to the American Master Mechanics' Association by its Committee on flange lubrication as a means of reducing tyre and rail wear The report dealt with various methods of lubricating the wheel flanges, among them being that employing the Elliott flange-lubricator, which is being introduced into this country by Messrs. Davis and Lloyd, of 26, Victoria-street, Westminster, S.W.

This lubricator is on the sight-feed system. It is illustrated in Figs. 1 and 2, herewith, which are part sections, in order to show the various features. The lubricator consists of the usual body or oil receptacle, with sight-feed attachments and the necessary steam supply. Steam is brought along pipe *a* from the boiler to the lubricator, where it encounters a small choking-nipple. On the other side of this nipple the steam can flow in three directions either towards the branch-pipes *b*, *b* or to the condenser coil *c*. In flowing down the condenser coil it is reduced to water, and is in this form carried down to and delivered at the bottom of the lubricator body containing the oil supply by the pipe *d*. The oil is thus raised, and passes to the feed needle-valve *e*. The drip from the latter can be regulated according to requirements, the supply given being visible through the glasses *f*, *f*, held in their fitting by gasket and gland nuts. A delivery-valve *g* is placed at the base of the sight-feed arrangement. On the upper side of the valve *g* connection is made with the steam branch-pipe *b*, and steam flowing down this carries with it the oil delivered by the valve *e*, past the valve *g*, to the delivery-pipe and nozzle *h*. A valve is provided at the base of the condenser coil, and a filler-valve in the top of the lubricator body. A drain-cock is also fitted to the latter, for emptying the water of condensation before re-filling with oil. The spray-nozzle *h* is placed 15 in. above the rail and 2 in. from the flange, at the inclination shown in Fig. 2. The lubricator itself is placed in the cab.

It is the custom, in fitting this lubricator to ordinary road engines, to apply the nozzles to the leading coupled wheels. For Mallet compounds on heavy pusher and other service, it is usual to employ two two-feed lubricators, or one four-feed lubricator, supplying, by means of T connections, six nozzles. On these engines each side requires three nozzles, one fitted to the front coupled wheel of the articulated frame, and one each to the front and back coupled wheels of the main frame. Cocks allow the supply to be directed to either, according to the direction in which the engine is working. For shunting engines one two-feed oiler is used, with four nozzles applied to the leading and trailing coupled wheels.

The oil used is crude asphaltum oil, the Californian oil proving to be very suitable. This oil is heavy enough to cling to the flanges, and is transferred to the side of the rail-head, where it is of benefit to the following wheels of the whole train. If such an oil is used, there is no fear of it spreading on to the tread. This lubricator is in use on over seventy roads in America. In addition to the favourable particulars given regarding its use in the Master Mechanics' report referred to, statistics have been furnished to us, showing that on the Santa Fe, Prescott, and Phœnix Railway, its introduction has led to a great reduction in the number of sharp flanges found on engines and cars. The number of sharp flanges on tenders reported on that line in 1906 was 63. Equipment commenced in June of that year, resulting in a gradual reduction, until, two years later, only 21 tender tyres were reported for sharp flanges in twelve months. Car tyres were affected in a similar way, the number of sharp flanges per twelve months being reduced from 71 to 22 in two years. No driving-wheel tyres have been turned for sharp flanges since the use of this lubricator. Engines have run 153,630 miles and 122,308 miles without developing sharp flanges, though the road is no easy one to work, there being bad and continuous curves in many parts. Some engines have been kept in service for forty-two months without shopping for extensive repairs since adopting flange lubrication.

With regard to cost, the Santa Fe, Prescott, and Phœnix Railroad reports that one gallon of crude oil suffices for 575 miles in freight service, and 800 miles in passenger work. The Atlanta, Birmingham, and Atlantic Railroad puts the cost at 3 cents per 100 engine-miles, a figure which is also very similar to that reported by the Norfolk and Western Railroad.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, November 1.

THE steel industry is thoroughly aroused over the possible consequences of the suit of the Government against the United States Steel Corporation, looking to its dissolution. There are some twenty-eight subordinate companies and a number of individuals involved. Freight rates are to be reduced on ore from the Lakes, but the amount is uncertain. The Corporation will probably insist upon a 60 cent rate from the mines, while the independents will insist upon a 40 cent rate. The cancellation of the lease with the owners of the Hill ore properties, it is estimated, with the reduction in freight rates, will reduce the cost of making pig iron as much as 1 dol. per ton, but these reductions will not go into effect until the close of the shipping season. This means, of course, that the long contracts for the 1912 pig iron will not be closed at present. It is this possibility which has restrained the making of next year's delivery contracts so long.

The users of crude steel, such as billets, have begun to place large contracts at the very low price of 19 dols. The larger buyers are now engaged in placing contracts which will see them through with material up to April 1. Makers of billets are accepting this business in a very grudging way, as they naturally hope for a reaction which will bring them better prices. There are also inquiries for large quantities for structural material. The Illinois Central Railroad is placing an order for 112 steel cars of a new pattern, costing a total of 1,500,000 dols. The cars will have six-wheel trucks, and will be 70 ft. long, or 10 ft. longer than the present standard size. Other big contracts may be placed at any time. The car-builders are filling up once more, and are promptly arranging for the delivery of material to complete the contracts. In the smaller products, such as merchant steel and bar iron, further improvement has developed within a week. This improvement is also due in part to the heavy requirements of the car-builders.

STEAM-TURBINES.

TO THE EDITOR OF ENGINEERING.

SIR,—With regard to Mr. Samuelson's letter published in ENGINEERING, dated October 20, I do not think that he has quite correctly construed my remarks.

My statement that the thermal efficiency of a compound wheel would not exceed 58 per cent. was meant to apply only in the case of high-pressure stages, in which a large heat drop is employed, and not to a whole turbine in which a series of compound wheels are used. I explained this more fully in my reply to the discussion on the paper read before the Institution of Mechanical Engineers in Zurich.

I agree that a good thermal efficiency can be obtained with a compound-velocity wheel in the low-pressure portion of a turbine, or when working with a comparatively small drop in heat. For this very reason I have adopted this particular design for marine turbines where only a low number of revolutions is permissible, in combination with a large number of stages with a small heat drop in each.

The comparison drawn by Mr. Samuelson between the efficiencies of a Curtis and a Zoelly turbine of similar size is not altogether a fair one, as the total adiabatic drop in heat in the case of the Curtis turbines mentioned is only about 175 calories, whereas in the Zoelly turbine design it is about 215 calories.

It is obviously much more difficult to obtain such a high thermal efficiency in the turbine in which a large drop is used than in the turbine in which a small heat drop is used.

Yours faithfully,

November 6, 1911. H. ZOELLY.

"JET PROPULSION."

TO THE EDITOR OF ENGINEERING.

SIR,—Perhaps I may be allowed to make a few observations on this subject in view of your article thereon in ENGINEERING of October 20.

First, in regard to the main question. A good deal is taken for granted in accepting the high efficiencies usually claimed for screws as propellers.

Thornycroft's results of model tests, given by S. W. Barnaby, touch 70 per cent., and gave an average of 65 per cent. efficiency, but obtained by eliminating all losses but those in the screw itself. What the efficiency $\frac{\text{Thrust} \times \text{Speed}}{\text{I.H.-P.} \times 550}$ or $\frac{\text{Thrust} \times \text{Speed}}{\text{B.H.-P.} \times 550}$ was is not given.

Other tests have been made, but it is doubtful if $\frac{\text{Thrust} \times \text{Speed}}{\text{I.H.-P.} \times 550}$ in many cases exceeds 50 per cent.

Froude took 40 per cent. as the average for screw propulsion, but improvements have been made since his time.

It does not appear to me that any vast improvements would be required in jet propulsion to equal these results, or go one better. The writer of the article on the subject seems to convey the idea that bad as were the results of bygone tests with jet propellers, they could not be much improved upon at the present day. Let the usually given figures speak for themselves. The gunboat tested had the following efficiencies:—Engine, 77 per cent.; pump, 46 per cent.; jet, 71 per cent.; total efficiency, 25 per cent., or thereabout.

Will any ordinary engine-maker of first-class high-speed triple-expansion engines not do a great deal better than 77 per cent. to-day? An engine of that efficiency would not now be accepted as a gift.

As for the pump, I have guarantees from several makers of pumps to give 85 per cent., but, accepting the article-writer's estimate of 75 per cent., even that is a slight improvement on 46 per cent. Taking the jet as without improvement, and an engine efficiency of 90 per cent., we would get $0.90 \times 0.75 \times 0.71 = 47.9$ per cent.; not so bad for an over-all efficiency. I think it is high time that marine engineers should at once and for all time reject these reported results of tests on jet propulsion. They are trotted out every time anyone mentions jet propulsion, as if they were conclusive tests for all time, whereas they were nothing of the kind, but *merely tests of jet propulsion machinery as it was made at that date* of their trials. And the machinery was of very low efficiency all over.

Then as to pumps, I may observe that the whirling velocity of the water in the pump is converted into pressure in present-day pumps with very little loss, whereas in old pumps the velocity was destroyed, or only partially conserved, in diffusers. It is therefore, I think, justifiable to call the centrifugal pump a pressure pump; whatever happens inside, the result aimed at is to raise the pressure of the water.

Then in regard to losses in expanding tubes reducing the velocity and increasing the pressure of water, the

fact that the limit of taper should be about 1 in 10 for a straight conical tube has been known to me for forty years, and probably to more engineers before that. We at that time made expanding conical tubes, cones, and trumpet-shaped tubes, for ejector condensers, and soon found the limits. Expanding tubes for Venturi meters at water works are all made of a very long taper for the same reasons, so that the experiments at Dundee have not revealed much that was unknown about Venturi tubes or cones at this date.

Applied to the inlet of a centrifugal pump and of proper trumpet-shape and angle, the loss is absolutely negligible. Applied, badly designed, and ignorantly, there, of course, might be any amount of losses.

I believe from what I have seen of the Humphrey gas-pump that it may yet put jet propulsion on a competitive footing. Any direct-acting internal-combustion pressure on the water, producing a jet of correct velocities, would place the jet propulsion ahead of the screw; and even now, with a good high-speed modern engine and modern centrifugals, correctly designed on modern knowledge and experience, the jet propulsion would approximate very nearly the efficiency of the screw.

Yours truly,
RANKIN KENNEDY.

47, Argyll-street, Rothesay, November 3, 1911.

[We are unable to share our correspondent's sanguine anticipations as to the future of jet propulsion, nor his estimates as to the efficiency of the trumpet-shaped inlet sketched in his paper.—ED. E.]

"THE RESIDUARY RESISTANCE OF VESSELS."

TO THE EDITOR OF ENGINEERING.

SIR,—I notice in your issue of this week you publish a paper of mine on "The Residuary Resistance of Ships."

I regret, owing to a clerical error, that one of the columns of the page of figures, "The Form of Ends," has been wrongly copied in the paper sent you. I am sending you a revised and correct list, and if it would not inconvenience you, I should be much obliged by your inserting it in your next issue.

I remain, yours truly,
November 6, 1911. ERNEST SAXTON WHITE, B.Sc.

[We reprint Mr. White's table, as corrected, in the adjoining columns.—ED. E.]

THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—The alarm with which the proposed new articles of association of the Institution of Electrical Engineers have been received by the members all over the country, and the informal discussion in London, have proved that there is a wide difference of opinion between the Council and the general body of members. The Council have agreed to an open discussion, which no doubt will result in a large number of amendments being sent in. As, however, hundreds, and possibly thousands, of amendments cannot be taken into consideration, the purpose of the deferred discussion will be frustrated unless some definite method is adopted beforehand to reduce the number of amendments to the vital points only, leaving matters of detail to be put at the meeting in London.

As points affecting the future policy of the Institution, on which a vote should be given, I would propose the following:—

1. Inadvisability of creating the new class of licentiates (par. 4).
2. Necessity of keeping the Institution a strictly scientific and professional body (par. 12*d*).
3. Increase of fees (pars. 26 and 27).
4. Examinations (par. 16).
5. Nomination and election of Council (pars. 49, 51, and 52).

Under the present by-laws the local sections have no power to vote or pass any resolution in respect to the affairs of the Institution, and, therefore, whatever votes are taken will have to be forwarded direct from the members to the secretary. In order to enable any member to gauge the strength and the direction of the opinion of the body of members, I would suggest that copies of the resolutions passed on the above points should be published in the technical Press, together with the number of the members in favour.

Yours faithfully,
R. ORSETTICH, M.I.E.E.

Villa Nova, Gravelly-hill, Birmingham,
November 6, 1911.

THE INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.—The opening address will be delivered by Mr. C. P. Sparks on Wednesday, November 15, in the Institution Lecture Theatre, at 7.45 p.m.

THE JUNIOR INSTITUTION OF ENGINEERS.—At the recent annual general meeting of this institution the scrutineers reported that the election of officers, &c., had resulted as follows:—Chairman, Mr. Walter T. Dunn; vice-chairmen, Messrs. S. Bylander and Percy L. Young; librarian, Mr. S. V. Cooke; hon. auditors, Messrs. H. Norman Gray and W. D. MacPherson; members of council, Messrs. D. N. Hunt, J. B. Knowles, Reginald Krall, and J. J. Page; provincial members of council, Messrs. R. Hockly (Newcastle-on-Tyne), Ernest King (Sheffield), R. H. Parsons (Peterborough), Eustace W. Porter, (Southampton), T. P. Hosegood (Bristol), A. Knight Croad (Glasgow), W. E. Lilly (Dublin), and H. F. Hunt (Pembroke).

"THE RESIDUARY RESISTANCE OF VESSELS."

RESULTS OF SPEED TRIALS, SHOWING RESIDUARY POWER.

Type of Ship.	Length on Water Line.	Beam over Shell.	Draught Ex. Hanging Keel.	Coefficient. Block	Midship Area Coefficient.	Form of Ends.	Results of Actual Speed Trials. Maximum Speeds.	I.H.-P.	Propulsive Coefficient.	E.H.-P.	Skin Resistance H.-P.	Residuary Resistance H.-P.	Coefficient of Form K.	Residuary H.-P. by Formula $K \times V^6/\Delta^{2/3}$.
	ft.	ft.	ft.											
S.S.	374	49.5	24.0	0.794	0.977	1.415	11.2	2,620	0.470	1,231	785	446	0.67	455
S.S.	420	55.0	19.78	0.777	0.973	1.540	12.54	3,530	0.470	1,660	1140	520	0.54	500
T.S.S.	449	55.1	20.25	0.712	0.965	2.12	16.0	7,290	0.510	3,720	2357	1363	0.752	1341
T.S.S.	428	55.0	24.2	0.623	0.92	2.514	17.05	9,600	0.515	4,940	2760	2180	1.018	2155
T.S.S.	481	56.6	21.7	0.602	0.932	3.008	19.9	14,900	0.536	7,988	4528	3460	1.075	3480
T.S.S.	432	66.0	23 3	0.537	0.91	2.685	22.1	19,050	0.500	9,525	5760	3765	0 863	3680
T S.S.	500	62.2	23.3	0.488	0.877	3.565	26.1	34,600	0.520	17,970	9990	7980	1.171	7825
T.S.S.	506	60.3	23.3	0.5	0.88	3.710	25.92	32,300	0.555	17,910	9792	8118	1.261	8275
T.S.S.	485	63.15	23.4	0.49	0.884	3.425	25.7	32,600	0.520	16,950	9550	7400	1.122	7194

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a firm tone, but business was confined to 2000 tons of Cleveland warrants at 46s. 4d. and 46s. 5d. cash, and 47s. 3d. three months. Closing sellers quoted 46s. 6d. cash, 46s. 9d. one month, and 47s. 4d. three months. Cash buyers of hematite quoted 60s. 9d., and there were sellers at 62s. three months. The market was nominally steady in the afternoon, and one Cleveland warrant changed hands at 46s. 5½d. cash, with closing sellers at 46s. 6d. cash, 46s. 9½d. one month, and 47s. 3½d. three months. On Friday morning business continued quiet, and 2000 tons of Cleveland warrants were dealt in at 46s. 5½d. cash, 46s. 8½d. twenty-seven days, and 46s. 9d. one month. At the close the quotations were 46s. 5½d. cash, 46s. 9d. one month, and 47s. 3½d. three months sellers. In the afternoon the market was quietly steady, and only one lot of Cleveland warrants was done at 46s. 5d. seven days. Sellers' closing quotations were 46s. 5½d. cash, 46s. 9d. one month, and 47s. 3d. three months. On Monday morning Cleveland warrants were firmer, and a good business was done at 46s. 5d., 46s. 6d., and 46s. 5½d. cash, 46s. 5d. four days, and 46s. 9d. one month. The turnover was 8000 tons, and the closing prices were 46s. 6d. cash, 46s. 9d. one month, and 47s. 4½d. three months sellers. Hematite was quoted 61s. 3d. cash sellers, and 61s. one month buyers. The tone was a shade easier in the afternoon, when 2000 tons of Cleveland warrants changed hands at 46s. 5½d. four days. Quotations at the close were 46s. 5½d. cash, 46s. 9d. one month, and 47s. 3½d. three months sellers. On Tuesday morning firmness prevailed, and 3000 tons of Cleveland warrants were put through at 46s. 6d. cash, 46s. 9½d. one month, and 47s. 4d. three months. Closing sellers quoted 46s. 6½d. cash, 46s. 10d. one month, and 47s. 4½d. three months. Hematite was firm, with buyers at 60s. 9d. cash, and 61s. 1½d. one month. In the afternoon the dealings only amounted to 1000 tons of Cleveland warrants at 46s. 6d. cash, with closing sellers at 46s. 7d. cash, 46s. 10d. one month, and 47s. 5d. three months. When the market opened to-day (Wednesday) the tone was strong, and 3000 tons of Cleveland warrants were dealt in at from 46s. 7½d. to 46s. 8d. cash, and from 46s. 11d. to 47s. one month. At the close sellers quoted firm at 46s. 9d. cash, 47s. 0½d. one month, and 47s. 7d. three months. The afternoon session was not active, but Cleveland warrants were again firm, and changed hands at 46s. 8½d. and 46s. 9d. cash, and 47s. one month. The turnover was 2000 tons, and closing sellers quoted 46s. 9½d. cash, 47s. 0½d. one month, and 47s. 7d. three months. Sellers of one-month hematite quoted 61s. 7d., with buyers at 61s. 1½d. for that position, and at 62s. for three months. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 61s. 6d.; Gartsherrie, 62s.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 63s. 6d.; Shotts (at Leith), 62s. 6d.; and Carron (at Grangemouth), 63s. 6d.

Sulphate of Ammonia.—The market for sulphate of ammonia is again strong, and the inquiry is good. The current quotation is from 14*l.* 5s. to 14*l.* 7s. 6d. per ton for prompt lots, Glasgow or Leith, and business is reported at 14*l.* 6s. 3d. per ton. Shipments from Leith Harbour last week amounted to 445 tons.

Scotch Steel Trade.—There has been little change in the Scotch steel trade since last report and conditions are practically unaltered. The various works are well employed, and a large output is general both for the home market and for export abroad. Fresh business is still slow, owing mainly to the newness of the rebate scheme which is now in operation, and as a consequence buyers are not committing themselves to any extent, and most of the present activity is due to specifications against old contracts. Inquiries for shipment lots amount to a fair tonnage, and the prospects point to a good business being put through. Makers of structural sections are hopeful of an improvement in the near future, and the demand for thin sheets and plates for export is of a very healthy description. Official selling prices are without change.

Malleable-Iron Trade.—The West of Scotland malleable-iron makers continue to be fairly well occupied, and are turning out quite a lot of material. With regard to prices, however, no change can be reported; but with a better local inquiry the outlook is, perhaps, more promising.

Scotch Pig-Iron Trade.—During the past week the tone of the Scotch pig-iron trade has been rather quieter, and although deliveries have been fairly large, the booking of new contracts has not been very heavy. Some inquiries have come to hand from the Continent for a fair tonnage of No. 1 iron, but buyers in the South have not been quite so much in evidence during the last week. No change can be reported in the hematite position, and only a limited business is passing.

Shipbuilding.—Messrs. Bremner, Dunlop, and Co., Port Glasgow, have received the order to build a steamer, 250 ft. in length and of 2500 tons, for Messrs. J. and J. Denholm, Greenock—the Park Line. This vessel is for the firm's Continental and Baltic trade, and is to replace the Mountpark, which was sunk in collision in the North Sea last February. She will be constructed to Lloyd's highest class, and will be supplied with engines by the builders.

WATER-WORKS DIRECTORY AND STATISTICS.—Messrs. Hazell, Watson, and Viney, Limited, 52, Long Acre, W.C., have published this volume for 1911—the twenty-ninth issue of this directory—at the price of 10s. 6d. net. It gives detailed information concerning water-distribution in this country, arranged alphabetically as per towns. A shorter section at the end of the book contains similar data on foreign water works with offices in London.

ELECTRIC TOWING LOCOMOTIVES FOR THE PANAMA CANAL.—We read in the *Canal Record* that specifications have been sent to Washington with a view to obtaining tenders for the supply of forty electric locomotives for towing ships in the locks of the Panama Canal. The towing scheme has been prepared by Mr. E. Schildhauer, of the Panama Canal engineering staff. It is proposed, in the first instance, to ask for tenders for one locomotive only, which will be thoroughly tested; the remaining thirty-nine would be delivered should the trials with this first one prove satisfactory. The scheme in question provides for the towing of a ship through the Gatun, Pedro Miguel, and Miraflores Locks at a speed of 2 miles per hour, the ship being held between four lines of hawsers; the ship would stop in the fore bay of the lock, and four hawsers would then be fixed to it—two forward and two aft. The hawsers would be fixed at their other ends to the windlasses of four electric locomotives on the lock walls, there being two locomotives in front for towing, and two locomotives aft being towed, and holding the ship steady. Except when passing from one lock to another, the locomotives would travel on a level track. Two systems of tracks are provided for, one for towing and one for the return of the locomotives when not towing. Crossings between the tracks are to be located at each end of the locks only; there are to be no switches. The tracks are to be of the 5-ft. Panama Railway gauge, built of 90-lb. rails. Two towing-tracks, with a return-track between them, are to be laid on the centre wall, there being also a towing and a return-track on each side-wall. The towing-tracks are to be provided with a central rack over their whole length. Racks are also to be provided on the return-tracks, but on the inclines between the locks only. After they have hauled a ship through the last lock-gates and into the forebay, the locomotives will coil their cables and will return to take another ship through the same way, or they will immediately take charge of a ship going in the opposite direction. The type of locomotive proposed is to consist of two traction trucks, one at each end of the locomotive, with an electrically-driven windlass in the centre, carried on a frame joined to the traction trucks by a draw-bar and trunnion forming a universal joint. The electric equipment for each traction-truck is to consist of one three-phase traction-motor, with its controlling mechanism. The motors on both traction-trucks are to be operated in parallel. Current will be collected by each traction-truck by means of a plough fitted with two contact-shoes, each in contact with a separate rail laid in an open conduit, one for each of two phases, the third phase being carried by both track rails. The maximum load on the traction motors will occur, it is stated, when the locomotive is on the gradient between the locks; this will be greater than the actual towing load. Since weight will not be required for tractive effort, the locomotives are designed comparatively light; they are to weigh about 30 tons. The windlass drum will have two motors, one for driving it under a towing load, and the other for the rapid coiling of the hawser. The former motor is to have a full-speed torque of 120 lb. at 1 ft. radius; it is to be capable of a 50 per cent. greater torque for one minute, and will have a full-load speed of not less than 630 revolutions per minute. The coiling motor is to have a 30-lb. torque at 1 ft. radius; it is to be capable of exerting a 50 per cent. greater torque for one minute, and will also have a full-load speed of 630 revolutions per minute.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—So far as Cleveland pig iron is concerned a marked improvement can be reported. Buyers are now coming forward rather freely, having apparently concluded that they are not likely to benefit by further delaying purchases. A good deal is now being purchased for shipment before the northern navigation season closes, and long-delayed deliveries to inland Continental customers are being executed, several canals and rivers abroad, which have been practically dried up during the summer and autumn, having become navigable once more. Higher prices than have ruled for nearly two months past are now being realised for Cleveland pig iron. No. 3 g.m.b. is now fully 47s. f.o.b., and, in fact, that is more a buyers' than a sellers' quotation. No 1, which is still by no means plentiful, runs from 50s. 6d. to 50s. 9d., and the other qualities are firm, No. 4 foundry being 46s. 6d.; No. 4 forge, 46s. 3d.; and mottled and white iron, each 46s.—all for early delivery. Quietness still prevails in East Coast hematite pig. Sales are slow; the output is in excess of needs, and quotations are easy. Mixed numbers are offered rather freely at 60s. 6d., and some second hands are prepared to sell at a trifle below that figure. Dealers in foreign ore report rather more doing, consumers showing less reluctance to enter into contracts. Prices are very strong, being based on fully 20s. ex-ship Tees for Rubio of 50 per cent. quality. Coke is in good request for local use, and medium blast-furnace qualities command 15s. delivered here.

Manufactured Iron and Steel.—Encouraging accounts continue to be given of the various branches of the manufactured iron and steel industries. Producers of all descriptions are busily employed, many firms having orders booked which will keep them in full swing over the greater part of next year. Under these favourable conditions prices show a decided upward tendency, but have not as yet been quotably advanced. Principal market quotations stand:—Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron girder-plates, 6*l.* 17s. 6d.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 7s. 6d. to 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 11*l.* 5s.—sheets less the usual 4 per cent. f.o.b., railway material net at works, and all other descriptions less the customary 2½ per cent. discount.

New Tees Dry Dock.—We understand that Messrs. Smith's Dry Dock Company, of North and South Shields and Middlesbrough, have secured from Messrs. Bolckow, Vaughan, and Co., Limited, a long tract of land on the east side of their present yard and graving-docks at South Bank, Middlesbrough, for the purpose of providing a new dry dock and any other facilities that may be required by the shipping of the Tees. It is the intention of the directors, we believe, to proceed with the construction of an additional dry dock at once; also that they have acquired a considerable portion of the Eston jetty of Messrs. Bolckow, Vaughan, and Co., with the view of making a deep-water quay about 700 ft. long, where there will always be a sufficient depth of water for any size of vessel which trades with the Tees. This important development, following on the comparatively recent enterprise of this firm, shows its determination to keep abreast of the requirements of the Tees as a first-rate shipping port.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Industrial Exhibition.—Although it cannot be said exactly that Sheffield has hidden her light under a bushel, still it is the fact that, unlike many other large towns, she has not been particularly prominent in making herself familiar to the world at large. The magnitude of her industries is certainly not known to the average person, and there is a large proportion of the inhabitants of the city who themselves do not realise the multiplicity of industrial activities which flourish in their midst. Sheffield's present position as premier city in Yorkshire has created a favourable opportunity of drawing attention to herself by some big scheme. Undoubtedly something of this kind is in the minds of a special committee which has been appointed by the City Council to consider the question of holding an industrial exhibition on a large scale, in which every branch of Sheffield industry would be represented, from the products of the big armament and engineering firms down to the work of the silversmith and cutler. Such an exhibition would be a revelation of Sheffield's industrial possibilities. Not only would visitors be impressed by the gigantic nature of the operations of the great East End firms, but they would be delighted with the specimens of art craftsmanship which Sheffield is still producing, in spite of the narrowing demand and the competition of the machine. A big open space in one of the suburbs would be used for the exhibition, which it is intended should last a whole summer. The co-operation of the Cutlers' Company, of the Sheffield Chamber of Commerce, and of the leading manufacturers will be sought, in order that the exhibition may be thoroughly comprehensive and in every sense worthy of the city. Councillor Bashforth is the chairman of the special committee.

South Yorkshire Coal Trade.—The position in the hard-coal market may be said to be satisfactory. For some weeks now there has been steady buying, both for shipment and for industrial purposes, and prices have remained firm. Collieries have been continually working against time, in endeavours to clear up contract arrears of deliveries, and on this account there is not a great weight of steam coal on the open market. The railway companies are still buying freely, and the general industrial demand manifests a strengthening tendency. Buyers in some cases are endeavouring to renew contracts over next year. Prices tend to advance. Deliveries of gas-coal on contract continue to be considerable, and stocks are being accumulated at some of the works. Inquiries for slacks have been more numerous, and coke is selling well. House coal is naturally quiet for the moment. Recent ordering was sufficient to meet consumers' requirements for some time, and the only thing likely to bring about an increased demand just now would be a spell of severe weather or active fears of trouble in the colliery world. Prices accordingly are easier and there have been some slight reductions. The London trade is very quiet, and orders are arriving at collieries only very slowly. Latest Exchange quotations are:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. to 13s.; Silkstone, 11s. 6d. to 12s. 6d.; Derbyshire best brights, 11s. to 12s. 6d.; Derbyshire house, 10s. to 11s.; large nuts, 10s. to 11s.; small nuts, 6s. 6d. to 8s.; Yorkshire hards, 9s. 3d.; Derbyshire hards, 9s. to 10s.; washed nuts, 8s. 6d. to 9s. 6d.; rough slacks, 5s. 6d. to 7s. 6d.; seconds, 4s. 6d. to 5s. 6d.; smalls, 2s. to 3s.

Iron and Steel.—The iron market has not been very satisfactory on the week, although the position has not shown any real weakening. Whilst makers have displayed a tendency to advance prices, a few merchants have been accommodating customers at lower figures, so that any tangible result is practically cancelled out. On the other hand, makers have not changed their attitude in consequence, and the bulk of the consumers are keeping out of the market for the time being. The common irons are in a good position, with the Derbyshire makers asking increases. The bar-iron makers are busier than they have been for some considerable time. Good orders have been received from the wagon-builders and a considerable amount of overtime is being worked. Steel scrap remains in a depressed condition. Nothing has so far occurred to check the increasing prosperity of the general industries of Sheffield. The reports of armament departments and shipbuilding branches being in a state of quite exceptional activity are amply confirmed in a recent statement made by one of the directors of Vickers, Limited, who said that their firm alone had 5,000,000*l.* worth of shipbuilding construction work in hand for the British and foreign Governments. This will give some idea of the value represented by the orders on the books of the three big East End firms put together—Messrs. Vickers', Cammell's, and Brown's. Some interest is evinced locally as to the effect upon Government ordering of Mr. Churchill's transference to the Admiralty, but whatever that may be, the present position of affairs in Europe is scarcely likely to mean less work for the armament departments. Railway steel manufacturers are busily engaged on the extensive orders recently given out, and there is considerable work in prospect for makers of tramway material. Practically all the general steel trades are fully occupied. The demand for engineers' tool-steel is growing, and there is a very big export of this and other special steels. American trade prospects also are better, and there is good reason to anticipate that all branches of the steel trade will be able to record a remarkable year.

COAL STORAGE.—On October 28 Mr. Edward A. Harman, M. Inst. C.E., engineer and manager of the Huddersfield Corporation Gas Works, read a paper having the above title before the Manchester District Institution of Gas Engineers. He dealt with the various methods followed in this country for the stacking of coal, stated their advantages and defects, compared tests made with fresh coal and coal which had been stacked, and expressed the hope that other members would contribute their experience to the question.

IRON AND STEEL INSTITUTE.—The Council of the Iron and Steel Institute have unanimously elected Mr. Arthur Cooper, of Middlesbrough, to succeed His Grace the Duke of Devonshire in the presidency of the Institute in May next. The presidency is held for two years, the Duke having been elected in 1909, in succession to Sir Hugh Bell, Bart. Mr. Arthur Cooper was elected a member of the Iron and Steel Institute as far back as 1874, was appointed on the Council in 1894, and became a vice-president in 1906. In 1892 he was awarded the Bessemer Gold Medal for his services to the metallurgy of iron and steel. He is the managing director of the North-Eastern Steel Company, Limited, and is also a director of Messrs. Dorman, Long, and Co., Limited, Middlesbrough.

A NEW ORDNANCE MAP.—Mr. Edward Stanford, of 12, 13, and 14, Long Acre, official agent for the large-scale ordnance maps, announces the publication of the first 165 sheets of a new issue on the scale of 50 in. to a mile (1 : 1250). Hitherto, apart from the town plans, the largest scale on which urban districts have been obtainable has been the well-known 25 in. to a mile, and the new issue is based on an enlargement of that map. The larger scale map has been specially prepared for use primarily in connection with land valuation, and the area covered by each sheet is one-quarter of that of a 25-in. sheet. The size of the sheets is 40 in. by 27 in., and the price 2s. 6d. each. A number of sheets relating to districts in the counties of Cheshire, Durham, Hampshire, Lancashire, Leicestershire, Northumberland, Sussex, and Yorkshire have already been issued.

NOTES FROM THE SOUTH-WEST.

Cardiff.—One of the current features of the Welsh steam-coal trade is a keen demand on the part of the Italian Government, which requires large supplies of combustible in connection with the extremely serious conflict with Turkey into which it has drifted. Business in steam-coal has, however, at the same time, been rendered difficult by delays in steamer arrivals, in consequence of unfavourable weather. The best large steam-coal has made 16s. 9d. to 17s. 3d. per ton; ordinary qualities have ranged between 15s. and 16s. 9d.; ordinary bunker smalls between 7s. 3d. and 7s. 6d.; and cargo smalls between 6s. and 7s. per ton. House-coal has remained at about its former level; the best ordinary qualities have made 14s. 6d. to 16s. 6d.; No. 3 Rhondda large, 17s. to 17s. 6d.; and smalls, 10s. 3d. to 10s. 6d. per ton. No. 2 Rhondda large has brought 12s. to 12s. 6d.; and smalls 6s. 3d. to 6s. 9d. per ton. Foundry coke has made 18s. to 20s. 6d.; and furnace ditto, 16s. to 17s. per ton. As regards iron ore, Rubio has realised 18s. 6d. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Bristol City Engineer.—Mr. T. H. Yabbicom having given notice of his intention to retire from the offices of city engineer and city surveyor, the sanitary committee of the Bristol City Council proposes, with the approval of the Council, to appoint Mr. L. S. McKenzie, at present one of the divisional engineers, to the vacant offices, at a salary of 700*l.* per annum, rising in five years to 1000*l.* per annum, the amount now paid to Mr. Yabbicom. Mr. Yabbicom's services are not to be entirely dispensed with; indeed, he is to receive 400*l.* per annum as consulting engineer, to be reduced at the end of five years to 250*l.* per annum.

The Severn.—Mr. W. R. Needham, speaking on the question of the development of the Severn waterway at a meeting of the Worcester Chamber of Commerce, on Thursday, said he had always maintained that the improvement of our waterways was more a question of organisation than of reconstruction. After pointing out that the railway companies found it much to their advantage to carry heavy goods by water, he said there was no doubt that if the Worcester and Birmingham Canal and the Severn Navigation were under the control of one of the great railways, the volume of traffic down the canal and the Severn would be much increased. But while that would be an advantage to the railways, it would not be for the benefit of the trading community. What was wanted was a waterway board, under which the several canals could be unified. There should also be legitimate competition between waterway and railway.

New Slipway for Devonport.—A contract to build a large steel brow at No. 3 building slip, Devonport Dockyard (from which the Centurion will be launched to-morrow week), has been let to Messrs. Redpath, Brown, and Co., Riverside Works, East Greenwich. The work has to be completed by February 4, as the brow will be required during the construction of another battleship, which is to be laid down soon after the launch of the Centurion.

MOTOR TRACTION ON BRITISH CANALS.—The Canals Motor Navigation Syndicate, Limited, whose offices are at Norfolk House, Laurence Pountney-hill, E.C., are working in conjunction with Messrs. J. W. Brooke and Co., Limited, Adrian Works, Lowestoft, for the development of motor traction on our canal systems. Barges fitted with a 10-horse-power Brooke paraffin-engine have been running between Birmingham and London. An engine of this type propels a barge 71 ft. 6 in. long, 7 ft. beam, carrying 30 tons of goods on a 3-ft. 6 in. draught, at a speed of 3¼ miles per hour.

THE LATE PROFESSOR L. J. TROOST.—We regret to record the death of Louis Joseph Troost, a veteran scientist, one of the last surviving links with the great scientists of the middle of the past century, a pupil and collaborator of Sainte-Deville, Hautefeuille, Debray, and Marie-Davy Claire, who died in his eighty-sixth year, enjoying unimpaired faculties and excellent health almost up to his very last days. Troost was a chemist, and is most widely known, perhaps, for his early work on vapour densities and high-temperature research, and for his later investigations of the constitution of iron. Born and educated in Paris, he spent all his life in the capital of France, except four years, when he was teaching in Angoulême in the 'fifties. Up till 1900 he was professor of chemistry at the Sorbonne. He entered the Ecole Normale in 1848, and first made a name by his researches on lithium, then regarded as a rare element—though now known to occur almost everywhere, always, however, in small quantities—and its compounds. When he took up the investigation of vapour densities and dissociation at high temperatures together with Deville, the preparation of suitable vessels and thermometers for the experiment caused the greatest difficulties. It was this work which secured wider acceptance to the doctrines of Avogadro and of Ampère. His subsequent work concerned molecular volumes, zirconia and its compounds, the allotropic state, the influence of gases dissolved in metals, and the porosity of metals; one of the constituents of carbon-iron is named troostite, after him. His "Traité Elémentaire de Chimie" has seen many editions. In 1884 he was elected a member of the Institut de France, as successor to Wurtz; Moissan, whom he survived, was his own successor when he resigned his professorship at the Sorbonne. He was a man of remarkable activity, both as experimenter and writer.

EXHIBITS AT THE OLYMPIA MOTOR SHOW.

(*For Description, see Page* 626.)

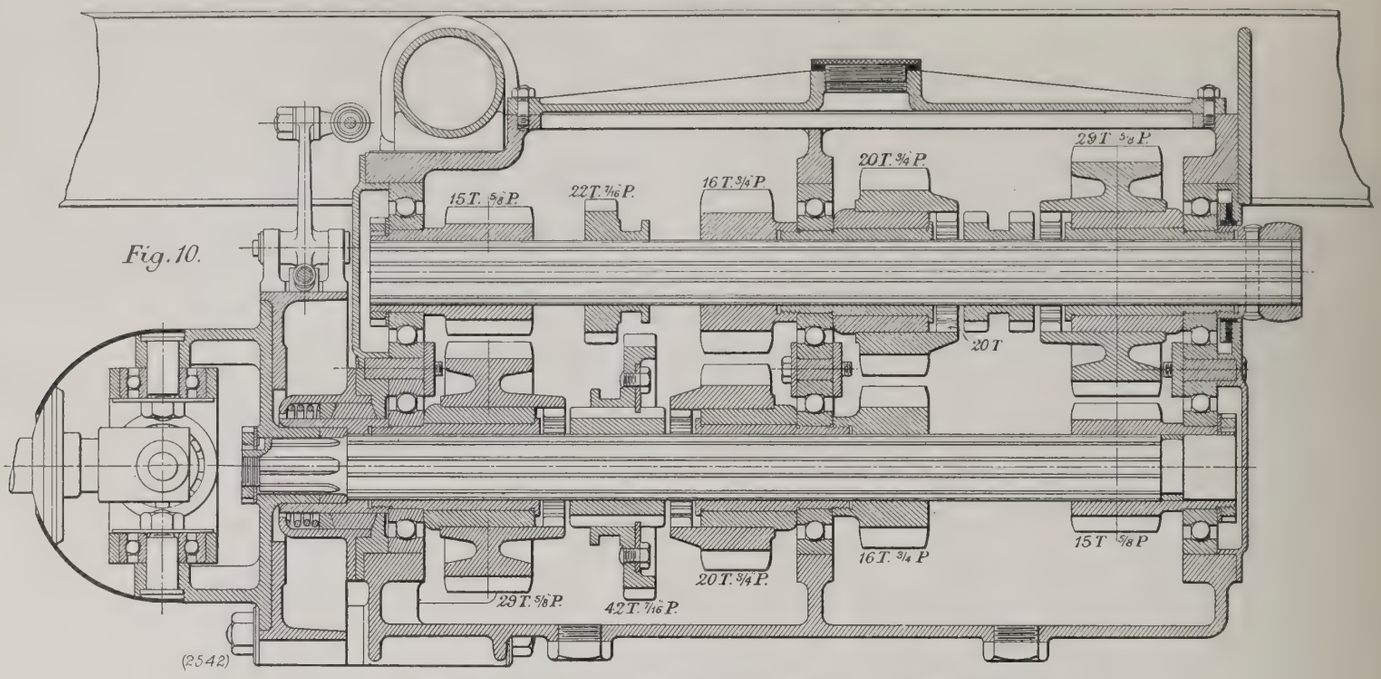
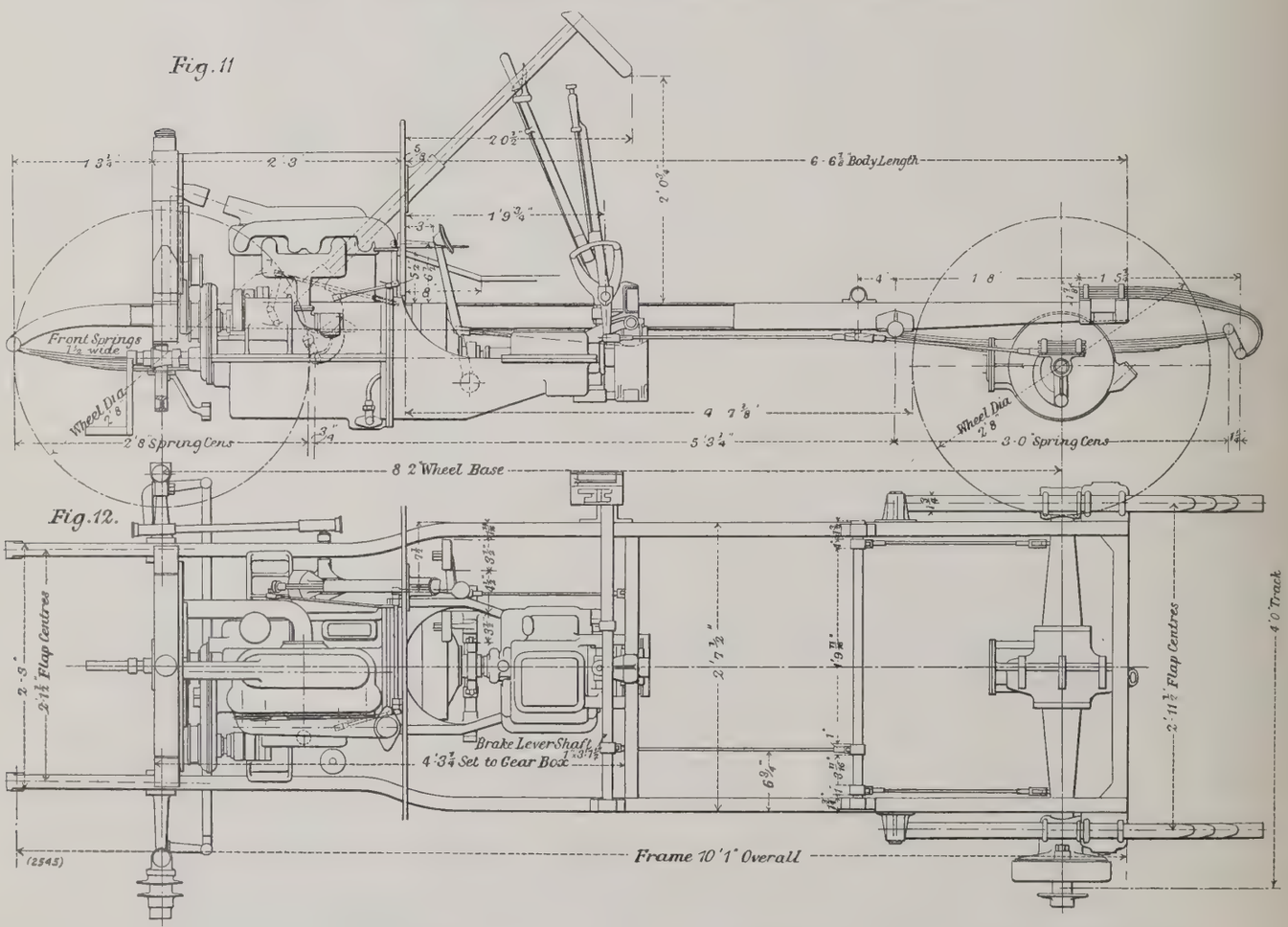


Fig. 10. Gear-Box by the Maudslay Motor Company, Limited, Coventry.



Figs. 11 and 12. Chassis of 10-Horse-Power Car by the Star Engineering Company, Limited, Wolverhampton.

The Tempering of Tuning-Forks.—In giving tuning-forks their blue temper, the Reichsanstalt had formerly made use of a cylindrical oil-bath; that is to say, a cylinder the air in which was heated with the aid of an oil jacket. The oil had to be kept boiling by means of gas-burners, and this operation required constant attention, although the vapours passed up a condenser and were returned to the bath. Experiments were therefore made with baths of fused mixtures of potassium and sodium nitrates, kept at 320 deg. Cent; it was found, however, that the tuning-forks became speckled, unless they were pre-heated in the air before being dipped into the fused salts, which would coat the fork with a crust of solid salt. Air-baths were again resorted to, therefore, but electric heating was adopted, as F. Göpel described in the *Deutsche Mechaniker Zeitung* of June 15, 1911. A clay cylinder is wound with bare constantan wire, which is covered by two layers of asbestos cord, and further by asbestos paper. A copper cup fits into the cylinder, forming a metallic lining for the bottom and the lower portion of the cylinder, in order to equalise the temperature in the cylinder. The best temperature for producing the blue tint, 315 deg. Cent., can easily be maintained in this bath; but the operation takes nearly an hour, and the method is not economical. In recent years, fifty-two standard tuning-forks have been treated on an average by the Reichsanstalt in the course of a year.

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NOTICES OF MEETINGS.

THE INSTITUTION OF POST-OFFICE ELECTRICAL ENGINEERS.—Monday, November 13, at 6 p.m., in the Lecture Hall of the Institution of Electrical Engineers, Savoy-place, Victoria Embankment, W.C. "Departmental Contracts," by Mr. W. S. Mountain.

THE SURVEYORS' INSTITUTION.—Monday, November 13, at 8 p.m. The President, Mr. W. Edgar Horne, M.P., will deliver an opening address.

THE INSTITUTE OF SANITARY ENGINEERS.—Monday, November 13, at 8 p.m., at Caxton Hall, Westminster, S.W. A lecture will be given on "Camp Sanitation: My Experiences during the Annual Training, 1911," by Sergeant Dunworth, 1st London (City of London) Sanitary Company, R.A.M.C.T.

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—Monday, November 13, at 8 p.m. A paper on "Modern Locomotives," by Mr. James Brander, Graduate, of Bristol, will be read. Chairman, Mr. H. A. Ivatt, Member of Council.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 14, at 8 p.m. Papers to be read:—"The Loch Leven Water-Power Works," by Mr. Alfred Henry Roberts, M. Inst. C.E.; "The Hydro-Electric Plant in the British Aluminium Company's Factory at Kinlochleven," by Mr Frederic Bolton Sonnenschein, Assoc. M. Inst. C.E.

THE ROYAL SANITARY INSTITUTE.—Tuesday, November 14, at 8 p.m., at 90, Buckingham Palace-road. A discussion will be held on "Sewage Farms," to be opened by Mr. H. A. Roechling, M. Inst. C.E., F.G.S. (Fellow). The chair will be taken by Mr. H. Percy Boulnois, M. Inst. C.E. (Chairman of the Council of the Institute).

THE INSTITUTION OF ELECTRICAL ENGINEERS: YORKSHIRE LOCAL SECTION.—Wednesday, November 15, at 7.30 p.m., at the Hotel Metropole, Leeds. The chairman, Mr. T. Harding Churton, M.I.E.E., will deliver his inaugural address.

THE ROYAL SOCIETY OF ARTS.—Wednesday, November 15, at 8 p.m. The opening address of the 158th session of the Society will be delivered by Lord Sanderson, G.C.B., K.C.M.G., I.S.O., Vice-President and Chairman of the Council.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, November 15, at 7.30 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Papers to be read:—1. "The Abnormal Summer of 1911," by Mr. Charles Harding, F.R. Met. Soc. 2. "Notes on Solar Halos," by Mr. Walter Larden, M.A.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 16, at 8 p.m., in the lecture theatre of the Institution. Second informal meeting of members and associate members, for the purpose of hearing any further suggestions regarding the proposed new articles of association.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, November 16, at the Rooms of the Geological Society, Burlington House, Piccadilly, London, W., at 8 p.m. The following papers will be discussed:—"Fallacies in the Theory of the Organic Origin of Petroleums," by Mr. Eugene Coste, Member. "The Economics of Tube-Milling," by Mr. H. Standish Ball, M.Sc., Student. "The Whim Well Copper Mine, West Pilbara, North-West Australia," by Mr. H. R. Sleeman, Member.

THE NORTHAMPTON INSTITUTE ENGINEERING SOCIETY.—Friday, November 17, at 5.45 p.m. Mr. A. H. Perrett will read a paper on "The Design of Electric-Power Stations."

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 17, at 8 p.m. Adjourned discussion upon the paper by Messrs. E. M. Eden, W. N. Rose, and F. L. Cunningham, on "The Endurance of Metals; Experiments on Rotating Beams at University College, London." Paper to be read and discussed (if time permits):—"Double-Cutting and High-Speed Planing-Machines," by Mr. J. Hartley Wicksteed, Past-President, of Leeds.

THE ILLUMINATING ENGINEERING SOCIETY.—Friday, November 17, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, London. The honorary secretary will present a brief report of progress during the vacation, and a paper will be read by Dr. H. R. B. Hickman, M.A., M.B., M.R.C.S., L.R.C.P., entitled "Notes on the Design of Motor-Car Headlights."

ENGINEERING.

FRIDAY, NOVEMBER 10, 1911.

THE STRENGTH OF MATERIALS.

IN his noteworthy presidential address to the Junior Institution of Engineers, delivered four years ago, M. Gustave Canet referred to the time when, as a young man fresh from college, he had discussed the principles governing the construction of ordnance with a reverence for formulæ and mathematical science which further experience showed him to be more or less misplaced. All young men, we think, leave college with very similar views, and are commonly quite confident that there exists a satisfactory and non-empirical science of the strength of materials. From calculations based on a few simple elementary principles the young student of engineering is quite ready to state boldly that such and such a bar or structure is safe or unsafe, whilst his more experienced elder is correspondingly more cautious and less dogmatic. Few living engineers can rival Dr. Unwin's experience in the scientific testing of materials, or match his exceptional acquaintanceship with the best work of the ablest investigators abroad. His experience goes back to the time when he was associated with Fairbairn in the experiments on the effect of repeated loads on a girder, which a little later led to the classical researches of Wöhler on the effects of fatigue. To Dr. Unwin must also, we think, be given the credit of popularising in this country a knowledge of the memorable researches of Bauschinger which resulted in the discovery of the fact that many materials had an "elastic range," a conception which went far to rationalise the purely empirical conclusions drawn from Wöhler's experiments. The new President of the Institution of Civil Engineers is therefore peculiarly well fitted to pronounce an authoritative opinion as to the adequacy of the various theories as to the fixing of working stresses which have from time to time been proposed. Naturally, we are not a little gratified in finding that Dr. Unwin's views on this head, as stated in his most interesting Presidential Address delivered last Tuesday evening,* are substantially in agreement with those which have from time to time found expression in these columns.

The only rational theory as to the strength of structures yet offered is based on the circumstance that, if a bar of certain materials is loaded up to, and not beyond, a certain limit, it recovers its original dimensions on the removal of the load. It was concluded, accordingly, that the bar had been totally unaltered by the loading it had undergone, and the natural and logical deduction was that any stress not exceeding the elastic limit was safe. In the minor field of technology, as in the greater affairs of the world, pure logic is, however, likely to be a most misleading guide, and, as Dr. Unwin points out in his address, this theory, which is that most frequently adopted in technical schools and places where they teach, is, perhaps, the most ambiguous and elusive of all. Many metals have no elastic limit, as the term is commonly understood, and experience shows that a bad steel and a good one may have practically identical elastic properties. The basing of factors of safety on the elastic limit is thus in no way more scientific than the plan of making the working stress some fraction of the ultimate strength. The latter, indeed, probably gives a somewhat larger margin of security. Steels are known in which the elastic limit is nearly equal to the ultimate strength, but it is by no means certain that the comparative working strengths of such a steel and of an ordinary ductile mild steel are accurately proportional to their elastic limits. In some recent automobiles, crank-shafts have been used, made from a special steel having a strength of over 100 tons per sq. in., and an elastic limit of but little less. No data exist by which safe working stresses on such a material can be fixed *a priori*, and as Dr. Unwin well points out, the use of scientific data and rational or semi-rational formulæ should not be allowed to conceal the fact that a purely empirical element is always involved in the fixation of working stresses. Piano wire, for instance, has a tensile strength of about 110 to 120 tons per sq. in., and, as Dr. Pole pointed out years ago, such wires are commonly strained in use up to very nearly their limit of resistance. Were a similar material built into a riveted girder, however, we believe it would be found necessary to greatly reduce the working stress. In short, the plan of basing working stresses on the elastic limit completely ignores the reserve of strength possessed by a plastic metal when subjected locally to stresses in excess of the yield-point. Recent researches in the mathematical theory of elasticity show, for example, that the stresses round a rivet-hole attain to no less than three times the average stress, and in this fact probably lies the explanation of the universal practice of using a mild material for riveted structures.

A material like the special steel already mentioned may possibly be stressed quite safely up to a large fraction of its ultimate strength, provided the conditions in which it is used are not likely to give rise to local concentrations of stress. In fact, it would seem that, to a very considerable degree, structures of ductile material may be proportioned on the basis of average stresses, whilst with harder materials scantlings must be fixed, so far as may be, by a consideration of the maximum stresses sustained. At the best, however, as has already been argued in these columns, the only really scientific method of proportioning a machine or a structure is by trial and error. Such a method automatically takes into consideration every possible straining action to which resistance must be offered. Life, however, is too short, and the process too costly, for the plan to be followed in its entirety, and the engineer is therefore compelled to adopt a less certain, but more rapid and less costly, system of proportioning, in which he avails himself of every artifice suggested by the mathematical theory of elasticity, or by his experience of the behaviour of his materials under conditions as nearly similar as he can find.

Dr. Unwin acutely remarks that most practical problems in designing, if traced to their foundation,

* We publish Dr. Unwin's address on page 643.

are merely applications of the law of similarity, which, he suggests, is really the basis of the so-called "mechanical instinct" which many practical engineers have developed to so high a pitch of utility. Within the limits of their experience such men completely out-class the mathematical analyst, fixing proportions and guessing weights with an accuracy truly astonishing. One man of this type, we remember, had, as the result of long experience, an extraordinary instinct for fixing the proportions and estimating the cost of railway bridges of the type common on British railways, where considerations of weight are of much less importance than questions of durability. His limitations, however, became immediately apparent when his firm were called on to tender for bridges to be sent many thousand miles over seas and up country, and where it was accordingly essential to save every pound of useless weight. Here he utterly failed, and his firm were only rescued from their dilemma by calling for the assistance of a lad in little more than his teens, fresh from a technical college, and with but a few months' shop experience.

At their worst bridges are relatively simple structures, but elsewhere engineers have often to make provision for resisting very complicated straining actions. Even where these are statically determinate there is as yet no general agreement as to what criterion of strength should be adopted. Many of those who have developed the theoretical side of the subject have adopted the hypothesis that the danger of failure is proportional to the maximum strain experienced: that is to say, to the maximum amount by which the distance between adjacent molecules has been increased. There is a certain semblance of logic in this hypothesis which makes it a very attractive one; but it receives no support from either experience or experiments. The results of the latter are, however, conflicting, as they seem to show that the failure of ductile materials depends upon the maximum shearing force to which they are subjected, whilst with non-ductile materials failure seems to be determined by the value of the principal stress.

Where the stresses are indeterminate other considerations arise, and we are very much inclined to doubt whether, in such cases, the value of the maximum stress, as calculated by the mathematical theory of elasticity, bears any very direct or simple relationship to the safety of the structure. Elasticians tell us that if a hole, even $\frac{1}{1000}$ in. in diameter, be drilled through the centre of a rotating disc, the stresses due to the centrifugal forces are immediately doubled in value. Were such disc spun up to the bursting point, however, we question whether it would fail at any notably less speed than a similar unpierced disc. The old puzzle as to the strength of solid beams affords another and better known instance of the fact that calculated stresses in compound structures afford only partial and imperfect evidence as to its danger of failure.

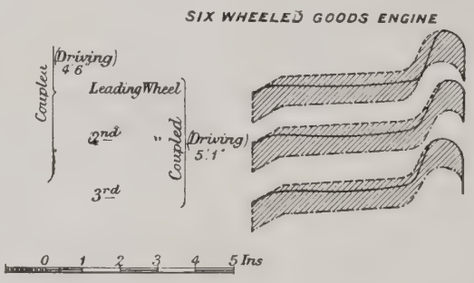
In the second portion of his address, Dr. Unwin deals with an equally controversial, but less technical, matter of debate. A general agreement as to methods of training engineers is, perhaps, even less likely of attainment than is the adoption of a universal and uniform system of basing working stresses, and it would be impossible to discuss Dr. Unwin's recommendations briefly. We hope, however, to deal with them in a future article.

WEAR OF RAILWAY TYRES.

The state of the tyres is often the deciding factor when it becomes a question of temporarily withdrawing rolling-stock for repairs. Under many conditions it is far more than this. It frequently happens that it is the sole reason for keeping stock out of service when, in other respects, it is in good order, and tyre wear is therefore a matter of great importance, not only from the point of view of cost of maintenance, but also because of its crippling effect on the earning capacity of the stock.

Wear of the tyres takes two forms, one of which is known as "tread wear," and is due to the rolling of the tread on the rail, the unavoidable slipping of one wheel or the other on curves, &c., and the action of the brake-blocks on the tyres. The second form of wear affects the flanges, the easy curve at the heel or root of the flange being cut away, leaving a sharp flange of a shape liable to result in accident. The relative seriousness of these two forms of wear depends on many factors. Curvature of the road worked over, and the length of the rigid wheel-base of the vehicle, most marked, generally, in the case of locomotives, are probably the most important items, though, of course, with these, speed also comes into the question, and in some cases—as, for instance, with locomotives—the efficacy of guiding devices also plays a part. With great curvature of the road flange wear becomes very much more important than tread wear, and several expedients are resorted to in the attempt to ameliorate these conditions. Efforts to reduce this wear by employing harder tyres result, of course, in it being transferred to the rail, whose life is thus shortened. The engineer is thus between the devil and the deep sea. A working compromise is all that is commonly secured, there being properly some most economical distribution of wear between the rail and the tyre, which, with the aid of experience, may be arrived at by careful adjustment of their relative hardness. The situation is sometimes helped out by the provision of guard-rails stiff enough to hold the vehicle off the outer rail, by means of the back of the inner wheel-flange. This only transfers the wear to another point, and though the expedient has been made to serve, it is by no means the best that can be done under many circumstances.

A glance at a tyre template will show how great is the waste occasioned by sharp flanges, and all flange wear, when it comes to re-turning. A diagram illustrative of this is contained in the report presented to this year's convention of the American Railroad Master Mechanics' Association, by its Committee on Flange Lubrication. This diagram shows how much of the tread of the tyre has to be turned off in order to build up again a



flange of the proper section, if it has become worn in the usual manner. With only $\frac{3}{32}$ in. tread wear in conjunction with a worn flange, the thickness of the tyre has to be reduced, in the case illustrated, another $\frac{3}{8}$ in. on the tread in order to form a flange to template. On the other hand, a tyre worn on the tread, but not at the root of the flange, only needs cleaning up to the desired taper on the tread, and the flange trimming up. Of these two operations, the latter does not affect the life of the tyre, while the former can be effected with very little loss of life, so that for an approximately equal reduction of tyre thickness on the tread, with flange wear only three-fifteenths of the reduction results from useful work, and twelve-fifteenths is pure waste, while with tread wear only as much as, and even more than, eleven-fifteenths may go in useful work, and the small remainder in trimming up the flange.

Most of the railroads reporting to the Master Mechanics' Committee give evidence to the effect that the mileage between re-turning of locomotive tyres is very seriously affected by wear of the flanges. In the case of some roads with certain classes of engines on mountain divisions only half or one-third the estimated proper tyre-mileage is obtained. In the case of yard engines it is sometimes only one-tenth of the proper mileage life. Twenty-one systems, or large divisions of important roads, reported to the Committee on this question, and of these, twelve give figures showing the life to be much smaller than it would be if tread wear alone occurred. Of the nine remaining, two roads only state that tyres last for their full estimated life, while the other seven have refrained from offering statistical evidence, in some instances for very evident reasons. A very instructive table has been drawn up by the Atchison, Topeka, and Santa Fe Railway, based on the average for a class of 4-4-2 type engines, with which, as a matter of fact, the particulars of loss due respectively to wear and to re-turning, already referred to, have to do. This table shows that the mileage between turning for flange wear on these engines was 18,600 miles. The tyres only stood three turnings, resulting in a total life of 74,400 miles. Between turnings for tread wear it was subsequently found that the tyres would run for 60,400 miles, and with three turnings this gave a total life of 241,600 miles, or about $3\frac{1}{4}$ times as long.

We give herewith a figure which illustrates this point. It is taken from the paper entitled "Locomotives Designed and Built at Horwich, with Some Results," by Mr. G. Hughes, read before the Institution of Mechanical Engineers in 1909, at the Liverpool Meeting. It is usual in English practice to turn all tyres of coupled wheels down to the diameter of the most worn wheels. This involves considerable loss, of course, on wheels which ordinarily wear slowly. American practice, as will be seen below, is often different in this respect. The accompanying figure represents the tyre templates of a six-coupled goods engine. The dotted line represents the original thickness, and the full line the wear. In re-turning, to bring the tyre again to template, machining has to be continued down to the chain-dotted line. It will be noticed that the flange wear is severe for the leading tyre, and this tyre diagram shows how much unavoidable waste occurs in the process of building up a good flange again. The wear to the driving and trailing wheels is not nearly so severe, and these wheels would clearly show a much higher mileage per $\frac{1}{8}$ in. reduction of thickness were it not for the need of turning the set down to uniform diameter. The mileage per $\frac{1}{8}$ in. reduction for this engine is 9105 miles. The loss of tyre mileage by turning to uniform diameter is estimated at 80,942 miles in this instance, due largely to the flange wear of the leading wheels. Other diagrams illustrating tyre wear, in Mr. Hughes's paper, are equally interesting. For instance, in the 4-4-0 and 4-4-2 types, where the guiding effect of the leading truck comes in, the result is shown by heavy flange wear on the leading bogie-wheels, which necessitates so much turning down that mileage per $\frac{1}{8}$ in. reduction of 21,553 and 9497 miles respectively is obtained on these wheels, compared with which the wheels of the second axle of the bogie show 60,340 and 17,412 miles for $\frac{1}{8}$ in. wear for the two types. The leading drivers show considerable flange wear in the case of the 4-4-2 type, as do the trailing wheels. In a 2-6-2 type of tank engine the leading drivers show a good deal of flange wear, but the leading wheels (radial axle) show much less. Similarly in a 2-4-2 tank the leading drivers show considerable flange wear. Such results would seem to lead to the conclusion that, even if no other expedients were possible, it would prove beneficial if the guiding effect of the truck were to be increased. It is evidently better to have to turn up one pair of bogie wheels than to have to reduce to uniform diameter a whole set of drivers.

The second loss resulting from excessive flange wear involves frequently great inconvenience. It is dependent, however, in intensity on many factors, which vary in every case. The practice of dealing with worn tyres differs; the facilities for re-turning vary, so that it is impossible to suggest any length of time for the enforced idleness due to the necessity of attending to the tyres. In America practice permits of the employment of many methods which are not at present tolerated here. The tyres are, for instance, sometimes removed from the wheels by means of heaters, without taking the wheels out, and they are similarly replaced. Drop-pits for expediting the removal of wheels are in use in both countries, but it is only at certain sheds that they can be provided. At the large shed with pits and lathes on the spot, but little delay may occur in doing what is necessary to tyres; but at the small centre it cannot help being considerable. The lifting appliances are often, in these cases, crude, and the wheels must be sent away to be turned, so that it is just where the stock is small, and the temporary loss of a unit most severely felt, that worn tyres may cause the maximum of inconvenience. The time an engine may be kept out of service for attention to worn tyres may thus vary, according to practice and facilities, between five hours and a large number of days, during which time it, of course, earns nothing, in addition to which account has to be taken of the cost of taking out and of changing the tyres or of turning them up. In order to reduce expense and keep the engines out as long as possible, it is the practice on some American roads to change the tyres, shifting those from wheels where the wear is least to those where it is greatest. In this way an engine may

be kept at work until it has be be shopped for tread wear or for general repairs.

Such methods will probably not commend themselves to the generality of British engineers, and there are other and better means of overcoming the trouble. We refer to the lubrication of the side of the head of the rail, in order to reduce the wear which concurrently occurs there and on the flange. The lubrication of the rail may be effected in several ways. It may be direct, or it may be indirect. Several devices have been tried with the object of providing a direct system, while cruder systems of application by hand have also been attempted. The indirect system consists in lubricating the flanges of the wheels, whence the lubricant is transferred to the side of the rail-head. This seems in many cases to have proved most efficacious, though all the systems tried have not proved equally successful. The systems reported on by the Master Mechanics' Committee cover the use of crude oil, engine and car oils, solid lubricant, water, and exhaust steam. Some of these are not new, of course, but the information brought together in this report probably covers for the first time the use of so many systems on a large number of independent roads. The particulars as to the value of the use of water or steam as a flange lubricant are meagre, though one line states that water sprayed on to driving-wheels of passenger engines has increased the life between re-turning three or four-fold. The solid-lubricant system is perhaps the simplest, but it is reported to fail to give satisfaction in either hot weather or cold. In simplicity some of the cruder devices using oil probably rank next, such as, for instance, waste pads saturated with oil, held up against the flange; but these devices also appear to fail in cold weather.

There are several points to be thought of in deciding on a system. It is necessary that the lubricant shall be of such consistency that it will be able to resist being thrown off the flange. There must also be no risk of application of the lubricant to the tread. The systems apparently conforming best to these and other requirements employ crude oil containing a high percentage of asphaltum, with gravity or pressure feed. Reports of the use of such systems are most satisfactory, and several hundreds of engines are so equipped in the United States. Among the appliances working on these principles is the Elliott flange-lubricator, which we illustrate on another page this week.

At twenty-two centres from which reports were sent in it is the opinion, except in four instances, that flange wear is much reduced by lubrication. Of the four exceptions, one stated that its experience was too limited as yet to determine the point, and only one produced any evidence supporting its conclusion that it was of no service. By far the majority of the other lines report that tyres will run, if lubricated, until re-turning is necessary on account of wear on the tread. The life between turnings is increased in some instances from three months to twenty, or six weeks to six months. In other instances, measured in mileage, the improvement is from 25,000 to 75,000 miles, from 8000 to 30,000, from 30,000 to 100,000 miles, and so on. Another line reports that whereas formerly it was able to obtain only half the proper life as determined by tread wear, now it obtained the full life.

The Kansas City Terminal Railway reported a case of a yard engine wearing its tyres so sharp on the flange in three months that they had to be changed. The opportunity was taken to fit on a flange-lubricator, after which the engine stayed in service thirteen months, when, though the tyres were still in good condition, it had to be shopped for other repairs. Another interesting case is reported from the Atlanta, Birmingham, and Atlantic Railway. In this instance an engine had worn its flanges sharp after about 18,600 miles. As it could not be spared, a flange-lubricator was fitted, and it ran another 34,500 miles without further appreciable wear, after which the tyres were shifted, and the engine still kept in service. The Southern Pacific Railway estimates that it saves 16,710 dols. per year on the tyres of sixty-nine consolidation engines on one of its mountain divisions, and 7390 dols. on the tender tyres, owing to reduced cost of attention to and work on the tyres, due to the adoption of lubrication. Other reports are no less interesting. The Wabash Pittsburg Terminal Railroad states that since adopting the system tyres are only turned because of wear on the tread, and not on account of sharp flanges.

The improvement is naturally not confined to the wheel; the rail also benefits. Though exact figures are not available, it is estimated that, on the New Mexico division of the Santa Fe road, the life of rails in certain places has been increased from 13 to 15 months. On the Southern Pacific Railway, on bad curves, where the life was formerly 8 or 10 months, it has been extended to three years or so. There is thus plenty of testimony favourable to flange lubrication where, from the nature of the country or district, sharp curves are unavoidable.

BLADELESS TURBINES.

From a recent issue of the *Scientific American* it appears that Mr. Nikola Tesla has revived a method of steam-turbine construction which recalls one tried here some nine or ten years ago. The idea was patented by Mr. E. C. Thrupp in 1901, but Mr. D. J. Smith, of 58, Compton-street, E.C., informs us that at a still earlier date he assisted an Australian inventor to experiment with a similar type. The Tesla turbine is represented diagrammatically by Figs. 1, 2, and 3, which we reproduce from the *Scientific American*. As will be seen, its mechanical simplicity is extreme. The whole machine consists of a series of 25 thin discs 18 in. in diameter and $\frac{1}{32}$ in. thick mounted side by side on a shaft, with a small clearance between them. Steam is admitted tangentially through a nozzle on the right, and after flowing through the interspaces between the discs, escapes at the centre, causing the rotor to rotate by its frictional drag on the discs. To reverse the direction of rotation, the nozzle on the right is closed, and that shown on the left opened.

Mechanically nothing could be simpler, but unfortunately this mechanical simplicity is purchased at the expense of hydraulic inefficiency, as any of the various inventors, who have experimented on the device, could have ascertained had they applied to someone with a competent knowledge of theoretical mechanics. That the system is likely to be defective in this respect is obvious from the consideration that in a perfect turbine the steam must expand adiabatically. Now, in turbines of the type under consideration, the whole impelling force is due to the fact that the fluid slides over the surfaces of the discs with friction, against which it does work, and this frictional work is returned to the steam as heat. The whole impulsion of the rotor accordingly is dependent on the wasting of work by friction. If there were no friction, the steam would expand adiabatically, but would do no work, whereas, in the case of an ordinary turbine, could adiabatic expansion be secured, the efficiency would be a maximum. It can be shown, in short, that the maximum possible hydraulic efficiency of such a turbine is 50 per cent., and any experiments showing a better result than this can safely be discarded, though some allowance may be necessary for the fact that an hydraulic efficiency of 50 per cent. may, in a compound turbine, owing to the reheat factor, correspond to a somewhat higher thermodynamic efficiency, since the work wasted in friction at the high-pressure end of such a turbine is partially recoverable in subsequent stages.

Obviously, the system of maintaining a motion and doing work by the frictional drag of a fluid is not confined to cases of rotation, and the mathematical aspect of the question is, perhaps, more simply presented if we consider a case of rectilinear motion. Thus, suppose a stream of fluid moving at v ft. a second to be discharged into a tank mounted on wheels. Let the latter at the outset be held fast, then, although the jet exercises a frictional drag on the tank, no work is done, since motion of the latter is prevented. The frictional drag on the tank is equal to the momentum destroyed per second; or if W denote the weight discharged per second, the thrust on the tank is given by the relation $T = \frac{W}{g} v$.

At the same time the kinetic energy destroyed per second is $W \frac{v^2}{2g}$. Next assume the speed of the jet and the speed of the tank are both increased by the amount s. Then assuming, as before, that the fluid merely collects in the tank, the frictional drag is unaltered, since the fluid enters with an absolute velocity $v + s$, and remains there with an absolute velocity s. Hence the frictional drag impelling the tank is again $T = \frac{W}{g} v$, and the useful work done per second in propelling the tank is $T s = \frac{W}{g} v s$.

The kinetic energy supplied by the jet is now, however, $\frac{W}{g} \frac{(v + s)^2}{2}$.

Hence the efficiency of the device is

$$\frac{W}{g} v s \div \frac{W}{g} \frac{(v + s)^2}{2} = \frac{2 v s}{(v + s)^2}$$

By differentiation, it is easily seen that this is a maximum when $v = s$, in which case the efficiency is $\frac{1}{2}$. Finally, let the speed of the jet be still further increased by an amount y, whilst the speed of the tank remains constant at s. The fluid is now delivered from the tank with an absolute velocity $s + y$, and a relative velocity y. The case, therefore, is exactly analogous to the Tesla turbine. The frictional drag remains the same as before—viz., $T = \frac{W}{g} v$, and the work done is still $\frac{W}{g} v s$.

The kinetic energy supplied is now, however, $W \frac{(v + s + y)^2}{2g}$, so that the efficiency is $\frac{2 v s}{(v+s+y)^2}$, which is less than when the whole of the fluid remained, and moved with the tank. In that case the maximum possible hydraulic efficiency was 50 per cent., so that when the fluid is delivered as it is in the case of the Tesla turbine, the hydraulic efficiency must be less than $\frac{1}{2}$. Of course, the motion in the latter is not rectilinear, but the argument above set forth applies identically, if for linear momentum we substitute moment of momentum, for frictional drag frictional torque, and for linear velocity angular velocity.

To make an efficient turbine of the device it would be necessary to provide vanes. We should then get a construction analogous to the "Jumbo" turbine patented and experimented with by Sir Charles Parsons many years ago. This was abandoned because it was found that any solid particles which might accidentally get into the turbine were kept in a constant state of flux between the rotor and the standing portion of the machine. They were carried in with the steam and flung out again by the centrifugal force, and the wear was consequently excessive.

Fig. 1.

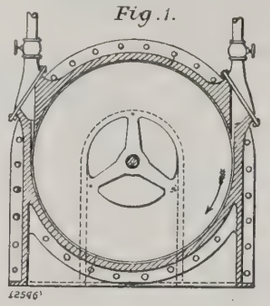


Fig. 2.

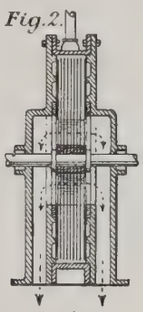
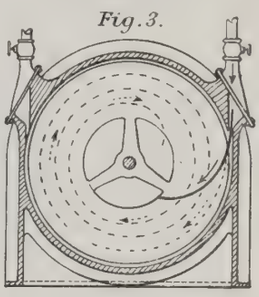


Fig. 3.



THE METROPOLITAN WATER SUPPLY.

It is well known that, in accordance with sound principle, the Metropolitan Water Board are taking steps to increase the storage capacity of their works. This move is one of importance for several reasons. In the first place, the growth of population in the area served has resulted in an expansion in the demand for water for several years, and the probable continued increase in the future renders it essential that adequate steps should be taken to ensure growth in supply commensurate with still greater requirements during the years to come. For this reason alone, therefore, it is necessary that the capacity of water storage should be enlarged. In addition there is the advantage of having such ample capacity that in times of flood the water

may be drawn off, to serve in times of less copious supply. Working this principle to the limit would entail withdrawing water from the river supplies only in flood time, and storing it in such quantities as not only to reduce the risks of flood, but also to avoid withdrawing from the rivers at other times. The third and perhaps the most important reason for securing ample storage, if anything in advance of increase of population, arises from the necessity of reducing to a minimum the risks of water-borne disease. In this connection the Board's Director of Water Examination, Dr. Houston, carried out recently some very convincing experiments. Dr. Houston infected raw river water with typhoid bacilli, and found that on the water being kept the bacilli perished rapidly. In two experiments the typhoid bacillus was dead within one week, and in two others it was dead within two weeks. On the twenty-fourth day after the commencement of the test, Dr. Houston drank half-a-pint of the water which had been infected without any harm. The value of lengthy storage is thus demonstrated, and for these and other the reasons already mentioned steps have been taken to increase the reservoir capacity of the Metropolitan works.

The existing storage capacity amounts to 9745 million gallons. The population served at the present time numbers about 7 millions, and the average daily supply, according to the last report, is about 223,461,000 gallons. It is estimated that in 1941 the population supplied will probably number about 12 millions, and that the daily supply will then need to be about 420 million gallons. At the present time 55.5 per cent. of the water is drawn from the Thames, and by the time a supply of the amount above cited is required, it is calculated that 71.4 per cent. of the water will have to be taken from the Thames. To provide for this would require a storage capacity in the Thames Valley of 27,276 million gallons, of which about 7000 million gallons is now available, leaving 20,000 million gallons additional storage to be provided.

In 1910 a scheme was drawn up by the Board formulating this undertaking, and a Bill was introduced into Parliament in the early part of this year providing for the construction of eight new storage reservoirs, but the project has since been modified. The proposed reservoirs were, with one exception, in a group in the vicinity of Staines. The sites for Nos. 1 and 2 lay between the Thames and the London and South-Western Railway, west of Staines, at Wraysbury. That for No. 3 was between Horton and the London and South-Western Railway, a little further west. The site for the proposed reservoir No. 4 was near Runnymede, between Colne Brook and the Staines Branch of the Great Western Railway. No. 5 was planned alongside the existing Staines reservoir, near Staines Moor. Nos. 6 and 7 were to be near Littleton, while No. 8, away from the others, was to be on the north side of the river west of Sunbury.

This scheme was not proceeded with in complete form owing to opposition by public authorities and others. The last-mentioned reservoir, that opposite Walton, was abandoned, and for the moment Parliamentary sanction has only been obtained for the construction of reservoirs Nos. 5, 6, and 7. The former when constructed will have a capacity of about 2290 million gallons, while the two latter together are expected to have a capacity of 7312 million gallons. In addition to these undertakings, the Bill, to which Royal Assent was given in August last, provides for the construction of two other reservoirs, one near Greenford, on Horsenden Hill, and one at Wembley, on Barn Hill, with conduits, &c. These, however, are service reservoirs, and not storage reservoirs in the ordinary sense. There is thus in contemplation additional storage for nearly some 9600 million gallons in the Thames Valley, for which sanction has been obtained.

The latest addition to the storage reservoirs of the Board was that which was officially opened by the Lord Mayor of London with no little ceremony on Saturday last, the 4th inst. This reservoir is situated in the urban district of East and West Molesey, on the south of the Thames. It occupies an island bounded by the Rivers Ember and Mole, and has been named the Island Barn Reservoir after some farm buildings, part of which still remain on the site. The situation of this reservoir is shown on the map, Fig. 1, on this page, while a plan of the reservoir itself is shown in Fig. 2. This reservoir has been constructed upon land acquired by the Lambeth Water-Works Company. In 1907 the Metropolitan Water Board obtained

ISLAND BARN RESERVOIR; METROPOLITAN SUPPLY.

MR. W. B. BRYAN, M. INST. C. E., CHIEF ENGINEER.

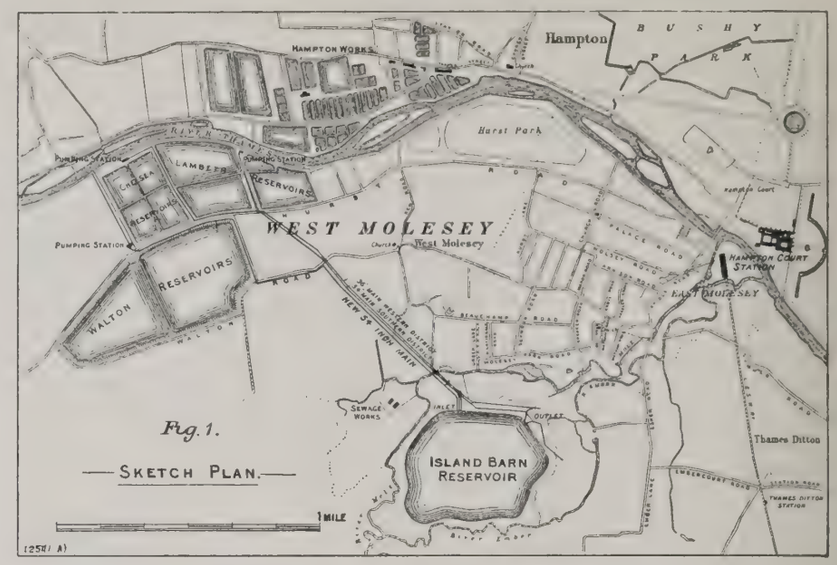


Fig. 1. —SKETCH PLAN.—

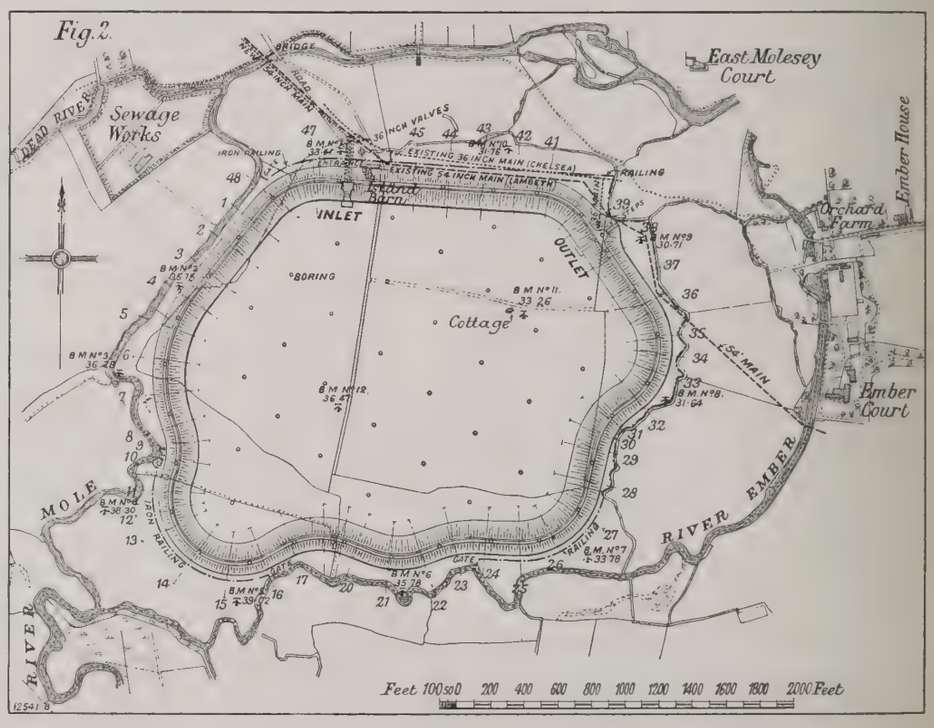


Fig. 2.

powers to construct it, and work was commenced upon it in October, 1908, the contract having been let to Messrs. Robert McAlpine and Sons at the sum of 152,727*l*. The reservoir has a capacity of 1000 million gallons, and, when filled, the water surface is about 120 acres in extent.

The embankment enclosing the reservoir is composed of the material excavated from the site, about 950,000 cubic yards of earth having been utilised in this part of the work, exclusive of the 112,000 cubic yards of clay used for the puddle trench inside the embankment, and of a length of 3000 yards.

The puddle trench is carried down to the London clay through a bed of gravel. In the embankment proper, the puddle is 9 ft. thick, reduced to 5 ft. at the top; but below the normal ground level the thickness is reduced to 6 ft.

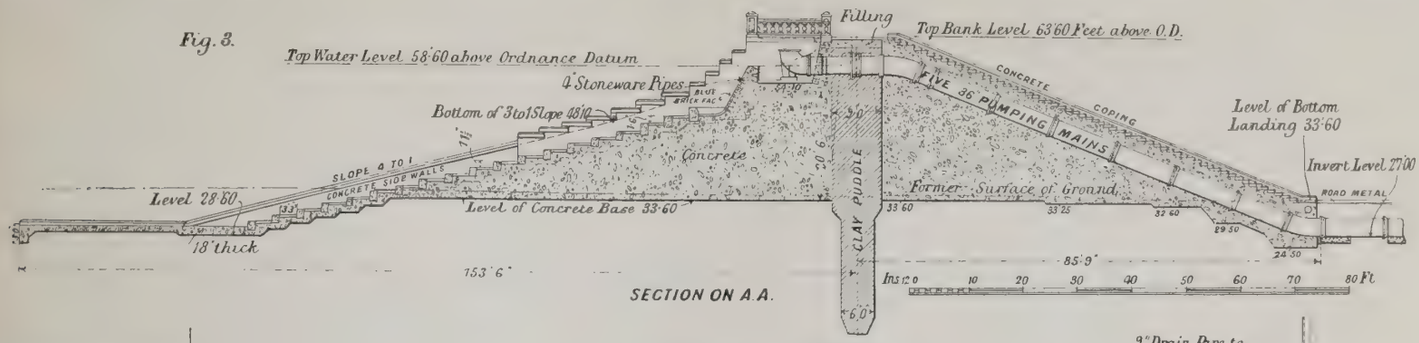
The interior face of the embankment is on a slope of 4 to 1 for the lower unlined portion, and of 3 to 1 for the upper lined portion. The outside slope is about $2\frac{1}{2}$ to 1. The interior slope is lined with concrete slabs measuring 5 ft. by 4 ft. $10\frac{1}{2}$ in. by 6 in., extending from $10\frac{1}{2}$ ft. to 4 ft. below top water-level. Above the later level the lining is composed of concrete blocks 2 ft. 8 in. by 8 in. by 8 in., the whole being finished by a moulded concrete coping.

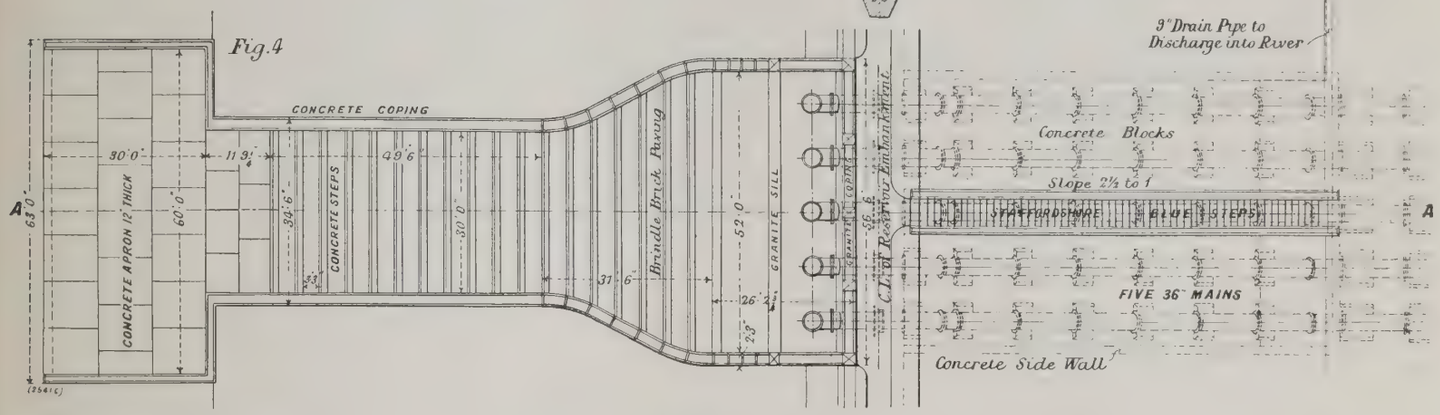
The inlet is shown in Figs. 3 and 4, on the opposite page. There are five 36-in. mains provided for at these works, communicating with the Walton pumping-station and the Knight and Bessborough reservoirs at Walton, and also with the Molesey reservoirs. Water can, if necessary, be run by gravity into the Island Barn reservoir from the Walton reservoirs, the top water-level having been kept at the necessary height for this to be possible. The five inlet-pipes are shown in the plan, Fig. 4. They are carried up the outer slope below the surface, and are supported on concrete blocks. They terminate in a trough or basin provided with a granite sill, below which is a spillway with the upper steps of blue bricks, and the lower sills of concrete. At the top sill the inlet works are 52 ft. across between walls, but lower down the sills are 30 ft. between the concrete side-walls. At the base is an apron 60 ft. by 30 ft., composed of concrete slabs 12 in. in thickness. A coping, 9 in. high and 18 in. wide, is carried round the sides of the apron. The upper part of the works is finished with granite balustrade and coping.

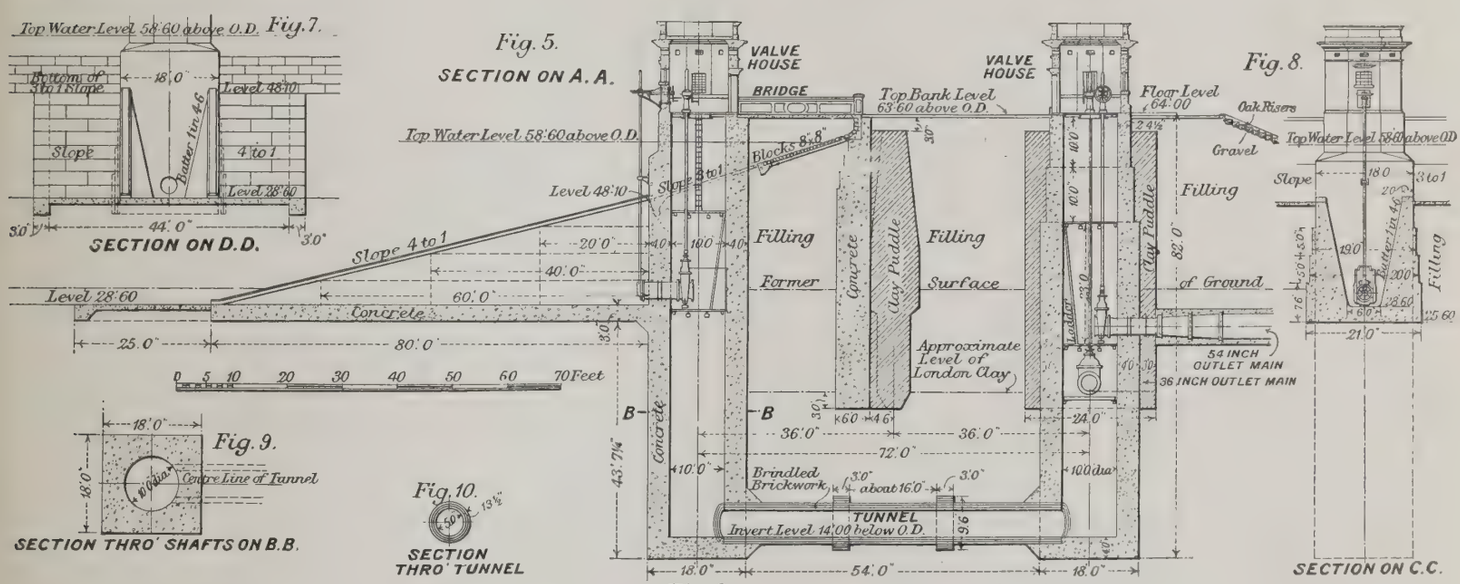
The outlet works are illustrated in Figs. 5 to 10. They consist of two valve-towers, forebay, tunnel passing under the puddle trench, &c. The two valve-towers are placed one 36 ft. inside and the

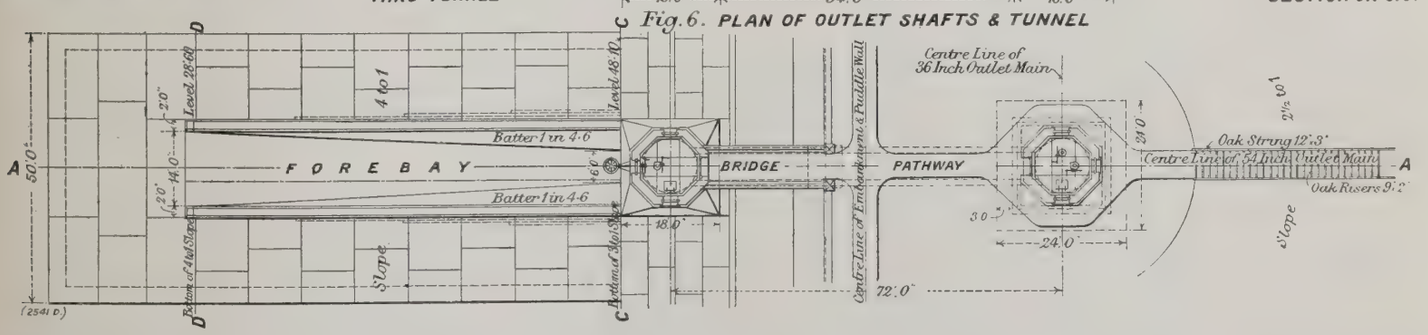
THE ISLAND BARN RESERVOIR OF THE METROPOLITAN WATER BOARD.

[MR. W. B. BRYAN, M. INST. C. E., CHIEF ENGINEER; MESSRS. ROBERT McALPINE AND SONS, GLASGOW, CONTRACTORS.









other 36 ft. outside the puddle trench. The main portion of the valve-tower inside the puddle trench is 18 ft. square outside. It is of concrete, and extends to a depth of over 46 ft. below the floor of the reservoir. It contains a shaft 10 ft. in diameter. The forebay has a floor of concrete 3 ft. thick, with side walls having a batter of 1 in 4.6. The slope of the embankment is protected on each side of the forebay for 16 ft. by slabs of concrete, and an apron, 50 ft. by 25 ft., is placed on the reservoir floor in front of the forebay. This tower contains one valve. The two towers are in communication with each other by a brickwork tunnel 5 ft. in internal diameter. The outlet tower is similar in its main features to that just described, but is surrounded by 3 ft. of puddle clay down to the London clay level. It contains two valves, one communicating with a 36-in. main, and one with a 54-in. main. These mains are connected with the filter-beds at Surbiton.

The reservoir, when full, will contain water to a depth of 30 ft., the bottom being 28.6 ft. above O.D. The top of the embankment is 63.6 ft. above O.D., the top water level being from 36 ft. to 38 ft. above mean river level.

COLESBOURNE BOILER EXPLOSION.—The formal investigation ordered by the Board of Trade to be held in this matter is fixed for hearing in the Town Hall, Cheltenham, Gloucestershire, on Wednesday, the 22nd inst., at 11 a.m.

INDEBTEDNESS AND SOLVENCY OF METROPOLITAN BOROUGHS.

In the past ten years the metropolitan boroughs have borrowed 8,914,187*l.*, and although there has been a falling-off of loans under all heads during the later years of the decade, principally under the heads of "lighting" and "paving works," the London County Council have issued a special minute on the subject with a view of urging greater caution on the part of these boroughs in adding to their already heavy debts. The London County Council, it will be remembered, is the sanctioning authority for most of the loans raised by the metropolitan borough councils, although since 1900 these councils have had a right of appeal to the Local Government Board. Six appeals have been made, but in only one case was the decision given against the London County Council's attitude. Now it is pointed out that the last quinquennial valuation, taken this year, showed, for the first time, a decrease in the assessable value of the County of London. In the aggregate this decrease, it is true, is small, being 189,505*l.*, due in large measure to the effect of finance legislation upon the valuation of licensed property; but beyond this there was "indication of arrest in the expanding power of the assessable value of the county," which is "of importance in considering the burden on the rates of future years which borrowing involves." It is, too, in the boroughs less able to bear the heavy burdens that this decrease has arisen, and amounts in some cases to nearly 5 per cent. The Finance Committee of the County Council consequently urge more careful scrutiny as regards loans, because "if the local rate in any borough is much in excess of the average throughout the county, whether the average be regarded as high or low, the fact is likely to affect adversely the assessable value of that borough by driving away the population and reducing rents, and this in turn must involve a further increase of rate; if the rates became unduly high, this might in course of time affect prejudicially the security for loans advanced to the local authority." No mention is made of the capitalist who is anchored in such boroughs, and finds himself handicapped in the struggle for work owing to the high rates, and to the increased cost of living, which results from high rates upon house and shop property. No more convincing statement of the evils of extending municipal trading could have been made, and the warning ought to be carefully kept in mind.

The procedure adopted by the Finance Committee in recommending the sanctioning of a loan includes, in the first place, consideration of the financial position of the borough—its existing debt, assessable value, the extent of local and county debt chargeable on the rates, and the percentage which such debt bears to assessable value, the proportion due to unremunerative debt, and the amount of the local rates. In the second place, the accuracy of the estimated cost of the work is investigated with the assistance of the professional officers of the County Council. The third point has reference to the necessity for the work for which the loan is desired. Here, of course, there is room for wide latitude in decision, but no strictures are passed on the greatest evil—unjustifiable trading. The Council very properly state that paving works, because of their constantly recurring nature, should be paid for by the current revenue. Even in the case of original permanent paving, where there is more tendency to permit a loan, the Finance Committee try to get the borough council to do the work in such sections as will enable it to be paid for out of the rates.

As to the repayment of the loan, the general principle adopted is that the loan should be repaid during the "life" of the work, so as to preclude the possibility of future ratepayers being saddled with the cost of exhausted works. Two of the subjects of appeal to the Local Government Board have arisen in connection with this matter. The Poplar Metropolitan Borough Council appealed against the decision to limit the period of repayment of part of the loan for paving works to five instead of ten years, the plea for the County Council in favour of five years being that the need for all the paving was not proved, and the financial circumstances of the borough. But the Local Government Board gave Poplar permission to extend the repayment of the loan over twelve years. In the case of an appeal by the Hackney Council the decision of the County Council was maintained that the loan for Jarrah wood-paving should be repaid in seven instead of ten years, and for repaving in three instead of seven years. In 1908 the Electric Light Supply Act provided that in the case of loans for freehold land, and local improvements which include the cost of freehold land, the time for repayment should be 60 years, and in some cases under the Housings Act the statutory term is 80 years; but the County Council are trying to reduce the period. In the case of loans for substantial buildings—say, for housing purposes—the maximum period allowed is 60 years; for electricity buildings, 50 years; and for town halls and other buildings, 30 years. It is difficult to understand the reason for these differences. Up to 1906, most of the loans for electric light plant were sanctioned for an all-round term of 42 years, although this period, according to the Finance Committee, exceeds the probable life of some of the mechanisms for which such loans were required. His Majesty's Treasury exacted the condition that if renewals were necessary during the 42 years, the cost of these should constitute a maintenance charge. The practice, however, now is to considerably limit the term, the repayment period for plant and machinery being 20 years. The County Council has made great endeavours to induce borough councils who have loans for a period of 42 years to reduce the outstanding periods of repayment for such loans. This is undoubtedly a wise proceeding, because machinery depreciates at a much greater rate than is met by the 42 years term of the loan, apart altogether from the probabilities of such plant becoming obsolescent.

NOTES.

The Training of Naval Officers.

The critics of the new scheme which provides for common entry and training of all naval officers, irrespective of the branch of the service in which they are ultimately to take rank, have all along contended that, apart from the insufficiency of the special education and experience required for undertaking the responsible duties of the respective ranks, there was possibility of failure owing to lack of volunteers for some of the branches of the service. The military officer of the ship is practically always "in the limelight." He has opportunities of adding to his emoluments by special grants in the form of pilotage money, &c. In action he has chances of distinguishing himself which do not arise in the case of other officers, and thereby of securing promotion, honour, and distinction. In peace, too, honours have gone to the military officer more freely than to the other branches, even when allowance is made for the numbers of officers of the respective branches on the active list. In view of the superior inducements thus offered to the military branch of the Service, cadets and midshipmen may not care to volunteer for Engineering and Royal Marine ranks. Evidence of such disfavour is afforded in the official announcement now made that "an insufficient number of candidates entered at the naval colleges have exercised their choice in favour of joining the Royal Marines." The consequence is that the Lords Commissioners of the Admiralty have had to resort to the modified arrangement made some months ago. They invite candidates to enter by examination to fill fifteen vacancies for appointment as second lieutenants in the Royal Marines, instead of all these vacancies being filled by officers trained under the common system. Moreover, such officers of the Marines will not, as was the intention in the original scheme, have permission at certain periods of their career to pass into the military branch. It remains to be seen whether the same result will not be experienced when vacancies have to be filled in the engineering branch of the Service. The examination for candidates for the Royal Marines is to be held in December next, and the candidates must be not less than seventeen or more than eighteen years of age. After medical examination and satisfying the physical requirements (the height being specified as 5 ft. 5 in.), the candidates will be subjected to a written examination in mathematics (including statics and dynamics), elementary physics and chemistry, and English (mainly on composition, but not including history and geography). No candidate will be accepted who does not show a fair proficiency in mathematics and science. Successful candidates will join the Royal Naval College, Greenwich, in January next, and parents or guardians will be required to make allowance of at least 60*l.* a year until the new officer's pay amounts to 7*s.* 6*d.* a day, which will, it is anticipated, be in three years; while for the succeeding two years, when the pay will be 10*s.* a day, the allowance must be 45*l.* This is in addition to the cost of outfit and the additional uniform authorised upon the candidate receiving his commission.

Education in Japan.

A perusal of the thirty-sixth annual report of the Minister of State for Education shows that the Japanese are not only making the details of their educational administration very complete, but also that they take very wide and liberal views of the aims and objects of education from the national point of view. During the period under review the development which has been going on for years has been continued with all its former zeal and success. The Emperor issued a rescript on the realisation of the national destiny, pointing out the duties of individuals, officials, and the public; and the Minister of Education not only issued an instruction relating to the observance of this gracious command to the directors of Government schools and local governors, but also instructed them to lay it to heart. Those engaged in education, in particular, were cautioned to keep always in mind and to put into practice this command, together with another urging all engaged upon education, which is the basis of morality, to fulfil their duties of instruction and discipline, and to aim at the formation of a healthy, vigorous nation, as well as the realisation of the national principle of uniting the whole nation into one, manifesting at the same time the glories of the fundamental character of the empire. It is this national aim in education which is the striking characteristic of all that is done in Japan, and is in marked contrast to the individualistic aims in Western countries. The arrangements for elementary, secondary, and higher education are being made more and more complete, while the number of schools for special purposes is now very large. These are established for the purpose of training those who intend to engage in productive labour, such as agriculture, manufactures, and commerce. The total number of such schools is 5167, but, of course, a large proportion of these are small, and are suited to the requirements of the localities in which they are situated. Some of them are, however, very complete, and compare favourably with similar institutions in Europe. The crown of Japanese education is the Imperial Universities. That of Tokyo is the oldest and most complete, and consists of the six colleges of law, medicine, engineering, literature, science, and agriculture, and a university hall. In the year under review, it had 314 professors and instructors, 5411 students, and 1154 graduates. We have, on previous occasions, given details of the colleges of engineering and science, and meantime we need not repeat them. The Imperial University of Kyoto consists of a university hall, and colleges of law, medicine, literature, science, and engineering. The number of professors and instructors was 178, of students 1412, and of graduates 409. What may be called the auxiliary institutions connected with education are very numerous, and a perusal of the report lets us into the real secret of the success of the Japanese in almost everything to which they put their hands.

Brakes on Motor-Cars.

The fact that every year a certain number of accidents occur through the brakes of motor vehicles failing on hills shows that there is still room for a good deal of improvement in this very essential part. Motor vehicles are by law compelled to have two quite independent brakes, each of them capable of stopping the machine. If the law is complied with properly, this should provide for perfect safety. The usual arrangement is to have a foot-brake acting on the countershaft, and a hand-brake acting direct on the back wheels. In addition to this, it is usually possible to keep the vehicle under control on a hill by putting in one of the lower speeds and shutting the throttle. This will not necessarily stop the car, but will generally keep it down to such a low speed that there is no risk of accident. If there is a large enough margin of safety in the various parts, and they are kept in good order, it is quite clear that this arrangement provides for the full control of the vehicle under all circumstances. Unfortunately, there have been several accidents due to vehicles having run away. In these cases it is therefore quite clear that the law has not been

properly complied with. The sequence of events is usually the same. The foot-brake fails, and the hand-brake, when wanted, is found to be useless. In some cases the failure of the foot-brake has been caused by the transmission gear giving way in some part. This, of course, also prevents the driver using the engine as a brake. In case of such brake failures the fault lies either in the construction or the maintenance. However good brakes may be, it is necessary that they should be kept in order, while if they have such small surfaces that they want constant adjustment, or have very small margins of safety in the various parts, failure is inevitable sooner or later. An examination of the chassis shown at many of the Exhibitions will, however, show that brakes are not invariably given large enough margins for wear, and are often very light in the various parts. In such cases, if an accident occurs, the makers usually blame the drivers for what is really their own fault. Thus, in a case of a hand-brake failing, when wanted suddenly, the driver (who in the case referred to had been killed), was blamed for "applying it too suddenly." In cases of emergency, however, brakes generally are used suddenly, and if not capable of standing the strain are not safe. It is high time that those responsible for the building and running of motor vehicles should recognise that brake failures are not more inevitable than any other failure of machinery, and that makers incur a very serious responsibility if they disregard mechanical laws in this matter. No doubt there is always a temptation to cut down the weights of brakes, either to reduce the total weight of the car or to put more weight into the engine or other parts, and thereby make it suitable for a greater load. No doubt also purchasers are unreasonable, and expect too much on a given weight of chassis. These are, however, only questions between the user and maker. What the public has a right to expect is that no user should put a vehicle on the road unless it complies with the law, and it is for the user to insist on the maker giving the various parts enough margin to enable them to comply with the law without excessive attention.

"La Metallurgia Italiana."—We have received a copy of the Italian journal *La Metallurgia Italiana*, Milan, for September-October, giving a few data on the recent meeting of the Iron and Steel Institute, held in London (see pages 460 and 483 *ante*), and reproducing the papers by Mr. L. Dompé, Mr. F. S. Pucci, and Mr. R. Catani. These were on the programme for the Turin meeting, which was abandoned. The journal also gives a few interesting notes on the electro-metallurgical and electro-chemical industry of Italy.

Contracts.—Messrs. Joseph Kaye and Sons, Limited, South Accommodation-road, Leeds, and 94, High Holborn, London, W.C., have again secured the whole of the contract to supply His Majesty's naval establishments with their seamless serrated oil-cans during the next three years, ending 1914.—Messrs. Ernest Scott and Mountain, Limited, Close Works, Gateshead-on-Tyne, have recently booked orders for six large centrifugal pumps for collieries, iron works, and shipbuilding concerns in this country.

Apprenticeship.—We are informed by the Institution of Automobile Engineers that the Institution has collected a lot of information in regard to the terms and conditions for taking apprentices and pupils which are in vogue in the various automobile works in the country, and this information is placed at the disposal of parents and guardians without charge. The secretary adds that the utility of the department would be greatly increased if manufacturers who have not already done so would kindly apply to him for a form to fill up regarding the conditions obtaining in their works, and if they would also inform him as to the probable dates at which vacancies will occur in their works.

The Non-Ferrous Metals Exhibition.—The first meeting of the vice-presidents and honorary advisory council of the above Exhibition was held at the Holborn Restaurant on Wednesday. The President of the Exhibition, Sir Gerard Albert Muntz, Bart. (President of the Institute of Metals), was in the chair, and said that the Exhibition would serve the useful purpose of bringing to the front all the various non-ferrous metals, showing the uses to which those metals could be applied, and affording all manufacturers of machinery and apparatus connected with the working up of those metals an opportunity of making known their specialities. Mr. Bridges, the organiser of the Exhibition, then briefly referred to the prospectus, from which, he said, it would be seen that this Exhibition would be of a threefold character—it would show non-ferrous metals from the crude ore up to the finished article; it would show the various purposes to which non-ferrous metals could be applied, and would convey a wider knowledge of the machinery employed in turning out the goods. Special efforts would be directed to ensure the attendance of buyers and users of everything shown at the Exhibition.

INDUSTRIAL NOTES.

On Saturday last the executive committee of the four railwaymen's unions—the Amalgamated Society of Railway Servants, the General Railway Workers' Union, the Locomotive Engineers' Union, and the Signalmen and Pointsmen's Society—decided to take a ballot of their members on the question of a national strike. Having failed to secure the conference which they sought with the representatives of the railway companies, they have taken this step. The object of the ballot is to decide whether the findings of the Royal Commission of Inquiry shall be accepted or whether a general strike, to secure the "recognition" of the unions and a national programme, is desired. There will be no immediate strike, however, for a month will be allowed for taking the ballot, the papers being returnable up to December 5. The directors of the Midland Railway Company have decided that the minimum rate of pay for all adult members of the staff shall be 22s. per week if employed in London, 20s. per week at certain of the large towns, and 19s. per week at all other places. The minimum rates for station-porters, porter-shunters, and porter-guards will be 1s. per week above the rates of the platform-porters at the respective classes of stations. Allowance for passenger-train trips worked by porter-guards will be calculated in accordance with existing regulations, and the sums so earned in excess of the increase of 1s. per week in wages will be paid to the men concerned. The minimum rates referred to came into force on November 3. Under the revised scale of pay, passenger porters will receive an advance in some cases of 3s. and in others of 4s. per week.

The leading British railway companies are taking steps with a view to more united action in the event of a general strike, and communications are passing between them with this end. In the case of the late strike they were taken by surprise, and so had not a fair chance of showing what they could really do to meet such trouble. Even as it was, however, they did remarkably well, and had it not been that the Royal Commission was appointed, they would probably have broken down the strike in a few days more. They are very wise, however, in now making preparation for coming eventualities, whatever they may be. Of course, it does not necessarily follow, even in case the ballot of the union men is in favour of a general strike, that a general strike will take place; but if it should, the railway companies will be far better able to co-operate than they were last August with a view of minimising inconvenience to the public. There are several suggestions put forward, one of them being for the enrolment by the companies of large numbers of special constables, duly sworn in and provided with the uniforms of the railway police, in order to protect men who remain at work when picketing of a too aggressive kind is being carried on. It is said that many of the leaders among the railway officials declare openly that they are in favour of a fight to the finish, as being preferable to the uncertainty that at present exists, and they feel that with proper organisation beforehand they may face another strike with confidence. That this view has much to support it can hardly be disputed, for in the present temper of the men there is not much likelihood of permanent peace until the matter is fought to a finish, and the present is probably as good a time as any for the companies to face the trouble. The perpetual unsettlement kept up by the men is so bad, both for the railway companies and the country, that almost anything is to be preferred—however serious, from a financial standpoint, a strike must be for all workers. In some places the men appear to be getting out of hand, and are threatening sectional strikes before the ballot is taken. This is particularly the case in South Wales and on parts of the Great Northern Railway between Sheffield and Doncaster. It has already been resolved by the Llanelly railway men to stop work, and the coal strike committee has been authorised to intimate at once to other branches in the country their intention to strike and to ask for support. Next Sunday is fixed for the strike to commence. The action of the Government during the late coal strike seems to have given offence to the men, and it is recommended that in future the Government be left severely alone and the fight fought to a finish.

The question of a minimum wage came up again before the South Wales Coal Conciliation Board at Cardiff on Saturday last, and at the close of the meeting the coal-owners directly refused to accept the principle for which the men are contending. Although the meeting was private, it is understood that the following were the minimum sums per day that were asked for by the workmen's representatives of the Conciliation Board:—Miners, 8s.; timber-men and rippers, 8s.; assistant timber-men and rippers, 6s. 6d.; underground road-men and block-layers, 7s.; haulers over eighteen years of age, 7s.; rope-men and traffic-men, 7s.; hitchers, 7s.; banksmen, 7s.; assistant banksmen, 6s. 6d.; tippers, 5s. 6d.; screen-men, 5s.; and labourers, 5s. The masters contend that the Conciliation Board agreement was entered into for five years, and that it was balloted upon by the men; the masters further declare that they are not prepared to abrogate the agreement in any way whatever.

Sir Lindsay Wood, Bart., presided at a meeting of the Durham Coal Trade Conciliation Board at Newcastle on Friday last. The appointment of an umpire was the first matter to be considered, and it was agreed that Sir David Harrel should be invited to accept reappointment. It was resolved that wages remain unaltered for the present. At the last meeting, in August, there was a 2½ per cent. reduction of wages, which left them 38¾ per cent. above the basis of 1879.

At a private meeting of the Scottish Coal Trade Conciliation Board, held at Glasgow on Monday last, the following demands were made by the miners:—That an individual district minimum wage be paid under all circumstances to all men working at the coal-face; that the wages of underground on-cast men be standardised in accordance with a scale proposed; and that the wages of all lads employed underground be standardised in accordance with a scale proposed. The owners' reply is that they cannot agree to the demands for an individual district minimum wage for all miners working at the coal-face, and they adhere to the agreement made at the Board of Trade on July 30, 1909. The demands of the men in respect of the wages of on-cast men and lads, and the question of machinery to deal with wages in abnormal places, will be laid before the coalowners, and will be discussed at a future meeting of the board.

As an example of misguided Government interference, cases of which have been only too frequent of late, the proposed legislation with regard to pit-brow women is quite as ridiculous as any, and makes one wonder how far this sort of meddlesomeness is going. The women themselves resent any suggestions that their work needs legislative control, as there is nothing about it that is unduly hard, it is much healthier than many occupations followed by women and sanctioned by law, and the morals of the workers are quite as good as those of any other working women. Indeed, all these reasons why the work should not be interfered with appear to be substantially supported by the best evidence, both by medical men familiar with the district, and by those who have charge of the moral welfare of the women. It is therefore sincerely to be hoped that these honest workers will be left alone, and no more wretched charges made as to their lack of health or morals.

The end of the dispute which has existed between the Boiler-Makers' Society and the Shipwrights' Society since May last has come. The question was whether members of the former organisation should be allowed to work in the shipbuilding yards of Messrs. Short, Sunderland, where only members of the Shipwrights' Society have hitherto worked. In future members of the Society will be allowed in other yards on the Wear from which they had previously been excluded, and the boilermakers will be permitted in the yard of Messrs. Short. The firm will take back the men discharged at the beginning of the dispute.

About one hundred men were idle at the beginning of the week in consequence of the London stevedores' dispute, some of them being on strike and others having been suspended or discharged by the Port of London Authority for having refused to unload the steamer Sea Belle, which vessel was, when the dispute originated, diverted from the Mark Brown Wharf. The general council of the National Transport Workers' Federation resolved to instruct all transport workers to refuse to do the work of the men who have been dismissed or suspended for refusing to discharge the Sea Belle or any other vessel at any wharf or dock that may be affected, and a general stoppage throughout the port was discussed. On Tuesday, however, it was decided to submit the matter to arbitration.

There does not appear to be any immediate prospect of a settlement of the strike at the works of the Birmingham Small-Arms Company, and there are said to be now about 4000 employees idle.

On Friday last a large number of spinners, twisters, and goffers, employed at Northside Mills, Bradford, went on strike. They were mostly boys and girls, who in a small way committed some rioting, and broke some of the mill windows with stones. The police, however, soon restored order.

There was a meeting of the Motor-Cab Proprietors' Association on Tuesday last, at which it was unanimously decided that garages should remain closed for the present. One of the non-associated firms, however—the British Motor-Cab Company, Limited—decided to open their garages to drivers who would

resume work under new conditions, the men retaining the extras and paying a hiring fee of 6d. a day each. It was stated that if these terms were not accepted by to-day, the directors will endeavour to obtain abolition of all extras. At the time of going to press there appears to be a prospect of the strike coming to an end soon.

The Grand Committee of the House of Commons began on Thursday, last week, consideration, clause by clause, of Part II. of the National Insurance Bill. This part sets up a system of insurance against unemployment, and its provisions apply compulsorily to five groups of occupations to begin with—namely, building, construction of works, shipbuilding, mechanical engineering, and the construction of vehicles, occupations which include nearly 2,500,000 workers. Mr. Buxton stated that the Bill had been in preparation for nearly three years, and great consideration had been given to it. Two clauses, Nos. 60 and 61, were passed, the first being "that every workman who, having been employed in a trade mentioned in the sixth schedule to this Act (in this Act referred to as 'an insured trade') (that is, the trades set out above) is unemployed, and in whose case the conditions laid down by this part of this Act (in this Act referred to as 'statutory conditions') are fulfilled, shall be entitled, subject to the provisions of this part of this Act, to receive payments (in this Act referred to as 'unemployment benefit,' at weekly or other prescribed intervals, at such rates and for such periods as are authorised by or under the seventh schedule to this Act, so long as those conditions continue to be fulfilled, and so long as he is not disqualified under this Act for the receipt of unemployment benefit." The following addition was made to the clause :—"Provided that unemployment benefit shall not be paid in respect of any period of unemployment during the six months following the commencement of this Act (May 1, 1912)." The other clause, No. 61, which was passed, is couched in the following terms :—(1) "The sums required for the payment of unemployment benefit under this Act shall be derived partly from contributions by workmen in the insured trades, and partly from contributions from employers of such workmen, and partly from moneys provided by Parliament. (2) Subject to the provisions of this part of this Act, every workman employed within the United Kingdom in an insured trade, and every employer of any such workman, shall be liable to pay contributions at the rates specified in Part I. of the English schedule of this Act. (3) Except where the regulations under this part of this Act otherwise prescribe, the employer shall, in the first instance, be liable to pay both the contribution payable by himself and also on behalf of, and to the exclusion of, the workman, the contribution payable by such workman, and, subject to such regulations, shall be entitled, notwithstanding the provisions of any Act relating to truck or any contract to the contrary, to recover from the workman, by deductions from his wages or otherwise, the amount of the contributions so paid by him on behalf of the workman. (4) Notwithstanding any contract to the contrary, the employer shall not be entitled to deduct from the wages of, or otherwise recover from, the workman the contributions payable by the employer himself. (5) Subject to the provisions of this part of this Act the Board of Trade may make regulations providing for any matters incidental to the payment and collection of contributions payable under this part of this Act; and in particular for (*a*) payment of contributions by means of adhesive or other stamps affixed to or impressed upon books or cards, and for regulating the matter, times, and conditions in, at, and under which such stamps are to be affixed and impressed; (*b*) the issue, sale, custody, or delivery up of books or cards, and the replacement of books or cards which have been lost, destroyed, or defaced. (6) A contribution shall be made in each year out of moneys provided by Parliament equal to one-third of the total contributions received from employers and workmen during that year, and the sums to be contributed in any year shall be paid in such manner and at such times as the Treasury may determine."

The sitting was resumed on Tuesday, when Clause 62, which lays down the conditions qualifying for unemployed benefit, was proceeded with, and was passed, as well as Clause 63 relating to disqualifications for benefit.

Gas-Works Directory and Statistics.—The volume for 1911-12 of this directory—the thirty-fourth issue—has been published by Messrs. Hazell, Watson, and Viney, Limited, 52, Long Acre, W.C., at the price of 10s. 6d. net. It opens with a general index of officials of gas-lighting works, which is followed by a directory and statistics of gas works classified alphabetically according to towns in England and Wales, Scotland and Ireland, with similar data on colonial and foreign gas-works having London offices. This directory gives the population, the owner, capital or amount and date of loans, dividends, coal carbonised, gas-production, illuminating power, price paid, and so forth.

THE TURBINE-DRIVEN STEAMER "NEWHAVEN."

BUILT BY THE FORGES ET CHANTIERS DE LA MEDITERRANEE, HAVRE.

Fig. 15.

The latest addition to the series of cross-Channel steamers which run between Dieppe and Newhaven is the turbine-driven passenger boat Newhaven, built by the Société Anonyme des Forges et Chantiers de la Méditerranée, at their Havre works, to the order of the French State Railways. We illustrate the Newhaven in the view above, and in Figs. 11 to 14 on our two-page plate, on which is given a side elevation of the ship, a longitudinal section, plans of the shelter, promenade, main and lower decks, and various cross-sections.

The Newhaven is divided into eight compartments by seven water-tight bulkheads, which extend up to the main deck; the openings in the bulkhead at the turbine-room and at the propeller-shaft tunnel are closed by water-tight doors which are operated from the main deck. The principal dimensions are as follow :—

Length between perpendiculars	89 m. (292 ft.)
Length over all	92 m. (302 ft.)
Breadth	10.55 m. (34 ft. 7 in.)
Depth	6.75 m. (22 ft. 2 in.)
Maximum draught	2.95 m. (9 ft. 8 in.)

As will be seen from the plans and sections, Figs. 1 to 14, the boat is provided with a central deck-house, with side gangways on the promenade deck which communicate with each other forward at the back of a screen built up of plates and angles, an arrangement generally followed on the Dieppe-Newhaven steamers; the screen extends upwards from the promenade deck to the roof of the steering-house. Accommodation has been provided for 1000 passengers; the first-class cabins are forward and the second-class cabins aft. The galley and engineers' and stokers' quarters and bath-room are in the centre of the ship on the main deck, and separate from the passenger accommodation.

The Newhaven is propelled by Parsons turbines; a high-pressure turbine drives the central shaft, and two low-pressure turbines the side shafts. The two latter contain the turbines for running astern. The chief engineer's station is level with the main deck; it is well lighted, and is provided with all the connections for working the turbines. Stairways give access from this station to the turbine-room underneath. All the connections are grouped together, and are located on the forward bulkhead of the chief engineer's station. The various connections are protected by a casing in which openings are cut; through these openings run the hand-wheel shafts and levers operating the connections. The reversing-gear of each low-pressure turbine contains two valves operated by a toothed wheel and an endless screw driven by a hand-wheel; this gear enables reversing to be effected in four seconds. When the ship is running at a speed of 12 knots, she can be brought to a deadstop in 30 seconds over a length of 90 m. (295 ft.), or less than her extreme length, instead of the 100 m. (328 ft.) which were stipulated in the contract. All the donkey, bilge, main feed, and service pumps are in the turbine-room under the main deck, with the exception of the feed-pump for the auxiliary boiler. There are two condensers, each having 392 sq. m. (4220 sq. ft.) of cooling surface; they are connected to a centrifugal circulating pump capable of dealing with 1750 cub. m. (385,000 gals.) of water per hour, and arranged to draw from the holds if necessary. Each condenser has a separate air-pump which can draw from either condenser; each air-pump has a capacity of 400 cub. m. (14,120 cub. ft.) per hour.

The turbine rotors, and the intermediate and propeller shafting, are all of Siemens-Martin steel; the latter shafts can be drawn through the stern gland. The stern tubes and propeller-shaft supports are steel castings; the propellers are of Stone's bronze, fitted to the boss with nut and double feather. The bearings are water-cooled by service pumps. Separate pumps ensure lubrication.

The turbines are supplied with steam by two sets of Belleville boilers working at a pressure of 17 kg. per sq. cm. (250 lb. per sq. in.), and their centre line is parallel with the centre line of the ship. The set forward consists of four boilers of twelve elements provided with feed-water heaters; the set aft consists of two boilers of twelve elements and two of thirteen elements provided with similar feed-water heaters.

Total grate area	60 sq. m. (646 sq. ft.)
Heating surfaces of boilers	1587.60 sq. m. (17,100 sq. ft.)
Heating surface of feed-water heaters	402.40 ,, (4,330 ,,)

The grates are of the Belleville type. The feed is ensured by three double-acting Belleville pumps, having a cast-iron steam-cylinder and a brass pump-cylinder. The eight boilers work under forced draught in closed stokeholds, the draught being supplied by two Belleville air-compressors, having each a capacity of 800 cub. m. (28,250 cub. ft.) of free air per minute. Air is also supplied to the stokeholds by four fans driven by vertical engines. The steering-gear is of the Brown type.

The full speed trials have shown that there occurs no vibration throughout the ship, apart from the stern, where the propellers drive the sea-water against the hull. The builders attribute this satisfactory result to the strength of the structure in general, and more especially to the good longitudinal stiffening of all the parts forming the hull. The Newhaven covered the distance from Dieppe to Newhaven in 2 hours 43 minutes 28 seconds, as against the 3 hours contracted for; this gives a speed of 24 knots.

The ship is provided throughout with electric lighting. All the cabins and saloons are carefully ventilated; they are heated by steam from the main boilers when the ship is running, and by steam from the auxiliary boiler when in harbour. The fitting up and upholstery work of the cabins and saloons have been carried out by Messrs. Jeanselme, Paris. We may mention, as a special feature, the fact that the promenade deck has been strengthened on each side of the hatch giving access to the aft hold with a view to the transport of four motor-cars of the largest type, weighing each up to 2.5 tons. These can be lashed down fast by means of shackles, which have been provided for the purpose.

The Newhaven replaces a former unit, the Tamise, which is to be sold out of the service.

The American Society of Automobile Engineers.—The programme of the European trip of the American Society of Automobile Engineers included, on the 7th, 8th, and 9th inst., visits to the Olympia Show, to the works of the London General Omnibus Company, and to South Kensington Museum; and on Wednesday, the 8th inst., at 8 p.m., a joint meeting with the Institution of Automobile Engineers, at the hall of the Institution of Mechanical Engineers. To-day there will be a visit to the National Physical Laboratory. Visits to motor-car works in the provinces and on the Continent down to Wednesday, the 22nd inst., have been arranged or are being planned. Information can be obtained on application to Mr. A. Ludlow Clayden, St. Ermin's Hotel, Westminster.

THE TURBINE-DRIVEN CROSS-CHANNEL STEAMER "NEWHAVEN."

BUILT BY THE SOCIÉTÉ ANONYME DES FORGES ET CHANTIERS DE LA MÉDITERRANÉE, ENGINEERS, HAVRE

(*For Description, see Page* 642.)

Fig. 1.

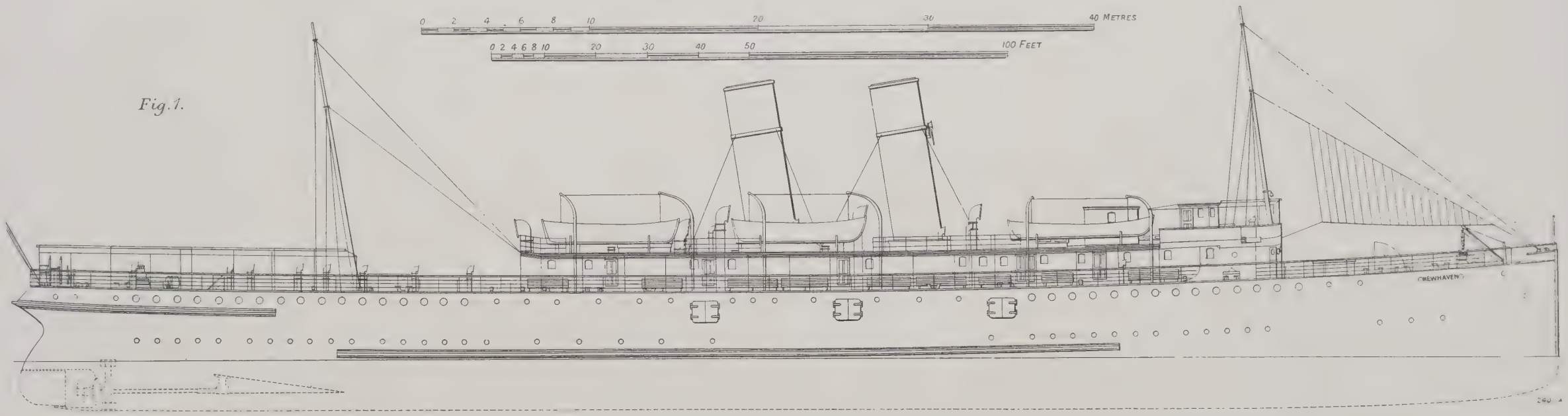


Fig. 2.

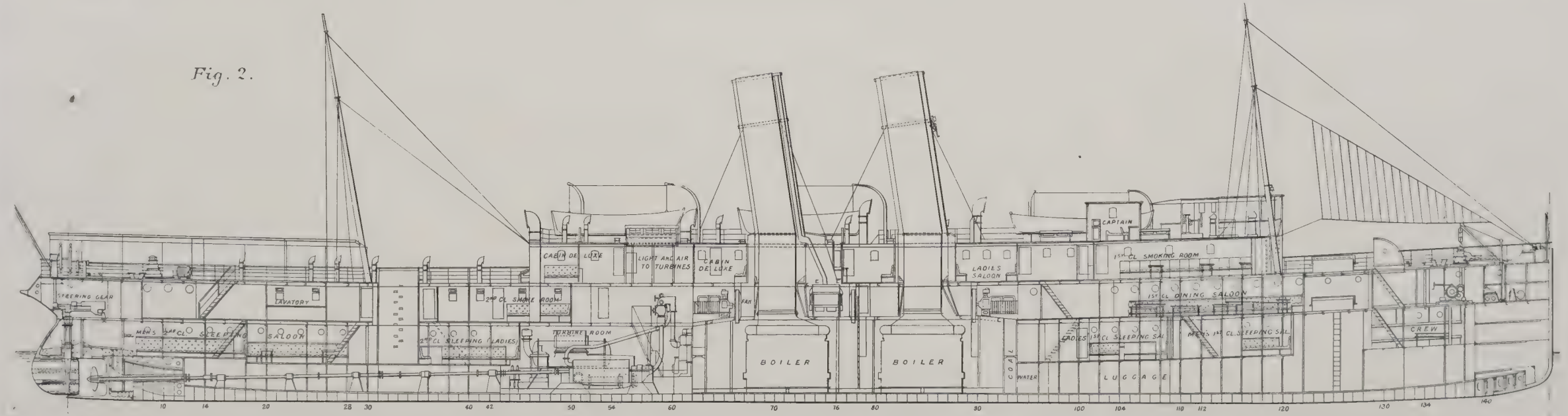
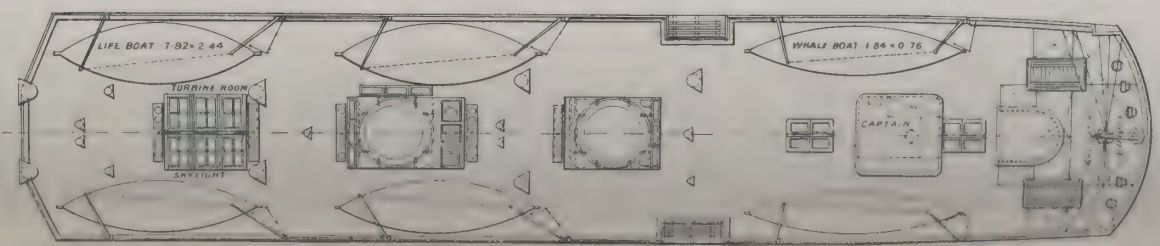


Fig. 3.
SHELTER DECK



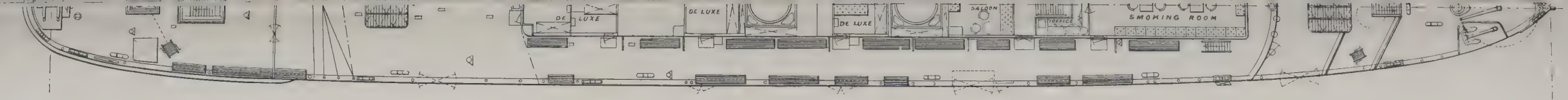


Fig. 5. MAIN DECK

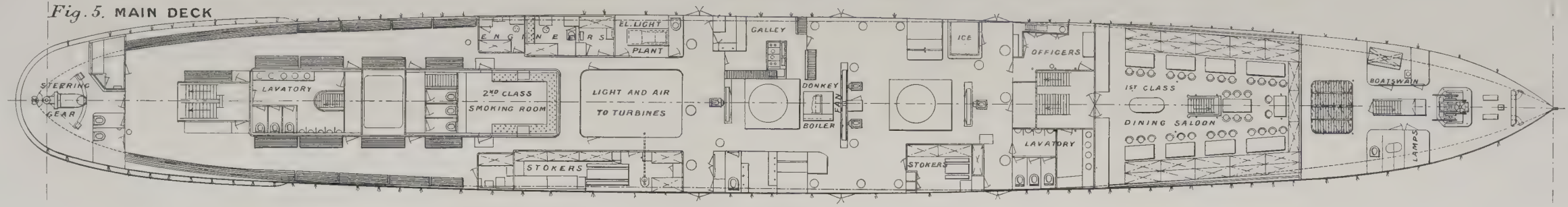


Fig. 6. LOWER DECK

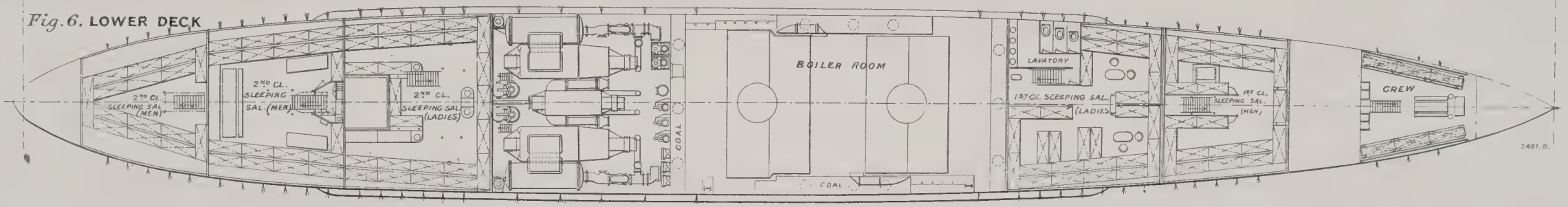


Fig. 7.
Section at Frame 14

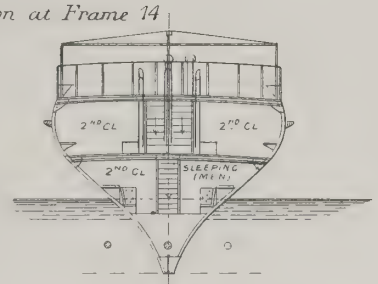


Fig. 8.
Section at Frame 28

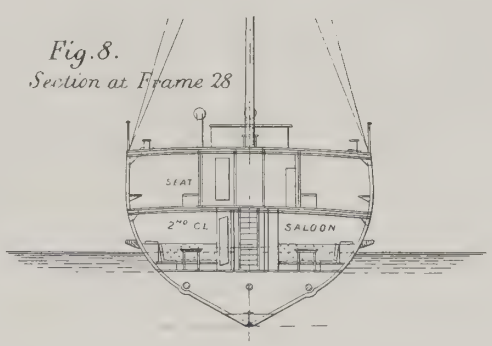


Fig. 9.
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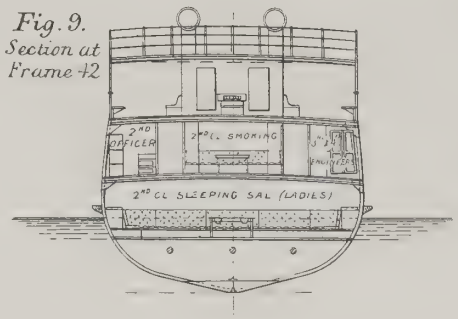

Fig. 10.
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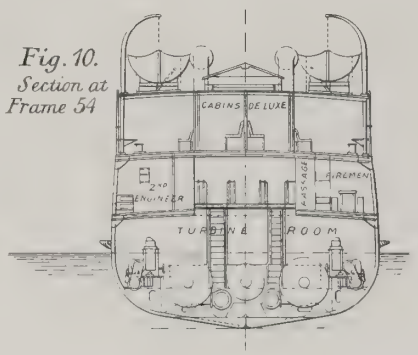

Fig. 11.
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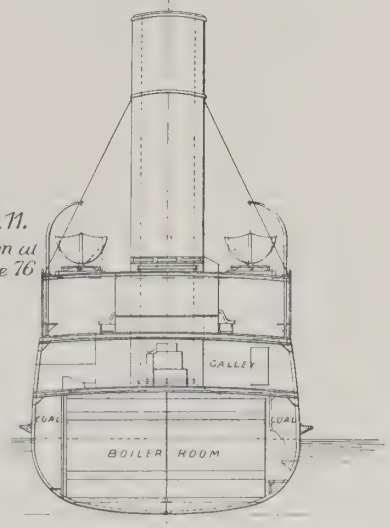


Fig. 12.
Section at Frame 104

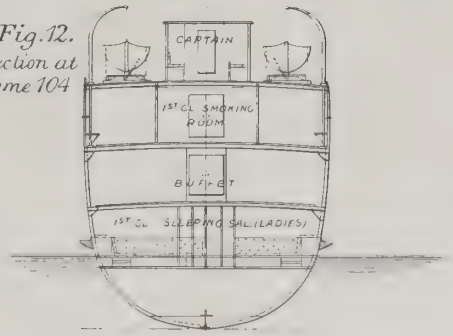


Fig. 13.
Section at Frame 112

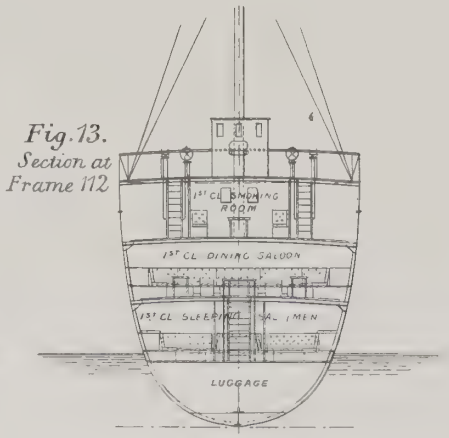
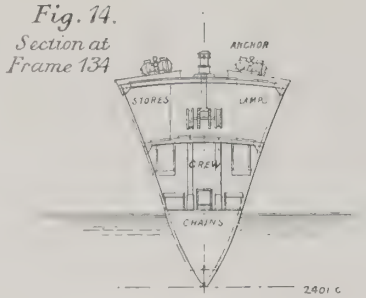


Fig. 14.
Section at Frame 134



THE INSTITUTION OF CIVIL ENGINEERS.

Address of William Cawthorne Unwin, LL.D., F.R.S., *President*, *November* 7, 1911.

It is first of all a duty to thank the members of the Institution for the honour they have done me in electing me their President. It is the greatest honour they can confer, and the highest reward I have received. I assure them that I will devote myself to the increasing business of this great and influential society, and that, relying on the assistance of the Council and officers and on your goodwill, I will endeavour to the best of my ability to promote the interests of the important profession to which we belong.

I accept the presidency with some feeling of hesitation, because your choice is in some respects unusual. Generally your President has been one who has added glory to the records of engineering by the magnitude and importance of the constructive work he has carried out. I have not that claim to distinction. My work has lain somewhat outside the territory of constructive engineering, though not far from its borders. I have been concerned in studying the application of science to the practical problems of engineering and in training young engineers to be more competent members of the profession. I take it that, as in establishing an examinational qualification of membership, so in electing me you have meant to recognise the importance of systematic technical training for the maintenance of the status of what is, in one of its aspects, a learned profession. No profession or industry has been more indebted in its development to the advancement of scientific knowledge and research. It is true of engineering more than of most activities that, to quote some words of Huxley, "As industry becomes more complicated and competition more keen, the sciences are dragged in one by one to take their part in the fray, and he who can best avail himself of their help is the man who will come out uppermost in the struggle for existence."

It is a consequence of the scientific basis of engineering that it is international, not national. Scientific advances are not restricted within political boundaries. If we gave the world the steam-turbine, Germany returned us the gas-engine and Diesel engine. Ability to appreciate the value of new discoveries, and readiness to take advantage of them, depend as much on a widespread scientific education as the making of the discoveries themselves. At any rate, I hope that is so, because it is the best justification of the work of a professor of engineering. It is forty-four years since I became an associate member, and thirty-four since I was made a member of the Institution, and it would be impossible to overrate the debt I owe to it. It is difficult for a professor, especially for one responsible for the organisation and discipline of a large technical school, to undertake, in addition, the anxieties of an arduous business. To me, membership of the Institution, a share in its proceedings, and association with engineers engaged in practical work have been of the greatest service in enabling me to keep abreast of the progress of engineering.

With regard to the new building for the Institution, the protracted and very difficult negotiations carried out by a committee under the chairmanship of Sir William White have come to an end, and the erection is now proceeding in charge of the architect and the contractors, with whom we believe we have every reason to be satisfied. We have confidence that we shall get a stately and convenient building, worthy of its position in Westminster.

It is the privilege of a president to be allowed in his address to take a retrospect—rather to gather some lessons from the past than to give new material for discussion. My distinguished predecessor, out of a long and varied experience in the development of the most modern of the many branches of engineering industry, discussed the economic conditions of production on which successful manufacture results. It will be more natural to me to deal with some of the technical principles on which the successful design of engineering structures is based.

Strength of Materials.—The object of a study of the strength of materials is to determine the proper dimensions to be given to parts of machines or structures, in order that they may resist the straining actions to which they are subjected without breaking or prejudicial deformation. It is a modern study, for the earlier architects and builders seem to have had no definite knowledge: only it may be noted that the earliest buildings were the most massive. The Egyptian columns were not more than five or six diameters in height, the Greek about nine. Mediæval buildings depend more on considerations of stability than of strength, but there are mediæval columns carrying arches which are twenty-six diameters in height.

So far as we know, however, Galileo (born 1564, died 1642) was the first scientist definitely to consider strength. He found that a rod of copper suspended vertically might have a length of "4800 arms," or, say, yards, before breaking in tension by its own weight—a reasonable result. Having no conception of elasticity or of variation of stress due to variation of deformation, he seems to have assumed that bodies always broke by tension, and that tension was uniform at the surface of fracture. Applying these notions to determine the strength of a cantilever, he supposed the whole cross-section would be in tension uniformly distributed. He arrived at an equation for bending strength which for rectangular sections is right in form, but affected by an erroneous constant, and he acutely deduced the result that, while a model of a structure might be strong enough to carry a load, the structure itself might be so large as to break by its own weight. This is the germ of the law of a limiting span for bridges. On the same false assumptions Grandi, in 1712, published elegant and correct demonstrations of what we know as solids of uniform resistance to bending. It is not the first instance in science of false assumptions leading to partially correct results. In fact, the vast edifice of the mathematical theory of elasticity rests fundamentally on an unverified generalisation of Hooke's law, and on one or other of two unverifiable assumptions, either an assumption as to the molecular constitution of matter or another still more abstract hypothesis. Nevertheless the theory can be verified as at least very approximate in so many applications that it can be trusted, in spite of the uncertainty of its mathematical foundations.

It was not till 1660 that Robert Hooke discovered the fundamental law that stress is proportional to strain in elastic materials. It was not till 1680 that anyone made further experiments on the strength of materials. Then Mariotte made rough tests of very small bars of wood and glass strained in various ways. He first perceived that in flexure, part of the cross-section is in compression and part in tension, and placed the neutral axis for a rectangular bar at half the height, correcting Galileo's result. It was not till 1776 that Coulomb determined the position of the neutral axis for simple sections, and not till 1824 that Navier determined it for all sections.

In 1729 Muschenbroek, at Leyden, published the results of what may be considered the first tests of materials made with precision. He made tension and bending tests, and tests of long columns, but on a very small scale. Perronet, occupied with the construction of the Bridge of Neuilly, in 1758, constructed the first comparatively large testing-machine, a machine capable of applying a stress of 18 tons. Rondelet, in 1787, constructed a testing-machine with knife-edges, and with a screw arrangement for taking up the deformation of the test-bar. This was employed for testing the stone and timber used in the construction of the Panthéon in Paris. It was the first machine containing in principle all the essential elements of a modern testing-machine. Labardie, soon after, constructed a 100-ton machine for the port of Havre, and Girard carried out with it the first tests on a large scale of the elasticity of materials. In 1813 and 1817, Brunton and Company and Captain Sam Brown constructed cable-testing machines. The latter machine was erected at Millwall, and had gearing at one end and a lever system at the other. Telford used these machines for testing the links of chains for suspension bridges.*

Theory of Elasticity.—A very great step in the simplification of the mathematical expression of formulæ of strength of materials was taken by that very remarkable English physicist, Thomas Young (1773-1829), who defined the coefficient of direct elasticity, or Young's modulus, and first considered shear as an elastic strain. Young practised for a time as a physician, was a classical scholar, but in mathematics largely self-taught. He was Foreign Secretary to the Royal Society, Superintendent of the Nautical Almanack, made extraordinary advances in many branches of physics, and is described by Helmholtz as one of the clearest-sighted men who have ever lived. From Galileo to Young—a period of two centuries—Professor Love has said, "The fruit of all the ingenuity expended on elastic problems might be summed up as an inadequate theory of flexure, an erroneous theory of torsion, an unproved theory of the vibration of bars, and the definition of Young's modulus." But this statement no doubt leaves out of account the foreshadowing of clearer conceptions in the work of the earlier workers. The time had come for the development of a general theory of elasticity. Navier, in 1827, first investigated the general equations of equilibrium of an elastic solid, starting from an assumption as to the molecular constitution of matter. Navier's equations are still accepted, though part of his reasoning is considered to be unsound. At the same time Cauchy founded the theories of stress and strain, and Lamé and Clapeyron made important developments. It is impossible to follow further the development of the theory of elasticity which has involved the most strenuous efforts of the very highest mathematical genius, which is valuable, as all definite knowledge is, but which, for the most part, is not of practical importance for engineers. One may note the fundamental controversy as to multi or rari-constancy—a controversy not settled, and, perhaps, never to be settled, because no material substance sufficiently conforms to the mathematical definition of an isotropic solid. For the engineer, the constitution, say, of steel, a conglomerate of crystals and eutectic, with different elastic properties, seems very widely removed from the ideal solid with uniformly-distributed molecules or centres of force assumed in mathematical theories. For the engineer, it is sufficient that Hooke's experimental law is very approximately satisfied for structural materials and for such straining actions as are permitted in structures, and that the results of elastic theory are sufficiently accurate for practical purposes for small finite strains. As to the condition of things if the elastic limit is exceeded, there is at present no satisfactory theory, though the experiments of Tresca are very interesting, and throw light on some engineering operations.

Reverting to experimental work in this country, early in the last century George Rennie made investigations of the resistance of structural materials, and Peter Barlow, who was a professor of mathematics at Woolwich Academy, and an honorary member of this society, made experiments on the strength of timber at the Dockyard and at the Arsenal. This led to his association with engineers, and he assisted Telford in calculations for the Menai Suspension Bridge. His "Essay on the Strength of Timber," in 1817, when developed in later editions, may be regarded as the first general treatise in English on the strength of materials.

Down to about the end of the first quarter of the last century most of the knowledge of strength of materials was due to the work of Continental engineers and physicists. Then an advance was made here in a very characteristic way. Thomas Tredgold was a working carpenter to the age of 25, and was almost entirely self-educated. In 1820 he published a treatise on the principles of carpentry. This, which has been republished down to 1886, dealt scientifically and practically with all the then known data of resistance. In 1822 he published a treatise on cast-iron, which was re-edited by Eaton Hodgkinson in 1860. His book on the steam engine, dealing specially with questions of strength, was published in 1827 and republished down to 1850. It has been rather a fashion amongst elasticians to ignore or depreciate the work of Tredgold. But he had a practical insight into what was important and what was negligible in engineering problems greater than that of writers with more ample mathematical resources, and he rendered essential services to the engineers of his time. It must be remembered that the problems dealt with by Barlow and Tredgold were simpler than those with which engineers are now concerned.

A little later, Professor Eaton Hodgkinson, whom I knew in my apprentice days, and some of whose testing apparatus I used, began the researches on strength of materials which give him a foremost place among careful experimenters. His apparatus was rough, but he knew how to reduce the relative amount of error. He was for a few years a professor at University College, London, where he lectured, I think, during two months of the year. He is credited with the discovery of permanent set, and of the position of the neutral axis. His paper of 1830 on "Iron Beams," and that of 1840, on "Columns," were very valuable contributions to practical science.

There is not time to trace further the history of the science of strength of materials. Experimenters and laboratories in the last fifty years have increased enormously, and theoretical investigations have been pushed to great lengths. But I wish to take the opportunity of paying a tribute to one who seems to me the prince of observers in this branch of science. I mean the late Professor Bauschinger, of Munich. Born in Nuremberg in 1834, the son of an artisan, he studied at Munich University, and in 1866 became professor of mechanics and graphic statics at the Technical High School at Munich, in which he worked for twenty-five years. There he established a laboratory, rather more for research than instruction, where engineering experiments were carried out with a thoroughness and delicate accuracy never previously equalled. In 1868 he published the result of indicator observations on eight locomotives, on seven different journeys extending over 63 miles. But his special field of work was that of tests of materials. He created the first public laboratory for this purpose, under government auspices, and it has served as a model for the numerous great engineering laboratories since established on the Continent. He first applied Gauss's method of reading by reflection in instruments for measuring the deformation of bodies when strained.

Amongst many researches remarkable for their extent, it is only possible just to mention one on cements and cement and lime mortars, demonstrating, amongst other things, the importance of fine grinding, and one on the building stones of Germany. His researches on timber first indicated the precautions necessary for securing comparable results, especially the law of variation of strength with moisture. He carried out many researches on cast iron, wrought iron, and steel, especially some with reference to the variation of the position of the elastic limit under different conditions of straining, which first gave a key to the explanation of Wöhler's law. Perhaps one of his most important achievements was the foundation of the International Association for Testing Materials, which has done, and is doing, most valuable work in investigating methods of testing.

Testing Materials for Quality.—Down to the middle of the last century the only generally used tests of the quality of iron and steel used in construction were bend-tests, and in certain cases shock-tests. Such other researches as were made were directed to a different object, either to determine the constants in formulæ on which engineers relied, or to prove the sufficiency of complete structural members. In constructing the suspension bridge over the Seine at the Invalides in Paris, Navier required all the chain-links and suspension-bars to be tested to 11 tons per square inch, a precaution justified by the imperfect knowledge of materials at that time. Chain-cables have been tested for a century, not to determine the quality of the material, but to detect defects of manufacture. It was the introduction of Bessemer steel, and cases of unexpected failure of steel structures, which forced on engineers the necessity of systematic tests of quality. An important series of tests carried out by the late Mr D. Kirkaldy, at the instance and at the expense of Messrs. Napier, in 1860, led to the adoption of a tension test as the usual test of quality. Its special merit is that exact figures can be specified for elastic limit, resistance to fracture and elongation.

With the introduction of definite tests the importance of accurate and reasonable specifications became urgent. The engineer is responsible for the careful drafting and strict enforcement of his specifications, and in fixing on tests of quality, questions of cost, and of the convenience of manufacturers must not be disregarded. Recently the work of the Engineering Standards Committee, the creation of which is due to the action of this Institution, at the suggestion of Sir John Wolfe Barry, and on which users and producers of material are equally represented, has done very much to guide the engineer in securing trustworthy material without imposing conditions too

* Mr. Wicksteed has described a testing-machine capable of applying a straining action of 130 tons, stated to have been constructed at the Cyfarthfa Ironworks, Merthyr Tydvil, in 1829. It had hydraulic straining and lever-measuring arrangements. Proceedings of the Institution of Mechanical Engineers, 1906, 545.

irksome or costly on the producer. Hence it has come about that the testing engineer has been created, having functions partly as an investigator of the properties of materials, partly as adviser of manufacturers, and partly as inspector of materials. It was the opinion of the late Dr. Dudley, who organised the testing department of the Pennsylvania Railway, that the testing engineer was destined to play a more and more important part in the development of civilisation.

Application of the Science of Strength of Materials to Practice.—The general object of the accumulation of experimental and theoretical knowledge of strength of materials has been to determine the minimum amount of material and the best disposition of it in machines and structures to secure safety. Putting it another way, by theory the stress conditions due to any given straining action can be calculated, then it has to be determined what is the greatest permissible working stress, and in what way does it depend on such physical properties of the material as can be ascertained by testing. As to this there are still considerable differences of opinion.

The oldest and still the most common method of proceeding is to reduce the straining actions to simple tension, thrust or shear, by calculations based on the assumption of Hooke's law, and to provide material enough to limit the intensity of these stresses to a fraction of the breaking strength of test-pieces similarly strained. The ratio of the breaking strength to the working strength is termed the factor of safety. In by far the largest number of cases with which an engineer has to deal, the breaking strength of a structure cannot be calculated, for Hooke's law ceases to be true for stresses much below the breaking stresses. Hence the engineer sometimes proceeds one step further. He tests a scale model of a structure to breaking, and from this deduces the breaking load of the full-size structure by the law of similarity. Thus a model of the Conway Bridge was constructed, the linear dimensions being one-sixth those of the complete bridge, and it was assumed that the breaking load of the bridge, including its own weight, would be thirty-six times that of the model, including its own weight. There have been recently some similar tests of large-scale models of some of the members of the Quebec Bridge.

In the case of complex structures, in which the determination of the exact maximum stresses is beyond the resources of mathematical analysis, the value of model experiments is unquestioned.

Now it is easy to show that the ratio of the breaking stress to the working stress, or the breaking load of a girder to the working load, is not a real factor of safety; the point at which danger occurs in different cases is not a fixed fraction of either the real or the calculated breaking load. It has even been contended with some plausibility that the fashion of dividing the breaking stress by a factor to find the working stress is a barbarous method. The factor must be varied for different conditions, and can only be fixed empirically.

The ductile materials chiefly used in construction yield or suffer a large deformation at about half to two-thirds of the breaking stress. The deformations, if the yield stress is exceeded, would be at least in very many cases far too large to be tolerated in either machines or structures. If the yield stresses are taken as the limits of safety, then the real factor of safety is only about half the ratio of the breaking to the working stress. Further, the ratio of the yield stress to the breaking stress is not a very constant ratio.

Shall we, then, drop the breaking strength, and adopt the yield-point as the measure of the constructive value of a material. Many constructive materials, such as stone, timber, and cast iron, have no yield-point. Besides, even for ductile rolled material, such as mild steel, the point ordinarily determined as the yield-point is not a very fixed point for a given material. It depends a little on the rate of loading. Yielding really begins at the elastic limit, a point below the yield-point, spreading along the bar and becoming general over the bar at the yield-point.

Mild steel is a conglomerate of crystals and eutectic, the components of which are of different hardness. At the yield-point slipping at crystalline cleavage planes occurs, and the harder become better bedded in the softer. But in any case can the yield-point be taken as the measure of constructive strength? In a simple uniform tie-bar, no doubt, the deformation at the yield-point fixes a limit to the possible working stress. So, in telephone wires, rigidity is desirable to limit their deflection, and a maximum elongation is prescribed. In composite structures, such as reinforced concrete, no doubt, the whole relation between the concrete and steel assumed in calculation is disturbed if the stress on the steel passes the yield-point. But in most other cases only indefinitely short portions of a structure are exposed to the maximum stress, and the deformation due to these is not necessarily serious. In a riveted girder, for instance, designed for a limiting stress on the planes of weakness through the rivet-holes, only very short portions of material near the planes of weakness reach the maximum stress under an increasing load, and the great mass of the material is subjected to much lower stresses. In fact, no marked yield-point is shown in testing a riveted girder. In a riveted joint the effect of slight yielding of short portions near the rivet-holes is to render the distribution of stress more uniform. The yield-point of the material does not appear to me to measure a definite limit of safe load in such cases.

Some writers assume that the elastic limit, as determined in a tension test, is the real measure of the constructive strength of a material, but I am not sure that this is not, when rigidly examined, the most ambiguous and elusive of all the measures proposed. Cast iron has no elastic limit, nor have copper and most alloys unless hardened by straining, cold rolling or drawing. Either the stress strain relation is not linear, or possibly, in use, they acquire an elastic limit corresponding to the stresses to which they are subjected. In mild steel there is a primitive tensile elastic limit or limit of proportionality determinable by careful measurement. But it is not an absolutely fixed point, its position can be altered by straining, and its primitive position is in general a somewhat artificially raised one, due to the processes of manufacture. Mild steel is a conglomerate, and Professor Arnold has stated that the elastic limit of pearlite is 23 tons per square inch, of normal ferrite 10 tons per square inch, of laminated pearlite 13 tons per square inch. I do not know how those numbers have been determined, or how trustworthy they are, but it is certain the different constituents have different elastic properties. In what sense, then, is the elastic limit found in a tension test to be understood?

No doubt there are cases where the primitive tensile elastic limit does fix a superior limit to the stress consistent with safety. But it cannot be taken generally as an exact measure of constructive value, though it certainly is a valuable indication. Further, the elastic limit in compression is seldom observed, and the elastic limit in shear is experimentally almost unknown. Yet resistance to shear is probably for ductile materials the most important element of constructional value. It would be interesting to have the elastic limit in torsion of thin tubes accurately determined.

The classical research of Wöhler showed that, subjected to equal alternate tensions and thrusts, a steel bar would in time fracture, if the stress exceeded about one-third of the statical breaking strength. The ratio is, however, not a constant one, and must be determined independently for different materials or different qualities of the same material. Bauschinger showed that a bar, subjected to equal alternating stresses gradually increased, would be found to have ultimately equal elastic limits in tension and thrust of about one-third the statical breaking weight, and these he termed "natural elastic limits." These limits do appear to define the range of variation of stress a material can sustain, but we do not know much about them except in the case of steel. It is when these limits are exceeded in alternating stress that fatigue ensues, and the bar breaks. Dr. Stanton's results confirm this. But for the engineer's purpose the natural elastic limits are not easily found.

Hence, whether we take the breaking stress, the yield stress, or the primitive elastic limit, we have not found a satisfactory rational basis for measuring the constructive strength of a material. There is not a fixed ratio between the greatest safe working stress and either of these. But I do not wish to be understood as depreciating the value of the determination of breaking stress, yield-point, and elastic limit in testing materials.

A composite factor of safety has sometimes been proposed. For instance, you take a factor of 1½ to 2 for the ratio of the breaking to the yield stress; a factor of 1 to 3, according to the character of loading in accordance with Wöhler's law; a factor of 1 to 2, according to the rapidity of loading, or as an allowance for shock; and, finally, a factor of 1½ to 4 to allow for unknown contingencies. Multiplying all these together, you obtain a so-called factor of safety by which the breaking stress is to be divided to find the working stress. I do not know that any practical designers proceed in this way, and the margin of choice in selecting the factors is so wide that the method is not really useful. But there is a more serious objection. The component factors are not independent factors forming sub-multiples of a real factor of safety. It is quite irrational, for instance, to multiply a factor 2 for the ratio of yield to breaking strength by a factor 3 for alternating loading. The product is meaningless. None of these sub-factors is unimportant or to be disregarded, but we do not reach a rational rule or even a safe rule of thumb by merely multiplying them together. Valuable as are the data of breaking strength, yield-point and elastic limit determined in a tension test in influencing the judgment of the engineer, they do not furnish any purely rational rule for fixing the working stress for designers. Experience in similar cases must always be the ultimate appeal.

Compound Stress.—So far all that has been said relates to cases of simple tension, thrust, or shear. But in a very large number of cases two of these stresses are combined. In such cases the theory of elasticity furnishes the principal stresses and the principal strains, but the question, What is the criterion of safety? involves another of the unsolved problems of engineering. Two schools arose amongst theorists, one holding that the maximum stress, the other that the maximum strain, determined fracture. For simple stresses either assumption leads to the same result. It is not so with compound stress. Very early Coulomb suggested that fractures would be determined by shear, as is the case with cast iron under compression. The subject is now under investigation experimentally, and, speaking generally, it seems that for ductile materials, the material gives way at some limit of shearing stress, while for brittle material in tension the principal stress is the best criterion of strength.

Comparative Structural Value of Materials.—It is only when comparing two different materials that an engineer needs to consider relative constructive value, and then he bases his judgment on all the properties of the material. Ordinarily, the safe working stress is fixed by experience in similar cases, theory helping mainly in explaining why in different cases different stresses are suitable. The history of engineering design is a history of experiments in construction, in which by trial and error right proportions have been found—and in the settlement, the different relative importance of cost and weight enter into the question as well as considerations of mechanical strength. The fact that scientific data and rational or semi-rational formulæ are conveniently used should not be allowed to conceal the fact that an empirical element always enters into the solution.

New designing is really a process of comparison, in which the engineer extends experience in known cases to new conditions, and the problem is, in what proportion dimensions must be varied to allow for differences of size, of material, of loading, of speed, or of form.

Most practical problems in designing for strength reduce themselves, if traced to their foundation, to applications of the law of similarity. At a time when steam-engines all worked at about the same steam pressure, it was broadly stated that the drawings of an engine of any size could be used for constructing engines of any other size, by merely altering the scale of the drawing; that is, two geometrically similar engines would be equally strong for a given steam pressure, and, subject to some restrictions, the principle is correct. Generally two geometrically similar structures are equally safe with loads of the same intensity, applied at corresponding places. Two pipes are equally stressed by a given fluid pressure if the diameters and thicknesses are in the same ratio. Two uniform flooring slabs similarly supported will carry equally well a given load per square foot if the lengths, widths, and thicknesses are in the same proportion. If all the linear dimensions of two girder bridges are in the ratio N, they will be equally stressed by total loads in the ratio N^2. So-called mechanical instinct is, no doubt, really reasoning based on the law of similarity.

Note that the total load on a structure is made up of the useful load and the weight of the structure, and that the latter increases as the cube of the linear dimensions. Hence, as the strength of the structure, or total load it will carry, increases only as the square of the linear dimensions, the weight of useless load becomes a larger fraction and the useful load a smaller fraction as the size increases. A limit of size is reached at which the structure will only carry itself. Hence proportions will in general vary greatly with size. In the Britannia Bridge the depth of girder was about one-sixteenth of the span. To make the Forth Bridge possible, the depth of the cantilevers is about one-fifth of the span. In that bridge the possible limit of span in a steel structure is nearly reached.

In the case of machines, another consideration enters. The weight stresses are not usually important, but the inertia stresses due to variation of velocity or direction of motion are very important. The stresses in a fly-wheel rim due to radial acceleration are proportional to the square of the rim velocity whatever the cross-section. Hence fly-wheels are equally safe in this respect if the rim velocity is the same, or if the rotations per minute are inversely as the diameters.

The exceedingly interesting application of a law of similarity in determining the resistance of ships by model experiments is outside the questions treated in this address. It is by an application of the law of similarity that the Engineering Standards Committee have been able to define the forms of test-pieces, so as to give comparable results as to percentage of elongation.

Engineering Education.—I turn to another subject which, indeed, has frequently been discussed in presidential addresses, but which seems to be appropriate in a year in which the Institution has held a Conference on the education and training of engineers. An important change is going on in all types of education. In all it is being recognised that they should be such as to afford a training for the duties of life. The free discussion of this subject at the Conference was no doubt interesting and useful. Only eight years ago, the Institution appointed a distinguished and representative Committee, with Sir William White as chairman, to report on the character and conditions which should obtain in the training of engineers. This Committee consulted widely other members of the profession, and arrived at definite conclusions, which appeared to be generally in accordance with the opinions of the majority of engineers. The valuable and influential report of the Committee* deals in detail with the whole subject, including preliminary and college education and practical training. It was curious to me that in the discussion at the Conference, most speakers treated as still quite open questions matters as to which the Committee had arrived at definite conclusions. It seemed to me that the report had hardly received the attention which so weighty a pronouncement deserved.

The term "engineer" is used in such wide and loose senses that it is necessary to be explicit as to one's point of view. There are vocations associated with engineering work for which no special training is absolutely required beyond that of the factory or commercial office, or for which any other training required is different and more limited in scope than that of the professional engineer or director of engineering works. But the Conference and the Committee were considering the case of those who aim at becoming ultimately professional engineers—that is, men who advise, design, and direct the execution of works of civil engineering in the wide sense in which that term is used in this Institution. If the course of training of such men is provided for, the less complete training of men for lower grades of service is not likely to be wanting. But I do not think that we distinguish sufficiently at present the different type of education required for leaders and subordinates, the heads and the hands.

It must be recognised that the professional or consulting engineer is not solely concerned with technical problems, though as to these he must be an expert. But he is more and more concerned with economic, legal, and commercial problems of much intricacy, and must be prepared to meet men of affairs and of liberal education on an equal footing.

In his presidential address, in 1898, Sir John Wolfe

* Minutes of Proceedings of the Institution of Civil Engineers, vol. clxvi., page 159

Barry said that "no profession requires more education, theoretical and practical, and more training of the mind, than the profession of a civil engineer." A distinguished American member, Dr. E. L. Corthell, has said that "the civil engineer of the twentieth century must be an educated man, and prepared for his life's work by the highest order of educational instruction and training."

Now the earlier great engineers in this country had no formal technical training; indeed, very little general education either. Brindley, George Stephenson, Fairbairn, had only parish-school education; Smeaton, Telford, and Watt only grammar-school education. They picked up even their practical experience gradually and casually. They differed in this from their contemporaries in France. Perronet, Gauthey, Rondelet, and Navier, for instance, were of a more academically educated type.

It is no doubt due in part to such early conditions of English engineering, in part to the narrow and unscientific character of secondary and university education in this country, that until recently the education and training of engineers has been so unacademic and unsystematic.

That the state of things was gradually recognised to be unsatisfactory is shown by many passages in our Proceedings. For instance, Sir John Fowler said in his address in 1866: "We of the passing generation have had to acquire our professional knowledge as best we could, often not till it was wanted for immediate use, generally in haste and precariously, and merely to fulfil the purpose of the hour. Therefore it is that we earnestly desire for the rising generation those better opportunities, and that more systematic training, for which in our time no provision had been made, because it was not then so imperatively required."

It was just after this time that ninety-three pupils of members of the Institution petitioned the Council to consider the training of engineers, "so that they might worthily maintain the reputation of their predecessors in face of the strenuous and increasing competition of their rivals on the Continent and in America."

Preliminary Education.—A very great obstacle to the progress of technical education in this country has been the want of any definite aim, the unsuitable character and poor average quality of our secondary education. Lord Haldane has pointed out the enormous advantage Germany has had over us in the organisation of her secondary schools. The dominance of classical studies, the imperfect teaching of mathematics, the exclusion of science and modern languages, and the excessive interest in games in the schools of half a century ago, are only slowly giving way to more rational ideals of education. When Sir Henry Roscoe became a governor of Eton, he found that, in a not very laborious curriculum, twenty hours per week were given to Latin and Greek. Grant whatever can fairly be urged as to the honourable spirit, the pluck and resourcefulness of boys from the better public schools; grant also the value of dead languages as a means of culture for those who really master them, it must still be recognised that the average boy left, and to some extent even still leaves, school sadly unfitted for any form of higher education. The success of the clever and brilliant few, educated for university prizes, has obscured the poor quality of the intellectual equipment of the average many. What is to be said for a system in which "lads spend most of their working time in spelling out languages which not 5 per cent. of them learn to read, and in writing such prose and verse in those languages as no mortal would write in English."

Happily, if the state of things is not yet satisfactory, if secondary education is still unorganised, and the schoolmaster is only partially converted, still science has obtained a footing, and school-leaving and other examinations have secured that the average lad is better taught. As Lord Haldane has said, "The Teutonic spirit is moving amongst us." Even the *Times* tells us that our schools must do more than they have done, if England is to become, as Germany has become, an educated nation.

It was partly a cause, partly a consequence of defective school education, that the great universities have not addressed themselves, in a responsible and scientific manner, to securing that candidates for admission to higher courses had reached a reasonable standard. Still less were the engineering schools, with one or two exceptions, able to insist that students were properly prepared for technical instruction. Rankine, in notes for the guidance of candidates applying to attend his classes, merely stated that it was desirable, if possible, that the elementary part of mathematics should form part of their preliminary education, and that they should, if possible, obtain some knowledge of drawing outside the university. In several engineering schools students were permitted to enter all or any classes without preliminary examination. It is only recently, and partly under pressure from the Institution, that a fairly satisfactory entrance examination has been prescribed in some English and Colonial engineering schools. To admit lads with imperfect preliminary education to advanced instruction lowers the whole standard of work in the classes. Lads who have taken technical instruction without a serious basis of knowledge are likely to lower the estimate of academic training by employers, and it is such half-educated lads who are most likely to get a bad reputation for conceit.

An erroneous opinion has prevailed that technical instruction requires little or no literary and scientific education to prepare the way for it.

I noticed the statement in the address of the Chancellor of St. Andrew's, on the occasion of the quincentenary of the University, that the test now imposed for entrance would in some respects compare not unfavourably with that for graduation about half a century ago. In the best engineering schools a similar change has occurred, and should indeed make further progress. The possibility of effective technical teaching depends on suitable previous preparation, and on this point the Committee of the Institution in 1906 came to very decided and definite conclusions, and laid down explicitly a scheme of school education for engineering students.

Technical Education.—I do not think it is generally known that the earliest universities were strictly technical schools. They were intended for the education of clerics, lawyers, and doctors. Salerno was a medical school, Bologna was a school of civil law. Paris was the first university to have a faculty of arts in addition to faculties of theology, law and medicine. It is only in modern times that universities came to be regarded as solely concerned with a general liberal, and, except as regards medicine, an entirely non-technical education. "The colleges were in their inception," says Mark Pattison, the Rector of Lincoln, "endowments not for the elements of a general liberal education, but for the prolonged study of special and professional faculties by men of riper age;" and he lamented that they no longer promoted the researches of science or directed professional study. That state of things is happily changing, especially in the modern provincial universities.

The new vocation or profession of engineering grew up in this country with very little academic encouragement. It is true that since 1840 engineering schools were attached to a few universities. But they were generally unendowed, unequipped, or uninfluential. The most distinguished of them was that at Glasgow, where the Regius Professorship was held by Gordon and Rankine. Some distinguished engineers owe stimulus to Rankine's teaching; but his influence was much greater through his writings than through his school. He was the first really powerful thinker in this country to bring the highest mathematical resources to bear on engineering problems. He became a professor after eighteen years of practical engineering, and while in some subjects, such as thermodynamics, he was a discoverer and pursued an original line, he was largely indebted in other subjects to his unusual knowledge of Continental writers.

Meanwhile, in France and Germany, there had long existed remarkable engineering schools with distinguished teachers. The Paris Ecole Polytechnique was instituted in 1794, the Ecole des Ponts et Chaussées in 1795, the Ecole des Mines in 1778, the mining school at Freiburg, where many foreigners obtained education, in 1765. In the first quarter of the nineteenth century were established the technical high schools of Carlsruhe, Hanover, Berlin, Dresden, Vienna, and the Ecole Centrale at Paris. The great Zurich Polytechnicum dates from 1854.

With one exception, I do not think there were any engineering schools in this country with what could be regarded as a reasonably complete and satisfactory curriculum or equipment before 1870.

In giving this date I am passing over the system of education adopted by the Admiralty for naval engineers and architects in 1843. In that system lads were educated in the dockyard schools, and selected lads of marked ability were given the means of obtaining advanced technical education in the school of naval architecture and marine engineering. Some of the lads so trained passed into private employment, and became the chiefs of some of the largest shipbuilding yards. Others rose to the highest positions in the Admiralty. Sir William White has pointed out that this system of education has had a very great influence upon the leading position which Great Britain occupies in the shipbuilding and shipowning industries of the world.

Sir Alexander Kennedy established the first college engineering laboratory in 1878, and from that may be dated the beginning in this country of a necessary equipment of engineering schools. In the establishment of what are now costly institutions, many leading engineers have taken a generous and conspicuous part. There are now a number of university engineering schools, or schools of university rank, directed by teachers of eminence, not only in science but in practical engineering, with systematic courses of instruction, covering broadly all branches of engineering up to the graduate stage, and of a thoroughly practical character. Quite recently a beginning has been made of post-graduate instruction of a specialised character. It is only in a post-graduate course that engineering students can be usefully or efficiently employed in research.

Advanced Education and Practical Training.—I cannot help thinking that there is a tendency amongst some practical engineers to suspect those of us who are interested in formal technical instruction of indifference to the value of practical experience. But surely that is a mistake. Most engineering professors are themselves engineers of considerable practical experience. What, in fact, they do somewhat doubt is the value of so much practical experience as an ordinary apprentice gets, who goes straight into works without technical training, and who has to pick up his knowledge as he can. At the best his experience is a narrow one. Some of the jealousy occasionally shown as to college training seems to arise from the feeling that it interferes with the traditional English system of articled pupilage, which, as far as I know, hardly exists in any other country. It does seem to me that the old apprenticeship system for professional engineers, taken by lads direct from school, was uneconomical, wasteful of time, involving unnecessary drudgery, and in some respects unfair.

No more lucid account of the difference in this respect of the English and Continental methods is to be found than the memorandum, prepared by Professor Fleeming Jenkin, in the volume on the education and status of engineers, printed by the Institution in 1870. He pointed out that practically all the civil engineers in the narrower sense, in public or private employ in France, were members of the Corps des Ponts et Chaussees, and had passed through the Polytechnic and the Ecole des Ponts et Chaussées, or the Ecole des Mines. Other engineers in France had nearly all been pupils in the Ecole Centrale, and the one recommendation which proved they were worth a salary, and by which they obtained employment, was the diploma of the school. In contrast with this, in this country, the path to employment as an engineer lay through the works or office of a civil or mechanical engineer. Professor Fleeming Jenkin had been a pupil, had reached a distinguished position as a practical engineer, and was not an advocate of the abandonment of a pupilage system. But he does not give any favourable view of the working of the system in 1870 before it had been sensibly affected by engineering schools. He says that young Englishmen very imperfectly educated "crowded the doors of offices and workshops, offering premiums of 300*l.* to 500*l.* for mere permission to pass three years within the magic gates." And of the results he says: "Notwithstanding their ignorance at starting, the neglect in which they were left during pupilage, and the absence of opportunities for increasing their theoretical acquirements, many of them do become useful men." That is surely a very unsatisfactory account of a pupilage system pure and simple in the days of its predominance forty years ago. No doubt in many cases at the present time some standard of education is exacted in accepting pupils, and care is exercised in training them. But I want to urge that the change has not yet gone far enough.

There is another consideration as to the pupilage system as it existed forty years ago. It was suitable only for the wealthy; but many of the most hard-working, capable, and even brilliant students are not of the wealthy class. In these days there are ladders from the elementary school to the university and the technical college. It would be a loss to the country and the profession if really able, but comparatively poor, students could find no way to employment. In this competitive time we can least of all afford to neglect or waste intellectual ability.

The Institution has, by its system of examinations, expressed its view of the importance of such theoretical and practical technical education as it is the object of technical schools to give, while at the same time it has done what is possible by its bye-laws to encourage or require a term of pupilage or apprenticeship as a means of acquiring experience.

Further, in the report of the Committee of 1906, while insisting on the value of pupilage or apprenticeship, it has most definitely expressed the opinion that a three years' course in a technical college is equally necessary, and should form an integral part of the training of an engineer, and this conclusion was endorsed by a large majority of the engineers who were consulted by the Committee.

The question arises, and I think it is a serious one, how far engineers now are taking any steps to carry out the recommendations of the Institution Committee as to the requirement of preliminary training antecedent to pupilage. It is clear that young men will not incur the expense, the labour and the delay of a college course, if it gives them no advantage in entering the profession.

Some inquiries were lately made by the Institution of more than a hundred engineers in various branches of engineering as to the conditions on which they accepted pupils or apprentices. In a few cases it appears that pupils or apprentices are required to have passed an examination equivalent to the studentship examination of the Institution. In a very few cases the possession of a degree is accepted as a reason for shortening the period of apprenticeship. But what is desirable is that a lad should reach the standard of the associate membership examination or the examination for a first degree before entering on pupilage. If he does not he will only be able to reach it by cramming, which, though not quite useless, is much inferior to a systematic course of study. As a matter of fact, however, within my own knowledge the colleges have more influence than these returns seem to show, and, especially in the case of the provincial universities, local patriotism ensures preference to men trained in the local university. But it cannot be said that the state of things is satisfactory, or will be so, till complete college courses are recognised as a necessary step to engineering employment of the higher type.

This is already the case in the United States and Canada, where college-trained men are sought for by railway and structural engineers and by large corporations, and where, after a short trial, such men always receive wages. In this connection I might, perhaps, mention that I recently received an interesting letter from one of the most eminent of American engineers, Dr. Corthell, in which he states, as to the men trained in the engineering schools, that "they go to work immediately in good positions, and with a living salary, and that the railroads, the mines, the hydro-electric works, the waterways and ports, and the United States Government want and apply for them." Conditions in the United States are, no doubt, different from ours, and here the intermediate pupilage or apprenticeship stage is generally insisted on; but American engineers are not shortsighted or unbusinesslike, and their experience has lessons for us.

The Transition from College to Practice.—It seems to me that the great efforts made during the last forty years, and the expenditure incurred, largely from private sources, in establishing engineering schools, lack in one respect full recognition by the profession. Many engineers have given generously in money and in time; but engineers in general might do more in facilitating the transition from school to works. With an experience of twenty years, I believe that more organised and recognised relations between the schools and offices and works are desirable and possible. It is not that my students did not find employment, but that the procedure in finding it was so casual, and in some cases

demoralising. It would be ungrateful, however, not to acknowledge how often I was helped by engineers in practice. The most difficult part of a young engineer's career is the step between college and full capability in some special branch. No engineering school can prepare students completely for any special position in the engineering field without very undesirable narrowing of the scope of the instruction. Two years of pupilage or employment is desirable as a transition period, and the difficulty is that generally engineers expect that someone else should have the task of rounding off the college training. Even in the United States it is perceived that, as Mr. Kimball, of Cornell, has put it, to make technical education effective the employer must shoulder a part of the load imposed by the old apprenticeship system, which in the United States has been to a great extent thrown on the schools.

I am, therefore, much in sympathy with the proposal which Mr. Yarrow placed before the conference that there should be an endeavour to produce some co-ordination between the colleges and employers, by making an inquiry as to the conditions under which well-qualified students may be able to get practical training, whether they seek employment later in the mechanical or electrical branches of engineering or in constructional or administrative work. Some scheme might be evolved linking the colleges and the manufacturing, municipal, or other public works, so far that the first stage of practical experience might be gained under conditions less haphazard than at present. No doubt, college graduates who want to fit themselves for service in India, or for starting in private business, are fairly asked to pay for the privilege of entering works or office. But in other cases, well-trained students who are quite capable of being useful might very well be taken on easy terms, for a trial of a year or two, in the expectation that they would remain afterwards as valuable assistants. In the engineering departments of municipalities greater facilities for apprenticeship might be given. By choosing technically well-educated lads, and directing their practical training, they would form a loyal staff, ultimately more competent and useful than others less educated, but selected as more immediately useful. Further, it is now proved that technically-educated lads are very fit, with some experience added, for the commercial branches of an engineering business.

If a university degree or college diploma is to be taken as a qualification for beginning an engineering career, it must not be overlooked that degrees and diplomas are of very varied value, and that one great function of a college is to distinguish the more and the less capable amongst its students. It has been a surprise to me for many years that employers, who took my students into works or offices, so rarely cared to inquire as to my opinion of their abilities. Generally the degree or diploma has the highest value when it certifies to education in an institution of great prestige, with high ideals of work and conduct, where the influence is felt of teachers distinguished both for practical knowledge and scientific attainments.

I believe there are no schools of university rank where the work is more strenuous, the methods more practical, or new ideas more welcome than in the best of the engineering schools of the day. What was said of Eton in the seventeenth century may be said of more than one engineering school to-day: "This is a brave school and the best teaching in the world." The association of young men at their most formative and impressionable time in such an institution has a value for them which no apprenticeship can replace.

Dr. Henry Smith Pritchett, the late President of the Massachusetts Institute of Technology, has said that "there are few human organisations for which it is so difficult to estimate either the value of the energy which goes in or the value of the product which comes out, as it is for a college. Any subject may be so taught as to tend towards the upbuilding of the intellectual and the moral life of a student, or it may tend the other way. So much depends on the personality of the teacher." But I have not been so long concerned with engineering education without concluding that generally the engineering schools are efficient instruments of education, or without acquiring a faith in what Dr. Pritchett calls the stream of moral earnestness and moral energy which flows through them. It is not merely the specific knowledge acquired, or the capability of using the tools of the engineer, but also the comradeship of students and professors which happily in so many cases is the most valuable part of college training.

The Institution of Civil Engineers is the oldest and most important representative of the profession in this country, the evidence to the public of its honourable past, its great traditions and high standards of conduct and ability. It requires for its members and associate members theoretical knowledge, tested by its own examinations or by others accepted as equivalent, and a definite amount of practical experience. It has striven to promote a high standard of honour, of culture and attainment among those to whom it extends recognition. The education and training it demands involve prolonged and expensive study, and a period of unremunerative activity in the early part of our engineers' career. Does not this place on employers, who have at heart the welfare and dignity of the profession, an obligation as to the conditions under which they select young engineers for employment. Especially in appointments in the public and municipal services, it seems desirable that the technical staff for constructive or administrative services should not be recruited by tests inferior to those accepted by the Institution.

I have touched on various subjects, unavoidably in a short address, with some one-sidedness. We have been driven lately to recognise how intimately the very existence of society, as now constituted, depends on the work of the engineer. It is because I have come to believe in the importance of coherent and systematic instruction, and in the value of the play of mind on mind, and the influence of generous rivalry, best enjoyed at a plastic and impressionable age during studentship, that I have ventured to urge the claims of engineering schools in preparing the engineer for service in shaping the destinies of the Empire.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting on October 27, held in the Imperial College of Science, Professor H. L. Callendar, F.R.S., President, occupying the chair, a paper on "*Further Observations on the Afterglow of Electric Discharge and Kindred Phenomena*" was read by the Hon. R. J. Strutt, F.R.S.

It is shown that ozone prepared by means of the Siemens ozone tube used at atmospheric pressure is able, when mixed with nitric oxide, to give the greenish yellow after-glow flame. This result is only attained, however, when the ozone has been concentrated by fractional distillation. A blue glow is obtained under the same conditions with sulphuretted hydrogen and ozone.

The effect of sulphur compounds in improving the air-glow noticed by the older experimenters is shown to be due not to any direct intervention of these bodies in the reaction, but to their power of destroying organic matter prejudicial to ozone. When once this is got rid of, the sulphur compounds are of no further advantage.

It is found that pure oxygen does not give an afterglow. The afterglow seen in electrodeless bulbs containing oxygen is due to some interaction with water vapour.

The luminosity given out when ordinary spring water is shaken with ozone is shown to be due to oxidation of peaty matter contained in it. Brown peat water gives greatly enhanced luminosity.

Mr. A. Campbell inquired whether quartz would not be better than glass in vacuum-tube work for preventing occlusion of moisture and gases.

Mr. Egerton asked whether the afterglow might not be due to ozone decomposing into oxygen. In this case both liquid air and phosphoric pentoxide would prevent the glow by removing the oxone.

The author replied that quartz would undoubtedly be superior to glass, but pointed out the difficulties of working with it, and the impossibility of making sealed joints. In reply to Mr. Egerton he stated that there was some evidence that moisture was necessary for the afterglow in oxygen, as it was found that the afterglow disappeared at the same time as the red hydrogen line.

A paper on "*Homogeneous Fluorescent X-Radiation of a Second Series*," by Professor C. G. Barkla and J. Nicol, was read by Professor Barkla. It was shown by one of the writers that the fluorescent X-radiations emitted by elements exposed to primary Röntgen radiation can be arranged in series, one radiation in a particular series being emitted by each element, and the radiation belonging to that series becoming more penetrating with an increase in the atomic weight of the radiating element (Proc. Camb. Phil. Soc., May, 1909). The homogeneity of radiations of only one series (the K series) was shown by Barkla and Sadler. This paper describes experiments showing the homogeneity of fluorescent X-radiations in the second series (the L series), and exhibiting the homogeneity of radiations of the two series from a number of elements. Details are given of the observations on the radiations from barium. Similar results are recorded in the case of the radiations from iodine, antimony, and silver.

The homogeneous fluorescent radiations of different series are emitted simultaneously by an element exposed to Röntgen radiation of more penetrating type than either. The fluorescent X-radiations can thus be analysed into well-defined radiations widely different in penetrating power, and may be said to give a line spectrum in X-rays.

The absorbability of the fluorescent radiations is given by the following values of $\frac{\lambda}{\rho}$, where λ is the coefficient of absorption of these radiations in aluminium of density ρ:—

Ag radiator:	(Series K)	[2.5];	(Series L)	700
Sb	,,	,,	1.21	,,	435
I	,,	,,	0.92	,,	300
Ba	,,	,,	0.8	,,	224

Dr. S. Russ inquired as to the mechanism of the production of scattered radiations, and asked whether scattered radiation would be produced by homogeneous radiations.

Professor C. G. Barkla, in reply, said that scattered radiation was produced by a pulse passing over an electron disturbing it, and so causing it to radiate a pulse of the same wave-length or hardness. No satisfactory explanation of either X-ray fluorescence or ordinary fluorescence had been given, but he pointed out that after the pulse had passed over an electron the latter would continue to vibrate with its natural frequency.

London Chamber of Commerce: National Insurance Bill.—At a special meeting of the Engineering Section of this Chamber, held on Friday, the 3rd inst., the terms of this Bill, especially Part II., relating to unemployment, were considered. Reports were presented showing the amendments which had been tabled on the suggestion of the Chamber, which the Section generally approved. In the course of the discussion it was pointed out that the condition of the engineering trades was such, owing to the relatively small profits earned by many of the firms and companies, especially the smaller concerns, that the cost of unemployment insurance, in addition to that for sickness, would materially reduce the margin of profit.

VOLUME CHANGES IN THE ALLOYS OF COPPER WITH TIN.*

By J. L. Haughton, M.Sc., and Professor T. Turner, M.Sc. (University of Birmingham).

(*Concluded from page* 611.)

The next volume change of considerable interest is that occurring at 500 deg. Cent., where $\alpha + \beta$ changes into $\alpha + \delta$. This should be shown on bars containing from 15 to 25 per cent. tin. The 25 per cent. alloy was unfortunately not cooled down far enough to show it, but it can readily be seen on the 20 per cent. alloy by placing a straight-edge along the curve. The change appears to last, according to the expansion curve, from about 540 deg. to 480 deg. Cent., due, doubtless, to the fact pointed out earlier in this paper, that the rate of cooling, and therefore the temperature of the bar, differs in different parts. Further confirmation of this is obtained from the photograph shown in Fig. 10, page 610 *ante*. This represents the fracture of one of the bars in three different places; A is from the head of the bar, near the cross-piece; B, from about two-thirds of the way down; and C, from the end close to where the pin enters. The difference in crystal size is very striking, the most probable explanation being that the cooling was slower near the head where the mass of metal was so much greater. The change above referred to is also visible, though much less pronounced, in the 15 per cent., and possibly in the 28 per cent. alloy.

The alloys containing 33, 34, 37, and 39 per cent. tin show an alteration in the rate of contraction at somewhat above 600 deg. Cent., corresponding, presumably, with the separation of η from γ. This is specially marked in the bars containing 34 and 39 per cent., and although the temperature of the change cannot be determined very accurately, yet it will be noticed that it agrees quite reasonably with the values given by Shepherd and Blough. Attention is drawn to the cooling curve of the 34 per cent. alloy, which shows two definite arrests at 600 deg. and 630 deg. Cent.; these correspond almost exactly with the figures given by Shepherd and Blough.

The 43 per cent. alloy appears to contract uniformly after the first expansion, the allotropic change at 400 deg. Cent. being hardly, if at all, shown, although it is quite visible on the cooling curve. On the 50 per cent alloy, however, it is very plainly marked, and bars of 52, 55, 59, 60, 65, 66, 69, 70, and 76 per cent. tin content all show this separating of ϵ, as it is called by Shepherd and Blough. After this it becomes masked by the preliminary expansion of the alloy. It appears to be at a maximum in the 65 per cent. bar, where it renders the rate of contraction abnormally slow for over four minutes, under the cooling conditions of the experiment.

Between 25 and 40 per cent. tin the polymorphic changes indicated by Shepherd and Blough are so rapid that it is impossible to expect the extensometer to show them with the rapid cooling employed. With these exceptions it may be said that every important line crossed on the equilibrium diagram is accompanied by a change in the rate of contraction, as shown by the extensometer. This fact causes the author to attach great importance (perhaps undue importance) to the changes which have no such explanation, and he would run the risk of being over-importunate by once more urging the importance of taking slow heating and cooling volume change curves of these alloys.

At this point attention may be drawn to a few peculiarities shown by some individual bars. Thus the 25 per cent. tin bar contracts much more rapidly than any of its neighbours, although the pyrometer curve shows that the rate of cooling was almost identical. It appears to be pure β down to 550 deg. Cent., below which its rate of contraction was not measured. This seems to suggest that the coefficient of expansion of pure β is greater than that of α or γ, while it appears that $\alpha + \beta$ has a smaller coefficient of expansion than $\alpha + \delta$. Much more work, however, must be done on the subject before it is safe to draw any conclusions.

35 per cent. tin, after it has passed the 600 deg. line, behaves in a similar way, though its cooling curve is shown by the pyrometer to be slower than those of adjacent bars; 37 per cent. tin seems to do the same, but the absence of pyrometric data renders this uncertain.

It has been urged by several metallographists, Dr. Desch in particular, that the phenomena observed during solidification are not really volume changes, but are caused by crystal thrust, and in the discussion following the paper read before the Institute of Metals on volume changes in the copper-zinc alloys (2) he instanced the case of a crystal of alum being able to exert a force of 2 kg. In this connection it is interesting to notice that, in the series at present under discussion, at least three alloys giving quite large expansions exerted a very small force, so small indeed that, owing to the extensometer not working quite freely, a zero result was registered, although the contraction appeared to be quite uniform once solidification was complete. Before each bar was cast, the freedom of the extensometer was tested by moving the pin backwards and forwards in the mould a few times, so that the resistance exerted must, of necessity, have been very small, and, had the apparent expansion been due to crystal thrust, it would seem probable that no difficulty would have been experienced in overcoming this small resistance, the assumption being that a skeleton of crystals is formed, one of which is connected to the pin; if, however, we assume a kind of muddy mass—a mixture of solid crystals and mother-liquor—each particle of which expands at the moment of solidification, it is very easy to conceive of such a mass failing to grip the extensometer

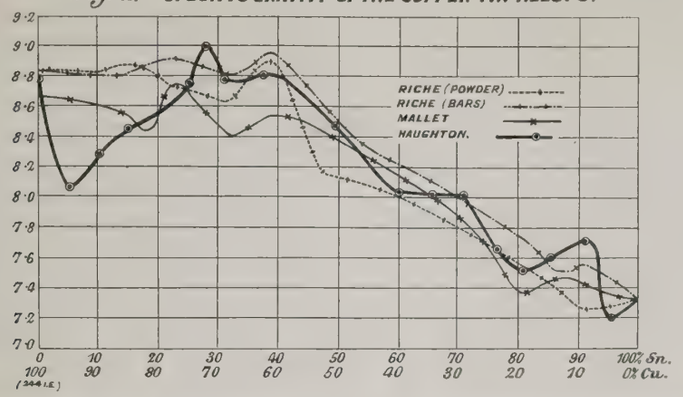
* Paper read before the Institute of Metals at Newcastle.

pin until almost all the material is solid. Incidentally this observation shows the need of checking all zero points on the expansion curve.

It was also noticed that pure copper, when melted without a covering of charcoal, gave a large expansion. The same effect was observed by Wüst [12], who attributes it to the liberation of dissolved gases. This is obviously a case of a real volume change which affects the extensometer. It is noteworthy that the value of this expansion, as obtained on two occasions by the author, is almost identical with that of Wüst; this seems to suggest that a definite amount of gas is absorbed by the molten copper and is given off on cooling. The agreement is all the more remarkable in view of the fact that one of the author's bars seemed to consist more of blow-holes than of metal, while the other was reasonably sound. Reference to Fig. 11 will show that the bars containing from 0 per cent. to 20 per cent. tin have abnormally low specific gravities, doubtless due to blow-holes from occluded gases. This will probably explain the low results obtained by Mallet [13] in the same neighbourhood, and also the fact that Riche found that the density of powdered specimens was greater than that of cast bars between about these limits, while beyond them the converse is true.

All these results are shown in Fig. 11.

Fig. 11. SPECIFIC GRAVITY OF THE COPPER-TIN ALLOYS.



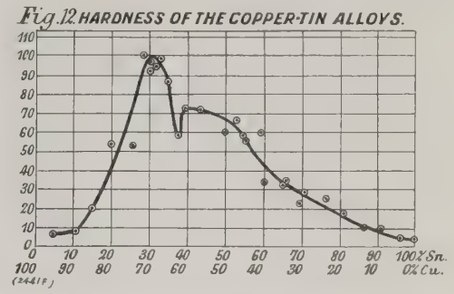
5. Hardness Tests.

Hardness tests were carried out on the bars by means of the scleroscope, the results of which are plotted in Fig. 12. The striking feature of this curve is the high maximum occurring at 30 per cent. tin, which corresponds, as has already been pointed out, with that shown by the expansion curve. It seems almost impossible to find any agreement between the observed hardness and the theory of Kurnakow and Shemtschusny [14], but the very complicated state in which the castings exist, and the impossibility of determining exactly what that state is, without prolonged annealing and quenching experiments, renders it very difficult to apply the theory.

It is rather disconcerting to notice that the scleroscope returns gun-metal as only slightly harder than tin.

The results plotted in Fig. 12 are from the mean of ten fairly concordant results, any abnormal readings not being included in these ten.

Fig. 12. HARDNESS OF THE COPPER-TIN ALLOYS.



6. Microstructure.

The microstructure of the copper-tin series is exceedingly complicated, and, although each bar was examined, any attempt to consider it at all fully would be quite out of place in this paper. Nevertheless, a few typical photomicrographs are reproduced to show the exceedingly complicated conditions in which the bars exist, and how far they are removed from being in equilibrium.

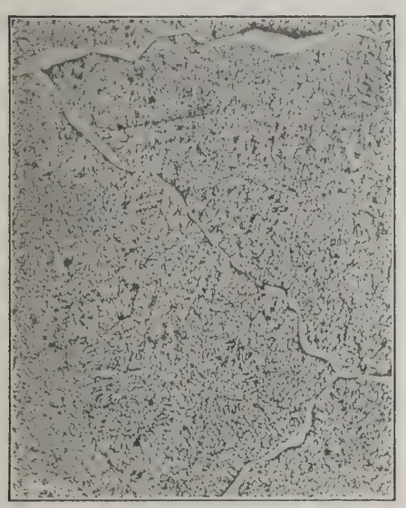


Fig. 13. Tin, 30 per Cent. Magnified 100 Diameters (Reduced 30 per Cent. in Reproduction). Etched with $FeCl_3+HCl$.

Fig. 14. Tin, 34.5 per Cent. Magnified 100 Diameters. Etched with $FeCl_3+HCl$.

Fig. 15. Tin, 34.5 per Cent. Magnified 1000 Diameters. Etched with $FeCl_3+HCl$.

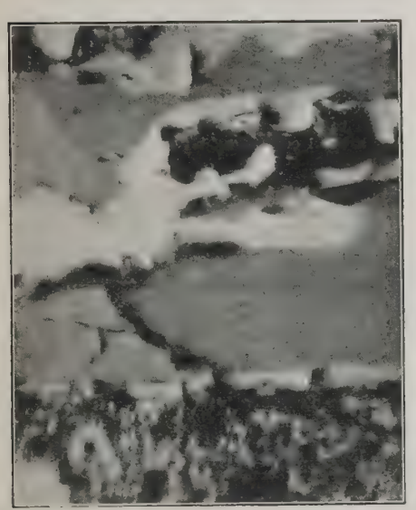


Fig. 16. Tin, 60.5 per Cent. Magnified 1000 Diameters. Heat Tinted and Etched with $HCl+FeCl_3$.

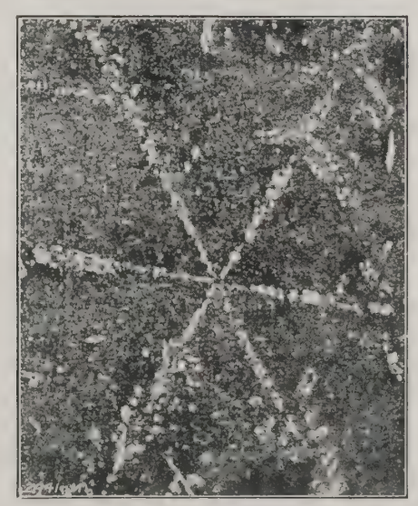


Fig. 17. Tin, 94 per Cent. Magnified 100 Diameters. Etched with $FeCl_3+HCl$.

Fig. 13 is interesting as showing the alloy with the inexplicable maxima of expansion and hardness (30 per cent. tin). Under very high magnification the dark constituent shows signs of being resolved into two materials.

Figs. 14 and 15 are both from the same bar (34.5 per cent. tin), the former being magnified 100 diameters and the latter 1000 diameters. The eutectoid structure of the latter is very remarkable.

Fig. 16 is from the bar containing 60.5 per cent. tin; the three constituents are the H, η, and H+Sn eutectic of Heycock and Neville.

Fig. 17 represents the alloy whose tin content is 94 per cent.; the beautiful six-rayed stars are very striking, and show well the hexagonal structure of the metal.

The majority of the specimens were very hard to polish owing to their extreme brittleness, and several of the photographs show holes from which pieces have fallen out during polishing.

It was generally found best, when preparing the specimens—after the usual treatment with emery paper—to use Globe metal polish, followed by gentle rubbing on parchment dusted with calcined magnesia.

7. Résumé.

To sum up these results it may be said:—

1. That, as pointed out by Murray, the expansion during solidification is closely related to the crystallisation interval, but that the exact nature of the relationship is not at all clear, and that in two regions the relationship does not hold good.

2. That allotropic changes during and after solidification cause variations in the coefficient of expansion.

3. That it is not possible to get accurate determination of the densities of the copper-rich bars on the original castings, owing to blowholes.

4. That the hardness curve does not fit in with the theory of Kurnakow and Shemtschusny, probably owing to the metastable condition in which the bars exist.

There only remains to the author the pleasant task of expressing his thanks to those who have helped him in

this work. To mention all by name would be impossible, but he would refer in particular to Professor Turner, under whose guidance the research was carried out, and who always took the keenest interest in everything relating to it; to Messrs. O. F. Hudson and D. M. Levy his best thanks are also due for their continual willingness to help, both by advice and in many other ways; to Mr. R. M. Field for assistance in erecting the apparatus and in designing the new extensometer, and to Mr. J. Ward for help in making the chronograph, and for melting and pouring the metal, he also tenders his sincere thanks.

APPENDIX.

Chemical Analyses.

The earlier members of the series were analysed by the method recommended in all the text-books for the analyses of bronzes, gun-metal, &c.—*i.e.*, dissolve in HNO_3, filter off the SnO_2, ignite and weigh; take down filtrate with a little H_2SO_4 to dryness, take up with water, neutralise and titrate with $Na_2S_2O_3$ and KI. This worked satisfactorily with alloys containing up to 30 per cent. tin. Beyond this a residue was left which was insoluble in nitric acid. Sixty per cent. tin was hardly attacked by the acid at all unless ground exceedingly fine, and even then a considerable residue was left. Both aqua-regia and potassium chlorate in HCl attacked it readily, but the tin chloride formed was so volatile that it was quite impossible to get any results for the tin. It may be noted that Heycock and Neville do not make any mention of the method that they employed for analysis—indeed, it seems probable that they made the alloys very carefully, and trusted to the non-volatile properties of copper and tin to keep the results accurate; Shepherd and Blough distilled off the tin as chloride in a stream of HCl, but do not claim any considerable accuracy for the method which, at best, is very clumsy and tedious. Several other methods were tried, but without success, until it was found that the whole series was easily soluble in bromine. On diluting and boiling, the tin is precipitated as tin hydroxide, leaving the copper in solution. More fully the method employed was as follows:—½ gramme of the finely-ground alloy is treated with about 5 cub. cm. of strong bromine in an 8-oz. beaker, and approximately 20 cub. cm. of water added. This is very gently warmed for a few minutes, and then diluted to 50 cub. cm. with water. The solution is boiled in a water-bath till all the bromine is driven off and the tin precipitated. The clear liquid, after settling, is poured off, and the precipitate is washed several times by decantation, all the washings being poured through the filter. The precipitate is then washed into the filter, where it is further washed with water, and then dried, ignited, and weighed as SnO_2. The washings are boiled down to a very small bulk to ensure any remaining traces of bromine being expelled, and are then neutralised and titrated with sodium thiosulphate and potassium iodide in the usual way.

As a test of the method, 0.3 gramme of copper and 0.3 gramme of tin were treated as described above, and yielded 0.2989 gramme of copper and 0.2990 gramme of tin respectively.

BIBLIOGRAPHY.

1. T. Turner.—"Volume and Temperature Changes during the Cooling of Cast Iron." Journal of the Iron and Steel Institute, 1906, No. 1.

2. Turner and Murray.—"The Copper-Zinc Alloys: A Study of Volume Changes." Journal of the Institute of Metals, No. 2, 1909, Vol. II.

3. Ewen and Turner.—"Shrinkage of the Antimony-Lead Alloys and of the Aluminium-Zinc Alloys during and after Solidification." Journal of the Institute of Metals, No. 2, 1910, Vol. IV.

4. Hague and Turner.—"The Influence of Silicon on Pure Cast Iron." Journal of the Iron and Steel Institute, 1910, No. 2.

5. H. I. Coe.—"Manganese in Cast Iron and the Volume Changes during Cooling." Journal of the Iron and Steel Institute, 1910, No. 2.

6. Heycock and Neville.—"On the Constitution of the Copper-Tin Series" (Bakerian Lecture). Philosophical Transactions of the Royal Society, Series A, Vol. CCII., 1903.

7. Shepherd and Blough.—"The Copper-Tin Alloys." Journal of Physical Chemistry, 1906.

8. Giolitti and Tavanti.—"Sulle Leghe di Rame e Stagno." *Gazzetta Chimica Italiana*, 38, 2.

9. A. Riche.—"Recherches sur les alliages." *Ann. de Chimie et de Physique*, vol. xxx., page 359 (1873).

10. Behrens.—"Das Microscopische Gefuge der Metalle und Legierungen."

11. Roberts-Austen.—Fourth Report of the Alloys Research Committee, 1897.

12. Wüst.—"Uber die Schwindung der Metalle und Legierungen." *Metallurgie*, December, 1909.

13. Mallet.—"The Physical Conditions Involved in the Construction of Artillery," page 82.

14. Kurnakow and Shemtschusny.—Journal Russian Physical Chemical Ges., 1908 (40), pages 1067—1104.

See also:—

Turner.—"Volume Changes in Cast Metals." Proceedngs of the Staffordshire Iron and Steel Institute, 1911.

Stansfield.—Third Report of the Alloys Research Committee.

THE INSTITUTION OF NAVAL ARCHITECTS.—The dates fixed for the next annual meetings of the Institution are March 27, 1912, and two following days.

THE PHYSICAL SOCIETY'S ANNUAL EXHIBITION.—This exhibition will be held on Tuesday, December 19, and will be open both in the afternoon and evening.

NEW INDUSTRIAL PROCESSES FOR THE CASE-HARDENING OF STEEL.*

By Dr. F. GIOLITTI (Genoa).

DURING the last four years the author, in collaboration with Carnevali, Tavanti, Astorri, and Scavia, has carried out a series of experiments, the results of which have served to clear up several highly controversial points connected with the theory of the processes of the case-hardening of steel, by means of which it has been possible to formulate a few rules for the application of those processes on an industrial scale.

It was at first the author's intention to present here a brief *resumé* of his previous results in order to show how those rules, the application of which forms the principal object of the present paper, have been deduced. Considerations of space, however, obliged him to omit such a review, and he decided instead to compile a short bibliography containing a list of some of the memoirs published by him, in which reports readers will find the logical conclusions of the experiments which have led to the establishment of the scientific principles forming the basis of the practical processes. The list of reports referred to will be found at the end of the paper. The results of some of the first of these experiments have already been reviewed by Portevin,† who also makes many interesting personal observations.

As the result of the experiments and from the theoretical considerations elaborated by the author in his several reports, and chiefly in the more recent ones, several fundamental facts, besides many of secondary importance, have been proved with certainty. It has, moreover, been specially demonstrated in the report marked No. 15 in the list at the end of the paper, that these facts are in perfect agreement with the work of previous investigators, although they were unable to arrive at exact conclusions on account of the lack of the necessary theoretical knowledge which has become available to science only within the last few years.

These fundamental facts, the discussion and proof of which the reader will find in the reports contained in the bibliography, may be briefly enumerated as follows:—

1. Where case-hardening is carried out with solid cementing agents having a carbon base, the carburising effect of the free carbon on the iron, the materials being in simple contact and without the intervention of gaseous carbon compounds, is exceedingly weak, and in any case is entirely negligible in industrial practice. This assertion has been fully confirmed by the more recent investigations of Guillet, Griffith, Weyl, and Charpy. The last-named experimenter even comes to the conclusion, already dealt with by others, that the direct effect of carbon in cementation with solid agents is absolutely nil.

2. Where case-hardening is effected with the solid case-hardening agents ordinarily employed in the industry, the specific effect of the nitrogen is very weak, as admitted and variously explained by many investigators. Only with the cementing agents containing a high proportion of the cyanogen compounds (alkaline cyanides, ferro-cyanides, &c.), does the direct action of volatile nitrogen compounds have any marked effect.

3. In the cementations by means of the solid agents ordinarily employed in the industry, the specific direct carburising effect of carbon monoxide preponderates enormously over every other carburising effect.

4. Pure carbon monoxide carburises iron at all temperatures within the range (700 deg. to 1300 deg. Cent.), at which the process of case-hardening can be performed by means of any other medium whatever. Moreover, the rate of case-hardening (by which is understood the depth of carburisation which can be obtained in a given time) when working under suitable conditions is greatest when carbon monoxide, or a mixture in which the carbon monoxide can efficaciously exercise its specific carburising effect, is used as the agent.

5. This specific carburising effect exerted by the carbon monoxide on the iron at high temperature is due to a series of chemical reactions, the course and state of equilibrium of which have been actually observed with precision. Moreover, the conditions of equilibrium of the systems in which these reactions take place are in general comprised within the ranges of temperature and pressures ordinarily employed in practice. It is therefore possible to obtain with certainty a predetermined result using case-hardening agents whose activity is due, if not exclusively, at least very largely, to the specific carburising action of the carbon monoxide. More particularly, it is possible to obtain with such agents carburised zones in which the concentration of the carbon does not exceed a predetermined maximum limit and varies in a well-defined degree towards the inside of the carburised zone. Such definite results, variable at will within sufficiently wide limits, are obtained by varying, in accordance with fixed rules, the temperature at which the case-hardening is performed, the pressure of the carburising gas, and the amount of carbon monoxide which, in a given time, comes in contact with the unit surface of the steel to be carburised.

6. The results obtained by the use of carbon monoxide as an agent vary regularly, other conditions being equal, as the chemical composition of the steel to be carburised is varied.

7. It is possible to vary regularly and within fairly wide limits the characteristics of the desired product by subjecting the steel to the action of substances along with carbon monoxide which are capable of modifying the conditions of equilibrium of the chemical systems under which the reactions due to the specific carburising effect of the carbon monoxide are completed. Such substances may be gases, such as hydrocarbons or nitrogen, or they may be solids, such as carbon in various forms, and their actions can proceed simultaneously with that of the carbon monoxide throughout the whole cementation period or during a portion only of it.

8. In particular, by means of the agents, the activity of which is due to the specific carburising effect of carbon monoxide, it is possible to obtain with ease and certainty—whatever kind of steel is being operated upon—soft case-hardenings and graduated case-hardenings; that is to say, carburised zones in which the concentration of the carbon without being excessive in the outer layers, diminishes slowly and with regularity in the succeeding deeper layers. This is the essential condition for the avoidance of the dangerous phenomena of brittleness and peeling, which defects manifest themselves so frequently in steel pieces case-hardened by the processes ordinarily used in the industry.

9. The chemical reactions produced by agents in which cyanogen is the active element are at present but imperfectly understood, particularly as regards their condition of equilibrium, upon which depends the concentration of carbon in the carburised zones. It is, however, certain that in the conditions under which case-hardening should be performed in practice, the conditions of equilibrium just now alluded to correspond to a very high concentration of carbon passing into solution in the iron. Thus it happens that the cyanides, ferro-cyanides, and other derivatives of cyanogen, if used alone as case-hardening agents, always give rise to too rapid (energetic) a case-hardening; that is, carburised zones are produced in which the concentration of the carbon is excessively high in the outer layer up to a certain depth, and is then suddenly lowered in the succeeding layers. Zones of that type, the formation of which has been fully studied and their cause explained by the author, produce brittleness and peeling.

10. Further, gaseous or volatile hydrocarbons, when used alone as agents, also give rise to too rapid case-hardening, the causes being identical with those referred to in the case of cyanogen and its compounds.

The author repeats that the experimental proofs and theoretical explanations of all the foregoing statements are fully dealt with in the memoirs, the list of which is given at the end of the paper.

In the light of the facts recited in the foregoing, the great advantage of the use of agents, the activity of which is due, if not exclusively, at least principally, to the specific carburising action of carbon monoxide, is clear. In order to obtain the best results with such an agent, the author has demonstrated in his publications previously quoted that it is necessary to satisfy the following fundamental conditions:—

1. The chemical composition of the agent should be absolutely definite, and should be accurately known.

2. The compounds should be as simple as possible.

3. The reactions which take place during the case-hardening process between the various constituents of the agent and those of the steel should be simple, and should proceed rapidly—under the conditions most easily obtaining in practice—to a well-defined state of equilibrium corresponding to definite concentrations of carbon in the carburised zones.

The author in his previous work has demonstrated from the theoretical point of view that the agent which best satisfies these conditions would be pure carbon monoxide, except that by its use the concentrations of carbon in the carburised zones, which correspond to the conditions of equilibrium, are in general too low, when working within the ranges of temperature and pressures ordinarily maintained in practice, and when the metal subjected to case-hardening is an ordinary mild carbon steel or a steel containing a low percentage of nickel or chromium.

On the other hand, that inconvenience can be avoided, and the three conditions indicated above can be sufficiently well realised by the use of case-hardening agents, in which along with the carbon monoxide small quantities of hydrocarbons of known composition, or solid carbon in a properly divided state, are allowed to act either throughout the whole period or during a portion only of it.

Further, of these two classes of agents, those of the second-class, based on the simultaneous use of free carbon and of carbon monoxide, are the most suitable for the majority of ordinary technical applications,* since by their use the operation can be performed with the maximum degree of simplicity and the certainty of obtaining predetermined results.

Below are enumerated the principal technical advantages which the author has shown† to be obtainable by the employment of case-hardening agents, which satisfy the three essential conditions previously mentioned, and, in particular, of the "mixed" agent based on the simple simultaneous action of carbon and carbon monoxide. The following are the principal advantages:—

1. The great speed of penetration of the carburised zone. That fact, if indeed it does not constitute the chief value of any given case-hardening process, as many manufacturers still believe, is certainly most advantageous on economical and technical grounds too numerous to mention.

2. Great uniformity in the distribution of carbon in the carburised zones, which is the cause of the fact, as already stated, that the peeling of case-hardened and tempered pieces is reduced to a minimum.

3. The possibility of regulating, either by diluting the carbon monoxide with nitrogen, or by limiting the contact

* Paper read before the Iron and Steel Institute, October 5, 1911.

† "Sur la Cémentation par les Gaz," *Revue de Métallurgie*, vol. vii., 1910, pages 895 to 885.

* See reports Nos. 6, 9, 13, and 15 in the bibliographical list at the end, which particularly deal with this matter.

† See bibliographical list.

of the solid carbon with the surface of the steel, or by suitably varying the temperature during the case-hardening process, the concentration of the carbon in the carburised zone so as to maintain it within the most suitable limits for conferring the maximum hardness combined with minimum brittleness. The extent of carburisation must, of course, vary according to the composition of the steel subjected to cementation.

4. The possibility of establishing with certainty from the start the necessary conditions for obtaining a predetermined result which may be chosen within sufficiently wide limits, and may be obtained with great accuracy.

5. Continuous use of the same carburising materials (solid carbon and carbon monoxide), which do not become attenuated, but may be used up to their last residue. This also permits of carburising to any depth without the necessity of renewing the agent during the operation.

6. Absolute security against the introduction into the steel of any foreign substance apart from the carbon. This is an advantage of the highest importance in most cases, and cannot be realised in the case of most of the case-hardening powders habitually used, consisting of organic nitrogenous substances, such as alkaline cyanides, or ferrocyanides.

7. The ease with which the surface of the case-hardened pieces is preserved without alteration, thus obviating the necessity of any subsequent dressing of the case-hardened pieces.

8. The deformation and change of volume which the steel pieces may undergo during case-hardening are reduced to a minimum. In any case it is possible to determine from the start the extent of such volume changes as may occur.

For a full account of the experiments and their results the author would refer readers to his previous reports on his research work on this subject.

Besides the advantages enumerated above, which refer particularly to the quality of the product, the use of the mixed agent having a carbon monoxide base offers other practical benefits, consisting in the ability to modify very advantageously the method of operation. In one of the reports referred to,* it is shown by the author how the method may be used even without discarding the ordinary horizontal muffle generally used for case-hardening. The same advantages, to a greater extent, may be more easily secured by using the mixed agent in a furnace the form of which differs radically from that of the ordinary case-hardening furnace, and by following a special method of operation.

The particular object of the present paper* is to present a short description of this furnace, of the accessory apparatus,† and of the method of its operation which will enable the specific advantages of each to be readily understood. Nevertheless, the author will refrain from describing at great length either the special conditions which the substances used as case-hardening agents must fulfil (granular carbon and carburising gas), or the qualities of the products obtained, these having been made sufficiently public in the author's previous publications, in which the characteristics and conditions are fully discussed and illustrated.

Description of the Furnace and its Operation.

The type of furnace which experience has proved to be best adapted to the case-hardening of small and medium-sized objects with the mixed case-hardening agent above referred to, consists of cylindrical muffles arranged vertically and heated by producer-gas. It is a double-muffle furnace provided with regenerators, of the kind constructed by Messrs. C. M. Stein, of Paris, for the Sampierdarena Engineering Works of Messrs. G. Ansaldo, Armstrong, and Co.

With regard to the construction of the furnace, Figs. 1 and 4, above and page 650, convey a sufficient idea of its principal parts to render unnecessary any further description. It may, nevertheless, be of interest to give some information concerning those parts more directly connected with the carrying out of the case-hardening operations, and to describe briefly the procedure. The parts of the apparatus particularly applied to the case-hardening process are represented in Fig. 1, which shows a section through the centre of the vertical muffles of the furnace with the accessory apparatus completely mounted. For the sake of clearness, the dimensions of the several parts are omitted on the drawing, but they can be readily measured, if desired, by the help of the metric scale, which has been shown on the drawing for that purpose. Inside of each of the muffles of refractory material is placed a cylindrical retort of mild steel A, the external diameter of which is about 10 mm. to 20 mm. less than the internal diameter of the muffle. Mannesmann seamless tubes serve very well for making the retorts, as they are easily obtainable in stock sizes up to 35 cm. in diameter. For retorts of larger diameter, as in the case of the furnace here represented, tubes welded by the autogenous process are used. The retort is supported on a bottom flange attached to a frame fixed to the brick-work of the furnace. The arrangement which serves to hold the retort, whether it is being supported by the bottom flange or by the upper flange H, intended to receive the cover, is such as to enable one retort to be replaced by another in a few minutes. To the bottom flange is attached a cast-iron funnel B, closed at the bottom by a non-return valve Q.

The steel nozzle C, admitting the carburising gas, passes through an opening in the side of the funnel, provided with a good-sized boss. The gas, which, as has been previously stated, may consist of carbon monoxide or dioxide, in a pure state or mixed with other gases, is introduced, through the screwed tube D, and through the nozzle C. This latter is connected to the hollow cast-steel dish E, intended to support the pieces to be case-hardened by means of the disc F, consisting of a steel plate covered with refractory material.

The carbon monoxide, after passing through the hole bored axially in the nozzle C, is delivered into a small distributing device placed inside the dish E, from which it passes to the case-hardening chamber G through a number of holes provided in the disc F. During case-hardening the dish E is supported upon a series of projections on the same lower flange to which the funnel B is attached. This ring has thus to sustain the entire weight of the dish E, the disc F, and any articles to be case-hardened which may be resting directly or indirectly on the disc. The section shows exactly the position of the various parts during case-hardening.

Considering now the method of operating, beginning with the charging of the retort, the mode of this varies very much according to the dimensions and shape of the articles to be case-hardened. The author will therefore confine himself to giving a few special examples.

In the case of spur-wheels, the maximum diameter of which might be 100 mm. to 150 mm. less than the internal diameter of the retort, the first thing to be done is to unscrew the tube D; then by means of the plunger L, actuated by the hydraulic cylinder I, the whole of the parts C, E, and F are lifted together, the blunt conical end of the plunger M engaging with these as it rises. The plunger L M is cooled internally with water circulation, so as to avoid the heating of it in case it should accidentally remain raised inside the retort for too long a period. When the piston L has reached the end of its stroke, the upper surface of the disc F being now only about 30 cm. below the cover of the retort, the cover R is removed, and the wheels to be case-hardened are piled horizontally one on top of the other upon the disc F. As the wheels are inserted one by one, the apparatus carrying the weighted portions C, E, and F is gradually lowered, and when the charge is complete the apparatus must have reached the lowest position indicated in the figure. In that position the last wheel charged should be at least 30 cm. below the upper edge of the retort.

Generally, the articles to be case-hardened are charged hot at a temperature of about 800 deg. to 900 deg. Cent., this being a matter of prime importance, as it affects most favourably both the quality of the product and the economy and regularity of the operation.

For the preliminary heating of the pieces a small coal-fired muffle will serve, since the uniformity of temperature which can be obtained in such a furnace is quite sufficient for the purpose. If, however, the case-hardening

Fig. 1. SECTION SHOWING GENERAL ARRANGEMENT OF VERTICAL CASE-HARDENING FURNACE.

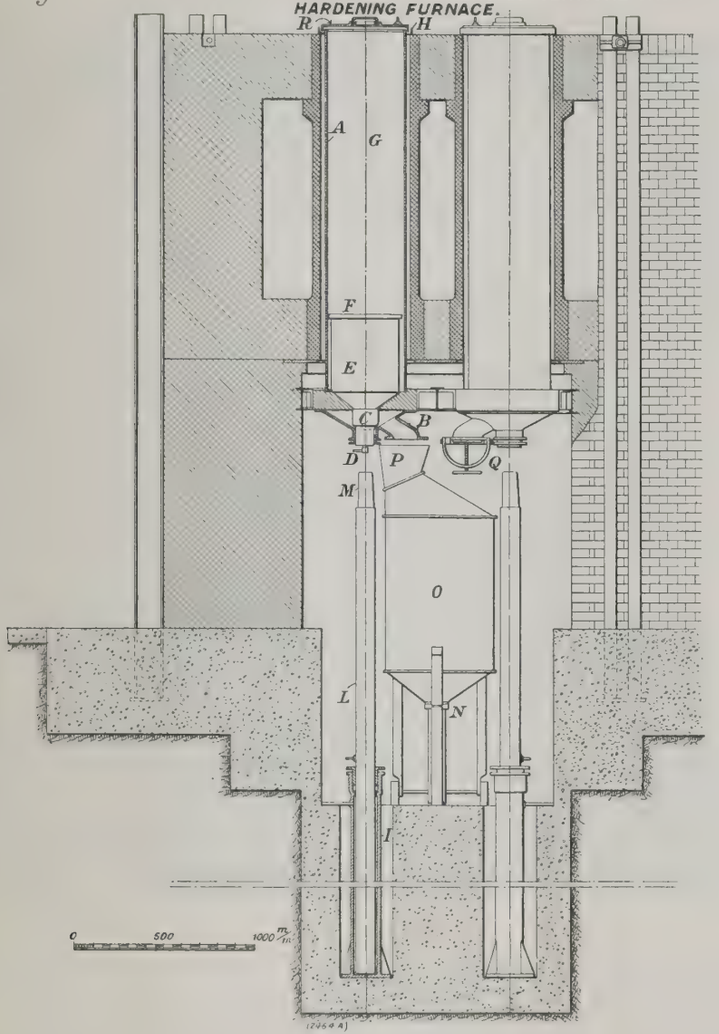


Fig. 2.

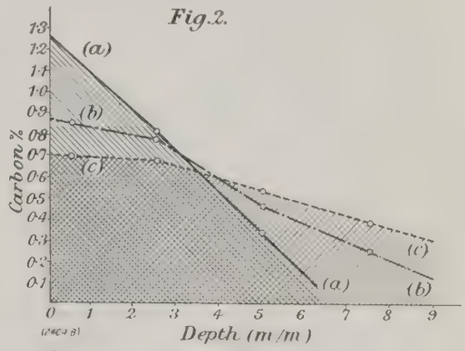
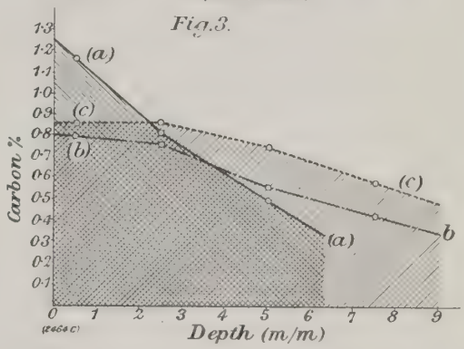


Fig. 3.



* Report No. 13 in the bibliographical list.

* Both the apparatus and the process about to be described are patented in many countries.

† In the construction of this apparatus the author has to acknowledge the great assistance rendered to him by Mr. G. Scavia.

furnace is not being worked to its fullest capacity, one of the vertical muffles may be used for the preliminary heating of the articles, while the case-hardening of the charge is proceeding in the other. In that case the best method of working the furnace is to use the muffles alternately, the one for case-hardening and the other for pre-heating the pieces.

As soon as the articles to be case-hardened have been inserted as described, the cover is placed on the retort and the bottom discharge pipe N, leading from the iron box O, is passed through the central opening in the cover. This box is full of the granular carbon still hot (generally at about 900 deg. Cent.), which was discharged from the retort after use during the last case-hardening operation just concluded. The box is easily swung above the muffles, being suspended by a tackle from a swinging arm. The outer walls of the box, notwithstanding that its contents of granular carbon are at a temperature of nearly 1000 deg. Cent., do not become heated above 200 deg. to 250 deg. Cent. during the time required for the loading and unloading of the retort, even when working under the most unfavourable conditions. This is due to the small thermic capacity and the very low conductivity of the mass of granular carbon which, although at a high temperature, can only impart to the walls of the box containing it a small proportion of its heat in a unit of time. The heat is quickly dissipated simply by the cooling action of the air currents passing round it.

The box O having been adjusted as indicated, the butterfly-valve which closes the lower end of the opening N is gradually opened, and in a few seconds the whole of the free space in the retort surrounding the pieces is filled with glowing granular carbon. The author has previously pointed out (see Report No. 13 in the bibliography) that the hot granular carbon employed by him for case-hardening with his mixed medium constitutes a mass which, particularly at high temperatures, is endowed with a mobility comparable to that of a liquid. On this account it is able to penetrate simply by its own weight into all crevices among the articles to be case-hardened, and between these and the walls of the retort. The filling up may be further assisted by means of iron rods introduced through holes in the cover and manipulated by the operator, who stands on the furnace.

When the granular carbon has been filled in up to a level of 2 cm. or 3 cm. below the upper edge of the retort, the butterfly-valve of the tube N is closed, the box O is lifted, the central opening of the cover is closed, the plunger L is lowered right down, and the tube D is screwed into the nozzle C, through which the carbon monoxide or dioxide, pure or mixed with air, is admitted gradually to the distributor in E and thence into the retort. In order to regulate the current of carbon monoxide according to the method indicated in the report already referred to, an ordinary gas meter of the dry type is used. The case-hardening then proceeds without further trouble, the only thing that is necessary to be watched and regulated being the current of gas and the temperature.

For the observation of the temperature, an operation which, with the type of furnace described and when adjusted properly, does not often require to be made, an ordinary thermo-electric pyrometer is used by passing it through any one of the holes in the cover from time to time and inserting it into various parts of the mass of granular carbon. The temperature should be maintained quite constantly at a fixed point between 900 deg. and 1100 deg. Cent., chosen in accordance with the rules laid down by the author in the reports previously referred to.

The gas issuing from the retort through the pipe fixed in the cover can be collected in a gasometer, and after suitable regeneration it will serve for further heats. The necessary length of the heating period can be determined with the greatest precision, and is dependent on the result which it is required to obtain. When the heating has proceeded long enough, the current of carbon monoxide is shut off, the tube D is removed, and the discharge of the retort is undertaken.

Where results of a very special nature are not aimed at, the discharging operation begins by withdrawing the whole of the granular carbon at once, and removing it through the non-return valve Q into the box O, now placed underneath.

Where, however, exceptionally graduated case-hardening is required, the specific action of the carbon monoxide is isolated during the last phase of the case-hardening from the direct action of the granular carbon. In that case the box O is placed so that the neck of the funnel B is inserted into the open end of the tube P, the box for this purpose being placed in the chamber below the muffle, where it can be manœuvred on a small bogie. The non-return valve is then opened gradually, and a quantity of the granulated carbon is drawn out from the retort.* Only those parts of the case-hardened pieces are uncovered in which a well-graduated case-hardening is required. Sufficient solid carbon is retained in the retort to ensure the desired chemical equilibrium of the gas. The remainder of the carbon is removed from the retort after the second phase of the case-hardening with isolated carbon monoxide has proceeded long enough to attain the desired results.

In either case, as soon as the whole of the granular carbon has been evacuated from the retort, the cover of the latter is lifted. In performing that operation the operator must be careful to remain at some distance from the upper open end, because the air which enters forms with the carbon monoxide contained in it, a mixture which explodes suddenly at the high temperature of the retort. The explosion, which in any case is light and not at all dangerous, may be avoided by rapidly scouring the muffle with a little carbon dioxide after the removal of all the solid carbon. Care must be exercised, however, to perform this operation as quickly as possible, in order to prevent the carbon dioxide causing a superficial decarburisation of the case-hardened pieces.

When the pieces rest direct on the disc F, as in the present supposed case, they may be lifted by means of the appliances C, E, F, up to the open top of the muffle without first discharging all the granular carbon from the retort. In that manner the light explosion just referred to is avoided, but the picking up of the pieces for quenching is made more difficult, and a considerable quantity of the solid carbon is apt to get burnt in the retort. At all events, whether the carbon is removed from the retort or not, as soon as the cover R is removed the plunger L is raised until its conical head beds itself in the recess provided for it in the part C. The hydraulic ram then continues to move slowly, gently lifting the weight-supports C, E, F, with the case-hardened pieces resting on them. It only remains then for the operator, standing above the furnace near the open muffle, to pick up the case-hardened pieces one by one as they come within reach and quench them in the tank, also placed above the furnace (in case double quenching is desired), or bury them in hot ashes. When all the pieces have been removed, the furnace is ready for a fresh charge.

As already mentioned, the method of loading the pieces to be case-hardened into the retort varies greatly according to their shape or size. Pieces of cylindrical shape can be piled on one another as in the foregoing example. If the pieces are of small diameter, such as pinions, cutters, cups and rings for ball-bearings, several columns can be built up for one heat; but in that case it is desirable to keep the pieces in position by threading them on iron rods, assuming that the external surfaces only require to be case-hardened. For cylindrical pieces to be case-hardened internally, such as rings for ball-bearings, the rods are placed outside the columns. Pieces of great length or of irregular shape have also to be suitably supported in the retort. Finally, very small pieces are placed in cages formed of iron framework, held together with iron wire-netting. Such pieces can also be laid free on successive layers of granular carbon.

As regards the necessary time for the purpose of the single operations above indicated, it is impossible to give it exactly for every case, for it must naturally depend on the shape, size, and number of pieces forming the charge. A few definite data may, however, be quoted here, giving the approximate time required for the several operations to be performed in the special case which has been under consideration above, where the charge was assumed to consist of about thirty cylindrical pieces, or spur-wheels of such a size as to form a single column in the retort. In that case the times are as follow:—

(*a*) Placing the pieces on the supporting disc; from 1 to 2 minutes.

(It is clear that this operation is longer according as to whether the pieces are smaller in size and larger in number; but even with quite small pieces packed in alternate layers of carbon, this being the least favourable condition, the time does not generally exceed 5 minutes.)

(*b*) Closing the lid of the retort and placing in position the box containing the granular carbon; about 1 minute.

(*c*) Filling up the retort completely with granular carbon; from 1½ to 2 minutes.

(This operation is also prolonged when the pieces are very small and there is a large number. Generally in the least favourable case the time does not exceed 4 minutes.)

(*d*) Lowering the plunger of the hydraulic ram, adjusting the pipe for admission of carbon monoxide, removal of the box containing granular carbon, and complete closing of the cover of the retort; altogether 1 minute.

As will be seen in the case under consideration, the entire period for the operation of charging the retort may vary from 4½ to 6 minutes. In the most unfavourable cases it may, however, be increased to 10 or 12 minutes.

The following are the approximate times occupied by the discharging operations:—

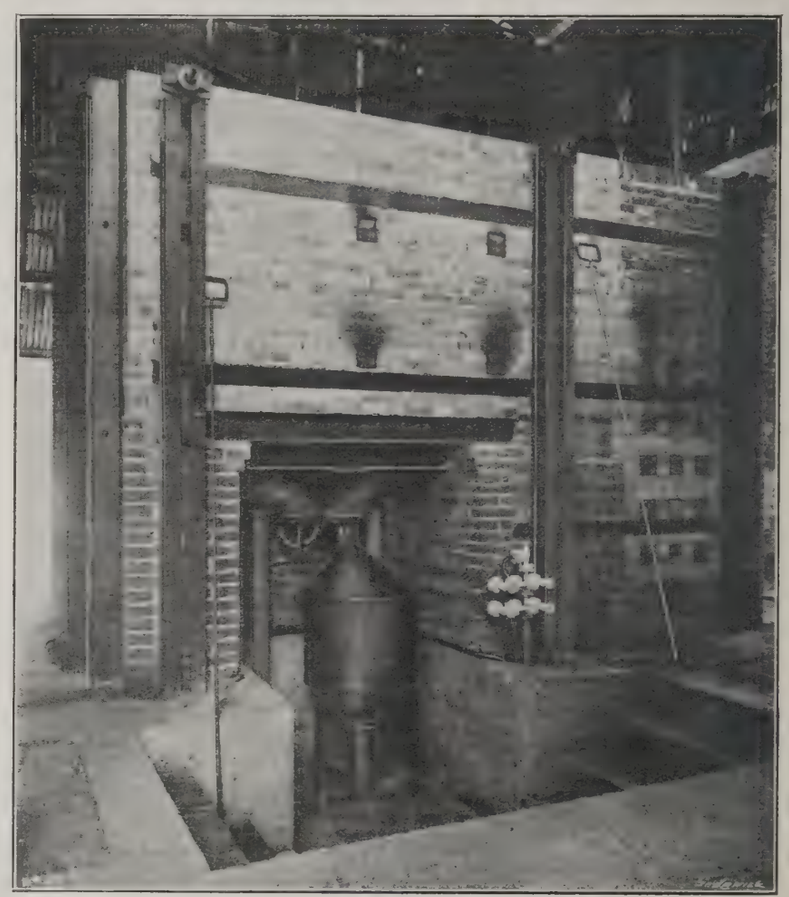


Fig. 4.

(*a*) Removal of the pipe admitting carbon monoxide, placing the box for granulated carbon below the lower neck of the retort, and opening the non-return valve; 1 to 1½ minutes.

(*b*) Evacuation of the whole of the carbon from the retort into the receptacle and closing the valve; 1½ to 2 minutes.

(*c*) Raising the supporting disc, and unloading of the case-hardened pieces; 1 to 2 minutes.

(If the case-hardened pieces are very small and numerous, and particularly if they are laid out on layers of carbon, this last operation may be lengthened to 10 minutes. The time required for the complete discharge of the retort is therefore 3½ to 5½ minutes, though in the most unfavourable cases it may extend to 13 or 14 minutes.)

Further, in the case of the process described and in almost all cases occurring in the practical production of case-hardened pieces for machine construction, in which the carburised zone is seldom required to exceed 2 mm. in thickness, the period of case-hardening never exceeds 2 hours, and may even be reduced to 1 hour, the time being reckoned from the moment of completing the charging operation to that at which discharging begins. It therefore includes the time necessary for bringing the temperature up to working point, which requires not more than 10 minutes, owing to the fact that both the solid carbon and the pieces are already hot when charged.

The foregoing particulars show that in practice, under ordinary working conditions, the time for a complete heat is less than 2½ hours, and since the weight of a charge, which retorts of the size shown in the section on page 649 can conveniently hold, varies from a

* The carbon contained in the retort falls out from below, passing first through a series of holes in the bottom flange, upon which the apparatus C, E, F rest. It was, however, not possible to show all these holes in the sectional view of the furnace.

minimum of 100 kg. in exceptionally unfavourable cases, to a maximum of over 500 kg., it will be seen that the productive capacity of each retort ranges from a minimum of 1 ton to a maximum of 5 tons of case-hardened steel pieces per 24 hours.

From the preceding statements, and leaving aside all considerations as to the superiority of the product, which is due to the principle on which the process is based rather than to the method of its application, it is clear that the furnace with vertical muffles has distinct advantages as compared with horizontal muffles, the application of which latter for case-hardening with the mixed agent has been dealt with by the author at some length in Report No. 13 in the bibliographical list.

The advantages consist mainly in the greater speed of working for a given charge, greater simplicity of operating, and in the increased uniformity of the treatment of all the pieces forming the charge in the muffle. The uniformity is not limited to the temperatures of starting or of working, but, what is more important, it applies also to the distribution of the carburising gas (carbon monoxide pure or mixed with other gases). Besides, in the vertical furnaces arranged as described, the clearance spaces left in the retort are reduced to a minimum, whereas in the horizontal muffles the clearance spaces have a considerable effect, especially at the head of the retort, where they cause appreciable losses of heat and of carburising material, thus lowering the productive capacity. For these reasons the vertical type of furnace is superior in every respect, especially as regards economy of production, as already stated.

Before concluding the paper, it may be useful to discuss a little more fully some of the more interesting results which are obtainable with ease and regularity in the new type of furnace when using the mixed case-hardening agent having carbon monoxide as its base. Referring first to the special feature of the distribution of the carbon in the carburised zones, which can be graduated by isolating the action of the carbon monoxide during a part of the carburising period, it has already been shown how that result can easily be obtained, when using the vertical furnace, by removing from the case-hardening chamber at the proper moment that portion of granular carbon which, during the first part of the operation, has been in direct contact with the surface of the pieces, leaving in the lower part of the retort a layer of carbon of sufficient thickness to maintain the chemical equilibrium of the gaseous mixture passing over it.

The effects of the isolated action of the carbon monoxide on the carburised zones obtained at the commencement of the operation, using the mixed agent, has been dealt with fully in Report No. 9 in the bibliographical list. It may, however, be of interest to consider the effects to which that method of procedure gives rise in case-hardenings of medium depth (from 5 mm. to 10 mm.) in which (and still more in the case of very deep case-hardenings) the application of the process in question presents the greatest technical interest. In the accompanying tables are collated the results of estimations of the carbon in successive layers of a thickness of 0.5 mm., obtained by case-hardening with the mixed agent, followed by exposure to the action of carbon monoxide isolated in the manner previously described. The same results are graphically represented in the diagrams, Figs. 2 and 3, which will be found on page 64. In the tables the exact conditions are stated under which the two distinct phases of the operation are conducted.

Series I.—The material used was an ordinary mild steel of the following composition :—

	Per Cent.
Carbon	0.12
Silicon	0.06
Manganese	0.47
Sulphur	0.02
Phosphorus	0.03

The results after each phase of treatment were as follows :—*

(*a*) Case-hardening for ten hours at 1100 deg. Cent. with the mixed agent :—

No. of the Range of Single Layers Analysed.	Distance from the Surface of the Central Portion of the Layer Analysed.	Amount of Carbon in the Single Layers.		
		First Determination.	Second Determination.	Mean.
	mm.	per cent.	per cent.	per cent.
1	0.5	1.16	1.18	1.17
5	2.5	0.80	0.82	0.81
10	5.0	0.33	0.35	0.34

(*b*) After re-heating the same carburised zone for five hours at 1100 deg. Cent. in isolated carbon monoxide :—

No. of the Range of Single Layers Analysed.	Distance from the Surface of the Central Portion of the Layer Analysed.	Amount of Carbon in the Single Layers.		
		First Determination.	Second Determination.	Mean.
	mm.	per cent.	per cent.	per cent.
1	0.5	0.84	0.86	0.85
5	2.5	0.76	0.80	0.78
10	5.0	0.46	0.46	0.46
15	7.5	0.23	0.27	0.25

* Both in the first series of experiments, as well as in the succeeding series, similar pieces of steel were subjected simultaneously to each of the various treatments and under identical conditions, one piece of which was used after each operation for the purpose of making a quantitative determination of the carbon in the successive layers.

(*c*) After re-heating same zone for another five hours (altogether ten hours of re-heating) at 1100 deg. Cent. in isolated carbon monoxide :—

No. of the Range of Single Layers Analysed.	Distance from the Surface of the Central Portion of the Layer Analysed.	Amount of Carbon in the Single Layers.		
		First Determination.	Second Determination.	Mean.
	mm.	per cent.	per cent.	per cent.
1	0.5	0.69	0.71	0.70
5	2.5	0.66	0.68	0.67
10	5.0	0.52	0.54	0.53
15	7.5	0.38	0.40	0.39

The numerical data contained in the three tables relating to the first series are graphically represented in the diagram, Fig. 2.

Series II.—The material used was a chromium nickel steel of the following composition :—*

	Per Cent.
Carbon	0.33
Silicon	0.06
Manganese	1.15
Sulphur	0.02
Phosphorus	0.015
Chromium	1.50
Nickel	3.17

The results after each single phase of treatment are as follows :—

(*a*) Case-hardening for ten hours at 1100 deg. Cent. with the mixed agent :—

No. of the Range of Single Layers Analysed.	Distance from the Surface of the Central Portion of the Layer Analysed.	Amount of Carbon in the Single Layers.		
		First Determination.	Second Determination.	Mean.
	mm.	per cent.	per cent.	per cent.
1	0.5	1.18	1.14	1.16
5	2.5	0.79	0.82	0.81
10	5.0	0.49	0.51	0.50

(*b*) After reheating the same carburised zone for five hours at 1100 deg. Cent. in isolated carbon monoxide :—

No. of the Range of Single Layers Analysed.	Distance from the Surface of the Central Portion of the Layer Analysed.	Amount of Carbon in the Single Layers.		
		First Determination.	Second Determination.	Mean.
	mm.	per cent.	per cent.	per cent.
1	0.5	0.80	0.81	0.80
5	2.5	0.76	0.78	0.77
10	5.0	0.58	0.58	0.58
15	7.5	0.45	0.44	0.45

(*c*) After reheating the same zones for a further five hours (total reheating period ten hours) at 1100 deg. Cent. in isolated carbon monoxide :—

No. of the Range of Single Layers Analysed.	Distance from the Surface of the Central Portion of the Layer Analysed.	Amount of Carbon in the Single Layers.		
		First Determination.	Second Determination.	Mean.
	mm.	per cent.	per cent.	per cent.
1	0.5	0.87	0.85	0.86
5	2.5	0.85	0.88	0.87
10	5.0	0.75	0.75	0.75
15	7.5	0.60	0.58	0.59

The numerical data contained in the three last tables, relating to the second series, are graphically represented in the diagram, Fig. 3.

In view of the detailed study, of which the author has given an account in his previous reports, upon the causes of the various phenomena of brittleness and peeling which may occur in case-hardened steel, any further comment in explanation of the data in the preceding tables and represented in the two diagrams will be superfluous. In fact, bearing in mind the conclusions to be drawn from the author's previous research work, a simple examination of the gradual changes of the form and position of the curves of concentration and depth of zone due to the effect of the treatment gradually prolonged with isolated carbon monoxide is sufficient to demonstrate clearly how, with the rational application of the process of case-hardening under consideration here, it is possible to obtain carburised zones in which are eliminated the principal causes of brittleness and peeling which always occur, in a greater or less degree, in steels case-hardened by the ordinary processes. The principal causes of these defects are excessive concentration of carbon in the superficial zones of the case-hardened pieces, and the rapid diminution of the carbon in passing to the deeper layers. It is also worthy of note that this rapid diminution contributes in a high degree to render more intense the phenomenon of liquation of the cementite or of the corresponding complex carbides of the various special steels, and of the ferrite. These phenomena in their turn are productive of the sudden local variations of the concentration of carbon in the carburised zones to which is due the peeling off of the carburised and quenched zones.*

Finally, the ability to alter the form of the curves of case-hardening, as shown in the diagrams, suggests that case-hardening can also be successfully applied to those special steels on the exterior of which the ordinary processes of case-hardening yield carburised zones, which are practically useless on account of their excessive brittleness.

The author hopes on a future occasion to be able to present results of technical interest in this direction which practical experience has already amply proved to be possible, and also to deal specially with the question of cementation to great depths.

* As will be seen, this is a steel of the kind ordinarily used for Krupp armour-plates. On this account the data here given relative to case-hardening at moderate depth are of peculiar interest. But the author proposes later to present particulars of even greater interest relating to case-hardening to considerable depths as carried out upon this steel by the process described in the paper.

BIBLIOGRAPHY.

The following is a list of reports on the principal research work carried out by the author alone and conjointly with other collaborators, on case-hardening :—

1. F. Giolitti.—"Researches on the Manufacture of Case-Hardened Steel." Part I. *Gazzetta Chimica Italiana*, vol. xxxviii., No. 2, 1908.
2. F. Giolitti and F. Carnevali.—"On the Lower Limit of the Temperature Range within which the Process of Case-Hardening is Effected." *Rendiconti della Società Chimica di Roma*, vol. vi., No. 17, 1908.
3. F. Giolitti.—"On the Phenomenon of the Peeling in the Case-Hardening of Steel, and the Means for its Avoidance." *Ibid.*
4. F. Giolitti and F. Carnevali.—"Researches on the Manufacture of Case-Hardened Steel." Part II. ("Case-Hardening of Low Carbon Steel with Gas at Atmospheric Pressure and at Pressures below the Atmosphere.") *Gazzetta Chimica Italiana*, vol. xxxviii., No. II., 1908.
5. F. Giolitti and G. Tavanti.—"Researches on the Manufacture of Case-Hardened Steel." Part III. ("Liquation Phenomena which Occur in Case-Hardened Steel.") *Ibid.*, vol. xxxix., No. II., 1909.
6. F. Giolitti and L. Astorri.—"Researches on the Manufacture of Case-Hardened Steel." Part IV. ("On the Specific Function of Gaseous and Solid Agents in the Case-Hardening Process.") *Ibid.*, vol. xl., No. I., 1910.
7. F. Giolitti and F. Carnevali.—"Researches on the Manufacture of Case-Hardened Steel." Part V. ("Case-Hardening with Highly Compressed Gas.") *Atti della Reale Accademia delle Scienze di Torino*, vol. xlv., 1910.
8. F. Giolitti and F. Carnevali.—"Researches on the Manufacture of Case-Hardened Steel." Part VI. ("Case-Hardening of High Carbon Steel with Gas at Atmospheric Pressure and at Pressures below the Atmosphere.") *Ibid.*
9. F. Giolitti and G. Tavanti.—"Researches on the Manufacture of Case-Hardened Steel." Part VII. ("Study of a Process of Case-Hardening Based on the Specific Action of Carbon Monoxide.") *Ibid.*
10. F. Giolitti and F. Carnevali.—"On the Case-Hardening of Nickel Steel." Part I. *Ibid.*, vol. xlvi., 1911.
11. F. Giolitti and F. Carnevali.—"On the Case-Hardening of Chrome Steel." *Ibid.*
12. F. Giolitti and G. Tavanti.—"On the Case-Hardening of Nickel Steel." Part II. *Rassegna Mineraria, Metallurgica e Chimica*, vol. xxxiv., No. 18, 1911.
13. F. Giolitti and G. Scavia.—"On the Use of Horizontal Muffle-Furnaces for the Case-Hardening of Steel with Mixed Case-Hardening Agents." *La Metallurgia Italiana*, August, 1911.
14. F. Giolitti and G. Scavia.—"On the Formation of Cementite." *La Metallurgia Italiana*, September, 1911.
15. F. Giolitti.—"On the Actual State of Our Knowledge Concerning the Process of the Case-Hardening of Steel." *Ibid.*, August, 1911; *Rassegna Mineraria, Metallurgica e Chimica*, September, 1911.

* See reports previously quoted, more particularly report No. 9 in the bibliographical list.

LITHERLAND BOILER EXPLOSION.—The formal investigation ordered by the Board of Trade to be held in this matter is fixed for hearing in the Chancery Court, St. George's Hall, Liverpool, on Tuesday, December 5, at 11 a.m.

THE ROYAL SOCIETY OF ARTS.—The Royal Society of Arts begins its 158th Session on Wednesday, November 15, with an address from Lord Sanderson, G.C.B., the chairman of the council. Five meetings are announced before Christmas, at which papers will be read on "The Industrial Progress of America," by Professor James Douglas, LL.D.; on "The Efficiency of the Aeroplane," by Mr. A. E. Berriman; on "British Guiana," by Mr. J. A. J. de Villiers; on "London Transport," by Mr. W. Yorath Lewis; and on "Bengal Fisheries," by Dr. J. Travers Jenkins. Four Cantor lectures on "The Carbonisation of Coal" will be delivered by Professor Vivian Lewes, and two juvenile lectures on "Soap-Bubbles" will be given in January by Mr. C. V. Boys, F.R.S. A long list of papers for the meetings to be held after Christmas is also published.

TRADE WITH THE PHILIPPINE ISLANDS.

The development of the trade and industry of the Philippine Islands since they came under the Government of the United States of America has received a great amount of attention from American capitalists and merchants, and many important extensions have taken place. When the islands were under Spanish rule, things were generally allowed to drift, and little real progress was made, but now they are attracting the attention of many who are interested in the trade of the Pacific area. According to the latest advices, some of the leading citizens of Manila have been interesting some of Australia's most prominent men and mining financiers in the development of the mineral resources of the Philippines, and it is stated that arrangements have been made for the importation of some of the most improved machinery and appliances in order that practical operations may be at once commenced. Other groups of capitalists are also actively engaged in prospecting, and some have already made considerable progress in carrying out their work. The residents in the islands are doing what they can to make their resources known, and thus to encourage external trade and the starting of industries of various kinds. In February of next year what is to be known as the Philippine Exposition is to be opened. Advantage is to be taken of the annual carnival to attract large numbers of visitors to the Exposition.

During the last session of the Philippine Legislature it was determined to make a special appropriation of a large sum of money which would more adequately serve to bring to the metropolis during the Carnival week, in 1912, comprehensive exhibits of the products, industries, and resources of the provinces. With that end in view the Legislature passed an Act providing for such an Exposition of Philippine products. It is the earnest desire of the Philippine Government to make the Exposition as complete as possible, and to show the nature and extent of the natural resources and the uses to which they are put. There will be splendid exhibits from the Bureaux of Forestry, Constabulary, Public Works, Agriculture, Internal Revenue, Navigation, Health, Science, and various others. There will be a large Machinery Hall, where machinery of all kinds used in the islands will be actually in motion. Several of the large importing firms will have splendid exhibits in this hall. Here the visitor will be able to see in actual operation rice and sugar-mill machinery of the latest pattern, as well as all sorts of ground-tilling devices and electrical appliances. It is also contemplated to have an ice-making machine in full operation in this building. All information with regard to the Exposition may be obtained from the Director-General of the Philippine Exposition, Manila, P.I., and we suggest that it would be in the interests of British manufacturers who trade in the Far East to make themselves acquainted with what is proposed.

According to the last report of the British Acting Vice-Consul, the value of the imports of iron and steel in 1910 was 1,159,222*l.*, a gain of more than 50 per cent. as compared with the preceding year. The United States maintain a good lead in this department of trade, and although an increased volume of business was shown by the United Kingdom and the Continent of Europe, the increase in the imports from the United States, favoured by a protective tariff, was very marked. A good business has been done in steel rails, a fair supply having been drawn from the United Kingdom and the Continent of Europe, the latter supplying a good quantity of rails of lighter section for light and portable railways. There was a substantial gain to United States manufacturers in agricultural machinery, to the detriment of British and other makers. The trade in the heavier class of machinery, steam-engines, &c., is practically divided between the United States and the United Kingdom. The trade in petroleum and gasoline motors and electrical machinery is controlled by manufacturers in the United States. The great advance in the importation of motor vehicles is, perhaps, the most noticeable feature of the year. United States manufacturers, assisted by a 20 per cent. advantage in tariff, have entered the field with much energy and enterprise, and with the exception of a few cars of well-known European make, the trade is almost exclusively American.

Projected Pipe-Lines for Motor Spirit.—The General Committee of the Commercial Motor-Users' Association, of which Colonel R. E. Crompton, C.B., is chairman, had before it, at its last meeting, Sir Marcus Samuel's recent statement that a three days' fog on the river would be followed by a serious interruption, if not complete cessation, of the supply of motor spirit for London. As this would involve the virtual stopping of all motor-omnibus, motor-car, motor-cab, and motor-van traffic, the Committee has decided to bring before the association a project for the laying of one or more pipelines for the conveyance of motor spirit from the Thames estuary to various parts of London. For this project Parliamentary sanction will be required and the associatio will support an application for the necessary powers.

PERCENTAGE WEIGHING-MACHINE.

CONSTRUCTED BY MESSRS. W. AND T. AVERY, BIRMINGHAM.

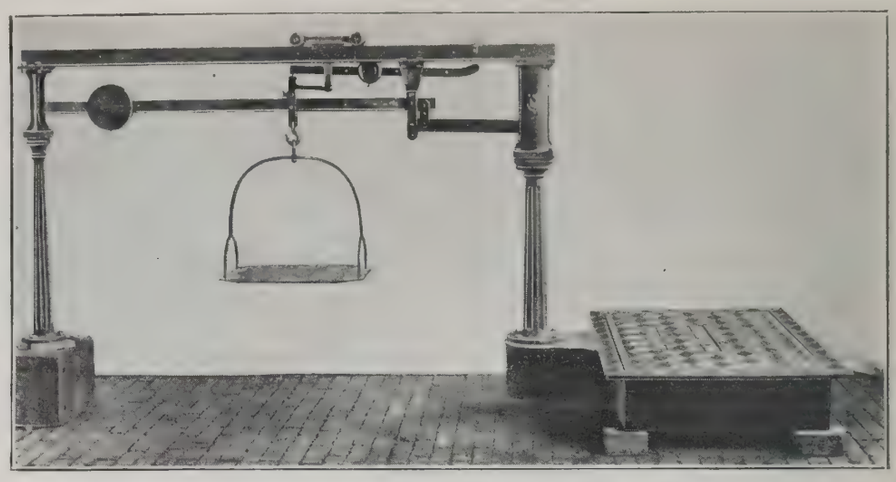
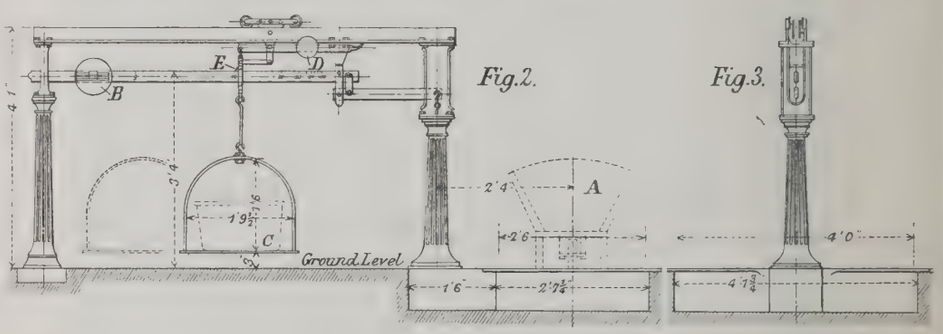
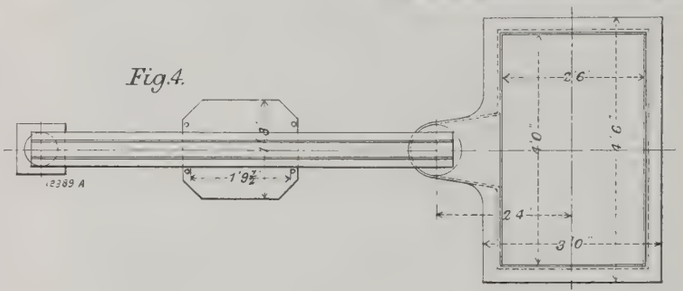


Fig. 1.





The need in several trades of employing accurately proportioned materials has resulted in Messrs. W. and T. Avery, Limited, London and Birmingham, developing the form of weighing-machine illustrated in Figs. 1 to 4 herewith. Fig. 1, a reproduction of a photograph, gives a general view of the machine before final installation. Figs. 2 and 3 give respectively front and end elevations, and Fig. 4 a plan.

This weigher is of the platform type, the platform measuring 48 in. by 30 in., and is capable of weighing up to a maximum capacity of 3 cwt., the percentages of the component materials being varied according to requirements. In working, the barrow or hopper, or other receptacle A, to contain one component of the mixture, is placed on the platform and tared, by means of the movable poise B on the large steelyard. The receptacle C for the second component is placed on the swinging pan and poised by means of the bob D on the smaller steelyard. The runner E carrying the bucket C is then adjusted along the frame until its position coincides with the percentage which it is desired the material contained in C shall bear to that in the receptacle A, the percentages being marked off on the large steelyard. Within the limits of the machine material to any amount is then placed in A, and the receptacle C is then filled with the other component until the two balance, when they bear the exact proportions required to one another and may be mixed together. This use of this machine avoids all possibility of errors in calculating or of the need of making up the larger quantity to any definite weight. In this way it should prove to be a good time-saver

Though specially designed for cement making, it is evident that machines of this kind should prove serviceable in many trades where proportions have to be accurately worked to.

CATALOGUES.

Brush-Holders and Carbon Brushes.—From the Globe Electric Company, Limited, 11, Farringdon-avenue, E.C., we have received a pamphlet giving particulars of "Supra" brush-holders, and carbon brushes suitable for them. Other types of brush-holders are also dealt with.

Liquid Controller for Electric Motors.—A small pamphlet, giving prices and particulars of "Phœnix" liquid controllers for electric motors, has reached us from Messrs. E. G. Appleby and Co., 10, Victoria-street, Westminster, S.W. The makers claim that these controllers are specially adapted for use in steel-foundries, rolling-mills, shipbuilding yards, and engineering works.

Ships' Fittings.—Two catalogues of fittings for ships have reached us from the Carron Company, of Carron, Stirlingshire, N.B. One of these gives particulars of ornamental castings for cabin-seat stands, smoking-room tables, deck ventilators and fittings, gangway hinges, rigging-screws, tackle-blocks, &c. The other deals with saloon lights, deck-house lights, side lights, engine-room skylights, &c.

Ships' Steering-Gears and Ash-Hoists.—A sectional catalogue, illustrating some of the different types of steam steering-gears they manufacture, has been issued by the Carron Company, of Carron, Stirlingshire, N.B. The illustrations, which are reproductions of scale drawings, show vertical and horizontal gears for steam only, or for combined steam and hand-power. The Carron improved ash-hoist is also illustrated.

Motor-Starters.—We have received from Messrs. A. Reyrolle and Co., Limited, of Hebburn-on-Tyne, a copy of a pamphlet giving particulars of lever-type starters for direct-current motors. In these starters the special kind of resistance material employed allows the current passing through it to increase gradually, so that the motor can be started on the first contact stud at all loads. Prices are stated for open and protected starters ranging from ½ to 250 horse-power for voltages up to 600.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

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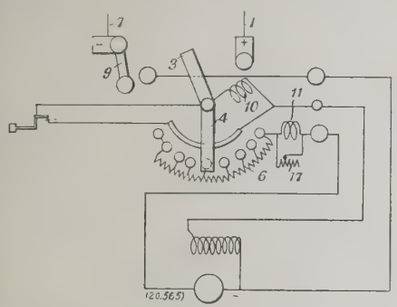
ELECTRICAL APPARATUS.

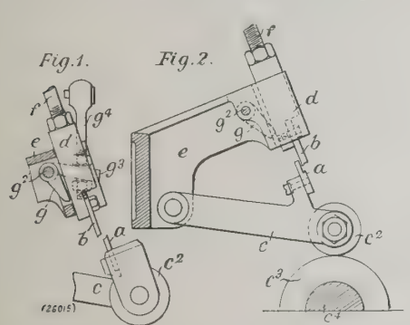
20,565/10. W. F. Perry, Tipton. Motor-Starting Rheostats. [6 *Figs.*] September 3, 1910.—In a motor-starting rheostat of the type in which the circuit-breaker arm is held on its contact by an electromagnet and released by the de-energising of same on overload by means of a second and de-magnetising winding, an adjustable resistance in shunt with either winding is employed, according to this invention, for the purpose of regulating the amount of overload at which the magnet will be de-energised and the circuit-breaker arm released. The main 1 is connected to the motor by the circuit-breaker arm 3, control-lever



4, and adjustable resistance 6, whilst the second main 7 is also connected to the motor through a switch 9, which is automatically closed and opened when the circuit-breaker is closed and opened. The magnet coil 10 is provided with a magnetising winding 11 so arranged that on an overload occurring it de-energises the coil 10 and releases the circuit-breaker. In order to set the de-magnetising winding 11 so that it will open the circuit-breaker at various overloads, an adjustable resistance 17 is connected across the magnet coil 10. By this means the current passing through the coil 11 may be altered, and the coil caused to release at various overloads. (*Accepted September* 13, 1911.)

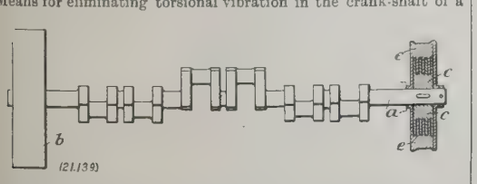
GAS ENGINES, PRODUCERS, HOLDERS, &c.

26,015/10. E. Ashworth, Manchester. Internal-Combustion Engines. [9 *Figs.*] November 9, 1910.—This invention has reference to devices which impart movement to the air and gas-valve spindles. The gas-valve is arranged vertically and concentrically with the air-valve, and is actuated through a hit-and-miss contrivance. The steel bit *a* of the hit-and-miss gear is carried by a projection forming part of a pivoted actuating lever *c*, which lever *c* bears a bowl c^2 acted on by a cam c^3 on the side shaft c^4. The other steel bit *b* is attached to a block *d* which fits the jawed end of a guide-bracket *e*, the connecting-rod *f* for



the gas-valve lever being attached to the block *d*. In the rear of the block *d* is mounted a trigger-lever *g*, carried upon a small spindle g^2, to which is attached a cranked and slotted lever-arm g^3, coupled up by a connecting-rod g^4 to a lever pivoted on the governor stand, and which lever is influenced by the governor. As the governor rises and falls, the lastly-mentioned lever is affected, and motion is conveyed through the connecting parts to the trigger-lever *g*, the arm of which, acting on the block *d*, causes the steel bit *b* to hit or miss the bit *a*, as occasion requires, and so the supply of gas is controlled. (*Accepted September* 13, 1911.)

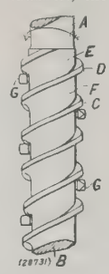
21,139/10. F. W. Lanchester, Birmingham. Internal-Combustion Engines. [4 *Figs.*] September 12, 1910.—Means for eliminating torsional vibration in the crank-shaft of a



high-speed reciprocating engine, according to this invention, comprises a rotational damper consisting of a body of adequate moment of inertia connected to the crank-shaft by a yielding coupling operating by friction between surfaces or by fluid friction or viscous friction. In carrying the invention into effect, there is keyed to the rotating shaft *a*, at the end furthest from the fly-wheel *b*, a coupling-piece *c* provided with discs projecting outwardly. Over the coupling-piece *c* there is fitted a heavy wheel *e* having internally-projecting discs projecting between the discs of the coupling-piece *c*. The wheel *e* is provided with a bearing on the crank-shaft. A suitable oil film is formed between the wheel *e* and its ribs, and the coupling-piece. In this form of the invention, if the shaft is rotating uniformly, the wheel *e* is carried round at the same velocity as the shaft. If, however, owing to the action of the connecting-rods on the shaft there is at any given speed a tendency to set up torsional oscillations at the end *a* of the shaft, these oscillations cause variations of speed between the end of the shaft *a* and the uniformly moving wheel *e*, and the pull between the coupling-piece *c* and the wheel *e* through the oil film will tend to damp out these oscillations. (*Accepted September* 13, 1911.)

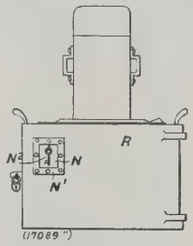
MINING, METALLURGY, AND METAL-WORKING.

28,731/10. Mavor and Coulson, Limited, Glasgow, and A. W. Davies, Carmyle. Coal-Cutting Machines. [4 *Figs.*] December 10, 1910.—A cutter-bar of the type having two or more helical fins for coal-cutting machines has, according to this invention, one or more of the helical channels, of which the body of the bar forms the base, and the fins the sides, furnished with picks, and one or more of the helical channels left unobstructed. A designates the root of a cutter-bar through which the drive is transmitted, and B designates the body of the cutter-bar, which, in the form shown, is furnished with two fins C, D, thus forming two helical channels E, F. In furnishing a bar of this character, according to this invention, picks G are fitted in one of the helical channels, the complementary channel



being left unobstructed to act solely as a conveyor for the cuttings. In some cases, the picks G are set against or close to what may be termed the following side of the fin, in distinction to the leading side—viz., the side which acts to thrust the cuttings in the operation of conveying, and are arranged so that their cutting points project above the periphery of the fins. In some cases, one helical channel may be formed of a width somewhat greater than, or only sufficient to accommodate the picks G, and the channel may be wide in comparison therewith. In formation, the fins may be constructed to present a vertical or approximately vertical leading side, and the juncture which the following side makes with the body of the bar may be curved to strengthen the fin. (*Accepted September* 13, 1911.)

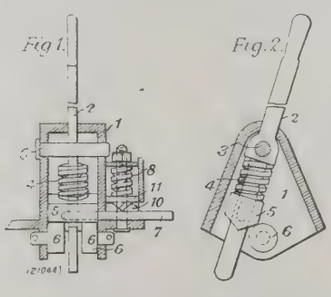
17,089/11. E. A. Hailwood, Morley. Miners' Safety Lamps. [1 *Fig.*] August 4, 1910.—In order that a miners' lamp may be relit down in a mine, or where bad gases are prevalent, and in the event of a disaster, and in which the person in charge of the relighting mechanism is not available, the relighting apparatus R is provided with an auxiliary casing or chamber N let



into the door or other suitable portion of the apparatus, the chamber N having a door or window N^1 therein, and painted thereon or attached thereto a label bearing instructions that in the event of a disaster the door or window should be broken and the key N^2 abstracted in order to enable the relighting apparatus to be operated so that the lamp may be relit. (*Accepted September* 13, 1911.)

RAILWAYS AND TRAMWAYS.

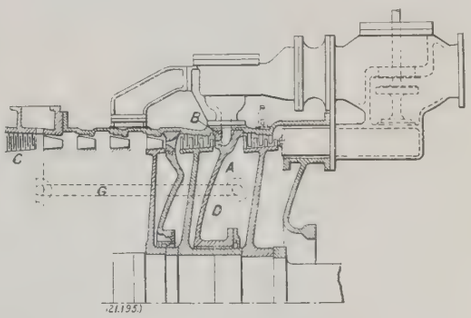
21,044/10. H. A. Thomson, Glasgow. Points and Switches. [5 *Figs.*] September 9, 1910.—This invention relates to two-way reversible ground levers. 1 is a casing that may be fixed to sleepers. 2 is a hand-lever fulcrummed at an intermediate part of its length to the casing 1 by a pin 3. 4 is a spring encircling the lever 2. One end of this spring 4 is relatively fixed,



whilst the other end is free to bear against a V-shaped contact-piece 5, slidably mounted on the lever 2 and moving therewith. 6 are rollers supported by the casing 1 in such position as to contact with the V-shape piece 5. 7 is a bell-crank lever pivoted to the casing and engaging with the V-shaped piece 5. If desired, as shown on the right side of Fig. 1, the spring 4 may either be supplemented, or be replaced, by a spring 8 mounted to bear against a notched piece 11, which engages with similar notches 10 on the bell-crank lever 7. The action of the mechanism is as follows:—When the lever 2 is operated, motion is imparted to the points. When the switches are run through trailing ways by a train and changed to another set position, the movement given to the switch-blades reverses the switch mechanism. The spring 4 or 8 resists movement of the switch-blades during the first half of their travel, but after the dead centre is passed the spring 4 or 8 tends to complete the movement of the blades and retains them securely in their reversed position. (*Accepted September* 13, 1911.)

SHIPS AND NAUTICAL APPLIANCES.

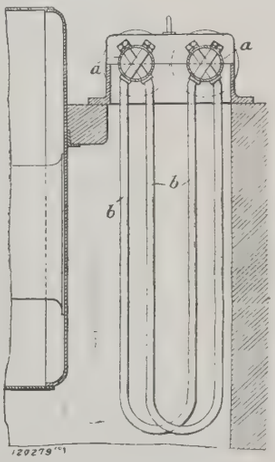
21,195/10. The Warwick Machinery Company (1908), Limited, London, and S. J. Pigott, Helensburgh. Marine Turbine Propulsion. [2 *Figs.*] September 12, 1910.—The invention comprises a main turbine and a cruising turbine mounted on the same shaft, the cruising turbine being connected to a low-pressure stage of the main turbine. The cruising turbine, when in operation, exhausts through suitable valve-controlled nozzles into the main turbine, and in order to prevent abnormal increase of pressure in the cruising turbine in the event of failure to open these valves, a by-pass connection, controlled by an automatic valve, is provided between the two turbines. The main turbine consists of a number of impulse stages B and a reaction stage C. A cruising turbine A is mounted on the same shaft as the main turbine, but is housed in a casing, so that it is isolated from the main turbine when full power is being developed, by means of a diaphragm in which the inlet



valves for the main turbine are located. The cruising turbine consists of a single-stage impulse-wheel, but it may consist of any number. In order to prevent leakage of steam from the high-pressure stage of the main turbine into the cruising turbine when the main turbine is working, the diaphragm D between the two is provided with a labyrinth shaft packing. It may also be provided with carbon ring packing, held in place by a garter spring. Should any fluid pass through this packing into the cruising-turbine casing, it would tend to lower the efficiency of the main turbine, and to overcome this objection the cruising-turbine casing is connected by a valve-controlled pipe G with a low-pressure stage of the main turbine, so that a low pressure may be maintained in the cruising stage while the main turbine is in operation, and also so that the motive fluid which has leaked through may be returned to the main turbine, where it can do useful work. (*Accepted September* 13, 1911.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

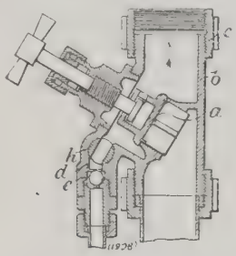
20,279/10. F. K. Woodroffe, Newton, and J. C. Blythe, Liscard. Superheaters. [3 *Figs.*] February 28, 1911.—In a superheater, according to this invention, the ends of U tubes are inclined or bent to the general direction of the legs of such tubes, and in parallel directions, and such inclined or bent ends are passed diagonally through the centre of the two circular headers in which they are held. The two parallel headers *a* are in the form of cylindrical tubes, and the upper ends of the heating U tubes *b* pass through the headers in an inclined and parallel direction; and they are provided at one part, where they fit up against or pass into the header, with a shoulder or collar; whilst at the opposite end, which passes through the other or opposite wall of the header *a*, they are threaded exter-



nally, and each tube end has a nut passed over it, by means of which the shoulder or collar is drawn up to the outside surface of the header, whilst the nut itself is also drawn up on the surface of the header; and over the end of the tube end also a cap nut is fitted and screwed, and it is screwed or brought up on to the outside of the nut. Between the shoulder or collar and the header, and between the nut and the header, there is preferably employed a jointing, which may advantageously consist of copper or equivalent metal rings or washers. The tube ends which extend through the headers are perforated with a suitable number of holes for forming communication between the interior of the tube ends and the header. By the ends of the U tubes *b* being disposed at an angle, and these ends in the alternative tubes being oppositely inclined, the holes in the headers through which the

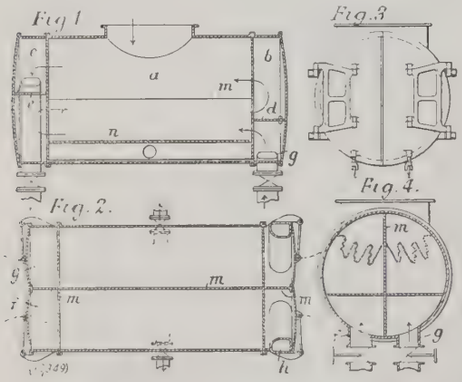
tubes pass will be spaced some distance apart, as will also be the fastening devices which fit on their upper outer ends, so that these tubes may be placed closely together about the headers, and the jointings between the headers, and the parts of the tubes and their fastenings will be in planes which are tangential to the circle of the headers, as the axes of these end portions of the U tubes which pass through the headers, will also pass through the axes of the headers. (*Accepted September* 13, 1911.)

19981/11. H. E. Gresham, Salford. Injectors. [2 *Figs.*] January 26, 1911.—This invention comprises the provision of automatic means which shall allow of the escape from an injector of the hot water which remains therein when the steam supply is cut off, so as to prevent the water returning to the hot-well or feed-tank, and causing difficulty, due to its high temperature, when the injector is restarted and creates a vacuum in the feed-pipe for lifting purposes. A non-return valve *a* is provided in the feed-water supply-pipe *b* which opens when the injector is in operation, and tends to draw water from the pipe, but closes immediately the injector ceases working so as to prevent a return flow down the pipe to the hot-well or feed tank. The injector is connected to the fitting illustrated by means of the union piece *c*. Adjacent to, and on the injector side of, the valve *a*, a by-pass or release connection *d*, having a non-return



valve *e* thereon, is provided. The latter closes when the injector is working normally, due to the difference in the pressures at its two sides, but is opened by the pressure of the water in the feed-pipe *b* above the valve *a* when the injector ceases working. By the means aforesaid, the escape of the hot water which remains in an injector when the steam supply is cut off is provided for, and the difficulty experienced with lifting injectors when restarting after short stoppage, due to the presence in the feed-pipe of water at practically boiling point is obviated. The non-return valve *e* is, preferably, of the ball type, having means to prevent the ball moving more than a predetermined distance from its seat. A cock *h* is provided upon the by-pass or connection to the non-return valve *e*, which can be closed if the water-level in the hot-well or feed-tank is higher than the automatic valve *e*, or if the water in the feed-tank is being heated by steam from the injector. (*Accepted September* 13, 1911.)

12,349/11. Aktiengesellschaft Brown, Boveri, et Cie., Baden, Switzerland. Surface Condensers. [5 *Figs.*] June 8, 1910.—The invention consists in the arrangement, in a horizontal surface condenser, of an internal partition and the formation of each of the two ends of the condenser as a pair of swing doors in such a manner that one part of the condenser can be shut down and cleaned out whilst the other part is in use. The space in the condenser containing the tube nests is denoted by *a* and the two water chambers at the two ends by *b* and *c*. These latter are divided by the horizontal walls *d* and *e* so as to compel the water repeatedly to change its direction of flow. Through the space *a* and the chambers *b* and *c* passes a partition *m* which divides the space *a* and each of the chambers *b*, *c* into two portions. In the space *a*, the partition *m* is of such a height as not to interfere with the inflow of steam, and is not connected at the bottom with the casing of the condenser. The two spaces on the two sides of the partition *m* thus communicate with each other, so that condensed water rises on both sides of the partition to an equal height, and forms a water seal to shut off one-half of the condenser from the other during clean-



ing. In the lower part of the space *a* is a perforated plate *n*. The two ends of the condenser are formed as swing doors. In normal working, the whole condenser is used. The cooling water enters simultaneously at *f* and *g*, flows first through the two lower spaces of the water chamber *b*, and thence through the tubes which open into these spaces, into the space *a*, after which it is compelled by the wall *e* to reverse its direction in the two lower spaces of the chamber *c*, and flow back through other tubes into the two upper spaces of the chamber *b*, in those to again change its direction of flow, and after passing through the upper pipes in the space *a*, to attain the two upper spaces of the chamber *c*, and flow away through the side-pockets at *h*. When the condenser is to be cleaned, the water-inlet *f* and the air-suction pipe are closed. The swing-doors are opened, and the insides of the tubes in this part of the space *a* can be cleaned while the plant is still at work. The same space is available for the inflow of the steam as before, and the steam is drawn by means of the vacuum to one side of the partition *m*, away from the steam-inlet, into that part of the condenser which is kept working. On the other side of the partition *m* the level of the water prevents any ingress of the steam, and rather assists to condense it. (*Accepted September* 20, 1911.)

VEHICLES.

9637/11. R. J. Marshall, Newcastle-on-Tyne, and W. H. Penman, Gateshead-on-Tyne. Vehicle Fenders. [6 *Figs.*] April 20, 1911.—This invention relates to vehicle fenders comprising a plough with inclined sides arranged so that they make in plan an angle one with the other, the apex being in advance, and a rotary obstruction-lifting device located in proximity to each of the lower edges of the angular plough. According to this invention, the rear end of the fender is connected to its support by a pin and slot or other connection adapted to allow free up and down movement of that end of the fender, and the front end of the fender is connected to a lifting lever adapted to be operated, as by foot, from the corresponding end of the vehicle. At the lower edge of each side *a* of the fender is a rotary brush *b* that also constitutes the obstruction-lifting device, the two brushes being driven by a track-wheel located in the longitudinal centre line of the fender. Each side *a* is downwardly curved at an angle that gradually increases in steepness from the longitudinal centre line of the vehicle towards the sides

Fig. 1.

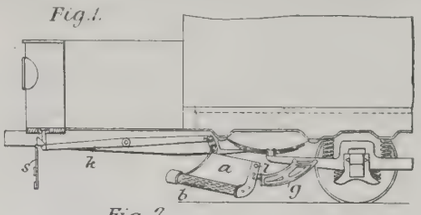
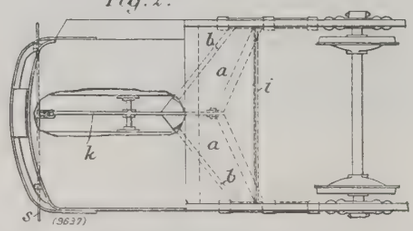


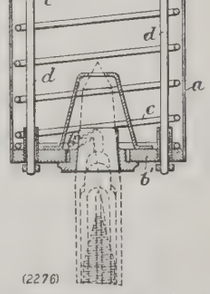
Fig. 2.



thereof, so that objects deposited thereon will slide off to one side or the other. The rear of the fender is free to rise in order to clear small obstacles when in its inoperative position, as shown in Fig. 1, and for this purpose it is connected to its supporting brackets *g* by pins working in slots formed therefore in the end brackets of the fender. At the rear the two sides of the fender are connected by stays *i*. The front end of the fender is connected to the inner end of a lever *k* pivoted to the vehicle underframe, and the outer end of which is fitted with a pedal conveniently arranged for operation by the driver. The connection of the lever to the fender is by means of a link. At each end of the vehicle is a gate *s* freely suspended. Midway of its length the top of the gate is provided with a forked catch inclined at its upper face and adapted to engage automatically the end of the lever *k* when it is depressed to raise the fender. (*Accepted September* 13, 1911.)

TEXTILE MACHINERY.

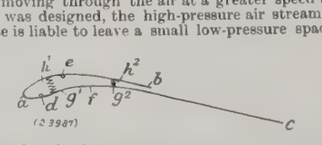
2276/11. J. R. Bradshaw, Haslingden. Threading Loom-Shuttles. [3 *Figs.*] January 30, 1911.—This invention relates to a device for enabling the thread to be drawn through the eye of a shuttle by atmospheric suction, and consists in providing a compressible case *a* having discs *b*, *b*¹ at its ends. Guide-rods *d* are secured in the disc *b*. The opposite ends of the rods *d* are passed through bushes in the disc *b*¹. A spring *c* is placed within the case *a*, and a non-return valve *g* is fitted in the disc *b*. In the centre of the disc *b*¹ is an aperture *b**, in which is fitted a rubber bush which will prevent air passing into the case around



the outside of the shuttle when inserted in the bush. When it is required to thread a shuttle, the weaver lays the free ends of the yarn in the hollow portion of the nose at the eye end of the shuttle, the end of the shuttle is then inserted in the rubber bush in the aperture *b**, thereby compressing the case *a*, out of which the air is driven through the valve *g*. When the end pressure on the shuttle is removed, the spring *c* causes the disc *b*¹ to recede from the disc *b*; a partial vacuum is thus created in the case *a*, and the air passing in through the eye of the shuttle, the thread is drawn through the eye of the shuttle. (*Accepted September* 13, 1911.)

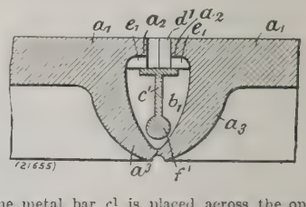
MISCELLANEOUS.

23,987/10. H. D. de M. Carey, Ilchester. Flying-Machines. [7 *Figs.*] October 17, 1910.—If an aeroplane having a vertical longitudinal section, as shown, or in any way similar thereto, be moving through the air at a greater speed than that for which it was designed, the high-pressure air stream shooting past the nose is liable to leave a small low-pressure space at the



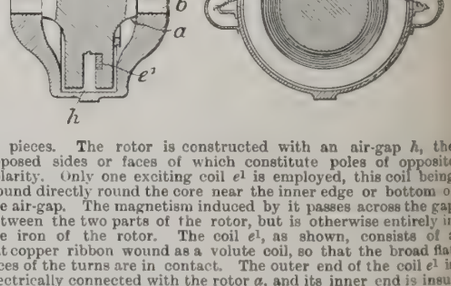
under surface just behind the nose (behind the point *d*) and to impinge with full pressure further back on the under surface, while at the same time downward pressure increases about the nose at the upper surface, these changes of pressure, on increase of the relative velocity, give a tendency for the nose of the machine to dip. Now in dipping, lift is reduced, and the machine may dive to earth at a steep angle, the speed increasing and instability increasing with the speed, and if, in descending, the nose enters a horizontal current, equilibrium may be wholly lost. This has been a constant source of accidents in descending at high speeds, and the primary object of this invention is to prevent dipping or undue dipping relatively to the air stream when speed is increased. This object is attained by constructing the main aeroplane in such a way that while the sustaining surface is rigidly secured to the machine, the entering edge and upper surface are adapted to be rocked relatively to the sustaining surface on increase of air pressure beyond a given quantity. The upper surface *d*, *a*, *e*, *b* is constructed so as to be movable within certain limits when pressure on it is increased beyond the pressure exerted in normal flight at the speed at which the aeroplane is primarily designed, in such a way as to throw the centre of downward pressure further back on the upper surface, while at the same time the entering edge is so moved as to avoid the tendency of the air current at increased velocity to skip part of the arc of camber of the sustaining surface. The under surface *d*, *f*, *c* is rigidly secured to the framework of the whole machine and the axis through *d* is permitted to rock in bearings which are rigidly secured also to the framework of the machine. The surface *e*, *b* is jointed at *e* to the surface *d*, *a*, *c* and is free to rock about the joint at *e*. The section *d*, *a*, *e* is connected by a stout spring h^1 to the under surface at g^1, which is part of the rigid framework of the whole machine, and the spring h^1 is positively stopped from expanding beyond such limits as may be desirable to maintain the section *d*, *a*, *e* in a suitable position in normal flight. The resultant pressure on the section *d*, *a*, *e* in normal flight passes a little above the axis at *d* so as to cause the section to exert some pressure on the spring h^1; when the relative velocity of the current increases considerably the section *d*, *a*, *e* will rock about the axis through *d* in such a way as to cant up the surface *d*, *a* and push backwards and downwards the point *e* compressing the spring h^1; the section *e*, *b* is permitted to slide over another spring h^2 which is similarly secured to the under surface at g^2, the spring h^2 being also stopped from expanding beyond such limits as is desirable in normal flight; the spring h^1 may be very light and the device may operate sufficiently for practical purposes without a spring at this section *e*, *b*. (*Accepted September* 6, 1911).

21,655/10. J. A. King, London. Glazing. [1 *Fig.*] September 17, 1910.—This invention provides a simple and efficient means of erecting or laying glass plates for use as pavement, floor or roof lights, and obviates the use of centering or shuttering, at the same time affording a special reinforcement. The glass plates a^1, a^1 have projections or ledges a^2, a^2 at the sides, and these projections or ledges enable the plates to be lodged on the top of a metal bar c^1. Curved ribs a^3, a^3 are also formed on the lower or undersides of the plates a^1, a^1 the curved ribs butting



closely. The metal bar c^1 is placed across the opening to be glazed with the glass plates a^1 lodging on the top thereof, and with the ribs a^3 of adjacent plates abutting. Liquid grout is then poured in through a space d^1 between the adjacent plates and passes through grout-holes e^1, e^1 in the projections a^1, thereby filling the hollow space b^1 and making a solid joint. The top of the metal bar c^1 serves as a ledge for the glass plates, and as a compression flange in the reinforcement of the rib. On the lower portion of the bar a bulb f^1 is formed to resist the tensile stresses. (*Accepted August* 30, 1911.)

21,671/10. R. H. Barbour, Crawley Down, and E. K. Scott, Bromley. Gyrostats. [4 *Figs.*] September 19, 1910.—According to the present invention, a gyrostat wheel is so arranged and constructed as to itself constitute the rotor of a homopolar electric-motor. In carrying out the invention, all the iron of the magnetic circuit is carried by the rotor; the usual stationary part of the magnet circuit is thus dispensed with. The exciting-coil or coils may also be conveniently carried by the rotor. By this method the inertia, which otherwise would retard the operation of the gyrostat, is greatly diminished. *a* is the gyrostat fly-wheel constructed to constitute the iron rotor of a homopolar motor, the fly-wheel being made all in one piece or built up, as desired. The shafts, or trunnions, *b* are mounted in bearings in a casing *c*, preferably air-tight, which may conveniently be built up of a number



of pieces. The rotor is constructed with an air-gap *h*, the opposed sides or faces of which constitute poles of opposite polarity. Only one exciting coil e^1 is employed, this coil being wound directly round the core near the inner edge or bottom of the air-gap. The magnetism induced by it passes across the gap between the two parts of the rotor, but is otherwise entirely in the iron of the rotor. The coil e^1, as shown, consists of a flat copper ribbon wound as a volute coil, so that the broad flat faces of the turns are in contact. The outer end of the coil e^1 is electrically connected with the rotor *a*, and its inner end is insulated from *a*, and is connected with the slip-ring *i* by an insulated conductor. Current is led into the rotor and out of the slip-ring *i* by the brushes *f*, one bearing on the core within the air-gap, and the other bearing on the slip-ring. (*Accepted September* 13, 1911.)

Metric Tables and Equivalents. — The Central Translations Institute, 16, Eastcheap, E.C., have recently issued a card giving fifty metric equivalent tables. The calculations are based upon figures supplied by the Board of Trade, and they are guaranteed to be absolutely accurate. The price equivalents deal with feet, yards, square feet, square yards, cubic feet, gallons, pounds, hundredweights, and 40 cub. ft. measurements. The prices are calculated at the rate of exchange: 25.22 francs to the £.

THE DEVELOPMENT OF THE HOLLAND SUBMARINE-BOAT.

The pronounced success of the United States navy submarine-boats in manœuvres with the Atlantic fleet, held in July and August of this summer, off Newport, Rhode Island, and Provincetown, Massachusetts, has again drawn attention to the great progress which has been made in the design, construction, and reliable service of submarine-boats in the United States. The present high state of efficiency of this type will not be surprising when it is remembered that the modern underwater fighting craft really originated in the United States, where, in the hands of the Electric-Boat Company (the owners of the Holland Torpedo-Boat Company) a progressive and uninterrupted logical development has taken place. Students of the history of naval construction will recall the fact that the modern submarine-boat is of recent origin, dating back no further than the last decade of the nineteenth century. At that time there were produced in France and in the United States the two forerunners of all modern submarines—viz., the Narval, designed by M. Laubeuf, and constructed in a French dockyard, and the original Holland, designed and constructed by the Holland Torpedo-Boat Company. As the Holland somewhat ante-dated the Narval, and, moreover, was equipped with internal-combustion engines for surface propulsion, she was, perhaps, more truly the prototype of the large flotillas which now form part of the naval forces of all the great Powers.

The Holland* was a small vessel of about 70 tons displacement when submerged, with a speed of about 6 knots on the surface, and of 5 knots when submerged. She was completed in 1898, and in 1900 was purchased by the United States Government, remaining in active service until last year, when she was struck off the active list as obsolete. She is now preserved, however, as a naval relic at the Naval Academy, Annapolis. The value of the practical results achieved by the Holland won immediate appreciation from naval experts throughout the world, and her appearance unquestionably ushered in the era of the submarine-boat. Simultaneously with her purchase by the United States Government seven additional boats were ordered. These boats, of the Adder type, were enlarged and improved Hollands, of 122 tons displacement when submerged. To give a surface speed of 8½ knots and a submerged speed of 7 knots they had a single-screw power installation, including a gasolene engine of 160 brake horse-power, and an electric motor of 70 horse-power. These boats were fitted with a single torpedo-tube, and carried two spare torpedoes arranged for reloading when submerged. These vessels are still in active service in the United States navy, and a flotilla of four of them has recently completed a noteworthy self-supporting cruise in the Philippines, where they are now stationed.

Five vessels of the same design were constructed for the British Government by the Vickers Company at their Naval Construction Works, Barrow-in-Furness; seven of the same type are in active service in the Russian navy, five in the Japanese navy, and one in the navy of Holland.

In the United States, the seven vessels of the Adder class were followed by three of the Viper type, of 170 tons displacement when submerged, of 9 knots speed on the surface and 8 knots speed when submerged. In addition to an increase in displacement and speed, many new features were incorporated. Simultaneously with this group a still larger vessel, the Octopus, of 272 tons submerged displacement, was constructed. This was the first example of the twin-screw submarine boat. This vessel was very exhaustively tested by the United States naval authorities in competition with other types, and was pronounced to be greatly superior to all the other types and designs submitted. The speed on the surface was 11 knots, and when submerged 10 knots. As a result of the successful trials, the Electric-Boat Company received an order for seven more vessels, four of which were substantially duplicates of the Octopus, while three were of a still further improved type, and of enlarged displacement—337 tons submerged, with higher speed both on the surface and when submerged. It was this group of seven vessels, comprising the third submarine flotilla, which achieved such brilliant results in the naval manœuvres last summer. Preliminary to these manœuvres much attention had been drawn to this flotilla by its unprecedented voyage from the harbour of Newport to Gloucester, 150 sea-miles. This whole journey was accomplished submerged except that part across the shoals of Nantucket, where a lack of depth of water required the vessels to run awash.* During this voyage the flotilla made uninterrupted runs, submerged, of 12 hours' duration, and only came to the surface as was necessary at night to recharge the storage batteries. The whole voyage was accomplished without an accident of any kind, and without any undue hardship on the crew, which speaks very well not only for the excellent qualities of the boats for running submerged, but for the training, discipline, and intelligence of the American crews. While such a voyage accomplished by a single vessel would have been a noteworthy performance, it could not be compared with the voyage of a whole flotilla of seven vessels, as a demonstration either of the efficiency of the type or the good organisation of the service.

Among the vessels which took part in this record-breaking run was the Salmon, illustrated by Fig. 1, which attracted much attention last year by her over-seas voyage from Boston to the Bermudas and return, about 1500 nautical miles over-seas. This voyage was made under the vessel's own power, without assistance from any external source, and it served to demonstrate thoroughly the habitability and safety of these vessels at sea in all kinds of weather. The Salmon is also noteworthy as the holder of the world's record for submerged speed, which, on trial, reached 12 knots.

Number of Submarines Built and Building: Accidents.

The United States flotilla in active commission now comprises the eighteen vessels above mentioned, all of which were built by the Electric-Boat Company. In addition this company has now in hand for the United States Government seventeen additional vessels, six of which are due for delivery this autumn and next spring, and the balance within the next year. Exact data of the vessels building is not available, but it is known that they will range from 400 to 500 tons displacement when submerged, with a surface speed of at least 14 knots and a submerged speed of from 10½ to 11 knots. They are all twin-screw vessels with heavy-oil engines, and in all cases they are equipped with at least four bow torpedo-tubes. Besides the work done in the United States thus briefly summarised, the Holland type is well known in Europe, owing to the work done by the well-known European firms holding licenses from the American company — viz., Vickers, Limited, in England, the Whitehead Company in Austria, the Nevsky Works in Russia, the Deutsche Parsons Turbinia Company in Germany, and the "De Schelde" in Holland. In some cases their work has been from designs by the American company, and under the supervision of the American company's engineers. In other instances modifications have been introduced into the designs by the licensees working in conjunction with the Admiralties of the respective Powers for which the boats have been built. Leaving aside the very large number of boats built and building in Europe from designs modified by the European builders, the number of vessels up to date built or building to the detailed designs of the American company is sixty-seven, the orders coming not only from the United States, but from Europe, Japan, and South America. This number excludes the 74 boats built or being built for Britain, and the others owned or ordered for Holland and Denmark, and also the boats built for Japan by Messrs.

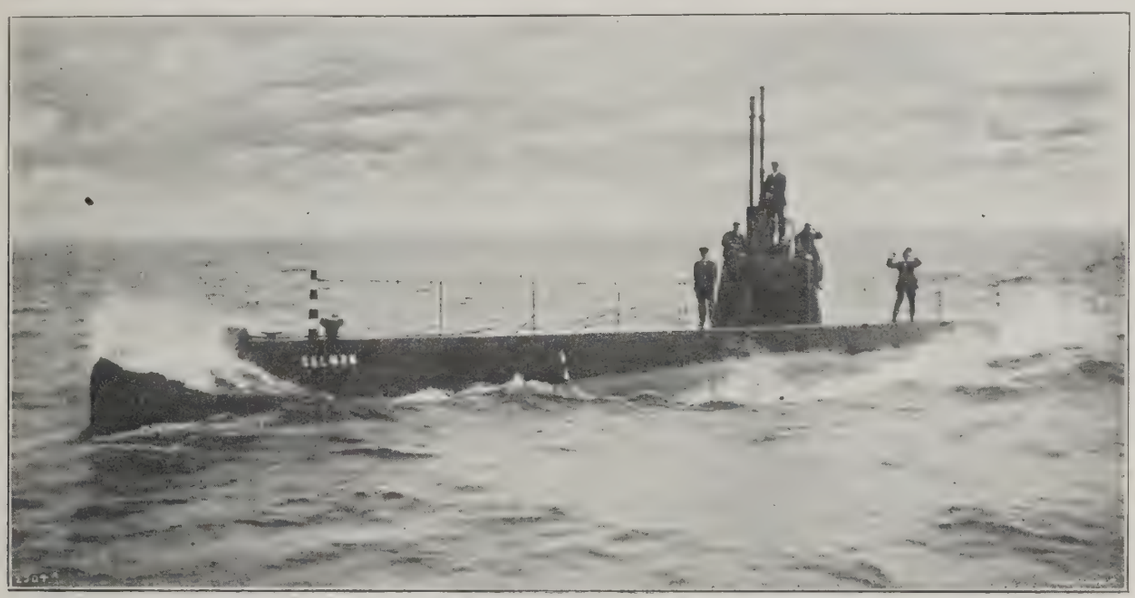


Fig. 1. The United States Submarine-Boat "Salmon" (Speed 13 Knots) Cleared for Action. Ready for Quick Dive.

* See Engineering, vol. lxxi., page 395.

* Acting Secretary of the Navy Winthrop stated that the run across Massachusetts Bay was an excellent performance. "One vessel," he said, "made a considerable run at a depth of 60 ft. The course from Newport to Gloucester was 150 miles, and some of the boats made 120 miles of this run submerged. The longest time submerged was between eleven and twelve hours. There were no mishaps, and officers and crews came in in fine condition on Saturday, after being out two days and nights. It was a splendid practice cruise, and the practicability of submerged cruising is proved by the fact that the entire run was made by all seven boats without a single one being discovered by a score of other ships in their immediate vicinity from time to time."

Vickers, Limited. In all 152 boats belonging to the Holland generic type have been built or are being built—more than half the number owned by all the Powers. Britain, according to the latest Government returns, has 74 built or building; France, 81; United States, 35; Russia, 30; Italy, 20; Japan, 13; and Austria-Hungary, 6; the number for Germany is uncertain.

When the number of boats now in operation, and their wide distribution throughout the world, are remembered, it is remarkable that up to the present time not a single disaster has occurred to any boat built to the unaltered designs of the Electric-Boat Company of New York. Good fortune, of course, must have contributed to this fine record, since there is at least one danger inherent in submarine operations which cannot be fully guarded against by any amount of skill and experience in design and construction. We refer to the case where the submarine, operating submerged, is run down by a large surface vessel, as illustrated by the sad accidents to the British boat A 1 and to the French boat Pluviose. The number of disasters in Europe and Japan from other causes makes notable the entire freedom of the American designed boats from such disasters, especially when it is remembered that in numbers and in wide distribution this is by far the leading type. To some extent, at least, this immunity from accidents must be ascribed to the wide experience of the Electric-Boat Company, and to its refusal to incorporate into its designs the dangerous "fads" so often advocated by inexperienced persons. In connection with the technical staff of these builders, too, it is interesting to note that the company early recognised that the successful development of this type of craft could only be ensured on safe lines by combining the special qualities and experience of the naval officer, the engineer, and the naval architect. Thus their technical staff has for many years been under the direction of Mr. L. Y. Spear, late naval constructor, United States Navy, assisted by Mr. G. C. Davidson, late lieut.-commander, United States Navy, who had specialised in engineering and torpedo work.

The development in size, speed, and fighting power during the past ten years is set out in chronological order in Table I. The displacement of vessels, it will be seen, has risen from 70 to 950 tons; the surface speed from 6 to 17 knots; the horse-power of the internal-combustion engines from 50 to 2000 brake horse-power; the surface cruising radius from 200 to 5000 nautical miles; the submerged speed from 5 to 12 knots; the radius of action when submerged from 20 to 140 nautical miles, and the armament from one torpedo-tube to eight. The last column in the table gives the collective displacement tonnage of vessels built in each year.

TABLE I.—Dimensions, &c., of Typical Holland Submarine-Boats Built in Successive Years, with Total Tonnage of Vessels Built.

Date of Design.	Displacement Submerged.	Surface Speed.	Surface Radius of Action.	Maximum Speed Submerged.	Submerged Radius of Action.	Number of Torpedo-Tubes.	Horse-Power on Surface.	Horse-Power when Submerged.	Total Tonnage Built or Building.
	tons	knots	miles	knots	miles		b.h.-p.	e.h.-p.	tons
1895	70	6	200 at 6 knots	5	20 at 5 knots	1	50	50	70
1900	122	8.5	300 at 8.5 knots	7	25 at 7 knots; 40 at 5 knots	1	160	70	3,050
1904	170	9	540 at 9 knots	8	60 at 5 knots	2	250	150	510
1904	273	11	900 at 9 knots	10	80 at 5 knots	2	500	320	1,911
1907	337	13	1300 at 11 knots	10½ and 12	100 at 5 knots	4	600	350 and 500	1,011
1908	370	13½	2200 at 11 knots	11	100 at 5 knots	4	600	500	740
1909	430	14	2500 at 11 knots	11	100 at 5 knots	..	800	600	1,720
1910	475	14½	3200 at 11 knots	10½	100 at 5 knots	..	950	..	1,425
1911	520	14½	4500 at 11 knots	10½	120 at 5 knots	..	1000	—	—
1911	950	17	5000	11	140	8	2000	..	7,924
							Grand total tonnage ..		18,361

The figures for 1908-11 are approximate; official data are not available.

Note.—This table is exclusive of the boats built by licensees from modified designs, and is also exclusive of certain special designs.

While the so-called Holland and modified Holland boats are fairly well known in Europe, it would appear that, outside Admiralty circles, but little is known in Europe of the diversified products of the Electric-Boat Company of New York. In other words, the name is usually associated only with the type of vessel developed, step by step, from the original Holland, and still retaining some of the principal characteristics of its progenitor. These highly-developed and perfected Hollands still constitute the principal output of the firm, which considers that for general service that system presents on the whole the best possible combination of qualities. For special service, however, and especially where limitations are placed on draught, special designs are used, departing radically from the "Perfected" Hollands. We are enabled to illustrate on Plate LVI., published with this week's issue, sections and plan (Figs. 2 to 8) of a good example of the "Perfected" Holland type, as well as similar drawings of an interesting special design of a much larger and more powerful boat (Figs 9 to 14). A number of vessels to both designs are now under construction by this firm.

The "Perfected" Type of Holland Boat.

Referring first to the perfected Holland (Figs. 2 to 8), the general characteristics of the vessel illustrated are as follow :—

Length...	150 ft.
Beam	15 ft. 6 in.
Displacement, surface ...	390 tons
,, submerged ...	520 tons
Buoyancy percentage of submerged displacement ...	25 per cent.
Buoyancy percentage of surface displacement... ...	33 per cent.
Surface speed	14½ knots
Surface cruising radius ...	4500 nautical miles
Submerged speed	10½ knots
Submerged radius	120 nautical miles
Armament	4 torpedo-tubes and eight torpedoes

All torpedo-tubes are of the internal type, thus permitting access to the torpedoes at all times for adjustment, charging, &c. Provision is made for reloading the tubes while submerged. A complement of two officers and eighteen men is provided for. The stores and fresh-water supplies are for twenty days. The safe depth of submersion is 200 ft.

The general arrangement of the vessel will be sufficiently clear from the plans and sections, so that a very brief description will suffice. The extreme bow of the vessel (Fig. 3) is occupied by four torpedo-tubes, installed in accordance with a special system patented by the firm. This enables double the usual number of tubes to be employed, and, at the same time, preserves great rapidity, simplicity, and certainty of action of all the operating mechanisms. The space around the tubes is used for water-ballast, and is divided into two compartments by a complete transverse bulkhead. The cap or shutter which forms the outboard closure for the tubes is protected by a very heavy steel stem, which ends in the overhanging superstructure forward (Figs. 2 and 3). The tubes themselves are of strong construction, and serve, together with their connections, to give great strength and rigidity to the bow, affording thorough protection to the vessel against the effects of a head-on collision. The efficiency of this arrangement has been amply demonstrated by collisions which have actually occurred in service, as, for instance, in the case last year, when the mother ship Castine was rammed by the submarine Bonita, when the latter was proceeding at full speed submerged. The ship was seriously damaged, and had to be hurriedly beached to prevent sinking, but the submarine escaped without any injury worth mentioning; no leaks were started, and no damage was done except to the superstructure forward and to the periscopes.

The working space in the boat, from the torpedo-tubes aft, is divided into five separate compartments by complete transverse steel bulkheads, each being fitted with a suitable water-tight door. Beginning forward, the first compartment is the torpedo-storing compartment, which contains the breech-doors of the torpedo-tubes (Fig. 8), illustrated also in the engraving, Fig. 21, on page 659, the spare torpedoes, the torpedo-loading gear, &c., and the submerged anchoring-gear. Underneath, between bottoms, are tanks for a good portion of the oil fuel. This compartment is also arranged as a separate living compartment for the two officers.

The next compartment is the forward crew-compartment, under the floor of which, in a water-tight tank, is half of the electric storage batteries; this is entirely surrounded by ballast-tanks, which extend well up the sides of the hull. In this compartment, too, twelve men are berthed, comfortable sleeping accommodation being afforded for the two watches off duty during surface cruising.

The next compartment constitutes the central operating compartment (Fig. 7), in which is located the eye-piece of the commanding officer's periscope, as well as all the other important elements of submerged control, such as diving-gear, air-system controls, ballast-tank floods and drains, &c. Views in such control station are given in Figs. 22 to 26, on pages 659 and 670. By this arrangement all members of the crew having important duties in connection with submerged operations are under the immediate control of the commanding officer, who is enabled to see exactly what is being done, and can thus easily prevent errors on the part of the crew. The conning-tower is located immediately above this compartment, and is separated therefrom by a quick-closing water-tight hatch. An additional periscope is fitted in the conning-tower, which is also equipped with all the necessary fittings to enable it to serve efficiently, first, as a deck conning and steering station for severe or cold weather; second, as a trimming-station; and, third, as a submerged look-out station. Both periscopes are equipped with special range-finding and torpedo-directing apparatus, and the torpedo-firing apparatus is located within easy reach thereof.

The next compartment aft is the after crew compartment, in which, when at anchor, four men are berthed, thus providing, together with the forward compartment, separate berths for all the crew except the two on anchor watch. Under this are the electric storage batteries, while ballast-tanks occupy the sides and the lower part of this compartment, the construction being identical with the corresponding forward compartment. In this compartment also are located the galley and mess arrangements.

The after compartment constitutes the engine-room (Fig. 5), in which is installed a twin-screw power equipment. Each shaft is fitted with a heavy-oil engine directly connected to an electric motor (Fig. 4), the power being 1000 brake horse-power in the case of the main engines and 600 electric horse-power for under-water propulsion. Fuel and lubricating oilare stored underneath the engines and in the after part of the compartment; the main bilge-pumps and air-compressors are installed in duplicate, one set on each side of the ship, driven from the main shaft by a suitable arrangement of gears controlled by friction clutch. This enables the auxiliary machinery to be operated either by the oil-engine or by the electric motor.

The superstructure, which is of the self-bailing and filling type, provides a working deck, which, on account of the good freeboard and buoyancy arranged for in the design, is dry and comfortable in moderate weather. For very heavy weather, an elevated station, fully equipped as a deck steering-station, is constructed on the top of the conning-tower, and a weather "dodger" is fitted thereon (Fig. 7). Access to this elevated station is obtained through the conning-tower and from the after crew's compartment, and ample area is provided to accommodate all the crew off duty at any time, so that fresh air and exercise can always be had, even in severe weather.

Provisions for Safety.

It will be noted from Fig. 3 that hatches are fitted in each of the internal compartments except the forward crew's department. These serve not only to provide convenient access to the various compartments when the vessel is on the surface, but also as a means of escape for the crew in the event of a disaster when the vessel is submerged. A hatch being located in each of the compartments where men are stationed submerged, the means of escape are thus ready to hand for each member of the crew. In connection with these hatches, a special system of partial and complete bulkheads is so arranged that air-locks are automatically formed in each compartment, so that,

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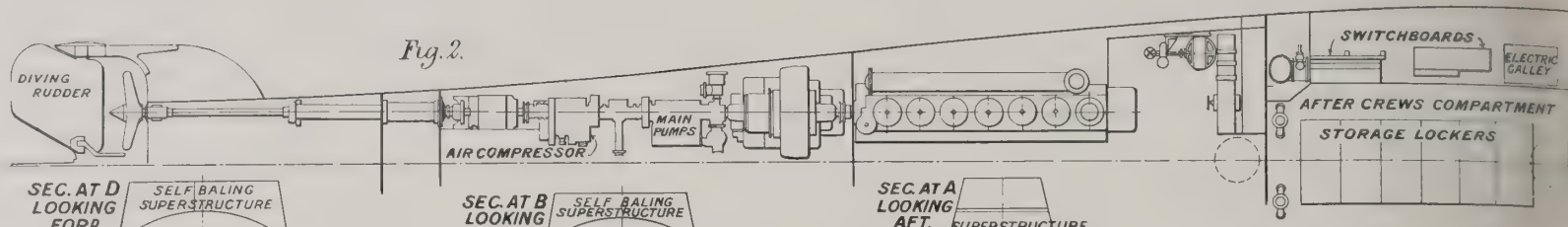
Fig. 2.



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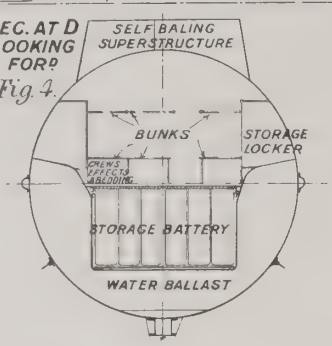

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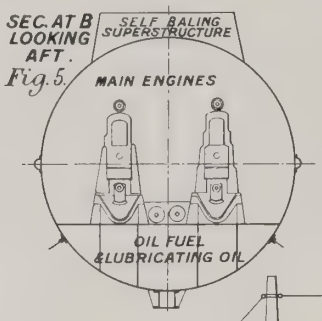

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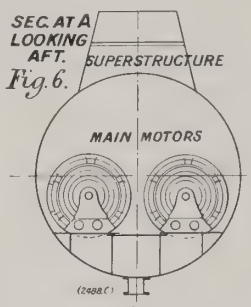

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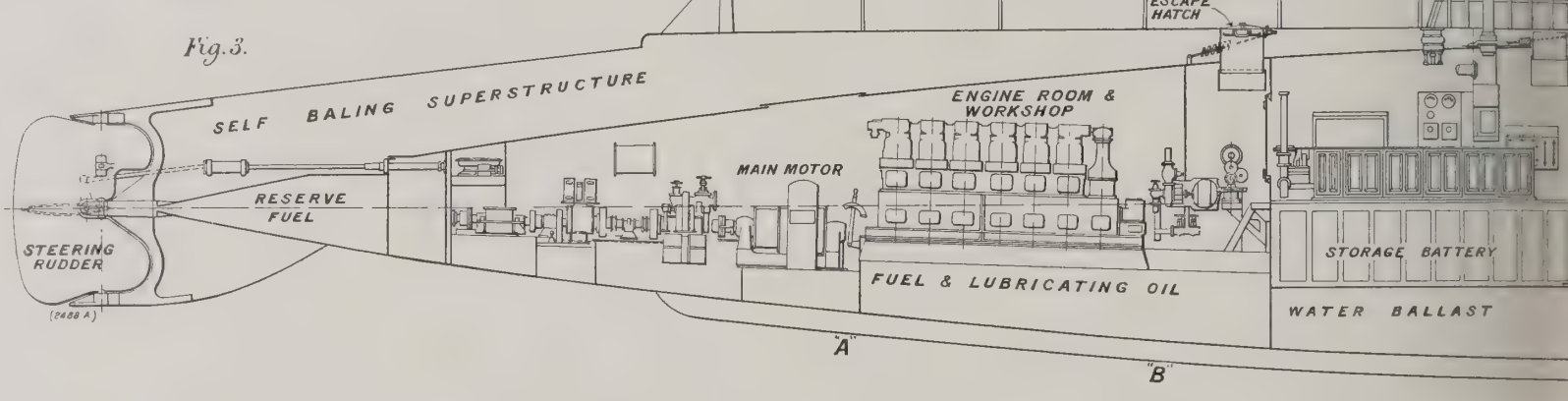

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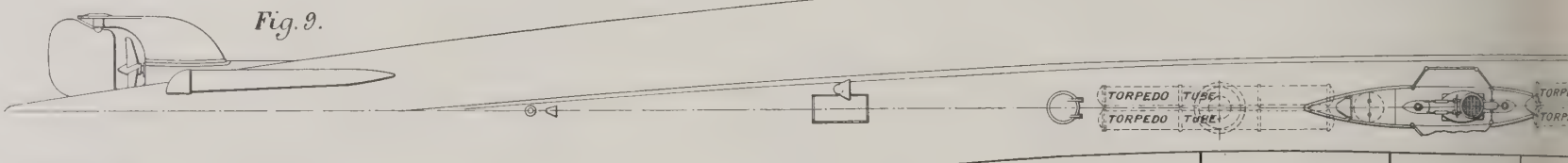

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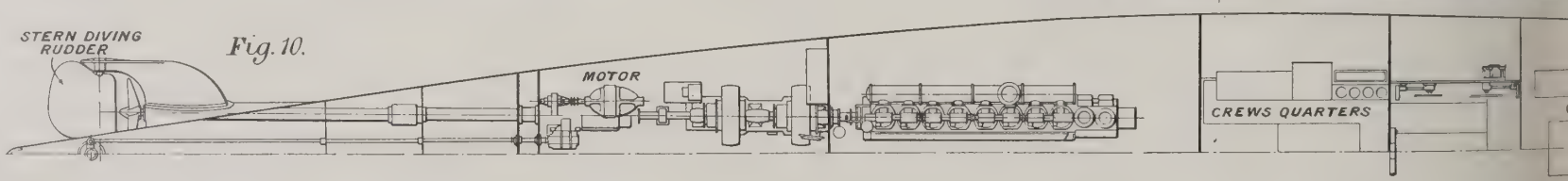


Fig. 12.

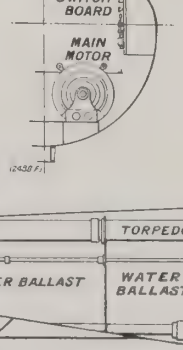
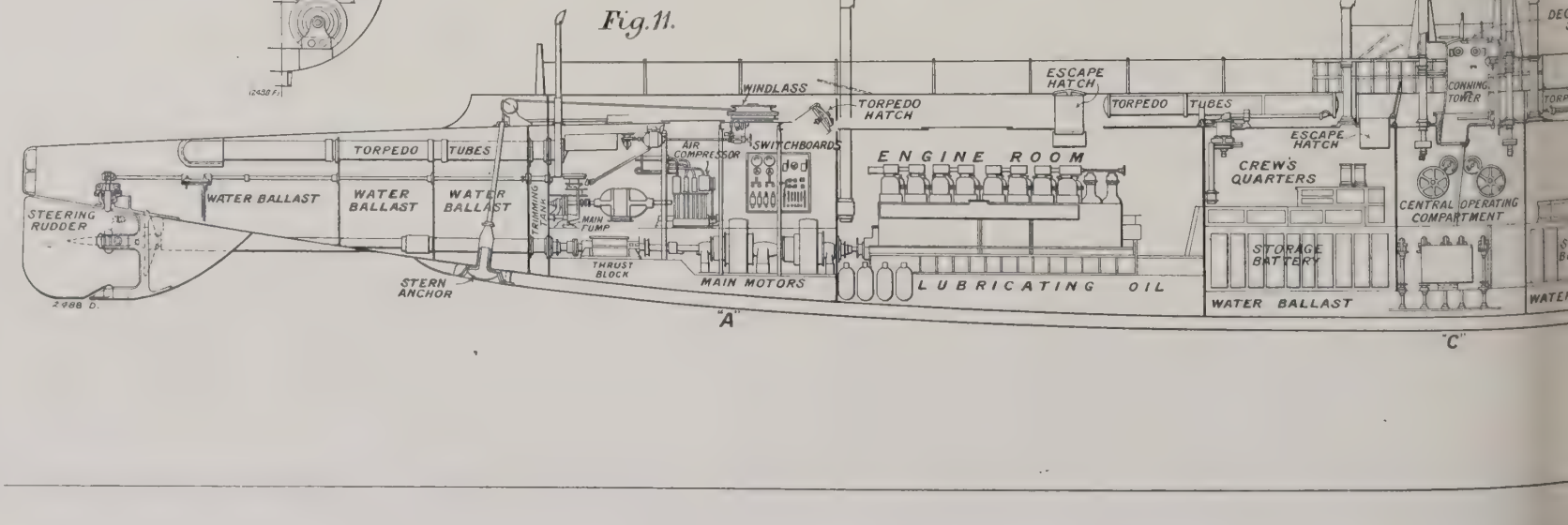


Fig. 11.



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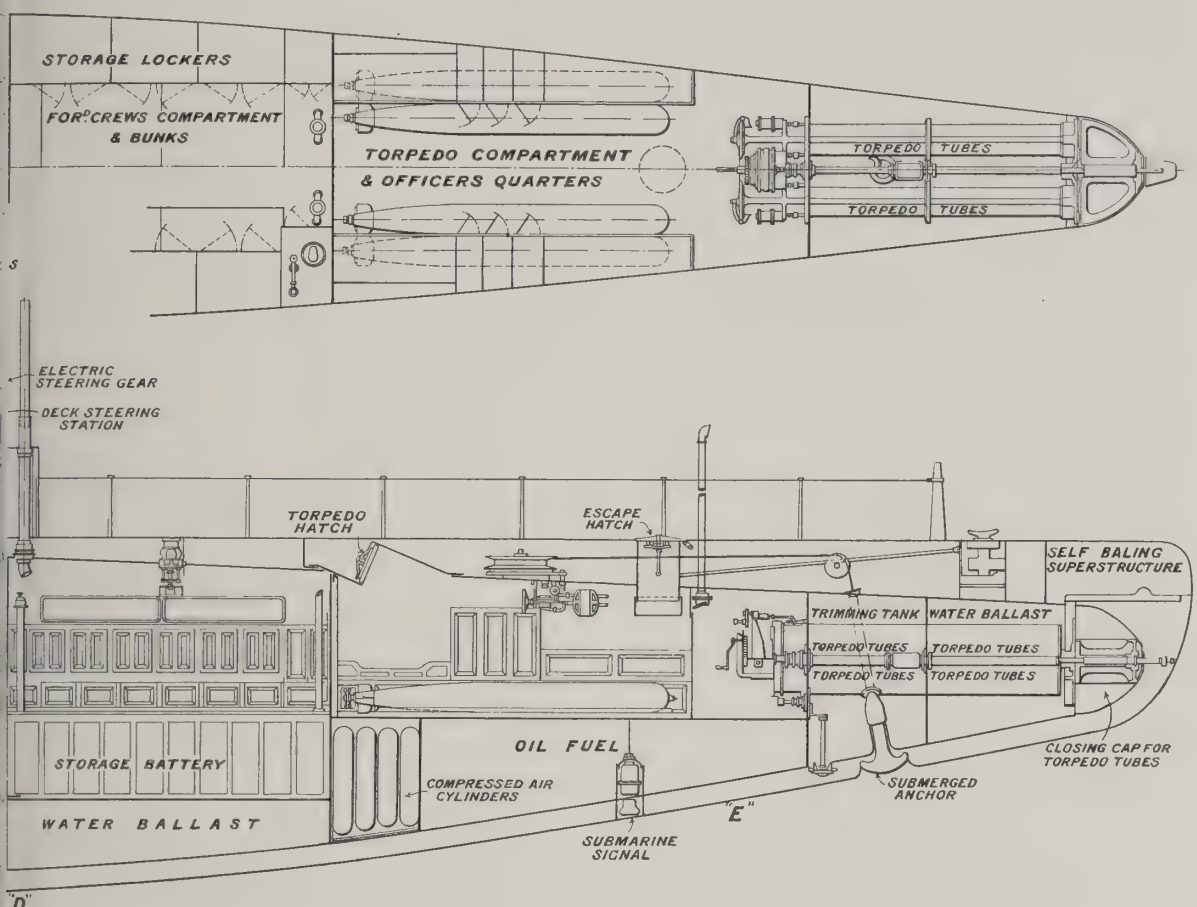
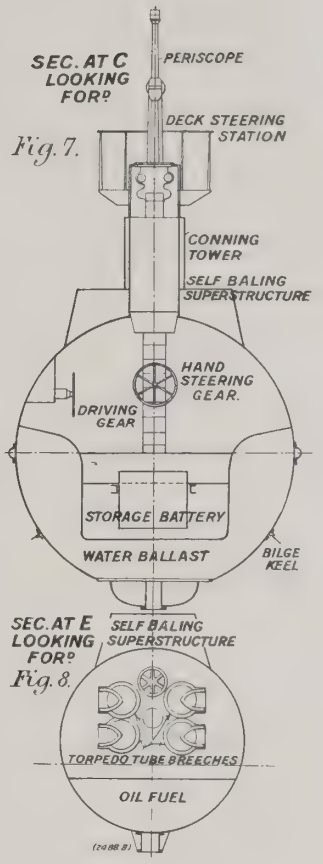
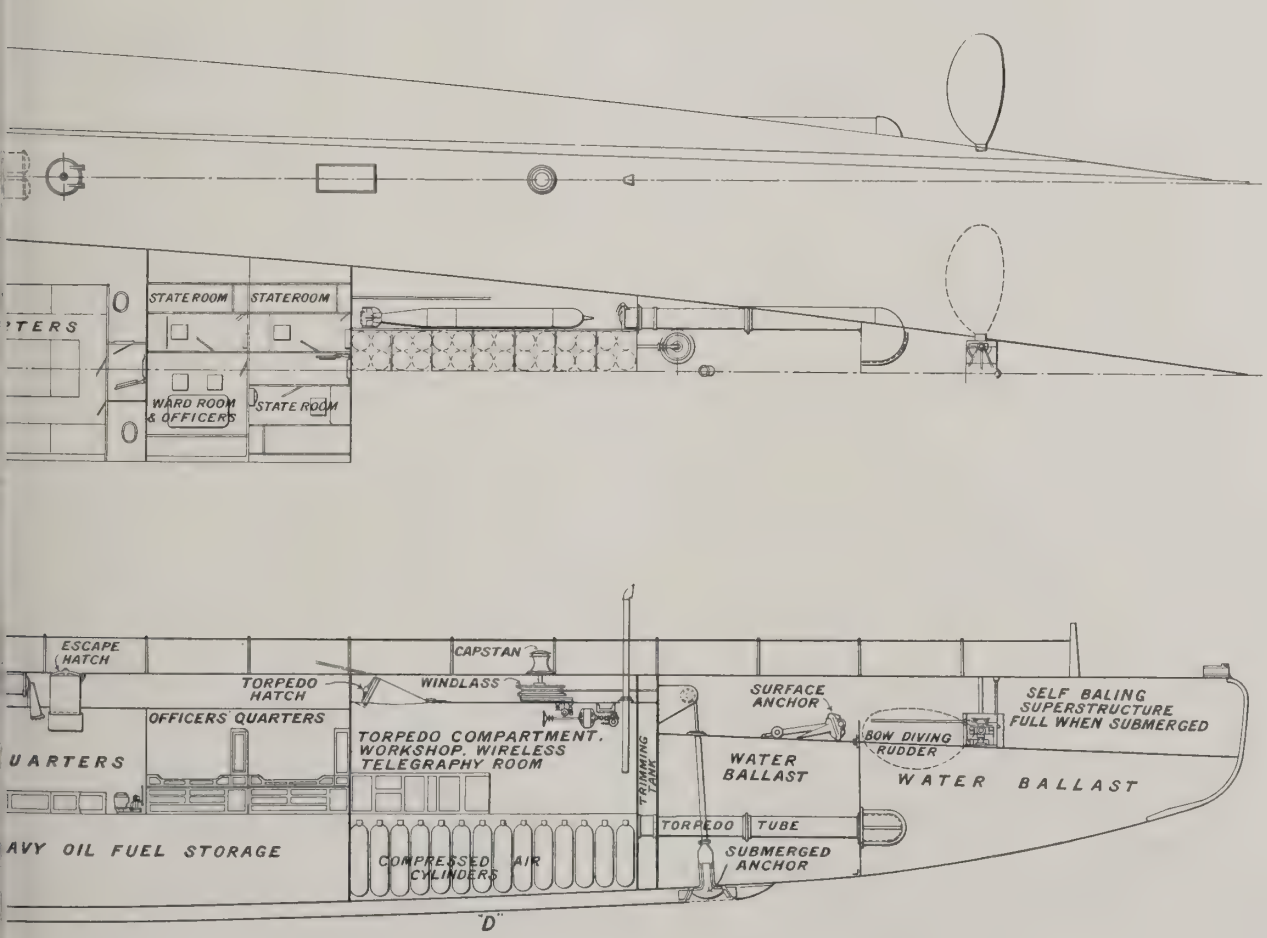
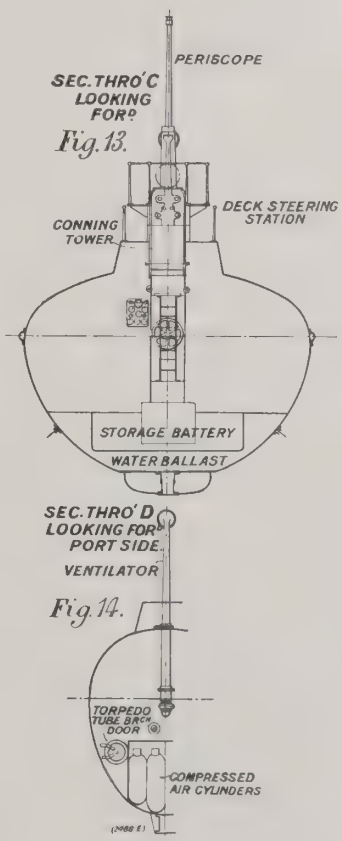








in the event of a disaster in water of moderate depth, escape may safely be made without the necessity of operating any special appliance. Special escape-helmets are employed for escape from the ship in deep water; these embody the patents of the Siebe Gorman Company and the Electric-Boat Company.

Owing to the special installation of the electric storage-batteries, the bulkhead arrangements, &c., the crew are efficiently safeguarded against the effects from gas poisoning which would follow a disaster allowing salt-water access to the storage battery and to the electric terminals generally. The designers consider this arrangement superior to the provision of special escape compartments for the crew, as it would be impossible under many circumstances for the crew to make their way to such a compartment. Again, the patented system adopted in this design does not interfere in any way with the military qualities of the vessel, which cannot always be said in the case of the other system, where space and weight have to be specially reserved for the escape arrangements.

The general theory of safety upon which the design is conceived is that, as far as is possible, the general structure should provide against the possibility of admitting water to the hull, even as the result of a collision, and, secondly, that ample provision should be made for rapidly freeing the vessel of water, either from the ballast-tanks or other parts of the interior. This is accomplished, so far as the latter is concerned, by providing powerful quick-acting pumps, and, as far as the ballast-tanks are concerned, by constructing all the walls of great strength, so that they may be freed by air at high pressure as well as by the pumps. These arrangements permit of the rapid creation of a large amount of buoyancy at any depth. A simple hand-control serves to achieve this end, while at the same time there is an automatic apparatus which prevents the vessel passing beyond a predetermined depth. Thus if, as in the A 1 accident, the crew should be incapacitated through shock of collision, and the vessel should take on board sufficient water to sink, her tanks would be cleared automatically when she reached the depth for which the apparatus is set.

Rescue measures, in the event of a disaster, should be directed generally to ensure the escape of the crew from the boat rather than the salvage of the vessel itself. The latter, for obvious reasons, presents almost insuperable difficulties; lifting-shackles, sometimes fitted, are regarded by many as of no practical value, except as a convenience to the salvage company in securing an abandoned submarine wreck. The arrangements for the escape of the crew should not involve their working of special apparatus only capable of being operated under the conditions following a disaster. On the contrary, the gear should be of the simplest character and should form an integral part of the structure of the vessel, located with particular reference to the positions actually occupied by the crew during submerged operations.

Submergence Tests and Strength.

The exterior form of the hull amidships, it will be seen from the cross-sections (Fig. 7), is circular, except as modified by the superstructure. Suitable modifications are introduced at the bow and stern (Figs. 5, 6, and 8) in order to avoid certain natural operative defects encountered when a pure cigar shape is adopted. This form of structure has certain advantages, one being that the maximum strength against crushing forces is obtained on a minimum weight. Vessels of this type are considered to be good for a submergence of at least 250 ft., and are all actually tested to the depth of 200 ft., as against 100 ft. to 140 ft. for other well-known types. As many of these vessels have been actually subjected to these tests, no doubt is now entertained as to the strength provided for in the design, and the submergence test made is regarded merely as a final precaution for guarding against the existence of hidden defects in the material. Indeed, it is looked upon as analogous to the cold-water test of a boiler, and is therefore generally made without the crew. Where, as on the Atlantic Coast of the United States, sheltered water of great depth, 200 ft. to 250 ft., cannot be obtained, the carrying out of the test presents some difficult and delicate problems. The earliest tests of this kind were made by lowering the vessel from a floating derrick to the bottom with negative buoyancy. This, however, is an exceedingly delicate operation, for while the actual weight being lowered is only a matter of a few tons, the inertia effects correspond to the full submerged displacement of the vessel. It is easy to see that the inertia effects of 400 or 500 tons might easily prove disastrous, so that when this method is employed, special arrangements have to be made to restore positive buoyancy to the submerged boat in the event of the lines parting. To avoid these difficulties, the method has been changed so that the vessels have positive buoyancy, and are hauled down to the bottom by suitable anchorage gear. Should the hauling-lines part, the vessel, of course, automatically rises to the surface. This method has the further advantage that the test can be made in other than dead-smooth water, which is not the case with the first system.

The Principle of the Diving Mechanism.

To those who are familiar with the earlier examples of this general type, the study of the above design will reveal the principal aims of the designers, which evidently have been to secure a large development in the speed, radius of action, armament, habitability, and sea-going qualities, without sacrificing any of the sound principles responsible for the mechanical success of the earlier boats. In making this development account has necessarily been taken of the enlarged *rôle* of the under-water craft. The work of the earlier boats was assumed to be confined to harbour defence, so that operations on the surface for long periods in bad weather were not taken into account in the early designs. Obviously a mere increase in displacement would not fit the vessels to keep the sea for long periods, so that special modifications have necessarily been introduced for the purpose. For instance, the percentage of reserve buoyancy allotted to the earlier vessels—viz., from 12 to 14 per cent.—has been increased to suit the enlarged scope of the work they have to do, and in the latest types it is as much as from 23 to 28 per cent. of the submerged displacement.

Perhaps the best illustration of the experience of the Electric-Boat Company will be found in the fact that it is the only firm which claims to be able to produce vessels, running up to 300 or 400 tons displacement, that can be perfectly controlled by the use of stern diving-rudders only. All other builders employ (except for very small vessels) additional horizontal rudders at the bow, supplemented in many cases by submerging planes or hydroplanes fitted amidships. Such appliances (while generally necessary in large boats) are considered objectionable in so far as they interfere seriously with the submerged speed, and are exceedingly liable to disarrangement either through the action of the sea when cruising on the surface, or when coming alongside docks or other vessels.

It has been claimed for the submerging planes that they confer on the vessels fitted with them qualities not possessed by others, especially that they enable the boats to rise and sink at will, without fore and aft inclination of the axis of the boat. The advocates of this system attach great importance to such qualities, and contend that safe and certain operation submerged is not otherwise possible. In the attempt to prove this allegation, it has been a common practice to assert, first, that operation by stern rudders alone can only be made practicable by reducing the stability to a minimum, and, second, that, in practice, vessels so operated must necessarily use large and dangerous angles of inclination. Practical experience with the Holland boats shows that, far from reducing the submerged stability of the boat controlled in submerging solely by stern rudders, the designers have endeavoured to make it a maximum, and this object has been achieved, as the Holland boats' metacentric height submerged is materially greater than in the prevailing practice with other types. Again, in practice, no difficulty has been encountered with respect to uncontrolled dives; as a matter of fact, the angle of inclination of the fore and aft axis is entirely within the control of the operators. Where there is ample depth of water, and the time required to dive must be minimised, angles as large as 4 deg. and 5 deg. are employed, but under ordinary circumstances the maximum angle of inclination does not exceed from 2 deg. to 2½ deg., which is about the angle necessary when the diving apparatus is complicated by the additional bow-rudders and submerging planes, or hydroplanes above referred to. It has sometimes been stated that Holland vessels are subjected to the danger of plunging their noses into the bottom when diving in shallow water. The improbability of such result is established by the fact that the change in draught for diving does not exceed 3 in. or 4 in. In other words, these vessels can dive without striking the bottom in a depth of water only 4 in. greater than would be required if they sank on a perfectly level keel.

The operation of diving and the small angle necessary, as already explained, is well illustrated in a series of views on page 658 (Figs. 15 to 20), which show the angle at different stages and various depths.

950-Ton Displacement Submarine-Boat.

The vessel illustrated in Figs. 9 to 14 on the two-page plate is one of the most interesting of the special designs of this firm, and has the following characteristics:—

Length	212 ft.
Beam	21 ,,
Surface draught	12 ,,
Surface displacement	650 tons
Submerged displacement ...	950 ,,
Buoyancy percentage of submerged displacement	31½
Buoyancy percentage of surface displacement	46
Armament	Eight torpedo-tubes
Surface speed	17 knots
Submerged speed	11 ,,
Surface radius of action ...	5000 nautical miles
Submerged radius of action ...	140 ,,
Complement	3 officers and 24 men
Stores and supplies for 30 days.	

Special designs of this or similar character are ordinarily employed only when the boats have to meet severe conditions on a limited draught. Wherever possible, the main features of the design first described are incorporated also into these special designs; and thus, in many respects, the two boats illustrated on Plate LVI. are identical. The special design (Figs. 9 to 14), however, is materially different to the other in the form of the hull, the cross-sections of which depart greatly from the circular sections employed in the other design. As this special form of hull has not the natural strength to resist external pressure possessed by the hull with circular sections, a special system of hull construction has to be used, as well as a special arrangement of ballast-tanks. The arrangements in these two respects constitute the principal differences between the two types illustrated. In general appearance this special type is more nearly analogous to the submersibles built in France from the designs of M. Laubeuf, and in Italy from the designs of Major Laurenti. The system of construction, however, is quite different to either of these familiar types, and special advantages are claimed for it.

As the plans and sections give a good idea of the general arrangement and appearance, no detailed description will be attempted here. We shall content ourselves with pointing out that in this design also great attention has been paid to the provision of comfortable accommodations for the officers and crew, and that the standard features employed in all designs with respect to safety and certainty of operation submerged are preserved, including the system of complete bulkheads, means of escape, central operating compartment, &c. Moreover, as with this system the conditions as to stability, &c., on the surface are quite different to those obtaining in the "Perfected" Hollands, it has been found desirable to give this type a still greater percentage of reserve buoyancy, in order to secure entirely satisfactory results while operating on the surface.

With vessels of this special type the percentage of weights allowed for the hull construction must necessarily be greater than for the type previously described. Consequently, certain advantages of the previous type must be sacrificed. Two of these may be mentioned here. One is the strength for deep submergence. For this special type this depth has to be materially reduced, and they are therefore tested, not to 200 ft. depth, but only to 125 ft., or in certain cases to 150 ft. Again, owing to the nature of the ballast-tank construction, sufficient weight cannot be allowed to ensure that all walls of ballast-tanks will be of great strength, hence the greater proportion of the water ballast cannot be pumped out at great depth without endangering the outer walls of the tanks. Recourse must therefore be had, in the interests of safety, to special arrangements for freeing the tanks of water by compressed air without exceeding the maximum allowable difference in pressure between the tanks and the sea. It is proper to note, however, that

THE HOLLAND SUBMARINE-BOAT; STAGES IN DIVING.

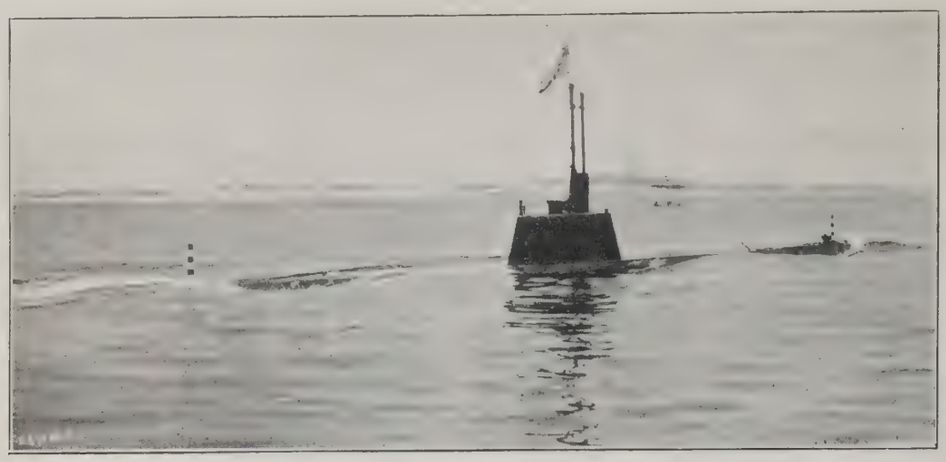


Fig. 15. First Stage; Angle, ½ Degree.

Fig. 17. Third Stage; Angle, 2 Degrees.

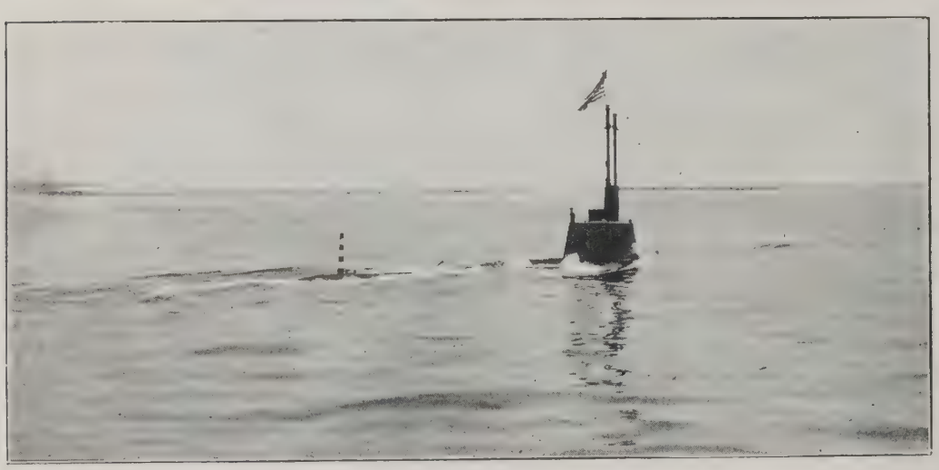


Fig. 16. Second Stage; Angle, 1¼ Degrees.

Fig. 18. Fourth Stage; Angle, 1¼ Degrees.

these disadvantages are inherent in the general scheme, and apply equally well to those solutions of the problem found by other designers.

Both systems of construction, as well as the important details common to both, are the subjects of letters patent granted or pending in all the maritime countries, where already many hundreds of claims have been allowed.

Interior Views in Typical Submarine-Boat.

On pages 659 and 670 we give a series of views of the interior of a submarine which will render clearer the description already given of the arrangement at the various stations within the two types of submarine-boats illustrated on Plate LVI. These views, however, do not apply to the two boats shown in the sectional drawings, but are views of one of the most typical submarine-boats recently completed by the firm. Fig. 21 is a view taken in the torpedo compartment and officers' quarters, showing the breeches of the four torpedo-tubes, together with the operating and firing-gear of the tubes. Overhead is seen one of the special escape-scuttles.

Figs. 22 to 25 are views within the central operating compartment underneath the conning-tower. Fig. 22 shows one of the separating bulkheads, along the lower part of which will be seen the levers for operating the ballast-tank flooding-valves. The ladder seen leads to the conning-tower; overhead is the eye-piece of the commanding officer's periscope, and on each side the electric blowers for the special ventilation of the storage battery. Fig. 23 shows in more detail the eye-piece and operating-gear of the commanding officer's periscope. On the right is seen the diving-gear and depth-gauge used in connection therewith. Fig. 24 shows the diving-gear, together with the duplicate depth-gauges used in connection therewith. The separating bulkhead and the ladder to the conning-tower are seen on the left.

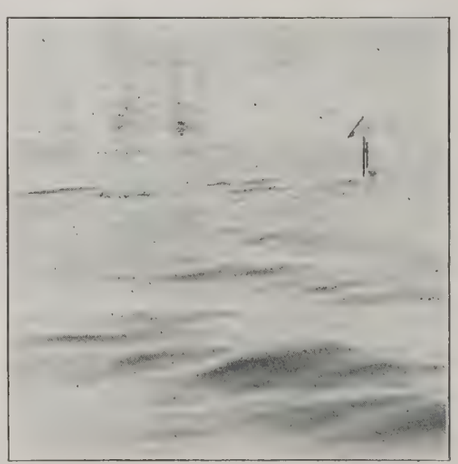


Fig. 19. Completion of the Dive.

Fig. 20. Running Submerged.

Fig. 25 is a view on the side opposite to the diving-gear, and shows the control station for the compressed-air and auxiliary pump, by means of which all the ballast may be quickly controlled from one station. On the left there will be seen an air manifold, containing blow and vent valves for all ballast-tanks, above which will be noted the gauge-board. In the centre is the automatic blow apparatus, and on the right the manifolds and other control features for the auxiliary pump.

Fig. 26 is a view taken in the after crew's quarters, showing the internal hand steering-gear, and on the bulkhead to the left the control-box for the electric steering-gear. Fig. 27 illustrates the engine-room, looking aft, showing the twin internal-combustion engines. The practice of the company is to make up the engines in six-cylinder units on account of the fine balance and even turning moment thus obtained. The air-compressors for the injection air used in the engines are built as an integral part of the engines and are operated from the engine crank-shaft. Fig. 28, a view from the aft end of the engine-room looking forward, shows in the foreground the electric motors, and in the background the internal-combustion

INTERIOR VIEWS OF HOLLAND TYPE OF SUBMARINE-BOATS.

CONSTRUCTED BY THE ELECTRIC-BOAT COMPANY, NEW YORK.

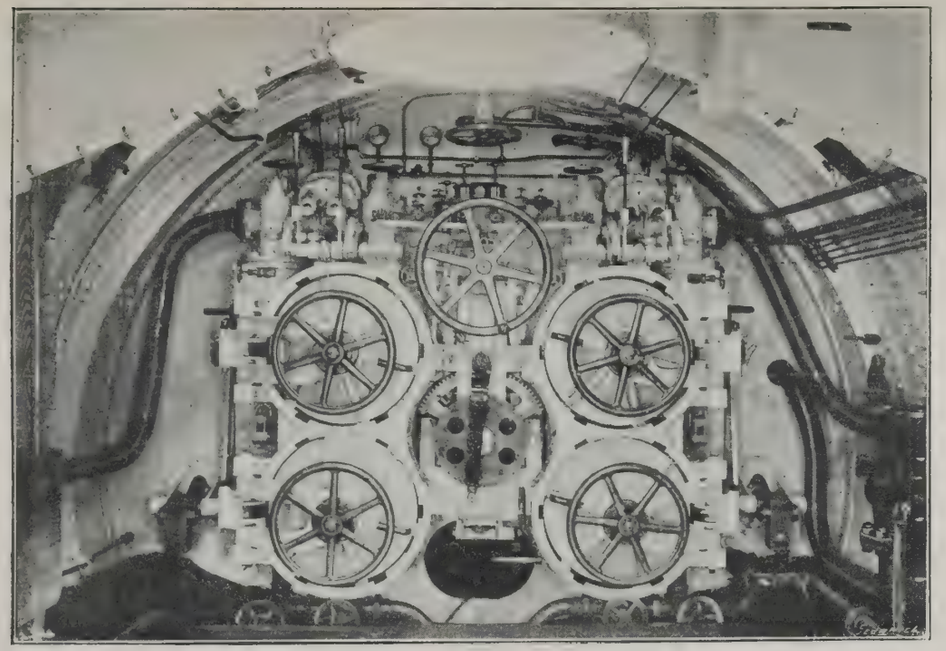


FIG. 21. VIEW SHOWING TORPEDO-TUBE BREECH-BLOCK.

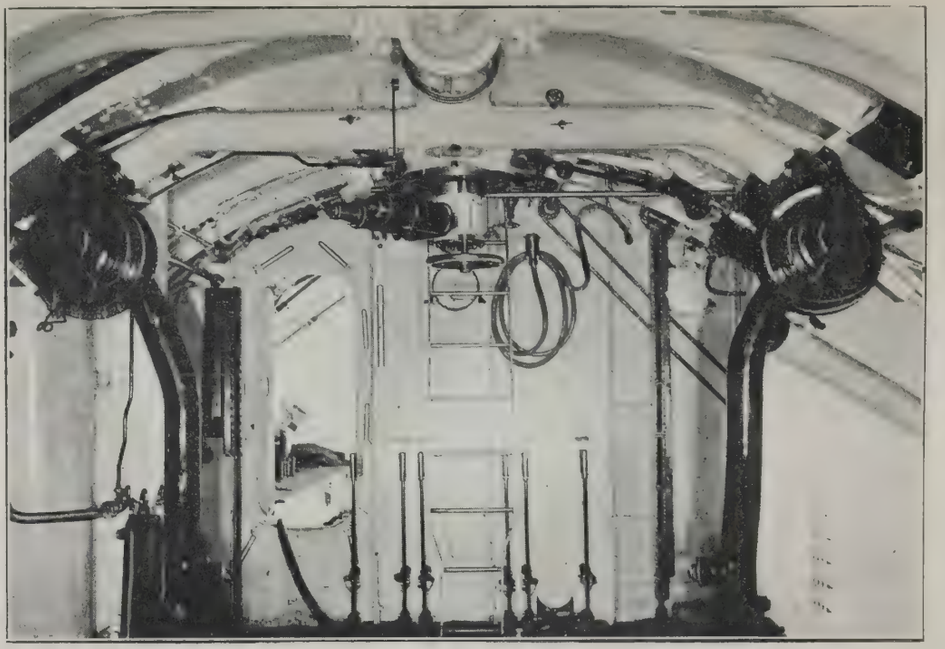


FIG. 22. CENTRAL OPERATING COMPARTMENT, SHOWING COMMANDING OFFICER'S STATION, &c.

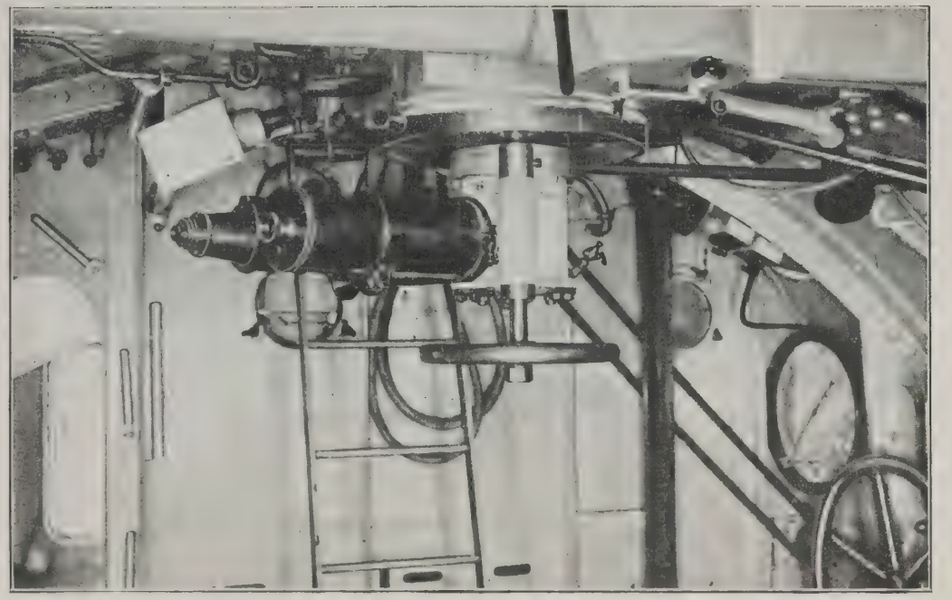


FIG. 23. COMMANDING OFFICER'S PERISCOPE, WITH DIVING STATION ON THE RIGHT.

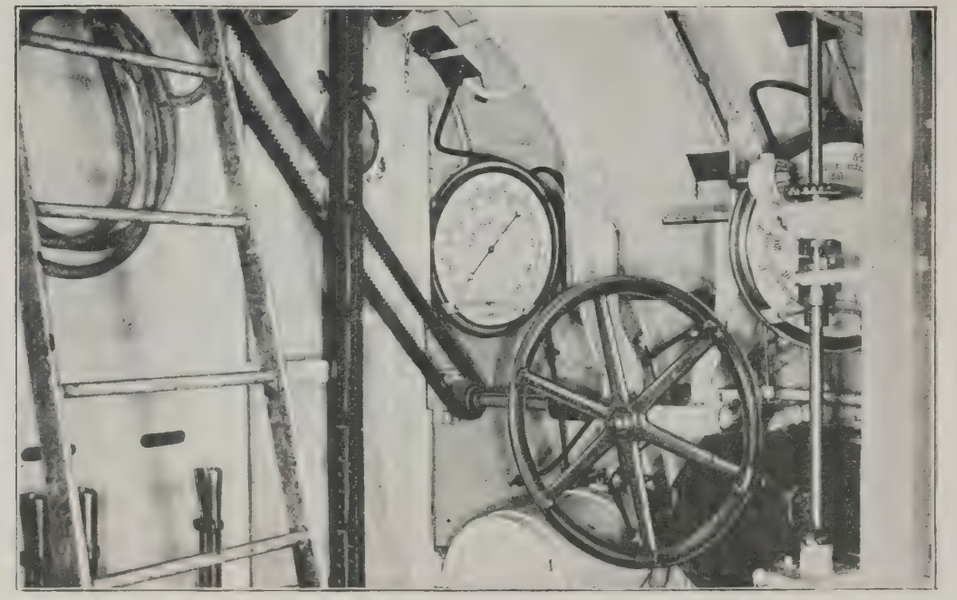


FIG. 24. DIVING STATION.

engines, together with the exhaust piping. The engines are connected to the armature shafts by a special clutch, shown in the view.

Stability Conditions.

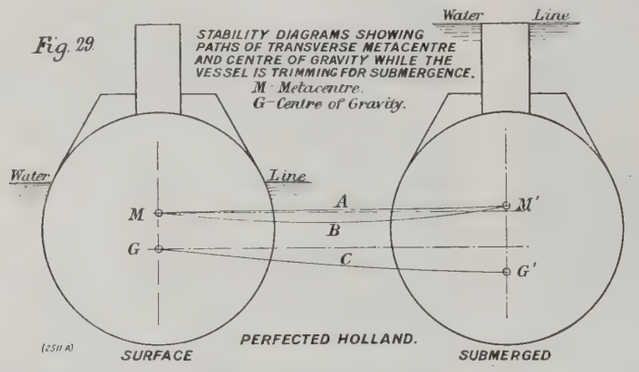
A few words as to stability conditions will not be out of place, since, in this respect, there is quite an essential and an important difference between the two systems of construction, illustrated on the two-page plate. As with any type of vessel, the statical stability of a submarine on the surface is measured by its metacentric height, and hence is determined partly by considerations of water-plane areas and their disposition and partly by considerations of the vertical disposition of the weights. To submerge such a vessel, it is first necessary nearly to destroy its buoyancy by the admission of water to the various ballast-tanks. This necessarily affects the statical stability in two ways: first, the admission of the water to the ballast-tanks necessarily affects the vertical position of the centre of gravity of the vessel as a whole. At the same time, the sinking of the vessel destroys the water-plane area, so that when submerged that element no longer affects the problem, the metacentre having then become coincident with the centre of buoyancy; thus the statical stability in the submerged condition is measured by the vertical distance between the centre of buoyancy and the centre of gravity of the vessel taken as a whole.

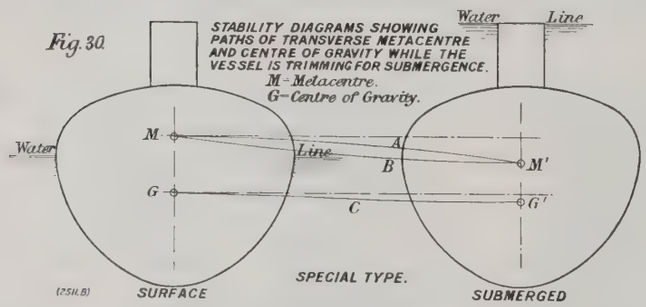
It is a characteristic of such forms as that of the boat illustrated by Figs. 2 to 8 that the position of the metacentre for different water-lines, and for all angles of inclination at any draught, remains almost constant. In practical cases it will be found to be located only a few inches above the axis of the vessel. A glance at the sections will show that all the heavy weights are disposed well down in the ship, the result being that the centre of gravity of the vessel, without water ballast, is well below the axis. This results in a moderate and safe metacentric height on the surface—from 8 in. to 11 in., depending upon the size of the boat. In such vessels the stability curve has an easy rise and a long range, and is, in fact, a curve of sines, with a range of 180 deg., maximum righting arm at 90 deg. These conditions result in a comparatively long period of oscillation, and an easy movement in a seaway. When such a vessel is subjected to the process of trimming for submergence, the superstructure is thrown open to the sea, and becomes, in fact, a non-watertight structure. Hence, for purposes of this description, the water entering the superstructure can be neglected. The principal ballast-tanks of the vessel are located in the bottom, and the boat is brought awash by filling these. During this process the centre of gravity is being lowered, while the vertical movement of the metacentre is upward, although very small. The net result is that the process of trimming increases the metacentric height generally by as much as 50 per cent.

Owing to the fact that free-water surfaces necessarily exist in the ballast-tanks during the process of trimming, it is necessary to take account of the virtual lowering of the metacentre due to these free surfaces. This makes the path of the metacentre a curved line B of the general character shown in the diagram, Fig. 29, A being the theoretical path of the metacentre, not taking account of the free water in the ballast-tanks, and C the path of the centre of gravity. In these designs the ballast-tanks are so shaped as to minimise the amount of free surface, so that at all times during the process of trimming there remains a very substantial margin of stability, and it is therefore safe to undertake this manœuvre in any state of the sea. To sum up, then, this general type has a moderate metacentric height on the surface which materially increases when submerged.

In the case of the special type (Figs. 9 to 14) the conditions are quite different. Owing to the shape of the hull, the water line areas in the surface condition are materially increased, resulting in a high metacentre. Taken as a whole, the centre of gravity of the hull in the surface condition is necessarily somewhat higher than for the first type, but the net result is quite a material increase in the surface metacentric height. The stability curve does not differ very greatly from that of a torpedo-boat or destroyer of ordinary design. In this case during the process of trimming the movement of the metacentre is necessarily down, because, when the water-plane area is destroyed, the metacentre must inevitably coincide with the centre of buoyancy. The movement of the centre of gravity is also down, but not to the same extent as the metacentre, and the net result is a decrease of stability, as indicated on the diagram, Fig. 30. It will be noted, however, that in all stages of the process a good margin of stability is preserved, thus avoiding the defect which has developed in certain other vessels of this general type, where, owing to the small final value of the submerged metacentric height, and the large free areas in the ballast spaces, a critical point is reached when trimming at which the stability is nearly zero. Some very unpleasant experiences have been had with such vessels when the trimming operation has been undertaken in a seaway.

While it is probably too much to expect that every possible virtue in an under-water boat will ever be combined in any one design, or that, having been combined, there will be unanimity of expert opinion as to that fact, nevertheless the conclusion seems to be warranted that the British Admiralty made no mistake when it selected the original Holland type as a basis for the development of British flotillas. Their judgment as to the soundness of the principles involved in the designs, and the competency and the ability of the firm responsible for them, has certainly been confirmed in a gratifying way by the wide acceptance of the same general type, not only in the United States, but in Europe, Asia, and South America. The policy of secrecy pursued by the Admiralty discourages any speculation as to the comparative results on the same tonnage achieved along the lines of development followed here, as compared with the divergent lines in the United States and elsewhere. It is to be hoped, however, that the Admiralty arrangements are such as to permit them to take full advantage of the very important developments elsewhere which have been, and are being, reduced to practice.





THE STEAM-TURBINE.

(*Continued from page* 553.)

As stated on page 309 *ante*, the theory established above makes it possible to determine separately the output and efficiency of each group of a reaction turbine in practically the same way as the corresponding figures are obtained in designing compartment compounded impulse-turbines.

In making such a calculation, however, it will be found in every way preferable to start at the exhaust end and work backwards. The fact is that large variations in the vacuum hardly affect at all the inflow, into the first group of a reaction turbine of the usual type, under a given initial pressure. Conversely, very small differences in the weight passed, under a given pressure through the first row of blades, correspond to very large differences in the final discharge pressure from the last group.

Starting from the high-pressure end and computing the turbine group by group down to the exhaust is almost analogous to working with a divergent series in algebra, whilst if the computation is started at the exhaust end, the operation may be likened to the use of a highly convergent series. To make such a calculation the curves plotted in Figs. 18, 19, and 20 may be used. These are all based on the condition of the steam on discharge from a group in place of its condition at entrance. They have been derived directly from equation (7), page 482 *ante*, by taking γ as 1.108. For those who wish to plot the curves to a larger scale the values of the coefficients are given in Tables VI., VII, and VIII., page 661.* The use of the curves will be best understood by taking an actual example, and in Table IX. is shown the complete calculation step by step of the work done by each group of a low-pressure marine turbine, having a drum 65 in. in diameter, and eight groups of blades of twelve rows each. The blade heights and clearances for each group are given in the first line of the table, and the effective area available for flow in the third line. At final

* In plotting such curves to a large scale the use of formulæ of interpolation is often very convenient, as it is not always easy to get a curve or a spline to fit the tabulated values when widely separated. The most useful of these formulæ is as follows:—If y_0, y_1, y_2, and y_3 be four consecutive values of y, for four equidistant values of x, which may be called x_0, x_1, x_2, and x_3, then the value of y, corresponding to $x_{1.5}$—*i.e.*, to a value of x, midway between x_1 and x_2—is

$$y_{1.5} = \tfrac{9}{16}(y_1 + y_2) - \tfrac{1}{16}(y_0 + y_3).$$

The calculation is most conveniently made as follows:—Add y_1 and y_2, and take the mean. Call this mean $\bar{y}$. Also add y_0 and y_3, and take the mean of these, calling this second mean y^1; then the required value of $y_{1.5}$ is $y + \frac{1}{8}(\bar{y} - y^1)$. This formula was published as new in the *Comptes Rendus* a few months since, but had previously been published in Engineering, vol. xliii., page 398, and is easily deduced from Lagrange's formula of interpolation. As an example, suppose a value of ϕ (Table VI.) is needed for $x = 2.125$ and $\delta_x = 0.2$. We have from the table $y_0 = 1.1948$, $y_1 = 1.6943$, $y_2 = 2.2421$, $y_3 = 2.8386$.

Then

$$\bar{y} = \frac{1.6943 + 2.2421}{2} = 1.9682$$

$$y^1 = \frac{1.1948 + 2.8386}{2} = 2.0167$$

and

$$\bar{y} - y^1 = -0.0485.$$

Hence the required value of y is

$$y_{1.5} = \bar{y} + \frac{\bar{y} - y^1}{8} = 1.9682 - 0.0060 = 1.9622.$$

If the values of x are not equidistant, then we may calculate $x_{1.5}$ corresponding to the above value of $y_{1.5}$ by an exactly similar formula—viz., $x_{1.5} = \bar{x} + \frac{\bar{x} - x^1}{8}$.

Obviously the formula given above cannot be used to calculate, in the case of Table VI., say, values of y corresponding to $x = 1.375$ or $x = 2.375$, but for these we may use the formula

$$y_{0.5} = \tfrac{5}{16}\left[y_0 + 3y_1 - y_2 + \frac{y_3}{5}\right].$$

TABLE VI.—*Standard Blades. Values of ϕ and μ for Plotting the Curves in Fig. 18.*

Values of $x = \frac{p^0}{p_N}$		1.25	1.5	1.75	2.0	2.25	2.5
$\delta_N = 0.2$	ϕ	0.3457	0.7449	1.1948	1.6943	2.2421	2·8386
	μ	0.4167	0.7526	1.0491	1.3211	1.5836	1.8230
$\delta_N = 0.3$	ϕ	0.3118	0.6703	1.0738	1.5219	2.0142	2.5516
	μ	0.3619	0.6498	0.9006	1.1282	1.3408	1.5478
$\delta_N = 0.4$	ϕ	0.2883	0.6202	0.9949	1.4181	1.8756	2.3848
	μ	0.3216	0.5743	0.7938	0.9931	1.1851	1.3600
$\delta_N = 0.5$	ϕ	0.2719	0.5865	0.9445	1.3480	1.7990	2.3011
	μ	0.2909	0.5183	0.7361	0.8955	0.9479	1.2290
$\delta_N = 0.6$	ϕ	0.2607	0.5652	0.9157	1.3162	1.7708	2.2856
	μ	0.2672	0.4757	0.6573	0.8238	0.9868	1.1378

TABLE VII.—*Semi-Wing Blades. Values of ϕ and μ for Plotting Curves in Fig. 19.*

Values of $x = \frac{p^0}{p_N}$		1.25	1.5	1.75	2.0	2.25	2.5
$\delta_N = 0.2$	ϕ	0.3553	0.7669	1.2447	1.7826	2.3745	2.9982
	μ	0.4326	0.7847	1.1059	1.4073	1.7000	1.9568
$\delta_N = 0.3$	ϕ	0.3201	0.6974	1.1357	1.6292	2.1722	2.7492
	μ	0.3772	0.6872	0.9695	1.2330	1.4864	1.7078
$\delta_N = 0.4$	ϕ	0.3019	0.6513	1.0654	1.5388	2.0662	2.6198
	μ	0.3440	0 6179	0 8718	1.1132	1.3494	1.5451
$\delta_N = 0.5$	ϕ	0.2871	0.6217	1.0252	1.4932	2.0216	2.5804
	μ	0.3159	0.5671	0.8 32	1.0306	1.2555	1.4408
$\delta_N = 0.6$	ϕ	0.2776	0.6048	1.0087	1.4868	2.0368	2.6268
	μ	0.2945	0.5296	0.9043	0.9746	1.1968	1.3842

TABLE IX.—CALCULATION OF LOW-PRESSURE MARINE TURBINE PASSING 13.4 LB. OF STEAM PER SECOND; ABSOLUTE PRESSURE AT ENTRANCE 36.15 LB. PER SQ. IN.; AT DISCHARGE = 1.524 LB. PER SQ. IN.

Group No.	1.	2.	3.	4.	5.	6.	7.	8.
h .. .. in.	1	1⅛	2	2¾	4	5½	5½	5½
Clearance .. .. ,,	0.050	0.050	0.055	0.055	0.065	0.070	0.070	0.070
Ω .. .. sq. ft.	0.50126	0.67484	0.9736	1.3332	1.9601	2.7328	4.0987	5.465
$\frac{h-c}{h+\sigma c}$	0.8583	0.8941	0.9183	0.9397	0.9505	0.9611	0.9760	0 9798
s .. .. ft. per sec.	135.31	136.1	137.36	138.92	141.47	144.54	144.54	144.54
p_N .. .. lb. per sq. in.	25.752	17.749	12.438	8.399	5.7441	3.7644	2.5182	1.524
V_N .. .. cub. ft. per lb.	14.83	20.902	28.756	41.17	58.23	85.89	123.65	197.0
v_N .. .. ft. per sec.	396.45	415.02	395.76	413.82	398.1	421.1	404.2	482.9
$\delta_N = \frac{s}{v_N}$	0.342	0.328	0.348	0.335	0 356	0.343	0.361	0.300
$p_N V_N$	381.89	370.95	357.6	345.80	334.45	323.3	311.4	300.1
x	1.404	1.451	1.427	1.481	1.462	1.526	1.495	1 652
B	0.849	0.832	0.841	0.823	0.830	0.810	0.820	0.775
Log x	0.147	0.162	0.154	0.170	0.166	0.184	0.174	0 218
$N + 1.05 \log x$	12.154	12.170	12 162	12.179	12.174	12.193	12.183	12.23
v_N B$_N$ cos α [$N + 1.05 \log x$]	3883.1	3988.0	3842.3	3936.6	3813.3	3947.2	3496.2	3525.9
$\frac{N s}{2}$	811.8	816.5	824.1	833.4	848.7	867.1	867.1	867.1
Q	3071.3	3171.5	3018.2	3103.2	2969.6	3080.1	2629.1	2658.8
$\frac{h-c}{h+\sigma c} \cdot \frac{s}{32.2} \cdot \phi$ .. .. ft.-lb.	11,078	11,984	11,823	12,580	12,391	13,289	11,519	11 693
Useful work done per 1 lb. of steam, in B.Th.U.	14.24	15.41	15.20	16.17	15.94	17.08	14.80	15.03
Indicated horse-power	275.9	293.6	294.2	313.4	308.8	331.0	286.9	291.3
Actual total heat in 1 lb. of steam, B.Th.U.	1103.49	1088.08	1072.88	1056.71	1040.77	1023.69	1008.89	993.86
Sensible heat	210.66	190.45	172.53	153.78	137.5	118.92	103.20	84.51
Actual heat latent	892.83	897.63	900.35	902.93	903.27	903.77	905.69	909 35
Latent heat of dry steam .. B.Th.U.	944.6	958.5	971.2	984.2	996.1	1008.6	1019.6	1032.6
Specific volume of dry steam	15.69	22.32	31 02	44.88	64.21	95.74	139.2	225.0

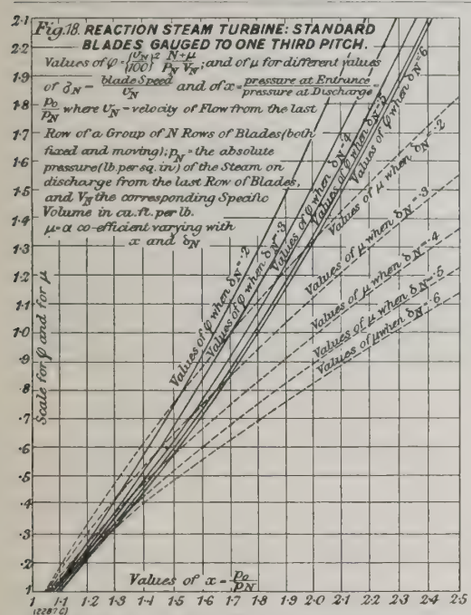


Fig. 18. REACTION STEAM TURBINE: STANDARD BLADES GAUGED TO ONE THIRD PITCH.
Values of $\phi = \frac{(v_N)^2}{(100)^2} \frac{N+\mu}{P_N V_N}$; and of μ for different values of $\delta_N = \frac{\text{blade Speed}}{v_N}$ and of $x = \frac{\text{pressure at Entrance}}{\text{pressure at Discharge}}$ $\frac{p_0}{p_N}$ where v_N = velocity of Flow from the last Row of a Group of N Rows of Blades (both fixed and moving); p_N = the absolute pressure (lb. per sq. in.) of the Steam on discharge from the last Row of Blades, and V_N the corresponding Specific Volume in cu. ft. per lb.
μ a co-efficient varying with x and δ_N
Values of ϕ when $\delta_N = 2$
Values of ϕ when $\delta_N = 3$
Values of ϕ when $\delta_N = 4$
Values of ϕ when $\delta_N = 5$
Values of ϕ when $\delta_N = 6$
Values of μ when $\delta_N = 2$
Values of μ when $\delta_N = 3$
Values of μ when $\delta_N = 4$
Values of μ when $\delta_N = 5$
Values of μ when $\delta_N = 6$
Scale for ϕ and for μ
Values of $x = \frac{p_0}{p_N}$
(2287 C)

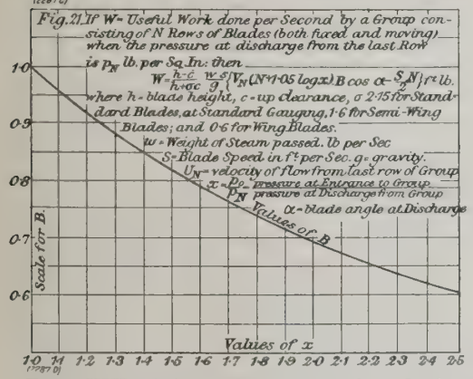


Fig. 21. If W = Useful Work done per Second by a Group consisting of N Rows of Blades (both fixed and moving) when the pressure at discharge from the last Row is P_N lb. per Sq. In.: then $W = \frac{h-c}{h+\sigma c} \frac{v_N s}{g} \{V_N (N + 1.05 \log x) B \cos \alpha - \frac{S_2 N}{2}\}$ ft. lb.
where h = blade height, c = up clearance, σ 2·75 for Standard Blades, at Standard Gauging, 1·6 for Semi-Wing Blades; and 0·6 for Wing Blades.
w = Weight of Steam passed, lb per Sec
S = Blade Speed in ft per Sec. g = gravity.
v_N = velocity of Flow from last row of Group
$x = \frac{p_0}{p_N}$ pressure at Entrance to Group / pressure at Discharge from Group
α = blade angle at Discharge
Values of B
Scale for B.
Values of x
(2287 D)

TABLE VIII.—*Wing Blades. Values of ϕ and μ for Plotting the Curves in Fig. 20.*

Values of $x = \frac{p^0}{p_N}$		1.25	1.5	1.75	2.0	2.25	2.
$\delta_N = 0.2$	ϕ	0.3675	0.7952	1.2805	1.82x6	2.4207	3.0787
	μ	0.4494	0.8168	1.1123	1.4700	1.7838	2.0718
$\delta_N = 0.3$	ϕ	0.3390	0.7328	1.1784	1.6811	2.2464	2.8882
	μ	0.4022	0.7279	1 0156	1.2856	1.5499	1.8123
$\delta_N = 0.4$	ϕ	0.3200	0 6932	1.1196	1.6010	2.1394	2.7388
	μ	0.3680	0.6650	0.9285	1.1729	1.4125	1.6385
$\delta_N = 0.5$	ϕ	0.3077	0.6699	1.0883	1.5671	2.1107	2.7267
	μ	0.3426	0.6200	0.8676	1.0995	1.3298	1.5512
$\delta_N = 0.6$	ϕ	0.3010	0.6604	1.0819	1.5740	2.1448	2.8071
	μ	0.3243	0.5888	0.8277	1.0555	1.2865	1.5152

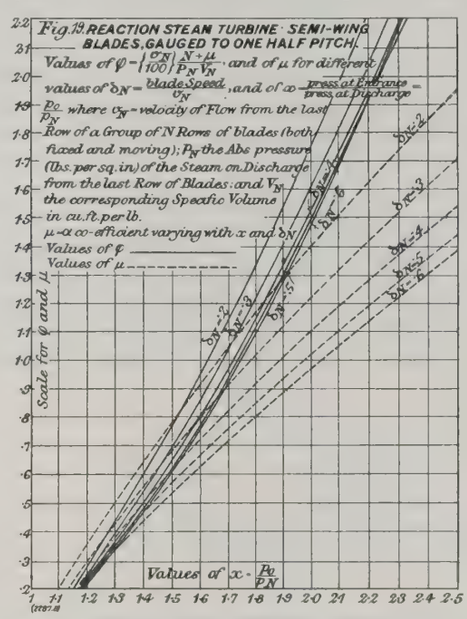


Fig. 19. REACTION STEAM TURBINE: SEMI-WING BLADES, GAUGED TO ONE HALF PITCH.
Values of $\phi = \frac{(v_N)^2}{(100)^2} \frac{N+\mu}{P_N V_N}$, and of μ for different values of $\delta_N = \frac{\text{blade Speed}}{v_N}$, and of $x = \frac{\text{press. at Entrance}}{\text{press. at Discharge}}$ $\frac{p_0}{p_N}$ where v_N = velocity of Flow from the last Row of a Group of N Rows of blades (both fixed and moving); P_N the Abs. pressure (lbs. per sq. in.) of the Steam on Discharge from the last Row of Blades, and V_N the corresponding Specific Volume in cu. ft. per lb.
μ a co-efficient varying with x and δ_N
Values of φ
Values of μ
Scale for φ and μ
Values of $x = \frac{p_0}{p_N}$
(2287 B)

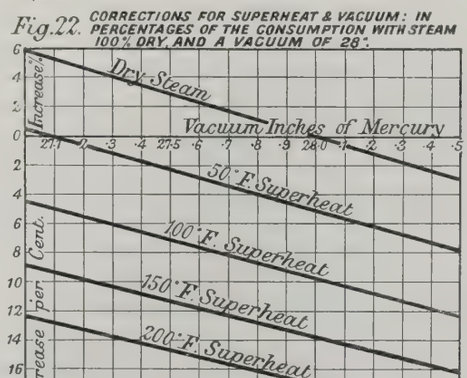


Fig. 22. CORRECTIONS FOR SUPERHEAT & VACUUM: IN PERCENTAGES OF THE CONSUMPTION WITH STEAM 100% DRY, AND A VACUUM OF 28".
Increase
Dry Steam
Vacuum Inches of Mercury
50° F. Superheat
100° F. Superheat
150° F. Superheat
200° F. Superheat
Per Cent.
Decrease
(2536. A)

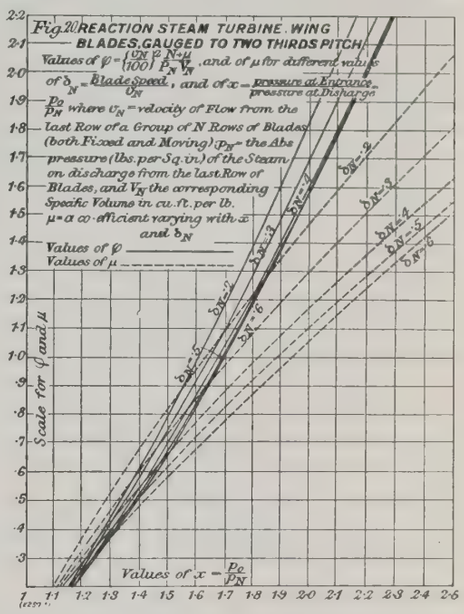


Fig. 20. REACTION STEAM TURBINE. WING BLADES, GAUGED TO TWO THIRDS PITCH.
Values of $\phi = \frac{(v_N)^2}{(100)^2} \frac{N+\mu}{P_N V_N}$, and of μ for different values of $\delta_N = \frac{\text{Blade Speed}}{v_N}$, and of $x = \frac{\text{pressure at Entrance}}{\text{pressure at Discharge}}$ $\frac{p_0}{p_N}$ where v_N = velocity of Flow from the last Row of a Group of N Rows of Blades (both Fixed and Moving) p_N = the Abs pressure (lbs. per Sq. in.) of the Steam on discharge from the last Row of Blades, and V_N the corresponding Specific Volume in cu. ft. per lb.
μ = a co-efficient varying with x and δ_N
Values of φ
Values of μ
Scale for φ and μ
Values of $x = \frac{p_0}{p_N}$
(2287 A)

exhaust the steam is assumed to be at an absolute pressure p_N of 1.524 lb. per sq. in., and to have a specific volume V_N of 197.0 cub. ft. per lb., corresponding to a dryness fraction of about 87½ per cent. The mean blade speed for each group is given in line 5. Then, assuming 13.4 lb. of steam to pass per second, the velocity of discharge from the last row of blades is $13.4 \times 197.0 \div 5.465 = 482.9$ ft. per second, so that $\delta_N = \frac{s}{v_N} = 0.300$, and $p_N V_N = 1.524 \times 197.0 = 300.1$.

The formula governing the flow is

$$\phi = \left(\frac{V_N}{100}\right)^2 \frac{N + \mu}{P_N V_N},$$

where ϕ and μ are taken from the curves in Figs. 18, 19, or 20. If we assume provisionally that μ in the formula for flow is equal to 1, then substituting the values above given for V_N, p_N, &c., we get

$$\phi = \left(\frac{482.9}{100}\right)^2 \frac{12 + 1}{300.1} = 10.102,$$

hence from the curve, Fig. 20, x is about 1.654, but the value of μ corresponding to this, it will be seen from the diagram, is 0.91. Hence the value of ϕ above calculated must be diminished by 0.075 per cent. That is to say, the true value of ϕ is 10.03; whence $x = 1.652$, so that the pressure in front of the group is

$$p_0 = x\, p_N = 1.652 \times 1.524 = 2.518 \text{ lb. per sq. in.}$$

We now have $\log x = \log 1.652 = 0.218$, so that $(N + 1.05 \log x) = 12.23$.

The work done by the group per pound of steam passed per second is

$$\frac{h - c}{h + \sigma c} \cdot \frac{s}{32.2} \cdot \left\{ v_N B (N + 1.05 \log x) \cos \alpha - \frac{N s}{2} \right\},$$

where B is taken from the curve in Fig. 21. The value corresponding to $x = 1.652$ is, it will be seen, $B = 0.775$.

The value of $v_N B (N + 1.05 \log x) \cos a$ is thus 3525.9, taking cos a for wing blades as 0.766.

As shown in the table, $\frac{N s}{2} = 867.1$, and putting

$$Q = v_N B (N + 1.05 \log x) \cos \alpha - \frac{N s}{2}$$

we get $Q = 2658.8$.

The work done per pound of steam is therefore

$$\frac{h - c}{h + \sigma c} \cdot \frac{s}{32.2} \cdot Q = 0.9798 \times \frac{144.54}{32.2} \cdot 2658.8 =$$

11,693 ft., or 15.03 B.Th.U.

THE WESTINGHOUSE REDUCTION GEAR ON THE U.S. NAVY COLLIER "NEPTUNE."

(*For Description, see opposite Page.*)

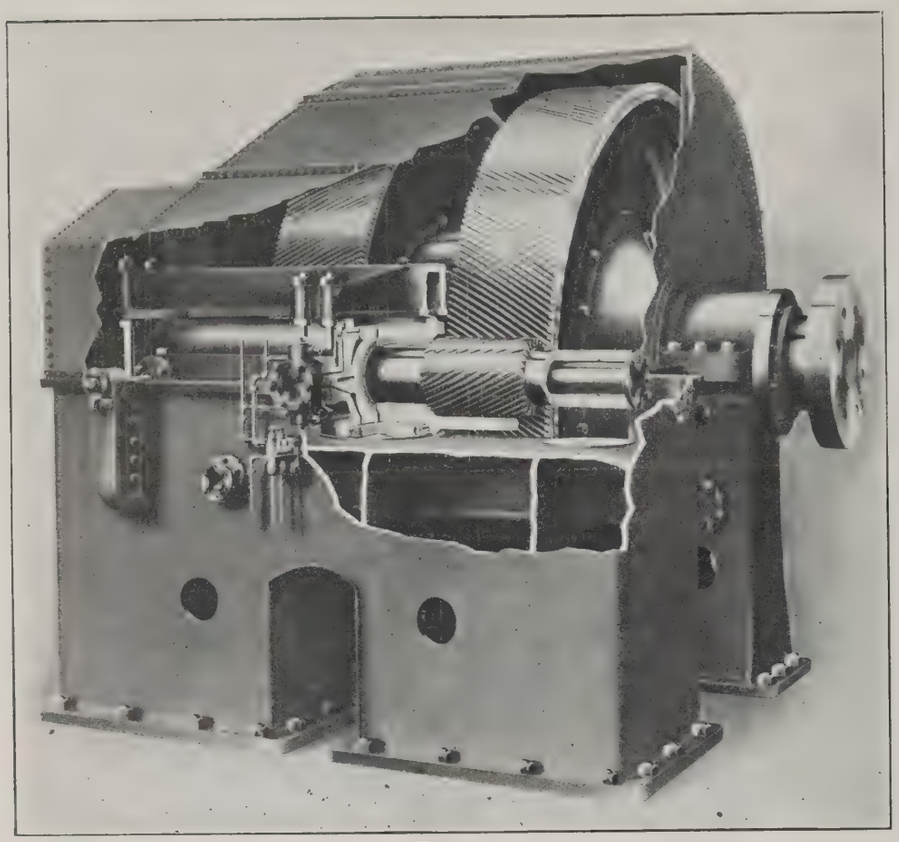


Fig. 1.

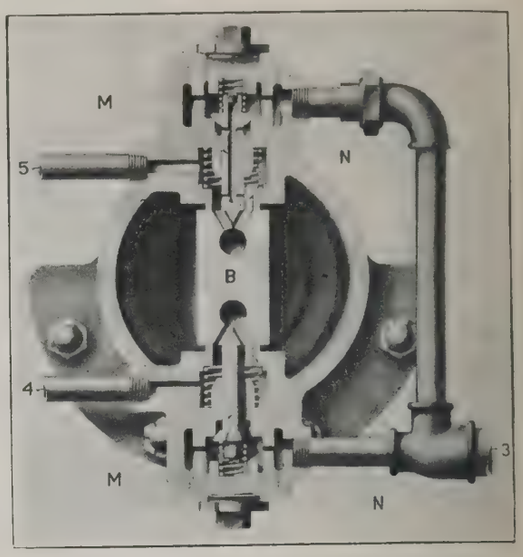


Fig. 4.

Fig. 2.

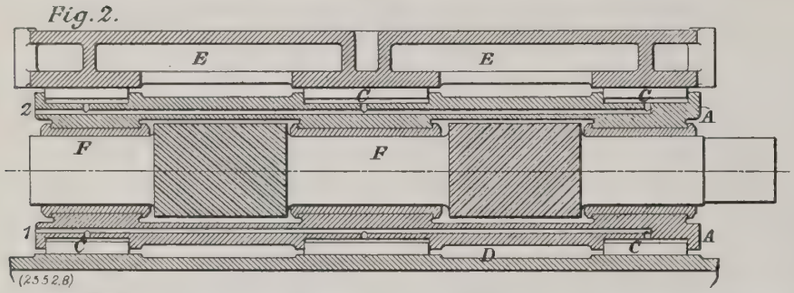
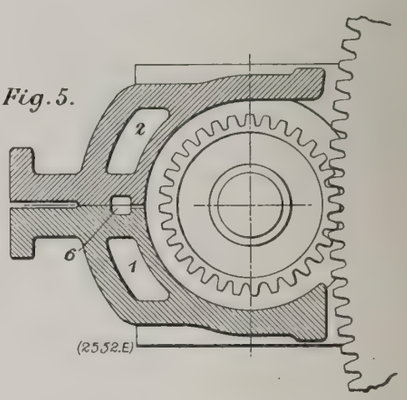


Fig. 5.



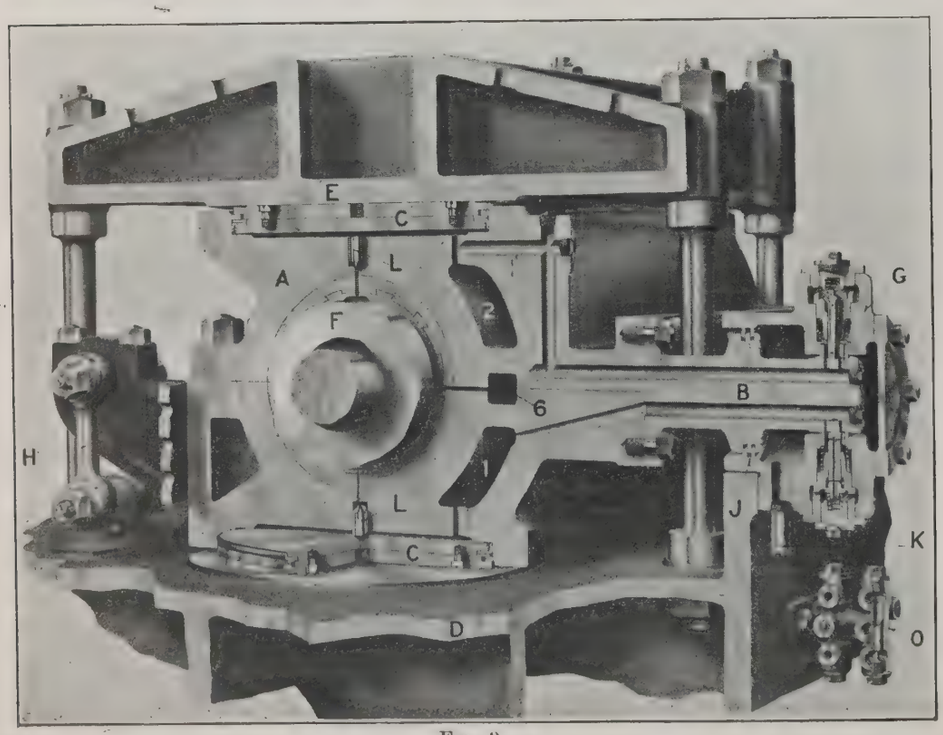


Fig. 3.

As 13.4 lb. pass per second the horse-power developed by the group is

$$\frac{13.4 \times 11.693}{550} = 291.2.$$

This completes the calculation for the group. To pass to the next group we have to find the values of p_N and V_N for this group. The value of p_N for the new group is the same as p_0 for the old group; *i.e.*, $p_N = 1.524 \times x = 1.524 \times 1.652 = 2.518$ lb. per sq. in.; but V_N cannot be found so simply. We note, however, that on discharge from group 8 the steam had a dryness fraction of 87½ per cent., and a reference to ordinary steam-tables shows, accordingly, that the total heat contained in 1 lb. of it was 993.86 B.Th.U. In the group as already shown 15.03 B.Th.U. per lb. were removed in the form of mechanical work. Hence before passing through the group the total heat contained in the steam was 993.86 + 1503 = 1008.96 B.Th.U. per lb., its pressure now being 2.518 lb. per sq. in. A reference to the ordinary steam-table shows that saturated steam at this pressure has a sensible heat of 103.20 B.Th.U., a latent heat of 1019.6 B.Th.U., and a specific volume of 139.2 cub. ft. per lb. Since the steam in its actual condition contains 1008.96 heat units, the amount latent is found by subtracting the sensible heat. Hence the actual amount latent is 1008.96 – 102.20 = 905.69 B.Th.U.

The dryness fraction is thus $\frac{905.69}{1019.6}$ and the actual specific volume V_N is $\frac{905.69}{1019.6} \times 139.2 = 123.65$ cubic feet per pound. Knowing this and the weight passed per second, the velocity of flow from Group 7 can be calculated, and the remaining steps in the computation are simply repetitions of those already described. Successive values of x for each group

THE WESTINGHOUSE REDUCTION GEAR ON THE U.S. NAVY COLLIER "NEPTUNE."

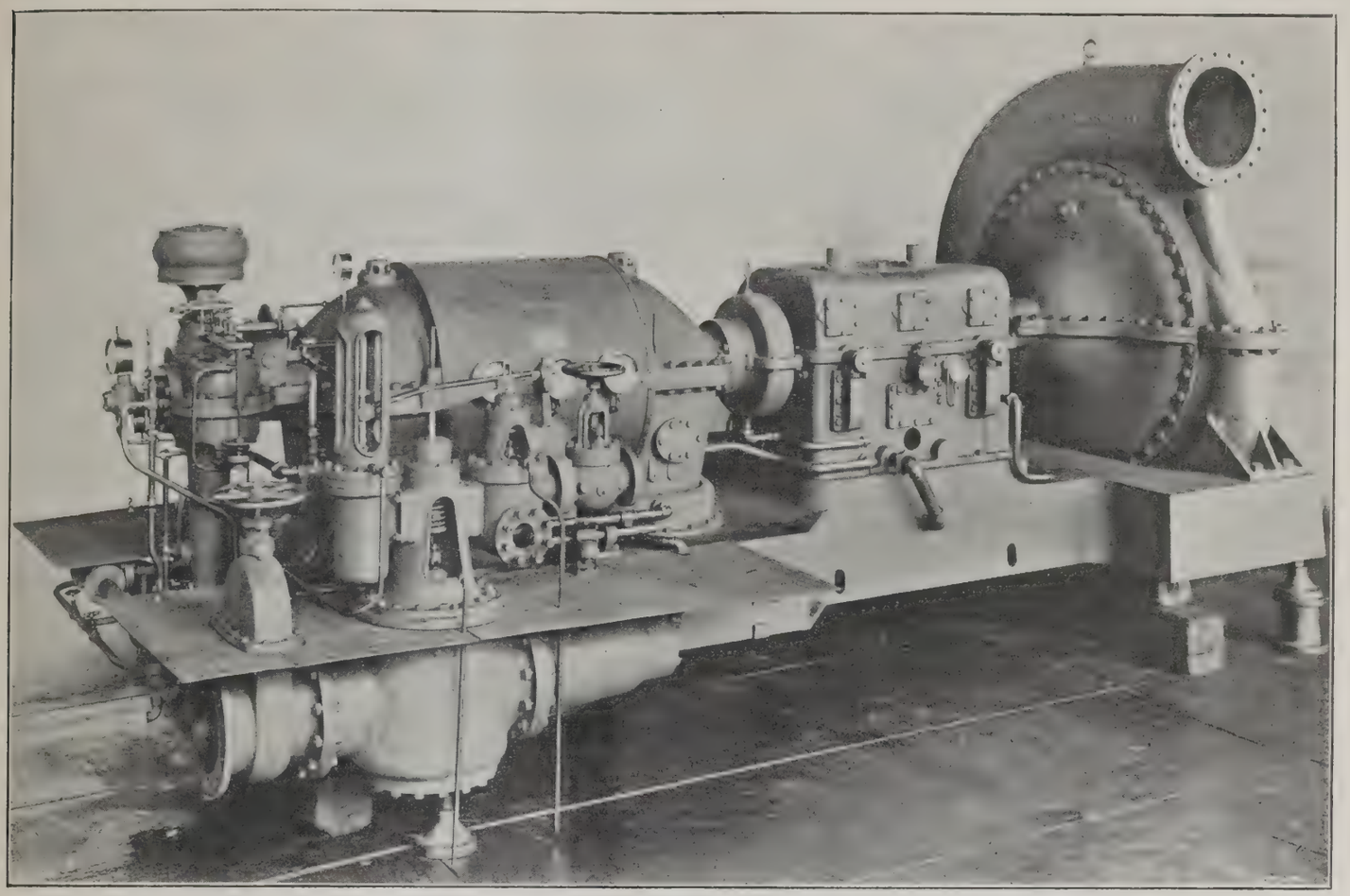


FIG. 6.

are thus obtained, the calculations being fully set forth in the table.

Of the various steam-tables, those of Reeves, published by Macmillan and Co., are by far the most convenient in use, and they are very cheap, though, perhaps, not quite as up-to-date as the excellent tables of Messrs. Marks and Davis (Longmans, Green, and Co.).

If the initial pressure of the steam at the entrance to a compound turbine and the final pressure on discharge are increased in the same ratio, the efficiency of the turbine remains unchanged, but its output is increased in the same ratio as the pressures have been. At all initial pressures the weight of steam passing into the turbine is very nearly proportional to the absolute pressure of the steam in front of the first row of blades of the first group. The velocity of flow into the first row of blades of the first group is very nearly constant, whatever the variations of initial pressure and of vacuum.

Corrections for changes of superheat and of vacuum are most conveniently made by means of correction curves such as are given in Fig. 21, the use of which is sufficiently obvious without a detailed explanation. It is taken from actual practice. With low superheats the efficiency ratio increases faster than would be anticipated on thermodynamic grounds, probably because superheated steam is less viscous than saturated.*

(To be continued.)

4000-HORSE-POWER REDUCTION GEAR ON THE UNITED STATES S.S. "NEPTUNE."

ON this side of the Atlantic engineers have for some years past been cautiously groping their way towards a solution of the problem of transmitting large powers through high-speed gearing, the initial steps being due to Dr. De Laval, who ten years ago or more had at work gears transmitting over 300 horse-power. Sir Charles Parsons's experiments in the same direction originated at a later date, but in 1896 he had running a launch driven by a geared turbine of 10 horse-power, and two years later he installed at the power-station of the Newcastle and District Electric Lighting Company a gear-driven alternator of 150 kw. capacity. Since then progress here has been made step by step up to the 900 horse-power of the Vespasian, and beyond that to the much larger transmissions now being fitted on board certain destroyers. Whilst, as already stated, progress in Europe has been effected by tentative advances, in America Mr. George Westinghouse, with characteristic courage and enterprise, tackled at once the problem of constructing high-speed gears to transmit several thousand horse-power. So large a stride as that involved in passing from hundreds to thousands cannot safely be based purely on the experience acquired in the smaller field, and hence very careful consideration was given to the theory of such transmission, with the result that Messrs. Melville and McAlpine introduced the system of supporting the pinion shaft in a device named by them a "floating frame." We do not know how far engineers in general are in agreement with the theory advanced by these gentlemen, but the engineers of the Westinghouse Machine Company, whose experience with very large gear transmissions is unique, have in their actual experience with high-power gear found no reason to question its accuracy, and through the courtesy of Mr. Westinghouse we are now able to illustrate an improved form of floating frame, which has been fitted on board the U.S.S. Neptune. In this case the pinion is direct-coupled to a turbine running at 1250 revolutions per minute and developing 4000 horse-power. The large spur-wheel, which is keyed to the screw-shaft, runs at 130 revolutions per minute, so that a reasonable propeller speed is combined with a high turbine speed. A view of this gear with the casing partly broken away is illustrated in Fig. 1, opposite, whilst Figs. 2 to 5 illustrate various details of the mechanism.

As will be seen, the gearing is of the usual double-helical type, and the whole of the novelty, apart from the magnitude of the power transmitted, lies in the method of supporting the pinion. This, as shown in Fig. 2, is carried in three bearings, formed in a frame, which is in turn supported on three hydraulic rams at both top and bottom, marked C in the figure. The whole pinion frame is thus mounted on hydraulic cushions, those at the bottom being in action when the rotation is in one direction, and those on the top when the rotation is reversed.

As will be seen, the hydraulic cylinders are formed in the floating frame, whilst the rams form part of the outer fixed frame, which is rigidly but adjustably connected to the housings of the large spur-wheels. The three cylinders of each set are in free communication with each other, so that the pressure in each of the three is the same. The supply of pressure oil to these cylinders is secured in a very ingenious way. As has long been known, a high-speed journal will draw in oil at regions of low pressure, and will drag it round to regions of high pressure, and if a vent is provided there, will act as a high-pressure pump. This fact is taken advantage of to secure the pressure necessary for supporting the floating frame. A section through one of the journals is illustrated in Fig. 3. A low-pressure oil-supply is fed in through the port 6, and, according to the direction of rotation, is discharged at the top or the bottom of the journal into the corresponding cylinder. The pressure thus obtainable is, however, much in excess of what is required to take the drive on the pinion, and a leak-off is therefore provided through the ports and passage shown on the right, which communicate with a valve-box G, of which another section is illustrated in Fig. 4.

The floating frame is, as will be seen in Fig. 3, tied down at the left by the link H, so that should an excess of pressure in the cylinders move it in either direction, the whole frame will slightly tilt. Hence the relatively long arm B moves either up or down. As will be seen from Fig. 4, an upward tilt of this arm will raise it clear of the lower valve-seat N, so that oil can then escape freely from the lower port in B, and away through the box to the escape-pipe K, Fig. 3. A baffle shown at J prevents any leakage of the oil into the gear-casing. This escape of oil lowers the pressure in the lower set of cylinders, and accordingly the floating frame will fall till the arm B is brought down again on to its seat. This throttles the escape,

* We regret that, by an oversight, in our last article we gave wrongly the initials of Mr. Chilton in mentioning our indebtedness to him for details. The name should have been printed Mr. W. Chilton.

and in this way the oil pressure in the supporting cylinders is maintained at such an intensity as to exactly balance the thrust on the pinion. Mr. H. E. Longwell, the consulting engineer to the Westinghouse Machine Company, informs us that the regulation is so accurate that the total motion of the floating frame is never more than a few mils.

The supplemental valves shown at M M, Fig. 4, are for using in starting up, since, until the journals have attained a considerable linear speed, they have no sensible efficiency as oil-pumps. The oil supply under pressure is then furnished through the branch 3, which communicates, it will be seen, with both the valves M. If the pinion is started in such a direction that a pressure is needed in the upper set of cylinders, the arm B will rise and lift the upper valve M off its seat. Pressure oil then passes through the hollow valve-stem of M and the passages in the arm B to the upper set of cylinders, bringing back the frame to its proper position of equilibrium.

The pipes shown at 4 and 5, Fig. 4, are connected up to gauges, which indicate at any moment the torque on the pinion shaft. The Westinghouse Company have worked out an arrangement by which these gauge readings can be transmitted by air-pressure to the bridge or other distant part of the ship. The fitting for this device is shown in position at 0, Fig. 3, but we have for the present no details of it. It will thus be seen that the method of supporting the pinion-shaft hydraulically provides at the same time a transmission dynamometer, and thus renders unnecessary the installation of a torsion-meter.

The method of lubricating the gear-teeth is illustrated in Fig. 5. The oil supply is fed in at 6, and escapes into the pinion casing by the small port indicated. It tends to collect, of course, at the bottom of this casing, but if the pinion is in movement, it flings out the oil on to the teeth of the main wheel just before these come into engagement, and this action takes place whichever way the pinion is rotating.

The advantages of reduction gear are equally great in turbine-driven direct-current generators and low-lift centrifugal pumps as they are in marine service, and several equipments have already been supplied by the Westinghouse Company. We illustrate in Fig. 6 one of the turbine-driven centrifugals. It will be noted that the dimensions of the gear-box are by no means excessive, the whole plant being very compact. As motion in such cases is required in one direction only, only one set of hydraulic cylinders is provided.

For the different services enumerated above the Westinghouse Company have already installed twelve 1000-horse-power to 2000-horse-power sets, many of which have now been in operation for some months, running at speeds as high as 3000 revolutions per minute. The efficiency of the gearing has been over 98½ per cent.; and the results obtained in service have been most satisfactory.

INDUSTRIAL NOTES.

According to the *Board of Trade Labour Gazette*, issued on the 16th inst., the state of the labour market in October was as follows :—

Employment in October was, on the whole, slightly better than in September. There was a seasonal decline in the building and brick-making trades, and some falling off in employment in the linen industry and at blast-furnaces. On the other hand, employment in the engineering trade remained good, and there was an improvement in nearly all the other industries.

Compared with a year ago, there was an improvement in all the principal industries, but there was a decline in the linen, jute, lace, and brick-making trades, and at blast-furnaces.

In the 394 trade unions, with a net membership of 792,685, making returns, 21,893, or 2.8 per cent., were reported as unemployed at the end of October, 1911, compared with 2.9 per cent. at the end of September, 1911, and 4.4 per cent. at the end of October, 1910.

Returns from firms employing 453,586 workpeople in the week ended October 28, 1911, showed an increase of 1.4 per cent. in the amount of wages paid compared with a month ago, and of 4.6 per cent. compared with a year ago.

The changes in rates of wages taking effect in October affected 97,000 workpeople, and resulted in a net increase of nearly 2600*l.* per week. Amongst those whose wages were increased were 18,600 coal-miners in Cumberland, the Forest of Dean, and the Radstock district, and 33,000 workpeople in the federated shipyards in England and Scotland. The numbers whose wages were reduced included 11,500 ironstone miners and limestone quarrymen in Cleveland and Durham, 6900 blastfurnacemen in Cleveland, Durham, and Cumberland, and 6250 blastfurnacemen and iron and steel workers in South Wales and Monmouthshire.

The most important disputes in progress during the month were those involving 5800 coal-miners in the Rhondda Valley, 2400 flax-workers at Belfast, 2300 engineers and other workpeople at Birmingham, 2000 coal-miners at Bristol, 2000 oil-millers at Hull, 1400 coal-miners at Wigan, and 1200 underskirt and blouse-makers at Nottingham. The number of disputes beginning in October was 74, and the total number of workpeople involved in all disputes in progress during the month was 58,528, or 1748 more than in September, 1911, and 120,641 less than in October, 1910. The total number of working days lost was 444,600, or 115,800 less than in the previous month, and 1,526,100 less than in the corresponding month of last year, when large disputes in the cotton and shipbuilding trades were in progress.

Cases dealt with under the Conciliation Act include those affecting railway-carriage workers in Manchester and district, tramway workers at Ashton-under-Lyne, &c., weavers at Congleton, boot and shoe operatives at Wolverhampton and Anstey, stevedores in East London, cable workers at Gravesend, and jewel-case makers in London. The Right Hon. Lord Robson, G.C.M.G., has been appointed umpire in connection with the Boot and Shoe Trade National Agreements, in succession to the late Lord James of Hereford.

Trade appears to be very much in the same condition with pattern-makers as it was in September last, at any rate if we are to judge by the monthly report of the United Pattern-Makers' Association for October, for there were at the end of the latter month 240 members out of employment, against 239 at the end of the former month. On the North-East Coast trade remains steady, and very few members in that district have been out of work for more than a few days, while on the Clyde a similar condition of things appears to exist. Trade is, however, still bad in Belfast, though that town seems to be an exception to the general state of affairs in the majority of the shipbuilding ports. Excellent reports come from Barrow, so far as the volume of employment is concerned. At inland centres little change is apparent, members being fairly well employed in Manchester and Lancashire. In the Midlands there are rather more men out of work than is usual in the district. Fair returns are, however, made from the London district. On the whole, prospects for the winter seem to be fairly well assured. The quarterly financial statement for the third quarter of the year appears in this report, and shows a gain of 2958*l.* during the quarter, which is exclusive of the interest due on house property loans. This sum exceeds the gain for the June quarter by 250*l.*, and that for the first quarter of the year by 1600*l.* The expenditure during the past quarter amounted to 3546*l.* 12s. 4½d., or 173*l.* less than during the preceding quarter. Unemployment benefit continues to be the most important item of the expenditure, the sum spent under this head during the quarter being 1228*l.*, whereas in the June quarter it was 1193*l.* On the whole, the financial state of the society appears to be satisfactory.

Further progress on the unemployment clauses of the National Insurance Bill was made by the Standing Committee of the House of Commons. On Tuesday, the 7th inst., the following clauses were passed:—Clause 64, dealing with the determination of claims, and providing that all questions shall be determined by insurance officers appointed under the Act; Clause 65, dealing with the appointment of an umpire and insurance officers, &c., by the Board of Trade; and Clause 66, which establishes a court of referees, to consist of employers and workmen's representatives selected from panels constituted by the Board of Trade, with a chairman appointed by the Board of Trade. On Thursday, the 9th inst., the questions that were considered related mainly to the powers proposed to be entrusted to the Board of Trade in connection with the administration of this part of the Act. The first of them—namely, Clause 67—is to the effect that the Board of Trade may make regulations under this part of the Act and the schedule therein referred to. Clause 68 provides that (1) there shall be established a fund called "The Unemployment Fund," into which shall be paid all contributions payable under this part of the Act by employers and workmen and out of moneys provided by Parliament, and out of such fund shall be paid all claims for unemployment benefit and other payments which, under this part of this Act, are payable out of the fund; (2) the accounts of the unemployment fund shall be audited in such a manner as the Treasury may direct; (3) any moneys forming part of the unemployment fund may from time to time be paid over to the National Debt Commissioners, and by them invested in any securities which are for the time being authorised by Parliament as investments for savings-banks moneys; and (4) the National Debt Commissioners shall present to Parliament annually an account of the securities in which moneys forming part of the said fund are for the time being invested. Clause 69 deals with the subject of Treasury advances. All these were added to the Bill. Clause 70, dealing with the power of employers to compound at reduced rates, was omitted, the intention being to bring forward a new clause, as described in our issue of November 3 (see page 599 *ante*).

The Bill was again before the Grand Committee of the House of Commons on Tuesday, the 14th inst., Clause 71 provides for the return to a workman, who has reached the age of sixty, the amount by which the total of his contributions has exceeded the total amount received by him out of the unemployment fund, together with compound interest at 2½ per cent., the repayment to be either by a lump sum or by an annuity. An amendment moved by Mr. Buxton, providing for the payment of the sum to a workman's representatives after his death, was accepted, as was also a new sub-section, in the name of Mr. Buxton, defining the position of a workman who continues at, or returns to, work after taking the refund. The clause was carried by thirty-four votes against nine. Clause 72 enacts that contributions paid during a period of depression in his business by any employer on behalf of his workmen shall be refunded out of the unemployment fund. Clause 73 defines the position of employers with regard to the labour exchanges (see page 599 *ante*). Clause 74 enacts that a workman who repeatedly fails to obtain or retain employment may be made to follow a suitable course of instruction, at the expense of the unemployment fund, in order to ascertain whether this can improve his prospects. These three clauses were added to the Bill, as also was Clause 75, dealing with penalties for false statements. On Wednesday, the 15th inst., the following were the clauses considered:—Clause 76, providing for the revision of the contributions made both by the employers and by the men, also for different rates of contribution for different insured trades and branches thereof; Clause 77, dealing with the extension by the Board, with the Treasury's consent, of the provisions of the Act to workmen in any trade other than an insured trade; Clause 78, providing the procedure for making special orders; Clause 79, indicating the arrangements with associations of workmen in insured trades for making payments to members whilst unemployed; Clause 80, giving power to the Board of Trade, with the Treasury's consent, to give repayments to associations making payments to persons, whether workmen in insured trades or not, whilst unemployed; and Clause 81, defining the term "workman" to mean any person of 16 employed in manual labour. As regarded benefits, the boy would not receive any in the first year, in the second year he would receive half benefit. Any balance which he might during that time have accumulated would be available for his benefit at a later period. The above clauses 76 to 81 were agreed to. A new clause was read a second time; this provides that whilst a man is being trained in the fighting service he shall be deemed to be in the employment of the Crown in an insured trade. This clause was also added to the Bill.

A temporary arrangement was arrived at on Thursday in last week, in consequence of which the taxi-cab drivers decided to return to work, and on Friday the result was directly noticeable, the crossing of important streets being once more a feat requiring care and foresight. The agreement is, it is understood, not looked upon as satisfactory, and has only been put into force in order to suit public convenience. Until a permanent settlement is arrived at the agreement to which the men have assented is that the two men whose discharge was one of the causes of the strike are to be reinstated; all "observers" are to be removed; no man is to be reported in future for "extras;" no notice is to be taken of the summonses against men for last day's earnings unpaid; men are to retain "extras," but to pay 6d. per day hiring fee, and receive 1d. per day for rank charges.

At a meeting of the Coal Conciliation Board for the federated districts of Great Britain, held at the Westminster Palace Hotel on Friday last, the following reply was given, on behalf of the coalowners, to certain proposals of the men which had been submitted to their consideration:—The amended proposals for a minimum wage for coal-getters which you have placed before us have had our careful consideration. Whilst we could recommend the adoption of the principle of the minimum wage, the matter is beyond our power to decide to-day. We propose to take it to our districts, and to suggest an adjournment to December 6 for the purpose. In the meantime, the negotiations with regard to abnormal prices, and boys' and datallers' wages shall continue in the various districts." Another meeting will therefore be held on December 6.

A special conference of the Miners' Federation of Great Britain was held at the Westminster Palace Hotel on Tuesday and Wednesday, the 14th and 15th inst., in accordance with a resolution which was passed at the Conference of the Federation held in Southport in the first week of October. The purpose of the special London Conference was to receive reports from the various districts as to the replies given by the employers to the demand for an individual district minimum wage for all men and boys. We may state here that since the Southport Conference in question, the colliery-owners of Northumberland, Scotland, and South Wales have refused the demand made by the men for an individual

district minimum wage. The colliery owners of the federated districts, on the other hand—*i.e.*, Yorkshire, the Midlands, Lancashire, Somersetshire, and North Wales—have stated that they "could recommend" the adoption of the principle of a minimum wage. This particular point had been adjourned for discussion at the meeting to be held on December 6, above referred to. At the adjourned conference, held in London on the 15th inst., a motion was proposed in favour of an immediate ballot as to the advisability of calling a general stoppage. The suggestion to make further efforts to arrive at a satisfactory settlement without a strike was put as an amendment, and this was carried by 366,000 votes against 238,000.

The following resolution was then carried, on a show of hands:—"That this Conference, having heard reports from all the districts in reference to the demand for an individual district minimum wage, is of opinion that the best course to pursue at the present juncture with a view to obtaining that object is to negotiate nationally, and we therefore instruct the executive committee of the Federation to formulate the claim for each district, and in order to give effect to this resolution the executive committee with additional representatives meet the coal-owners of Great Britain at the earliest possible date, and report immediately thereafter to a national Conference. But this resolution shall not prevent or interfere in any way with the negotiations being carried on in the various districts of the Federation."

The Conference stood adjourned until December 20, when final reports will be received as to the negotiations with the masters in all the districts. Claims will be put forward concerning the conditions prevailing in the different districts, and having reference to the question of the minimum wage to be fixed. Should these negotiations prove unsuccessful, the question of a general stoppage may then be reopened.

The trouble which arose between Messrs. Vickers, of the River Don Works, Sheffield, and their employees, in connection with the new pricing system, has been settled; and a vote of thanks has been accorded to Mr. Douglas Vickers by the men for the way in which their claims have been dealt with.

The monthly report of the Steam-Engine-Makers' Society for November denotes little change since the last report issued in October. Trade on the whole continues good, although there are now 193 men out of employment, which is an increase of 45 over last month. Discharges from Crewe works are said to be the chief cause of this increase. A great many of these men, however, soon obtained other employment. The report states that there are evidently far too many men in the North and South Shields district who fail to find other than casual employment—a system that appears to be a growing evil, affecting the individual workman, the employers, and the trade unions. This, the report goes on to say, is "a state of things largely, if not mainly, responsible for much of the present unrest that industry and the labour world generally is at present suffering from." Referring to "recognition," it says "this in itself may be over-valued, as we have had it for the past fourteen years. But unless it has at its back an organisation of a sound and stable character it is a snare and a delusion, and not worth the mention or the paper it is written upon. In other words, any given industry gets as much recognition as it deserves, but only in proportion as it is thoroughly organised or otherwise."

The feeling among the railway men appears to be somewhat divided as to whether they should strike or abide by the recommendations of the Royal Commission. At Crewe, on Sunday last, a resolution was passed deciding to accept these recommendations and to give the suggested scheme contained therein a trial. At Huddersfield and Bradford, however, the feeling of the men appears to be strongly in favour of a strike for "recognition." At Birmingham also there is a strong feeling that the question as to whether the men are in favour of withdrawing their labour in order to obtain "recognition" should be answered in the affirmative.

German Metallurgy.—The production of pig iron in Germany and the Luxembourg in Sept. amounted to 1,250,702 tons, as compared with 1,232,477 tons in Sept., 1910. The aggregate production to Sept. 30, this year, was 11,509,300 tons, as compared with 10,925,629 tons.

The late Mr. N. S. Arthur.—We regret to have to announce the death of Mr. Nicol Sinclair Arthur, shipbuilder and engineer, Glasgow. Mr. Arthur received his early training as a shipbuilder with Earle's Shipbuilding Company, Hull, and Messrs. Denny, of Dumbarton. Mr. Arthur invented the angle-bevelling machine, which has been used in all shipbuilding yards for the past twenty-five years, and without which the heavy sections now used in shipbuilding could not be worked. His latest invention was the roller-bending machine for bending beams and other sections to curves, which is rapidly coming into general use. Mr. Arthur was of a reticent and retiring nature, taking no active part in public affairs,

SHIPBUILDING AND THE NATIONAL INSURANCE BILL.

In *The Times* of Monday, the 13th inst., there appeared a letter from Dr. John Inglis, the well-known Clyde shipbuilder, on the National Insurance Bill; and as the facts given and the views expressed establish so convincingly the gravity of the handicap imposed upon industry by recent legislation and almost certain to be increased owing to the trend of political partisanship, we think the letter cannot have too wide a circulation, and we therefore reproduce it. We commend the letter to the serious consideration not only of employers, but particularly of workers, since they stand to lose most by any crippling of industry, which depends predominantly upon capital. Dr. Inglis's letter is as follows:—

Sir,—Amid the sound and fury of discussion on the National Insurance Bill one may listen in vain throughout the debates for a single word in the interests of the employer of labour, who is expected to supply no small part of the 9d. which the fortunate employee is to receive in exchange for 4d. It may be asked, why are the employers themselves silent where their interests are attacked? The reply is that no Member of Parliament is independent enough or has sufficient courage to present the case of the employer in the House of Commons. This is not a loose and random statement, but is one made after long and persistent search for a spokesman carried on by the officials of a powerful federation of employers.

The medical profession has been vocal to some purpose, and the friendly societies have compelled the attention of the Chancellor of the Exchequer. It is time, if, indeed, it is not rather late, for the employers of labour to inquire why they are to be singled out for special taxation which is escaped by all other members of the community, and to demand that some consideration be given to what is likely to happen if such taxation be imposed.

All employers are not prosperous. Enterprises might be named which are doubtless able to bear the impost with which they are threatened, but it only requires perusal of your financial columns to recognise how many undertakings in this country are barely keeping their heads above water. To some of those additional taxation is likely to mean total submersion.

In the important industry of shipbuilding and marine engineering, of which I have more than half a century's experience, the fierce competition which exists makes it difficult for any but the more fortunately-placed establishments to keep their position within the solvent group. The capital employed is large, the risks are great, the technical skill required not inconsiderable. The rewards, on the average, are hardly commensurate with what is at stake. The capital required may be assumed at 180*l.* per man employed. The profits realised do not, I am convinced, exceed, on the average, 5*l.* per employee per annum, or about 2¾ per cent. on capital, after making proper allowance for depreciation. This is what is called by the street-corner orator and Labour Member of Parliament the "exploitation of labour."

Considering that the employer finds premises, workshops, machinery, materials, designs, buyers of the finished product, takes all risks, and finances the workman weekly while often waiting for years for his own remuneration, he need not be grudged his 5*l.* as against the workman's share of 70*l.* to 100*l.* a year. He has to survey the world from China to Peru in search of work, and collect money from all quarters to distribute among his own and his sub-contractors' workmen. It is from these moneys that our Chancellor of the Exchequer proposes to find a large portion of his so-called "gifts" of millions with which he is not ashamed openly to bribe electors.

Much of the recent legislation which touches the industries of the country tends to hamper and impede production, increase costs, and lessen the gross amount from which all wages and profits are derived.

The Workmen's Compensation Act takes from the shipbuilding and engineering employer about 24s. per man per annum, equal to 3s. 10½d. in the £ of income-tax, or 13s. 4d. per cent. on capital.

The Insurance Bill is calculated to cost, in addition, about 23s. per man per annum, equal to 4s. 7d. per £ income-tax, or 12s. 9d. per cent. on capital.

The death duties may be expected to recur every twenty-five years, on an average, and will require at least 7s. 2½d. per man to be set aside each year to meet them, equal to another 1s. 5d. per £ income-tax.

These supertaxes amount to 1½ per cent. on capital—2*l.* 14s. 2½d. per man employed, or 9s. 10½d. per £ income-tax, besides the usual 1s. 2d., which is generally considered a severe impost in time of peace. The 6d. supertax on incomes of 5000*l.* and upwards fades into insignificance beside a crushing burden like this.

It may be objected that I have understated the profits of shipbuilding. To that I would answer that those who believe themselves to be better informed may make their own calculations—there is margin enough to bring out conclusions hostile to the Insurance Bill on any reasonable hypothesis.

There is no underpaying of workmen in the shipbuilding business, and no reason whatever for employers in that business being charged with any part of the cost of insurance which prudent men have hitherto provided for without any assistance. For the imprudent and the waster Solomon has already prescribed.

Still less is there any reason why employers should be tax-collectors at their own expense, or their already complicated accounts be rendered more complicated still. I am informed that it is proposed to have two cards or books for each man whereon the employer is to stick four adhesive stamps on each pay-day. In some establishments that may mean 40,000 to 50,000 stamps. Comment on such a proposal would be superfluous.

Our rulers have probably never found time to study the economics of industry, or to consider how wages come to be what they are. They may rest assured that, in the long run, capital will have a fair return or it will be withheld.

Wages will be paid out of what is left after capital is served, as far as that residue will go, and population will depend, also in the long run, on what is available for wages. The immediate effect of legislation of the "Social Reform" type will be to squeeze out employers who are financially weak, and, in course of time, wages will readjust themselves according to the gross product.

I may fitly conclude by quoting a piece of advice to working-men by John Ruskin, which appears to me well worth weighing and considering at the present time:—

"You need not think that, even if you obtained a majority of representatives in the existing Parliament, you could immediately compel any system of business broadly contrary to that now established by custom. If you could pass laws to-morrow wholly favourable to yourselves, as you might think, because unfavourable to your masters and to the upper classes of society, the only result would be that the riches of the country would at once leave it, and you would perish in riot and famine."

I am, Sir, yours respectfully,

John Inglis.

Pointhouse Shipyard, Glasgow, November 3, 1911.

Bristol Association of Engineers.—The first dinner of the current session was held on Wednesday, the 8th inst., at the Imperial Hotel, Clifton, under the chairmanship of Mr. T. J. Moss-Flower. The latter, in the course of his address, dealt with the developments which had taken place of recent years in the various branches of engineering. The field was, however, by no means played out in regard to this country, and great opportunities offered abroad to all engineers who were well equipped with knowledge. He also referred to the sewerage problem, dealing with it as it affects Bristol.

The Oil-Engined Ship "Jutlandia."—Messrs. Barclay, Curle, and Co., Whiteinch, launched on Saturday afternoon, the 11th inst., the twin-screw oil-engined vessel Jutlandia, which they have built to the order of the East Asiatic Company, of Copenhagen. The vessel is 384 ft. in length, 53 ft. 3 in. in breadth, 30 ft. in depth, 23 ft. 6 in. draught, of 10,000 tons displacement, 7000 tons deadweight, and 5000 tons gross. She will be supplied by the builders with two sets of Diesel oil-engines capable of developing 3000 indicated horse-power. She will have three masts, and the fumes from the engine-room will be led up inside the mizzen mast and exhausted at a height of 48 ft. above the deck, so that a funnel is not required, even for exhaust purposes. The siren, on the main mast, will be operated by compressed air. The vessel will have no steam for mechanical purposes, as even the donkey engine will be an oil-engine, and it will also generate the electricity which will operate the twelve cargo winches and the anchor windlass. Perhaps the most noticeable feature of the design is that the machinery space is only about a third of that which would have been necessary for steam-engines, and that the absence of boilers and boiler casings leaves a large amount of hold space for the stowage of cargo, and far more deck space for the use of passengers than would be possible if the vessel were fitted with steam-engines. It is expected that the Jutlandia will run trials next month.

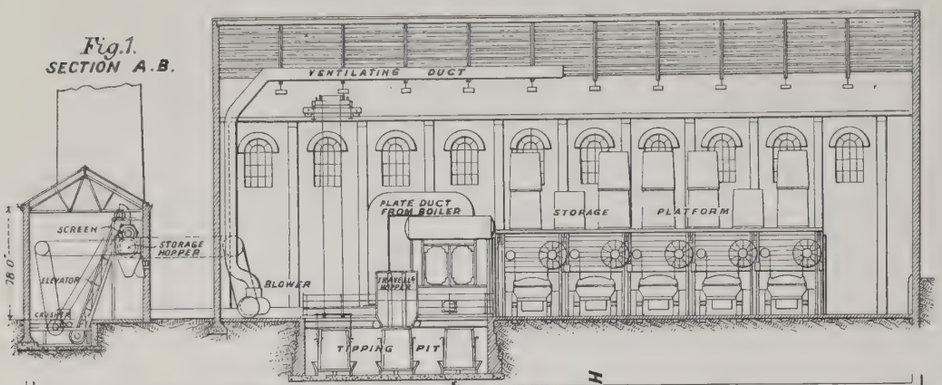
Personal.—The Watt Electric Incandescent Lamp Works, Scharf, Löti and Latzko, of 17, Schottenring, Vienna, have appointed Messrs. Ship Carbons, Limited, of 67, Aldersgate-street, London, E.C., sole agents in the United Kingdom for their "Monowatt" metallic filament lamps and carbon lamps.—Messrs. J. Holroyd and Co., Limited, engineers and machine-tool makers, of Milnrow, near Rochdale, have appointed Mr. Vincent Gartside, a director of the company. Mr. Gartside has been with the company for many years in various responsible positions.—Mr. H. G. Jackson has resigned his position as representative of Messrs. Schuchardt and Schutte, and has been appointed manager in Great Britain and the Colonies of the Korfund Company, 47, Victoria-street, S.W., makers of "Korfund" foundation plates for insulating vibrating machinery, such as gas-engines, motors, compressors, &c.—Messrs. Feld Brothers and Co., Limited, 25, Budge-row, London, E.C., have been appointed by the Brenne Hangarter Works, Haspe, Westphalia, as their sole British representatives for their manufactures of wagon and locomotive springs, buffers, &c., which they have been making since 1873.—Mr. C. C. F. Monckton, M.I.E.E., is leaving Parliament Mansions, Victoria-street, S.W., to become superintendent of telegraphs and telephones in Fiji. His business will be carried on by Mr. Arnold G. Hansard, B.A., M.I.E.E., of the same address, in conjunction with whom he has worked for the last five years.—Messrs. Edgar Allen and Co., Limited, Imperial Steel Works, Sheffield, inform us that their cement and crushing machinery department is now under the charge of Mr. W. J. Coles, M.I.E.E., late of the firm of Maxted, Knott, and Coles, consulting engineers, Hull. They have also concluded an arrangement with Mr. Frederick Siemens by which they are sole licensees for Great Britain for the manufacture and supply of his patent gas-fired rotary kilns. Mr. Coles's address will be at their London office, 52, Queen Victoria-street, E.C.—Mr. W. S. Smart, of the Gas Works, Saltley, Birmingham, has been appointed general manager to Messrs. W. J. Jenkins and Co., Limited, gas engineers and contractors, of Retford,

HORSFALL REFUSE-DESTRUCTOR; MERSEY DOCK AND HARBOUR BOARD.

CONSTRUCTED BY THE HORSFALL DESTRUCTOR COMPANY, LIMITED, ENGINEERS, LONDON AND PERSHORE.

(*For Description, see opposite Page.*)

Fig.1. SECTION A.B.



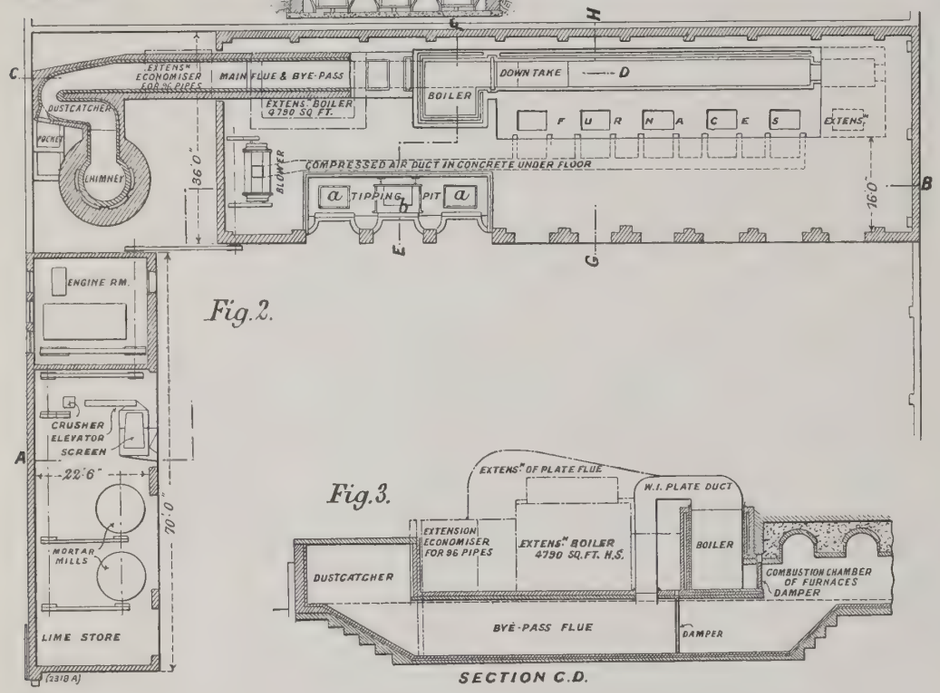


Fig.2.

Fig.3.

SECTION C.D.

Fig.4. SECTION G.H

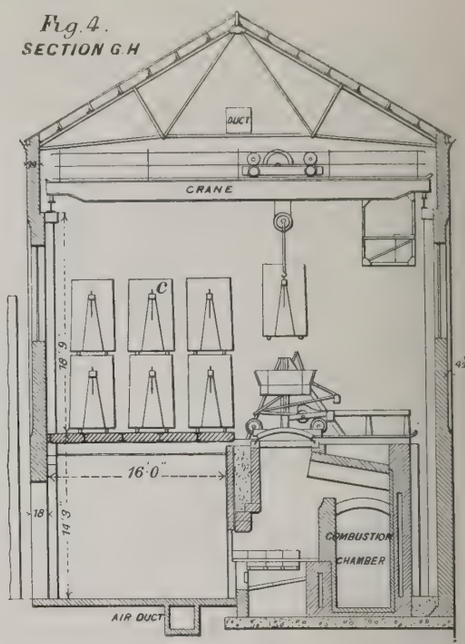
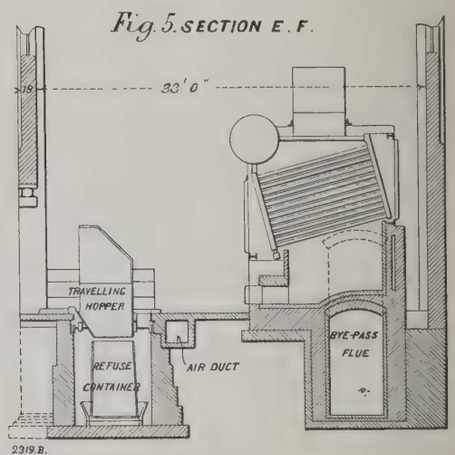


Fig.5. SECTION E.F.



2319.B.

Fig.6

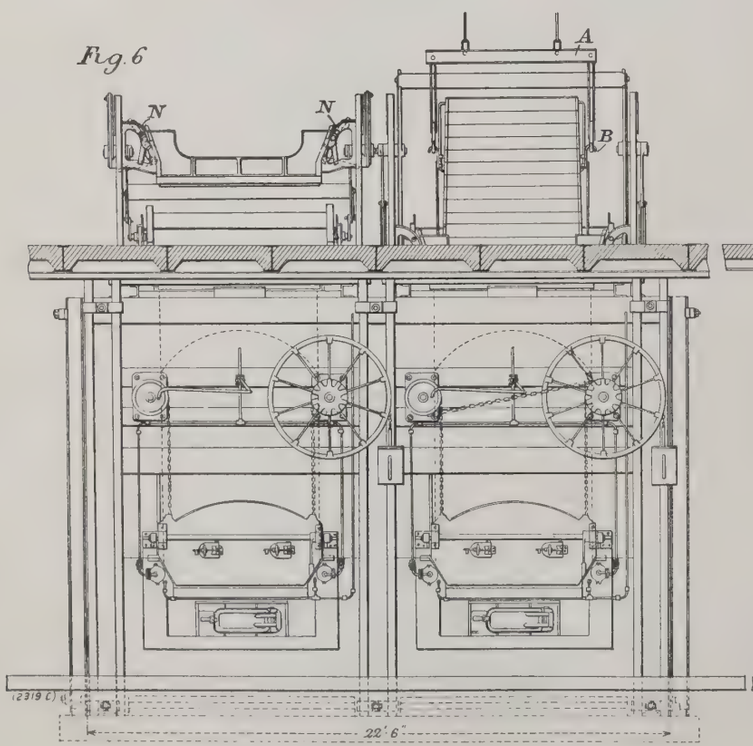
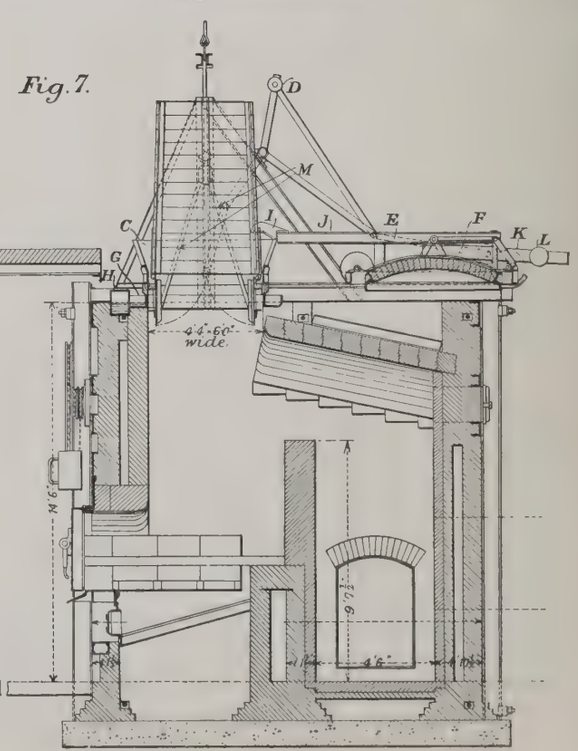


Fig.7.



HORSFALL REFUSE-DESTRUCTOR; MERSEY DOCKS.

CONSTRUCTED BY THE HORSFALL DESTRUCTOR COMPANY, LIMITED, LONDON.

Fig. 8.

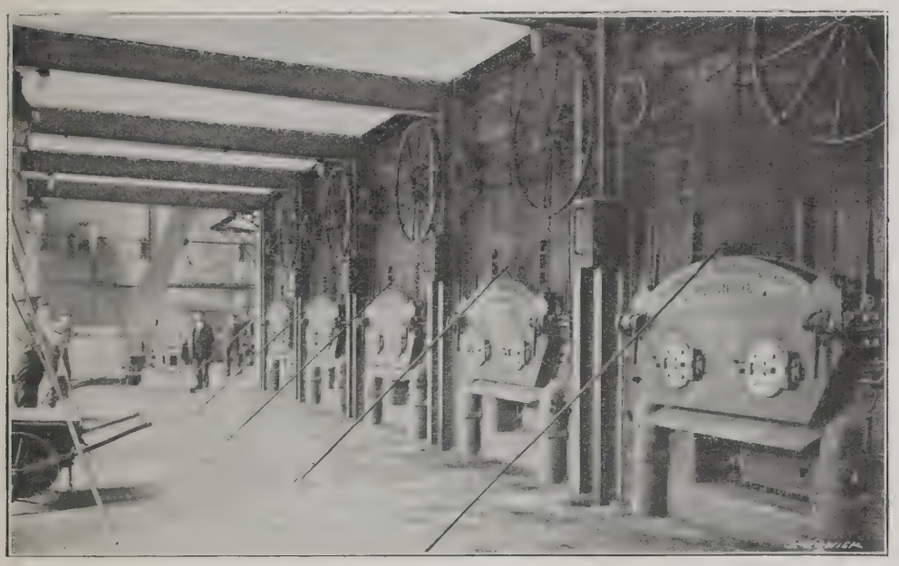


Fig. 9.

Fig. 10.

It is now some time since what is known as the Horsfall method of dealing with house and other refuse in towns came into use, the method being described by us on page 12 of our eighty-fifth volume. Since that time, however, the method has been improved and the plant simplified, while, at the same time, its efficiency has been raised, and the variety of purposes to which it can be applied has been extended.

One of the latest of these improved plants has been recently completed at Liverpool, where it has been installed in Lightbody-street for the Mersey Docks and Harbour Board, and is used for destroying the Harbour Board's refuse, which is collected from their warehouses, yards, and docks. The refuse is composed of condemned cargoes and sweepings from ships, quays, &c. Through the courtesy of Mr. Lyster, the dock engineer, we were able recently to make an inspection of the installation while at work.

The plant is shown in Figs. 1 to 4, opposite, and consists of five Horsfall patent cells fitted with the firm's side boxes. The forced draught enters through these, and, in its passage, gets heated up before being delivered to the underside of the grate bars. Fig. 1 is a longitudinal sectional elevation taken just in front of the furnaces, and through the tipping pits; Fig. 2 is a sectional plan; Fig. 3 is a longitudinal section through the flue; Fig. 4 a sectional elevation through the furnace; and Fig. 5 a transverse section through the boiler-house. The furnace to a larger scale is shown in Figs. 6 and 7, the former being a front elevation, and the latter a sectional elevation. Fig. 1 shows five furnaces side by side. The side boxes, to which we have before alluded, and in passing through which the air gets heated on its way to the furnaces, may be seen in Fig. 7. These boxes have also the effect of preventing the fire irons from damaging the brickwork of the walls of the furnaces. The grate-bars are made separate and are provided with numerous small holes, through which the forced draught passes. The area of each cell is 25 sq. ft. The general arrangement is shown very clearly in Figs. 1, 2. 4, and 5, which views will enable the following description to be understood:—

The gases generated in each furnace enter from each cell into one continuous-combustion chamber, which runs the full length of the block of cells, as is clearly shown in the plan, Fig. 2. An enlarged longitudinal section of a portion of this combustion chamber may be seen in Fig. 3. In this chamber the gases are thoroughly mixed and cremated at a very high temperature, and after being thoroughly amalgamated pass into a Babcock and Wilcox water-tube boiler, containing 2370 sq. ft. of heating surface, and working at a pressure of 120 lb. per square inch. Part of the steam generated is used for supplying steam jets, which are fitted to the furnace cells as a stand-by, and also for driving engine, crane, crusher, and mortar-mill; as well as engine and dynamo for lighting.

As before stated, forced draught is employed, and is supplied to the furnaces by a belt-driven blower, the air being drawn from the upper part of the building and conveyed along the square tube shown in Figs. 1, 2, and 4, an arrangement which enables a clear atmosphere to be maintained above the cells. The clinker doors of the furnaces have balance-weights and gearing, by which they can be raised and lowered as required for purposes of cleaning the cells. In each of these doors are also two small rake holes through which the fire can be managed, so that the doors need not be raised for a lengthy period.

The chief feature of this destructor, as compared with nearly all those previously installed by the company, is the method by which the refuse is fed into the furnaces, the destructor being fitted with what is known as the "Horsfall patent tub-feed system." The method of working is as follows:—Wooden tubs of 120 cub. ft. capacity are placed in a pit, a travelling hopper being provided over the tubs, as may be seen in the plan, Fig. 2; the tubs being shown at *a*, and the travelling hopper at *b*. The rubbish to be burned is tipped directly into the hopper and passes into the tubs. When the latter are filled they are lifted by an overhead travelling-crane and placed on a storage platform as shown at *c*, Fig. 4, or else put directly on the top of the furnace for charging, as may also be seen in the same illustration.

On the top of the furnace is provided a cast-iron hopper, connected to which by means of levers is the top door of the furnace, which fits into a water-tight trough, making a perfectly gas-tight joint whilst the cells are in operation. As this part of the plant is the chief feature, it will be well to give it a detailed description, which can be done with the aid of the illustrations, Figs. 6 and 7, opposite. When a furnace is to be charged, the crane attendant traverses the special lifting-bridge bar A of the crane, the bar being hung from two barrels on the hoisting-gear of the crane, until the hooks, shown at the side in Fig. 6, engage with the large hooks B on the sides of one of the tubs. The tub may be either one of those in the pit ready to be lifted, or it may be one of those on the storage platform, in case there is no refuse being delivered at the moment. This engagement of the hook takes place without guidance, and the man on the crane is able to perform the whole operation without any assistance. The tub is then lifted up and brought over the cell which has to be charged, and is lowered into a cradle C with sloping sides arranged to form a guide for the tub, as is shown in Figs. 6 and 7. This cradle is balanced, or almost balanced, in its top position by means of a weight, mounted on a bell-crank lever D, which is also connected, by means of a connecting-rod E, with

the furnace-lid F, which in Fig. 7 is shown removed from the furnace mouth to allow the refuse to be dropped on to the bars. The cradle is not entirely balanced by the weight D, but the lid F is allowed to have sufficient bias to keep the cradle normally in its top position (Fig. 6) when the lid F is shut. This lid is formed of a heavy cast-iron frame, with a firebrick arch built into it and well stayed in such a manner that only the lower side of the firebrick arch is exposed to the full heat of the furnace. The rim of the frame of this charging-lid dips into a water-seal G, which forms the mouth of the furnace, thus making a perfectly gas-tight joint. The great importance of having this joint perfectly gas-tight has been proved by experience, for the least escape of gas or flame would immediately commence to distort the frame of the lid, and would lead to considerable leakage and escape of fumes and smoke. With the water-seal lid, however, and a perfect closing of the opening, there is no tendency for the hot gases to travel in the direction of the lid when the latter is closed, and, as a matter of fact, the gases bank up under the lid, and act to some extent as a non-conductor of heat, protecting it from the highest temperature of the furnace. The water-seal is kept supplied with water by means of an ordinary ball-cock tank shown at H.

Still referring to Figs. 6 and 7, the action of the appliance may be described as follows:—As soon as the tub is lowered into the cradle C the weight of the tub and its contents immediately forces down the cradle, which slides between vertical supports, until it rests firmly upon the upper side of the water seal forming the furnace mouth. At the same time the furnace-lid is lifted and slidden away sideways to expose the mouth of the furnace, the two actions taking place simultaneously. The descent of the cradle works the bell-crank lever and balance D, and, by means of the connecting rod E, begins to push the lid towards the back of the furnace, the parts finally attaining the positions shown in Fig. 7. In order to do this the lid has to be lifted out of the water seal, and this is effected by means of a campath I and an inverted rail J. The lid is carried by means of a frame mounted on four wheels which run on rails on the top of the furnace, but it is also supported by means of a lever K on a fulcrum fixed to the frame with a parallel motion arrangement controlled by a wheel running on the underside of the campath I and the inverted rail J. As soon as the one end of the lever is depressed by the cam I, the other end tilts up and lifts the lid out of the water-seal, and supports it in its higher position until the lid has run back the full length of its traverse. This lever is also provided with a balance-weight L, which almost, though not quite, counterpoises the weight of the lid. When this action is complete, the weight of the tub and the cradle is, of course, supported on the furnace mouth, but the crane goes on lowering until the flap-bottom doors of the tub have been opened, as shown in Fig. 7, by the traversing of the hooks on the sides of the tub. This is effected by making these hooks slide on parallel guide-rods at the side of the tub (instead of having them fixed on the sides of the tub), and connecting the hooks by means of connecting-bars M with the flap-bottom doors of the tub. The effect of this arrangement is that as long as the tub is hanging with its weight on the crane by means of the hooks the lids are held tight shut. When the tub is resting on the platform the lids are also held shut, for the tub then rests on the lids. When, however, the tub is placed in the cradle of the charging mechanism, and when the cradle is depressed and is resting on the furnace mouth, so as to take the weight of the tub, then the lowering of the crane opens the flap-bottom doors.

As soon as the tub has discharged into the furnace it is lifted up again, but the tub cannot leave the cradle at once, because it has become connected to it by means of two automatic hooks N (Fig. 6), fixed in the side of the cradle. These hooks are so arranged that they fall into snugs at the sides of the tub when the latter is first placed in the cradle, thus binding it fast to the cradle during its descent, and also during the time when the cradle is being drawn up again into its normal position. The hooks only disengage from the tub when the cradle reaches to its top position, when pawls which are formed in connection with the hooks strike on pins fixed at the proper position, thus lifting the hooks out of the snugs in the tub and releasing it. All that has to be done by the crane-man, therefore, is to hoist, the first effect being to lift the cradle back into its top position, and thereby move back the lid into its normal position, and drop it into the water seal, once again completely closing the furnace. As soon as the cradle reaches its top position the tub is automatically released and is taken away empty to be placed in the pit on the ground floor ready for charging by the next cart that comes in. The whole of this operation only occupies from one half-minute to one minute, from the commencement of the lowering of the tub above the furnace until the time when the tub is again released.

It is claimed that this arrangement, besides effecting a great saving of labour, entails the advantage that the charging-door has to be opened for a very short time only, and offers no chance for cold air to get into the furnace and cool it down. With any system of hand-charging, it would take a couple of men twenty minutes to half-an-hour to put in the same quantity of refuse by means of shovels, with the furnace-door open the whole time. It should be remarked that, during the charging operation, the blast is invariably turned off, so as to prevent the escape of fumes and smoke. This, again, is another advantage in favour of the instantaneous charging, as it means that the blast is only turned off for one minute, instead of a possible half-hour, in each operation. The charge is burnt off in a period of from one to two hours, according to the amount of refuse put in, and practically the only time lost is that required for clinkering. The doors used for that purpose are very large and heavy and are opened only for clinkering the fire, any trimming that is required being done through two small round doors fixed in the large clinkering door, thus enabling the men to rake over the fire without being exposed to the heat of the furnace and without shutting off the blast.

An objection which is commonly raised to charging in bulk is that, owing to a heavy charge being put on a new fire a certain amount of time must elapse before combustion in that particular cell reaches perfection. Against this it may be said, however, that the furnace, being charged so rapidly as is the case with this plant, has not been cooled down by the admission of cold air, and, therefore, more perfect combustion is reached at a much earlier stage than could possibly be the case with a hand-fired furnace. A more important consideration, however, is that at the back of each cell is a large main flue or combustion chamber common to all the cells, in which the whole of the gases are thoroughly mixed, so that even if unburnt smoke is given off from one furnace for a short time after charging, it is so thoroughly mixed with the gases from the other cells, and with a sufficient excess of air which has passed through them, as to suffer complete combustion in the chamber itself. The temperature of the combustion chamber varies from 1800 deg. to 2100 deg. Fahr. The method is both sanitary and economical, the refuse not being touched by hand in any way from the time it is brought to the destructor, and there is no nuisance from the charging of the refuse, whilst any refuse which is not immediately required for the charging of the furnace is stored in enclosed tubs instead of being allowed to remain in heaps on the floor by the furnace. It is also unnecessary to provide an inclined road for the carts to tip their contents, as in many of the older destructors.

The chimney provided in connection with the destructor is 120 ft. high and 7 ft. in internal diameter, and is lined with firebrick. At its base it is provided with a dust-catcher, which we understand is very effective in its operation, and consists of an annular chamber, round which the gases laden with dust whirl by centrifugal force, the dust falling to the bottom and being caught in a pocket, from which it can easily be removed, the gases passing away up the chimney. The arrangement is shown on the left-hand side of the plan, Fig. 2, and also in Fig. 3. In connection with the destructor there is provided crushing and screening plant for dealing with the residue from the furnaces, which consists of hard innocuous clinker. The lumps of clinker are crushed, and by means of an elevator are conveyed to a screen having perforated plates, through which three sizes of clinker can be sifted. The clinker is used for various purposes: road-construction, brick-making, paving-slabs, concrete, mortar, filter-beds for sewage works, &c.

With regard to the output of this destructor a special trial was made after the completion of the installation, and it was then found that the rate of burning was 120 tons per twenty-four hours in the five cells, which is at the rate of 1 ton per cell per hour. In view of the miscellaneous nature of the refuse, which consists largely of dock sweepings, dust, and dirt, and a large proportion of light material, which sometimes measures nearly 200 cub. ft. to the ton, this appears to be a very good result. In Figs. 8, 9, and 10, on page 667, we reproduce some photographic views of the works, which show clearly the general appearance of the installation. The first of these is a general outside view, the second shows the front of the furnaces, and the last the cradles above the furnaces. The plant was constructed and erected by the Horsfall Destructor Company, Limited, 17, Victoria-street, Westminster, S.W., and Pershore, of which Mr. George Watson and Mr. Thomas W. How are managing directors.

Italian Naval Architects.—We read in the *Rivista Marittima* that the first Congress of Italian Naval Architects and Mechanical Engineers was held at Rome, on the 11th, 12th, and 13th inst., in the hall of the Società degli Ingegneri e Architetti Italiani, under the chairmanship of the Hon. Salvatore Orlando. Nineteen papers were read and discussed, dealing with warship construction, ordnance, oil-engines for ship propulsion, and merchant ship construction.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a firm tone, and Cleveland warrants were active. Business amounting to 8500 tons was done at 46s. 9½d. and 46s. 10d. cash, and 47s. 0½d. and 47s. 1d. one month, with sellers over at 46s. 10½d. cash, 47s. 2d. one month, and 47s. 8d. three months. Hematite was firm, and 1500 tons changed hands at 62s. 3d. one month, with sellers over at that figure, and at 61s. 3d. cash. The afternoon market was quieter, and 2000 tons of Cleveland warrants were dealt in at 46s. 11d. cash and eight days; closing sellers quoted 46s. 10½d. cash, 47s. 2d. one month, and 47s. 8½d. three months. On Friday morning Cleveland warrants were again strong, and after 5500 tons had been done at 46s. 11d. cash, 47s. seven days, and 47s. 3d. one month, the closing quotations were called 47s. cash, 47s. 3½d. one month, and 47s. 10d. three months. In the afternoon the market was quiet but firm, and the transactions consisted of 1500 tons of Cleveland warrants at 47s. 3d. and 47s. 3½d. one month, and 47s. 10d. three months. Sellers' closing quotations were 47s. 0½d. cash, 47s. 3½d. one month, and 47s. 10½d. three months. On Monday morning the upward movement made further progress, and Cleveland warrants were dealt in at 47s. 1d. and 47s. 2d. cash, 47s. 2d. and 47s. 2½d. four days, and at 47s. 5½d. one month. The turnover was 7500 tons, and closing sellers quoted 47s. 2d. cash, 47s. 6d. one month, and 48s. three months. One lot of hematite changed hands at 62s. one month. The afternoon session was very active, and 9500 tons of Cleveland warrants were put through at 47s. 2d. cash, 47s. 5½d. one month, and from 48s. to 47s. 11½d. three months. The closing quotations were 47s. 2d. cash, 47s. 5½d. one month, and 47s. 11½d. three months sellers. One lot of hematite was also done at 62s. 8d. three months. On Tuesday morning the market was just a shade easier, but a large business amounting to 11,000 tons of Cleveland warrants was done at 47s. and 47s. 1d. cash, 47s. 3d. twenty-four days, 47s. 9½d. February 10, and at 47s. 10d. three months. Closing sellers quoted 47s. 1½d. cash, 47s. 5d. one month. and 47s. 11½d. three months. In the afternoon Cleveland warrants were quiet and irregular, and the dealings only amounted to 1000 tons at 47s. 3½d. one month, and 47s. 11½d. three months, and the closing prices were called 47s. 0½d. cash, 47s. 4d. one month, and 47s. 11d. three months sellers. When the market opened to-day (Wednesday), the tone was good, and 6500 tons of Cleveland warrants were done at 47s. and 47s. 1½d. cash, 47s. 4d. and 47s. 5½d. one month, and 47s. 11½d. three months. At the close sellers quoted 47s. 2½d. cash, 47s. 6d. one month, and 48s. three months. Hematite was firm, with sellers at 62s. cash, and buyers at 61s. 8d. cash and 62s. one month. In the afternoon Cleveland warrants were again firmer and changed hands at 47s. 6d. one month and 48s. three months. The turnover was limited to 2500 tons, and the closing quotations were 47s. 3½d. cash, 47s. 7d. one month, and 48s. 1d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 62s.; Gartsherrie 62s. 6d.; Summerlee, 63s. 6d.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 64s. 6d.; Shotts (at Leith), 63s.; and Carron (at Grangemouth), 63s. 6d.

Sulphate of Ammonia.—Firmness is the prevailing feature in the sulphate of ammonia market this week, and with a strong demand the price has again advanced. The current quotation for prompt lots is now from 14*l.* 7s. 6d. to 14*l.* 10s. per ton, Glasgow or Leith, and the amount shipped from Leith Harbour last week totalled 2394 tons.

Scotch Steel Trade.—The state of the Scotch steel trade is not quite so promising this week, and specifications for heavy material are not so numerous. All the same, the majority of the works are still fairly well employed on old contracts, although fresh business for the home market is practically at a standstill. The conditions embodied in the rebate scheme are not being looked upon with too much favour by buyers generally, with the result that the latter seem to be holding off from entering into new engagements in the meantime, in the hope, no doubt, that the conditions or the current prices may be altered. Producers, on the other hand, are standing firm by the agreement, and there is little sign of a break in prices at present. Export inquiries are good and a satisfactory tonnage is going through. There is a little improvement in the inquiry for angles and sectional material generally, and the same may also be said of light stuff. Makers of black and galvanised sheets continue very busy, both on home and export account, and prices are very firm.

Malleable-Iron Trade.—The condition of the malleable-iron trade has not changed, despite the fact that Continental competition has fallen off considerably, owing to advances at home. The current quotation here, however, for local delivery is still on the basis of from 6*l.* to 6*l.* 2s. 6d. per ton for crown bars, which is from 2s. to 3s. per ton under the export figure.

Scotch Pig-Iron Trade.—There has been more doing in the Scotch pig-iron trade during the past week, and a large local business is reported. Inquiries on shipment account are satisfactory, and the orders received from the South amount to quite a considerable tonnage; indeed, the business from that quarter seems to be on the increase. Deliveries are large and the output is being well taken up. The prices all round are firmer, and a small advance is being asked. The demand for hematite has improved and consumers are buying more freely, which condition is perhaps due to the high price now quoted for scrap steel. With this increase in demand producers' quotations are now fully 1s. per ton firmer.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Returns.—Some of the recent decreases in the quantity of coal sent through the port of Hull have been in part made up by the tonnage for October, which was 653,152 tons, an increase of over 50,000 tons upon the figure for October, 1910. Notwithstanding this contribution towards clearing off arrears, the grand total for the ten months of the present year—5,350,400 tons—is 350,000 tons less than the amount dealt with during the same period last year. The foreign exports for October also show an increase over October last year, the respective figures being 375,231 tons and 355,057 tons. The comparative figures for the ten months' exports are 2,857,503 tons this year, and 3,267,194 tons January to October, 1910. The home traffic during the past month absorbed 89,533 tons. The Denaby and Cadeby Main pits, at the head of the South Yorkshire collieries for production, had an output in October of 110,544 tons.

Forty Years' Service.—Mr. Thomas Milner, secretary to the Brightside Foundry and Engineering Company, Limited, was recently presented by the directors and staff with a purse of gold, upon his resignation of his position after a forty years' connection with the company. He resigned on account of ill-health, and has gone to reside at Bournemouth. His successor is Mr. Frank Rodgers.

South Yorkshire Coal Trade.—Steam coal remains in a pretty active state. Collieries report good inquiries both for home and export. The railway companies are increasing their stocks, and the general industrial demands are still heavy, as manufacturers are anxious to be prepared against emergencies. Collieries are asking advances on contract renewals. Gas coal, both for consumption at home and for shipment, is in good demand. The market for best slacks is strong, and contracts are being renewed at advanced prices. For cheaper lots buyers are able to obtain concessions. Inquiries for house coal come to hand very slowly, although the index afforded by the London demand points to a little improvement. Prices are practically unchanged. There are one or two slight reductions, but in the present state of affairs quotations are not likely to alter much for the next week or so. The week-end quotations on the local Exchange were:—Best branch hand-picked, 14s. 6d. to 15s. 6d.; Barnsley best Silkstone, 12s. to 13s.; Silkstone, 11s. 6d. to 12s. 6d.; Derbyshire brights, 11s. to 12s.; Derbyshire house, 10s. to 11s.; large nuts, 9s. 6d. to 10s. 6d.; small nuts, 6s. 6d. to 8s.; Yorkshire hards, 9s. 3d.; Derbyshire hards, 9s. to 10s.; washed nuts, 8s. to 9s.; rough slacks, 5s. 6d. to 7s. 6d.; seconds, 4s. 6d. to 5s. 6d.; smalls, 2s. to 3s.

Iron and Steel.—There is a strong tone about the raw material market. Prices have a tendency to advance, although official quotations have not so far increased. No concessions can be obtained from the makers. Hematite is in a particularly strong position, and in the common irons the demand is about equal to the output. As a consequence of the disappearance of a good deal of Continental material from the English market, users of billets are buying largely in Sheffield, and some of the furnaces are working continuously. There is a considerable amount of work in semi-steels. Scrap continues to be in a weak position. Boom conditions are still ruling in the majority of Sheffield's industries. Renewed fears of a railway strike have brought another rush of buyers into the market, and so great is the tonnage of goods now being sent out of the Sheffield district that the railway companies have at some of the busier centres had a considerable difficulty in meeting the pressure. The armament houses show no diminution in activity, and the railway steel manufacturers have a satisfactory weight of work in hand. Forges are working full time, and makers of all kinds of special steels and tools have a superabundance of orders. In a very large number of departments overtime is being regularly worked. What may be regarded as an interesting "side line" in steel manufactures has been slowly coming into existence during the last year or two. This is the manufacture of steel window-sashes in place of wood. One Sheffield firm has set up special machinery for this purpose.

THE GREAT CENTRAL RAILWAY.—Mr. J. B. Ball, M. Inst. C.E., has been appointed to succeed Mr. C. A. Rowlandson, M. Inst. C.E., as engineer-in-chief of the Great Central Railway. Mr. Ball, who was articled to Mr. Joseph Hall, M. Inst. C.E., joined the staff of the Great Northern Railway in 1890, and in 1895 was engaged under Mr. Elliott Cooper, Vice-President of the Institution of Civil Engineers, upon the construction—amongst other important works—of the Lancashire, Derbyshire, and East Coast Railway. In 1899 he was appointed engineer of that railway, and occupied that position until it was absorbed on January 1, 1907, in the Great Central system. Early in January, 1906, he was appointed, under Mr. Rowlandson, as head of the new works department, and since that date has been engaged upon numerous works of construction, including the Ardwick and Hyde Junction widenings at Manchester, the new carriage and wagon works at Dukinfield, the gravity concentration yard at Wath, the Torside to Woodhead widening, the opening out of Bridgehouses Tunnel and re-arrangement of Sheffield station, the new avoiding line at Doncaster, and various other new railways and works, including the hydraulic equipment and the laying out of the permanent way—about 160 miles—the ferro-concrete bridges and gantries, granary, &c., of the new deep-water dock at Immingham, which will shortly be opened. Mr. Ball, in 1906, was President of the Permanent-Way Institution, and was largely instrumental in bringing about its incorporation.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—A marked improvement has set in in all branches of pig iron, and traders now take a most cheerful view of the outlook. Orders are coming in apace both for early and forward delivery, and values are steadily advancing. The most satisfactory feature of the market is the desire shown to place orders on forward account. Quite a number of rather heavy contracts over the first half of next year have been made at higher rates than are named for early delivery. The general tone of the market is decidedly more cheerful than for some months past. No. 3 g.m.b. Cleveland pig is now readily realising 47s. 6d. for early f.o.b. delivery, and for delivery over the first quarter of next year 48s. to 50s. have to be paid. The latter figure has been realised for certain named brands. The long looked-for improvement in East Coast hematite pig has at length made its welcome appearance. Prices are now moving upward, and sales are on a large scale, so that the rather heavy stocks of makers are likely to be considerably reduced in the near future. Nos. 1, 2, and 3 have advanced to 61s. for early delivery, and 61s. 6d. has been readily paid for delivery over the first half of next year for rather large quantities. Foreign ore is very firm. A very extensive business has been done recently, and there are still numerous inquiries in the market. Last week purchases were made amounting altogether to something like a million tons of Swedish ore. Quotations are on the basis of fully 20s. ex-ship Tees for best Rubio. Coke is steady and firm, and in good request for local use. Average blast-furnace qualities are quoted 15s. to 15s. 3d. delivered here.

Pig-Iron Shipments and Stocks.—Shipments of pig iron continue on a satisfactory scale. To date this month they average 3363 tons per working day, as compared with a daily average of 4026 tons to the same date last month, and 3868 tons for the corresponding part of November, last year. Stocks of Cleveland iron in the public warrant stores are being steadily reduced. So far this month the withdrawals have averaged some 590 tons per working day, and the total stock to-night stands at 570,336 tons.

Manufactured Iron and Steel.—Great activity prevails in the manufactured iron and steel branches of the staple industry. The output is very heavy, and demand continues good. Several firms have contracts made which will keep them in full swing over the greater part of next year. Values of several descriptions show a decided upward tendency, but as yet no actual advances have been made. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 5s. to 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 7s. 6d.; iron girder-plates, 6*l.* 15s.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 7s. 6d. to 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 11*l.* 5s.—sheets less 4 per cent. f.o.b., railway material net at works, and all other descriptions less 2½ per cent. discount.

Cleveland Institution of Engineers.—On Monday the annual meeting of the Cleveland Institution of Engineers was held in the lecture hall of the Cleveland Literary and Philosophical Society, Middlesbrough. Mr. H. Stonewall Jackson, of the firm of Messrs. Richardsons, Westgarth, and Co., Middlesbrough, marine-engine builders, took the chair, and delivered an interesting presidential address, to which we refer in another column.

BOLINDERS DIRECT REVERSIBLE CRUDE-OIL ENGINE.—This engine is achieving a very high degree of success in small craft, as is proved by the fact that Messrs. James Pollock, Sons, and Co., Limited, of 3, Lloyd's-avenue, London, who are the British representatives, have orders for upwards of fifty engines on hand. These are to be fitted to tugs, launches, yachts, sea-going and canal barges, and coasting vessels. The efficiency of the engine has just been proved once more by the results of the trials of a motor-barge and tug, the Ogarita, built for English Channel work. This vessel is 92 ft. 6 in. long, 19 ft. in the beam, and 7 ft. 8 in. deep, and she proved her seaworthiness by making the voyage from the Tyne to Portsmouth during the recent storms, when it was necessary to batten down the engine-room and to make other provision to save flooding. The engine in this boat is of 120 brake horse-power, and, on the trial, used Scotch shale oil, costing about 3d. per gallon, having a specific gravity of 0.863, and a flash point of 230 deg. Fahr. This fuel is intermediate between illuminating and lubricating oils. Cheap as this is, experiments are in progress by Messrs. Pollock which, it is hoped, will enable the Bolinders motor to work on oil costing 2½d. per gallon delivered in London. On the measured-mile trials at Stokes Bay the vessel maintained a speed of 10¾ miles per hour, as compared with contract speed of 9 knots. The consumption of fuel proved approximately 200 gallons for 24 hours when working at full load, and the estimate is that steam plant to do the same load would have required 3¾ tons of coal per 24 hours. As regards the initial cost of machinery, the saving is put at 20 per cent., while less space is occupied, and consequently more cargo can be taken. It may be added that Messrs. Pollock have a demonstration launch in the Thames, and they welcome visits of interested parties.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Interest in the Cardiff steam-coal market has chiefly centred in inquiries for British naval requirements next year. Buyers for distant dates and on contract account show a disposition to defer further business until a conference of the Miners' Federation of Great Britain has been held. The best large steam-coal has made 16s. 9d. to 17s. 3d. per ton; ordinary qualities have ranged between 15s. and 16s. 6d.; best bunker smalls between 7s. 9d. and 8s.; and cargo smalls between 6s. and 6s. 6d. per ton. House-coal has shown scarcely any change; the best ordinary qualities have made 14s. 6d. to 16s. 6d.; No. 3 Rhondda large, 17s. to 17s. 6d.; and smalls, 10s. 3d. to 10s. 6d. per ton. No. 2 Rhondda large has brought 12s. to 12s. 6d.; smalls, 6s. 3d. to 6s. 9d. per ton. Foundry coke has realised 18s. to 20s. 6d.; and furnace ditto, 16s. to 17s. per ton. As regards iron ore, Rubio has made 19s. to 19s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

South Wales Coal.—The shipments of coal from the six principal Welsh ports—Cardiff, Newport, Swansea, Port Talbot, Neath, and Llanelly—in October were:—Cardiff—foreign, 1,410,277 tons; coastwise, 233,216 tons; total, 1,643,493 tons. Newport—foreign, 329,450 tons; coastwise, 61,280 tons; total, 390,730 tons. Swansea—foreign, 103,881 tons; coastwise, 16,771 tons; total, 120,652 tons. Neath—foreign, 15,834 tons; coastwise, 12,050 tons; total, 27,884 tons. Llanelly—foreign, 18,750 tons; coastwise, 3522 tons; total, 22,272 tons. The aggregate shipments for the month were, accordingly, 2,469,547 tons. The aggregate shipments of coal from Cardiff to October 31 this year were:—Foreign, 13,045,946 tons; coastwise, 2,257,270 tons; total, 15,303,216 tons. From Newport—foreign, 3,596,389 tons; coastwise, 564,523 tons; total, 4,162,912 tons. From Swansea—foreign, 2,375,637 tons; coastwise, 223,259 tons; total, 2,596,896 tons. From Port Talbot—foreign, 1,295,700 tons; coastwise, 141,474 tons; total, 1,437,174 tons.

Welsh Coal-Mining.—A meeting of the South Wales and Monmouthshire branch of the National Association of Colliery Managers was held at Swansea on Saturday. Mr. J. Kane, secretary, referred to representations which had been made from South Wales as to the new Coal Mines Bill, especially with regard to Clause 42, Section 4, which enacts that when in any mine or seam the air current in the main return contains more than ½ per cent. of gas, the air-way shall not, except within a distance of 300 yards from the shaft, be used for the haulage of coal from the face. This clause has been energetically objected to by South Wales managers. Their point was that if it became law, 60,000 men would be thrown out of employment, and something like 12,000,000 tons of coal would be lost in the annual output in South Wales alone. They suggested that, instead of the ½ per cent. of gas, there should be inserted the words, "such a quantity of gas as shows a definite cap on the flame of the safety lamp." The result of the representations made was that the clause objected to would probably be amended.

Dowlais.—The production of crude iron has been in excess of current requirement. The Goat Mill has been engaged on urgent orders for steel rails, tin-bar, and steel sleepers. The Big Mill has been at work upon light steel rails of short lengths.

THE ROYAL SOCIETY OF ARTS.—Lord Sanderson, G.C.B., K.C.M.G., I.S.O., Vice-President and Chairman of the Council of the Royal Society of Arts, delivered an address at the opening meeting of the 158th session, on Wednesday, the 15th inst. He dealt with the immense development of international intercourse which has taken place of recent years, and reviewed this in all its various aspects, including diplomatic intercourse, the increased facilities for travelling, for the exchange of postal and telegraphic communications, and for the exchange of commercial products. A result of the movement was a general tendency to resort to combination as a supplement to, and, in some cases, as a substitute for, competition. International co-operation also obtained in science, and this had done much to extend our sphere of knowledge. The Society had taken a not unimportant share in all the work which had been done, and Lord Sanderson suggested that its future work would lie less in the province of stimulation than in the exercise of discrimination and guidance—*i.e.*, in pointing out the soundest methods and in selecting the most promising subjects.

THE LATE PROFESSOR S. LINDECK.—It is with sincere regret that we announce the death of Professor Stanislaus Lindeck, since 1895 editor of our contemporary, the *Zeitschrift für Instrumentenkunde*. The excellence of that journal, which has no equivalent in this country, is in no small measure due to the capacity and conscientiousness of its late editor. Dr. Lindeck was, at Berlin, a pupil of Kundt, and has been a member of the Reichsanstalt since its inauguration in 1887. He was head of the weak-current laboratory and was well known as a very able and careful worker, and an authority, especially on standard resistances and standard cells. He possessed at the same time considerable business capacity, and he proved a most useful member of the two International Electric Conferences on Units held in Berlin and London. He was a member also of Lord Rayleigh's committee appointed by the London Conference to carry on its work. The German Government sent him over to St. Louis and Paris to organise the German sections of the mechanical and optical exhibits at those international exhibitions. Dr. Lindeck died in Berlin in the last week of October after a short illness, and his death was and will be a great loss to his many warm friends and to all who came in contact with him.

INTERIOR VIEWS OF HOLLAND TYPE OF SUBMARINE-BOAT.

CONSTRUCTED BY THE ELECTRIC-BOAT COMPANY, NEW YORK.

(*For Description, see Page* 655.)

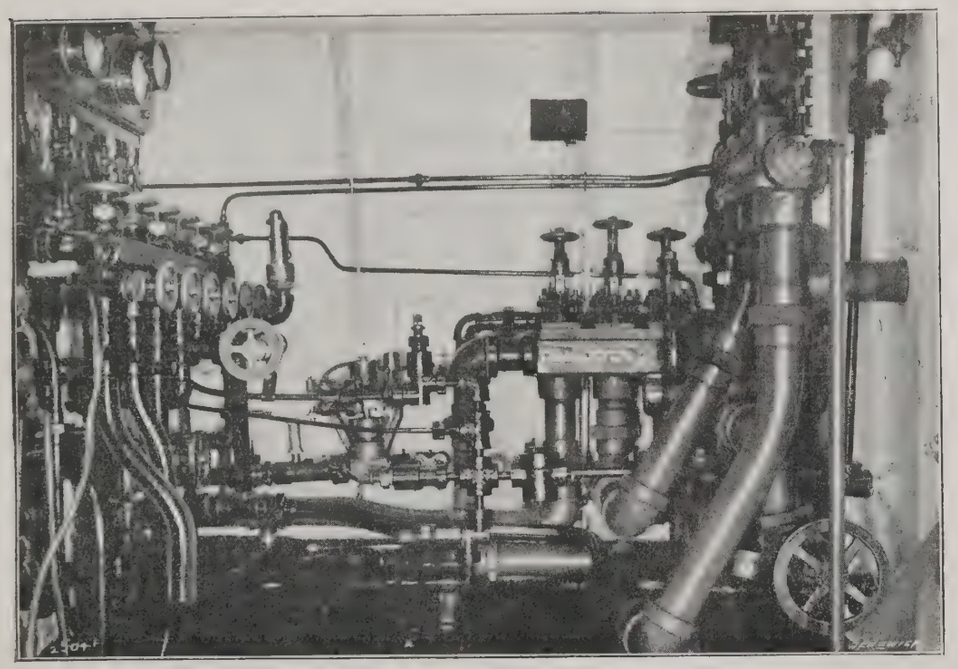


FIG. 25. CONTROL STATION FOR AIR AND AUXILIARY PUMP.

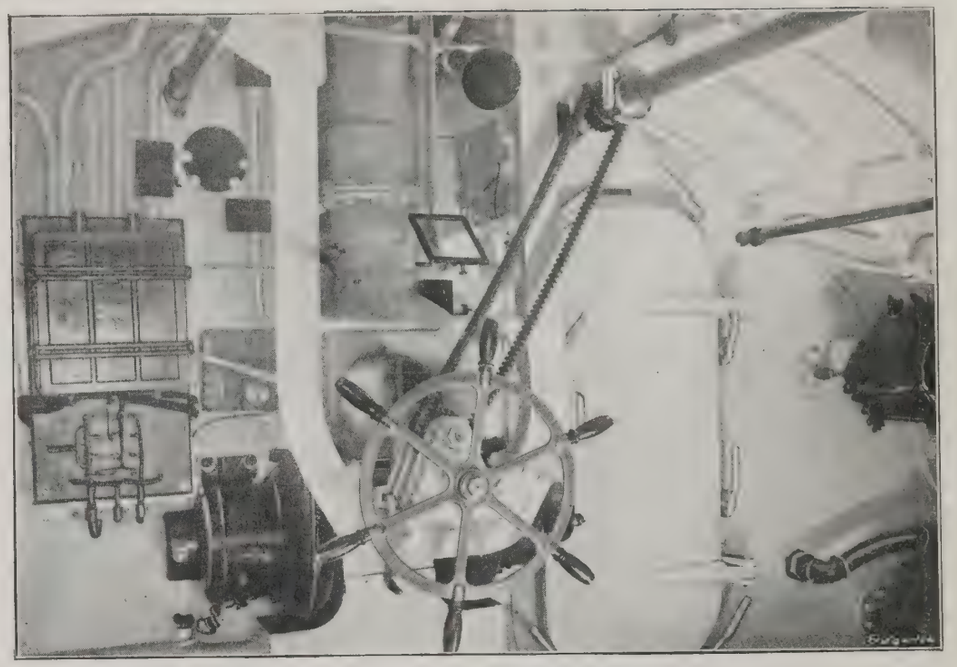


FIG. 26. INTERNAL HAND STEERING-GEAR.

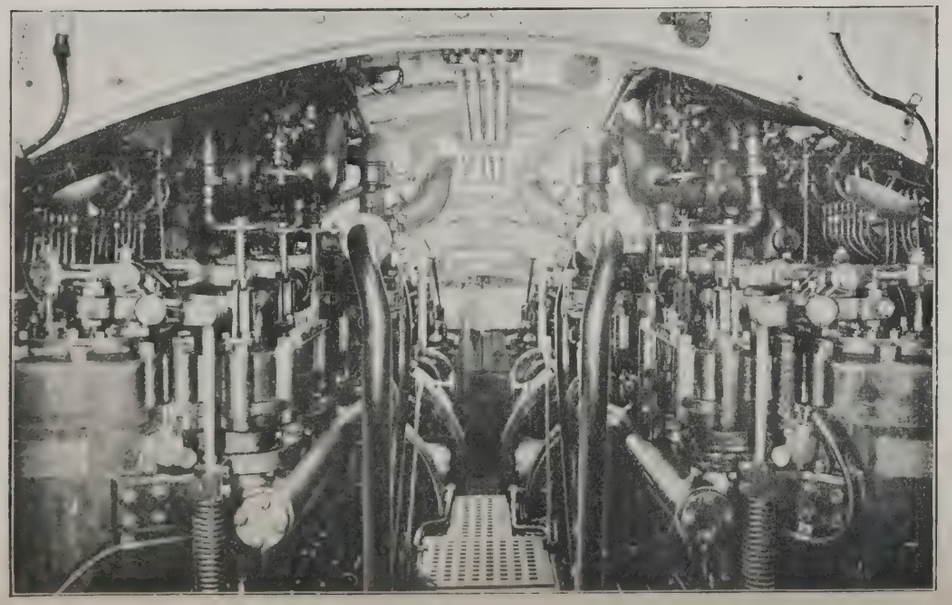


FIG. 27. ENGINE-ROOM, LOOKING AFT.

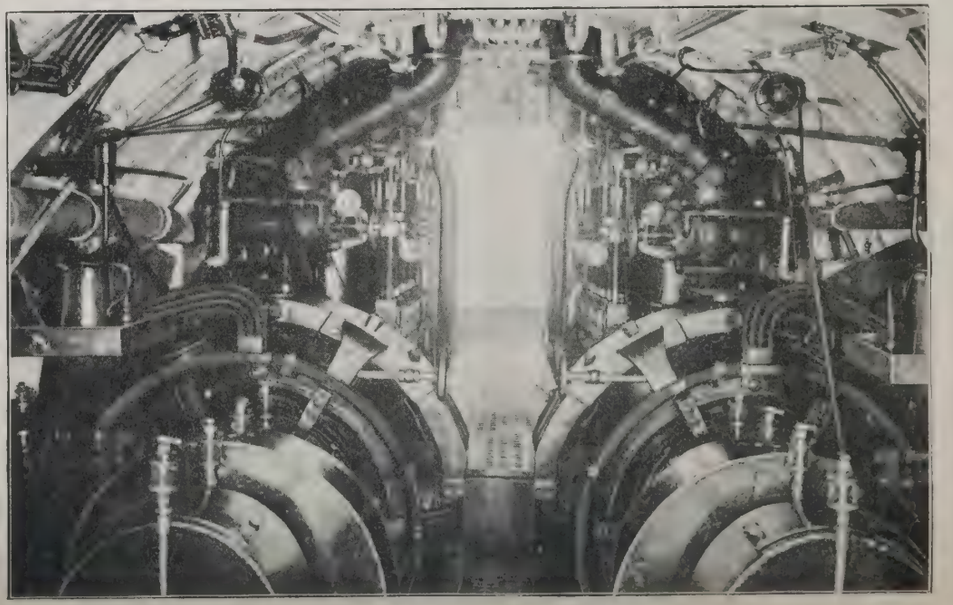


FIG. 28. ENGINE-ROOM, LOOKING FORWARD.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 17, at 8 p.m. Adjourned discussion upon the paper by Messrs. E. M. Eden, W. N. Rose, and F. L. Cunningham, on "The Endurance of Metals; Experiments on Rotating Beams at University College, London." Paper to be read and discussed (if time permits):—"Double-Cutting and High-Speed Planing-Machines," by Mr. J. Hartley Wicksteed, Past-President, of Leeds.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 21, at 8 p.m. Papers to be further discussed:—"The Loch Leven Water-Power Works," by Mr. Alfred Henry Roberts, M. Inst. C.E.; "The Hydro-Electric Plant in the British Aluminium Company's Factory at Kinlochleven," by Mr. Frederic Bolton Sonnenschein, Assoc. M. Inst. C.E.

THE ROYAL SOCIETY OF ARTS.—Wednesday, November 22, at 8 p.m. "The Industrial Progress of the United States of America," by Mr. James Douglas, LL.D., Past-President of the American Institute of Mining Engineers. The Right Hon. Sir Henry Mortimer Durand, G.C.M.G., K.C.S.I., K.C.I.E., late H.B.M. Ambassador at Washington, will preside.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 23, at 8 p.m. "Automatic Reversible Battery Boosters," by Mr. R. Rankin, A.M.I.E.E.

THE PHYSICAL SOCIETY OF LONDON.—Friday, November 24, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. Agenda:—1. "The Maximum Value of the Electric Stress Between Two Unequal Spherical Electrodes," by Dr. A. Russell. 2. "The Cubical Expansion of Fused Silica," by Mr. F. J. Harlow. 3. "On the Temperature Coefficient of Diffusion," by Mr. B. W. Clack. 4. "The α Particles Emitted by the Active Deposits of Thorium and Actinium," by Messrs. E. Marsden and T. Barratt. 5. "The Magnetic Transition Point of Cementite," by Messrs. S. W. J. Smith, W. White, and S. G. Barker.

ENGINEERING.

FRIDAY, NOVEMBER 17, 1911.

MIND AND MATTER.

IT is not many years since a distinguished admiral, in opposing the grant of executive rank to naval engineers, observed that he had known a mere Lascar run engines very adequately, the presumption being that engineering was not a matter calling for the exercise of any intellectual faculties. We are rather inclined to the belief that the gallant admiral's view is widely shared by the public at large. Both the glory and the weakness of the engineer lies in the fact that his mental exercises afford occupation for hosts of mere manual labourers, with the result that the public in general, and their literary guides in particular, unable to see the wood for the trees, are much disposed to deny that engineering is aught but a purely mechanical art. The extremists go even further, and refuse to rank the labours of the physicist and mathematician on the same intellectual plane as those of the poet and novelist. The argument, as we have heard it expressed by a distinguished Cambridge literary man, was to the effect that the work of each of the latter was unique of its kind, whilst if Dalton had not propounded the atomic theory, or Newton that of universal gravitation, it was probable that some other man of similar calibre would have done so sooner or later. If this contention were sound, the writer of the doggerel which occasionally disfigures a corner of some country newspaper, would rank intellectually above Archimedes and Clerk Maxwell.

The fact is, as pointed out by Mr. Campbell Swinton in his remarkably able and highly interesting address to the Röntgen Society on the 7th inst., literary men have the ear of the world, and constitute the best organised and most successful mutual admiration society on record. The prominent position taken by the literary guild, and their often prejudicial influence on public opinion, lies in part, no doubt, in the fact that relatively little labour or application is required to enable a man to appreciate good literature. It is thus easy to understand the fact that university extension lectures, devoted to culture studies, are very much more popular than those dealing with science, and, so far as we know, there are absolutely none in which mathematical studies are taken up. Everyone has views on literature, history, and sociology, and, with little or no training, can speak and argue on such subjects with absolute self-confidence.

It is for this reason that the most popular section of the British Association is now that devoted to economics. As this is as yet not one of the exact sciences, each man's opinion is, in his own view, as good as another, and statistics can always be found which, in their unanalysed state, appear to support the most contradictory of views. Now that a science of statistics is being gradually founded on the mathematical theory of probability, it will be of interest to learn whether the present enthusiasm of the inexpert for economics will be maintained. We fancy that when physical science was in its qualitative stage it excited rather more public interest than it does at present, when a somewhat prolonged and laborious course of study is a necessary preliminary to any adequate apprehension of points still at issue. A perusal of a recent paper in *Nature*, by Major Ronald Ross, in which the statistical relationship between malaria and mosquitoes is discussed by strict mathematical methods, would, we think, considerably surprise the leader-writers and politicians who glibly quote statistics in support of this or that particular ism.

A famous poet has declared that the noblest study of mankind is man; but the culture studies advocated by the literary guild are purely devoted to the interesting side of human endeavour, the personal deeds of this warrior or that statesman, who, after all, merely had their day and ceased to be. As a consequence the "humanities" have proved to be less a preparation for life than a form of distraction for leisure hours. Akin, therefore, to chess and golf, and like the latter pursuits, followed both by a small body of hard-working professionals and a very much larger mass of amateurs. No one, of course, advocates the abandonment of culture studies. Most of us sympathise with Herodotus when he avows as a reason for undertaking his history a reluctance to let fade into oblivion the great and admirable deeds of either the Greeks or the Barbarians. Nevertheless, the duties of life should take precedence of its distractions and general education should have a broader basis than that to which the literary guild would confine it.

The really effective force in moulding humanity has been the scientific imagination. As Mr. Campbell Swinton pointed out, no historical character has affected the destinies of the race to more than an infinitesimal extent when his influence is compared with that of the unnamed savage who first had the intelligence to see the uses of fire, and the courage to attempt to control it. Some other unknown engineer first saw the possibilities of flint weapons, and once his individual intellect opened the path, the whole tribe of men were able to follow it. The extraordinary influence of scientific thought on the destiny of nations has of late years received a remarkable illustration by the excavations made at Crete. Here a whole civilisation, in many respects of a very advanced type, appears to have been wiped out by invaders whose sole superiority lay in a better knowledge of the metallurgy of iron. It is the stupendous ignorance of the importance of mind, in what are commonly considered questions of mere matter, which is responsible for the pronouncements of certain speakers and writers, who, as Mr. Campbell Swinton says, appear to think that railways were invented by the rank and file of railway workers.

It will be a matter of surprise if this mental attitude does not receive a fresh illustration in the final transfer of the telephones to the Post Office. In this transfer all the "hands" are to be retained, but, if long-established precedent is to be followed, the controlling "minds" are to be largely reduced in number. A large proportion of those who by initiative and ability have raised themselves into important posts must expect to be retired. The fact that in the Post Office a second-class clerk can rise to a salary of 500*l.* per year, whilst the maximum allowed to a first-class engineer is 350*l.*, shows that our administrators share to a large extent the views of the gallant admiral already quoted. "The Republic has no need of chemists" was the reply to Lavoisier's plea for a respite from the guillotine, and the spirit which dictated it is still active. The same contempt for intellect as applied to the practical ends of life is also apparent in the Commonwealth of Australia. Were public works there permitted to be executed by private associations, there would at this time be some scores of engineers with minds worth 2000*l.* a year or more engaged in developing the country.

The existing veto on private enterprise is, in short, an attempt to economise in brains, and many of the advocates of Government railroads in this country are under a similar delusion as to the profitableness of such misguided attempts at thrift. Third-rate literary men, if they only write with sufficient political bias, may find themselves provided with a civil service pension, whilst the services of a doctor who has disabled himself by researches on X-ray work receives scant recognition from the Treasury. Truly, in its own generation the pen is mightier not only than the sword but than the implements of

the engineer and the apparatus of the physicist. These, however, get their revenge in that their work endures though their names may vanish. Our present minor sub-divisions of time, for example, are said to have originated with the Babylonian astronomers and remained when almost every record of contemporary kings and statesmen had been buried under the *débris* of centuries.

This underrating of intellect in its practical applications is no doubt partly due to the defective state of secondary education in this country. Germany, for instance, is proud of its science, and possesses in proportion to its population a greater number of trained engineers and physicists than any other country. If less original than England and France, the international character of modern science and engineering makes it easy for the nation to import new ideas, on which it afterwards works with unexampled industry and with a very high degree of success. As Professor Unwin pointed out in his address, delivered as President of the Institution of Civil Engineers last week, we owe to Germany the large gas-engine and the Diesel engine, and both are characteristic products of the country. They represent the triumph of patient and intelligent perseverance over inherent difficulties so great that it is hard to believe that either type of prime mover will be retained permanently. Some simpler solution of the problem of producing power by the explosion of combustible gases will probably ultimately supersede both, though whether this makes its appearance in five or in twenty-five years hence, time alone can prove. The German people understand and appreciate what science has done for Germany, but here the man in the street is a very Gallio in the matter of caring for none of these things.

In another part of his address Mr. Campbell Swinton raised again the old question as to whether or no living beings can evade the second law of thermodynamics, which fixes the proportion of the total energy of the universe which is capable of being converted into mechanical work. From a metaphysical standpoint no bar is to be found to such an evasion ; mind may well have the faculty of selection, which, as Maxwell pointed out, was all that was necessary to separate out a mass of gas into two groups of molecules, one of which is hotter than the other, and could this suggested power of selection be developed, our stores of available energy would be, as the president of the Faraday Society pointed out, indefinitely increased. In fact, we should get what in practice would prove to be perpetual motion. The doctrine of the conservation of energy would not be violated, since it is only the availability of the energy, and not its total amount, which would be affected. It is, however, by no means clear that the other great doctrine of mechanics—viz., the conservation of momentum—might not come into conflict with this attractive dream. A pointsman, by a small muscular effort, can alter the availability of a train for doing the work involved in a collision ; but though his own muscular effort is small, a very heavy pressure has been exerted at the points to change the direction of motion, and it seems probable that an ultimate analysis might show that the suggested selective action of mind would involve the exertion of a physical pressure by a non-material agent.

THE THAMES IRON WORKS AND INDUSTRIAL ECONOMICS.

The appointment by the Chancery Division of the High Court of a chartered accountant as official receiver and manager of the Thames Iron Works Shipbuilding and Engineering Company is an event of considerable significance, not only from the point of view of the industrial history of London, but also from the wider standpoint of economics. Regret must be entertained widely at the fate of one of our oldest naval shipbuilding establishments, and there will be general sympathy also with the head of the firm, Mr. Arnold F. Hills, who has long laboured with continuous courage to maintain the establishment against great disadvantages. Hope will also be entertained that even after existing contracts are worked off some arrangement may be possible to reconstruct the company. But the fateful facts of the case cannot be ignored. The economic conditions were so antagonistic that the practical impossibility of maintaining the industry might have been recognised long ago by those interested but for the desire to continue cherished traditions. The distance separating London from the sources of supply of raw material, the greater cost of living within the Metropolitan area, and the consequent higher wage exacted and necessarily paid under Admiralty and municipal contracts, apart altogether from peculiar circumstances applicable to this particular establishment, made it impossible to compete on anything like equal terms with naval construction works in the North, where the economic disadvantages indicated do not obtain. These northern establishments, through a long period of activity and relative prosperity, have also been able to improve their plant according to modern developments, and thus the mechanical conditions, combined with the less cost of labour, result in higher efficiency per unit of the wage. To those conversant with the conditions, it was indeed a great surprise when it was found that the Thames company had submitted a lower price for the building of the battleship which was later ordered from the firm—the Thunderer—because it was realised that not only would considerable additions require to be made to plant, involving augmented capital outlay, but that the cost of labour would seriously handicap the management in completing the ship at a less price than was considered necessary by northern firms. At the time doubt was even expressed as to the ethics of the Admiralty action, because they must have been conscious that the price paid would be inadequate for the work. The appointment now of an official receiver and manager, on the application of some debenture holders, is a proof of the accuracy of this view, and of the authenticity of some of the rumours of financial difficulties which have been current for some time. We do not propose to enter into these, and have only reviewed the general difficulties of the situation to demonstrate further the great courage which Mr. Hills has displayed, and to indicate why genuine sympathy will be entertained for the failure of his strenuous efforts.

His altruism has never been disputed. One of his strongest motives was undoubtedly to assist the working classes in the East End of London. It was a noble motive, as was also his ambition to carry on the traditions of the factory, but the laws of industrial economics are as unavoidable and as forceful as the elements of Nature. The civil engineer sets himself the task of subjecting the latter, but only within rigidly prescribed conditions, the neglect of which involves disaster. The limits within which the industrial financier works are as inexorably fixed, and it is the failure to recognise this truism that is at the root of much, if not all, of the industrial trouble now being experienced in increasing volume. The conditions obtaining in great cities militate against economy. All industries not directly maintained by the district should be located where the conditions are conducive to economy. There has thus been in recent years a great migration of factories and workers from London. In the naval industry alone we have had within a short period the cessation of Maudslay's engineering works and of Humphrey's establishment. Messrs. Yarrow have gone to the Clyde, Messrs. Thornycroft to Woolston, and of large establishments the Thames Iron Works alone were left after they had absorbed Penn's engineering shops. Those who aim at reconstructing the last-named company must consider the lesson which this migration teaches. We have it from the firms named, and from other general engineering and manufacturing concerns that have moved from London, that the reduction in cost and the improved efficiency of labour have made a vast difference in their ability to compete for work against other British establishments and against foreign rivals. This is only natural ; conditions must become increasingly more unfavourable for metropolitan works as compared with those in provincial districts. The local rates have increased greatly in London, partly due to such avoidable causes as extended municipal trading and to the extension of the pursuit of those practices which aim at what Lord Rosebery has called the "spoon-fed" nation. Increased taxation affects everyone, notably the shopkeeper, without bringing much, if any, compensating advantage. The increase in the rate of wage of transport workers and others involves an addition to the cost of all the necessaries of life, so that the effect of the collective demands of labour directly in respect of wages, and indirectly in the form of social legislation, is, like a snowball, gathering volume as it progresses. Again the migration of workers decreases the population in some districts—notably in the Metropolis—and therefore diminishes the number of people by whom the burden of municipal government must be borne. Thus the ultimate cessation of the Thames Iron Works, which, when existing contracts are completed, threatens to throw out of work about 3000 men, will intensify the economic situation in the East End of London. If these workers migrate, their needs will no longer have to be met in the district, and thus the numbers unemployed will increase, further public relief will have to be found, while the depletion of population will still further add to the burden of others.

These are truisms—they are perhaps even common-place—but it is necessary that, however obvious, they should be stated often and clearly. The cry of the labour agitator and of the zealous social reformer is that capital is unduly rewarded, and should bear an increasing burden. The fate of the Thames Iron Works demonstrates beyond doubt that the burden thrown upon capital ultimately falls on to the shoulders of labour. The worker cannot dispense with capital. If capital fails to get a reasonable reward, the means of support of the workers will be withdrawn or cease to increase with the needs of each case. There is no necessity to enter into details to prove that this has been the case with the Thames Iron Works. Dr. Inglis has put the position very definitely in a letter which we quote on page 665 of this issue. In shipbuilding the capital involved amounts to about 180*l.* per man employed, the profits realised for capital equal about 5*l.* per employee, or $2\frac{3}{4}$ per cent. per annum on capital. The workmen secure in wages from 70*l.* to 100*l.* per annum. The Workmen's Compensation Act, the Insurance Bill, the Death Duties, and other recent impositions, made or proposed, involve a payment by capital of 2*l.* 14*s.* $2\frac{1}{2}$*d.* per annum per man—equal to $1\frac{1}{2}$ per cent. of capital. This equals 9*s.* $10\frac{1}{2}$*d.* per pound income tax, in addition to the usual 1*s.* 2*d.* To this extent is capital handicapped and the inducement to increase capital commitments lessened. Indeed, the absence of capital not only prevents development in manufacturing plant, and thus lessens efficiency, but checks the courage with which great contracts involving financial responsibilities are entered into. Our factory equipment becomes more obsolescent than would be the case if prosperity were maintained and reasonable profits earned. In the absence of improvement in plant and of originality in design, due to hesitancy to embark on changes on account of the uncertainty of beneficial consequences, the handicap in foreign markets is increased, and right throughout the whole gamut labour suffers most. Social schemes tend to penalise the employer in large cities more than in small towns, because of the collateral disadvantages due to distance and aggregation of population, all of which increase disproportionately the cost of living.

This raises again the subject on which the undisciplined mind is most liable to go astray in considering economic problems. The "cost of living" is a very definite term, but is most indefinitely interpreted. The Government are instituting a departmental inquiry on the subject, but the present intention is to limit this to a consideration of the increase in the cost rather than to an elucidation of the cause of such increase. Everyone knows that there has been an increase, but the question as to proportion due to augmentation in the price of necessities, and that owing to the greater desire for superficialities which are only indirect necessities, ought to be investigated. As to the former, the increases may or may not be unavoidable, but it would be well to bring home alike to capitalist and to worker the direct influence on the value of money, and therefore on the cost of living, of the higher wages demanded so incessantly. Augmented labour charges act and react on the cost of living, and unless they are accompanied, as is not always the case, with higher efficiency of labour, either in the form of superior workmanship or augmented output, the economic condition of the community is not improved. Capitalists, on the other hand, are continually seeking to improve the value of the wage paid by introducing superior methods of production, mechanical and otherwise, in order to increase output for a given labour expenditure. The true interests of the State and the well-being of the working classes are to be promoted, the worker, for every addition to emolument, must seek to augment the volume of production either directly or through the medium of the superior mechanical appliances

placed in his hands by capitalists. It follows that capital must be encouraged towards perfection of appliances if the condition of the worker is to be improved by the payment of a higher rate of wage with the same or a greater purchasing power per unit of the wage.

On the other hand, the cost of living has been increased owing to the greater facilities offered for recreation and amusement. These are good in their way, but the question must be faced as to whether full value is got by the workers for the money spent in this way. It is the duty of everyone to keep himself fit, not only on his own account, but in the interests of industry and the State. Recreation and amusement are therefore essential to industry, but their nature, their cost, and their effect on physical and mental fitness must be carefully weighed. The worker in cities has too many temptations to pass his time under conditions which must be regarded as artificial and profitless from the view point we have stated. In the provincial towns, especially those of moderate size, there is less temptation, and fuller scope for outdoor health-giving recreation, and this is probably the reason why labour is more efficient in such districts. It would therefore be an advantage to have clear evidence as to the effect on the cost of living of the increased number of facilities afforded, because industry, while it must bear the burden of higher charges in the household, due to the increased cost of necessaries—which includes rational recreation—ought not to be charged with the artificial and profitless pursuits appertaining to recreation and to the conditions observed in connection with clothing and similar expenditure. There is, too, the question of the influence on the cost of living of inadequate education in household management in all its phases. If it can be brought home to the education authorities that there is remissness in their training of the housewives of the future, and that this entails consequent excess without physical advantage to the household, an improvement might accrue.

In the Metropolis and in the provincial towns, again, and, indeed, throughout the whole labour world, there is too much importance attached to the rate of wage, and too little to the value of labour, alike to the employer and to the worker. Were this difference recognised more fully, we should not have to-day the difficulty which threatens us with so many strikes. In the first place, a minimum wage is sought by many, because of the standard of living; but, as we have pointed out, it is impossible to determine such a standard, as the conditions not only vary in different communities, but are more or less consequent on the temperament of the members of the household and on the management of the housewife. The cost can never be a constant. Nor can the temperamental condition which makes a good, bad, or indifferent worker, so that the standard of wages, as of living, must be unjust to some and an undue reward to others. The wages paid ought to bear a definite relation to the honest effort put forth by the skilled worker, and without regard to conditions for which he is not responsible. An accident may result to render his effort nugatory, or, in the case of a miner, he may be working at an "abnormal" place and consequently may produce little coal. There are such risks common to all manufacturing and mining operations, and we have no doubt that employers will look with a liberal mind upon the question as affecting the miners if the Federation will continue to act in a conciliatory spirit. But the miners will gravely err if they insist on a general minimum wage irrespective of the value to commerce of the work which that wage represents. The same line of reasoning applies to the railway worker, and we are glad to recognise that there is increasing hope of a likelihood of the machinery evolved by the Commission being given a fair trial. This, we think, is all that is needed to ensure that railway labour will get a liberal reward according to its value.

SUBMARINES AND WAR TACTICS.

The possibilities of the effective use of submarines in war has been brought home most clearly in connection with the uninterrupted invasion of Tripoli by an Italian army, because it is fully recognised that had the Turkish authorities possessed even a comparatively small fleet of effective submarine boats, the transport operations would have been very seriously hampered. Indeed, it is difficult to conceive how, with such a Turkish fleet based on Tripoli, or even at Constantinople, since the separating distance is so short, a satisfactory landing could have been effected. The success of the transport of the Italian troops to Tripoli, and their safe debarcation there, must be recognised as a triumph of organisation; but it should not be forgotten that there was practically no opposition. In other words, it was magnificent, but it was not war. The interest thus awakened in the submarine-boat makes opportune our article on the development of the Holland submarine-boat in another part of this issue. It is true that in this we have confined ourselves to reviewing the development of one type, but it will he generally conceded that this type is the most widely adopted, a fact which, in itself, supports the view that it has achieved a high degree of efficiency. Thus, of over 300 submarine-boats now existent, or in course of construction, 152 are of the Holland type, or of designs evolved therefrom. To many it will be surprising to note that such a large number of submarine boats are in existence, because it is such a short time since doubt was entertained as to their practicability and efficacy in war operations.

The idea entertained at one time was that submarine-boats would act only as a moral deterrent, because the existence of a submarine fleet "in being" would so interfere with the nerve of an officer of any opposing naval fleet. But we have long since passed beyond that view, owing to the reliability of submarine-boats proved in long cruises, and to the great development in the size, power, speed, and radius of action of these vessels. The vessels built ten years ago were comparatively small craft, few were over about 200 tons displacement when submerged; but there has been a steady growth, conservative, no doubt, in regard to each step, but as a consequence successful in its result, and of great significance in its aggregate. Thus we find that some of the Continental Powers are building ships, such as that illustrated, of close upon 1000 tons, while in the case of the British Navy the submerged displacement has reached about 800 tons. It is recognised, however, that mere size will not render these vessels suitable units of an ordinary squadron. The speed of a squadron is determined by the slowest ship, and for strategic reasons it may be desirable for a fleet to steam long distances at the highest possible rate, so that with a fleet, including battleships, having a speed of at least 21 knots, surrounded by a curtain formed of 24-knot and 25-knot scout cruisers, and of 28-knot heavier armoured cruisers to pierce the screen of the enemy, a distinct handicap would result from the inclusion of submarine vessels of slow speed. There is no doubt, however, that in this quality of design great advances have been made even within the past year or two, and if there is similar advance within the next three or four years, such vessels will, no doubt, win their place in the squadron by virtue of speed, as well as of fighting power. It will be noted that the 950-ton Holland special type submarine illustrated is to have a speed of 17 knots on the surface, and a correspondingly high rate is anticipated in the latest British submarine ships. This, of course, demands great horse-power in the propelling internal-combustion engines — approaching 2000 brake horse-power in the case of the Holland boat. Advances have been, and are being, made in the development of heavy-oil engines for such craft, and weights have consequently not gone up at the same rate as power and speed. It will be noted also from the sectional drawings reproduced that the form of ship is undergoing modification, which is further conducive to efficiency in speed. As regards offensive power, the submarine-boats are able to take advantage of the recent improvements in the size, speed, and therefore range, of the Whitehead torpedo, as well as of the higher bursting charge. It would seem also as if with development in size there may come the emplacement of disappearing guns for use when the vessels are on the surface. Experiments are being tried, but it remains to be seen whether such a departure from what has hitherto been regarded as the exclusive function of the submarine-boat—the firing of torpedoes—will be widely approved. As to reliability, there have been many evidences afforded by performances in the course of manœuvres with squadrons, and also by the long voyages taken by individual boats and fleets of boats. Several of these cruises are referred to in our article, and it will be remembered that in a recent issue (page 226 *ante*) we recorded the successful results with some of the French submarines, one of which has traversed over 2200 miles. It is thus accepted that not only for defensive, but also for offensive operations the submarine has established its practicability, and it is pertinent to inquire into the work in progress by the various Powers.

France first recognised the possibilities of the submarine, and, with characteristic enthusiasm, entered vigorously on the building of such craft, but it is doubtful if there was at all times the requisite amount of prudence tempering this enthusiasm. It would certainly seem that many of the boats now possessed are unsatisfactory and are obsolete because of the improvements since made. The United States, on the other hand, adopted a more conservative procedure, and not before the most searching trials was the Holland type accepted. Germany has been still more conservative, but now rapid advance is being made. In this country theGovernment accepted, after comprehensive test, the Holland type, and very properly decided to confine the experimental design and constructional work to one firm, and by this arrangement secrecy has been scrupulously maintained, experimental work has been stimulated, and high economy of manufacture and great success in result achieved. At the same time, the Government have ensured that no foreign Power would gain the benefit of the experience and the research work which the private firm undertook, as a condition of the contract was that no foreign work in connection with submarines should be undertaken. There was the great advantage, however, that as the firm were the sole licensees in this country for the Holland and other types, the Government secured such advantage as was obtainable from the extensive research work and large experience of the builders of those other types. The consequence has been, without entering into details, that the British boat is probably the most efficient type now built, and this eminently justifies the continuance of the policy pursued since the first boat was constructed.

It remains open to question, however, whether the Admiralty have continued to ensure that preponderance in submarine craft which is absolutely essential to our sea supremacy. The amount provided in the Navy Estimates for the current year for the building of submarine-boats is 709,580*l.*, twenty-one vessels being in various stages of construction. In the case of Germany, on the other hand, the expenditure this year is 734,214*l.*, but no data are available as to the number of vessels in progress. In France the total is 448,260*l.*, thirty-five vessels being in hand in the various works. In the United States the money vote is about 800,000*l.*, there being twenty vessels in progress; but this sum is larger than the average, owing to delay in placing the orders for the vessels authorised in the previous year. In view of the extent of our coast-line, the volume of our ship-borne traffic, and our vulnerability generally, it is obvious that we are not devoting a sufficient amount of money to the building of the latest types of submarine craft. Nearly every Power is adding rapidly to the number of submarine-boats; and, as has been pointed out in connection with the Turco-Italian war, the whole face of operations might have been materially affected by the possession of a few submarine-boats at the port of invasion. The tactics which might have profited Turkey may be used by the weakest as well as the strongest Powers against Britain, and the only safeguard is to be able to meet the opponent with the same type of weapon, but stronger in power and greater in numbers.

ACHESON CARBORUNDUM AND GRAPHITE.

In the course of a lecture, delivered before the Faraday Society on Wednesday, November 8, Dr. Edward G. Acheson, of Niagara Falls, communicated many interesting facts. He discoursed on his researches in general, but spoke mainly on carborundum and of graphite. The discovery of carborundum (carbon silicide) was made in 1891, when Mr. Acheson was heating mixtures of clay or sand and coke in a crucible, into which a lamp-carbon was lowered as electrode, for the purpose of preparing some abrading material. A crystal was obtained which cut glass and spoilt the diamond in his ring. The new abrading material had proved of extraordinary utility; it would polish diamonds, and carborundum wheels had replaced the old grinding-stones and emery wheels which twenty

years ago were mounted in some dark corner, while the carborundum wheel was now given the place of honour in the workshops. Ten million pounds of carborundum were now made in America per year. The pure crystals were colourless and more brilliant even than diamonds; most carborundum crystals, however, contained iron, and had a greenish metallic lustre for this reason, and were apt to tarnish by oxidation. When the carborundum furnace had become too hot, some silicide would be decomposed with formation of soft graphite; such carborundum would smudge white paper like black lead. The furnace walls were protected from the heat by the mixture of materials; but 10 lb. more or less in the charge of a furnace with a 7-ft. core, 7½ in. in thickness, might make a furnace efficient or inefficient.

Passing to graphite and other products, Dr. Acheson pointed out that lumps of overheated carborundum would retain their shape, but be converted into a very soft graphite. That observation had induced him in 1898 to take up the manufacture of graphite, of which they had made thirteen million pounds last year; their new works at Niagara had an annual capacity of twenty-five million pounds. The raw material was amorphous carbon, anthracite; objects, rods, tubes, &c., were made of the desired shape of finely-ground carbon and pitch or tar and baked, and mixed with sufficient ash or metallic salt to form some carbide which would be decomposed afterwards in the electric furnace. If 20 to 40 per cent. of ash were used, the resulting graphite was very loose in texture and of low density.

Dr. Acheson showed one block of graphite which had seven times the volume of another block of graphite of the same weight. On the other hand, he stated, very dense graphite and graphite of any grade could be produced up to pure non-unctuous carbon which would still yield graphitic acid when oxidised. By drawing carbon monoxide through the hot graphite, almost perfect purity could be secured; graphite of 99.98 per cent. of carbon had been prepared, and a purity of 99.7 per cent. was turned out as a commercial product. This purity and homogeneity of a furnace product is most remarkable, as Dr. Harker subsequently pointed out during the discussion; he had found blocks 6 in. square, 4 ft. long, quite uniform.

Having briefly touched upon the use of carborundum as a reducing agent, for the reduction of silicon and also of aluminium, Dr. Acheson turned to the finest subdivision of graphite in the unctuous graphite. His ordinary graphite could be ground up to yield 40,000 grains to the square inch. But the subdivision could be carried much further, down to molecular dimensions probably. The history of the discovery of the unctuous graphite is instructive, and characteristic of the real inventor. Dr. Acheson told his audience how he had, in 1901, in his endeavours to produce crucibles of artificial graphite, been led to a study of clays, and that he had found the German clays much more plastic and of higher tensile strength than the American clays of the same composition. It had struck him, moreover, that the residual clays—*i.e.*, those found near the spots at which the parent feldspathic rock was being decomposed—were poorer than the same clays occurring in sediments at some distance from their origin. The greater plasticity and strength seemed to have been developed during the period of transportation of the clay from its origin to its final bed, and he had ascribed the change to the presence of extracts from vegetable matter. Experimenting, he observed that weak clays were very much improved by being treated with extracts of gallotannic acid or of straw; their strength increased two and three-fold, they required less water to acquire a certain fluidity, remained longer in suspension, and passed turbid through the filter.

These facts recurred to him in 1906, when he tried to make lubricants by stirring his finest graphite into oil; it would settle quickly. He treated the graphite-pseudomorphs of carborundum with a tannin solution, about 5 per cent. of the weight of graphite, and he made similar, less satisfactory experiments with graphite from Ceylon and Ticonderoga. After masticating the best graphite with the organic solution continuously for a month, he obtained his deflocculated graphite, known as dag (the initials of deflocculated Acheson graphite). This graphite, the lecturer demonstrated, formed an emulsion when mixed with water; the emulsion would not settle, looked like a dense pure black ink, though it contained only 0.3 per cent. of carbon, and passed black through the filter. When some hydrochloric acid (salts would have the same effect) was added to the emulsion, and the emulsion heated to hasten the process, a clear, colourless filtrate was obtained. Alumina and silica could be deflocculated in a similar way, but magnesia and calcium oxide could not be deflocculated. Among the best agents for the kneading or mastication process were tannin, extracts of straw (straw boiled in water), tea infusion, and cow dung. When carbon dioxide was bubbled through an emulsion or solution of graphite, the carbon particles settled in a few hours. This fact, Dr. Acheson thought, might be important in the household of Nature. The sap rose in trees before the leaves developed, through which the tree would absorb carbon dioxide from the air; the extract from decaying leaves, still present in spring, might favour the rising of the sap. The graphite appeared to fix the organic compounds with which it was being treated and to cause the water to wet the particles; when the graphite had flocculated and settled, it dried to a hard mass, reminding one of sun-dried clots of clay. That the subdivision of the carbon particles in the unctuous graphite was carried to its extreme limits, Dr. Acheson demonstrated in the following experiment:—He let one drop of the emulsion or solution, containing 0.3 per cent. of carbon, fall into a test-tube filled with pure water. No change could be seen in the water, even after two and three drops had been added. After the addition of more drops, a slight darkening could be noticed in the colour of the water. It would be interesting to make electro-osmotic experiments with these solutions of what may be regarded as colloidal carbon.

Passing to the uses of the deflocculated graphite, Dr. Acheson mentioned lead-pencils, which ordinarily contained up to 60 per cent. of clay, and which could be very much improved by using the softest graphite. That applied also to electrotyping processes, which, by the use of the finest imaginable grains of graphite, would bring out the finest lines. This had not been practically tried yet, however; another use was for filtering bacteria. Of direct and high importance was the use of the unctuous graphite as a lubricant. The reduction of friction was perhaps the most important problem the engineer had to face. But the natural oil stores were being exhausted, and the formation of a film of most minutely subdivided carbon on the surfaces in contact would best reduce friction. When half a per cent. of deflocculated graphite or dag was mixed with oil, the lubrication was much improved; 1 cub. in. of graphite was equivalent to 5 gallons of oil. The New York Rapid Transit Company had reduced the oil consumption in its power-houses to one-third by using dag. The dag was applied in two preparations, aqua-dag, graphite prepared with and mixed with water; and oil-dag, water-dag subsequently embodied in oil. Both the preparations formed bright black, smeary masses very much like Indian ink. Aqua-dag, for some not understood reason, prevented the rusting of iron, and it had been employed with remarkable success for lubricating the tools in cutting pieces of shafting, the work turned out being thereby increased several times.

As regards the preparation of his dags, Dr. Acheson merely stated that aqua-dag was made in barrels; the emulsion was decanted after standing for three weeks, and then sent through filter-presses; the filters had been made of canvas impregnated with rubber or gasoline; but recently a special cloth had been introduced. The aqua-dag would not mix with oil, and any oil-dag prepared would not mix with water. The original product was always aqua-dag, however. To convert this into oil-dag, oil was poured over the filtered dag, and the liquid, oil with some of the water, poured off again. The dag was then treated in a vacuum to remove the water, and the oil finally added. Different kinds of oils were used for different purposes. The oil-dag had the advantage over aqua-dag that the oil did not evaporate. Yet at present the two lubricants were used in about equal quantities, and the consumption had enormously increased during last year.

The discussion of Dr. Acheson's discourse was essentially of a complimentary character, but it brought out several of the points we have already alluded to. The introduction of Acheson graphite has certainly helped electric-furnace work and technical electrolysis on to a wonderful degree. The great advantage of Acheson graphite is that it can be machined, cut on the lathe, drilled, provided with a screw-thread, &c., and this with the greatest ease. What that means will be understood by any one who has to deal with furnace electrodes and electric furnaces. The lubrication of rifle and gun barrels with graphite, to which Mr. A. Hiorth, of Christiania, referred during the discussion, does not concern the deflocculated graphite. Mr. A. Hiorth mentioned that he placed the graphite in the cartridge, and that they had, in Norway, thereby decidedly improved the rapidity and accuracy of shooting, and the range; the graphite lining in front of the powder-chamber prevented the escape of gases past the bullet or ball. Dr. Acheson spoke of similar trials and practice adopted by the United States Army; in these trials 4 grains of his finest graphite (not dag) had been placed in a cartridge—probably ordinary rifle cartridges. Dr. Harker, of the National Physical Laboratory, mentioned an interesting feature relating to the electric conductivity of carborundum. It was not a conductor of the second class, as the German scientists say, which only conduct when hot. For when a crystal of carborundum, about an inch long, was placed between the rod electrodes of an arc, the crystal allowed the current to pass; the carborundum would afterwards be dissociated in a few minutes.

MANCHESTER AND SALFORD SMOKE-ABATEMENT EXHIBITION.

The efforts of the Coal-Smoke-Abatement Society to bring before the public some idea of the extent of our present knowledge of appliances by means of which the smoke nuisance in our large towns may be minimised, if not entirely abolished, are worthy of much praise and deserve success, for the matter is one of so much importance that we ought all to be grateful for any measure of advance that may be made. The society is not old, having been formed in 1898. Its sphere of action has been mainly confined to the Metropolitan area, though work has also been carried on in the provinces, where exhibitions of smoke-preventing appliances have from time to time been held, the latest of which is now open in the City Hall, Liverpool-road, Manchester. It is on lines similar to those adopted in other centres, and forms an interesting and instructive Show. In spite, however, of all the advances that have been made, as illustrated at this Exhibition, there remains a feeling that they only take us a little way towards a great end. Not that the many means of reducing smoke that are on view fail to fulfil their object, but they only touch the fringe of the subject, leaving the great and difficult question of how to deal with domestic fires almost untouched, for, after all, the domestic fires are worse, on the whole, than factory furnaces, on account of their relatively vast number. True, there are at the Show many stands at which gas-fires, gas-furnaces, &c., as well as anthracite stoves and the like, may be seen; but, after all, how much does the use of these (which is very limited) really affect the amount of smoke that issues in a day from the chimneys of ordinary dwelling-houses? It may be said that their use will grow. Doubtless it may, but we fear that the growth will be very slow, for there is in this country such an inbred love of the open coal fire that most people would rather suffer the inconvenience of a certain amount of dirt and an occasional fog than give it up. The feeling is to be deprecated, but the fact remains. In addition to this prejudice in favour of the open coal fire, there is also the fact that, as a rule, it costs less in fuel than the gas fire, although the latter is in many cases so convenient that economy is not allowed to weigh; and, where gas fires are used only occasionally and intermittently, they are, of course, not costly. It must not, however, be thought that we wish to discourage the efforts that are being made for the prevention of smoke, for they are admirable; we only desire to point out that too much reliance must not be placed on them, for so long as the open coal fire retains its place in the affections of the people, so long will the efforts of the reformers fail of full fruition. But we must turn to the business in hand—the Exhibition, for which a better place than the greatest centre of Lancashire industry could hardly have been chosen.

The City Hall is not by any means filled, the galleries being empty, and the body of the hall only about three-quarters full; what there is on

view, however, is well worth a visit. To the engineer the striking feature of the Exhibition will no doubt be the mechanical stokers, and the means of consuming smoke on hand-fired furnace-grates. Among the former class—mechanical stokers—two types are shown by Messrs. Ed. Bennis and Co., Limited, Little Hulton, Bolton, which are both fed by means of bucket elevators, distributing shoots, and band-conveyors. One of these is what is termed by the makers "a high temperature smokeless and gritless coking stoker," and is one of their latest type. It is arranged to burn from 10 lb. to 60 lb. of fuel per square foot of grate per hour without smoke or grit. The other furnace is a link-chain-grate stoker which embodies all the makers' recent improvements. The links are halved together and rounded at the ends, and six variations of speed can be given to the drive to suit varying classes of coal and differences in the load. Forced draught can also be used. This link-chain-grate stoker is shown as fitted to a water-tube boiler, while the coking-stoker is adapted to an internally-flued boiler. The firm have also on view an automatic CO_2 recorder and a calorimeter. Messrs. Meldrums, of Temperley, Manchester, also show a mechanical stoker, with which is combined their system of forced draught. It is claimed that these stokers are quite smokeless in operation, even when cheap kinds of coal are consumed. They also show a sprinkler stoker, which has moving bars similar to all mechanical stokers of this class, and delivers the clinker to the ashpit. The fuel is thrown over the grate by means of a mechanically-worked shovel actuated from the front of the boiler, and the system is claimed to be superior to any in attaining the maximum rate of evaporation with a minimum weight of fuel. Almost any kind of fuel can be used with it. Tests with one of these stokers, made with Yorkshire slack coal, gave an evaporation of 10.61 lb. of water per pound of coal (from and at 212 deg. Fahr.), but the percentage of water in the steam is not given. The heating surface of the boiler was 846.5 sq. ft., and the total grate area 30 sq. ft. A Lancashire boiler was used for the tests, the length of the boiler being 27 ft. and the diameter 7 ft. 6 in. No economiser was used.

Another stoker of the "sprinkler" type is shown by Triumph Stoker, Limited, 85, Kirkstall-road, Leeds. The principal features of this are that the main shaft which works the sprinkler-shovels and the feeder is fixed behind the coal-hoppers and raised above the feeder-box, of which it is quite clear, and is not exposed to the heat of the fire. The bearings are adjustable, are fitted with lubricators, and can be easily got at. The pusher or feeder is actuated by a train of steel wheels, and not by the usual cam and lever, and the amount of feed can be varied over wide limits. The shovel is very strong, the two arms that carry it being of forged steel. The steel trigger that releases the shovel has wide case-hardened surfaces. A chilled cam having four arms of different lengths enables the distance to which the coal is thrown to be varied, and the coal is distributed evenly over the surface of the grate. Small steam-jets are used, but chiefly for the purpose of keeping the bars cool. The strength of the parts appears to be one of the chief features of this sprinkler installation. It is claimed that a smokeless fire is obtained with a maximum efficient CO_2 record, and also that the cost of upkeep and repair is very small. The bars are moved in the usual way. Messrs. James Hodgkinson (Salford), Limited, Ford-lane Works, Pendleton, Manchester, also show a coking-stoker, which is arranged for natural draught without the use of blowers, and is guaranteed by them to be smokeless under all conditions.

Opinions, of course, differ as to whether the coking type of stoker or the sprinkler type is the better, some makers maintaining that the latter is really the more satisfactory of the two, taking all things into consideration, because it approaches more nearly than any other to the best form of firing—namely, hand-firing (when properly carried out). With this consideration in view, Messrs. James Proctor, Limited, Hammerton-street Iron Works, Burnley, have designed a mechanical stoker which is now on view at the Exhibition. The result aimed at is obtained by throwing the coal mechanically in small quantities equally distributed over the grate, with closed doors, and the throw can be adjusted to cover any length of grate-bar. The principal working parts are enclosed, and are self-lubricating. The makers state they have already fitted as many as 13,000 furnaces with this type of stoker. In addition there is a coking stoker shown at this stand. In this the coal is laid well within the furnace. The coal is carried forward by the ram and falls off on the fire during the return stroke of the ram. When the next stroke occurs the partially coked fuel is pushed forward, and a bright fire is left underneath to receive the next charge. In addition to these stokers an elevating and conveying plant is on view in which the coal falls in front of a ram, which pushes it forward into the ascending bucket, the usual trouble caused by jamming and wear in the old system of dragging the buckets through the coal being avoided.

Leaving mechanical stokers, we come to smoke consumers and economisers adapted to hand-fired grates. One of these may be seen at the stand of the Victory Smoke-Consumer and Fuel-Economiser Company, Limited, Victory Works, Chamber-road, Oldham. Two types of this are on view. The object of the appliance is to obtain perfect combustion of the gases by mixing them with air that has been heated to a high temperature before it is distributed at the bridge wall. No steam jets are required, and the apparatus is non-mechanical, in that no power is required to drive it. One of the types consists of a number of weldless steel tubes which are placed vertically in the flue at the back end of the boiler, the upper ends of the tubes being expanded into a box or header that is built into the brickwork, and is open to the atmosphere, while the lower ends of the tubes are, in a similar way, fixed in another header, from which two pipes are brought back through the internal flue of the boiler to the back of the bridge. At this point they enter a box with openings in its top communicating with the back of the bridge. The action of the apparatus is as follows:—The air, which is drawn through the tubes in the flue at the back end by the pull of the draught over the bridge, passes along the pipes in the internal flue, and in doing so becomes highly heated, up to about 1200 deg. Fahr. At this temperature, as it passes out at the back of the bridge, it ignites the unconsumed gases coming from the fire, causing intense combustion and preventing smoke. In the other type, which is smaller, a number of bent U-shaped steel tubes are placed horizontally behind the bridge in such a way that the two sides of the U lie in the same vertical plane, the ends of the lower sides being built into the bridge and projecting through into the ash space below the fire-bars, while the ends of the upper arms enter an iron box at the back of the bridge, this box having openings at its upper side, similar to the box used in the first type described. The action of this simpler type is like that of the other. The air drawn by the draught through the tubes from below the fire-bars is highly heated, and meets the unconsumed gases passing from the fire, preventing smoke, and adding to the economy of the furnace. The apparatus can be fixed to Lancashire, Cornish, or marine type of boilers in a very short time.

Another smoke-consuming appliance that can be used with hand-fired furnaces is Tyler's patent smoke-preventer and fuel-economiser, made and shown by the Epoch Syndicate, Limited, 34, Old Broad-street, London, E.C. It consists of a small cylinder containing a plunger working in oil—in other words, a dashpot—which is fixed on the front of the boiler, the piston being connected by a system of rods and levers to an air-grid in the fire-door, as well as to a gridded door below the bridge. The piston in the cylinder is drawn out by means of a spring, but its motion can be regulated by means of a by-pass cock on the cylinder, the cock controlling the passage of the oil from one side of the piston to the other. When the furnace door is closed after firing, the air-grids on the door are open, and allow free admission of air over the coal just thrown on. The action of opening and closing the door has also opened the air-grid below the bridge, and air that has been slightly warmed by its passage below the fire-bars enters behind the bridge, and, after striking a deflecting wall built a short distance beyond the bridge, is turned upwards, and mingles with the gases from the fire, causing combustion of the smoke. As the piston in the cylinder is gradually drawn out by the spring, before mentioned, the grid on the fire-door and that under the bridge are slowly closed as the fresh coal burns bright, and less air is required, the time occupied till they are again closed being usually a few minutes.

Messrs. Galloways, Limited, Manchester, exhibit one of their steam-superheaters, which are well known to steam-using engineers. It is fixed in the downtake at the end of the boiler. The chief points about this superheater are that all the parts are of wrought steel, and there is easy access to all the tubes. By removing one cap, five tube-ends at a time can be readily examined or expanded. The apparatus may also be lifted out of its position without disturbing any pipes by simply disconnecting the steam-pipes at the ends. The firm also have a very fine specimen of a Galloway flue on view. Another steam-superheater may be seen at the stand of Messrs. James Gordon and Co., Ltd., 81 to 83, Knightrider-street, London, E.C., which is also formed of U-shaped steel tubes, placed at the back end of the boiler. In these superheaters any group of tubes may be taken out and examined in about half-an-hour's time. Each group of tubes is fixed to the boxes by flanges, and the tubes are not expanded into the boxes, so that they can be easily removed and a blank flange placed over the hole. One feature of this stand is, however, not connected directly with smoke consumption. This is a Pelton water-wheel, which is well worth examination on account of its excellent workmanship and design. It is fitted with ball-bearings, and is intended to develop 70 brake horse-power under a head of 400 ft. when running at 900 revolutions per minute. There is also a three-way valve of special design. This will act as a main boiler-stop or junction-valve, and can, by a slight movement of a hand-lever, divert the steam either through the superheater, or allow the steam to flow in the direction of the main steam range, or it will allow a portion to flow through the superheater and a portion to the main range, by which means any desired temperature can be obtained. We hope, however, to be able to describe and illustrate this valve more fully at a future date, so will not refer to it further now.

Of gas-fires there are, of course, numerous examples, the best-known makers being well represented, including Fletcher, Russel, and Co., Ltd., Palatine Works, Warrington; the Davis Gas Company, Limited, Diamond Foundry, Luton; the Parkinson Stove Company, Limited, Stour-street, Spring Hill, Birmingham; the Richmond Gas-Stove and Meter Company, Limited, 132, Queen Victoria-street, London, E.C.; Messrs. Wilsons and Mathiesons, Limited, Carlton Works, Armley, Leeds; the John Wright and Eagle Range, Limited, Essex Works, Thimble Mill-lane, Birmingham; Messrs. R. and A. Main, Limited, Gothic Works, Falkirk; Mr. A. Bell-Lennox, Pearl Buildings, Northumberland-street, Newcastle-on-Tyne; and the Cannon Iron Foundries, Limited, Deepfields, near Bilston, Staffs. In addition to gas-stoves, Messrs. Fletcher and Co., of Warrington, have some excellent gas-furnaces and muffles on view, which we hope to illustrate at a future date.

There are many good types of kitchen-ranges to be seen, among them being one by the Ferrybridge Foundry Company, Limited, Ferrybridge. It has been named the "Howmatash." There are several sizes, some of which are in operation. These cooking-ranges burn soft coke, and are said to be very economical in fuel. They are very well made, and are conveniently arranged. There are also many exhibits of anthracite-stoves by the Carron Company, Carron, Stirlingshire; Messrs. J. M. Leigh and Sons, 22, King-street West, Manchester; and Messrs. McDowall, Steven, and Co., Limited, Laurieston Iron Works, Falkirk, besides others.

It is intended to hold a conference on the subject of smoke abatement in works and domestic fires on the 21st and 22nd inst., probably in the Lord Mayor's parlour in the Town Hall, Manchester; and on the former of these dates Mr. A. Gordon C. Harvey, M.P., will deliver a presidential address. Mr. John W. Graham will explain the Act of Parliament which is to be promoted by the League. Short lectures will also be delivered, and several papers read. All communications in connection with the Exhibition are to be addressed to Mr. Walter Cawood, 196, Deansgate, Manchester. The Exhibition closes on the 25th inst.

The Health Resorts Association.—This association has prepared an illustrated pamphlet describing Falmouth. A copy of this can be obtained free on application to the Town Clerk, Municipal Offices, Falmouth.

INTERNATIONAL CONGRESS OF RAILWAY ENGINEERS IN ITALY.

By Lawford H. Fry.

In honour of the semi-centennial of the Kingdom of Italy, the Association of Italian Railway Engineers gave an international character to their annual meeting, held last month, by inviting the attendance of railway engineers from Hungary, France, England, Austria, and Belgium. Meetings were held in Rome and Turin, with excursions to points of interest in the neighbourhood of these cities. At Rome the inaugural meeting was opened by Signor Sacchi, the Italian Minister of Public Works, who pointed out the vast development which had taken place since a statesman opposed to Stephenson's project the fear of the consequences of a cow straying on to the track. In Italy, by reason of her shape, her mountainous character, and her lack of coal and iron, railway building was difficult. In spite of this, Italy had now 13,300 km. of railway lines, the passenger receipts had grown in the fifty years from 30 to 200 million lire, and the goods receipts from 24 to 300 millions. The train-mileage had increased from 10 to 111 million km., or more than ten-fold, the number of passengers had increased from 15 to 110 millions, and the weight of goods from 5 to 40 million tons. From 500 locomotives the number had gone to 5400, and the fuel consumption had risen from 300 to 2000 million tons per year, costing over 60 million lire (2,400,000*l.*). Commendatore Rinaldo Rinaldi, vice-director general of the Italian State Railways, and President of the Congress, who spoke next, emphasised the important part that the railways had played in the unification of Italy. The construction of the railways had been begun before the opening of the War of Independence, the greatest progress being made in Piedmont, and that largely due to the efforts of Cavour. In a French review, which appeared in 1846, Cavour traced a plan of development for the lines of the entire Peninsula, and this plan with slight modifications corresponded generally to that adopted after the founding of the Kingdom. Commendatore Rinaldo Rinaldi recounted the history of the building of the Italian railways, and described the difficulties which were found awaiting the State when the three main railways were taken over by the State in 1905. Approximately 1250 million lire (50,000,000*l.*) were spent in renewals and improvements.

Signor Lanino, President of the Association of Italian Railway Engineers, in an eloquent speech full of classical allusion, thanked the Minister of Public Works, the Mayor of Rome, and the foreign engineers for their presence at the meeting, which, he reminded them, was being held on the Capitoline Hill. Near the foot of that hill, he said, stood the gilded column of Augustus, the common focus in older days of all those long consular roads over which the legions carried the Roman civilisation to the world. Southwards, between its temples and its tombs, ran the sacred Appian Way, undeviating, in spite of obstacles, till it dropped by the easy southern slopes to populous Partenope and luxurious Pompeii. Northwards, on the other hand, went the Via Aurelia, past the rich colony of Etruria, up to Genoa, and thence by the Domitian Way to the colonies of Narbonne and Spain.

The Cassian Way, piercing the dense Ciminian Forest, pushed by Bolsena and the Trasimeno to Arezzo, and on to the rich valley of the Arno, where sprang later, from the Latin seed, the language of Dante, and the reborn Italian art.

The Via Flaminia, crossing the Tiber by the first bridge to span the sacred river, climbed by works which still to-day command wonder and admiration, the Scheggia and the Furlo, to descend the wide Metauro valley to Fano and Rimini. Here the broad Emilian Way crossed the fatal Rubicon, and leading up to Italian Gaul, penetrated to the heart of the fertile plain of Lombardy; while the Augustan Way led on to Turin, the first stage of the Roman legions in crossing the Alps. At the ends of all these great roads were others which traversed the rich continent of Asia or the burning plains of Africa, or which ran beside the great rivers of Europe, the Rhone, the Rhine, and the Danube, to the far countries of the Celts and of the Belgians, and to the extreme borders of Pannonia and Thracia. To-day these old roads still lived, but beside them others, and more numerous, had sprung up, armed with iron and steel, and binding in their meshes the entire world, to which their pulsating currents gave new life. These new iron roads carried their travellers, for the most part, not for war, but for peace and for the solidarity of civilisation; and hence all those, whether high officials or humble workers, who devoted their best efforts to the development and operation of that greatest, and at the same time that most complicated and most delicate of the public services—the railways—laboured directly for the advancement and for the benefit of humanity.

M. Cartaut, of the Paris, Lyons, and Mediterranean Railway, spoke briefly on behalf of the visiting engineers.

The technical session was opened by Signor Lanino with a paper on "Private Railway Concessions," in which he examined the existing Italian laws under which the construction and exploitation of railways are conceded to private individuals in Italy and other countries. He emphasised the need for an extension of the Italian railway system, and argued that the Government should encourage this by simplifying and rendering less onerous the laws governing the railway concessions. In general, he desired to see the concessionnaire given a freer hand, and to have the financial arrangements brought into better harmony with existing conditions of operation. The paper evoked considerable discussion, the conclusion of which was postponed.

Signor Dore presented a paper on "Ferro-Concrete Sleepers," in which he described various forms of sleepers, and gave information regarding the experiments being carried out on the Italian State Railways. The question was an important one for Italy, in view of the scarcity of wood, and the experiments were being pushed forward in the hope of developing a form of sleeper which would prove satisfactory and economical. The second session was almost entirely devoted to a discussion of the "Engineering Education for Railway Engineers." The subject led, as it usually does, to an animated discussion, which was opened by M. Moutier, who referred to the proposal made by Commendatore Bianchi, the Director of the State Railways, to inaugurate a school for the training of railway engineers, and went on to define the theme for discussion, as whether it were better to leave each engineer to seek personally the means of perfecting himself in his profession, or whether detailed instruction should be provided, so that at the conclusion of his training every student should be ready to take a responsible position. Signor Ancona offered a resolution to the effect that in the existing technical schools it was desirable that the teaching be of a general character, and that there should not be special courses for railway engineers, but that much was to be hoped from the institution as proposed by Commendatore Bianchi, which was to be founded and controlled by the railways.

An animated discussion took place regarding the type of institution desirable. Signor Ancona thought that a formal school could be developed, which would be able to take young men with a general engineering training, and to render them rapidly capable of filling executive positions. Signor Lanoni objected that the most practical plan was to undergo an apprenticeship, and that it was undesirable to attempt to replace this practical training by a formal school. What was needed was a special educational institution developed by the railway itself, in close touch with the practical operation of the line, which could complete the practical training of the apprenticeship. Signor Valenziani emphasised the necessity of a practical apprenticeship, and Signor Pugno proposed that the resolution should state in more general terms that the engineers entering on probation should be given an opportunity of acquiring the practical knowledge necessary to enable them to fill an executive position.

During the course of the meeting in Rome visits were paid to the new locomotive running sheds under construction at San Lorenzo, by the firm of Messrs. Chiocci, Baggi, and Co., and to the new Trastevere Station, constructed by Messrs. Vitali and Co.

From Rome the members of the Congress went by special train to Genoa, being entertained to lunch during the journey by the International Sleeping-Car Company. At Genoa a visit was paid to the central power-station just completed by the Italian Westinghouse Company to operate the section of the State Railways between Porte Decimo and Busalla. This section, which has been operated electrically since March 1 of this year, is 10.5 km. in length, with an average grade of 2.5 per cent., and a maximum grade of 3.5 per cent., and curves of 400 metres radius. Three-phase current is employed, generated and transmitted at 14,500 to 15,000 volts, and transformed at the substations to 3300 volts. The locomotives have five coupled axles, and weigh in working order 60 metric tons; each is capable of handling a train of 190 metric tons up grade at 45 km. an hour. In descending the grade brakes are not used, the motors being used for braking and energy returned to the line.

In the case of a train descending when current is not required for an ascending train, the energy is dissipated in a water rheostat formed by the overflow from the condenser, in which, while the length of water traversed by the current remains constant, the section is varied automatically in proportion to the amount of energy to be dissipated.

From Genoa the members of the Congress went to Turin, where the Exhibition was visited, and whence an excursion was made to Bardonecchia to inspect the central station of the Frejus line. Here a most hospitable reception was offered by Messrs. Brown, Boveri, and Co.

Throughout the duration of the Congress the foreign visitors found much to interest them in the developments which have been made in the equipment of the Italian railways since these were taken over by the State, but doubtless their most lasting memory will be of the hospitality extended by their Italian colleagues. The arrangements for the Congress were in the hands of a committee, of which Commendatore Rinaldi was the President, and Cavaliere Canonico the indefatigable and courteous secretary.

NOTES.

Recovery of Damages from Workmen.

In these days, when legislation and litigation both appear to favour the worker as against the employer, it is seldom that the lawyer is able to unearth a statute which will assist the employer to recover some of the expenses of a strike. A case recently decided in the House of Lords, however, reminds one of a very safe and certain method of recovering damages for breach of contract of employment. A colliery company summoned a collier under the Employers and Workmen Act, 1875, claiming damages for breach of contract by the appellant, and further claiming that wages due to the man from the company might be ascertained, and that the respective claims for damages and wages be adjusted and set off by the court. The collier was one of many who had broken their agreements by staying away from work for a day. Wages were due, but had not been claimed by the collier at the time when the case was brought before the magistrate; and the question in this case was whether the magistrate had power to make the set-off, although wages were not claimed by the man. The magistrate held (and his decision was eventually affirmed by the House of Lords) that the claims with which he was entitled to deal were not limited to claims put forward to the exclusion of claims not put forward, and that he was entitled to make the set-off. In the result the whole dispute was settled by the employer paying the wages due less the amount of damages. Such a deduction, if made without proper sanction, might amount to a breach of the Truck Acts. One passage from the judgment of Lord Atkinson is of interest as contrasting the different relations between employers and employed in 1875 and the present time. He pointed out that in those days claims by workmen against employer were almost as few as claims by employer against workmen. There was then no Employers' Liability Act, and the doctrine of "common employment" and *volente non fit injuria* were available for the protection of the employer against actions for negligence. Now, however, the time of the County Courts is largely taken up in settling disputes between employers and employed.

Boulton, Watt, and Murdock Relics Presented to Birmingham.

Many engineers have had the privilege and pleasure of inspecting the unique collection of relics of Boulton, Watt, and Murdock, collected with so much discrimination and enthusiasm by Mr. George Tangye, of Heathfield Hall, and they will consequently recognise the munificence of his gift of this collection to the Birmingham Corporation. By this means, too, the relics are placed practically at the

disposal of the nation. The presentation took place at Wednesday's meeting of the Birmingham City Council, when the Lord Mayor read a letter from Mr. Tangye, in which he stated that the collection consisted of a large number of important mounted and unmounted drawings and business letters dating from 1775 from the engineers named, as well as from men of light and leading in the latter part of the eighteenth century. The models are numerous, and include Watt's engine-indicator, roller copying-press of 1780, the copying-press and desk of the younger James Watt, Murdock's rotary engine and pump, section of a Newcomen engine, with several cases of drawing - instruments, besides numerous letter-books containing copies of Boulton and Watt's correspondence, one of Watt's letters to the Abbé de Calonne dated 1787, and "as applicable to events transpiring to-day as when written 124 years ago." The correspondence is most interesting and suggestive; it throws considerable light upon Watt's and Boulton's methods, and reflects on the probable solution of problems which are still exercising the minds of engineers. Mr. Tangye's industry is also reflected in the excellent catalogue of the drawings and engines which accompanies these relics. His generosity to Birmingham is further shown in his gift being accompanied with a contribution of 250*l.* towards the cost of housing the collection in a suitable room in the public library. The Lord Mayor, in proposing the resolution thanking Mr. Tangye for his generous offer, stated that about 16 years ago the then Free Libraries' Committee inspected the relics and other objects, and endeavoured to purchase them, but Mr. Tangye outbid the Committee. It must be gratifying to the citizens of Birmingham, where Boulton and Watt's works were located, to have this unique collection presented to them by an engineer, who has also done much for the renown of the Midland city, in supplement to many other gifts from the same family.

Developments in Marine Propulsion.

In reviewing the progress of marine engineering in the course of his presidential address at the Cleveland Institute of Engineers on Monday evening, Mr. H. Stonewall Jackson had naturally something to say regarding the internal-combustion engine, particularly as his firm, Messrs. Richardsons, Westgarth, and Co., Limited, are manufacturing engines of the Diesel type of 1000 horse-power for a 3200-ton vessel. He stated that although the weight of fuel used will be 60 per cent. less, the cost will be about the same; but the saving in weight of fuel carried on a 30-day voyage will be about 270 tons, and to this extent the vessel, on the same draught and displacement, will have increased cargo capacity. In addition, there will be the saving in weight of the machinery, bunkers, &c., equal to about 70 tons, and a reduction in the engine-room staff equivalent to about 150*l.* per annum. These estimates naturally justify a wider consideration, if not a more liberal attitude, on the part of builders and owners as to the potentialities of the system. At the present time there are two sea-going vessels in service with crude-oil engines. One is the Vulcanus, with a cargo capacity of 1000 tons on a 10-ft. 2-in. draught, built at Amsterdam, and fitted with a six-cylinder, four-cycle, single acting engine of 500 brake horse-power when running at 180 revolutions per minute. On a voyage from Rotterdam to Stockholm, a distance of 735 nautical miles, the time occupied, when fully laden with 1000 tons of cargo, was 100 hours, the maximum speed being 8½ knots, and the consumption 1 ton of crude oil per 100 miles. The estimated saving over coal and steam-engines is given as 50 per cent., without taking into consideration the reduction in *personnel* charges and the increase in cargo capacity. The other vessel is the Toiler, built by Messrs. Swan, Hunter, and Wigham Richardson, Limited, of 2650 tons cargo capacity on a 14-ft. draught. She has two Diesel engines, each of 180 brake horse-power, built by a Swedish firm. The results given by Mr. Jackson in this case apply to the first voyage from the Tyne to Calais, when the speed was 6¾ knots, and the consumption 1¾ tons of Texas oil per 24 hours, equal to a consumption of about 6d. per mile run with a full cargo of 2700 tons. There are also a large number of small vessels in use, all establishing the practicability of the system, while twelve sea-going vessels are now being built to be propelled with oil-engines. Some data were also given relating to the application of coal-gas engines—notably in the Holzapfel I., a vessel 120 ft. long, carrying 300 tons on a draught of 10 ft. This vessel, which has two producers, each of 100 horse-power capacity, and an engine with Föttinger reversing-gear, attained a speed of 7½ knots. The actual consumption of fuel in the first seven voyages varied from 25 cwt. to 33 cwt. of coal per twenty-four hours when the vessel was carrying cargo varying from 242 to 340 tons. The initial cost of the engines and plant is slightly in excess of that for steam-engines and boilers, but the saving in fuel—given as from 40 per cent. to 60 per cent. — compensates for the additional prime cost. The vessel uses anthracite coal in her producer, but many engineers ar working at the problem of designing a producer which will use ordinary bituminous coal without the necessity of a gas-scrubbing plant. It is understood that Mr. Holzapfel proposes to construct a new vessel of large size, utilising the experience already gained in practice. Mr. Jackson had much to say also in favour of the use of liquid fuel in marine boilers, and gave the increase in calorific value as 75 per cent. in weight over coal. Generally, the address contained much information regarding recent developments, notably in connection with the condenser problem.

NOTES FROM THE UNITED STATES.

Philadelphia, November 8.

The cut in ore freight rates made by the Steel Corporation has come into effect, reducing the rates 20 cents per ton. The uncertainty as to the ultimate cost of ore and freight have cut off all negotiations and have caused a withdrawal of negotiations started some time ago. This means that the 1912 ore contracts may not be placed for some time, as lake navigation soon closes and ore deliveries will not commence until next April. The effect of these developments has been to lower the quotations on Bessemer and basic to the extent of about 0.50 dol. a ton. This outcome is something of a surprise to the trade. Quotations in consequence have been reduced on material used by railroads, such as steel cars, axles, bolsters, trucks, and car-wheels. This action has been due in part to the competition of the independent concerns. Oil-well placings and oil supplies have also declined. Further activity has developed in structural material. The Carnegie Steel Company has a contract for 8000 tons for elevated-track work in Cleveland. The American Bridge Company has taken contracts for 6000 tons for two western enterprises not mentioned. Information just received modifies a recent announcement concerning the Hell Gate Bridge at New York, in that the American Bridge Company has secured the contract for the 70,000 tons of material for that construction, on which work will begin in the Pittsburg mills before the close of this month. Eastern structural mills are confidently awaiting the letting of contracts for eastern enterprises, aggregating some 60,000 tons, exclusive of the pending contracts connected with the New York subways and adjoining railroad work. In one respect the situation has materially improved. The heavier demand is not so much due to the lower prices as to the fact that the enterprises calling for these immense requirements have reached a point where the material had to be purchased.

Contracts.—Messrs. Fawcett, Preston, and Co., Limited, Liverpool, have now in hand additional machinery for the Beira Rubber and Sugar Estates, Limited, which includes Babcock and Wilcox boilers, a 34-in. by 72-in. cane-mill fitted with hydraulic attachments, driven through compound steel gearing by a horizontal steam-engine; also juice-heaters, clarifiers, crystallisers, ten centrifugal machines, filter-presses, and accessories.

The Royal Arsenal, Woolwich.—A new department, entitled the Mechanical Engineering Department, has been recently inaugurated by the Chief Superintendent of Ordnance Factories, Sir H. F. Donaldson, K.C.B. This department, in addition to discharging the functions hitherto allotted to the staff of the Chief Mechanical Engineer, has also under its care all work connected with electric power and illumination, hydraulic power, water and gas supply, locomotives and rolling-stock. Mr. Douglas T. Heap, who has been connected with Woolwich Arsenal since 1902, and who for the past six years has been the head of the Chief Mechanical Engineer's Department, under Sir Frederick H. Donaldson, K.C.B., has been appointed the superintendent of the new department. Mr. Heap received his early training at the Swindon Works of the Great Western Railway Company, and was subsequently engaged with Messrs. Crompton and Co., Limited. Later he was resident engineer on the Croydon electric-lighting scheme, and the Waterloo and City (Electric) Railway under Sir Alex. Kennedy, and superintendent in charge of the power-station, rolling-stock, &c., of the railway just named, under Sir Charles Owens. On resigning this appointment he joined the firm of Messrs. Dick, Kerr, and Co., Limited, as power engineer, and was chiefly engaged on railway, tramway, and power-house work.

THE LATE MR. HOLT S. HALLETT.

We regret to record the death, in his seventy-first year, of Mr. Holt Samuel Hallett, on Saturday last, after a long illness. Though Mr. Hallett's engineering career, strictly speaking, was practically concluded thirty years ago on his retirement on pension from the Indian Public Works Department, he continued until quite lately to concern himself with developments in India, &c.

Educated at Charterhouse, Mr. Hallett was trained under Mr. W. Baker, M. Inst. C.E., engineer-in-chief of the London and North-Western Railway, being articled for three years. Subsequently he was engaged on new railways in Lancashire and Cheshire, acting as resident engineer on the Sandbach-Middlewick branch and the Hartford branch. In 1868 he accepted an appointment as assistant engineer, first grade, in the Government of India Public Works Department, and before retiring in 1879 passed through several grades of executive engineer. During that time he was connected principally with the development of railways in Burma, being connected with the construction of the line from Rangoon to Prome, 161 miles in length—in 1877. He was a keen advocate of connecting the Indian and Burma railway systems, and took an active part in pointing out the need of railway connections with China and Siam, in order to enable British commercial interests to expand. In the interests of this cause he undertook a large amount of travelling and exploration, adding thereby considerably to the available geographical knowledge of the countries he traversed, and carrying out exploratory surveys for railways. He was consulted by the King of Siam as to railway projects in that country.

In subsequent years Mr. Hallett occupied himself in the improvement of factory conditions in India, and a large share of the credit for reforms in this direction was due to him. He was very active in any cause in which he took a part, and through his writings and speeches had a considerable amount of influence. He was a Fellow of the Royal Geographical Society, before which body, in 1883, he gave an account of his explorations in Upper Burma and Siam. In 1885, at the request of the Foreign Office and the War Office, he made a report on affairs in Indo-China. He was admitted to the Institution of Civil Engineers as a member in 1880.

THE LATE MR. WILLIAM SMITH.

The death occurred in Liverpool, on Sunday last, of Mr. William Smith, who was formerly connected with the London and North-Western Railway. Mr. Smith, who retired from active work twelve years ago, had reached the age of eighty-six. Born at Preston, he was articled in 1840 to Mr. J. J. Myres, of that town, and was engaged during that time in section work on the routes of the Liverpool, Ormskirk and Preston, and the Bolton, Wigan, and Liverpool Railways. In 1845 he was engaged under Mr. C. E. Cawley, M.P., M. Inst. C.E., on surveys and the preparation of Parliamentary plans, &c. Subsequently he was in business for four years on his own account. In 1850 he became connected with the Soho Foundry, Preston, his duties occupying him in the works and drawing-office. From 1851 to 1857 he was engaged in surveying work and in the preparation of Parliamentary plans, and in assisting in carrying out alterations at Buxton, under the supervision of Sir Joseph Paxton. In the latter year he was placed in charge of the Cromford and High Peak Railway as engineer and secretary, and retained that position when the line was leased, in 1861, to the London and North-Western Railway. In 1867 he was appointed to the engineering department, Crewe division, of the London and North-Western Railway, and in 1873 was given the Holyhead division. He was elected a member of the Institution of Civil Engineers in 1874.

The Manchester Ship Canal.—Mr. H. A. Reed, M. Inst. C.E., has been appointed chief engineer of the Manchester Ship Canal Company as from January 1 next, in succession to the late Mr. Hubert Congreve. Mr. Reed was one of the contractors' engineers engaged on the construction of the Manchester Ship Canal. Subsequently he had charge of several other important works. He was the contractors' chief engineer on the harbour and dock-yard extension at Gibraltar for the Admiralty, a work which took ten years to construct.

The International Engineering and Machinery Exhibition of 1912.—The International Engineering and Machinery Exhibition, to be held next October, has been recognised by the Board of Trade as an Industrial Exhibition under the provisions of the Patents and Designs Act for the protection of exhibitors showing inventions or designs which have not yet been patented. The members of the committee are taking steps not only to protect their exhibitors, but also to ensure a certain attendance of buyers in this country and abroad. With this end in view they are sending out many thousands of invitations to our colonies, and also to foreign countries.

OLYMPIA MOTOR EXHIBITION.

(*Concluded from page* 629.)

Among the accessories there were not many novelties which were interesting from an engineering point of view. There were, of course, in the gallery innumerable accessories which contribute very largely to the comfort of those who travel in cars, but the principal items in this section which are really part of the motor-car are the carburettors and ignition apparatus.

In the case of ignition we appear, for a time at all events, to have reached a stage when there is not likely to be very much advance except in the matter of pure detail. The high-tension magneto is nearly universal, and performs its work so satisfactorily that there is little apparent need of alteration. In fact, it appears likely that in the near future the manufacture of high-tension magnetos will be standardised, and be in the hands of a very small number of manufacturers.

The general use of high-tension magneto-ignition for marine work and also for motor-cycles has drawn attention to the question of the insulation of these machines in the wet, and for some time makers have produced more or less special machines which are water-tight. For car work this has not been considered necessary, as the engine is under a bonnet, but the Bosch Magneto Company, Limited, 40-42, Newman-street, London, W., however, showed examples of water-tight machines for car work, and we understand that they intend to make them their standard for all purposes. All the various parts are thoroughly cased in. In fact, one of these machines was shown on the stand working satisfactorily with water pouring over it. Although the ordinary magneto works extremely well, there can be little doubt that it will be a distinct improvement to make it more water-tight, for although the bonnet of a car keeps off rain, &c., it is by no means absolutely impervious to wet, besides which it is always possible for a car to have to stand for a time in a damp place.

In the matter of carburation improvement was apparently mostly in detail. The majority of carburettors are still of two types: firstly, those in which the air opening is controlled by the throttle, and secondly, those in which the throttle is independent of the extra air opening, and the latter is automatic.

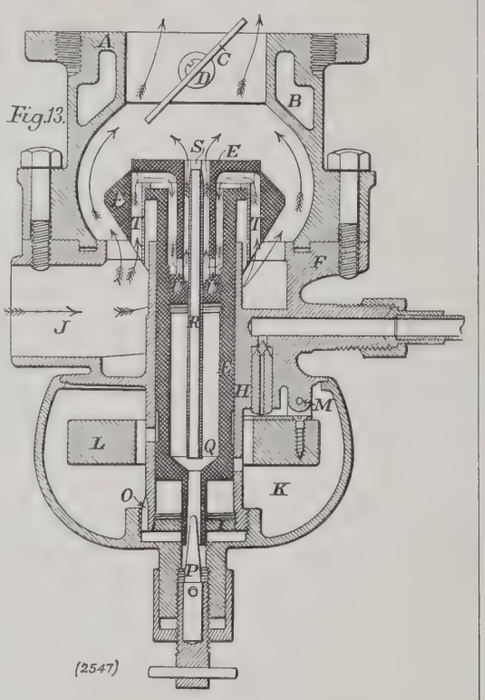
The former type is very largely used, and undoubtedly works very well on the whole. In its most primitive form it consists simply of a small jet and air nozzle through which all the air passes when the throttle is nearly shut, and a supplementary air port which is opened as the throttle opens. This pattern is, however, passing out of use, and it is now more usual to open both the petrol jet and the air simultaneously. In many cases there is a separate jet and nozzle for running dead slow, the carburettor, in fact, consisting of two different sizes with one float chamber. Sometimes this principle is carried further, and there are several nozzles of different sizes which are opened successively. All these arrangements work well with good driving, but have the disadvantage that in order to make the engine pull well at slow speeds it is necessary partly to shut the throttle. The second-class is therefore theoretically the more perfect. In this, as the other, the simplest form is that in which there is simply an extra air-port opened by a spring-loaded valve. This is, however, giving way to the type in which the petrol and air are varied together by some automatic valve. Among this class comes the Stewart Precision Carburettor, shown by the Motor Supply Company, Limited, 110-111, Piccadilly, London, W., which we illustrate in Fig. 13.

In this carburettor the float-chamber K lies entirely below the rest of the carburettor, and can be easily detached for cleaning purposes. Petrol passes into it by the needle-valve H controlled by the cork float L. From thence it passes past the tapered needle-valve P up the tube R and out of the nozzle S. Air enters at the passage J and travels partly up the passage T and past the jet S, partly past the air-valve E. The regulating action is as follows:—When the engine is at rest the air-valve E rests on its seat, and the only passage is that past the petrol-jet S. In this position the tube surrounding the tapered needle P is at its lowest point. As the throttle is opened the air-valve E rises, carrying with it the tube surrounding the tapered pin P, and therefore opening the petrol passage. The height of the pin P can easily be adjusted while the engine is running, and, if desired, it can be changed for a pin of different taper.

Among the accessories not forming essential parts of the car, perhaps the most interesting are the dynamos for electric light. There is no doubt that this form of light has very great advantages over acetylene, if it can be worked out in a practical form at a reasonable price. The usual plan is to have accumulators, and a dynamo to keep the accumulators ready charged.

As a petrol motor is run at very various speeds, and is often stopped altogether, there are two problems in connection with this. The first is to have some means of disconnecting the dynamo, to prevent the accumulator from discharging through it; and the second, to have some means of regulating the voltage of the dynamo when working. For the former purpose there are three main alternatives: first, a mechanical cut-out, which disconnects the dynamo below a certain speed; second, an electric cut-out, which disconnects it below a certain voltage; the third is possibly the simplest, and consists of driving the dynamo with a free-wheel clutch so that it can overrun the engine. In this case, if the engine is stopped, the dynamo continues to run as a motor, but the current consumed by

Fig.13.



it is very small. Of course, if it were left on for long, it would eventually discharge the accumulators, but this is not likely to be the case, as the noise it makes when running is enough to call attention to the fact that it has not been switched off.

For the regulation of the voltage there are many alternatives. The simplest is to have a machine with permanent magnets in place of electromagnets, in which case the armature can be so arranged that the self-inductions in it prevents any excessive current being supplied at any speed. Possibly the next simplest is to have a centrifugal governor controlling the speed of the dynamo by a friction clutch. This system has been used for a long time in the States for the regulation of dynamos for the ignition of gas-engines, and can be made to work perfectly satisfactorily even under continuous daily running. Alternatively to this there are many arrangements for the short-circuiting of either armature or field-magnet coils, or for reducing the intensity of the field-magnets as the speed rises by forms of compound winding.

While there is no doubt that the various machines in the market will do their work very well, there seems room for a simple outfit which could be sold at a moderate price. At present the electric light outfit for a car usually costs anything from about 25*l.* to 70*l.* No doubt there are a fair number of people who are willing to pay such prices, and if an elaborate outfit of ammeters, voltmeters, &c., is desired, the price is bound to be high. There should, however, be a good market for a much cheaper outfit capable of giving enough light for driving at moderate speeds, and in this case measuring instruments might be dispensed with. As self-governing dynamos of small size are sold in America for 4*l.* and under, and are in many cases well enough built to stand some years' work running the usual shop hours, it seems that it should be possible to make something of the kind over here, which could be sold, with a suitable cut-out, accumulators, and a head-light, for some 10*l.* to 15*l.*

The question of carrying the very heavy cars, with large covered bodies, on pneumatic tyres is a serious one, and is now receiving special attention. There is a limit to the diameter of tyre which will answer satisfactorily with a given diameter of wheel, as the size of the tyre gets out of proportion to the diameter of the wheel. No doubt the proper way of carrying really heavy weights would be to increase the diameter of the wheels; 36 in. is the largest diameter in common use, and this is very small to carry weights of about 2 tons. There are, however, some difficulties in the way, one of which is that it is convenient for the purposes of tyre replacement to have the front and back wheels the same diameter, and large front wheels entail difficulties in connection with the steering. In order to overcome these, twin tyres are being adopted in some cases. This has the advantage that the back wheels can be made with twin tyres, while the front are single, thus they are all interchangeable, and yet the back tyres are suitable for carrying the extra weight. The two tyres can be mounted on detachable rims of special design carried on a broad felloe. In this case the same spare rim will serve for both the front or back wheels.

An alternative plan was shown at the stand of Messrs. J. Sankey and Sons, Hadley, Salop, and consists in mounting two of their detachable wheels side by side on a long hub, with a distance-piece between them. The wheels themselves are of the ordinary Sankey pattern—*i.e.*, of hollow stamped steel, and as their hubs are narrower than the rim, they can be placed as closely together as desired, which would not be the case with wire wheels. The wheels being the ordinary pattern, the back and front wheels are, of course, interchangeable.

While this twin-tyre system appears to have great advantages, there is one point which occurs to us as a source of possible trouble. In the case of a puncture to one tyre, it seems possible that the other would carry the weight for some time well enough for the puncture not to be noticed, at all events by a careless driver. In this case the one tyre would be carrying the weight intended to be borne by two, and if the car was run for some time before this was remedied, it seems that serious damage might be done. Whether this will be a disadvantage in practice remains to be seen.

In considering the progress of the year, as shown by the exhibits, it is, of course, to be expected that as each year goes by the change will be less, as there is less room for improvement. This is fairly evident from a consideration of the present Show. The changes in most makes were mainly in matters of detail, and in some there has been hardly any change at all for the last two or three years. On the whole, however, there is distinct improvement, especially among the smaller and cheaper cars. There are few examples of really bad design, and the majority are well thought out, though there is still plenty of room for further improvement.

In the general design of the chassis the main feature is the tendency to combine the gear-box either with the engine or back axle. This is largely, no doubt, a matter of price, for there is no doubt that it is cheaper to build the gear-box as a unit with either of these than to build it separate. In the latter case it has to be erected carefully in line with the engine, and even then must have flexible connections between it and the engine to make it run nicely, for the frame is always liable to slight distortion. Not only will the separate gear-box cost more to make, but it will also be liable to get out of line afterwards, and so the unit system should give the greater satisfaction if well designed. In summing up the relative advantages of the two systems, however, there are various points to consider. In the matter of cost there can be little doubt that a well-designed arrangement in which the gear-box forms a unit with the engine will be cheaper than one where it forms one with the back axle. The latter entails the change-speed connections being taken half the length of the car, and some arrangement being made to allow of the motion of the axle on the springs without this affecting the gears.

With regard to the actual merits of the two

positions of the gear-box there are considerable differences of opinion. For the gear-box on the back axle it is claimed that the noise of the gears is heard less, and that the propeller shaft can be made lighter, as the maximum torque on it is less. The gear-box on the axle considerably increases the unsprung weight on the back axle, however, as not only is the weight of the gears, &c., added to it, but it also entails both brakes being on the axle, and the wheels, &c, have the extra shocks of this unsprung weight to take. Most authorities appear to agree that the smaller the proportion of the weight unsprung the better, on account of the wear of the tyres. On the whole, therefore, it appears that the gear-box in the usual place is likely to be distinctly the better.

Several makers are placing both the brakes on the back hubs. This does not in itself appear to be such a good plan as the usual arrangement of one on the countershaft and the other on the hubs. It increases the unsprung weight, and, further, using either brake heats up both of them. It also entails more complication and expense. It allows, however, of a very neat arrangement of torque-rod. Front wheel brakes did not appear to be much in evidence this year.

In the matter of the number of cylinders used there was not a great deal of change. The four-cylinder engine was in an enormous majority, but there were still a certain number of one and two cylinder engines, while there was a slight increase in the number of small sized six-cylinder engines, and one example at least of an eight-cylinder.

With regard to the single-cylinder engine, this will probably survive, at all events for some considerable time, on account of its extreme simplicity and cheapness. The case of the two-cylinder engine is much more doubtful. If made as a diagonal engine, with a built-up crank-shaft like a bicycle engine, it is no doubt cheap to construct, and there were several such engines shown. The ordinary two-cylinder engine, however, has the cylinders vertical, and a forged crank-shaft with split main bearings, &c. This is very nearly, if not quite, as expensive to construct as a four-cylinder engine of the same total cylinder capacity with a two-bearing crank-shaft, which would in every way be much superior in running.

The four-cylinder engine, if well made, runs so smoothly that the necessity for six cylinders is very doubtful, save in such large sizes that the four cylinders would be of impracticable dimensions. At the same time there appears to be a market for small six-cylinder cars for those who want ultra-smooth running. Of these one of the neatest designs was that shown by Messrs. Delage et Cie., 60, Boulevard Percire, Paris. The cylinders in this car are 65 by 126 mm. ($2\frac{9}{16}$ in. by 5 in.) and are all cast in one piece. This seems a great improvement on the plan of casting them in sets of three, as it stiffens the crank-case throughout its length. The crank-shaft has only three bearings, and the engine therefore is very compact.

It is noticeable that Messrs. De Dion Bouton (1907), Limited, 10, Great Marlborough-street, London, W., showed an example of an eight-cylinder diagonal engine. If more than four cylinders are required, it seems very doubtful whether it is not best to go straight to the eight-cylinders. As the cylinders can in this case be put diagonally, the eight-cylinder engine is much shorter than the six, and therefore lighter, and is probably quite as cheap to make owing to the simpler form of crank-shaft and crank-case, while the smoothness of running should be as superior to the six-cylinder as the latter is to the four-cylinder.

The matter of the weight of the smaller cars is receiving more attention, though there is still room for improvement here. The weights of the American cars are far less than those of English cars of the same size, although they are very much cheaper. Considering the high prices they get, and therefore the fact that both better material and workmanship can be had, the European makers ought to be able to produce cars of the weight of the American, and yet retain the required durability. The fact that such cars were actually produced here six years ago or so, and are still running perfectly well, shows that it can be done. It will be necessary, however, to make different chassis to carry open bodies from those used for the heavy closed bodies, and at present the tendency of European builders appears to be to make their chassis to carry any body that can be put on it, with the result that it is far heavier than necessary for the ordinary open body.

Much is to be said in favour of the practice, which is largely coming into use, of putting supplementary spiral springs between the parts of the main leaf-springs. These springs can be made of a different period to the main springs, and can, therefore, if desired, be made light enough to take up the small road shocks, while, as their range is limited, they will not let the car down on the axle.

The most interesting feature of the Show was the number of new small cars. This was undoubtedly due to the introduction of the American light car, which in many cases is very much cheaper and lighter than any European cars which were available a year or two ago. This makes a comparison between the American and European practice interesting.

In considering the American cars, the first point which strikes one is that they are very rapidly approximating to European practice in their general design. The typical American car of a few years ago had a horizontal engine and an epicyclic change-speed gear, with a chain drive to the back axle. This has apparently been found inferior to the European plan of the engine in front, with a bevel-geared axle, and all the American cars shown were of this pattern, the engines having the conventional four cylinders. In some few cases the epicyclic change-speed gear has been retained, but all the better quality American cars have the conventional sliding-gear, and there is a strong tendency to adopt it in the cheaper cars. There can be little doubt that in this matter the European practice is right. The advantage claimed for the epicyclic gear is simplicity and cheapness. As a matter of fact, a study of the arrangement will show that there are usually as many wheels in the epicyclic two-speed gear and reverse as there are in the ordinary three-speed gear-box, while there are also several clutches or band-brakes to take the place of the ordinary single clutch. If the epicylic gear is made cheaper, therefore, it must be by the use of inferior workmanship or materials.

Pressed-steel frames, H-section front axles, &c., have all been taken from European practice. In matters of detail the gear-box in American cars is often placed on the back axle, though this is by no means always the case. We have already discussed the merits of this arrangement and need not therefore go into the matter again beyond saying that one of the principal claims for it is that the gears are more silent, and this may be largely due to the slower speed at which the engines are run. The essential point in which the American practice really differs from the European is the matter of the sizes of cylinders and engine speeds, and the weights of the lighter cars.

If we compare an American with a European car of a given weight, size, and price, we find that the American engine is very much larger, and the speed at which it runs consequently slower. Thus if we take the ordinary side-entrance car, weighing about a ton and costing not more than 300*l*., we find that with these limits of weight and price the American car will have cylinders at least 4 in. by $4\frac{1}{2}$ in., having a capacity of, say, 225 cub. in., while the European car will not have cylinders larger than 80 mm. by 120 mm. ($3\frac{1}{8}$ in. by $4\frac{3}{4}$ in.), and a capacity, therefore, of about 150 cub. in. Possibly there will be very little difference in the power developed, for the European engine will be tuned up to run a great deal faster, and will be made heavy enough to do so. The smallness of the cylinders, however, means that for any given power the engine has to run 50 per cent. faster, and this means, firstly, that all the bearings, valves, valve-gear, &c., must be quite as heavy as those of the larger-cylindered engine to get the same durability; and, secondly, that the gears, &c., all have to run half as fast again, and therefore will make a great deal more noise. As the weight of an engine depends far more on the size of the shafts and bearings, &c., than on the size of the cylinders, there is nothing surprising in the American car being quite as light in spite of the larger-sized engine.

What is true of this size car is also true of others. Thus there are American cars, weighing under 15 cwt, having over 150 cub. in. of cylinder capacity, while the ordinary European car of that weight has cylinders from 70 by 100 mm. to 70 by 120 mm., giving a total capacity of from about 95 to 115 cub. in. The European makers claim that as they get the same power from smaller cylinders, their engines are more "efficient." Efficiency is, however, not usually considered to mean simply a reduction of cylinder dimensions for a given power, but economy either in weight or fuel consumption, and there is no evidence whatever that the very small cylinders

PARTICULARS OF CERTAIN AMERICAN AND BRITISH CARS.

NAME.	Maker.	CYLINDERS.					Weight Complete.	Cylinder Capacity per Cwt.	Wheel-Base.		Track.		Number of Speeds.	Price, Complete.
		Diameter.		Stroke.		Total Capacity.								
	h.-p.	mm.	in.	mm.	in.	cub. in.	cwt.	cub. in.	ft.	in.	ft.	in.		£
AMERICAN, UNDER 200*l*.														
Ford	20	95	$3\frac{3}{4}$	102	4	176	$13\frac{1}{2}$	13.1	8	4	4	8	2	175
Flanders	15—20	92	$3\frac{5}{8}$	95	$3\frac{3}{4}$	154	16	9.6	8	6	4	$8\frac{1}{2}$	3	195
Hupmobile	12—14	83	$3\frac{1}{4}$	88	$3\frac{1}{2}$	117	13*	9.0	8	2	4	$6\frac{1}{2}$	2	180*
AMERICAN, 200*l*. TO 300*l*.														
Bedford	15—18	95	$3\frac{3}{4}$	95	$3\frac{3}{4}$	164	$16\frac{1}{2}$	10.0	8	6	4	8	3	278
Krit	15—20	95	$3\frac{3}{4}$	102	4	176	17	10.3	9	0	4	$8\frac{1}{2}$	3	210
Overland .. .	15—20	90	$3\frac{1}{2}$	114	$4\frac{1}{2}$	174	18	9.6	8	0	4	8	2	2 5
Overland	20—25	102	4	114	$4\frac{1}{2}$	225	$20\frac{1}{2}$	11.0	8	10	4	8	3	250
Hupmobile	12—14	83	$3\frac{1}{4}$	88	$3\frac{1}{2}$	117	14	8.3	9	6	4	$6\frac{1}{2}$	2	210
Hupmobile	15—18	83	$3\frac{1}{4}$	140	$5\frac{1}{2}$	184	17	10 8	9	8	4	$6\frac{1}{2}$	3	225
AMERICAN, 300*l*. TO 400*l*.														
Bedford	18—22	102	4	102	4	200	19	10.5	8	10	4	8	3	336
Overland	25 30	105	$4\frac{1}{8}$	114	$4\frac{1}{2}$	240	22	10.9	9	6	4	8	3	325
Overland	30—35	110	$4\frac{3}{8}$	114	$4\frac{1}{2}$	270	$22\frac{1}{2}$	12.0	9	10	4	8	3	395
AMERICAN, 400*l*. TO 500*l*.														
Caddillac	30	114	$4\frac{1}{2}$	114	$4\frac{1}{2}$	286	25	11.4	9	8	4	8	3	442
BRITISH, UNDER 300*l*.														
Austin	10	64	$2\frac{1}{2}$	90	$3\frac{1}{2}$	69	$14\frac{1}{2}$	4 7	8	0	4	0	3	290
Belsize	10	69	$2\frac{3}{4}$	130	$5\frac{1}{8}$	118	14*	8.5	8	0	4	2	3	210
Standard	15	80	$3\frac{1}{8}$	120	$4\frac{3}{4}$	147	22	6.6	9	6	4	8	3	300
Star	10	68	$2\frac{3}{4}$	120	$4\frac{3}{4}$	106	14	8 2	8	2	4	3	3	250
Vulcan	10	75	3	110	$4\frac{7}{16}$	119	16	7.5	8	0	4	8	4	225
Vulcan	15.9	80	$3\frac{1}{8}$	120	$4\frac{3}{4}$	147	18	8.2	8	10	4	8	3	295
BRITISH, 300*l*. TO 400														
Argyll	12	72	$2\frac{3}{4}$	120	$4\frac{3}{4}$	120	20	6.0	9	0	4	3	4	325
Austin	15	90	$3\frac{1}{2}$	127	5	173	$21\frac{1}{2}$	8.1	9	3	4	6	4	390
Star	15	90	$3\frac{1}{2}$	120	$4\frac{3}{4}$	186	20	9.3	9	10	4	3	4	345
Swift	10—12	68	$2\frac{3}{4}$	110	$4\frac{5}{16}$	98	$15\frac{1}{2}$	6.3	8	0	4	0	4	315
Swift	15—18	85	$3\frac{3}{8}$	120	$4\frac{3}{4}$	165	21	7.9	9	0	4	4	4	400
Belsize	14—16	92	$3\frac{5}{8}$	120	$4\frac{3}{4}$	192	22	8.7	8	9	4	3	4	3 5
Vulcan	19.6	89	$3\frac{1}{2}$	120	$4\frac{3}{4}$	181	20	9.0	9	0	4	8	4	350
BRITISH, 400*l*. TO 500*l*.														
Argyll	20	90	$3\frac{1}{2}$	140	$5\frac{1}{2}$	218	28	7.8	10	4	4	7	4	500
Argyll	15	80	$3\frac{1}{8}$	120	$4\frac{3}{4}$	147	23	6.4	9	8	4	3	4	435
Napier	15	83	$3\frac{1}{4}$	127	5	164	23	7.2	8	10	4	9	3	465
Straker-Squire ..	15	87	$3\frac{3}{8}$	120	$4\frac{3}{4}$	174	24	6.3	9	3	4	5	3	443
Thornycroft ..	18	102	4	114	$4\frac{1}{2}$	225	23	9.8	10	0	4	6	3	495

* Two-seated body. Other weights and prices are with four-seated body. Weights are necessarily approximate only. Prices of American cars are those at which they are sold at here, and generally include hood, screen, and head-lights.

show any superiority in either one or other of these two points.

The table on page 679 gives some particulars of a few representative American and British cars.

Whether the buying public will prefer the fast-running engine or one of more moderate speed remains entirely to be seen, but there is no doubt whatever that there are very practical advantages in the latter from an engineering point of view.

No doubt in the matter of both weight and price the American makers are very much helped by the fact that it is usual for the cars to be sold complete with their bodies and all their outfit. This means that the manufacturer knows the exact weight that the chassis has to carry, and need only build it strong enough for this; whereas the European maker has to provide for any body that it is possible for the purchaser to put on. There is no doubt that the plan of supplying the car complete has very great advantages, as the weight of the body can be kept down as carefully as other parts, while there is a very great saving in cost by making bodies in large quantities. The same thing applies, perhaps, even more to the accessories. The American maker supplies his car complete, with screen, hood, lamps, &c., and these can therefore be made and fitted to standard in quantities, and, further, the question of weight can be considered in their case also. The weight of accessories often adds up to far more than purchasers think, and it is quite easy to add 2 cwt. or 3 cwt. to the weight by piling these on, even in a small car, for very few of them are made with a very great regard to what they weigh.

It is noticeable that hardly any of the American cars have more than three speeds, and many of them only two. This is the natural result of having an engine well up to its work, and there can be little doubt that the principle is right. If four speeds are fitted, as is now common in European practice, it means that for the same weight and cost a smaller engine must be used. Possibly, if the small engine is always kept at full speed, and the gear constantly changed, the extra speed may largely compensate for the smaller engine, but it can only be so at the expense of more wear and tear and noise.

Steam on the Ohio.—The centenary has just been celebrated of the commencement of steam navigation on the Ohio. Just 100 years ago a small steamboat named the New Orleans, and built by Nicholas Roosevelt, started down the great stream.

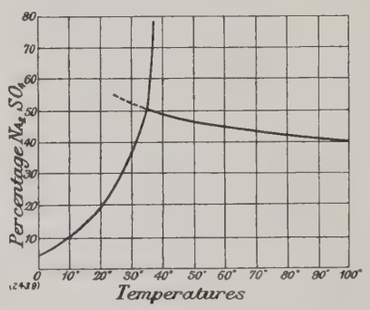
The Institution of Automobile Engineers.—On the 8th inst. a meeting of this Institution was held at the Institution of Mechanical Engineers, to welcome the members of the American Society of Automobile Engineers who are at present on a European visit of inspection. A paper read by Mr. H. E. Coffin, Past President of the American Society, on "Chassis Design," resulted in a lengthy discussion, in which many of the visitors took part. The paper dealt with American practice, and pointed out the effect of the bad road conditions on the general design. It would appear also that the American user is much harder on the car, and objects to changing gears. The different climatic conditions, too, existing in various parts of the States have necessitated the production of engines capable of working satisfactorily without adjustments, and duplicate cars are regularly sent out which are suitable for either working at sea-level or in the mountainous country. The author mentioned a form of disc clutch which appears to be little known to car-builders here. In this the alternate discs are studded with cork having a projection of about $\frac{1}{32}$ in., and very satisfactory results are obtained, provided a sufficiently strong spring be employed to prevent slipping. Self-starters are becoming more universal, and also enclosed valve-gears, and the introduction of electric car-lighting has caused many important improvements in the gas-lighting equipment, the more important being the extended use of compressed acetylene, which is now obtainable at even the smallest villages at low cost. In the case of valve-gears the author expressed the opinion that the substitution of poppet-valves would be made in America only by an equivalent not having reciprocating motion. Gear-boxes were often placed on the rear axle, and worm drives were not much used as yet. Standardisation of the materials of construction was receiving much attention, and had resulted in steel-makers, &c., arranging to hold stocks for immediate delivery. During the discussion it was mentioned that a very large number of electrically-propelled delivery-cars, carrying up to 5 tons, were in use for parcel delivery, and that the number was continually increasing. On the 11th inst. a very enjoyable evening was passed, when the American visitors were entertained at dinner at the Trocadero Restaurant, with Mr. L. H. Legros in the chair. Some 130 members and guests were present, amongst the latter being Mr. H. E. Coffin and Mr. H. F. Donaldson, past-presidents of the American Society, Sir George Gibb, and Mr. E. B. Ellington. The American engineers expressed their great satisfaction with the unlimited hospitality and information they had received, and extended a hearty invitation to their hosts to visit them in America.

FURTHER NOTES ON THE NATURE OF SOLID SOLUTIONS.*

By C. A. Edwards, M.Sc.

(Research Chemist, Messrs. Bolckow, Vaughan, and Co., Middlesbrough.)

In a paper read at the annual general meeting in January, 1911,† the author briefly discussed the nature of a constituent which so frequently occurs in metallic alloys, and which is usually described as a solid solution. This gave rise to a most interesting discussion; and though some few points were alluded to which supported the conclusions embodied in the paper, for the most part these conclusions were received with little favour. The objections to the author's views were numerous, and, if valid, indeed very serious. Owing to the magnitude of the criticism, the author considered it advisable to make his reply in the form of a short paper, because it would be easier to handle, and also because it would afford another opportunity for further criticism. Before again opening this interesting question, the author would like to make it perfectly clear that it is not one of nomenclature, for it is of little consequence whether we use the term "solid solution" or "mixed crystal;" but whichever term is used, it is most important for metallurgists to acquire a true and clear conception of the nature of that constituent, and thus remove the ambiguity which is now undoubtedly associated with the use of those terms. Solid solutions are probably of more frequent occurrence in industrial alloys than in any other constituent, and if their internal architecture could be conceived, it would be a step of some scientific value which may lead to an explanation of phenomena that have been hitherto inexplicable. In his previous paper the author's main conclusion was that "a solid solution of two metals or intermetallic compounds is an intimate crystalline mixture, and whilst the crystals are so small that the mass appears quite homogeneous, they are nevertheless sufficiently large to retain their identity." The most serious objection to this view was that it was opposed to the phase rule, and it is to this



objection that the present paper is chiefly directed. Therefore, in order to decide if this definition is correct, or even theoretically possible, depends upon the answer supplied to the following questions:—

1. Are there any physico-chemical laws opposed to such a conception?

2. Is this definition in accordance with what is known of other types of solution?

Since solid solutions are regarded as being analogous to ordinary aqueous solutions, it is necessary to define the condition in which a salt exists when in solution before the state of a metal in solid solution is definable. It will be advisable, therefore, carefully to consider each kind of solution, after which it may be possible to fix the precise physical meaning of the term "solution." That there is, indeed, some uncertainty as to the meaning of this term will be evident on reading a quotation from Findlay's book on the phase rule. He says:—"With the conception of gaseous and liquid solutions everyone is familiar. Gases can dissolve in, or be absorbed by, liquids; and solids also, when brought into contact with liquids, 'pass into solution,' and yield a homogeneous liquid phase. On the other hand, the conception of a solid solution is one which, in many cases, is found more difficult to appreciate; and the existence and behaviour of solid solutions, in spite of their not uncommon occurrence and importance, are in general comparatively little known. The reason of this is to be found, to some extent, no doubt, in the fact that the term 'solid solution' was introduced at a comparatively recent date, but it is probably also due in some measure to a somewhat hazy comprehension of the definition of the term 'solution' itself."

A solution is usually defined as a homogeneous phase the composition and properties of which may be varied within certain limits. This is, however, only a general definition, which does not signify the condition of a substance when in solution.

Gaseous Solutions.—The first, and perhaps most perfect, class of solution is that of gases in gases. In gaseous solutions the molecules of each gas move freely round each other without producing any change in their respective properties. If we take, for example, a solution of nitrogen and oxygen, we know that the individual properties of these two gases are absolutely the same when in solution as when separated. Moreover, gaseous solutions are capable of being separated into their constituents by diffusion. Hence we are quite justified in concluding that gaseous solutions are finely-divided mixtures.

Solutions of Gases in Liquids.—With regard to solutions coming under this class, it is well known that all gases are more or less soluble in liquids. The amount of gas actually taken up by any liquid upon which that gas has no chemical action depends upon:—First, the nature of the gas; second, the temperature of the liquid; and, third, the pressure of the gas.

1. At 0 deg. Cent. water dissolves 2.1 volumes of hydrogen and 1.9 volumes of oxygen, proving that the amount of gas dissolved is different for different gases.

2. On raising the temperature it is found that the volume of gas dissolved by the liquid decreases.

3. From Henry's law, we know that the volume of gas which can be absorbed by a liquid varies directly with the pressure, but since the volume of a gas is inversely proportional to the pressure, it follows that at equal temperatures the volume of a gas dissolved by a liquid is the same at all pressures.

Dalton considered that the particles of a gas dissolved in a liquid were held between the molecules of the liquid. While this explanation does not account for the fact that a liquid dissolves dissimilar gases to different degrees, nor the fact that the solubility decreases as the temperature increases, yet it requires less assumption than any other explanation so far advanced, and for this reason, and also because it falls into line with the other types of solution, the author is inclined to believe in Dalton's opinion.

Solutions of Solids in Liquids.—In his previous paper, in discussing the action of the separation of water from an aqueous solution by means of a "semi-permeable" wall, the author said that solutions of salts in water are intimate mixtures which can be separated, to some extent, by mechanical means. This implies, and, indeed, the author said he was of the opinion, that salts preserve their identity when in solution. If this is not the case, on what other assumption can the osmotic phenomena be explained? If we now examine a few well-known examples, we will see that this statement is by no means without experimental proof. As a rule, the solubility of a solid in a liquid increases with rise of temperature; certain substances, however, such as slaked lime, decrease in solubility with rise of temperature; and this has been shown to be due to the fact that as the temperature rises the dissolved substance—in this case the calcium hydrate, $Ca(OH)_2$—loses water, and is converted into a less soluble substance—namely, lime, CaO. This is an instance of the dissolved salt actually being dehydrated when in water in the same way as when in solid pieces. This kind of decomposition, if it does not actually prove that the salt retains its identity when in solution, can only be explained with that assumption. If such changes are possible in aqueous solutions, with which metallic solid solutions are analogous, then it is quite reasonable to expect that similar changes may also occur in metallic alloys. Another interesting example is that of sodium sulphate; this salt exists as a solid in three forms—namely, the anhydrous salt Na_2SO_4, the heptahydrate $Na_2SO_4 . 7H_2O$, and the decahydrate $Na_2SO_4 . 10H_2O$. The solubility curve of sodium sulphate in water is shown in Fig. 1. The first portion of the curve represents the solubility of $Na_2SO_4 . 10H_2O$. It will be seen that the solubility of this salt rapidly rises with the temperature up to 34 deg. Cent., after which it gradually diminishes with further rise of temperature. The decahydrated salt decomposes at temperatures above 34 deg. Cent. into the anhydrous salt, and water saturated with that salt; therefore the second portion of the curve corresponds to the solubility of the anhydrous salt in water. Now in such cases of solution the changes which occur in the solution seem quite inexplicable if it is assumed that the dissolved substance is absorbed by the molecules of the solvent, or, as is frequently stated, that the solute actually liquefies.

From these facts we learn that a dissolved hydrate can lose its water of hydration even when the particles of the hydrate are apparently in contact with water; whether the particles of solute and solvent are actually in contact is a matter that will be considered later. In any case it is evident that a dissolved body may undergo the same changes when in solution as when in the pure solid condition.

Van't Hoff's Law.—When the temperature of a system in equilibrium is raised, that reaction takes place which is accompanied by an absorption of heat, and conversely, when the temperature is lowered, that reaction occurs which is accompanied by an evolution of heat.

Le Chatelier's Law.—When the pressure on a system in equilibrium is increased, that reaction takes place which is accompanied by a diminution of volume; and when the pressure is diminished, a reaction ensues which is accompanied by an increase in volume.

These two theories are embraced in Le Chatelier's law, which may be stated as follows:—If a system in equilibrium is subjected to a constraint by which the equilibrium is shifted, a reaction takes place which opposes the constraint—*i.e.*, one by which its effect is partially destroyed.

In accordance with this law, increase of solubility with the temperature must occur in those cases where the process of solution is accompanied by an absorption of heat; and a decrease in the solubility with rise of temperature will be found in cases where solution occurs with evolution of heat. In applying the theorem of Le Chatelier to the course of the solubility curve, it should be noted that by heat of solution there is meant, not the heat effect produced on dissolving the salt in a large amount of solvent, but the heat which is absorbed or evolved when the salt is dissolved in the almost saturated solution. Not only does the heat effect have a different value, but it may even have a different sign. Despite its many forms, it should be noted that the solubility curve of any substance is continuous so long as the solid phase, or solid substance in contact with the solution, remains unchanged. If any "break" or discontinuous change in

* Paper read before the Institute of Metals at Newcastle.

† See Engineering, vol. xci., page 200.

the direction of the curve occurs, it is a sign that the solid phase has undergone a change. Conversely, if it is known that an alteration of the constitution of the solid phase takes place, a break in the solubility curve can be predicted. From these facts it follows that a salt, even when in solution, may undergo the same changes on heating that solution as when the pure salt is heated alone, and as a logical consequence it follows that it is possible only if the salt retains its identity when in solution. Therefore the author considers he is amply justified in concluding that in all cases solutions are not absolutely homogeneous—that is, though they may have the same composition in all their parts so far as is shown by ordinary analyses or physical tests, yet there is a region beyond which a solution cannot be regarded as homogeneous, or, in other words, the particles of solute are not actually in union with the particles of solvent.

In the discussion on the previous paper it was suggested that this conception as applied to solid solutions was incompatible with the phase rule. Needless to say, the author fully appreciates the value of this important rule, and applies it whenever possible; but he would point out that there are limits to its application, and one of these limits is reached when it is attempted to apply the rule to the molecular constitution of a phase.

In deducing his law, now known as the phase rule, Gibbs regarded a system as possessing only three independent variables—viz., temperature, concentration, and external pressure; among other less important items no account is taken of the internal pressure of a phase, not even in the case of solutions. The rule defines the state of a system in equilibrium by the relation existing between the number of components and the number of phases present, quite independently of the amount of each phase and the internal constitution of the participating substances. Therefore, in attempting to determine the internal nature of a solution the phase rule, as expressed by the equation $F = C + 2 - P$, should not be applied, for with this equation it is presupposed that a solution is homogeneous. But because in the application of the phase rule it is supposed that a solution is homogeneous, it does not therefore follow that that is indeed the case; and if it is decided that a solution is a physical mixture coming outside the region of the above equation, it will not detract from the value of the phase rule. For, as a matter of fact, while the author is convinced that the phase rule should be disregarded in trying to decide whether a solution is, or is not, homogeneous, in the strictest sense of the word, once this question is decided, and if in favour of the author's conception, it becomes even more important to apply the phase rule in order to know exactly what substance is in solution. An example of the limitation of this rule is evident in the case of gaseous solutions, when, from the point of view of the phase rule, there is only one phase present—namely, vapour; and yet there is not the slightest doubt that in gaseous solutions each gas present retains its own properties, and is unaffected by the presence of others.

Another interesting question was raised by Dr. Guertler. He said:—"If it was assumed, with the author, that there existed a very fine mixture of separate crystals in the one solid solution, there would have to be assumed a third thing between crystal and molecule. No evidence of such a thing was given, except by the osmotic phenomena." The author readily acknowledges the validity of Dr. Guertler's argument, and would say that the necessary evidence for the existence of such a third force is furnished by the osmotic phenomena of liquid and solid solutions, phenomena which are closely related to the laws of gaseous pressure. It is, of course, less easy to experimentally show the existence of osmotic pressure, by means of diffusion through a semi-permeable wall, as in the case of aqueous solutions; but magnitudes which are proportional to the osmotic pressure are furnished by the depression of transformation points brought about by the presence of foreign substances in solid solution. The author regards osmotic pressure as a pressure which exists between the particles of solute and solvent. It would appear that, in the case of aqueous solutions, osmotic phenomena are produced by the pressure exerted upon the water by the particles of solute, which results in an actual expulsion of part of the water. The author uses the word "particle" advisedly, because it conveys no definite idea as to size or molecular aggregation. From the foregoing reasoning, the conclusions at which the author arrives are—

1. That gaseous, liquid, and solid solutions are members of the same family, the different states of these members being due to the differences in their molecular aggregation.

2. In all cases of true solution the molecules of each component remain unchanged—*i.e.*, there is no association of dissimilar molecules—*e.g.*, there can be no association of the molecules of a salt with those of water, when in the form of an aqueous solution, unless it results in the formation of a new compound. Thus in the case of gaseous solutions a uniform composition is maintained by the physical forces existing between what may be regarded as simple molecules; in liquid solutions a constant composition throughout the mass is maintained by the forces existing between dissimilar groups of molecules, but each individual group consists of only one kind of molecule. In the case of solid solutions, equilibria are maintained between the very small crystals of each component metal or intermetallic compounds.

3. With the expression $F = C + 2 - P$ representing the phase rule, solutions come under the head of homogeneous equilibria, but that equation should not be applied to disprove the author's conception of the internal nature of solutions, because, with it, the assumption is tacitly made that a solution is homogeneous, and thereby judgment is passed before the evidence is considered.

4. From a general point of view the term "solid solution" is to be preferred to "mixed crystals," but, whichever termed is used, the author considers that such bodies consist of extremely small crystals of two or more metals or intermetallic compounds; and whilst these crystals are ultra-microscopic, they retain their individual properties.

With regard to the practical aspect of this interesting question, the author will only say that with this conception, and, so far as he is aware, with this only, can the discontinuity in the mechanical properties of the *a* brasses (discovered by Bengough and Hudson) which occur at 470 deg. Cent. be explained. Further, many other facts which are still not understood become quite reasonable after accepting this theory.

It will be seen that this note deals more with the bearing of the phase rule upon the question; other less vital objections have for the moment been left out of consideration, because the author believes they were made as a result of some slight misunderstanding, and also because it is first necessary for members interested in the subject to decide whether they will accept the author's theory as being in agreement with well-known physical laws.

Without wishing to bind other people to the views expressed in this paper, the author feels compelled to say they are largely an outcome of many friendly discussions with the staff and students of the Metallurgical School of the Victoria University, Manchester.

ON CASE-HARDENING BY MEANS OF COMPRESSED GASES.*

By F. Giolitti (Turin) and F. Carnevali (Turin).

In a paper, published about two years ago,† we communicated the results of certain preliminary experiments carried out with the view of establishing what influence, if any, variations in the pressure of carburising gas (in the special case considered, carbon monoxide) exert on the characteristics of cementation zones.

These preliminary experiments had already furnished proof that the characteristics of cementation zones vary in notable fashion concurrently with the variation in pressure of the carburising gas, and more particularly in the case where carbon monoxide reacts on ordinary steel in the presence of free carbon, in the sense that an increase of pressure produces (all other conditions remaining unchanged) an increase in the depth of the cementation zone obtained within a given time, and an increased concentration of carbon within the zone itself.

Apart from the practical conclusions to be drawn from such results, the results in themselves constituted a fresh irrefragable proof of the direct and dominating intervention of carburising gases (and especially of carbon monoxide) in the process of cementation. In view, however, of the *ensemble* of theoretical knowledge recently acquired concerning the chemical reactions which take place in the course of case-hardening by means of case-hardening agents with a carbon monoxide base, and more particularly concerning the conditions of equilibrium of such reactions, it was only natural that we should not stop short at these first conclusions, but that we should endeavour to extend them by dint of more complete and more exact experiments.

With this object we thought it advisable, first of all, to modify some of the structural details of the apparatus utilised in the earlier experiments. Fig. 1, page 682, gives a general view of the new apparatus, detailed drawings and a complete description of which are not given here, because it differs in no essential point from the former apparatus, which was minutely described in the paper already cited. The principal differences between the old and the new apparatus, apart from modification in the dimensions of various parts, so as to obtain a fuller utilisation of heat and more uniformity in the heating process, are those devised in the methods of closure. The new methods, the arrangement of which is clearly shown in Fig. 1, and in the diagrammatic section (Fig. 2), while retaining the old facility of rapidly setting up and dismantling the apparatus, allow of maintaining the vessel perfectly gas-tight. This is an essential condition towards an exact knowledge of one of the variables which (as we have shown in previous papers) possesses preponderating influence on the results of experiments of this kind—namely, the velocity of the current of carbon monoxide which flows into the case-hardening chamber.

A and B (Fig. 2) are clamps attached to terminals (insulated electrically and gas-tight) which pass through the wall of the cast-iron receiver C, and conduct to the nickel-wire spiral D the current which is destined to produce the heating effect. This spiral is wound round the porcelain tube E, which can be easily detached from the apparatus and put back again, as it is merely enclosed in a fire-clay tube F of larger diameter. The space between this tube F and the wall of the cast-iron vessel is packed with asbestos. The gas (carbon dioxide, CO_2) enters the apparatus by the tube G, and leaves it by the tube H. By the tube of specially strong porcelain I is introduced the thermo-electric couple which is intended to measure the temperature along the entire length of the case-hardening chamber; beside it are placed the blocks which are to undergo case-hardening, completely surrounded by granular carbon.

The apparatus for regulating and indicating the pressure is identical with that described in the previous paper, and is represented in Fig. 1.

The experiments were carried out in the manner previously described, the case-hardening being accomplished by means of a mass of wood charcoal traversed by a slow current of carbon dioxide. We demonstrated on another occasion that this gas supplies with great rapidity, and without any possible excess of carbon monoxide, a mixture of carbon dioxide and carbon monoxide of a concentration exactly corresponding to the equilibrium with free carbon, under the conditions of temperature and pressure employed in the operation. We made use of steels of different composition in the form of tiny cylinders, measuring 10 mm. in diameter and from 70 mm. to 100 mm. (2.8 in. to 4 in.) in length, which we were careful to bury completely in the customary granular carbon. We indicate farther on, in the case of each experiment, the precise conditions of the operation, and, above all, the temperature, duration, pressure of gas, and velocity of the current of gas flowing through the apparatus. In regard to this last point, it must be noted that the numbers which we shall tabulate do not refer to the gas (dry carbon dioxide) which entered the apparatus, but to the gas which issued therefrom, measured under ordinary pressure. Now, since this latter gas—in equilibrium with the carbon at the temperatures at which we worked—was almost entirely made up of carbon monoxide (containing less than 2 or 3 per cent. of carbon dioxide), its volume was about double that of the carbon dioxide introduced into the apparatus, measured under the same conditions of temperature and pressure.

With regard to the temperature, the difficulty of insulating thermally the heating apparatus, and more particularly the necessity of water-cooling the cast-iron walls of the vessel, made it practically impossible to maintain the temperature rigorously constant during the entire process of cementation. As will be seen later on, we can only determine for each case-hardening operation a sufficiently ample interval during which the temperature remained constant.

The steels employed were of the following compositions:

1. Ordinary soft carbon steel, which we shall subsequently designate "carbon steel."

	Per Cent.
Carbon	0.11
Manganese	0.54
Silicon	0.05
Sulphur	0.02
Phosphorus	0.04

2. Soft steel with 2 per cent. of nickel, which we shall subsequently designate "nickel steel 2."

	Per Cent.
Nickel	2.03
Carbon	0.10
Silicon	0.26
Manganese	1.38

3. Soft steel with 5 per cent. of nickel, which we shall subsequently designate "nickel steel 5."

	Per Cent.
Nickel	5.02
Carbon	0.118
Silicon	0.20
Manganese	1.53

4. Steel with 25 per cent. of nickel, which we shall subsequently designate "nickel steel 25."

	Per Cent.
Nickel	24.92
Carbon	0.17
Silicon	0.10
Manganese	3.46

5. Steel with 2.3 per cent. of chromium, which we shall subsequently designate "chromium steel."

	Per Cent.
Chromium	2.33
Carbon	0.41
Silicon	0.15
Manganese	1.02

6. Chromium-nickel steel, which we shall subsequently designate "chromium-nickel steel."

	Per Cent.
Chromium	1.50
Nickel	3.17
Carbon	0.33
Silicon	0.06
Manganese	1.15

In all these steels the percentages of sulphur and phosphorus were less than 0.04.

Table I., on the next page, embodies a synopsis of the conditions attending the various case-hardenings, as well as some remarks (the value of which will be appreciated later) concerning the state of the surface of the various steels after case-hardening.

In order to follow the process of concentration of the carbon in the carburised zones, we availed ourselves of the microscope in the case of the steels carbon, nickel 2, and chromium; thanks to this microscopic investigation fairly precise data (especially in the case of the two first-named) were obtained and are set forth in the second table.

For the other three steels—nickel 5, nickel 25, and chromium-nickel—in regard to which microscopic examination, as is well known, could not yield reliable results, we carried out quantitative determinations of the carbon in the material obtained by machining away successively, and collecting separately, "co-axial" layers of about ¼ mm. thick from the small case-hardened cylinders.*

* Paper read before the Iron and Steel Institute.

† F. Giolitti and F. Carnevali, "Researches on the Manufacture of Cementation Steel—V. (Case-Hardening by Means of Highly-Compressed Gases)," *Atti della R. Accademia delle Scienze di Torino*, vol. xlv., February 13, 1910.

* In order to plane off the successive layers of the carburised steels of Experiments IX., X., XII., XX., XXI., XXII., and XXIII., it was found necessary to reheat them for five hours at a temperature of about 550 deg. Cent. in a neutral atmosphere. We have already shown (on another occasion) that reheating under such conditions in no respect modifies the character of the carburised zone.

We carried out also in the same way quantitative analyses of carbon on the layers of the case-hardened cylinders of chromium steel, because we wished to determine exactly the extraordinary increase in the carbon content in the outermost thin layer which had been revealed to us by the microscope. The results of these analyses are embodied in Table III.

One primary fact which meets the eye from the experimental data here tabulated is the influence which variations in the pressure of the carburising gas exert on the depth of the case-hardening and on the concentration of carbon in the carburised zones. This fact fully confirms the results to which our previous experiments* had led, and proves that they also apply to the special steels of different types on which we have now been working.

TABLE I.—*Conditions of Case-Hardening.*

No.	Steel Used.	Duration of Heat.	Pressure of Gas (in Kilogs. per Sq. Cm.).	Range of Temperature within which the Case-Hardening was Performed.	Velocity of Gaseous Current CO — Litres per Hour for every Sq. Decim. of Carburised Surface.	Remarks on the Condition of the Surface of the Steel after Case-Hardening.
		hrs.		deg. C.		
I.	C	3	15	900— 955	1.5	Surface unaltered.
II.	C	3	15	1020—1050	1.5	Ditto.
III.	C	2½	25	890— 960	1.5	Thick stratum of compact oxide
IV.	C	3	25	980—1015	3.0	Considerable oxidation.
V.	Ni 2	3	15	955— 975	1.5	Surface unaltered.
VI.	Ni 2	3	15	1035—1045	1.5	Ditto
VII.	Ni 2	2½	25	905— 955	1.5	Slight oxidation
VIII.	Ni 2	3	25	1030—1050	3.0	Surface unaltered.
IX.	Ni 5	3	15	850— 890	1.5	Ditto.
X.	Ni 5	3	15	945— 995	1.5	Ditto.
XI.	Ni 5	2½	25	840— 930	1.5	Thick stratum of compact oxide
XII.	Ni 5	3	25	875— 915	3.0	Ditto.
XIII.	Ni 25	3	15	870— 930	1.5	Surface practically unaltered
XIV.	Ni 25	3	15	1000—1045	1.5	Surface unaltered.
XV.	Ni 25	2½	25	870— 950	1.5	Thin stratum of non-compact oxide.
XVI.	Ni 25	3	25	942— 980	3.0	Slight oxidation
XVII.	Cr	3	15	935— 965	1.5	Ditto.
XVIII.	Cr	3	15	1035—1060	1.5	Thick stratum of compact oxide
XIX.	Cr	2½	25	900— 965	1.5	Ditto.
XX.	Cr	3	25	1010—1035	3.0	Ditto.
XXI.	Cr Ni	3	15	810— 850	1.5	Considerable oxidation.
XXII.	Cr Ni	3	15	875— 915	1.5	Thick stratum of compact oxide
XXIII.	Cr Ni	3	25	810— 845	3.0	Ditto.
XXIV.	Cr Ni	2½	25	850— 900	1.5	Ditto.

TABLE II.

Heat No. (See Table I.).	Thickness of the Hyper-Eutectic Zone in Millimetres.	Thickness of the Eutectic Zone in Millimetres.	Thickness of the Hypo-Eutectic Zone (up to about 0.4 per Cent. of Carbon) in Millimetres.
I.	0.4	0.3	0.5
II.	1.3	0.8	0.4
IV.	0.7	0.6	0.4
V.	0.25	1.1	0.35
VI.	0.9	0.8	0.7
VIII.	0.9	0.7	0.8
XVII.	0.1	1.0	?*
XVIII. ..	0.15	1.0	?
XX.	0.8	1.7	?

* For chromium steel having the composition of that adopted by us, the precise microscopic determination of the hypo-eutectic zone is extremely difficult.

TABLE III.

Heat No. (See Table I.)	Concentration of Carbon. In the First Layer (0.25 MM.).	In the Third Layer (Depth = about 0.7 MM.).	In the Fifth Layer (Depth = about 1 MM.)
	per cent.	per cent.	per cent.
IX.	0.71	..	0.12
XIII. ..	0.57	0.54	
XXI. ..	0.45	..	0.54
XVII. ..	2.22	..	1.03
X	0.99	..	0.29
XIV. ..	0.90	0.32	
XXII. ..	0.76	..	0.49
XVIII. ..	3.1	..	1.39
XII. ..	0.73	..	0.36
XVI. ..	0.61	0.37	
XXIII. ..	0.54	..	0.56
XX. ..	2.37	..	1.40

It is hardly necessary to examine in detail the numerical data set forth in the foregoing pages, in order to demonstrate the accuracy of this statement; for it will become perfectly evident on mere comparison of the data which we now publish, and on comparison with those previously published in sundry memoirs concerning the case-hardening of carbon steels and special steels† with the same case-hardening mixture as that utilised in the experiments here recorded, but utilised at ordinary atmospheric pressure. The effects of greater pressure of the carburising gas—effects which are more particularly manifested in the increased concentration in the carburised zones—confirm the conclusions at which we arrived on former occasions concerning the direct intervention of carbon monoxide in case-hardening effected by means of the "mixed" case-hardening agent.

Another fact is plainly to be deduced from a comparison between the results of Experiment VI. and those of Experiment VIII.; between those of No. IX. and those of No. XII.; between those of No. XVIII. and those of No XX.; and between those of No. XXI. and those of No. XXIII. Such comparisons, indeed, show how an increase in the velocity of the current of carbon dioxide tends to cause a diminution in the intensity of case-hardening to such an extent as to eliminate (in the four series of experiments just enumerated) the effects of increase of pressure. We have seen, however, these latter effects manifested with noteworthy intensity in those cases where comparison is made between carburised zones obtained by working under varying pressures (ordinary pressure and pressure ranging from 15 kg. to 25 kg. per sq. cm. (213 lb. to 355 lb. per sq. in.)), but with currents of carbon dioxide of constant velocity.

The cause of this phenomenon is that in case-hardening accomplished by means of a cementing mixture based on the simultaneous action of carbon dioxide and free carbon, a state of complete chemical equilibrium is never really attained; while the ultimate characteristics of the carburised zones depend in great measure on the relations between the velocities of the various reactions which take place during the process of case-hardening.

A third phenomenon of surpassing interest, both from the theoretical and from the practical point of view, a phenomenon which, according to the data tabulated in the foregoing pages (see especially Table I.), occurs with notable frequency and intensity in the course of case-hardening operations carried out under high-pressures by means of a case-hardening mixture based on carbon-monoxide, is the superficial oxidation of the case-hardened steel. Before examining in detail this phenomenon, it will be perhaps as well to set forth certain theoretical considerations.

An oxidation of this character had already been observed by Charpy in 1909,* when he exposed to the action of pure carbon monoxide at 1000 deg. Cent. chromium, manganese, and various chromium steels (containing from 1.99 to 7.71 per cent. of chromium) as also chromium-nickel steels (containing from 2.08 to 6.45 per cent. of nickel, and from 0.70 to 7.04 per cent. of chromium). This investigator had noted that when he used these special steels in the form of filings, the carbon monoxide was decomposed by the chromium, and there resulted "simultaneously the oxidation of the chromium and the carburising of the iron: the two elements behaved as if they were isolated" (page 513)). He adds, further (page 514), that "when, instead of working with metals reduced to filings, one utilises pieces of tolerable dimensions, the same phenomena do not recur; the oxidation of the chromium is restricted to the surface layer, beneath which case-hardening proceeds in the regular course by diffusion." From his experiments generally, Charpy concludes that "the action of carbon-monoxide at 1000 deg., which is a case-hardening one in the case of iron, as also in the case of tungsten and, perhaps, of nickel, is therefore oxidising in the case of chromium and manganese. We have already pointed out on various occasions† how these conclusions, deduced by Charpy from his extremely interesting experiments, were too incomplete and too dogmatic in their simplicity,‡ and

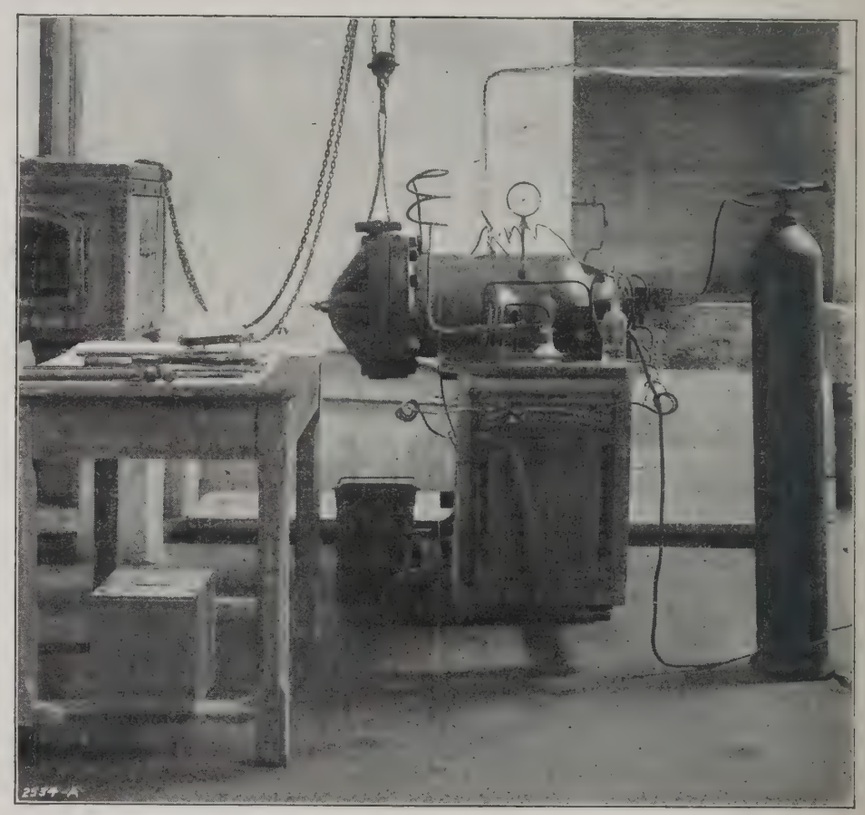
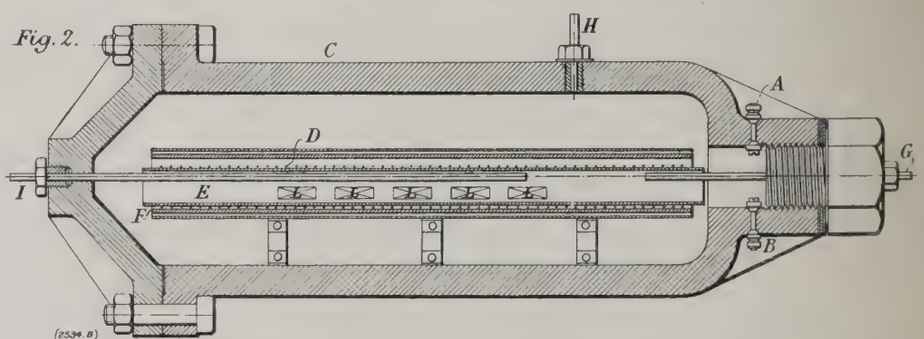


FIG. 1. APPARATUS FOR CASE-HARDENING BY GAS UNDER PRESSURE.



* See footnote, page 681.

† See *Gazetta Chimica Italiana* (1908); *Atti della Reale Accademia delle Scienze di Torino* (April 17, 1910; February 19, 1911; and April 2, 1911); also *Rassegna Mineraria, Metallurgica e Chimica*, June 21, 1911.

* G. Charpy, "Sur la Cémentation du Fer et de ses Alliages par l'Oxyde de Carbone," *Revue de Métallurgie*, vol. vi., May, 1909, pages 505 to 518.

† See the former papers already quoted.

‡ We shall, in fact, see in subsequent pages how, even for iron alone, the action of carbon-monoxide may be simultaneously "case-hardening" and "oxidising." And

were especially faulty therein that no account had been taken of the results of the important researches concerning the action of carbon-monoxide on the metals of the iron group, which had been published by Schenck some time before.*

In point of fact, Schenck's researches, of the results of which we have availed ourselves largely in the course of our technical investigations on the case-hardening of steel, had already led us to range within a single category the action of carbon monoxide in the various metals of the iron group, and thereby to simplify enormously and elucidate perfectly the theoretical treatment of the progression of reactions which take place in systems consisting of single metals, of carbon monoxide, of carbon dioxide, of carbon, and of the products of oxidation and carburisation of various metals.

Now, our experiments, the results of which have been summarised in the foregoing pages, allow us to give a notice five curves of equilibrium corresponding to five distinct reactions. Representing, as usual, along the axes of the abscissæ the concentrations (X) of carbon monoxide within the mixture consisting of carbon monoxide and carbon dioxide (varying from 0 to 1), and along the axes of the ordinates the total pressures (P) of the above-mentioned gaseous mixture, the five curves are those represented in Fig. 3, and designated by the numerals 1, 2, 3, 4, and 5.

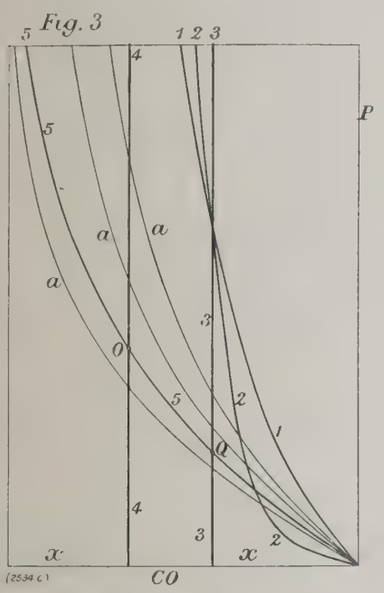
Let us recall here briefly the meaning and the equation of each of these curves:—

Curve 1.—Cubic hyperbola $\frac{x^2}{1-x} P = \mu$ (μ constant), corresponding to the conditions of equilibrium of the system (Fe_3C, Fe, CO, CO_2).

Curve 2.—$\frac{x^3}{(1-x)^4} . P = \theta$ (θ constant), corresponding to the conditions of equilibrium of the system (Fe_3C, Fe, CO, CO_2).

Curve 5.—$\frac{x^2}{1-x} . P = Z$ (Z constant), corresponding to the conditions of equilibrium of the system (C, CO, CO_2).

If, on the other hand, we work at a temperature higher than 700 deg. Cent., carbide of iron may yield solid solutions with iron, and in the diagrams of equilibrium must appear, alongside the five curves already enumerated, the curves of equilibrium of the systems resulting from the foregoing by the addition of the mixed crystals of iron-carbon to the above-mentioned constituents. To each coefficient of the concentration of carbon in the mixed crystals corresponds an equilibrium curve, the equation of which (in cases where the mixed crystals are present in sufficient quantity to prevent their concentration from varying appreciably with the variation—within certain limits—in the pressure of the gaseous mixture) is still that of a cubic hyperbola of the form



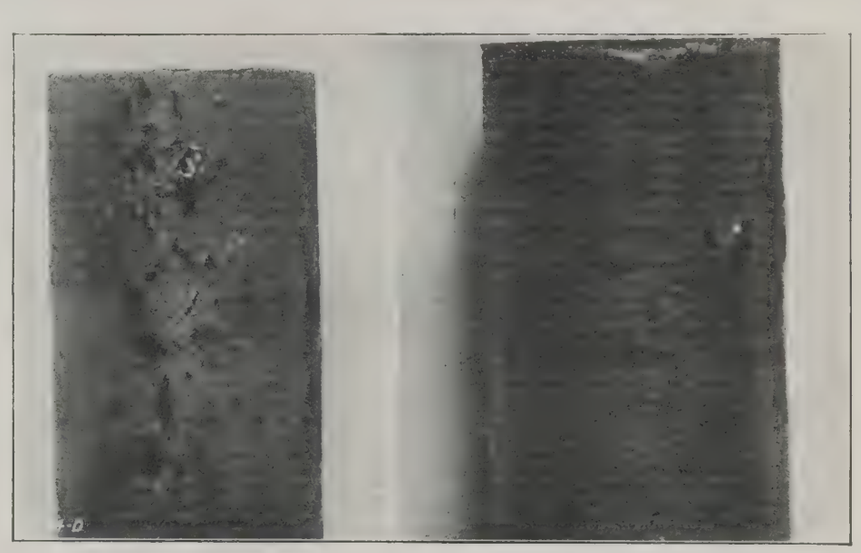


Fig. 4. Fig. 5.

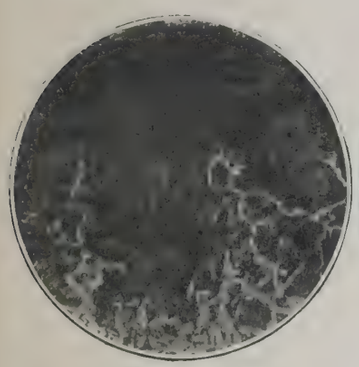


Fig. 6.

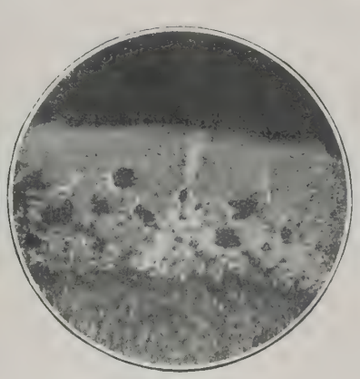


Fig. 7.

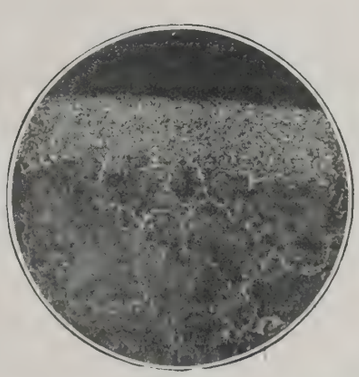


Fig. 8.

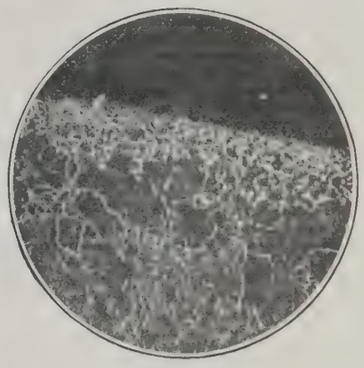


Fig. 9.

sufficiently concrete shape (though certainly not definite and far from complete) to the considerations which may be developed on the basis of Schenck's results, in order to elucidate the general laws which determine the process of the case-hardening of special steels, by means of those case-hardening mixtures the activity of which is due to the specific carburising action of carbon monoxide.

But, before examining from this standpoint our experimental results, it would seem necessary to refer briefly to certain physio-chemical laws connected with the action of carbon monoxide upon metals, in order to see how far these laws are applicable in the present instance.

If we consider the very complete diagram of isothermal equilibrium drawn up by Schenck,† in the case wherein the metal exposed to the action of carbon monoxide is iron alone, and at temperatures at which solid solutions (mixed crystals) of carbide of iron cannot be formed within the iron (that is, below 700 deg. Cent.), we

Fig. 10.

to the conditions of equilibrium of the system (Fe_3C, FeO, CO, CO_2).

Curve 3.—Straight line $\frac{x}{1-x} = \eta$ (η "constant of reduction"), corresponding to the conditions of equilibrium of the system (Fe, FeO, CO, CO_2).

Curve 4.—Straight line $\frac{x}{1-x} = k$ (k constant), corresponding to the conditions of equilibrium of the system (FeO, Fe_3O_4, CO, CO_2).

$\frac{x^2}{1-x} . P = V$; that is, analogous to the curve representing the systems (Fe, Fe_3C, CO, CO_2) and (C, CO, CO_2). Among all these cubic hyperbolas, constituting a sheaf or bundle, and all passing through the point ($x=1$, $P=0$),* there is one which presents especial interest from our point of view, wherein the process of case-hardening having been accomplished with the "mixed agent," all the reactions are invariably completed in the presence of a notable excess of free carbon ("granular" wood charcoal). This curve is that which corresponds to the special concentration of carbon in mixed crystals, whereby the constant V has (at equal temperatures) the same value as the constant Z of the equilibrium equation representing the system (C, CO, CO_2). It is obvious from all that we have stated that this curve coincides in its entire length with the equilibrium-isotherm of the system (C, CO, CO_2). If we assume that all the operations have been carried out with sufficient slowness to attain invariably the state of perfect equilibrium (this, as we know, never precisely happens in practice; but we may admit a sufficient approximation if we content ourselves with deducing from our argument conclusions of a qualitative nature), then the final concentration of carbon in mixed crystals will always be that which corresponds to a value of the constant V, equal to the perfectly well-defined value, which, at similar temperatures, is assumed by the constant Z, corresponding to the equation $2\,CO \rightleftarrows CO_2 + C$. We denote by Σ those mixed crystals wherein carbon has that well-defined concentration.

From what we have said above it may be inferred that,

so, too, in the case of chromium and manganese steels, for which it is neither necessary nor justifiable to admit that iron and manganese, or iron and chromium, behave as if they were isolated. Moreover, we shall see later on that it must be admitted that the behaviour of each of these (iron and manganese, or iron and chromium) is considerably modified by the presence of the other, with which it is united in the state of solid solution.

* See *Berichte der Deutschen Chemischen Gesellschaft*, 1903-7; also *Zeitschrift für Elektrochemie*, 1904.

† In the French edition of his "Physical Chemistry of the Metals" (translated by Lallement; Paris: Dunod and Pinat, 1911), Schenck has summarised with great lucidity the results of his most recent investigations concerning the matter with which we are now dealing.

* Some of these curves, marked *a*, have been reproduced in Fig. 3.

in the qualitative investigation of the reactions which take place during case-hardening by means of a case-hardening mixture based on the simultaneous action of carbon and the mixture of carbon dioxide and carbon monoxide in equilibrium therewith, we may eliminate all but one of the equilibrium curves corresponding to the various concentrations of carbon in mixed crystals.

In other words, in the instance of case-hardening carried out with our "mixed agent," the problem assumes the same simplicity as that which characterises it (as Schenck has demonstrated) when its investigation is limited to temperatures (lower than 700 deg. Cent.) at which true case-hardening does not take place, because the mixed crystals of iron and carbide of iron cannot form. We may, then, in a preliminary proximate study of the course followed by the phenomena in our experiments, confine ourselves to the consideration of the diagram built up of the first five curves.

Since in these experiments we have always started from gaseous systems rich in carbonic anhydride, operating in the presence of wood charcoal (to which form of carbon curve 5 of our diagram just applies), therefore in the event of no variations of temperature occurring, and on the supposition that conditions of metastability are excluded, the only portions of the diagram that should be taken into account are those on the left and below curve 5. We will begin with the examination of such a case. From the diagram it is immediately evident how the succession of phenomena varies fundamentally with the variation of pressure, and in this wise :—

(*a*) At pressures higher than that which corresponds to the point O* (intersection of curves 4 and 5), the formation of mixed Σ crystals and of magnetic oxide of iron takes place simultaneously in the presence of wood charcoal.

(*b*) At pressures ranging between that which corresponds to the aforesaid point O and that which corresponds to point Q (intersection of curves 3 and 5), there is simultaneous formation of protoxide of iron and of mixed Σ crystals, as before, in the presence of wood charcoal.

(*c*) At pressures lower than that which corresponds to point Q, the mixed Σ crystals alone form, as always, in the presence of wood charcoal.

Therefore, it is only at pressures lower than those which correspond to the point Q that the process of case-hardening with the "mixed agent" can take place independently—that is, unaccompanied by oxidation of the metal. Therefore, reasoning from what has already been said, we may foresee that, if the pressure of the gas is sufficiently raised in the case-hardening with the "mixed agent," phenomena analogous to those observed by Charpy in the case of chromium steels will also take place with pure iron or with the ordinary carbon steel.

This is abundantly confirmed by our Experiments I., II., III., and IV. (Table I.). In the first two of these the pressure (213 lb. per sq. in.) is lower than the pressure corresponding to the equilibrium point Q (for the temperature at which the case-hardening is completed) ; while in the last two the pressure (355 lb. per sq. in.) has a value higher than that which the ordinate of Q assumes at the temperature selected for the experiment (900 deg. to 1000 deg. Cent.). In point of fact, in the first two experiments the mere process of case-hardening is all that takes place ; whereas in the last two the process of case-hardening (formation of the mixed Σ crystals) is accompanied by considerable surface-oxidation of the metal.

The condition of the small case-hardened and oxidised cylinders of steel demands a little closer investigation. We refer more especially to the cylinder that has undergone case-hardening in Experiment III.

That cylinder is coated with a compact layer of oxide about 0.7 mm. thick, wherein the fragments of granular carbon which were in contact with the surface of the metal have remained firmly encrusted. The metal below the oxide layer is intensely carbonised.

This assemblage of facts, which at the first glance may appear curiously contradictory, is nevertheless perfectly explicable if we take into account the considerations already developed in this paper. It is illustrated by the three photographs (Figs. 4, 5, and Fig. 6, page 683), the first two of which show the external aspect of the two portions of the case-hardened and oxidised cylinder. In the first are seen the fragments of carbon embedded within the iron oxide ; while in the second the thickness of the oxide layer can be clearly seen at the point where it has been so split as to reveal the underlying metal. The third photograph represents, at a magnification of 65 diameters, a section (perpendicular to the axis of the cylinder) of the steel which immediately underlies the oxide layer. In this section, which has been cleansed with a 5 per cent. alcoholic solution of picric acid, it is plainly seen that the steel has undergone case-hardening, and that the concentration of the carbon attains, near the external surface of the carburised zone, a percentage of about 0.85.

Examination of the material which constitutes the external layer, easily detachable from the cylinder, shows it to consist of magnetic oxide of iron (Fe_3O_4), with which small quantities of carbon are intermixed.† It is, in fact, attracted energetically by a magnet. On analysis it is shown to contain 69.2 per cent. of iron ; the smaller percentage of the metal, as compared with that occurring in the pure peroxide (72.41), is evidently attributable to the presence of the occluded carbon.*

The position of the two points of invariant equilibrium, O and Q, whereof we may now appreciate the significance, varies concurrently with the variation in temperature and in composition of the steel which is subjected to cementation. Let us examine briefly the sequence of these variations.†

With regard to the changes in the two pressures of equilibrium that are assignable to variations in temperature, we may observe that the three curves 3, 4, and 5 (see diagram, Fig. 3), deviate all three towards the right when the temperature rises, in such wise that the variations in the ordinates of points O and Q depend on the relations between these deviations. These relations vary according to the composition of the steel, but generally they are such that the ordinates of points O and Q (minimum pressures of oxidation-cementation for each of the two degrees of oxidation) increase concurrently with rising temperature. Whence it follows that the higher the temperature of case-hardening the higher the pressure beyond which the oxidation which accompanies the case-hardening process begins to take place (in its two degrees). In other words, the higher the temperature the wider the range of pressures within which the case-hardening may be accomplished with the firm assurance that no oxidation of the metal will take place.

A comparison of the results of several of these experiments, taken two by two from among those carried out on identical steels, confirms this assertion,‡ and the same fact is again clearly demonstrated by the following experiment :—A small cylinder of ordinary soft steel, 60 cm. in length and 1 cm. in diameter, is subjected to case-hardening for about three hours in the accustomed apparatus and with the customary "case-hardening mixture," at a pressure of 15 kg. per sq. cm. Care is taken to embed it along its entire length in granular carbon. The temperature, maintained constant between 980 deg. and 1035 deg. Cent. over a belt of about 20 cm. near the median part of the cylinder, decreases gradually (in accordance with the structure of the apparatus which we have described) towards the two extremities, until it falls at the very ends to about 500 deg. Cent. The surface of the cylinder which is thus treated—case-hardening being unmistakable in all that portion where the temperature has exceeded 800 deg. Cent.—is absolutely unaltered in its central hottest part (which is also the most intensely case-hardened), while in those portions that have been subjected to a lower temperature the surface is coated with the characteristic layer of compact oxide in which are embedded the fragments of charcoal. Beneath the oxide layer the steel is still case-hardened, in all those portions, at least, where the temperature has exceeded 750 deg. to 800 deg. Cent.

The two pressures of equilibrium vary also, as we have already pointed out, concurrently with the variation in composition of the steel which is subjected to case-hardening. Since in this case curve 5 undergoes no deviation (for it must in every instance correspond to the conditions of equilibrium of the gaseous mixture and the wood charcoal), the displacement of points O and Q will be exclusively determined by the displacement of the two straight lines 3 and 4 (see diagram, Fig. 3). Now it is well known that these two straight lines deviate the more towards the left, the nobler the metal which is being subjected to the action of the gaseous mixture. And since the deviation of these lines carries with it the displacement of points O and Q, it follows that the nobler the metal the wider is the range of pressures (lower than those corresponding to point Q) within which we may conduct the cementation with the firm assurance that oxidation of the metal will not take place.

Among the metals which frequently alloy with iron and are capable of forming mixed crystals with it are manganese, chromium, and nickel. The first two (manganese and chromium) are less noble than iron; therefore, as their concentration in special steels increases, the temperature remaining unaltered, the two pressures O and Q (above which cementation is perforce accompanied by the two degrees of oxidation of the metal) become gradually lower and lower. For chromium steels a comparatively small proportion of chromium (from 2 to 3 per cent.) suffices to make the above-mentioned pressures, at temperatures which are not too high, decrease below ordinary atmospheric pressure. This explains the results recorded by Charpy, and demonstrates that they are by no means due to the fact that the gaseous mixture of carbon dioxide and carbon monoxide acts separately on the iron and on the chromium.

Nickel, when alloyed with steel, has an effect precisely contrary to that due to chromium and manganese, imparting to the solid solutions into which it enters with iron the character of a nobler metal than pure iron. Therefore, the higher the proportion of nickel in the steel subjected to case-hardening, the higher are the pressures which may be reached in case-hardening with the "mixed agent" without any risk of oxidation of the metal.

All these deductions are amply confirmed by the results of our experiments recorded in Table I.*

In special steels also the phenomena which we are considering produce effects analogous to those which we have described in the case of ordinary carbon steels. Thus, for example, the photomicrograph reproduced in Fig. 7, page 683, represents (at a magnification of 185 diameters) a strip of the external border of a plane section, perpendicular to the axis of the cylinder of chromium-nickel steel, case-hardened in Experiment XXIV.† Here also the case-hardened metal is coated with a layer of oxide, in which particles of carbon are embedded.

The photomicrographs reproduced in Figs. 8 and 9, page 683, taken under the same conditions as the foregoing, at magnifications of 65 diameters after elimination of the layer of oxide coating the cylinder, illustrate the intensity of case-hardening undergone by the chromium steels, which formed the object of Experiments XVIII. and XX., while at the same time these steels, as we already remarked in Table I., became considerably oxidised.‡

The same facts are noted in connection with nickel steels, when the operation is conducted at pressures sufficiently high to produce oxidation of the metal. This is well shown in the photomicrograph reproduced in Fig. 10, page 683 (Experiment VII.), taken under the customary conditions, and magnified 65 diameters. From all that we have said it is evident that the process of the case-hardening of special steels by means of the "mixed agent" is subject to the same conditions as those which attend the case-hardening of carbon steels. The differences for the various steels are purely quantitative, whether in regard (in accordance with what we have already said) to the pressures of oxidation, or in regard to the concentration of the mixed crystals in equilibrium, along curve 5, with the gaseous mixture ($CO + CO_2$) which in its turn is in equilibrium with the wood charcoal.

All the considerations developed in the foregoing pages remain valid until phenomena of metastable equilibrium cease to occur, and on condition that during each case-hardening operation the temperature is maintained constant. Now both the first condition (to which should be added the certainty that the low velocity of the various reactions shall not impede the attainment of the status of equilibrium) and the second are extremely difficult to realise in practice ; in fact, it may be said that they never are to be found in industrial practice. The consequence of the imperfect attainment of one of these conditions (and above all of the second), or of both, is the possibility that, during one or more of the phases of case-hardening, the point representing the system in which the reactions take place will be situated in a quadrant of the diagram, where it could not have arrived under the conditions of stable equilibrium. For instance, it is quite possible that, as a result of fall in temperature, the above-mentioned representative point will be found in the right-hand quadrant and above curve 5 (see diagram, Fig. 3). In such a case reactions different from those which we have been so far considering may occur ; as, for example, the decomposition of carbon monoxide, accompanied by the liberation of pulverulent carbon.§ Moreover, the representative point may meet one of the curves 1 and 2 (the significance of which has already been indicated), and these, in their turn, may undergo considerable deviations in consequence of changes in temperature. In this last case the reactions which may take place are much more complex.‖

Before concluding this note, we desire to draw attention to the fact that, from the considerations set forth in the foregoing pages, many useful practical axioms may be deduced for the purpose of carrying out, on a well-reasoned basis, the case-hardening of special steels with the "mixed agent." In proof of which we may merely cite one example : the case-hardening of steels with rather high percentages of chromium (more than 4 or 5 per cent.) with "mixed cement" at a temperature not higher than 1000 deg. Cent. (a limit which in many cases cannot be exceeded) is accompanied by considerable oxidation of the metal, even when the process is conducted at the ordinary atmospheric pressure. Now the results of our experiments, and the considerations developed in the foregoing pages, suggest immediately a method of avoiding this oxidation ; it will suffice, indeed, to reduce the pressure of the carburising gaseous mixture ($CO+CO_2$) below the minimum pressure of oxidation (Q) characteristic of the particular metal at the temperature at which it is being case-hardened. This can be in many cases easily accomplished by "diluting" with air (according to the rules indicated by us in previous papers)

* It should be noted that in our experiments the pressure is kept constant during the entire operation, from the moment of the arrival of the fresh gas in the apparatus. For, if the quantity of gas were limited, it is well known that the initial minimum pressure of the carbonic anhydride, at which the formation of the magnetic oxide takes place, would be lower than the pressure corresponding to point O.

† While it is easy to separate the oxide from fairly large fragments of wood charcoal, it is impossible to separate it from the pulverulent carbon (or charcoal dust) which is invariably mixed therewith.

* It is not improbable that a little ferric oxide also has been formed, as a consequence of some oscillation of temperature which may have lowered for a time the pressure of oxidation to Fe_2O_3 below the pressure at which the experiment was conducted.

† From the practical point of view the only one of these two points that presents real interest is the lower (Q). since to it corresponds the minimum pressure at which the oxidation of the metal to ferrous oxide (FeO) begins to take place. The second point O corresponds simply to a change in the "degree of oxidation" of the metal—in the sense that, at pressures higher than that corresponding to it, the stable oxide is no longer the ferrous oxide (FeO), but the magnetic oxide (Fe_3O_4). It is plain how, from the practical standpoint (in the present state of our knowledge, at all events), this change fails to present any particular interest.

‡ Thus, for example, the results of Experiment VII. may be compared with those of Experiment VIII. (and let it be borne in mind that in the latter the velocity of the gaseous current is double what it is in the former).

* Compare, for instance, Experiment VI. with XVIII., XI. with XV., XVI. with XXIV., &c.

† Etched by an alcoholic 5 per cent. solution of picric acid.

‡ We shall have occasion ere long to deal in another paper with the causes of the special distribution of carbon within these case-hardened steels (in which, as we have seen, the carbon tends more particularly to accumulate towards the surface).

§ The appearance of this new form of free carbon produces a displacement of curve 5.

‖ We propose to deal with these reactions ere long, in connection with certain special cases.

the carbon dioxide which is circulating through the mass of granular carbon. In this way the carburising gaseous mixture acts under partly reduced pressure, since it is "diluted" by the nitrogen of the atmosphere.

Experience has abundantly confirmed the efficacy of this method.

HAMBURG AND ANGLO-AMERICAN NILE COMPANY.—This company, whose London offices are 72, Regent-street, W., have issued their programme and time-table of pleasure trips on the Nile for the season 1911-1912. A large number of different tours have been provided for, the fares for which are quoted in detail.

ENGINEERING AND COMMERCIAL CONDITIONS AND PROBLEMS IN LATIN AMERICA.—An address having the above title was recently delivered before the Thursday Morning Club, of Great Barrington, Mass., U.S.A., by Mr. Elmer L. Corthell, D.Sc, civil engineer. After referring briefly to the geological formation and to the history of Central and South America, Mr. Corthell gave interesting statistical data showing the development of the principal States—Mexico, Brazil, Argentina, Chili, &c. In regard to the Panama Canal, he said that this would no doubt be ready for operation at the time stated —January 1, 1915. The Panama Canal will revolutionise the steam commerce of the world in the same way as the Suez Canal did in its time; it would further be of immense advantage by lowering the cost of transportation, especially if the tolls were at the outset fixed at 1 dol. per registered ton. In all likelihood the steamship lines of Great Britain, Germany, and Japan would have secondary lines as feeders at both termini—Colon and Panama. The region reviewed by the lecturer was undoubtedly one of the richest parts of the earth's surface; it was capable of absorbing many millions of people and of becoming a very great field of production and industry.

INTERNATIONAL ROAD CONGRESS, LONDON, 1913.—A meeting of the representative General Committee that has been formed to undertake the organisation of the International Road Congress, to be held in London in 1913, was recently held at the offices of the Road Board. Sir George S. Gibb presided. There was a large attendance of the members of the General Committee representing the various associations of local highway authorities, automobile, cycling and touring clubs, technical institutions, &c., interested in the improvement of the roads. M. Mahieu and M. le Gavrian, of Paris (the Secretary-General and Assistant-Secretary of the International Association of Road Congresses) were also present. A memorandum submitted by the Chairman dealing with the general question of organisation was considered, and generally approved. An Executive Committee was appointed as follows:—Sir George S. Gibb, Chairman; Lord Montagu of Beaulieu, Mr. W. Joynson Hicks, M.P., Mr. F. H. Berryman (County Councils' Association), Vice-Chairmen; Sir Charles D. Rose, Bart., M.P., Treasurer; and Messrs. J. A. Brodie, M. Inst. C.E.; H. P. Boulnois, M. Inst. C.E.; Dugald Clerk, F.R.S.; E. Manville, M. Inst. C.E.; M. Fitzmaurice, C.M.G.; E. Shrapnell Smith; John Kennedy, J.P., D.L.; S. Williams; H. P. Maybury, M. Inst. C.E.; and Colonel R. E. Crompton, C.B. Mr. W. Rees Jeffreys was elected Hon. General Secretary of the Congress, and Mr. G. Montagu Harris Hon. Deputy General Secretary. It was decided to prepare and issue at an early date a circular to the bodies and persons interested in the forthcoming congress.

THE LEWISHAM TRAMCAR ACCIDENT.—The report of the Board of Trade on the accident in which a tramcar overturned on a curve at Lewisham, on September 4, has been issued. The inquiry into this accident was conducted by Lieut.-Colonel P. G. von Donop. At the place where the derailment occurred, the line is on a falling gradient of 1 in 22, this having been preceded by a stretch of 45 yards on a 1 in 49 grade. At the centre of the stretch of the 30 yards of 1 in 22 grade, it is stated that on examination the line was found to be actually 1 in 16. The curve is one of 62½ ft. radius, and ⅝ in. superelevation is given to the outer rail. The car was in good condition, and the brakes (hand and Westinghouse magnetic) were found in working order after the accident. Evidence given at the inquiry tended to show that sand filled the grooves of the rails before the car passed over the curve at about this spot, but, on the other hand, there was evidence to the effect that the quantity of sand was small, and that it was soft and not hard packed, so that the suggestion that the accident was due to this was dismissed by the inspector. The car does not appear to have been travelling at a speed of more than 7 or 8 miles an hour after leaving the previous stopping-place, but instead of coming to a stop before passing round the curve, and proceeding over it at not more than 4 miles an hour, the practice has been apparently for the cars to be run rather further than the beginning of the curve before pulling up. On this occasion the man in charge was a learner, the regular driver being also, of course, on the platform. The car did not stop at the accustomed place. The magnetic brake handle had been placed in the third notch, but the brakes did not go on. Subsequent experiments show that the speed at which the third notch would be effective was 7.6 miles per hour. Thereupon the regular driver took charge, and not only put the handle round to the fifth notch, but applied the hand-brakes. This sudden application of both brakes appears to have jerked the car, so that the wheels left the rails, and the live load was thrown towards the outside of the car, which, after running on the off wheels for some distance, finally turned over.

FOREIGN ENGINEERING PROJECTS.

WE give below a number of foreign engineering projects, further particulars concerning which can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C.

Spain: The *Gaceta* notifies that the Compañía de los Ferrocarriles Suburbanos de Málaga has applied to the Ministry of Fomento for a concession for the construction and working of a secondary railway from Periana to Alhama.

Brazil: The *Diario Official* publishes a decree (No. 9031) opening, in favour of the Ministry of Communications and Public Works, a credit of 400,000 milreis (about 27,000*l.*) to meet expenses in connection with the surveying operations for the extension of the Central Railway of Brazil as far as Belém, State of Pará.

Argentina: The *Boletin Oficial* publishes a decree approving the plans and specifications prepared by Messrs. Quesada Hermanos for the construction of a tramway from Buenos Aires to the Partido de Luján.

Uruguay: The *Diario Oficial* notifies that the Ministry of Public Works has approved the plans and specifications prepared by Messrs. Félix Allard, Abel Couvreux, Julio Dollfus, Juan Sillard, and Luis Wiriot, for the carrying out of water and drainage works at Punta del Este.

Peru: H.M. Minister at Lima reports that surveys have been made and plans drawn up for the carrying out of irrigation works in the valley of Chicama. Owing to the insufficiency of private capital to carry out works on so large a scale, it is proposed to guarantee the interest on the invested capital to those undertaking the works. Plans are now to be prepared for irrigation schemes on the coasts of the Republic. *El Peruano* contains a notice, issued by the Directorate of Irrigation and Agriculture, granting to Don Luis Luccione permission to carry out surveying operations with a view to irrigating the lands which form the "Pampa de Camarones."

THE COPPER MARKET.—In their monthly report, Messrs. James Lewis and Son state that the variations in the price of Standard copper during the past month have extended over a range of 1*l.* 16s. 3d. per ton. Opening at 55*l.* cash, Standard fell to 54*l.* 6s. 3d. on the 11th ult., influenced by unfavourable American statistics; but the large reduction in the English and French stocks announced on the 16th ult., partly due to considerable exports of standard to Italy, and extensive purchases of three months prompt against sales of manufactured copper and sulphate of copper for forward delivery, advanced the market to 56*l.* 2s. 6d. cash and 56*l.* 17s. 6d. three months on the 23rd ult. In sympathy with a serious fall in industrial securities on the New York Stock Exchange, and the decision of the United States Government to prosecute the Steel Corporation, values declined to 55*l.* 5s. and 56*l.* respectively on the 27th ult. They had since recovered to 55*l.* 12s. 6d. and 56*l.* 6s. 3d., on the further material reduction in European stocks and an expected improvement in the American statistical position at the end of the month. The total sales amounted to about 24,000 tons. An exceptionally large business took place in manufactured copper towards the end of October, English railway companies and other consumers making extensive purchases. Advantage was taken of the reduced price at which American electrolytic was obtainable—down to 56*l.* 10s. c.i.f.—by manufacturers to replenish their stocks and to buy against their sales, and large quantities of refined and other copper were sold by American producers, including the Amalgamated Company, to English and Continental, as well as American, consumers, the quotation for electrolytic being raised to 58*l.* per ton c.i.f. and 12½ cents per pound in New York.

FIREPROOFING BUILDINGS.—America has always been regarded as a country of great fires, and it is therefore not unnatural that of late years, at any rate, there should have been a distinct movement towards the adoption of more efficient means of prevention than have for a long time existed. Vast sums have been spent in bringing to perfection fire-fighting appliances, while at the same time buildings of low fire-resisting properties have been erected, and correspondingly high rates of insurance paid. That the country is awakening to the importance of the fact that more stringent efforts must be made in order to secure buildings that are as fire-resisting as it is possible, under our present knowledge, to make them, is supported by the fact that a paper on the subject was recently read before the Concrete Institute, in Westminster, by Mr. Richard L. Humphrey, of Philadelphia, president of the National Association of Cement-Users. In this paper there is, however, little that was not already known in this country, although it is satisfactory to have methods that we ourselves have faith in confirmed, and in many cases these beliefs are confirmed. Mr. Humphrey points out that stone is an undesirable material on the whole to use as a fire-resisting material; but he mentions an interesting point in connection with granite, which stone can, he says, be quarried so as to offer almost 100 per cent. greater resistance to fire in one direction than it does in the other. If stone is used, it should, the author maintains, be fireproofed just in the same way as steel, which latter is, of course, useless in case of fire without adequate protection. Tiles as protection are often unreliable, being liable to crack. Plastered metal fabrics placed round columns have proved in many cases of little good, and something more substantial is required, and terra cotta flakes off on account of expansion. An important point also is the efficient protection of roof trusses. The faith of Mr. Humphrey appears, however, on the whole, to rest on reinforced concrete, as the material that will play a most important part in the fireproof construction in the future, and in this he is probably right.

CATALOGUES.

Electric Telphers.—We have received from Messrs. Strachan and Henshaw, Limited, of Bristol, leaflets illustrating and giving a few particulars of their electric telphers. Several of the installations shown are in gas works, where the telphers are used for conveying hot coke from the retort-house to the quenching-tank, and thence to the storage yard.

Grinding Wheels and Machines.—An abridged catalogue of grinding wheels and machines has been issued by Messrs. B. R. Rowland and Co., Limited, Climax Works, Reddish, Manchester. The catalogue contains a price-list of grinding wheels, which are manufactured in a full range of grades and grits for all requirements. Particulars are also given of the more generally used types of grinding machines, including bench grinders, universal floor grinders, tool grinders, twist-drill grinders, &c.

Hauling and Winding Plant.—Messrs. H. Mackay and Co., 4, Southampton-row, W.C., who have recently been appointed sole selling agents for the London district, for the Falcon Iron Works, Limited, of Oldham, have sent us two pamphlets illustrating some of the latter firm's productions, which include steam and electrically-driven hauling and winding gears of all sizes. Friction-clutches, an automatic device for greasing mine-tub axles, and a clip for wire-rope haulage are also illustrated.

Small Tools.—We have received from Messrs. George W. Goodchild and Partner, 30 and 32, Farringdon-road, E.C., a catalogue of small tools manufactured by Messrs. Ludw. Loewe and Co., A.-G., of Berlin. The book, which is well printed and fully illustrated, contains 240 pages, bound in limp cloth covers. It gives full particulars, with prices, of chucks, arbors, machine-vices, milling-cutters, reamers, taps and dies, threading-tools, chasers, limit-gauges, snap-gauges, screw-thread gauges, and standard machine parts, such as geared pumps, &c. An efficient index is provided to facilitate reference.

Mortising-Machines.—The Carron Company, of Carron, Stirlingshire, N.B., have issued a catalogue which deals principally with hand-power mortising-machines. Several patterns are illustrated, and a specification of each is given. Some of these machines are fitted with a boring spindle parallel to the mortising chisel, so that, when working on hard wood, a hole can be bored before the chisel is used. One machine, fitted with a special vice and dividing-plate, is intended to be used for mortising wheel naves. This catalogue also illustrates a circular saw-bench, and gives some particulars of "drunken" saws for cutting slots.

Steel Plates and Sections.—From the Consett Iron Company, Limited, of Consett, Co. Durham, we have received a little booklet giving particulars of their productions. The maximum dimensions to which steel plates and chequered plates are rolled are given, and the sizes of angles, bulb-angles, zed-bars, channels, flats, rounds, and other sections are also stated. The booklet also contains particulars of various tests of material for shipbuilding and boiler-making, as well as numerous useful tables. This company also supplies coal and coke, pig iron, steel scrap, firebricks, fireclay, sulphate of ammonia, tar, and other by-products.

STAYING THE END-PLATES OF LANCASHIRE BOILERS.

By J. F. L. CROSLAND, Chief Engineer of the Vulcan Boiler and General Insurance Company, Limited, Manchester.

ALL steam-generators, after some years of service, tend to develop defects, the nature of which varies with the type of generator and the conditions under which it has worked, and in the case of the Lancashire type of boiler one of the commonest defects met with is that known as "grooving."

"Grooving" is primarily a mechanical defect caused by severe localised bending strains of such intensity that the surfaces of the affected plates are stressed beyond the elastic limit of the material. The repeated application of such strains tends to break down the structure of the metal, opening out the outer fibres when in tension and crushing them when in compression, with the result that cracks appear on the surface of the plate, and in time extend into the metal until it fractures through.

The parts of a boiler most liable to such action are those which, under working conditions, have a movement relative to each other, and in the case of Lancashire boilers the expansive movement of the furnaces relative to that of the shell is the principal cause of grooving at the front end plate, and in the roots of the front end flanges or angles of the furnaces.

From gaugings taken at the ends of a number of Lancashire boilers, it has been found that when steam is being raised from comparatively cold water, the longitudinal expansion of the furnaces may be as much as $\frac{5}{16}$ in. greater than that of the shell, and the tabulated results of the gaugings given herewith may be taken as showing the behaviour of a boiler when steam is being raised under average conditions after a week-end stoppage for cleaning. Even after a boiler has been working for some time under normal conditions, and the shell bottom has attained its usual temperature, the difference in the furnace and shell expansive movement may remain at as much as ¼ in.; but this amount will, of course, greatly depend on the system of firing employed.

If the working conditions are such that the furnace-plates are liable to be heated to abnormal temperatures, due to a heavy deposit of scale or oily matter on the water side, or to the use of a system of firing by which a high furnace temperature is attained, or by a combination

of these conditions, the expansion of the furnaces must necessarily be greater than the amount given above; and if no provision is made for the absorption of this extra movement, the front end-plate and its stays, and also the furnace flanges, will be subjected to very severe strains, and grooving will develop very rapidly If in addition to

Fig. 1.

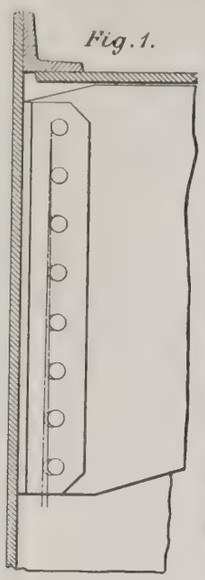


Fig. 3.

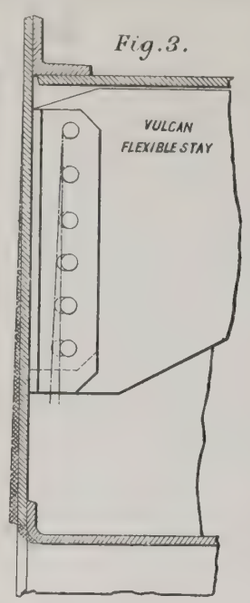


Fig. 2.

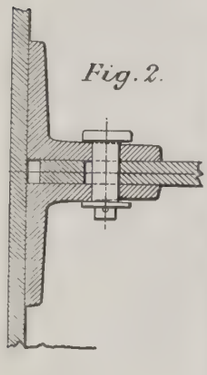
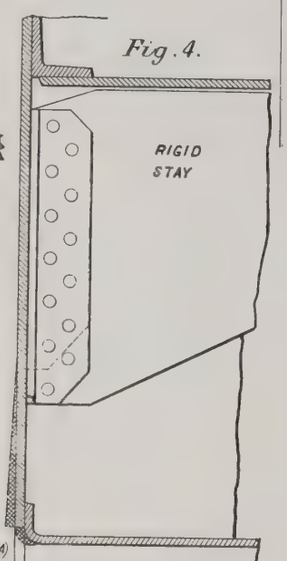


Fig. 4.



(2554.A)

the foregoing the feed-water is of a corrosive nature, the combination of mechanical and chemical actions will result in even more rapid development of grooving.

When working pressures were low, and boiler diameters did not generally exceed 7 ft. 6 in., it was possible to use comparatively thin plates in boiler construction; and as such plates were less rigid than the thicker plates now necessary in modern high-pressure boilers, bending stresses due to the expansive movement of the furnace were not so severe or localised, and consequently grooving did not develop so rapidly.

It is necessary, if grooving action is to be minimised, that some portion or portions of the boiler should be made sufficiently flexible to absorb this expansive movement of the furnaces; and with this object in view boiler designers have from time to time modified the design of front end-plates, furnaces, and staying, and the general trend has been in the direction of greater breathing space between the stays and the furnace crowns, or to the design of furnaces with a view to longitudinal elasticity. Many of these devices, however, have not been successful, and in some cases they have only transferred the trouble from one part of the boiler to another.

For some considerable time the Vulcan Boiler and General Insurance Company, Limited, have had before them this problem of prevention of grooving, and a description of an improved system of staying patented by them will be of interest to steam-users. The Vulcan patent flexible stay, as shown in Figs. 1 and 2, is a modification of the ordinary rigid gusset-stay, consisting of the usual double angles riveted to the shell and front end-plate. The gusset web-plate is rigidly riveted to the angles on the shell, but turned bolts are substituted for the rivets generally used for the attachment of this web-plate to the angles on the front end-plate. The bolt-holes in the gusset-plate are elongated, and permit a certain amount of end-plate movement before the stay takes any load.

It will be seen that by varying the elongation of the bolt-holes it is possible to design the staying so that the end-plate is free to move through any predetermined distance, and it is possible by this system to distribute the load evenly over all the bolts, instead of practically the entire load coming on the toe-rivets only, as is the case in the customary system of rigid staying. When the conditions of working are severe, such an arrangement of staying is of great value in reducing the strains that tend to cause grooving action or leakage from the rivets and seams at the front end.

When the Vulcan system of flexible staying is fitted, the shape assumed by the end-plate under working conditions is that shown by the shaded area, Fig. 3; and it will be seen that the deflection due to the furnace expansive movement and internal steam pressure is not localised, but is distributed over that portion of the end-plate situated between the furnace-crowns and the outer circumferential riveting by which the plate is attached to the shell, and the angle through which the plate is bent due to this movement is comparatively small, and severe local stresses are thereby avoided.

With a rigid system of staying, as shown in Fig. 4, it will be seen that practically all the movement due to furnace expansion &c., has to be taken up by the front end-flanges of the furnaces and a strip of plate, usually 10 in. to 11 in. wide, situated between the crowns of the furnaces and the bottom or toe-rivets in the attachment of the gusset-angles to the end plates. It will be seen from the shaded area, Fig. 4, that the angles through which the furnace flanges and end-plate are bent are very much greater than is the case when the Vulcan flexible system of staying is fitted, and the stresses at these parts must necessarily be much more severe, resulting in fracture of the end-plate, gusset-angles, or rivets, in some cases after only a comparatively short period of service.

The Vulcan patent flexible system of staying has been fitted to a number of large modern high-pressure boilers, some of which were originally fitted with the ordinary rigid stays, and several of these boilers have been working for a considerable time with satisfactory results. With the boilers so fitted there has been an absence of the troublesome leakages so often seen from gusset and furnace-mouth riveting at the front end, and this in itself would point to a reduction in the severe strains at these parts, and the internal condition of the boilers after a period of service confirms this.

As the behaviour of this system of staying under varying conditions of stress will be of interest to steam users, a table is given showing deflections at different parts of the front end-plate of a high-pressure boiler under hydraulic-pressure tests, and when raising steam from comparatively cold water. These results are also shown in diagram form in Figs. 6 and 7.

Table of Deflections at Front End of Boiler 8 Ft. in Diameter. Working Pressure, 160 Lb. Front End-Plate $\frac{3}{4}$ In. Thick. Gusset-Angles 6 In. by 5 In. by $\frac{1}{16}$ In. Bolts $1\frac{3}{8}$ In. in Diameter.

Pressure by Gauge.	Deflection at Bottom of Gusset Stays. (See Fig. 5.) Left Wing.	Left Intermediate.	Centre.	Right Intermediate.	Right Wing.	Deflection Around Furnaces. (See Fig. 5.) Left-Hand Side of Left-Hand Furnace.	Top Centre of Left Hand Furnace.	Between Furnaces at Centre.	Top Centre of Right-Hand Furnace.	Right-Hand Side of Right-Hand Furnace.	Bottom Centre of Left-Hand Furnace.	Bottom Centre of Right-Hand Furnace.
Hydraulic test:	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
160	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$
260	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$
Steam test:												
Atmospheric pressure	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{1}{32}$	0	$\frac{3}{32}$	0	$\frac{3}{32}$	0	$\frac{3}{32}$	$\frac{3}{32}$
20	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{1}{32}$	$\frac{1}{32}$	$\frac{3}{32}$	$\frac{1}{32}$	$\frac{3}{32}$	$\frac{1}{32}$	$\frac{3}{32}$	$\frac{3}{32}$
40	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$
60	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$
80	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$
100	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$
120-140	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$
160	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$

Fires light. Dampers open 3 in. to 6 in.

Fig. 5. DEFLECTIONS MEASURED ON FRONT END PLATE AT POINTS INDICATED ON SKETCH

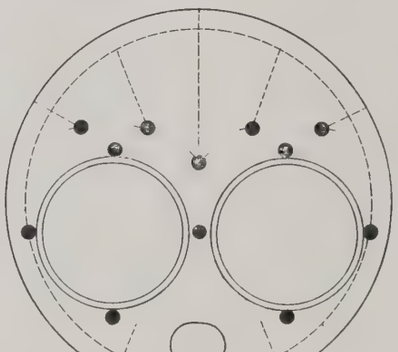


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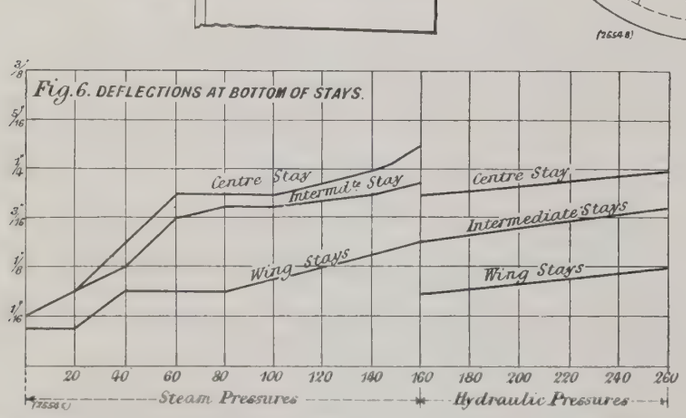
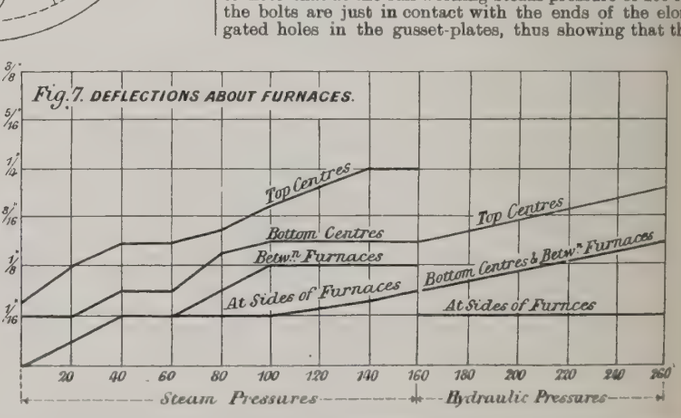
Fig. 6. DEFLECTIONS AT BOTTOM OF STAYS.



(2554.C)

Fig. 7. DEFLECTIONS ABOUT FURNACES.



Royal Institution.—The eighty-sixth Christmas course of juvenile lectures, founded at the Royal Institution in 1826, by Michael Faraday, will be delivered this year by Dr. P. Chalmers Mitchell, D.Sc., LL.D., F.R.S., Secretary of the Zoological Society, his subject being "The Childhood of Animals." The lectures will be delivered on the following dates, at 3 o'clock: Thursday, December 28, December 30, 1911, January 2, 4, 6, and 9, 1912.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

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ELECTRICAL APPARATUS.

26,009/10. M. J. Railing and C. C. Garrard, Birmingham. Electric Switches. [4 *Figs.*] November 9, 1910.—This invention has reference to an electric switch which gives a quick break on opening the circuit, holds the contacts securely open whatever may be the mounted position of the switch, and retains the contacts firmly together when in the closed position. The invention is carried into effect by mounting on the spindle A a crank B, on which is pivoted a link C, to the free end of which is attached one end of a spring D the other end of the spring being anchored at E. The spindle A also carries blocks F, upon which are mounted the contact-blades G. The arrangement of the crank B, link C, and spring D is such that when the switch is closed, the pull of the spring acts along a line which joins the centres of the spindle, crank, and anchorage of the spring, or, rather, along a line which approximates thereto, so that the switch-blades, besides being held by the friction of the contact clips, are locked in the "on" position by reason of the crank being

Fig. 1.

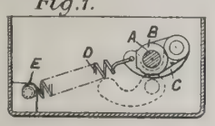
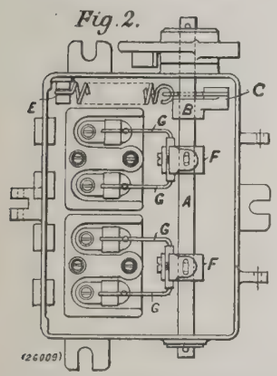
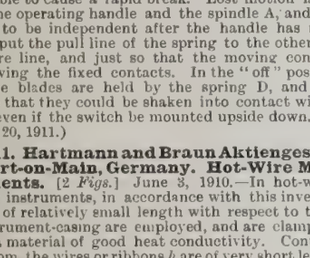


Fig. 2.



just beyond the dead centre, and consequently the force of the spring does not tend to pull the blades out of the contact clips. The crank B may, if preferred, be arranged to take the end of the spring D well over the dead centre when switching on, so as to emphasise the locking action. In opening the switch, the force of the spring D is made to act in the other direction, past the dead centre line, before the blades leave the contact clips, and is therefore available to cause a rapid break. Lost motion is permitted between the operating handle and the spindle A, and this allows the break to be independent after the handle has moved sufficiently to put the pull line of the spring to the other side of the dead centre line, and just so that the moving contacts G are nearly leaving the fixed contacts. In the "off" position of the switch, the blades are held by the spring D, and it is quite impossible that they could be shaken into contact with the fixed contacts, even if the switch be mounted upside down. (*Accepted September* 20, 1911.)

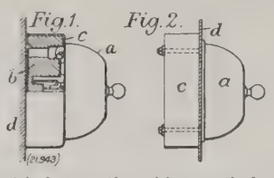
10,056/11. Hartmann and Braun Aktiengesellschaft, Frankfort-on-Main, Germany. Hot-Wire Measuring Instruments. [2 *Figs.*] June 3, 1910.—In hot-wire electric measuring instruments, in accordance with this invention, wires or ribbons of relatively small length with respect to the diameter of the instrument-casing are employed, and are clamped between blocks of a material of good heat conductivity. Contrary to the usual custom, the wires or ribbons *h* are of very short length, but by



reason, nevertheless, of the considerable heating produced in the wire, the elongation of this short piece can be used for the movement of the pointer with sufficient accuracy. The heat produced is, indeed, of such a character that clamping devices of comparatively small metal masses have not proved suitable, since they were not able to radiate the excessive heat with sufficient rapidity. This inconvenience is obviated by using stout blocks *k*, composed of material of good heat conductivity, as, for instance, iron. These blocks may be either cubical, or, if a symmetrical arrangement of the hot-wires or ribbons be preferred, cylindrical, the ribbons being distributed at equal intervals over the cylinder surface. Such blocks offer the further advantage that the clamping device can be made extremely strong and irremovable. (*Accepted Sept.* 27, 1911.)

21,943/10. A. F. Berry, Ealing. Switches. [6 *Figs.*] September 21, 1910.—This invention relates to tumbler switches, in which the metal cover presents a hard and relatively thin edge to the base or body carrying the live parts of the switch, or to which the switch is applied, and it has for its object to combine with such cover and base or body, packing means of a metal softer than that of the cover which is thereby earthed. Fig. 1 is a view partly in elevation and partly in section of a tumbler switch, where *a* is the metal cover, *b* the switch base, and *c* the packing means consisting of a flanged soft-metal sheath adapted to place

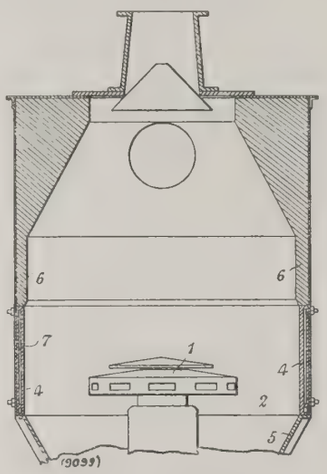
Fig. 1. *Fig. 2.*



the cover in electrical connection with an earthed metal base *d*, the cover then becoming slightly embedded in the soft-metal sheath *c*, as shown in section in the upper part of the figure. Fig. 2 illustrates a modified arrangement in which the switch base is secured to the interior of the earthed metal base *d*, and the switch cover *a* placed on the exterior of the metal base, the latter being suitably cut away for the electrical contacts and lever or tumbler of the switch. In this arrangement a ring of soft metal is placed between the metal base *d* and the switch cover *a*. (*Accepted September* 27, 1911.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

9099/11. A. Wilson, Doxey. Gas-Producers. [2 *Figs.*] April 12, 1911.—In gas-producers fitted with central tuyeres or grates through which the blast is admitted to the fuel, and having between the central grate or tuyere and the internal surface of the producer wall a space through which the ash has to descend on its way to the base of the producer, the lower portions of the producer walls, and more particularly those portions that surround the central grate or tuyere, are, according to this invention, composed of hollow segmental metal bodies through which liquid or air can be passed at a rate sufficiently rapid to



keep them cool enough to prevent clinker from adhering thereto. 1 is the central tuyere surrounded by an annular space 2, bounded by the lower portion of the producer wall. This portion of the wall is composed of vertical segmental castings 4, having gas-tight connection with the base 5 and upper brickwork portion 6, and in each casting there is cored out a cavity 7 provided with an inlet and outlet for cooling fluid. The external surfaces of the segments 4 may be in contact with a metal sheathing exposed to the atmosphere; but the brickwork 6 may extend downwardly and enclose them, the segments then forming a lining within the brickwork. (*Accepted Sept.* 20, 1911.)

23,983/10. B. S. Roberts and F. S. Roberts, Wolverhampton. Internal-Combustion Engines. [15 *Figs.*] October 17, 1910.—According to this invention, an internal-combustion engine is provided with a piston comprising a reciprocating sleeve, a reciprocating inner member having passages for the inlet and exhaust gases leading into the combustion-chamber, co-operating inlet and exhaust-passages in the sleeve adapted also to co-operate with inlet and exhaust-ports in the lower part of the cylinder, a connecting-rod for coupling the sleeve to the crank-pin, a connecting-rod for coupling the inner piston member to an eccentric or cam upon the crank-pin, and epicyclic gearing for rotating the eccentric or cam in order to impart the necessary relative movement to the piston members for placing the inlet and exhaust-passages thereof in communication with the inlet and exhaust-ports at the necessary times. The piston comprises two parts 1, 2, the former consisting of a closed crown portion or piston proper, which fits and works within the main bore of the cylinder 3, whilst the second part 2 consists of a sleeve member which also fits the main bore of the cylinder, and which surrounds, and can slide over, a reduced inner end of the part 1. The latter is guided by an extension 4 of its inner end working within an annular recess 5 upon the inner face of the sleeve 2. This sleeve is coupled up with the engine crank-pin 6 by a connecting-rod 7, whilst the piston proper 1 is coupled, by another connecting-rod 8, with the encircling strap of an eccentric 10 fixed upon the crank-pin, the rod 8 being rigid with the strap. The big end of the connecting-rod 7 is preferably forked, and embraces the opposite sides of the eccentric, the two branches running upon concentric hollow bearing-bosses which extend inwards from the crank-webs. The crank-pin 6 carries upon its end a spur-wheel 13 which meshes with a fixed central sun-pinion 14 carried by the stationary frame. The spur-wheel 13 is of double the diameter of the sun-pinion, so that the epicyclic gearing causes the eccentric to make one and a half revolutions for each revolution of the crank, thereby giving the necessary relative sliding movements to the two parts of the piston. The inlet and exhaust ports 19, 20 respectively are formed in the cylinder walls at opposite sides, near the lower end. The exhaust port is a little higher than the inlet port. Formed in the outer walls of the sleeve 2, on the side adjacent to the inlet port, is a longitudinal channel 21, which, at its upper end, runs into a transverse passage 22 formed through the walls of the sleeve, the passage being situated a short distance from the upper end of the latter. When the piston commences its suction stroke, or shortly after the commencement of the stroke (Fig. 1), the lower end of the channel 21 in the sleeve comes opposite to the inlet port 19, and the passage 22 is opposite to a passage 23 directed through the walls of the main power piston 1 so as to lead into the combustion space. The latter is thus placed in direct communication with the inlet port. As the suction stroke takes place, the longitudinal channel 21 continues to move past the inlet port 19, and the two parts of the piston remain in fixed relationship to one another, so as to allow of the mixture being drawn into the cylinder until the piston approaches the end of its stroke, when the main portion 1 commences to move at a faster rate than the sleeve, and soon the through communication between the passage 23 in the piston and the passage 22 in the sleeve is cut off, whilst also the sleeve passage moves past the inle tport. In order, however, to maintain a continuous suction right to the end of the stroke, another passage 24 is formed through the walls of the sleeve just above, but independent of, the passage 22. As soon as the principal passage 21, 22 has moved past the port 19, then the auxiliary passage 24 moves opposite the latter, and also registers with a second passage 25 through the power piston, thereby still maintaining the through communication between the combustion

Fig. 1.

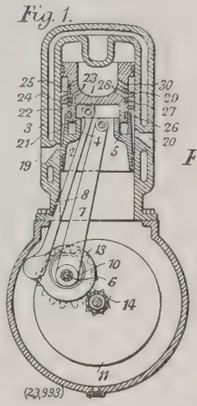
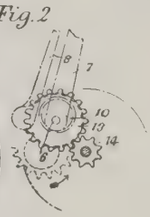


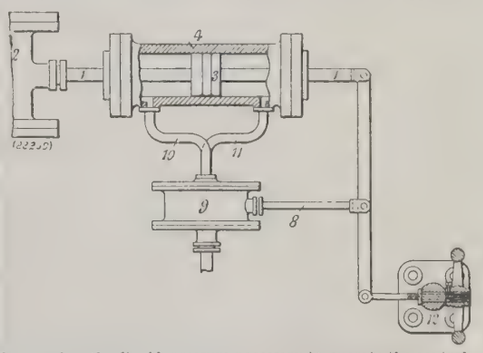
Fig. 2



space and the inlet port. By the time the stroke is completed the continued relative motion of the main piston member will have caused the auxiliary passages 24, 25 of the two parts of the piston to have moved out of register with one another, thus cutting off the admission of the charge. During the compression stroke the ports and passages remain closed, as do also the exhaust ports and passages to be described. For the first portion of this return stroke the two members of the piston move upwards together, but for the remainder of the stroke the main piston rises quicker than the sleeve. On the exhaust side of this sleeve is a longitudinal passage 26 similar to that on the admission side and leading through the walls, but it does not extend so high as the inlet channel and is separated therefrom, in the circumferential direction, by longitudinal webs. Just above, but independent of, the upper end of this passage 26 is another short passage or port 27 which passes directly through the walls, and, at the commencement of the power stroke, registers with a passage 28 in the main piston leading to the combustion space. During the power stroke the two parts of the piston move outwards until the passage 27 in the sleeve comes opposite the exhaust port 20, and is also in register with the passage 28 in the piston, so that the exhaust gases commence to pass out by their own pressure. Owing, however, to the relative movement of the sleeve, the passage 27 moves out of register with the passage 28, but immediately another auxiliary passage 29, cut in the end of the sleeve, is brought into register with a passage 30 in the piston and with the exhaust port, thus maintaining the communication during the remainder of the stroke. (*Accepted September* 27, 1911.)

HYDRAULIC MACHINERY.

22,259/10. H. S. Hele-Shaw and F. L. Martineau, London. Hydraulic Apparatus. [4 *Figs.*] September 26, 1910.—This invention has reference to hydraulic relay systems wherein the application of a small force actuates a primary controlling device, and the movement of this primary controlling device results in the movement of the larger controlling mechanism of a main apparatus, and the movement of the controlling mechanism of the main apparatus results in the return of the primary controlling mechanism to the normal position. According to the invention, the primary hand operation merely serves to set in effective operation a secondary apparatus

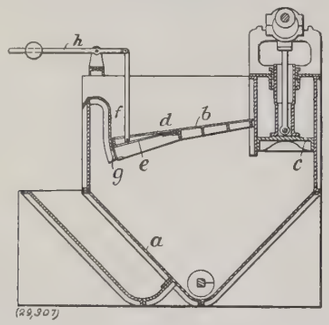


for causing the liquid pressure necessary to operate the control, gear of the main apparatus, and the movement of the control-gear of the main apparatus serves to cause the secondary apparatus to cease effective operation. 1 designates the controlling-rod of the stroke-varying ring of the main pump 2. This rod is provided with a piston 3, which operates in a cylinder 4. The extremity of the rod 1 is pivotally connected to one end of a floating-link mechanism, which is connected to the stroke-controlling rod 8 of a smaller secondary pump 9, and this secondary pump 9 has its orifices connected by pipes 10 and 11 with the cylinder 4. It will be understood that the orifices of the pump 9 must communicate with this cylinder 4, one at either end. The operation of the device

is as follows :—The floating link is moved about its pivotal connection with the rod 1 by means of the screw-gear 12, and this movement operates the rod 8 of the pump 9, which latter immediately commences to transmit liquid in a direction dependent upon the direction in which the floating link is moved. The liquid discharged from the pump 9 is transmitted to one side of the piston 3, and liquid on the other side of the piston 3 being withdrawn, the piston, and with it the rod 1, is moved, and thus stroke is given to the main pump 2. The movement of the piston 3 operating through the floating link returns the rod 8 of the pump 9 to its middle, or zero position, and thus the main pump 2 will continue to have the same stroke until the stroke-controlling mechanism is again operated. It will, of course, be understood that the initial movement of the floating link may be effected in many ways, such, for instance, as by connection with the controlling-rope of an hydraulic lift. (*Accepted September* 27, 1911.)

MINING, METALLURGY, AND METAL-WORKING.

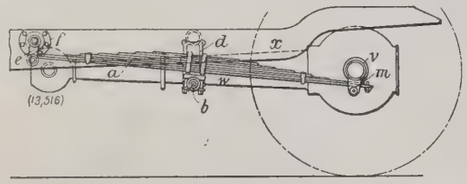
29,307/10. O. Sheppard, Bridgend. Coal-Washing Machinery. [3 *Figs.*] December 16, 1910.—In coal-washing apparatus of the kind wherein a grating is supported in a water tank, and a reciprocating piston or plunger is employed to produce an intermittent upward current through the grating for the purpose of agitating the materials thereon, so that the heavier portions thereof shall gravitate towards the surface of the grating, leaving the washed coal lying upon the refuse, means are provided, in accordance with this invention, whereby the refuse is discharged automatically from time to time, and to this end a hinged bottom to the grating is employed and is suitably counterbalanced and arranged in conjunction with a discharge opening in such a manner that the bottom intermittently, under the action of the weight of the material upon it, descends and uncovers an opening in the adjacent wall, and allows the material lying upon the grating to discharge through the opening. *a* is the tank of the washer, *b* the fixed grating, and *c* the plunger for producing the intermittent current of water through the grating. *d* is



a channel having a movable bottom formed by the hinged grating *e*, and *f* is the wall provided with the opening *g* through which the material is discharged into the tank. *h* is a balance-lever pivoted on the wall of the tank and connected to the grating *e*. The operation is as follows :—The material to be washed being upon the grating, and the pump being set in operation, the flow of water in alternately opposite directions will take place through the grating. It will be readily seen that as this operation continues, the shale or heavy refuse will accumulate against the grating, whilst the coal will lie upon the heavier material. When the weight of the accumulated material overcomes the weight on the balance-lever *h*, the perforated bottom *d* descends so as to uncover the opening *g* in the wall *f*, thereby allowing the refuse to discharge into the tank *a*. When a sufficient quantity of refuse has been discharged so that the weight on the hinged bottom is reduced, the balance-weight again returns the hinged bottom to its upper position, thereby closing the opening *g* in the wall *f*. (*Accepted September* 27, 1911.)

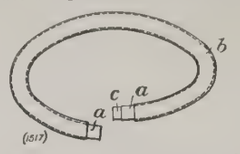
MOTOR ROAD VEHICLES.

13,516/11. F. H. Royce and Rolls-Royce, Limited, Derby. Spring Suspension. [2 *Figs.*] June 6, 1911.—This invention utilises inverted suspensory springs of the so-called cantilever type in a more simple manner than at present obtains, and consists in the combination with springs of the type mentioned, of a transmission gear of well-known live-axle type in which the propeller shaft is enclosed in a tubular member rigidly attached to the axle-case, and operating as a torque member and a radius-rod, and connected to the frame at its forward end by a universal joint arranged concentrically with the universal joint connecting the gear shaft with the propeller shaft. The inverted springs *a* are pivotally attached to the side members of the main frame *x* by means of blocks *b*. These blocks engage with pins attached to brackets *d* rigidly mounted on the side member. The front end of each of the springs *a* is supported by a link *e* pivoted



to a bracket *f* attached to the side member. The rear end of each of the springs *a* rests on a roller carried by a hanging bracket *m* attached to the rear axle casing *v*. The tubular member *w*, which is rigidly attached to the axle casing *v*, and envelops and encloses the propeller-shaft, is attached at its forward end to the main frame by a universal joint. The action of this improved suspension is as follows :—The axle casing and propeller-shaft casing form a rigid suspension unit which is attached at its front end to the main frame of the vehicle by a suitable form of universal joint. This arrangement, together with the lateral rigidity of the inverted springs, constrains the axle to move only in a vertical direction relatively to the frame, the said movement being controlled by the vertical resilience of the spring. It further allows either wheel to rise relatively to the other without straining the controlling mechanism in any way. (*Accepted September* 27, 1911.)

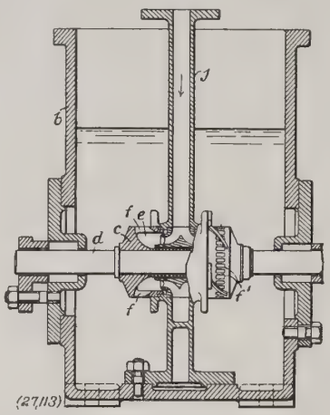
1517/11. C. W. Bluemel, F. H Bluemel, and E. A. Bluemel, Coventry. Steering-Wheels. [4 *Figs.*] January 20, 1911.—In the manufacture, in accordance with this invention, of a celluloid-covered metal rim of a steering-wheel, a weldless drawn-metal tube is first bent to a ring shape, with the ends out of alignment, and a sheath of celluloid then drawn over the same. The exposed ends of the tube are then united to form a completed ring, and the ends of the sheath are stretched and united to cover the joints in the tube. *a* is the weldless drawn-metal tube, bent approximately to a ring shape, with the ends out of alignment, over which a tubular sheath *b* of celluloid is drawn. The ends of the sheath *b* are at first forced back to leave the ends of the tube *a* exposed. After a short sleeve or liner *c*



has been inserted in the tube *a*, the ends of the latter are brought into alignment, and are butted together around the liner, and united. The ends of the celluloid sheath are then stretched to overlap one another, covering the joint in the tube *a*, and are themselves united. By bending the metal tube so that the ends are out of alignment, the drawing on of a seamless celluloid sheath is facilitated. (*Accepted September* 27, 1911.)

PUMPS.

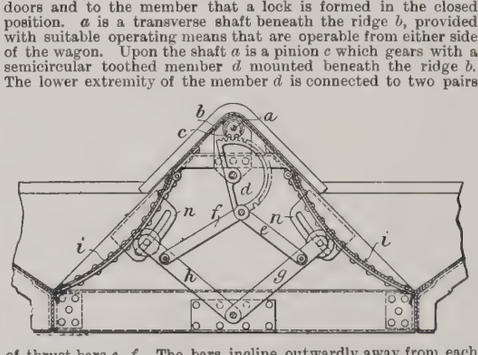
27,113/10. G. and J. Weir, Limited, and J. Petermoller, Cathcart. Rotary Air-Pumps. [4 *Figs.*] November 22, 1910.—In a rotary air-pump in which the air to be discharged is drawn into passages in a rotor which rotates in liquid, the air being swept from the exit ports of the passages by the difference in velocity between the periphery of the rotor and the adjacent portion of the liquid, there is employed, according to this invention, a conduit which passes through the liquid in which the rotor is immersed, the air being supplied to the rotor through this conduit. The pump is immersed in water contained in the tank *b*. The pump rotor *c* is fixed on the rotatable shaft *d* and is arranged on the double-flow principle in order to have no unbalanced axial pressure. The air enters by the conduit *j* and is divided into two portions, one portion passing into the annular



chamber *e* in the left-hand part of the pump, while the other portion passes into a corresponding chamber in the right-hand part of the pump. *f*, f^1 are discharge ports through which the air passes into the water. The rotation of the rotor causes a relative velocity between the periphery of the rotor and the water; and this relative velocity sweeps the air from the ports *f*, f^1. The air, when free from the rotor, then rises in the specifically heavier water. In this way a vacuum can be produced in the conduit *j*, and air drawn out of the condenser and discharged through the water into the atmosphere. The water is to a certain extent put into motion by the rotation of the rotor; but the absolute velocity of the water is comparatively low and considerably lower than would require to be given to the auxiliary medium in pumps of the jet or ejector type. (*Accepted September* 20, 1911.)

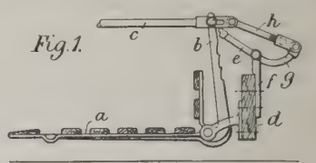
RAILWAYS AND TRAMWAYS.

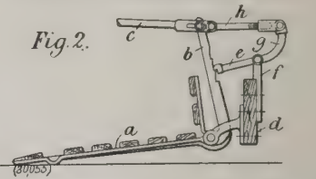
26,843/10. The Metropolitan Amalgamated Railway Carriage and Wagon Company, Limited, and W. H. Wigley, Birmingham. Hopper Wagons. [3 *Figs.*] November 18, 1910.—In operating gear for doors of hopper wagons, according to this invention, there is provided a semicircular or quadrant toothed member driven from a rotatable shaft and jointed to thrust-rods and links, so connected to the doors and to the member that a lock is formed in the closed position. *a* is a transverse shaft beneath the ridge *b*, provided with suitable operating means that are operable from either side of the wagon. Upon the shaft *a* is a pinion *c* which gears with a semicircular toothed member *d* mounted beneath the ridge *b*. The lower extremity of the member *d* is connected to two pairs



of thrust-bars *e*, *f*. The bars incline outwardly away from each other, and connect at their extremities with links *g*, *h*. The doors *i* are hinged to the walls of the ridge *b*, and when opening swing towards one another. The links are connected with the doors by slotted brackets *n*, and pins on the links work in the slots. In operation, as the shaft *a* is rotated, its pinion *c* raises the member *d* and draws up the thrust-bars *e*, *f*, which pull the links *g*, *h* inwards toward the centre of the ridge *b*, and permit the doors *i* to turn upon their hinges. The reverse operation throws out the thrust-bars, forcing out the links and raising the doors into the closed position. The links and thrust-bars form a hinged parallelogram, and, owing to the dead centering of the top joint on the member *d*, a lock is obtained in the closed position of the doors. (*Accepted September* 20, 1911.)

30,055/10. J. Bowring, Manchester. Tram-Car Life-Guards. [2 *Figs.*] December 28, 1910.—In life-guards or obstruction removers for tram-cars, means for holding and locking the tray when in its lowered position comprise, according to this invention, a lever or pawl mounted upon the pilot-board, and designed to engage teeth or notches on the arm connecting the tray to the connecting-rod of the re-setting means, and a further lever and link or rod for operating the lever or pawl. *a* is the tray with upstanding arm *b*, *c* is the connecting-rod extending from the arm *b* to the re-setting means, and *d* is the pilot-board from which the tray is supported. According to the invention, a lever *e* is mounted upon a bracket *f* carried by the pilot-board *d*, and is designed to engage teeth on the arm *b*. Mounted upon the

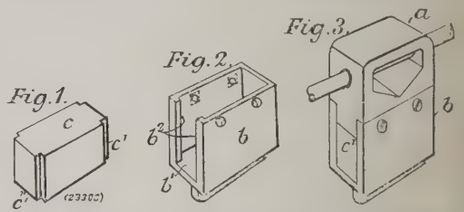




same fulcrum as the lever *e* is a lever *g*, to the free end of which is secured one end of a connecting-rod *h*. The other end of the rod *h* is secured to the end of the resetting connecting-rod *c*. With the tray in its normal position, the lever *e* lies clear of the teeth on the arm *b*, but immediately the tray *a* falls, the lever *e* is brought into engagement with the teeth on the arm *b*, and locks the tray in its lowered position. The connecting-rod *c*, where it engages with the arm *b*, is provided with a slot, so that, on re-setting, the rod *c* will raise the lever *e* clear of the teeth on the arm *b* before raising the tray. (*Accepted September* 27, 1911.)

TEXTILE MACHINERY.

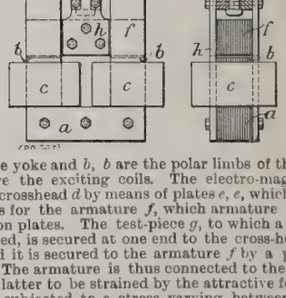
23,308/10. J. W. Taylor and Y. Yates, Hyde. Loom Pickers. [6 *Figs.*] October 8, 1910.—In loom pickers of the kind provided with a recess or chamber, and a renewable striking-block in such chamber, the opening from such chamber is provided with vertical flanges whereby the block is retained in the chamber, and the block is also provided with rebates at each edge whereby the end of the block, when in the chamber, may lie flush with the outer faces of the flanges. Fig. 3 illustrates the picker, *b* being the chamber and *c* the filling-block placed therein, and comprising the lower part of the picker. The chamber *b* is made, as shown in Fig. 2, with an opening b^1 and flanges b^2 on its working side. The block is made to the shape shown in Fig. 1,



and when in position within the chamber *b* the shouldered or reduced part c^1 lies between the flanges b^2, and its end face lies flush with the outer surface of the flanges. The upper part of the picker is also preferably rebated to fit into the top of the chamber *b*, and when the parts are assembled the upper part and chamber are secured together by screws and nuts. The opposite ends or faces of the block *c* are similar in design (see Fig. 1), so that when the block becomes worn or damaged on one face, it may be reversed, and its other end form the striking face. The parts being secured together as shown, it will be understood that the block *c* cannot be dislodged by the rough usage to which the picker, when in use, is subjected. (*Accepted September* 27, 1911.)

MISCELLANEOUS.

29,998/10. G. Kapp, Birmingham. Testing of Materials. [4 *Figs.*] December 24, 1910.—This invention relates to means for testing the durability of material exposed to repeatedly applied stresses. According to the invention, the stress is caused by the application of a magnetically produced force derived by an alternating electric current. The frequency of the application of the stress can thus be raised to such a degree as to render the length of time occupied in the experiment only a small fraction of that hitherto necessary. An alternating current sent through the winding of an electromagnet produces a maximum induction alternated by zero induction twice in each period. The armature of such a magnet is therefore attracted with a maximum force twice in each complete period, and at intermediate times there is no attractive force. Referring to Figs. 1



and 2, *a* is the yoke and *b*, *b* are the polar limbs of the magnet, of which *c*, *c* are the exciting coils. The electro-magnet *a*, *b*, *b* is secured to a crosshead *d* by means of plates *e*, *e*, which plates serve also as guides for the armature *f*, which armature is built up of laminated iron plates. The test-piece *g*, to which a tensile stress is to be applied, is secured at one end to the cross-head *d*, and at the other end it is secured to the armature *f* by a pair of cheek-plates *h*, *h*. The armature is thus connected to the test-piece so as to cause the latter to be strained by the attractive force, and the test-piece is subjected to a stress varying between zero and a maximum twice in each period. With a current of 50 frequency, for example, the test-piece will be subjected to 100 stresses a second, or over a million in three hours. (*Accepted Sept.* 27, 1911.)

INFLUENCE LINES.

By H. W. Mellor and A. M. Sims, B.Sc. Eng.

The application of influence lines to the design of structures on which loads travel is beginning to be recognised, but up to the present very little seems to have been published as to their use. The intention of this article is to show their application to the various members in structures connected with crane-making.

Definition.—An influence line is a line drawn to show the influence or effect produced by a travelling load upon a particular section or a particular bar of a structure during the passage of a concentrated load. Influence lines may be drawn to show variations of shear, or bending moment on any particular section of the structure, or variation of stress in a particular bar. It is usual always to draw the influence line for a rolling load of 1 ton, and then multiply the result by the actual load, and this rule will be adhered to in the following examples :—

Fig. 1.

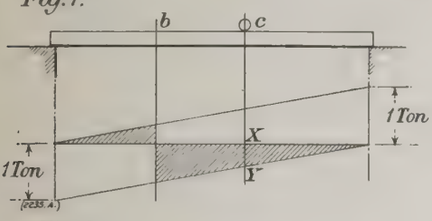
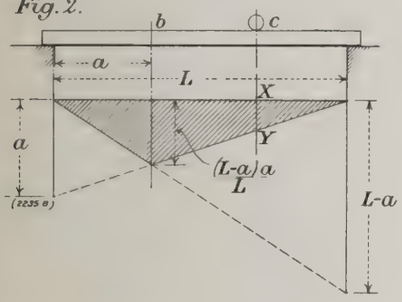


Fig. 2.



In Fig. 1, above, it is required to draw a shear diagram for section at *b*. Set out, as shown, the unit load above at one end, and below at the other, of a straight line equal to the span, and join across. The shaded area then represents the shear influence line for section *b* due to the passage of a load of 1 ton from end to end of span. The shear at *b* due to the load at any point *c* is the vertical height of diagram at X Y. The influence line for bending moment is shown in Fig. 2, and the method of getting the three depths marked on diagram. As with the shear, the bending moment at *b* with load at any point *c* is the vertical height X Y.

Coming now to braced girders, such as overhead traveller girders with the crab on the top boom, the method of showing the variation of stress in the booms, vertical and diagonal bracing, is shown in the next diagrams, Figs. 3, 4, and 5.

Fig. 3. DIAGONAL BRACING

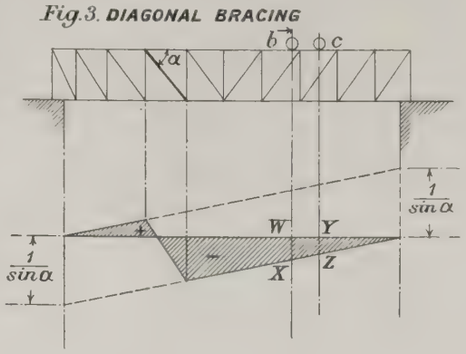
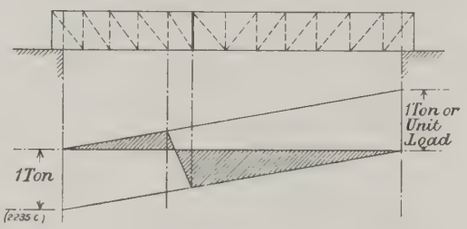


Fig. 4. VERTICAL BRACING



The variation in stress in diagonals of Linville-type girders (see Fig. 3), where the angle between boom and diagonal is represented by *a*, is shown by setting down at each end $\frac{1}{\sin a}$ and joining across; the shaded area then represents the actual variation of stress in diagonal under consideration (shown by dark line). For example, suppose the wheel pressures are each 5 tons at *b* and *c*, the stress in diagonal with crab in the position shown would be vertical height W X multiplied by 5 tons plus vertical height Y Z multiplied by 5 tons.

The Warren type of girder is similar to the above, excepting for the vertical, which is usually introduced to reduce the local bending moment in the top boom as the load travels over it. In the diagrams the load is assumed to run on the top boom, and the effect of the vertical member is shown in Figs. 6, 7, and 8.

In fish-bellied girders the construction is similar to that for parallel girders. In the ordinary construction the booms are produced till they meet (see Fig. 9), in order to find the stress in the bracing; but as that is frequently inconvenient, especially for the bracing near the centre of the span, where the booms are nearly parallel, another method is shown in Fig. 10, the construction for which does not go beyond the ends of the girder.

Fig. 5. BOOMS.

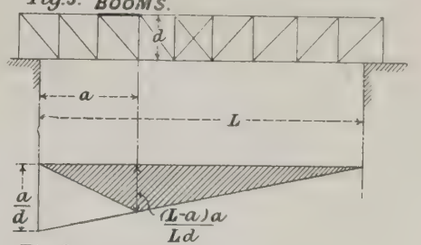


Fig. 6. DIAGONALS.

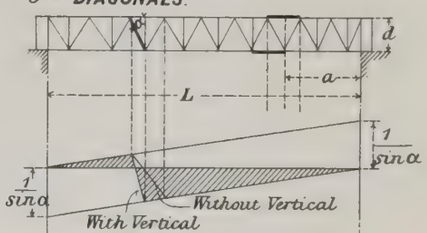


Fig. 7. TOP BOOM.

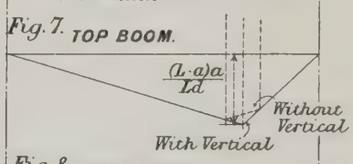


Fig. 8. BOTTOM BOOM.

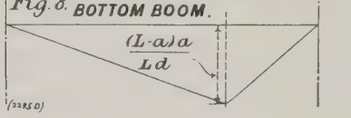


Fig. 9. DIAGONALS.

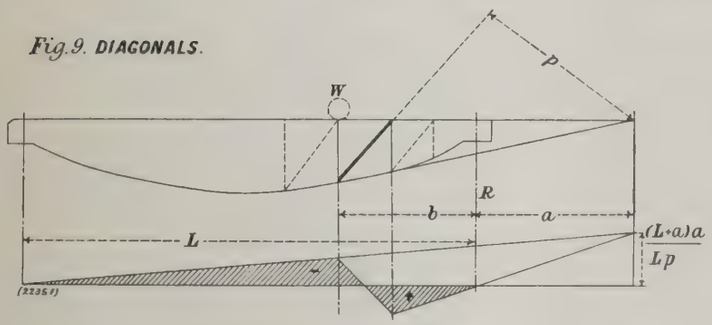
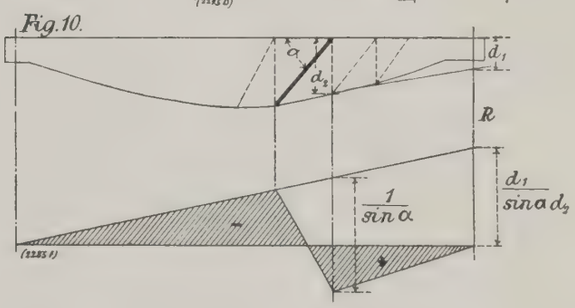


Fig. 10.



$\frac{(L+a)a}{Lp}$ is set up below point of intersection of booms, and lines drawn to both reactions, and one produced as shown to form the diagram, Fig. 9.

The object of this article is not to prove the accuracy of influence lines, but to show their practical application; it can, however, easily be seen in the above that for unit load the reaction at R is $\frac{L-b}{L}$, with load at W, which gives maximum tension stress on diagonal, the stress being $\frac{(L-b)a}{Lp}$, and so we get the first formula

$$\frac{(L-b)a}{Lp} \times \frac{(L+a)}{(L-b)} = \frac{(L+a)a}{Lp}.$$

To keep within the limits of the girder the method is as in Fig. 10.

At R set up $\frac{d_1}{\sin a \times d_2}$, d_1 being the distance at reaction of top and bottom flanges; d_2 being their distance at point where diagonal meets top boom. The top part of diagram can then be drawn. On line d_2, produced, set down $\frac{1}{\sin a}$ from its intersection with top diagram line, and complete as shown. The method of getting the influence line for the verticals without going beyond the reactions

Fig. 11. VERTICALS

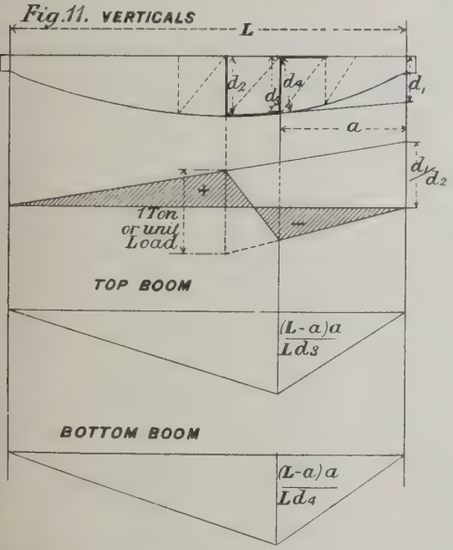
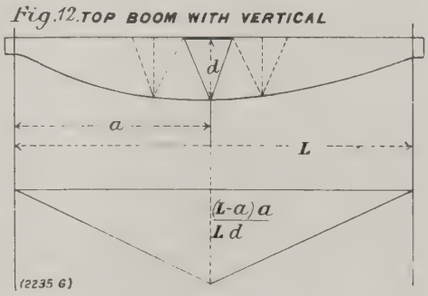


Fig. 12. TOP BOOM WITH VERTICAL



INFLUENCE LINES.

Fig. 13. TOP BOOM WITHOUT VERTICAL

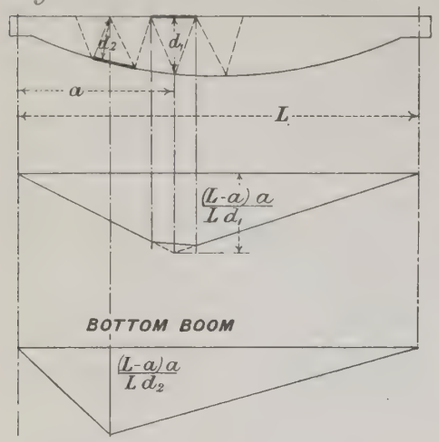


Fig. 14. DIAGONAL WITH VERTICAL

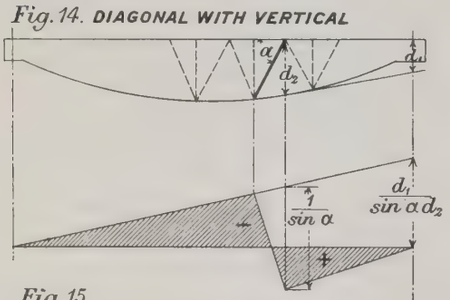
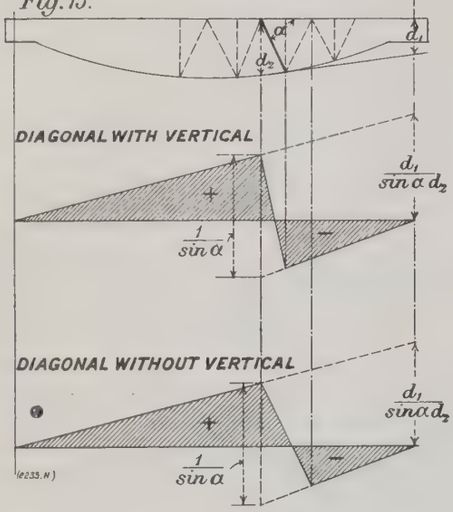


Fig. 15.



is shown in Fig. 11, as also for both booms. Members for which the lines are drawn are shown black, the other members are dotted to show the type of girder. For girders with fish-bellied boom and Warren bracing the booms are similar to the above, except for the influence of the vertical member, as shown in Figs. 12 and 13. Figs. 14 and 15 are the diagrams for diagonals.

Influence lines apply equally well to cantilevers; and for big work, such as giant cranes, they will probably be found the simplest and best method of determining the stresses, as the diagrams once made apply to any loading and any number and spacing of wheels. Fig. 16 shows an influence line for the bracing with the booms produced till they meet, to show the method; Figs. 17 to 20 show the diagram ending at the nose of the crane. If no vertical member is used, the diagram becomes as below, Fig. 16.

Stress in a diagonal due to four wheels in positions shown is equal to vertical line W W multiplied by load on first wheel, plus vertical line X X multiplied by load on second wheel, plus vertical line Y Y multiplied by load on third wheel, plus vertical line Z Z multiplied by load on fourth wheel. Fig. 17 shows the diagram when not produced to the intersection of the booms. For cantilever cranes with the Linville type of bracing the construction is very similar; this form, shown in Fig. 19, is often

Fig. 16.

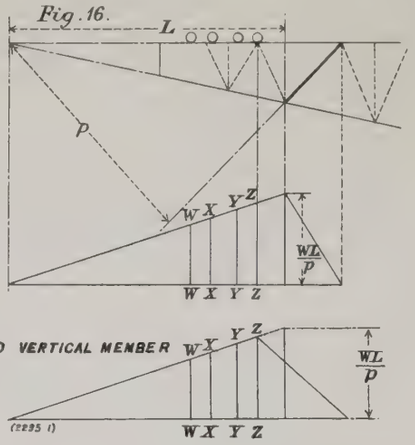
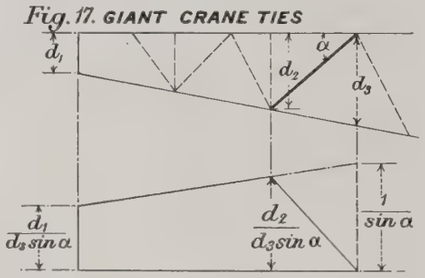


Fig. 17. GIANT CRANE TIES



GIANT CRANE STRUTS

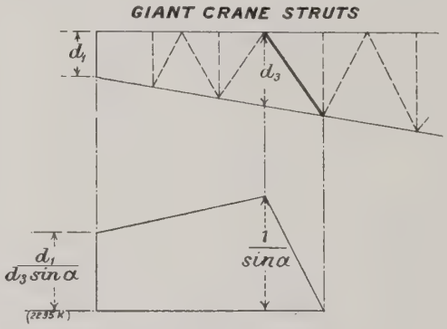
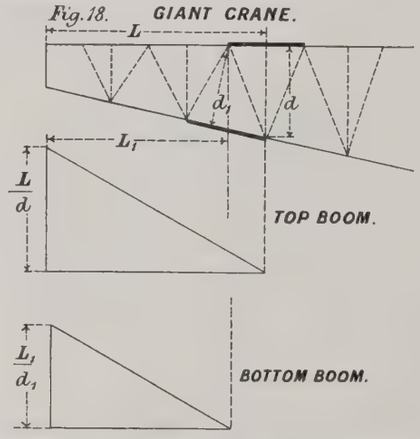


Fig. 18. GIANT CRANE.



used for Titans. Another form of cantilever is used for transporters, in which the load runs on the bottom boom; the lines for this form are shown in Fig. 20. The boom stresses for Titans and transporters are found in a similar way to those in Fig. 18.

FEED-WATER HEATING AND SUPERHEATING ON LOCOMOTIVES.—No. VII.

THE ECONOMICS OF COMBINED FEED-WATER HEATING AND MODERATE SUPERHEATING, AND OF HIGH-DEGREE SUPERHEATING, AND COMPOUNDING.

HAVING, in the last article of this series,* arrived at a measure of the saving in fuel effected by the Trevithick system of feed-heating and moderate

* See page 617 *ante*.

Fig. 19. TITAN CRANE.

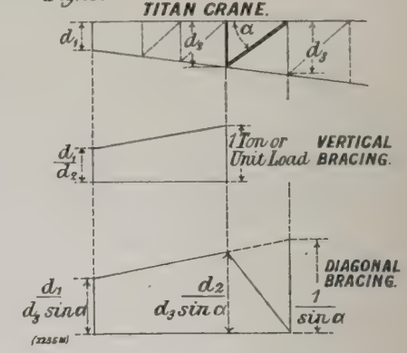
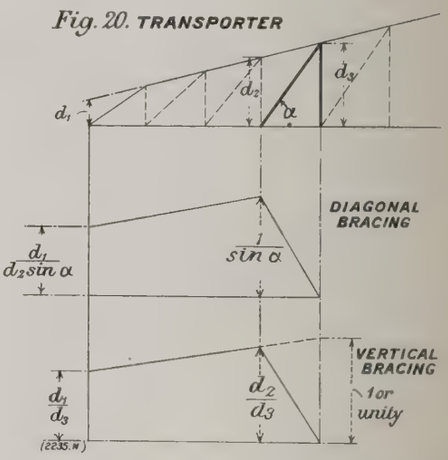


Fig. 20. TRANSPORTER



superheating, and of high-degree superheating, the commercial value of the arrangements has next to be considered. Before entering upon this in detail, it should be mentioned that the benefit derived will be taken as being confined to the coal-saving alone. The saving in water was not measured in the trials. It would be rather more in the high-degree superheating, than in the Trevithick, system; but since the cost of the commodity to railways varies too much for a typical figure to be taken, it has been thought best to omit it altogether. Again, the question of oil has not been included. Opinions vary considerably as to what degree, if at all, high-degree superheat entails greater cost in lubrication. Where mechanical lubricators are in use there appears to be little difference between heater and non-heater engines. The engines fitted with the Trevithick system involve no change whatever in lubrication, and work equally well with or without mechanical lubricators. These lubricators have, however, been adopted on the Egyptian State railways, for reasons quite apart from anything connected with superheating, and are gradually being applied to all passenger engines. Attention may also further be drawn to the fact that subsequent conclusions are, perforce, based on figures relating to the experience on the Egyptian State Railways. The figures for costs, therefore, given below, include royalty in the case of the high-degree system, but do not include it in the case of the Trevithick system.

The cost of the Trevithick system will be taken first. The cost to these railways of the apparatus required by the Trevithick system is placed, in Mr. H. W. Davis's report, previously referred to, at 180*l*. This system necessitates no structural alterations to any part of the standard Egyptian State Railways engines. The apparatus required is shown in full lines in Figs. 29 to 31, page 692. The necessary parts constitute additions or substitutions (as in the case of the pump) which can be applied without difficulty. Large smoke-boxes are the rule on these railways, and the smoke-box heater can be accommodated in existing smoke-boxes without the enlargement of the latter. The provision of additional length of smoke-box, if such should be necessary, is, of course, in no case a matter of great difficulty or expense.

As partly going to make up this figure of 180*l*., the following items, from tenders for material accepted in connection with the equipment of

engines of the "612" class, are of interest. Smoke-box heaters, delivered Alexandria, 44*l*. each; pump exhaust heaters, delivered Liverpool, 3*l*. 12s. 6d. each; main exhaust heaters, delivered Liverpool, 21*l*. 5s. the pair; pump, delivered London, 16*l*. 16s. The cost of this part of the equipment is thus 85*l*. 13s. 6d., and, including transit, is well under 100*l*. in Egypt. The piping, spark-arrester, blast-chamber hood, &c., were made at the Boulac works of the Egyptian State Railways, and the additional 80*l*. allowed leaves ample to cover the cost of these and of fitting the appliances to the engine. The cost of application is really comparatively trifling, the work being all straightforward and of a simple character. The figure of 180*l*. is thus arrived at from actual work undertaken, and is not merely an estimate pared down to the smallest possible amount. A deduction must be made from this sum for the discarded injector, which, though removed, is still capable of being put to useful work, as a spare or otherwise. About 10*l*. may be allowed for this, and the net cost of material and fitting of this system will thus be 170*l*.

The question of repairs and depreciation must, of course, be considered. There is every indication to show that the bulk of the material used in the Trevithick system has a reasonably long life. The deterioration of the smoke-box heater, the pump (subject to one or two small alterations from the standard Worthington pattern), the pipes, cocks, &c., is found in no way to be abnormal, and all these parts wear well. The exhaust-steam-heater shells, &c., also stand well, and these heaters only show deterioration of the tubes. There is in some cases a tendency for the steel tubes which are used to pit, and instances have been known of odd tubes requiring replacing after about 40,000 miles. With the majority of the engines, however, tubes only $\frac{1}{16}$ in. thick last for over 63,000 miles. One engine has done as much as 79,000 miles without needing any attention of this kind. It is clear that, by a slight increase in the thickness of the tubes, or by the adoption of some other material than steel, the mileage obtained could be increased. Experiments with galvanised tubes are about to be made. While the life of these exhaust-heater tubes must always depend to some extent upon the quality of the water, and will also be subject to the irregularities of pitting—a common phenomenon in other branches of steam engineering—it may be taken that, with suitable arrangement, they will last on an average for the ordinary mileage between shoppings.

As regards the life of the superheater, the shell itself keeps clean inside and out, and appears to be subject to practically no deterioration, while the tubes last for the full period between shoppings, having exceeded in some cases 72,000 miles. In order to ensure being on the safe side the practice has now been adopted of renewing the heater tubes when the engines are in for general repairs. The maintenance work so far necessitated on all the heaters, both steam and water, shows that an ample allowance per engine per annum for re-tubing, &c., would be 20*l*., of which 10*l*. would be for material, and 10*l*. for labour. Another 10*l*. easily covers the maintenance, in good order, of the pump, cocks, &c. Since the pump replaces one injector, its maintenance is not wholly a new expense, and some allowance should properly be made for this, though it is now omitted. The total for maintenance is thus, at the outside, 30*l*. per annum. It may be taken that the apparatus will average the same mileage life as a locomotive boiler, and so depreciation at the rate of about 10 per cent. should be taken into account.

In order to render the conclusions of wider interest than would be the case if consideration were restricted to Egyptian conditions, where the yearly engine-mileage is perforce comparatively moderate, and coal expensive, the balances below are worked out for a yearly engine performance of 55,000 miles with coal at 15s. per ton. This mileage for passenger engines, though higher than on some lines, is within the limits on others. On one of the principal lines of this country some passenger engines do 2200 miles per week, and, allowing for shopping, the above figure is therefore not an exaggeration. If the case were restricted to certain lines and types of engine, an even higher figure might safely be taken. In America 80,000 miles per annum is not uncommon for passenger engines.

It will be remembered that economies of 29 to 30 per cent. resulted in the trials alluded to in the previous article, for the heater engines, when the test conditions included the over-all service working, taking into account also the lighting-up coal. Since, however, the trial was concerned only with express working, which is favourable to the heater systems, it will be assumed that for average passenger service on the main line, the savings realised would amount to 23.5 per cent., a figure purposely taken for the sake of moderation, even below the service results on the Upper Egypt sections, on which there are more stops and slacks, obtained, too, it must be remembered, with an apparatus on which the later form shows improvement. Such a saving means a reduction in the average coal used per mile by the non-heater engines Nos. 697, 713, 717, 720, and 721, of practically 11¼ lb. of coal per mile. The following profit and loss account may thus be drawn up:—

TABLE XII.—*Profit and Loss Account for Engine Converted to the Trevithick System of Feed-Water Heating and Moderate Superheating.*

Dr.	£ s.	Cr.	£ s.
To interest (5 p.c.) on 170*l*.	8 10	By saving in coal ..	207 2
,, depreciation (10 p.c.) ..	17 0		
,, maintenance	30 0		
Total annual charges ..	55 10		
Balance (Profit)	151 12		
	£207 2		£207 2

Under these conditions, even with the liberal allowance of 55*l*. 10s., or 32.6 per cent. for interest, depreciation and maintenance, an annual saving per passenger engine of 151.5*l*. is shown. Evidently there is ample margin to meet other possible combinations, of annual mileage, price of coal, &c. To give some idea of what such saving means, consider the case of a railway capitalised at 40,000*l*. per mile, and just meeting the claims on its preference and debenture stock. In England there are 1.2 locomotives per open mile. If as an approximation it be taken that there would be one road locomotive per mile, and if the ordinary capital constituted, as it does here, about 37 per cent. of the total, the saving thus realised in locomotive operation would render available for distribution among the holders of ordinary stock an amount equal to additional dividend of 1.02 per cent.

In the case of new engines the figures would naturally be slightly different. An examination of tenders, submitted by nineteen firms, shows that on the average the price quoted for engines on the Trevithick system is about 154*l*. above that asked for engines of the same type but without heaters. The position would then be as in Table XIII. hereunder:—

TABLE XIII.—*Profit and Loss Account for New Engine Fitted with Trevithick System of Feed-Water Heating and Moderate Superheating.*

Dr.	£ s.	Cr.	£ s.
To interest (5 p.c.) on 154*l*.	7 14	By saving in coal ..	207 2
,, depreciation (10 p.c.) ..	15 8		
,, maintenance	30 0		
Total additional charges per annum	53 2		
Balance (Profit)	154 0		
	£207 2		£207 2

The allowance in this case for interest, depreciation, and maintenance works out to 34.6 per cent. of the cost of the additional equipment. It may be of interest to mention that the "695" class of engines with which these trials were made cost, on the average, delivered in Egypt, 2568*l*. per engine. The engines have cost an average of 170*l*. each for running repairs between shoppings, and 252*l*. each for shop repairs, thus making 422*l*. against the account of the mileage between shoppings, or 1.56d. per mile.

From the above balances it is clear that, in the case of either new, or converted, engines, the Trevithick system will practically pay for the cost of equipment in a year's working, though the exact benefit must naturally vary with local conditions.

The case of the high-degree superheating system is very different, and the difference between the cost of applying this system to new or existing engines is very great. Taking, again, first the question of conversion of existing engines, it will be found that in many circumstances the work involved renders the cost of adaptation to this system well nigh prohibitive. Contributing to this heavy cost are the various large items set out below, the new material required in the conversion to this system being shown in the full lines in Figs. 32 to 34, page 693. The figures here given were those quoted to, and accepted by, the Egyptian State Railways in connection with the conversion of engine No. 712 for material delivered at Gabbary.

	£
New copper and steel tube-plates, large smoke-tubes, superheater elements, superheater headers, steam-pipes, blast-pipe, damper and hand operating gear	254
New smoke-box	52
Set of cylinders with piston-valves, pistons, rods, valves, valve-rods, and rocking-shafts	325
Mechanical lubricator, pyrometer, valve-chest steam-gauge	40
Total	£671

This sum of 671*l*. does not include the new set of boiler-tubes necessary, neither does it include new fire-box stays, nor sundry other smaller items in the way of material. In addition there is the heavy cost of installation, which involves dismantling the whole engine, lifting and rebuilding a good part of the boiler, taking out the old and putting in new cylinders, &c., all of which operations require an expensive class of work. In Mr. Davis's report the total cost of installation is placed at 855*l*., so that the cost of the material not included in the above list, and of the work involved in converting the engine, appears to be no less than 184*l*., or as much as the combined system of feed-water heating and moderate superheating comes to altogether.

From this total of 855*l*. may be taken the value of the scrap material discarded. The copper tube-plate, old slide-valves, glands, &c., still have a good value. The pistons, rods, and valve-spindles might come in as spares for other engines, where, as on the Egyptian State Railways, these parts are largely standardised. The remaining material is, however, of comparatively little value, and it will probably be a sufficiently close estimate if 80*l*. be allowed for all the material displaced. Another 13*l*. or so must be deducted for the mechanical lubricator, since these are used also by other engines. Thus the net cost of converting an engine to the high-degree superheater system is, under these conditions, 762*l*. approximately.

With regard to depreciation a reasonable allowance appears to be about 9 per cent. in this case. In the consideration of the Trevithick system the life of the boiler material was taken as ten years. Such material accounts for about half the total cost in the high-degree superheating system, while the rest is on account of material which has a rather longer life, and for which 8 per cent. depreciation would probably be sufficient. The net result is thus an over-all allowance of 9 per cent.

The question of repairs is difficult to gauge accurately. The cylinders and tube-plates replace those formerly on the engine, and only additional cost of repairs due to the superheater, and the effect of superheating, have to be taken into account. The high-degree superheater itself appears to involve no abnormal expense in repairs, as far as can be ascertained, when properly handled. There is, however, evidence to show that valve-bushings, piston-rings, &c., are in need of more frequent renewal on these engines than is the case with saturated-steam engines. Some interesting figures bearing on this point have been published in a report presented at the Travelling Engineers' Association Convention, held recently in America. These are reproduced in the accompanying Table XIV., and show several cases of shortened life for piston and valve-rings when working with highly superheated steam. These figures are of considerable significance when it is remembered that lubrication in American practice errs on the lavish side.

TABLE XIV.—*Life of Piston and Valve-Rings with Saturated and High-Degree Superheated Steam.*

Railroad.	Piston-Rings. Life in Months.		Valve-Rings. Life in Months.		Material.
	Saturated Steam.	Superheated Steam.	Saturated Steam.	Superheated Steam.	
L.S. and M.S. ..	4	2	3 to 4	3 to 4	Special cast iron
C.P.R.	12 to 24	1 to 18	..	12 to 24	Cast iron*
C. and N.W. ..	6	½ to 1	..	..	Cast iron
C.R.I. and P. ..	6	†	6 to 7	†	Cast iron
St. L. and S.F.	3 to 12	2 to 9	6 to 18	3 to 15	Hunt Spiller iron
E.P. and S.W.	12	7 (still in service)	24	12 (still in service)	Cast iron

* No trouble experienced with valve-rings. For piston-rings special material is required. Dunbar packing gives good results.
† Life of grey cast-iron piston-rings is about 500 miles, and of valve-rings 600 to 800 miles. The life of Hunt Spiller iron piston-rings reaches as high as 150,000 miles.

On the other hand, there is some ground for

the belief that the repairs to the boilers of superheater engines are actually less than for saturated-steam engines; but opinion is divided on this point. It is held that the relief afforded to the boiler by the smaller demand for steam, or the lower pressure rendered possible, reduces the repairs necessary, there being no longer the need of forcing the boiler to its utmost capacity. This is a very reasonable theory, but it will equally apply to both the high-degree superheating, and the Trevithick system, which also relieves the boiler of work, and it can therefore be eliminated from the present discussion. As an approximation it will probably suffice to take 10 per cent. on the extra cost due to the superheater itself as covering repairs to it and all subsidiary gear, and including the increased repairs in the cylinders. The profit and loss account in these circumstances works out as in Table XV.

Fig. 23.

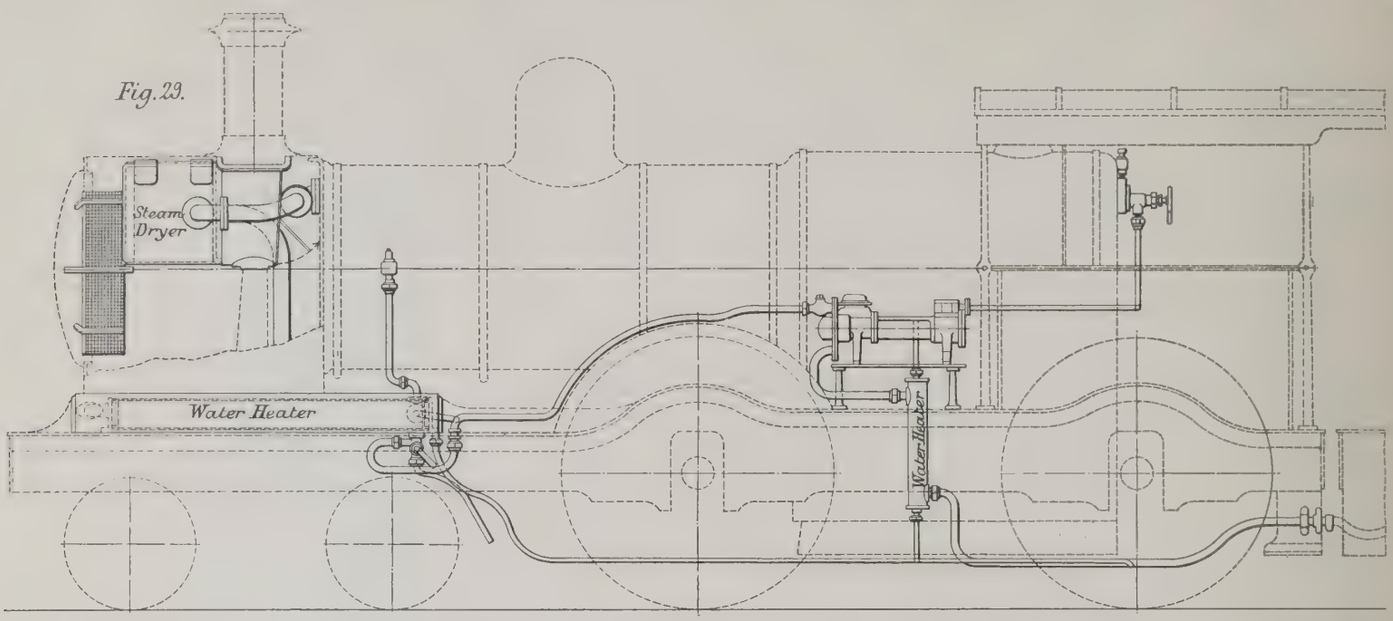


Fig. 30.

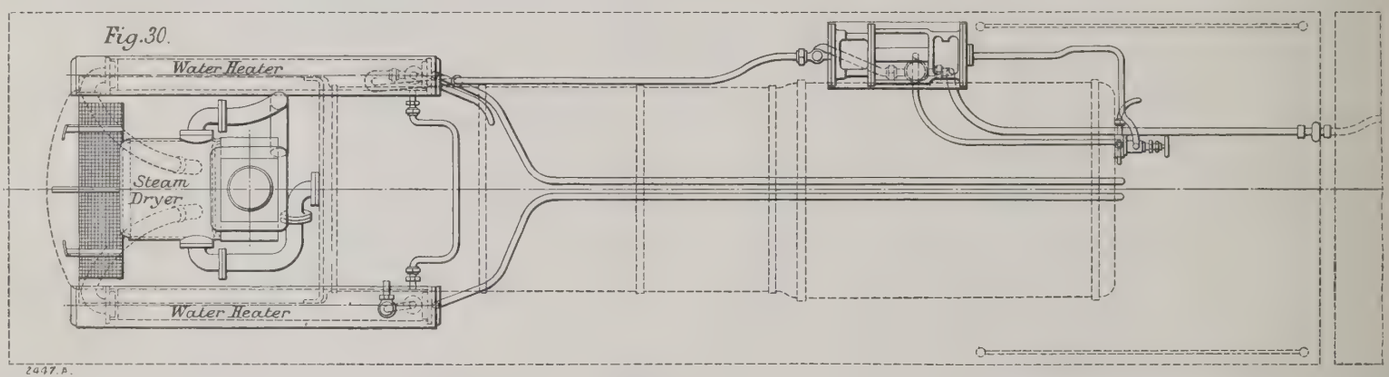


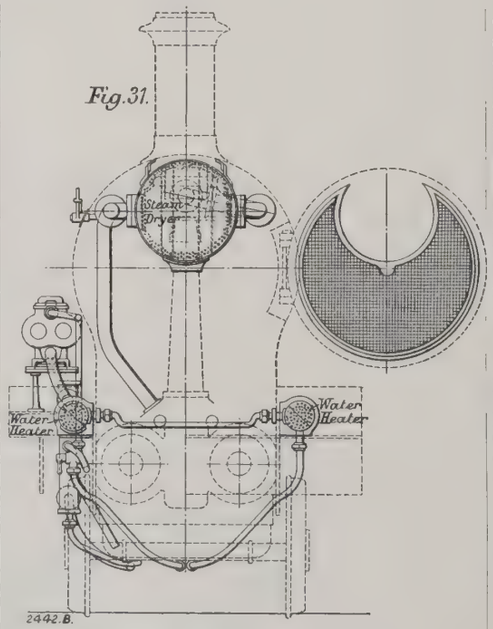
TABLE XV.—*Profit and Loss Account for an Engine Converted to the High-Degree Superheating System.*

Dr.	£ s.	Cr.	£ s.
To interest (5 p.c) on 762*l.*	38 2	By saving in coal ..	207 2
,, depreciation (9 p.c) ..	68 11		
,, maintenance (10 p.c.) on 200*l.*	20 0		
Annual charges extra ..	127 1		
Balance (Profit)	80 1		
	£207 2		£207 2

Though there thus remains a yearly saving even under these conditions, it must be admitted the combined system of feed-water heating and moderate superheating has a great advantage over high-degree superheating as regards conversion, owing principally to the cheapness of installation, due to which the combination system shows nearly double the annual gain.

With regard to new engines, the systems more nearly approach one another, and the high-degree system rises to a much more favourable position. A scrutiny of tenders for new engines of this type and ordinary sister engines shows, from prices quoted by nineteen firms, an average extra cost of 200*l.* for the high-degree superheater engines. The items in the balance are then, of course, altered. It is now a question merely of the depreciation of the superheater, and not of the average of that and other parts, so that the rate to be allowed increases to the 10 per cent., of which account was taken when the 9 per cent. average was arrived at above. Maintenance, however, is the same as before, and with the annual additional charges now amounting to about 50*l.*, made

Fig. 31.



up of 10*l.* interest, 20*l.* depreciation, and 20*l.* maintenance, a yearly net saving of 157*l.* 2s. is shown, or, if allowance be made for the slight difference in economy indicated by the Egyptian State Railway trials (see Table XI., page 620 *ante*), practically the equivalent of the amount arrived at in the case of the new engines on the Trevithick system. For new work the two systems have therefore about the same economic value, as far as facts available enable an accurate estimate to be formed. Since the gradual replacement of existing stock by new engines on either system must take some 25 or 30 years to accomplish, there is evidently a large field for any cheaply-applied system which will enable such substantial annual savings to be shown with existing engines. It is not proposed to go into calculations in support of this, but if figured out, the accumulated waste of, say, the 25 years which must elapse before the replacement of present stock by new engines would be complete, would probably astonish anyone who troubled to make the investigation. There are about 23,000 locomotives in the United Kingdom alone, and over 180,000 in the world.

We have considered the matter up till this point from the point of view of equal train-loads. Both heater systems, however, result in additional power, the Trevithick system, according to results on the Egyptian State Railways, having some advantage in this respect. The real saving to the railways is thus increased in the ratio of the train-loads taken by the heater and non-heater engines, since whether the additional load is revenue-earning or not (as it is frequently not in passenger service), the extra power enables the engine to handle properly the greater load, which otherwise would involve one or other of three things: either excessive coal consumption and lost time with one ordinary engine, or double heading, or the use of a heavier and more powerful locomotive.

To cope with the heavy loads the De Glehn engines were introduced on to the Egyptian State Railways some few years ago, before either heater system had been fully developed. These engines in service average loads of about 335 tons behind the tender, a figure almost identical with the loads taken by engine No. 706 in the trials. It is interesting therefore to compare the relative economic value of these engines. These De Glehn compounds cost the Egyptain State Railways 4800*l.* apiece, or 2078*l.* each more than an engine of the "695" class, plus the extra cost of the Trevithick system of heaters. In repairs the "695" class have cost 1.56d. per mile, to which must be added

the cost of repairs of the heaters—0.08d. per mile; while the De Glehn class cost 193*l.* for running repairs between shoppings, and 393*l.* for overhauling, for a much smaller mileage, the figure working out to 2.7d per mile. Supposing depreciation in both cases to be taken as 4 per cent., giving the engines a life of twenty-five years, which, as a matter of fact, would be rather high under

Fig.32.

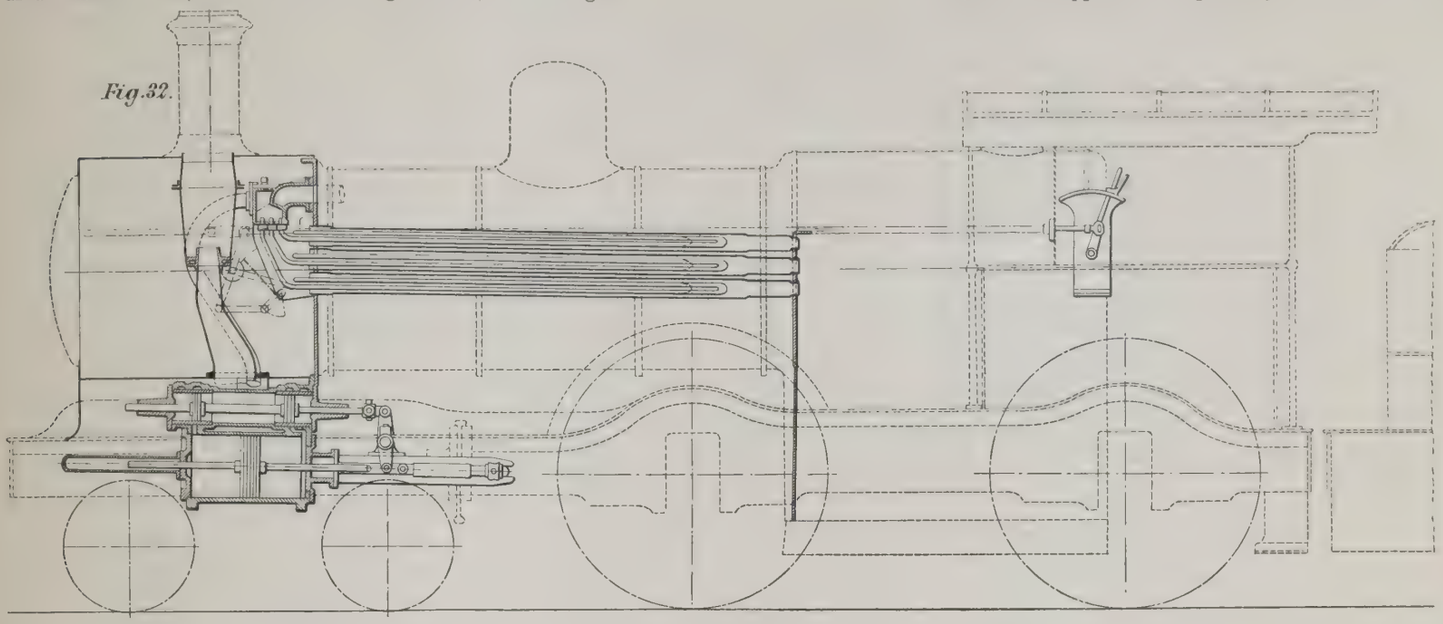
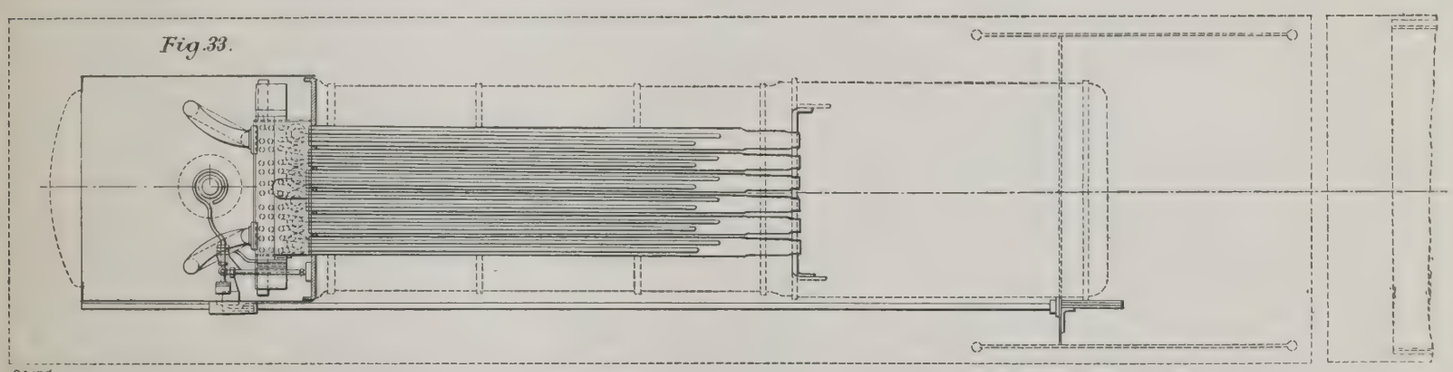


Fig.33.

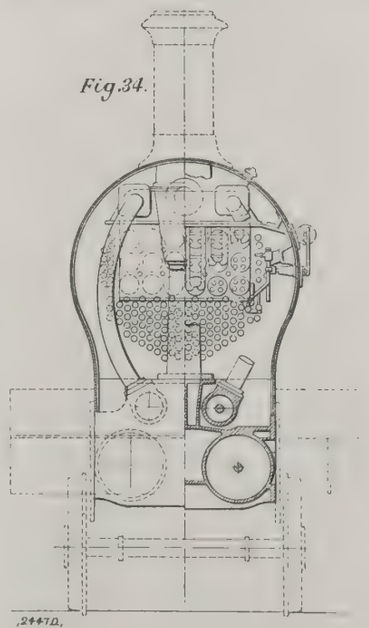


conditions identical with those taken above, the extra cost to be borne by each De Glehn engine, compared with an engine such as No. 706, is as follows:—

	£	s.	d.
Extra interest (5 per cent. on 2078*l.*)	104	0	0
Extra repairs (1.06d. per mile) ...	242	18	0
Extra depreciation (25 years life) ...	83	2	0
	430	0	0

To this annual loss must be added the difference in coal consumption between the two types of engines. Reference to Table XI., on page 620 *ante*, shows that the saving with the De Glehn compounds is only, in approximate figures, $\frac{1}{10}$ths of that realised by engine No. 706. The coal saving for engine No. 706 has been taken as 207*l.* per annum, and the loss by extra fuel used, due to the employment of De Glehn's, instead of engines of the "695" class, fitted with the Trevithick heaters, is therefore 121*l.* 8s. The total loss per annum attending the introduction of these engines is thus on this basis no less than 551*l.* 8s. per engine. If this sum were capitalised at 5 per cent., it would amount to 11,020*l.*, or the price of four additional engines like "706," fitted with heaters for every compound running. This is a striking illustration of the value of the heater systems, and of the advance made in the last few years in locomotive practice. It may be mentioned that the De Glehn compounds were manufactured throughout to designs and specifications of one of the best Continental firms, noted for this class of engine, so that it may be taken that they are fair examples of their kind. The very fact that they were so constructed would add, however, to some extent to the costs of repairs, which in any case are unavoidably rather high in Egypt, owing to various factors which do not affect European countries, while the annual loss to the railways is actually rather less than the figure arrived at, owing to the smaller mileage run. It must also be noted that the limiting train-loads taken by these engines is well above the 335-ton average; but, on the other hand, the limit of the Trevithick engines such as No. 706 is also much over this figure.

Fig.34.



During the trials, for instance, the Trevithick engine took the heaviest train of all, one of 396.4 tons tare behind tender, and on the day following the completion of these trials she handled one of 380 tons tare. The heaviest load this engine has been called upon to take was one quite recently of 406 tons tare behind tender. All these have been satisfactorily worked, in some cases time being actually made up. The coal consumption with these loads has kept very low indeed. A somewhat similar advantage is shown by the high-degree superheater engine over the compounds, but of a slightly lower rate, as the superiority of this engine does not appear to be quite equal to that of the engine fitted with the combined feed-heating and moderate superheating at the higher loads.

We have now dealt with feed-water heating alone, superheating alone, and feed-heating and moderate superheating combined. There remains but to consider the further combinations of high feed temperatures and moderate superheat, and high-degree feed-heating and high-degree superheating combined. These will be taken up in the next article.

THE INSTITUTION OF MECHANICAL ENGINEERS.

An ordinary general meeting of the above Institution was held on Friday last, the 17th inst., at Storey's Gate, Westminster, the President, Mr. E. B. Ellington, occupying the chair.

The Endurance of Metals.

After the formal business of the meeting had been transacted the adjourned discussion of the paper entitled "The Endurance of Metals: Experiments on Rotating Beams at University College, London," by Mr. E. M. Eden, of the Armstrong College, Newcastle-on-Tyne, Mr. W. N. Rose, and Mr. F. L. Cunningham, Graduate, of London, was proceeded with. This paper was read at the meeting of the Institution on Friday, October 20 last, and was then partly discussed. It was reprinted in our issues of the 27th ult. and the 3rd inst., and in the issue of the 27th ult. we also gave a full report of the discussion.

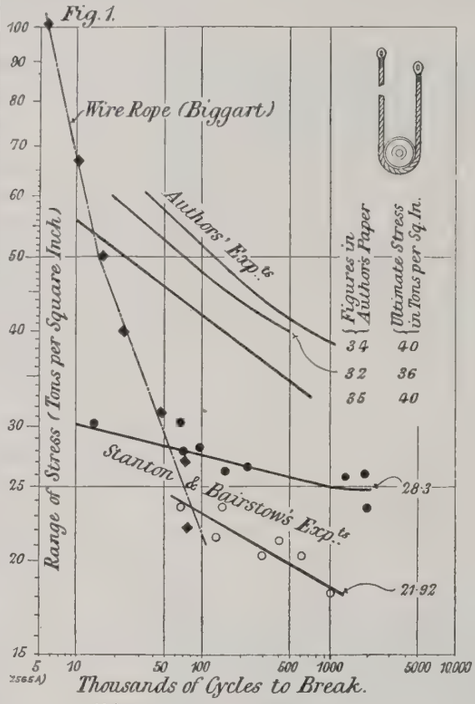
Professor J. D. Cormack, who spoke first, stated that since the previous meeting Mr. Stromeyer had very kindly offered to analyse a number of the mild-steel specimens which were used in the tests covered by the authors' paper, and he hoped the

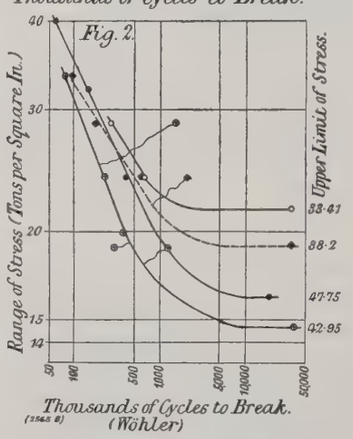
results of the tests would be available later for the members of the Institution. Two of his students had also prepared a number of micro-photographs of the various materials used in the tests, and these he exhibited at the meeting for subsequent inspection by the members. It appeared to Professor Cormack that there were one or two points in regard to the construction and use of the machine which were of interest. One was the absence of shear between the points of application of the load in the neighbourhood of the spot where the bending moment was uniform ; that was a distinct advantage, although the shear in most of the other cases was comparatively small. Another great advantage was the use of short specimens, which could be obtained from a limited supply of the material, and could be readily machined. The power taken to drive the machine, also, was very small, amounting roughly to about a quarter of a horse-power, something like two amperes and 100 volts being sufficient to drive the motor.

The authors had distinctly stated in the paper that they set out originally with the object of finding some material which would give consistent results, and they made no secret of the fact that they had failed to find such material. In the course of their tests, however, they had touched a very large number of interesting points, which, the speaker believed, would throw considerable light upon the behaviour of materials subjected to alternating stresses. He thought there was no doubt as to the manner in which such materials failed. In a paper by Messrs. Ewing and Humphrey, printed in the Transactions of the Royal Society for 1903, the whole process of gradual failure was fully illustrated by photographs. At the end of that paper there was a suggestion that perhaps if the material had some rest after it had been subjected to a number of reversals, it might retain, or return to, its original state—that was to say, it would be capable of sustaining a larger number of alternations of stress if it were frequently rested than if the test were continued straight away to destruction. The authors of the present paper had, he thought, furnished a reply to this, partly because they had noted on their curves the tests during which the specimen was subjected to rests, sometimes of considerable duration ; and, apparently from the curves, resting had no effect at all upon the total number of alternations that the material could stand. That was rather an important matter. It appeared that within the stresses employed in the tests there was no time factor occurring. It was known, of course, that as regards the plastic behaviour of material time was a very important element ; but from the authors' paper the tests were all taken at stresses well within the plastic stress, and no time effect was found.

Another suggestion put forward in the paper was that possibly heat treatment at a low temperature might also affect the result in producing a larger number of total alternations before fracture. He would like to ask the authors whether they tried heating the metal up to a temperature of the order of 100 deg. Cent. Research work had shown that when a material was strained beyond its elastic limit it lost a certain amount of its elasticity, which was, however, restored by the application of a temperature of 100 deg. Cent. for a few hours or more. It would be interesting to know whether the authors had investigated along those lines. As to the relation between the limiting stress which a material would bear with a varying number of repetitions, and the physical properties of the material, the speaker confessed he had no definite idea at present. The ratios that were shown in Table II. of the paper, between the range of stress and tenacity, were extremely interesting, showing that, roughly, for a number of steels, the ratio of range of stress to tenacity was in the neighbourhood of 1. He believed he could supply a figure omitted from that table. In the case of copper trolley wire hard drawn, the range of stress was given as 22 tons per sq. in. The tenacity was not given. Other specimens of similar material tested in the laboratory at the same time showed a tenacity of 25 tons per sq. in., giving a ratio of 1.14. It was an interesting fact that a number of materials gave a ratio of about 1, and that that ratio was more constant than any other ratio which the authors tried to obtain.

A difficulty in the acceptance of the theory of the natural elastic limit, mentioned by Professor Unwin at the previous meeting, was that if there were one natural elastic limit for a given material, then it might be expected, whatever the previous history of the material, that the same limiting stress should be endured for an unlimited number of repetitions. But turning to the curves given by the authors it would be seen that the annealing of a specimen greatly reduced that ultimate stress which the material could sustain with an unlimited number of repetitions. That was the difficulty which the speaker experienced in reconciling Bauschinger's natural elastic limit theory with the results of the tests. A number of other interesting points were explainable from the work of Ewing and Humphrey, and others, in connection with the method by which the material failed. It was shown clearly by the paper that roughness effects had a considerable influence on the endurance of a material. The polished specimens were stronger than the turned,

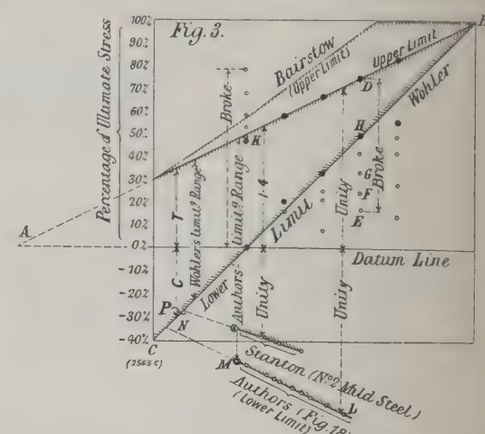


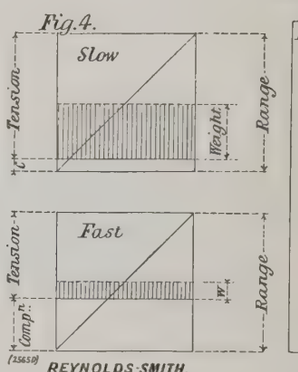


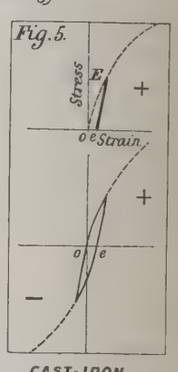
and the turned were stronger than the ground specimens, and that had a somewhat important practical bearing. All would know the effect of punching rivet-holes on the material in the immediate neighbourhood of the holes, and it was just possible that the heavy roughing cuts sometimes used in turning down shafts might have a very considerable effect upon the strength of the shafts afterwards; innumerable cracks might have formed, which might prove the starting-points from which a crack began leading finally to failure.

Mr. Druitt Halpin thought that a good deal of alternating-stress work had been done a long time ago. He would draw attention to a little machine he had brought for the subsequent inspection of members. It had been made early in the 'sixties by a Danish engineer, and, he believed, was shown in the Exhibition of 1862. It had been brought to this country by the late Mr. Olrick, a well-known member of the Institution, who died over thirty years ago. It was driven by clockwork, which, when wound up, imparted an oscillating motion to a horizontal bar. On this bar were five little vices in which the specimens were cramped, weights being attached at the lower end. The machine was set in motion until rupture took place, and a relative result was obtained. The machine included a little mill for cutting the specimens. They passed through that mill, and in that way a standard size was obtained. He was not prepared to say what was the result of using such small specimens, but he showed the machine as being old and historically interesting.

Mr. C. H. Wingfield, the next speaker, wished to draw comparisons between the work of the authors and that of other workers in the same direction. For this purpose he had prepared the diagrams, Figs. 1 to 6, herewith. In connection with Fig. 1, he would explain that in Dr. Stanton's and Mr. Bairstow's experiments the number of

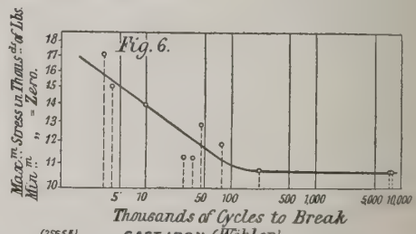






REYNOLDS-SMITH.
Inertia Effect much exaggerated.

CAST-IRON.
"Hysteresis" (?) or Cyclical "Set."



reversals of stress had been given. When those authors spoke of a reversal they meant bending in one direction and then bending back, which corresponded to one revolution of the rotating beam described in the paper under discussion. In Fig. 1 thousands of double bends were plotted along the horizontal. These, in the authors' case, were thousands of revolutions, and bends to and fro in Dr. Stanton's case. The two lower lines in Fig. 1 gave the results obtained with two steels by Dr. Stanton and Mr. Bairstow. This diagram was plotted logarithmically. The three lines above represented three of the authors' steels, copied to a different scale from Figs. 32, 34, and 35 of the paper. With the same number of alternations they had been able roughly to work with a stress nearly double that obtained by Dr. Stanton. This was not accounted for by the fact that the steels were twice as good. He did not think they were. He found, however, that in Dr. Stanton's tests the specimen was approximately equally stressed throughout. In the authors' case the outer fibres were stressed most, and when they began to fail the inner fibres took their place. As the middle of the specimen was approached he thought there

would be plastic yielding; the elastic limit had been exceeded. Assuming that the specimens were not cracked and were still elastic, the stresses would be as he had plotted. Actually, however, the stresses were lower, because of the plastic yielding and of the fibres beginning to help each other. When the authors' steel began to break, a core of sound metal held in the centre, and the outermost edges of the specimen, resting on each other and forming a sort of lever, caused a pull to be exerted on the central fibres of approximately equal intensity for all, and not unequal, as in a beam. They were, therefore, in a better position to take the stress, and this possibly accounted for the large figure obtained compared with Dr. Stanton's.

He had also plotted in Fig. 1 a curve representing tests of a wire rope taken from a paper read by Mr. Biggart before the Institution of Civil Engineers.* These tests had been carried out in connection with the determination of the size of pulleys necessary for the wire ropes used in the construction of the Forth Bridge. The curve representing Mr. Biggart's results went right up nearly to 100 tons range before the specimen broke. This wire had an elastic limit of 50 tons, and it would be seen that at this point there was a sudden kink in the curve, which sloped up more steeply after passing the elastic limit. That, again, was somewhat misleading, as plastic yielding again came in, and the real stress was probably lower than when figured on the assumption made in the diagram that the material was still elastic. He did not see how allowance was to be made for that, but he believed if such were possible the line would continue straight. Mr. Biggart's tests were carried out by running the wire-rope over a pulley, as in Fig. 1, and exerting a definite pull on the rope, first in one direction and then in the other, continuing this process until the rope broke. The authors had pointed out that they had not obtained a horizontal ending to their curve. It would be seen in Fig. 1 that that was so. The curve recording Dr. Stanton's tests was more horizontal.

The authors had omitted a series of Wöhler's experiments which Mr. Wingfield thought more important than any they had mentioned. He referred to that in which, instead of taking a range of stress of equal tension and compression, Wöhler had taken unequal stresses. In this work he had begun with a certain maximum stress and had first tried a large range of stress. If his specimen broke, he tried a smaller range, always maintaining the same maximum stress. The results Mr. Wingfield had plotted in Fig. 2. In one case the maximum stress was 33.4 tons, and in another 47.7 tons per sq. in., and it would be seen that that with the lowest stress was able to stand the larger range. Wöhler carried his tests up to 4 or 5 million revolutions without breaking, instead of stopping at 1 million. In every case he went on until he had satisfied himself that he had reached a permanent condition, though Mr. Wingfield did not think that he had convinced himself of this by plotting his results. The horizontal portion thus reached, the authors had failed to obtain.

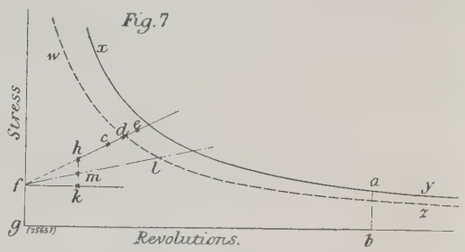
Fig. 3 showed a method of plotting adopted by Professor Goodman. The assumption made in it was that, taking the diagonal as a base, and plotting the range from it, the upper limit of range would come halfway between the lower limit and the line of maximum stress. In that way, Professor Goodman had set down the line A B before he placed any spots upon it. Mr. Wingfield had put down Wöhler's results on this diagram, but, for convenience, had taken the line A B as a base instead of the line B C. For instance, the point D represented the upper limit of stress of one of Wöhler's trials. Below that the point E represented a stress corresponding to a range which was far too big. The material broke. Wöhler then tried in turn ranges represented by the points F, G, &c., until he obtained the point H, at which it did not break; other points were obtained in the same way. From the datum line tension was measured upwards and compression downwards. Starting from zero stress, Wöhler, in another series of experiments, obtained the point K. Another point the speaker had not troubled to put down, but it was shown in Professor Goodman's book, and fell on the line A B at its lower end. The authors had not taken varying ratios of stress, in their case tension and compression always being equal. They had tried many ranges, but had never been able to get a result which gave the stress which they sought, corresponding to horizontality. The line L M represented the authors' experiments. If produced, it would cut the line C B at N, the only place where tension and compression were equal. Messrs. Stanton and Bairstow had done much the same thing, but had worked with a ratio of tension to compression of 1.4. There again, the ratio being constant, they could only get one point P in the Goodman line. Neither Dr. Stanton nor the authors had carried their work sufficiently far to arrive at these points. Wöhler's mode of experimenting was better adapted for the purpose engineers had in view—viz., of finding out the range which could be safely used with any given maximum or minimum stress.

A set of experiments by Professors Reynolds and Smith were shown diagrammatically in Fig. 4. In these the same method had been adopted as in Dr. Stanton's experiment, except that a connecting-rod took the material upwards and downwards instead of moving it horizontally. The test-piece was attached to a weight, the inertia of which ultimately broke it. Fig. 4 was the ordinary inertia diagram, which steam engineers would readily recognise. The weight applied had the effect of adding to the tension and diminishing the compression. When going fast, in order to get the same range it was necessary to use a lighter weight, with the result that the compression was nearly equal to the tension. The experimenters had confined themselves to weights which gave nearly equal stresses, as far as these were obtainable. It was clearly possible by this method to vary considerably the ratio of tension to compression.

Mr. Wingfield next passed on to the subject of cast iron. He had read a paper some years ago before the British Association* on "Piston Rings," in which he showed that the stress-strain curve for cast iron followed a line such as the dotted line O E in the upper diagram, Fig. 5; but if when a certain point E was reached the stress were relieved, the stress-strain curve would become a straight line E *e*. If there were always a plus tension on it, it would behave as an exceedingly good spring. This property had been utilised by Messrs. Willans and Robinson for springs for their piston-rings, and, whether cold or hot, could always be relied on. He had found that by merely squeezing the ring by hand it would take a set indicated by the distance O *e*. He believed that this effect corresponded to the hysteresis diagram for steel, which Mr. Bairstow had described in his paper† before the Royal Society. He had indicated that in the lower diagram, Fig. 5. He believed that cast iron would not stand indefinitely reversals of stress; but stressed to a greater or less degree always in the same direction, he thought it an exellent material. Tests by Wöhler, always in the same direction—from zero to maximum loads—gave a fairly definite curve, as shown in Fig. 6. The question had been raised as to why increased speed had the effect of reducing the stress at which materials broke in the case of the Reynolds-Smith tests, but not in the authors' tests. The Reynolds and Smith tests were run at 1200 revolutions and upwards, while the authors' did not go beyond that figure. The speaker had records of experiments made in America to find out why certain piston-rods broke. These experiments consisted in running model connecting-rods much in the same way as Dr. Stanton had done, but at a speed of 1200 revolutions. In nearly every case the rods became extremely hot before breaking, and that, the speaker thought, was the explanation of Professor Smith's results. Doubtless these rods got very hot indeed, all the fibres being equally stressed; whereas in the authors' tests the core would be available to conduct the heat away, as it was generated principally at the outer surface.

Mr. L. Bairstow, continuing the discussion, said that the authors had drawn some conclusions from their experiments and from those of others. Amongst the latter were the experiments carried out at the National Physical Laboratory, and associated generally with the name of Dr. Stanton. As Dr. Stanton was unable to attend, he wished to say a few words on the subject of those experiments, as being, after him, the person most nearly connected with them. Two of the authors' main conclusions were, speaking generally, not entirely new to Dr. Stanton and himself, but they had not so far been published in the reports of the Laboratory. The first of these conclusions was that the steel withstood alternations of stress—in other words, resisted fatigue—much better than wrought iron. The second conclusion was, that for rotating beams the effect of speed on the safe limit was negligible. So far he was entirely in agreement with the authors, but they had proceeded to make a rather important statement to the effect that there was not sufficient evidence for assuming that a limit of range of stress existed. This, the speaker thought, arose largely from the method, adopted in the paper, of plotting logarithmically.

From the point of view of interpretation, a more convenient method than that followed by the authors was to plot the stress against the reciprocal of the number of revolutions. Suppose *x y* (Fig. 7) to represent one of the authors' curves, then, if *b* represented a million reversals, and the reciprocal of *a b* were plotted, a point *c* would be obtained. A series of such points, *c*, *d*, *e*, &c.,



were obtainable, and these, for a considerable distance, lay in a straight line. If that straight line were produced back until it cut the axis of stress, the height *f g* would correspond to a stress which would be withstood by a specimen indefinitely; and if the authors' results were plotted in that way, the stress at one million reversals would not be very greatly higher than the limiting range of stress. If Bauschinger's relationship or suggestion, that the point *f* also represented the elastic limit of the material, were accepted, then the physical interpretation of this form of plotting was that the amount of damage done to the specimen per revolution, was proportional to the amount of stress by which the elastic limit was exceeded, as, for instance, *h k* in the case represented by the point *h*.

At the end of a million reversals the authors had not nearly reached the limit of stress. That was the experience of everybody else, and Bauschinger and Wöhler both found that for rotating beams the limit of stress was not reached at one million reversals. The same result had been obtained at the National Physical Laboratory in experiments not yet published. If, however, on the same diagram were plotted a fatigue curve for the same material with uniform distribution of stress, the curve would, on the whole, lie below the curve given by stressing under the conditions of a rotating beam, as, for instance, *w z*, and would gradually approximate to the same limit towards *z*. The line *f l* would then correspond to the reciprocal point line, being at a less angle, and the damage done would be represented by *m k* instead of *h k*.

When at the National Physical Laboratory they had thought of starting experiments on rotating beams, the question arose as to the most suitable form of test-piece, and, bearing in mind the sort of effect to which he had referred, a specimen was tried which was solid, and which was expected to break at a range of stress of about 27 tons per sq. in. As a matter of fact it stood $1\frac{3}{4}$ million reversals without breaking, at 31 tons per sq. in. The test-piece was examined microscopically, and found to be cracked; evidently it was in danger of breaking. A similar specimen was then made hollow, so that the stress was much more uniform than in the solid specimen, and the time of the experiment was thus reduced by rather more than one-half. The specimen broke before three-quarters of a million reversals, instead of remaining unbroken after $1\frac{3}{4}$ millions. It would seem, therefore,

* Proceedings of the Institution of Civil Engineers, vol. ci.

* See ENGINEERING, vol. lxxvi., page 401.

† In the paper referred to Mr. Bairstow had given the results of tests with varying ratios of tension and compression. Mr. Wingfield had replotted the tests on axle-steel in the upper part of Fig. 3. It was remarkable that Mr. Bairstow had apparently succeeded in getting quite a wide elastic range with an upper limit of over 99 per cent. of the ultimate stress.

that in order to get accuracy corresponding to that in the direct-tension test, it would be necessary to go to something in the order of 5 million or 6 million reversals to correspond to the one million reversals with the direct-tension test.

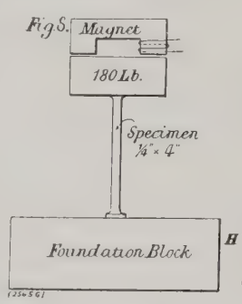
In considering the effect of alternating stresses generally, it was now fairly evident, the speaker said, that the types of machine which produced alternating stresses in rotation, gave, on the whole, higher results than the machines in which the stress was uniformly distributed across the section. It was interesting to try and trace some cause for this difference of result. The figures quoted for Wöhler were apparently somewhat too high; some uncertainty existed as to the exact units in which Wöhler worked, but the figures quoted by Bauschinger, and by Professor Ewing in the "Encyclopedia Britannica," gave results which were roughly two-thirds of those quoted in the paper, and that difference, if it really existed, would appear to be more due to the improved quality of modern material than the method of test. If the Wöhler test were left out, and Bauschinger were taken as typical of the remainder, it would be found that in 1886 he published a paper on the effect of changing stresses from zero to the maximum tension, and from these results he had ventured to predict the results that he would get later on on a rotating beam. As a matter of fact the results were not published until after he died, and the discrepancy was roughly 2 to 1, the rotating beam giving approximately twice as much range as the direct tension specimen.

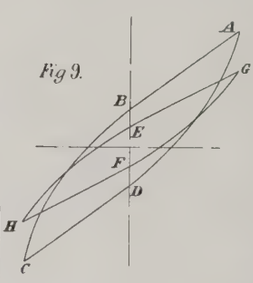
Mr. Bairstow thought there might be two explanations of the discrepancy between the two types of test. One was that fatigue was not yet thoroughly understood, and the other was that the difference was due to the testing machine. It was probable that the latter was the real cause of the difference. In the connecting-rod experiments which had been referred to by the previous speaker, the original crank had a throw of 2 in.; the specimens broke, and the results are quoted in the paper. In order to find out whether the obliquity of the connecting-rod had any effect or not, the throw of the crank was changed to $\frac{1}{2}$ in.; that meant that in order to get the same stress and the same speed, either the specimen had to be decreased in diameter or the reciprocating mass increased. The first experiment was to increase the mass, and the results were very decidedly lower than were expected. As a consequence, the whole machine was thoroughly overhauled; new slides were made, and still the results were discordant. The method of experimenting was then altered to a smaller specimen, and the tests were repeated and gave results identical with those previously obtained, showing no change due to obliquity. No doubt in this case the difference was due to the machine, and the speed effect found by Reynolds and Smith, and to a lesser degree at the National Physical Laboratory, was probably due to the peculiarities of the machine. It, however, illustrated the great difficulty of the whole question, for both machines were designed particularly from the point of view of being able to calculate the stress accurately, and yet, for no obvious reason, the machines did not give the stress expected of them. It was quite possible that a good many of the failures that occurred in actual practice were not due to faulty material, but to the fact that the stresses which occurred in machines were not correctly estimated.

There was one other question to which, in conclusion, Mr. Bairstow wished to refer. The alternating stress test certainly would pass brittle materials. He had had experience of materials, which subsequently fractured, passing the alternating tests quite easily. The proper test for brittle material was the impact test, or alternating stress test of Professor Arnold. The only thing that the impact test and the alternating stress tests did not do, was to detect material which was quite ductile and which had a very low resistance to alternating stress. It appeared that in order to ensure proper material both tests were quite necessary.

Professor B. Hopkinson was the next speaker. The part of the paper which most interested him was that giving the graphical representations of the results, Figs. 29 to 31, which, in his opinion, showed fairly conclusively that the speed at which the machine worked did not make much difference to the number of reversals of stress which a piece would stand before breaking. From Mr. Bairstow's remarks he gathered that this conclusion had been confirmed by the unpublished work done at the National Physical Laboratory. The speaker had recently been interested in the same question, and he had constructed a machine which gave reversals of stress at a much higher speed—about 7000 a minute, or 120 per second. With that machine, when the speed was pushed to the extent named, the resistance to stress, or endurance, reckoning the number of reversals, was not much increased beyond what it would have been at a lower speed. He would shortly be publishing elsewhere a full account of the machine, with the results obtained, and would now only briefly explain its principle and give a summary of results.

The machine was constructed as in Fig. 8. The test-piece, which was a bar about $\frac{1}{4}$ in. in diameter by 4 in. long, was fixed at its lower end to a heavy block of cast iron, which in turn was bolted to a concrete bed. It carried at its upper end a weight equal to about 180 lb., that weight being guided so that it could only move in a vertical direction. Above the weight was an electro-magnet made of laminated iron, with a laminated armature fixed on the top of the weight, there being only quite a small air space between them. The magnet was excited with alternating currents, and the weight carried on the top of the test-piece, which behaved as a spring, was so adjusted as to be equal, or nearly equal, to the period of the magnetic pull exerted by that magnet, so that a swing was got up on it. In that way it was quite easy for a magnet of moderate size to produce stresses up to 40 tons per square inch, in tension and compression alternately, at the rate of 120 times a second. That,





the speaker said, was the general principle of the machine, but, of course, a good many details had been necessary to make it a practical success.

He had carried out a good many endurance tests with the particular mild steels examined, and, to give an instance, he had found in one case one which would stand a range of stress of 28 tons per sq. in., applied at the speed named, for well over 10 million reversals. He gave those figures from memory. The same steel tested in a direct-stress machine working at 1000 revolutions per minute—according to tests which Dr. Stanton had carried out for the speaker at the National Physical Laboratory—would break on an average at about 100,000 reversals at the same range of stress. There was no question, without stating the figures, that the endurance reckoned in number of reversals was greatly increased at the higher speeds. Running at that speed meant, of course, a vibratory stress. As to the reason for expecting such a result, Mr. Bairstow had very well said that the endurance of stress should be measured by aid of the fact that at each reversal of stress a certain amount of damage was done to the test-piece; roughly speaking, that would be proportional to the amount by which the stress exceeded the elastic range. Consequently, so long as the stress-strain cycle were the same at each reversal of stress, so long might the number of reversals of stress endured be expected to be unaltered by the speed. At each reversal, whatever the speed, the same amount of damage would be done to the material. If, however, the speed were such that the relation between stress and strain were materially altered, then, possibly, a considerable variation in endurance might be expected.

Referring to this question of very high speed, he would say that Mr. Bairstow had, in a very interesting piece of work—buried, the speaker feared, in the "Transactions" of the Royal Society—examined exactly what happened to the stress-strain relation of a piece undergoing alternating stresses. He had found that the hysteresis curve took, after a time, the form shown in Fig. 9, in which the portions A B and C D corresponded to perfect elasticity, while for the portions B C and D A, which were curved lines, the material did not behave as "elastic," and during that time must be regarded as "flowing." It was known, from the researches of Ewing and Humphrey, that the damage originated in the small slips produced in the material when the stress exceeded the elastic limit. He would therefore re-state Mr. Bairstow's remark about damage done thus:—The damage done was proportional to the amount of the extra elastic strain, represented in Mr. Bairstow's diagram by B D, which Mr. Bairstow had called "the cycle of permanent set." He conceived that when the stress cycles were sufficiently slowly performed, the form of the stress-strain diagram would not be materially altered by the speed, as the flow would not change in amount. But if the speed exceeded a certain limit, then the material had not time to flow to the amount represented by B D. Instead of obtaining the diagram A B C D, therefore, one more like G E H F resulted, an area of the same general character, but smaller; that was, with a smaller amount of cyclical permanent set E F. He had little doubt that with frequencies of 2000 a minute, something of that kind was obtained; in other words, the steel became more elastic under a given range of stress, at a high frequency than at a low one. Since Professor Hopkinson had done the work referred to, he had, he said, learnt that Professor Kapp had designed a machine similar to his own, so far as making use of the pull of an alternating-current electro-magnet to cause stresses was concerned. Professor Kapp, however, had not employed the principle of resonance, which, in the case of the speaker's machine, was an important feature.

Mr. L. Pendred spoke on the subject of the corrosion of test-pieces in the holders, mentioned by the authors. They had said "there seems to be no doubt that this corrosion is due to the varying stress between the test specimen and its holder." Taken literally, that meant that corrosion, which was a chemical action, was being produced by an action which was purely mechanical. It would be wise, he had thought, in the present state of knowledge of the subject, to treat this statement with a good deal of scepticism. It was an elementary doctrine of science that of two possible explanations the simpler should be accepted. In the case under notice the simpler explanation would be that by some means or other an electrolyte has found its way between the jaws holding the specimen and the specimen itself. But there was difficulty in finding any means by which an electrolyte, or liquid of any kind, could get between the jaws. It was probable that, supposing the production of an oxide by mechanical means could really be substantiated, nearly all experimenters with this class of test would have found corrosion.

He had attempted to gather together some information on this point, and had written to Dr. Stead, Dr. Arnold, Mr. Kirkaldy, Mr. Heathcote (Coventry), and Professor Harbord, none of whom had found anything of the kind. On the other hand, Dr. Stanton and Mr. Saniter (of Messrs. Steel, Peech, and Tozer) had found it. He had brought specimens which these gentlemen had sent him, and they were remarkable. One was a specimen of a tube, tested at the National Physical Laboratory, which showed the corrosion marks where the jaws had held the specimen. The curious fact was that the patches of rust were separated by little bands on which there was no corrosion at all. That suggested that the corrosion was in some way set up by the action of the jaw itself upon the mild steel. There was no corrosion whatever inside the tube, where the alternating stresses must have been nearly the same as on the outside. Plainly, therefore, it was not due to atmospheric effect upon the specimen alone, but to some interaction, probably between the jaws that held the specimen and the specimen itself. That would be supported by knowledge of the fact that a specimen of steel that had been stressed was more subject to corrosion than a steel that was unstressed. Mr. Saniter's specimen was also interesting. In this case the specimen had been held in a hole drilled in a block of steel, which was rotated by an electromotor, the hole being only $\frac{1}{100}$ in. bigger in diameter than the specimen, which was held in place by set-screws spaced equally around it. The specimen was under test only for 150 minutes, and yet there was marked discoloration all round it. It had originally been polished, and was put in perfectly bright. There was no obvious reason why water should have got near it at all, or, if there had been water, why it should have acted with such extraordinary rapidity. Dr. Stanton's

THE JUNKERS OIL-ENGINE.

(*For Description, see Page* 698.)

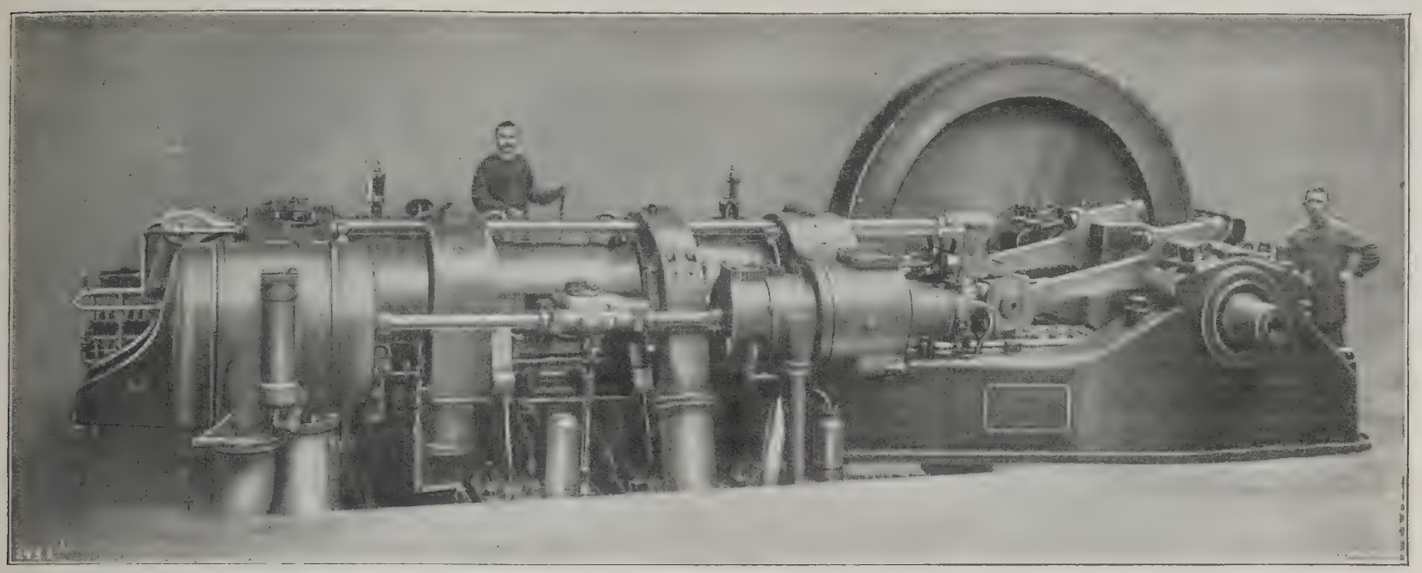


Fig. 1. 1000-Brake-Horse-Power Horizontal Engine in Testing Laboratory at Aix-la-Chapelle.

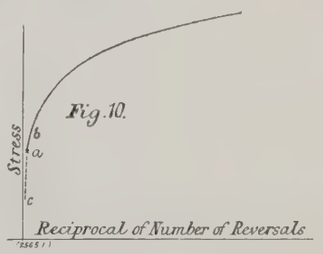
test had made 1.9 million reversals of stress, and Mr. Saniter's had made 600,000 revolutions at 4000 revolutions per minute.

It would be agreed that further investigation of so curious a fact was desirable. In many mechanical contrivances pieces of steel were pushed inside holes in steel and cast iron, and worked regularly under stress for long periods of time. One instance that might be taken was the case of crank-pins forced into cranks. These were under alternating stress frequently for many years. Corrosion was never found between shaft and boss, or between the pin and the boss, and the same might be said of wheel centres and axles, where there was a steel centre and a steel axle. He would suggest to the authors, in relation to this matter of corrosion, that they should try the effect of dipping the specimens in a 5 per cent. to 10 per cent. solution of bichromate of potash. That course had the effect of putting the iron into a passive state, and it then refused to corrode, even in a moist atmosphere. If that were not effective, dipping the specimens for five seconds in a fairly strong solution of sulphate of copper might be tried. That would deposit over it a very fine film of copper, which would probably have no effect on the strength of the material.

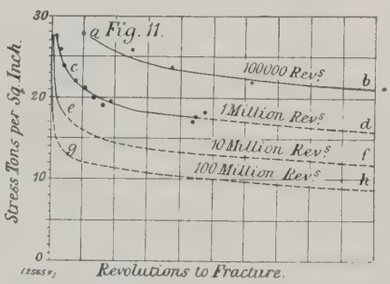
Mr. E. F. Etchells said that while the paper was very interesting, it had not revealed the existence of the limit of stress, the authors being even in doubt whether this existed or not. He would suggest that if the number of repetitions required to produce fracture were plotted reciprocally, there would be a massing of points at the beginning of the curve obtained, which would give an indication of the actual existence of the limit of stress. He would suggest that this limiting stress should be taken as the stress upon which the working stress should be fixed. Mild steel would withstand a stress of about 30 tons, but the working stress was usually taken as a fourth or a fifth of that figure. If it were believed that the material would break at 30 tons, it did not seem a very wise thing to stress it only to 5. Taking the limit of continued endurance as a base, the working stress might be taken as a somewhat higher fraction of that figure—perhaps half. That would cover the secondary stresses, which did not always appear in the calculations, but almost always existed. If the authors had helped to shorten the gap between theory and practice, between the very high stress and the lower working stress, the paper had fulfilled a very good purpose. Whether the limiting stress existed or not, it did not disturb engineers in their daily work. It was well known that a 100-year life at a 4-ton stress would fulfil all reasonable requirements, although perhaps a 3½-year life at 6-ton stresses would better please the vendors of machines.

Mr. E. Segundo said that in working out, about three years ago, the practical design of a machine, he had a very interesting instance of the extreme molecular changes brought about by vibration. Having no precedent to work upon in designing such a machine, he arrived at a section of 18 mm. square as the size for a beating arm, which rotated round a vertical axis at 750 revolutions per minute, presumably hitting the fresh material fed in, once in every revolution. The arm was therefore presumably subjected to bending action 750 times a minute, or about one million times in twenty-four hours. The factor of safety, as the speaker understood it, was about 100. Notwithstanding that the beater was made of tool steel, it broke off short after about a week's work. The fracture was exactly like that of very fine cast steel. He had then sought the help of Sir Robert Hadfield, and had had beaters made containing 15 to 18 per cent. of nickel. But exactly the same thing happened, though they may have lasted a day or so longer. He had tested a fresh beater on an anvil and had ultimately broken it by blows from a 28-lb. sledge. The fracture in this case was like a bundle of fibres quite different in character to that of the beaters broken in the machine. The only solution he had been able to resort to was to have the sections considerably enlarged. Two of these beaters he exhibited, one being worn down without breaking, although kept on day and night for two years continuously. The other beater showed the original form before wear.

Mr. E. M. Eden, in replying to the discussion, said that no attempt had been made in the paper to establish any relation between the limit of stress and either the tenacity or the elastic limit. The tenacity had been adopted in the authors' test as a better guide than the elastic limit as to whether the material would give a high limiting stress. In Table II. the steels were ranged in the order of their tenacity, and that was also the order of the range of stress causing fracture after a million revolutions; if arranged in the order of the limit of elasticity, that sort of agreement would not be obtained; with the exception of the Reynolds-Smith tests, agreement of that kind had been shown by other experimenters. He wished it to be understood that he did not say that there was no such thing as a limit of stress; it was much more likely that it existed than that it did not. All he wished to emphasise particularly was the great uncertainty in the determination of the limiting stress. A new method of finding out that value had that evening been suggested—viz., plotting the stress against the reciprocal of the number of revolutions. Professor Unwin and Mr. Stromeyer, and another speaker, had objected to one method which the speaker had shown—namely, the logarithmic plotting. There were certainly objections, but the speaker thought that the reciprocal method was even worse. Plotting the logarithmic stress against the logarithm of the number of revolutions tended to give the impression that there was no limiting stress. With the reciprocal method there was a tendency to get a definite value. He had himself used the reciprocal method of plotting, with the following result:—Plotting the stress against the reciprocal he had not been able to get a straight line, but a curve which went down like that shown in Fig. 10. It was easy enough to consider a short piece $a\ b$ a straight line, and to say that a was the limiting

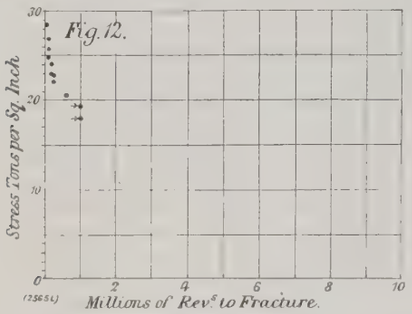


stress, but this could no more be rightfully done than to bring the curve down to c. The whole point of the matter was that there was a tendency to continue the curve on too far. Mr. Eden proceeded to illustrate this by a lantern-slide, reproduced in Fig. 11. This was prepared to illustrate the objection to the ordinary method of plotting.



If a logarithm of the stress were plotted, there was a likelihood of being fooled over it, and the same remark applied to reciprocal plotting. If the stress were merely plotted against revolutions, there was a likelihood of going wrong as to the limiting value, at the point where it becomes horizontal. In Fig. 11 were four curves, the stresses being plotted vertically, and the revolutions horizontally. A guess might be hazarded as to what the point, where they became horizontal, was, and a different point found for each; as a matter of fact, they were all

the same curves plotted on different scales. The curve $a\,b$, Fig. 11, represented series No. 29, stress being plotted against revolutions up to 100,000 revolutions; the curve $c\,d$ represented the same curve carried on to a million revolutions. The experimental part was represented by the points on the black portion only, and not by the whole curve prolonged by the dotted line. The next curve, $e\,f$, showed the same thing, but carrying the curve up to 10 millions, and again the only experimental portion was shown in a full black line; the rest was absolute guess-work. The last curve, g, h, showed the same curve carried up to 100 million revolutions, and it was the right-hand end of that curve that he believed the meeting to be interested in. The experimental part was again shown in the full line, and the form of the curve depended on this experimental part. It was possible to put the dotted part of this curve anywhere. It was too vague to convey accurately what the limiting stress was by these means. The limiting stress, if, as he was inclined to believe, it existed, had not been very definitely determined. The experimental part of the test did not go up to a very high figure—only half a million. In attempting to go further on that curve the points got very irregular, and it became more difficult to get a definite curve. He would point out particularly that it was no use going by the individual points unless a number of other points on the same curve were considered. In the steel test of Wöhler, where it was easier to get definite results, points were hopelessly irregular. The mere fact that two points happened to give different values for a number of revolutions with the same stresses did not prove that the curve had become horizontal. In looking at any of the curves he would warn those interested against being guided by the smooth straight line of the curves, and not by the observation points. In the diagram, Fig. 12, one of the series of tests (No. 22) was shown without any curve drawn in. To arrive at



the point where that curve became horizontal, it had to be continued on. To get the point of most interest—say 100 million revolutions, or something of that sort—it would be necessary to continue it on towards the right to about ten times the length of the diagram.

Mr. Eden continued that, as far as he could make out, Professor Arnold had argued that the Wöhler tests were useless. The Arnold testing-machine was certainly an alternating-stress test machine, but the reason why no results from that machine had been included in the paper was that they could not be compared with the Wöhler tests, as they gave entirely different results or effect. The speaker understood that the machine was originally intended to give a reflection of the Wöhler results in a short space of time. It was found that it did not do so, but gave quite different results. The arguments of Professor Arnold had been, to some extent, that the Wöhler tests did not show up unsatisfactory and brittle material. The speaker did not think they did, nor did he see any reason why there should be any assumption that they did so; brittle material was bound to be unsatisfactory for withstanding alternating stresses, and in the case of the machine referred to the brittle material could not possibly stand the test. It appeared that Professor Arnold's machine gave rather a test of toughness, or some figure of the kind, than anything else. The other point mentioned by Professor Arnold was that the Wöhler test gave a more or less faithful reflection of the elastic limit; the speaker did not consider that to be the case. In a test of a 25 per cent. nickel steel the authors had been thrown out by making that assumption. It was thought that because the material had a low elastic limit it would do badly in the endurance tests. In the first six tests the load was much too small, so that no fractures resulted. The first six test-pieces were absolutely wasted because the authors had been led away by the idea that the limit of elasticity might have been some sort of guide.

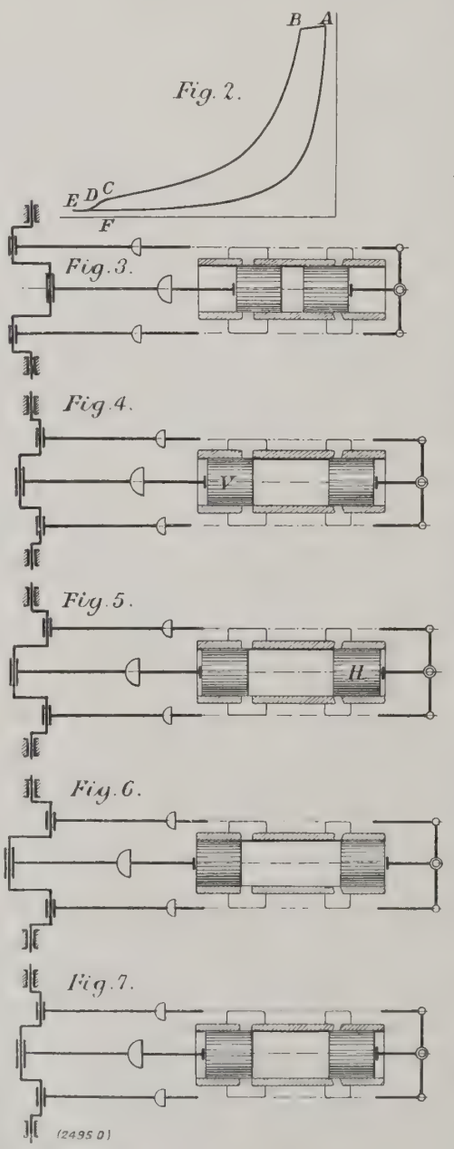
Double-Cutting and High-Speed Planing-Machines.

A paper entitled "Double-Cutting and High-Speed Planing-Machines," by Mr. J. Hartley Wicksteed, of Leeds, Past-President, was next read by the author. This paper we print in full in the present issue. The discussion on this paper was adjourned to the next ordinary general meeting, which will take place on Friday, December 15, at which meeting, if time permits, a paper on "Oil-Burning Locomotives on the National Railway of Mexico," will be read by Mr. R. Godfrey Aston, graduate, of Mexico University.

In connection with the above discussion on the "Endurance of Metals," it may assist our readers to know that a very complete account of Wöhler's work on the subject was given in 1871 in a series of nine articles in Engineering, vol. xi. These articles described the methods of testing, and the apparatus, and gave the results in full.

THE JUNKERS MARINE OIL-ENGINE.

Of the several marine oil-engines now being constructed in Germany for merchant ships, interest attaches to that designed by Professor Junkers, not only because it has been evolved as the result of considerable experience, but because it involves differences



in important features from other engines. Although fuller experience may modify the details, they are worthy of careful study in the present state of knowledge of this type of prime mover. We therefore reproduce on our two-page plate, and on this and the opposite pages, illustrations which show the principle of the engine, the mechanical details, and the general arrangement of the machinery to be fitted in an ocean ship for the Hamburg-America Line, being built by the Weser Company, of Bremen, who are also constructing the engines illustrated and hope to have them ready for trials in their works before the end of the year. Several other German firms* have acquired the right under licence to build this type of engine for both stationary and marine purposes.

A 200-horse-power experimental engine, constructed at Professor Junkers' testing laboratory at Aix-la-Chapelle, gave the data for the construction of a horizontal land engine of 1000 horse-power, which is now undergoing tests at Aix-la-Chapelle. The view, Fig. 1, page 697, shows this latter engine on the testing-bed. It has two tandem cylinders 450 mm. (17¾ in.) in diameter with a stroke of 450 mm. Two pistons work in each of the two cylinders, and these latter are placed one behind the other. As will be seen from details on the two-page plate of a vertical engine (Figs. 8 and 9), two of the pistons act through a return crosshead on cranks on each side of the central crank, which is actuated by the other pistons. The outer cranks are set at 180 deg. with reference to the middle crank. The engine works on the two-cycle principle; by the aid of the tandem arrangement of pistons there is double action. While the pair of pistons in the one cylinder is effecting an outward travel on the working stroke, the pistons of the other cylinder travel inward on the compression stroke. The scavenging air enters through a row of ports at the one extreme end of the cylinder and expels the exhaust gases through ports at the other end of the cylinder or combustion space between the pistons. The working pistons themselves open and close the port openings; complicated governing gear and scavenging-valves are thus obviated. Cylinder-covers and stuffing-boxes are also dispensed with.

The action of the engine may be explained by aid of the diagrams, Figs. 2 to 7, in which, for sake of simplicity, a one-cylinder arrangement is reproduced. In Fig. 3, showing the innermost position of the pistons, the combustion-chamber, after a preceding compression stroke, is filled with highly compressed and highly heated air. The fuel is then injected during part of the ensuing outward stroke, and by means of compressed air and in a finely divided condition, ignites and burns under almost constant pressure during the first part, from A to B in the diagram, of the outward stroke (Fig. 2). During the outward stroke the expansion of the products of combustion from B to C is effective. At C the pistons have reached the position shown in Fig. 4, in which the front piston V is about to lay bare the ports in the cylinder-wall through which the spent gases exhaust into the atmosphere. At the position of the pistons shown in Fig. 5 (C to D in the diagram), the pressure of the gases in the cylinder is equalised approximately with that of the atmosphere; in this position the rear piston H opens its ports and admits fresh air at low pressure to the cylinder, which, driving the remainder of the exhaust gases in front of it, expels them from the cylinder through the ports in the cylinder-wall. This scavenging takes place till the outer dead-centre position of the pistons (Fig. 6) has been passed up to about the piston positions shown in Fig. 7, in which the pistons on the return to the inner dead-centre have closed their respective ports (distance D, E, F in the diagram). At the point F, the cylinder is filled with fresh air, and the contents of the cylinder are then compressed as the pistons approach one another up to the inner dead-centre in Fig. 3 (distance F to A in the diagram). The compressed air becomes heated to such an extent that the fuel, which is injected at or shortly before the point A, ignites immediately, whereupon the process is repeated.

The scavenging-pumps and compressors necessary for the supply of air for scavenging and for spraying the liquid fuel are arranged symmetrically with respect to the cylinder axis; they are driven by the return crosshead, as shown in Fig. 8, on the two-page plate, which, however, illustrates a marine vertical engine.

Each cylinder is provided with two fuel-valves and one compressed-air starting-valve. The fuel injection is so designed as to spray the oil over a large surface of the combustion air, while the engine is on the dead-centre and during part of the working stroke.

In the Junkers engine the cylinders consist of simple castings; the side-rods are of forged material. The cylinders rest on simple elastic supports made of I-shape bars.

The cylinders have no covers; the latter, as is well known, frequently give much trouble in other types of oil-motors. The pistons are on one side always in contact with atmospheric air, and run during every outward stroke in cool portions of the cylinder, which

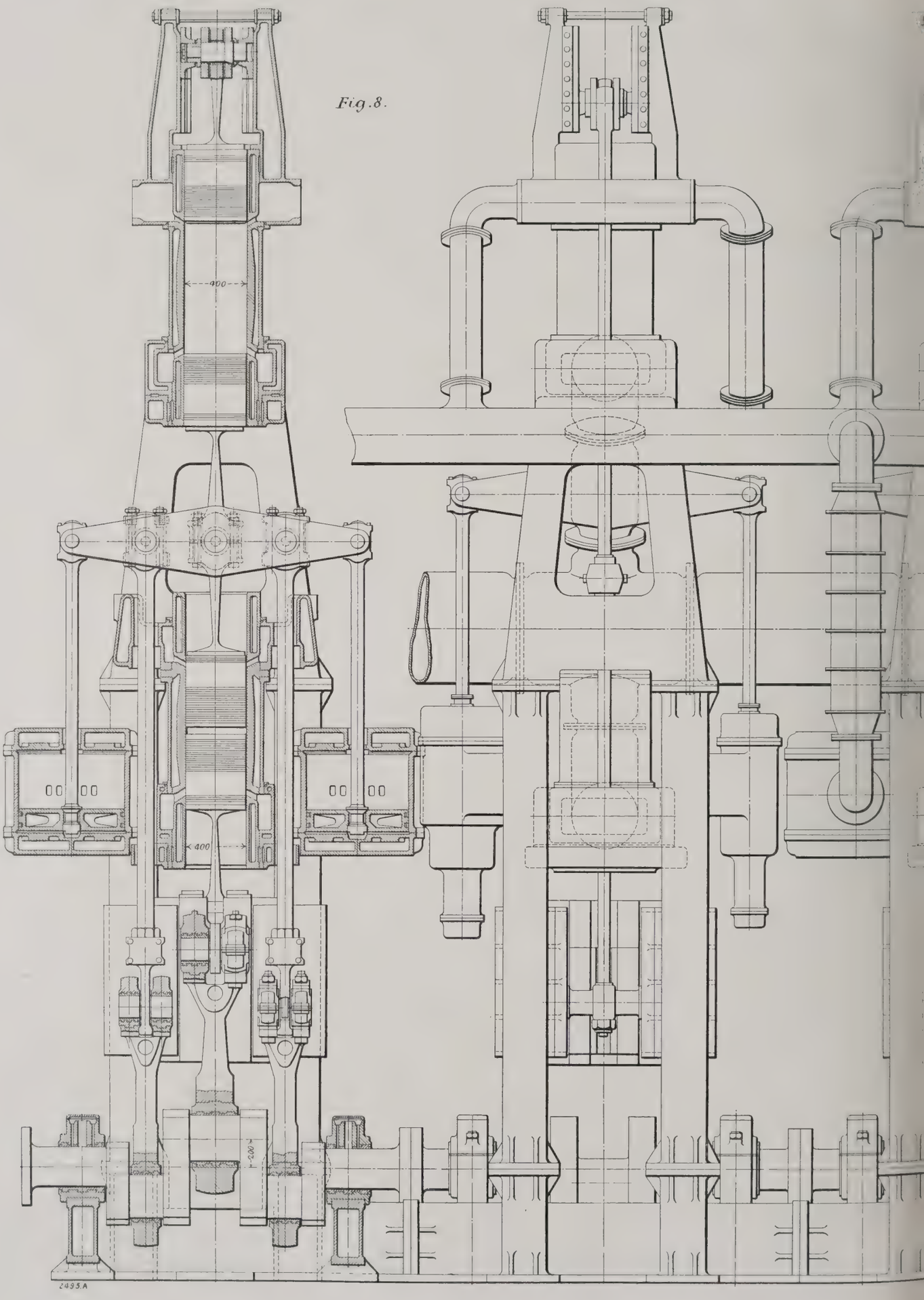
* Engineering Works of Messrs. Klein Brothers, Dahlbruch (Westphalia); the General Electric Company, Berlin; and Messrs. Frerichs and Co., Limited, Osterholz-Scharmbeck.

THE JUNKERS MARINE OIL-ENG

CONSTRUCTED BY THE ACTIEN-

(For

Fig. 8.



OR A HAMBURG-AMERICA LINER.

"WESER," BREMEN, GERMANY.

ge 698.)

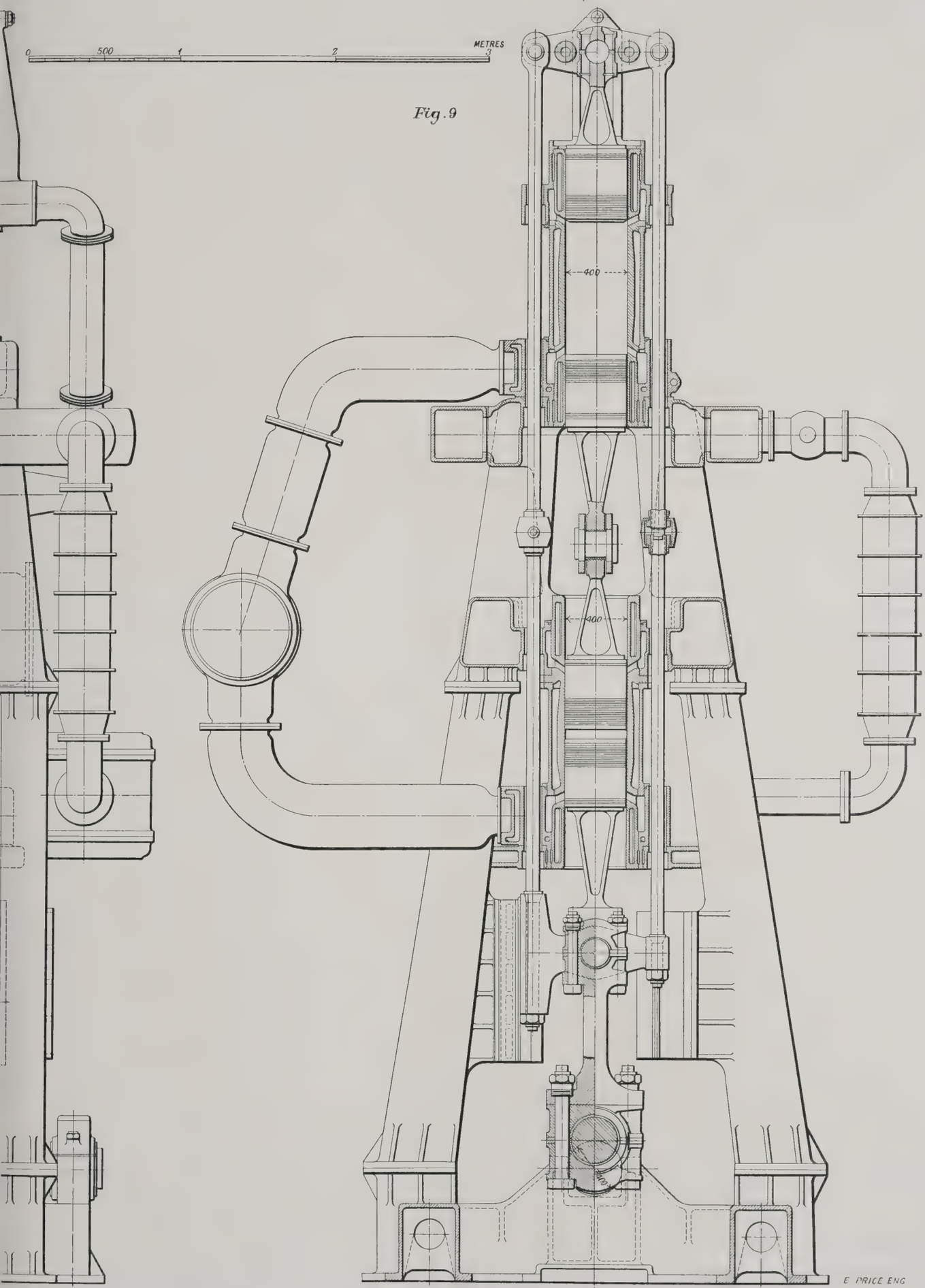


Fig. 9

ARRANGEMENT OF THE JUNKERS 1600-H.-P. OIL-ENGINE ON SHIPBOARD.

Fig. 10.

Fig. 11.

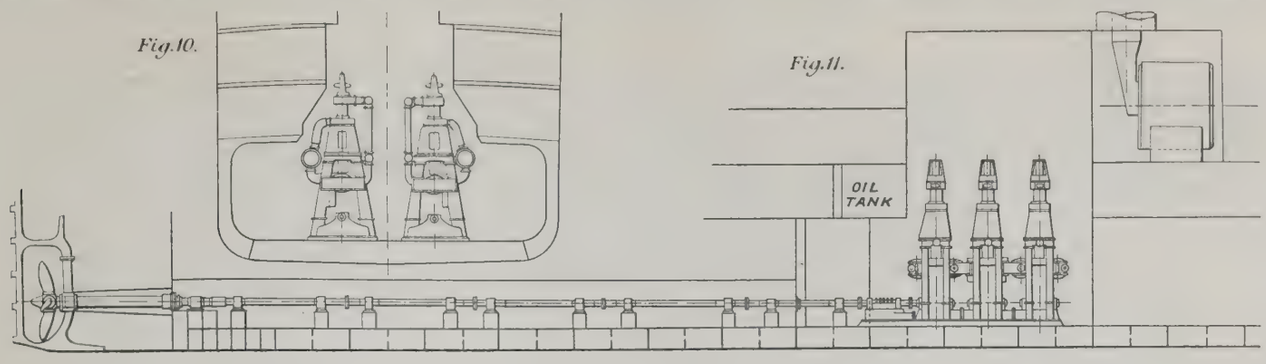
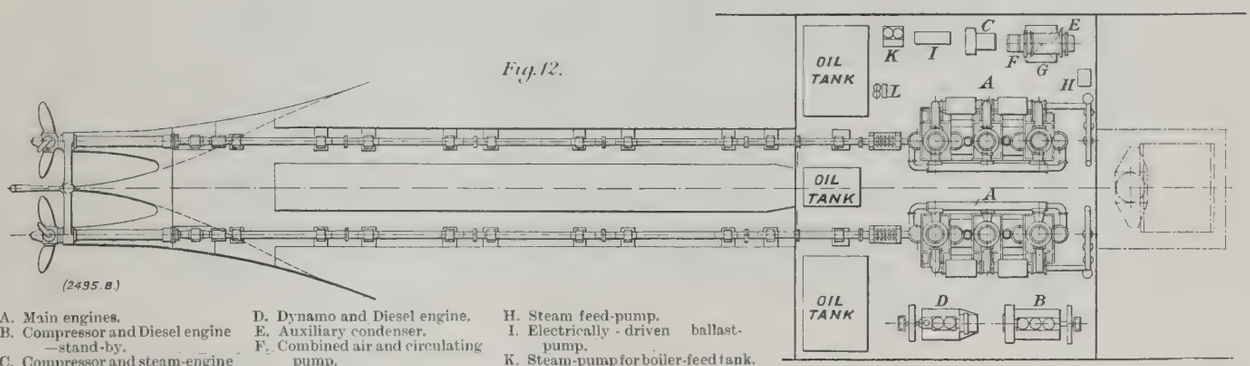


Fig. 12.



A. Main engines.
B. Compressor and Diesel engine —stand-by.
C. Compressor and steam-engine —emergency.
D. Dynamo and Diesel engine.
E. Auxiliary condenser.
F. Combined air and circulating pump.
G. Tank with float.
H. Steam feed-pump.
I. Electrically - driven ballast-pump.
K. Steam-pump for boiler-feed tank.
L. Steam-pump for oil-receiver.

are not touched by the products of combustion. This facilitates efficient lubrication of the pistons.

As in the Junkers engine the scavenging air does not enter by the aid of scavenging-valves permanently fitted to the combustion-chamber, which at every stroke take up a large quantity of heat from the latter and communicate it to the scavenging air rushing through them at a high velocity, the charge, under normal conditions, is much colder than in the ordinary Diesel engine, and this is responsible for the higher mean effective pressure, and the higher specific output attained by the Junkers engine.

The general design of the Junkers marine engine for mercantile marine work is shown in Figs. 8 and 9, on the two-page plate accompanying this issue. The tandem arrangement is followed, since the necessary height is usually obtainable in the engine-room without difficulty. Safety against swaying depends on a solid foundation, but on this point there will be some misgiving by marine engineers generally conversant with the influences of engine vibration, a beam sea, and pitching due to a following sea. As the illustrations show, the cylinders and power-transmitting gear are arranged in the same way as in the horizontal engine, but the general design has been made to suit the vertical arrangement. This design is also followed in its more important features in the engines of twin 800 shaft horse-power under construction for the freight vessel of the Hamburg-America Line. The longitudinal sectional view (Fig. 8) shows clearly the arrangement of the tandem cylinders, each with its pair of pistons, the design of the return crosshead with its rods to the side cranks, and, on the outer ends, the rods to the pumps for oil-spraying air and for scavenging air. The arrangement of the return crosshead for the top piston of the upper cylinder with its rods to the lower or main crosshead is better seen on the cross-sectional view, Fig. 9. The elevation shows the fuel, exhaust, and air-supply mains. The general arrangement of the machinery in the ship is shown in Figs. 10 to 12, above.

For men-of-war the tandem arrangement will have to be dispensed with, and recourse had to the single-cylinder design, owing to limited headroom.

The Sir John Cass Technical Institute.—At the Sir John Cass Technical Institute, on Wednesday, November 29, at 8 p.m., the prizes and certificates gained by students during the past session will be distributed by Mr. H. Livingstone Sulman, President of the Institution of Mining and Metallurgy.

Merchant Venturers' Technical College, Bristol.—The annual distribution of prizes by Mr. Alexander Siemens, past-president of the Institution of Civil Engineers, will take place in the great hall of the College on Friday, December 15, 1911; the Master of the Society of Merchant Venturers will occupy the chair.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

American Consul and Steel Progress.—Some interesting information and instructive comments are contained in the annual report, just issued, of Mr. C. N. Daniels, the American Consul in Sheffield, to his Government. He emphasises in the first place the value of Sheffield as a market for American produce. And then going on to deal with the trade of the city (during 1910) Mr. Daniels says a distinct advance was made in the sales of best crucible steel and the special alloy steels for tools and automobile construction, both the United States and Germany increasing their purchases. "The work of the city's metallurgists and experimenters on these specialities has," states the report, "resulted in bringing more and more trade to the city." This is particularly interesting, and goes to justify the outlay which Sheffield makes upon the Applied Science Department of the University. The report also states that although no new steels were introduced during the year under review, the varieties of steel were steadily increasing. At the same time electric melting had not made much headway, although the advancing price of Swedish iron was giving the crucible makers much concern.

To Protect Sheffield's Name.—After years of agitation, and a fight waged on behalf of Sheffield against very great odds, the manufacturers of the city are now in a position to enforce their rights, such as they have never occupied before. The practice of "false marking" foreign goods, and palming them off upon the unsuspecting consumer as Sheffield products, has been not only a considerable source of loss to the city's industries, but has had a damaging effect upon her reputation. Now an Advisory Committee has been formed of twenty-four of Sheffield's leading citizens, backed up by the Cutlers' Company, and with a fund of 11,000*l.* at their disposal to use in efforts to check, by means of prosecutions, fraudulent practices adopted by unscrupulous foreign rivals. So far the Cutlers' Company, who are not a wealthy corporation, have had to struggle alone against this evil, and their resources have been seriously weakened in the process. Within the last few years they have spent over 2000*l.* on cases in various parts of the world. The manufacturers have now come to the rescue, however, and 11,000*l.* has now been raised of the 15,000*l.* originally fixed to be the amount of the fund.

South Yorkshire Coal Trade.—The steam-coal market is in a fairly firm position. There is not quite so much fuel going for shipment from Hull, on account of the imminent closing of the Baltic season, but inquiries from manufacturers are rather on the increase than otherwise, and the railway companies are buying largely. Gas fuel, both for works at home and for export, is in steady demand. There is a good deal of slack on the market, due to large outputs at collieries, and plenty of coking smalls are to be had. Prices have kept firm in the house-coal market over the week, in spite of the fact that ordering has been on a very small scale, and that most of the merchants have considerable stocks on hand. Stocks have a tendency to accumulate at pits, but a brisker inquiry ought soon to be experienced, especially with the keener weather of the past few days. The prices on the Sheffield Exchange at the week-end were:—Best hand-picked branch, 14s. 6d. to 15s. 6d.; Barnsley best Silkstone, 12s. to 13s.; Silkstone, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. to 11s.; Derbyshire best large nuts, 9s. 6d. to 10s. 6d.; small nuts, 6s. 6d. to 8s.; Yorkshire hards, 9s. 3d. to 10s. 3d.; Derbyshire hards, 9s. to 10s.; washed nuts, 8s. to 9s.; rough slacks, 5s. 6d. to 7s. 6d.; seconds, 4s. 6d. to 5s. 6d.; smalls, 2s. to 3s.

Iron and Steel.—A marked improvement has taken place in the iron market. Prices have strengthened, advances are being asked, and there is a likelihood of a further rise. A good many buyers are still receiving deliveries at lower prices; but others, who have not booked far forward, are hastening to fix up contracts before prices go further against them. In the common irons, particularly Derbyshire makes, a corresponding activity has been manifested. The Derbyshire quotations are now, in fact, above Lincolnshire figures, and it is expected that the Lincolnshire Association will make an advance to bring them into line. The improved demand is for both forge and foundry sorts, and with prospects of even better business in the near future, the makers are not at all anxious to book long-date contracts. Scrap is a little better, but the demand is not equal to the output. The recent revival in bar iron is being followed by steady prosperity in this branch, and the production is on a larger scale than has been the case for several years. "Boom" conditions have become the characteristics of the general trades of Sheffield. There are varying statements as to the weight of work in the armament houses, but it is agreed that it is sufficient to provide employment for a long time to come. Even during the boom of 1907 there was not, in the opinion of competent authorities, so much work turned out of Sheffield as is now the case. Most of the firms have, in the interval, extended their resources and productive capacity, so that the fact of their being fully engaged means more to-day than it did four or five years ago. The great development of recent months in the home engineering trade is responsible for no small proportion of the large orders which have come to the East End of Sheffield. Further, general export trade is excellent. Colonial business is showing increases almost month by month, and there has been an improvement in inquiries from the United States. Forges and rolling-mills are working under extreme pressure. At a time when the tendency is to cut profits to the utmost margin, the present trade prosperity has a double value. It enables plant to be kept running and doing its maximum amount of work without appreciable increase in cost, as compared with the time when it can only be partially employed. This, of course, means reduced expenses for bulk of steel produced. All the departments of the lighter industries are sharing in the general activity. Most of the file manufacturers are working overtime, and tools of all kinds are in very great demand.

Institute of Chemistry of Great Britain and Ireland.—Mr. Bertram Blount will deliver his second lecture on "Cement" in the lecture theatre of King's College, Strand, on Friday, December 1, at 8 p.m.

Contracts.—The Mirrlees Watson Company, Limited, Scotland-street, Glasgow, have recently booked orders for a large number of their surface-condensing and jet-condensing plants for different works in this country, France, and the British Colonies.

DOUBLE-CUTTING AND HIGH-SPEED PLANING-MACHINES.*

By Mr. J. Hartley Wicksteed, Past-President, of Leeds.

The planing-machine, with its idle return stroke, is necessarily inferior in principle, for the economical removal of material, to a lathe, with its continuous-cutting action. Nevertheless, plain surfaces are best done on planing-machines, and this being so, the problem of minimising the time spent on the idle return stroke has naturally received great attention, with the result that, in some cases, it has been reduced to one-tenth of the whole time spent on the complete cycle of the table. But why do we not eliminate the idle stroke altogether, by making the machine cut equally on both the forward and the backward strokes, and thus make its cutting action very nearly continuous?

It is hoped that, in the following paper, the conditions will be explained under which this is undoubtedly the most economical method, and also the conditions under which single-stroke cutting should be preferred.

The recent development of change-speed reversing-motors has overcome the chief objection, previously existing, to the extended use of the double-cutting principle. The previous objection to the use of a double-cutting tool-box was that, with an equal speed to the planing-machine table on both the forward and backward cut, it followed that, when the work did not permit of the use of both tools for want of clearance at the end of the stroke, as, for instance, when planing in a steam-chest, and when therefore only one tool could be used, the absence of a quick return motion on the idle stroke discounted the advantages gained on other work where double-cutting could be employed. The variable-speed reversing motor removes this objection, because this drive can be set either to reverse at equal speeds for double cutting, or to drive slowly on one stroke, and quickly on the other, whenever it is convenient to plane only in one direction. Thus, in the machine illustrated in Figs. 1 and 2, which is a Buckton double-cutting planing-machine to plane 10 ft. square by 30 ft. long, driven by a 30-horse-power Vickers reversing motor with an auxiliary 3-horse-power motor for raising the cross-slide and side tool-boxes, and for feeding and traversing all the tool-boxes, the table is driven at speeds varying between 20 ft. and 60 ft. per minute, on either stroke. The motor is regulated by varying the field strength, and will stand heavier intermittent loading at the lower speeds than at the higher. Hence this motor will exert its full horse-power at all speeds, as the torque on the motor-shaft is approximately inversely proportional to the speed. The result of this is that the slower the speed the table is driven, the heavier is the cut that can be taken. In general, the machine cuts on both strokes, but the double-cutting tool-holder can be removed and a strong single tool-holder substituted, capable of carrying a long projecting toolstock for heavy cuts on steel, in any case where the work does not lend itself to double cutting. In planing cast-iron the advantages of double cutting are twofold; for, besides having two feeds to the tool-box on each cycle of the table, the back-to-back tools mutually assist each other by chipping away the scale in front of them in either direction, so that each tool has clean metal to enter at all the edges of the casting with which it comes in contact. The tools are thus saved from so much wear that, instead of two tools requiring more fixing, they require, on the whole, less fixing than a single tool, for the reason that the back-to-back tools so save each other from wear that they do not need to be removed and re-fixed during the progress of the work, for the purpose of being reground. Also, the first roughing cut is more uniform if made with two tools than with one tool, because they get so much less worn between the first cut and the last, partly because each tool only takes alternate cuts, thus reducing the wear to half what a single tool would be subjected to on one job and with one setting; and further, because of the assistance which each tool has rendered to its companion in preparing clean metal at all the edges where the single tool would have had to face hard scale. It has accordingly been found that turbine casings, for example, could be planed true in less time by double than by single cutting, even if the time taken by the idle return stroke were eliminated altogether. The reverse position of the back tool also makes it particularly advantageous for taking broad finishing cuts; it does not require cranking back to prevent making chatter marks, because it has no tendency to dig into the work. For the same reason it can be advantageously

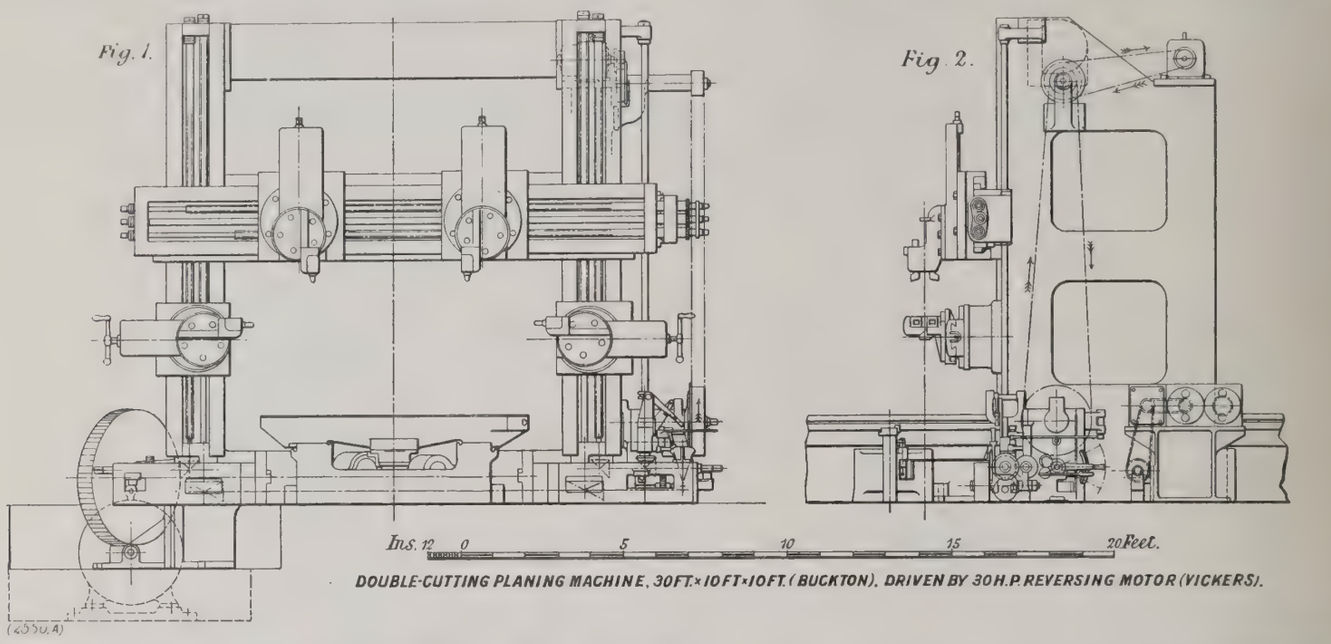


Fig. 1.
Fig. 2.
Ins. 12 0 5 10 15 20 Feet.
DOUBLE-CUTTING PLANING MACHINE, 30FT.×10FT.×10FT. (BUCKTON). DRIVEN BY 30 H.P. REVERSING MOTOR (VICKERS).

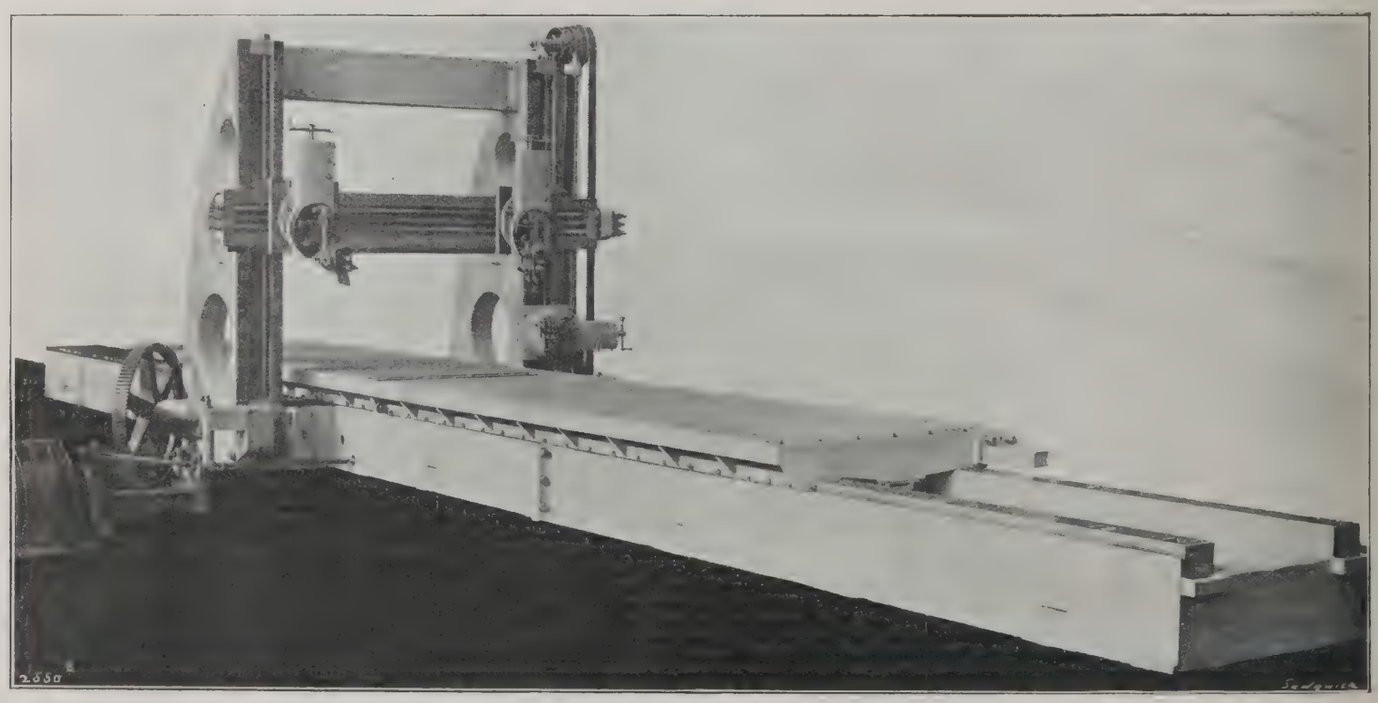


Fig. 3. Constant-Speed Double-Cutting Planer (Buckton) Driven from a Line-Shaft.

* Paper read before the Institution of Mechanical Engineers, November 17, 1911.

DOUBLE-CUTTING AND HIGH-SPEED PLANING-MACHINES.

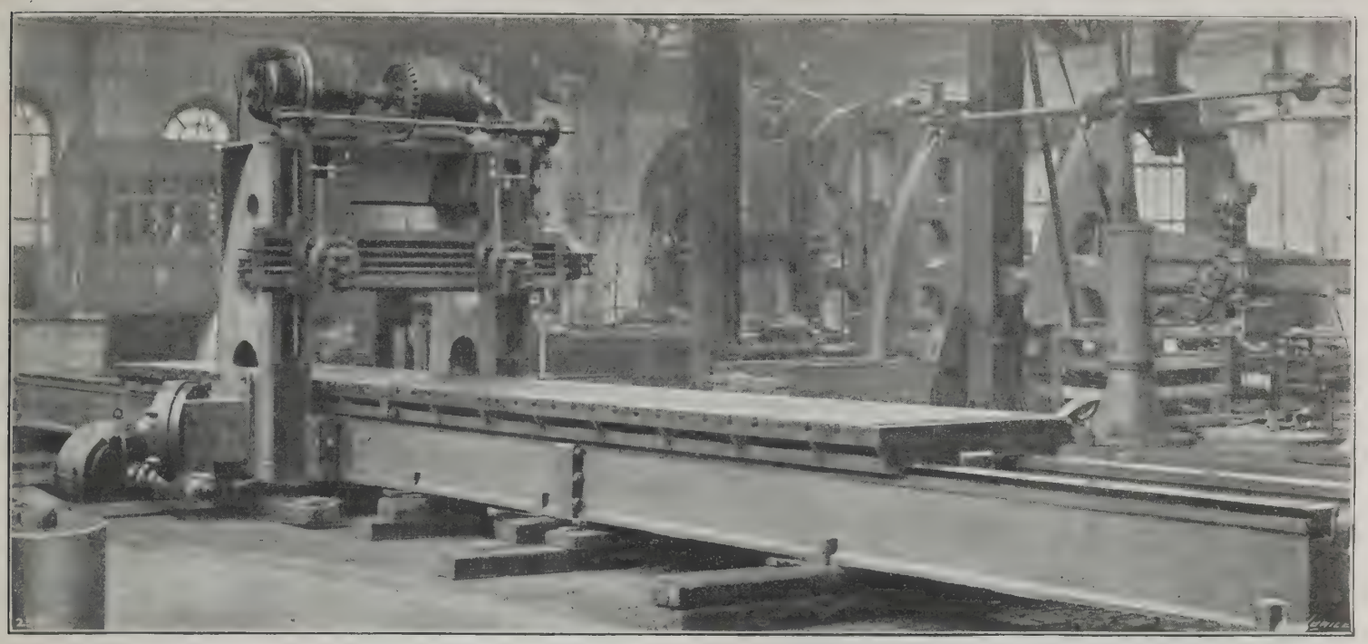
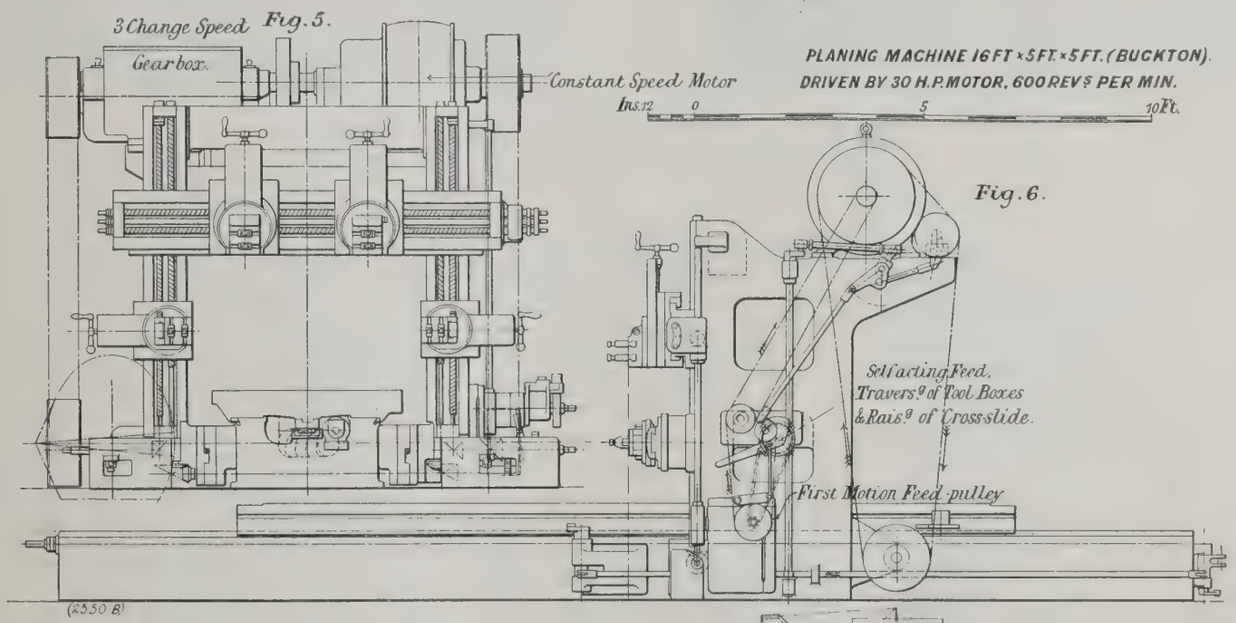
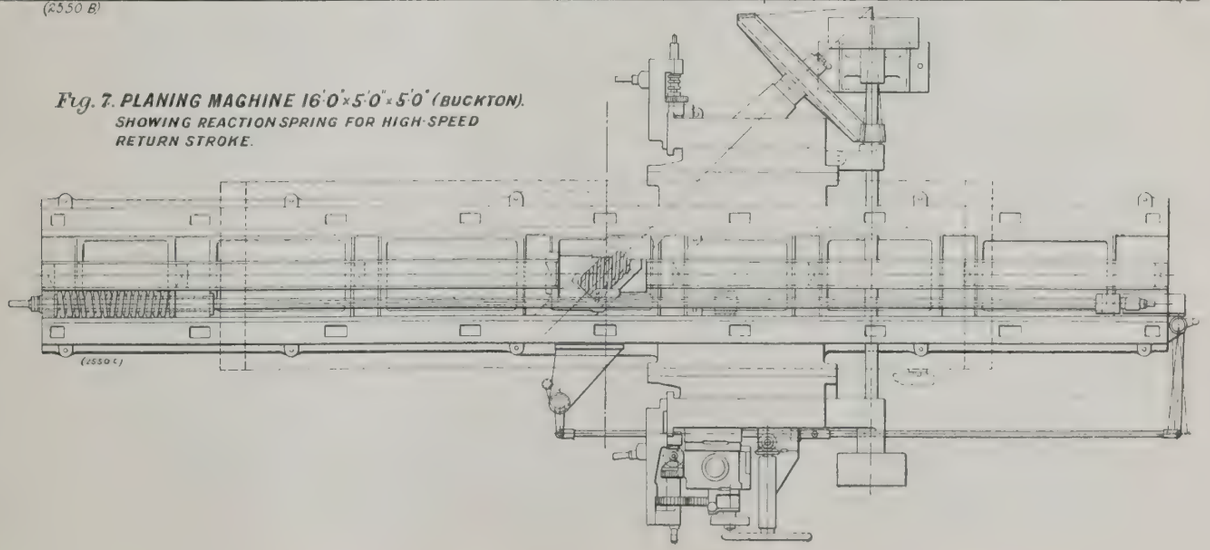


Fig. 4. Variable-Speed Planer with Tandem Tables (Buckton), Driven by 50-Brake-Horse-Power Electrical Set.


3 Change Speed Gear box.
Fig. 5.
Constant Speed Motor
PLANING MACHINE 16 FT × 5 FT. × 5 FT. (BUCKTON).
DRIVEN BY 30 H.P. MOTOR, 600 REV^s PER MIN.
Ins. 12
0
5
10 Ft.
Fig. 6.
Self acting Feed, Travers^g of Tool Boxes & Rais^g of Cross-slide.
First Motion Feed-pulley
(2550 B)



used for cutting grooves with a parting tool. In these cases, although the double cutting tool-holders are not changed, the back tool only is inserted and the back stroke can be driven at 20 ft. per minute, with an idle stroke on the usual forward stroke, of 60 ft. per minute. There are also occasions where it saves turning the work round end for end, to have a tool available for planing up to an obstruction in either direction.

The feed of the tool-boxes is effected by a continuous running belt-pulley and a friction clutch, which is thrown in at each reversal of the machine, and permits the belt-pulley to take one, two, or four complete revolutions before it is thrown out. Further changes of feed are provided in a gear-box. If one tool alone is in action, the tappet at one end of the table is turned back, so that the feed does not operate on that reversal.

The manner of double cutting is to fix both tools precisely back to back; in fact, the second tool is adjusted by simply dropping it into the furrow made by the first tool. The back tool follows in this furrow till the end of the stroke, when it receives a feed motion; it then cuts a further furrow, in which its companion follows free, and thus, on a single cycle of the table, two furrows have been cutof equal width and equal depth. Thus, assuming a feed of $\frac{1}{8}$ in. at each reversal, then at the completion of the cycle $\frac{1}{4}$ in. would have been traversed.

Fig. 3, page 700, shows a constant-speed double-cutting planer driven from a line-shaft. It planes 36 ft. long by 8 ft. square.

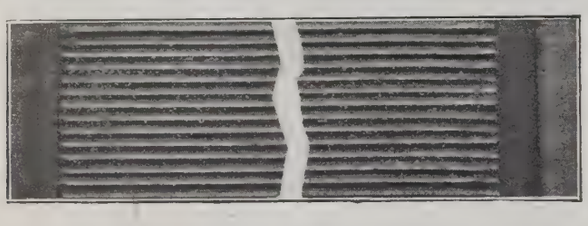
It is astonishing to the author to see any machines put down for the express purpose of planing engine base-plates, machine-beds, table, or tank-plates, with an idle return stroke, even if provided with gang tools, when two back-to-back tools would do all such work with much greater economy in the wear of the cutting-tools, the wear and tear of the machine, cost of driving power, the time of doing the work, and the quality of the work done.

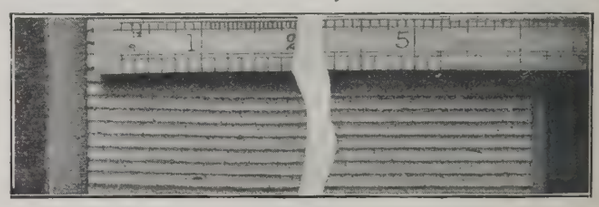
It must be conceded, however, that for work of great variety, and in some cases for special work, the bulk of as has been said, to convey the reverse motions to the cutting and return strokes. One belt, for the quick return, is driven from the countershaft or motor spindle, the other belt, for the variable cutting-stroke, is driven through a three-speed gear-box. The gear-wheels run in oil, and only one pair is in mesh at a time—namely, the pair giving the speed required for the cut in use. On account of the drum of this belt being driven through single-purchase gearing, it runs in a contrary direction to the quick-speed belt, and therefore it reverses the machine without being crossed, which enables it to drop plumb round its pulley. Each belt encloses a jockey-pulley. The pedestals for the jockey-pulleys are adjustable, so that a good endless belt never requires taking up and joining. Both jockey-pulleys are thrown from the same rocking-shaft, and when the reversing-gear rocks this shaft in one direction the driving-belt is tightened by its jockey-pulley, and when it rocks in the contrary direction the driving-belt is loosened and the quick-return belt is tightened. The belts are endless belts from the makers' works, without any laced joints or metallic joints, and any stretch that ensues in a new belt is taken up by moving the position of the jockey-pulley. The grip of these open belts is so smooth upon their pulleys that there is not the slightest knocking on the gearing, at the reversals, of the machine. They themselves form a most perfect friction brake drive, and no cushioning device or friction coupling is required to prevent knock at reversal. The belts are 8 in. wide, and as they are not subject to contrary flexure round the jockey-pulleys, and encounter no edge friction from belt striking forks, they are exempt from the elements of self-destruction usually found in heavy planing-machine belts.

It is perhaps needless to say that the chief inertia in stopping or starting a belt-driven planer resides in the rim of the driving-pulley. During the quick return stroke the shaft of this pulley makes about 800 revolutions per minute, and it is obvious that if this shaft be driven by a pulley 24 in. in diameter with 8-in. face, feed-motion jockey-pulley, and thereby tightens the feed-belt, just at the end of the quick-return stroke; but as soon as this tightened belt has driven the first motion of the feed-gear one revolution. It has also turned a stripping-disc $\frac{1}{4}$ of a revolution, stripped the pawl out of engagement, and allowed the handle to drop, loosening the belt, and, at the same time, pressing a brake upon the feed-pulley to prevent over-run, and has given a feed of $\frac{1}{32}$ in. The stripping-disc has four wipers, which, when all are in operation, strip the jockey-pulley after the first-motion feed-wheel has made one revolution.

The wipers can be turned down, and, when only two are left in action, the feed-pulley receives two revolutions before the pawl is lifted and the feed becomes $\frac{1}{16}$ in.; and when only one is left the feed-pulley receives four revolutions before the pawl is lifted and the feed becomes $\frac{1}{8}$ in. But the first-motion feed-pulley drives through two change-gearings, and when the quicker gear is thrown in, the feeds obtained from the stripper-plate become $\frac{1}{4}$ in., $\frac{1}{2}$ in., and 1 in. By this simple automatic gear, therefore, six rates of feed are obtained, varying from $\frac{1}{32}$ in. to 1 in. The tool-boxes can be traversed without altering any clutches.

For example, assuming that a feed is operating upon one of the tool-boxes, and that to pass over a part that does not require planing it has to be traversed 12 in. to come up to its fresh cut, then, without making any change in the feed-gear, but by simply holding the jockey-pulley into the belt by its hand-lever, the motion becomes continuous instead of intermittent; but the moment the hand-lever is dropped the intermittent feed motion is resumed. The direction of traverse is reversible by a handle. All the feed motions and the traversing motions of the tool-boxes and the raising and lowering of the cross-slide are effected by power from this same continuous-running belt. The table is driven through a rack by Sellers spiral gearing. The guides of the table and bed are flat horizontally and slightly undercut at the sides. The table cannot lift under any circumstances.





Specimens of Work from Spring-Balanced Planers (Buckton).

Fig. 10. Length of Stroke, 12 In.; Between Landings, $\frac{3}{8}$ In. and $\frac{1}{8}$ In. Wide.

Fig. 11. 40 Cutting Cycles per Minute, with Table Reversing 80 Times per Minute. Length of Stroke, 6 In.; Between Landings, $\frac{3}{8}$ In. and $\frac{1}{8}$ In. Wide.

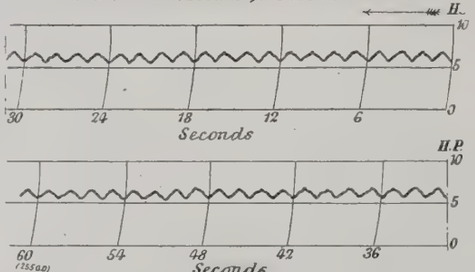
it may only lend itself conveniently for cutting in one direction, and therefore the saving of as much time as possible on the idle stroke is very advantageous. For instance, in planing railway switches, with heavy cuts on very hard steel, it would be dangerous to enter a tool in the direction of facing the point, and consequently this special work is done cutting on one stroke, and the quickest possible idle return. Also, in miscellaneous work fixed to the table by cramps and bolts which often project above the work, and would interfere with the 6-in. over-run of the back-to-back tools, there are advantages in cutting in one direction only. The consequence is that on machines of moderate size, where it is practicable to get a quick return of about 8 to 1, it is hardly worth while to have a double equipment of tools and tool-holders, especially as on short jobs requiring right and left-hand tools for planing down vertical faces, or for undercutting, or for rounding the corners of the work, the single-cutting tool-box would be almost constantly in use.

Fig. 4, page 701, shows a machine with tandem tables, each of which will separately plane 16 ft. long by 5 ft. wide by 5 ft. high. It will cut at any speed from 17 ft. per minute to 60 ft. per minute, and return at 136 ft. per minute. It is driven by a 50-brake-horse-power electrical set as made by the Lancashire Dynamo and Motor Company, Limited; the motor generator is placed upon the top of the machine and runs at a constant speed. The motor is driven from the mains and can be either alternating or direct current. The generator supplies current to the planer motor, the voltage of which is varied, thus giving changes of speed on the machine over a total range of 8 to 1. The machine will take the same strength of cuts at any speed from 17 ft. to 60 ft. per minute, the horse-power given out by the planer motor being directly proportional to the cutting speed.

The next machine to be described is of exactly the same strength as the foregoing, and it gives the same weight of cut at slow speeds and has the same ratio of quick return; but, instead of being driven and reversed by a reversing motor, it is driven either by a belt from the line-shaft or by a continuous-running motor.

Figs. 5 to 7 show the machine to plane 16 ft. by 5 ft. by 5 ft., driven by a 30-horse-power motor running at 600 revolutions per minute, whose power is delivered through belts to the machine. The belts do not shift on fast-and-loose pulleys, but are themselves tightened and loosened alternatively, and when at half-stroke of the jockey-pulleys each runs loosely in a loop under its respective pulley without touching it. The cutting speeds are 17 ft., 35 ft., and 60 ft per minute, and the return speed 136 ft. per minute. The machine has a self-contained countershaft, which may be belt or motor-driven, and two open belts,

Fig. 12. POWER DIAGRAM FROM PLANING MACHINE 10FT.×4FT.×4FT. (BUCKTON). 40 CYCLES PER MIN.



instead of a pulley 48 in. in diameter with 4-in. face, the weights of the pulley-rims would be about the same, but the peripheral speed of the one would be twice that of the other, and the inertia to contend with in the larger diameter pulley would be four times that in the smaller diameter pulley, although the belt-driving power would be the same. Therefore, by using broad belts of low velocity, instead of narrow belts of high velocity, to deliver the power of the motor on to the cut, the chief inertia has already been reduced enough to enable the return speed to be double, without increasing the inertia of the pulley-rim. Incidentally the broad slow belt is a better brake than the quick narrow belt, on account of its broad surface and low velocity.

The author does not claim to have discovered the advantages of the broad slow belt for reversing pulleys. That principle was first introduced by Mr. W. C. Mitchell, and has been applied by him to many heavy planing-machines. His system is that of tightening and loosening belts by jockey-pulleys acting upon the outside of the belts, and the chief difference in the author's system is that the jockey-pulleys act upon the inside of the belts, and that the rocking-shaft which works them is rocked from a crank-pin semi-revolving, so as to reach opposite dead-centres at each reversal. The same system of a loose belt tightened from the inside is also applied to the feed motion. A machine so fitted is illustrated in Figs. 8 and 9, page 704. When the handle (Fig. 8) of its jockey-pulley frame is lifted, the feed motion runs continuously for traversing the tool-boxes and for raising the cross-slide. When the handle is dropped the continuous motion ceases, but when the machine is running a lever from the rocking-shaft, which throws the main jockey-pulleys, pulls a pawl-lever engaging into the frame of the

The plan view of this machine, Fig. 7, shows the arrangement of a reaction spring placed in the bed of the planing-machine, which enables it to attain the speed named without distress upon the return-belt, or overload upon the prime mover. It will be seen from the drawing that there is a boss cast on the second cross-bar at the front end of the bed, and abutting against this boss is a spiral spring about 2 ft. long. Through this spring a screw-shaft is passed, carrying a collar to press against the outer end of the spring, and also carrying a heavy nut, against which a lug, cast solid under the table, impinges.

By turning the screw-shaft, the nut can be traversed over a length of 16 ft. into any position desired for the reversal of stroke. When the lug under the table impinges upon its nut, it moves the screw-shaft endways, and by the collar at one end compresses its spring. On one end of the screw-shaft a cam-plate is carried on a crosshead, and the end movement of the screw carrying the cam-plate with it, moves the lever of the belt-striking gear, and thus the same movement of the screw-shaft compresses the reaction spring and reverses the drive. The synchronism of these two operations is not disturbed by turning the screw round and altering the position of the nut to adjust the length of stroke, and this can be done even while the machine is in motion. The place at which the table ends the cutting stroke always corresponds with the position of the nut—namely, anywhere over the 16-ft. range of the screw-shaft. The screw is 1-in. pitch, which is convenient when the operator is setting the stroke for exact clearance, as each full revolution of the screw alters it a known inch. The screws can be turned by hand so rapidly that an adjustment over a range of 10 ft. can be effected in 1 minute. At the end of the screw-shaft, passing through the spring where the cam-plate is placed for reversing the table from the cutting to the idle stroke, it will be seen that there is a little space between the cam-plate and the belt-striking lever. This is to give a late cut-off to the belt-striking gear so as to prevent the driving-belt being loosened before the spring is sufficiently compressed. While the cam-plate is passing through this space on the 60-ft. cutting-stroke it is compressing the spring, wholly by the residual energy of the moving masses, and when the space is covered and the lever kicked, the spring has made a dead beat of 4 in. The scale of this spring is 1 ton per inch, giving a terminal pressure of 4 tons.

Thus, at the end of each cutting stroke, the spring being compressed 4 in., there is, at the moment of the table reversing, such a thrust upon it as will help to start it on its quick-return journey. The quick-return belt is thereby greatly relieved, as it is not called upon first to take out the kinetic energy of the table and the revolving

pulleys in one direction, and then to supply a further amount of energy to accelerate them in a contrary direction; but, instead of this, the whole of the residual energies of the revolving parts and of the moving table at the end of the cutting stroke are stored up in the spring and are immediately returned, by its reaction, to assist in starting up the quick-return stroke.

When the speed of cutting stroke is 60 ft. per minute, more than the necessary amount of work is supplied to compress the spring by the kinetic energy of the moving parts; but when the table is driven at its slowest speed of 17 ft. per minute, a little assistance is required from the drive at the end of the cutting stroke to complete the compression of the spring. Seeing, however, that the drive is from a constant-speed motor and acts through $3\frac{1}{2}$ times the multiplying power of gear when the cutting-speed is at its slowest, it happens that at the very time when there is a deficiency of energy in the moving parts for the complete compression of this spring, there is a surplus of power in the drive, beyond what is required to complete the maximum cut, without putting any overload upon the motor. By the reaction of the spring described the table has a good send-off at the beginning of the quick-return stroke, and no dwell is perceptible at the point of reversal; there is no shock on the gearing, and the curve of the power diagram does not rise above the full-load line. In starting up the quick-return motion the short spring delivers 0.66 foot-ton of energy in 0.26 second, which is at the rate of 150 foot-tons per minute, which is at the rate of 10 horse-power during the period of acceleration.

The following detailed description will explain the action of the spring. Picture, then, the table ready for starting its return stroke under the influence of a spring compressed to a load of 4 tons, and stored with 8 in.-tons of potential energy, which, being regulated by the speed of the return-belt, it delivers to the table in 4 in. of travel. The 30 horse-power quick belt with this assistance is able to accelerate the table, and keep the speed up throughout the stroke, without heating the pulley. The machine will at all times work dead-beat between two walls, and plane up to $\frac{1}{8}$-in. landing.

The reversal at the end of the quick-return stroke is dealt with quite satisfactorily by the broad belt on the 24-in. driving-pulley, and this belt motion is struck from the usual form of knocker on the table.

The machine will work with certainty at full speed and let the tool drop without marking the work between landings of $\frac{3}{32}$ in. for the start and $\frac{1}{8}$ in. for the finish, as will be seen from Fig. 10, on the opposite page. The reduction in idle clearance-spaces and the command of good feed-traverses, ranging from $\frac{1}{32}$ in. to 1 in., contribute greatly to the large output of work which has been realised with this machine. By this system of drive with continuous running prime mover, the full power of the drive is available at all speeds, and the heaviest chips can be taken at the slowest speed.

The power of the machine, as described, is equal to a 10-ton pull upon the table at the middle speed, and a 15-ton pull at the slow speed. The speeds given are such as could be worked continuously without heating or irregularity down to 12 in. length of stroke, and, if made without a reaction spring, the return speed, instead of being 136 ft. per minute, would be 110 ft. per minute; but if it were driven by shifting belts and without reaction spring, 90 ft. per minute.

It will be readily understood that in proportion as machines are made for lighter cuts, they can be returned at quicker speeds, because, as has been said before, the chief inertia lies in the rim of the driving pulley, and this rim must needs be made in proportion to the weight of the cut required. Thus, in a 4-ft. square machine, with a 5-ton pull on the table, fitted with a reaction spring, the quick return of 160 ft. per minute can be given; or in a quite simple machine for light cuts, with about 1-ton pull on the table, a return speed of 240 ft. per minute is attained without the assistance of any springs. On the other hand, it should be borne in mind that in a machine for extra heavy cuts requiring a 20-ton pull upon the table, the judicious return speed would be less than those quoted in proportion as the power might be greater.

Reverting finally to the 4-ft. square machine just mentioned as returning at 160 ft. per minute, Fig. 11 shows photographs of work done with this machine on a 6-in. stroke, making 80 reversals per minute, and Fig. 12 is the power diagram taken at the time.

In this machine there were two reaction springs, one of which was compressed by the table at the end of the cutting stroke, and the other similarly compressed at the end of the return stroke, so the table ran in almost complete balance, as shown by the almost horizontal line on the power diagram. Each hump on that line shows a cycle of the table, 40 of these cycles being completed per minute, involving 80 reversals.

Automatic Telephones.—A demonstration of their automatic telephone system was given by the British Insulated and Helsby Cables, Limited, of Prescot, on the 22nd inst. The system is that known as the Strowger, which has been developed by the Automatic Electric Company, of Chicago, and on which some 300,000 telephones are now in commercial operation in the United States. The British Insulated and Helsby Cables have secured the patent rights for the apparatus in this country, and are now supplying trial installations to the Post Office for the internal service of the General Post Office buildings, and for public service at Epsom. It is impossible to describe the details of the system within the limits of this paragraph, but we may refer our readers to a very complete account of the apparatus on pages 166 and 203 of our eighty-ninth volume.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened strongly, and a business of 4500 tons of Cleveland warrants was put through at 47s. 4½d. and 47s. 4d. cash, 47s. 5d. and 47s. 4½d. four days, 47s. 8d. and 47s. 7½d. one month, and 48s. 3d. three months. At the close sellers quoted 47s. 5d. cash, 47s. 8½d. one month, and 48s. 3½d. three months. One lot of hematite changed hands at 62s. 9d. three months, and there were cash buyers at 61s. 9d. The market was quiet in the afternoon, but the tone was again firm. Dealings in Cleveland warrants amounted to 2000 tons at 47s. 5d. cash, 47s. 6½d. eight days, and 48s. 4d. three months, with closing sellers at 47s. 6d. cash, 47s. 9½d. one month, and 48s. 4½d. three months. On Friday morning Cleveland warrants were steady, and 3500 tons were done at 47s. 6d. and 47s. 6½d. cash, 47s. 9½d. and 47s. 10d. one month, and 48s. January 11. The closing prices were 47s. 6d. cash, 47s. 9½d. one month, and 48s. 4d. three months sellers. Hematite was firm, with buyers at 62s. one month, and 62s. 9d. three months, and sellers at 63s. 3d. three months. There was little change in the afternoon, when 6000 tons of Cleveland warrants were dealt in at 47s. 5½d. cash, 47s. 8d. one month, and 48s. 2½d. three months. At the close sellers quoted 47s. 6d. cash, 47s. 9½d. one month, and 48s. 3½d. three months. Buyers of hematite quoted 63s. three months, and sellers 62s. cash. On Monday morning Cleveland warrants were again strong, and 4500 tons were put through at 47s. 7d. and 47s. 7½d. cash, 47s. 10d. and 47s. 11d. one month, and 48s. 6d. three months. Closing sellers quoted firm at 47s. 8d. cash, 47s. 11½d. one month, and 48s. 6d. three months. The market continued firm in the afternoon, and 8000 tons of Cleveland warrants changed hands at 47s. 8½d. cash, 47s. 10½d. twenty-one days, and 47s. 11d. and 48s. one month. The session closed with sellers quoting 47s. 9d. cash, 48s. one month, and 48s. 7½d. three months, and there were sellers of hematite at 63s. 3d. three months. On Tuesday morning the buying element prevailed, and Cleveland warrants were done at from 47s. 9d. to 47s. 10d. cash, from 48s. 0½d. to 48s. 1d. one month, and at 48s. 6d. January 30. The business amounted to 8000 tons, and closing sellers quoted 47s. 10½d. cash, 48s. 2d. one month, and 48s. 9d. three months. Hematite was in demand, and 2000 tons changed hands at 62s. 3d. cash, and 63s. 3d. three months, with buyers over at 62s. 9d. one month, and 63s. 4½d. three months. The afternoon session was quiet, and only one Cleveland warrant was dealt in at 48s. 8½d. three months. The closing quotations were:—47s. 11½d. cash, 48s. 2½d. one month, and 48s. 9d. three months sellers. Hematite was quoted at 63s. 3½d. buyers, and 63s. 6d. sellers, three months. When the market opened to-day (Wednesday) the tone was firm, and 6500 tons of Cleveland warrants were done at 47s. 11d. and 47s. 10½d. cash, 48s. 2d. one month, 48s. 2d. and 48s. 1½d. twenty-one days, and 48s. 9d. three months. Prices were firm at the close, with sellers quoting 47s. 11½d. cash, 48s. 3d. one month, and 48s. 9d. three months. Hematite was strong, and 1500 tons changed hands at 63s. 6½d. three months, with sellers over, and buyers at 63s. 6d. for that position and at 62s. 6d. cash. In the afternoon business was not very active, and the dealings amounted to 3000 tons of Cleveland warrants at 48s. cash, and 48s. 3½d. one month. The closing quotations were up to 48s. 0½d. cash, 48s. 4d. one month, and 48s. 10½d. three months sellers. Hematite was dearer, and sellers quoted 63s. 9d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde, 62s. 6d.; Calder, 62s. 6d.; Gartsherrie, 63s.; Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 65s.; Shotts (at Leith), 63s.; and Carron (at Grangemouth), 64s.

Sulphate of Ammonia.—The sulphate of ammonia market continues fairly active and a good amount of business is going through. The current price is quoted at from 14*l.* 6s. 3d. to 14*l.* 7s. 6d. per ton for prompt delivery, Glasgow or Leith. Shipments have recently been very satisfactory from the different ports, and the total exported last week from Leith Harbour amounted to 1861 tons.

Scotch Steel Trade.—There has been little change in steel trade affairs during the past week, and employment generally is good. With regard to shipbuilding material there seems to be no lack of demand, and specifications are coming to hand freely, both for ship and boiler-plates. The position brought about by the rebate scheme has not changed much; but while new business from merchants is very limited, a fair amount of direct buying on the part of local consumers is reported. The export trade is still very satisfactory, and a large tonnage is going through each week, and inquiries are presently in the market for a considerable amount of material.

Scotch Pig-Iron Trade.—Scotch pig-iron makers report a fair amount of buying during the past week, and in some instances local requirements for several months ahead have been booked. Export business is also fairly good, and fresh inquiries are satisfactory. Several lots have just been fixed up for shipment to Japan. Dealing in hematite has improved, and the current quotation is round 65s. per ton.

Institution of Engineers and Shipbuilders in Scotland.—At the meeting last night (Tuesday) of the Institution of Engineers and Shipbuilders in Scotland, held in the Institution head-quarters in Glasgow, Mr. E. Hall-Brown, the President, occupied the chair. Professor A. L. Mellanby read a paper on "The Initial Condensation in Steam-Engine Cylinders," and Professor F. P. Purvis also contributed a paper entitled "Windlass and Steering-Gear Engines."

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Very satisfactory accounts are given of all branches of the pig-iron trade. The tone of the market is more cheerful than for several months past, and prospects are regarded as bright and encouraging. Buyers are coming forward freely, and not only are they quite prepared to pay the advanced rates asked, but they are keen on making forward contracts. The statistical situation is steadily improving. No. 3 g.m.b. Cleveland pig iron readily realises 48s. 3d. for early f.o.b. delivery, and there are buyers over at 49s. for the first quarter of next year, whilst some named brands of No. 3 delivered to the end of March are quoted 50s. and upward. Other kinds of Cleveland pig have risen in proportion to the ruling quality. Thus No. 1 bar has become 52s. 3d.; No. 4 foundry 47s. 9d.; No. 4 forge 47s. 6d.; and mottled and white iron, each 47s. 3d.—all for early delivery, 9d. above these rates being quoted on forward account. East Coast hematite is in very good request, and producers—all of whom have sold well recently—take a much firmer stand than they were able to a little while ago. Buyers endeavour to put the price of Nos. 1, 2, and 3 at 61s. 6d. for early delivery, but it is doubtful whether orders could now be placed at that figure. The general market quotation is 62s. for this year's delivery. Prices range from 63s. to 65s. for delivery over the first half of next year, and for the second half 67s. 6d. is named. Foreign ore is very strong, and after heavy busines sales are not being pressed. Market rates are based on 20s. 6d. to 21s. ex-ship Tees for Rubio of 50 per cent. quality. Coke is in good request for local consumption, and average blastfurnace kinds delivered at Teesside works this year realise 15s. 3d., whilst business over periods next year has been recorded at 16s.

Stocks and Shipments of Pig Iron.—Makers have now very little stock of pig, but there is still 570,000 tons of Cleveland iron in the public warrant stores. This, however, is being reduced this month at the rate of some 400 tons per working day. Shipments of pig iron to date this month average 3117 tons per working day, as compared wfth a daily average of 3964 tons to the same date last month, and 3738 tons for the corresponding part of November last year.

Manufactured Iron and Steel.—Excellent accounts continue to be given of the manufactured iron and steel industries. All branches are kept busily employed, and not only have producers heavy contracts booked, but there are still good inquiries in the market. Under such favourable conditions values tend upward, but they are not quotably advanced. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 5s. to 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s. to 7*l.* 7s. 6d.; iron girder-plates, 6*l.* 17s. 6d.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; and steel joists, 6*l.* 10s.—all less the customary 2½ per cent. discount. Cast-iron columns are 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.—all net cash at works. Iron and steel galvanised corrugated sheets, 24 gauge, in bundles, stand at 11*l.* 5s. f.o.b.—le the usual 4 per cent. discount.

Shipbuilding Orders.—Messrs. Irvine's Shipbuilding and Dry Dock Company, of the Hartlepools, have booked orders for two large cargo steamers of about 10,000 tons each, for the Holland-America Line, and also for two large vessels for Messrs. Elder, Dempster, and Co.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has been quiet. Tonnage arrivals have been disappointing in consequence of a renewal of the gales which have recently disorganised business. Strong hopes are entertained, however, of an improvement in the arrivals; and, in view of this, colliery owners have shown no disposition to modify quotations. For rather more distant dates colliery owners are looking forward to pressure up to Christmas, as they anticipate that consumers—especially the Italian Government—will make efforts to meet current requirements. The best large steam-coal has made 16s. 9d. to 17s. 6d. per ton, while secondary qualities have ranged between 15s. 6d. and 16s.; best ordinary bunker smalls between 7s. 3d. and 7s. 6d.; and cargo smalls between 5s. 3d. and 6s. 6d. per ton. House-coal has been held with firmness; the best ordinary qualities have made 14s. 6d. to 16s. 6d.; No. 3 Rhondda large, 17s. to 17s. 6d.; and smalls, 10s. 3d. to 10s. 6d. per ton. No. 2 Rhondda large has realised 12s. to 12s. 6d.; and smalls, 6s. 3d. to 6s. 9d. per ton. Foundry coke has been quoted at 17s. 6d. to 20s.; and furnace ditto, at 15s. 6d. to 16s. 6d. per ton. As regards iron ore, Rubio has made 19s. to 20s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Welsh Railway Traffic.—The half-year now closing will not be a brilliant one for Welsh railway proprietors. The revenue of the Barry Railway, for instance, only comes out at 252,490*l.*, as compared with 277,399*l.*, and that of the Brecon and Merthyr at 41,383*l.*, as against 44,296*l.* The receipts of the Rhondda and Swansea Bay have declined to 47,584*l.*, as compared with 49,604*l.*; those of the Rhymney, to 124,960*l.*, as compared with 137,276*l.*; and those of the Taff Vale, to 350,274*l.*, as compared with 378,408*l.* It will be observed that the decline in receipts is general. Labour troubles and difficulties of all kinds furnish, of course, the explanation.

DOUBLE-CUTTING AND HIGH-SPEED PLANING-MACHINES.

(*For Description, see Page* 700.)

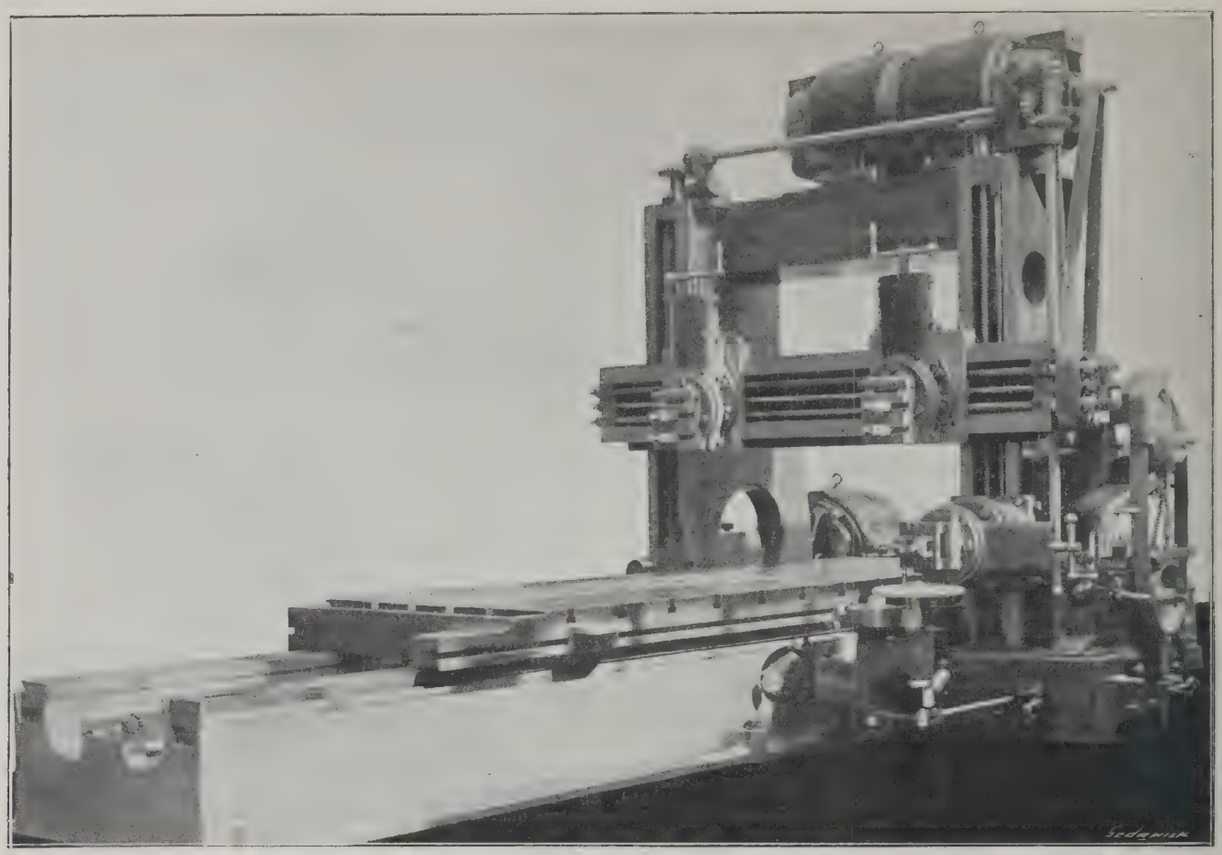


Fig. 8.

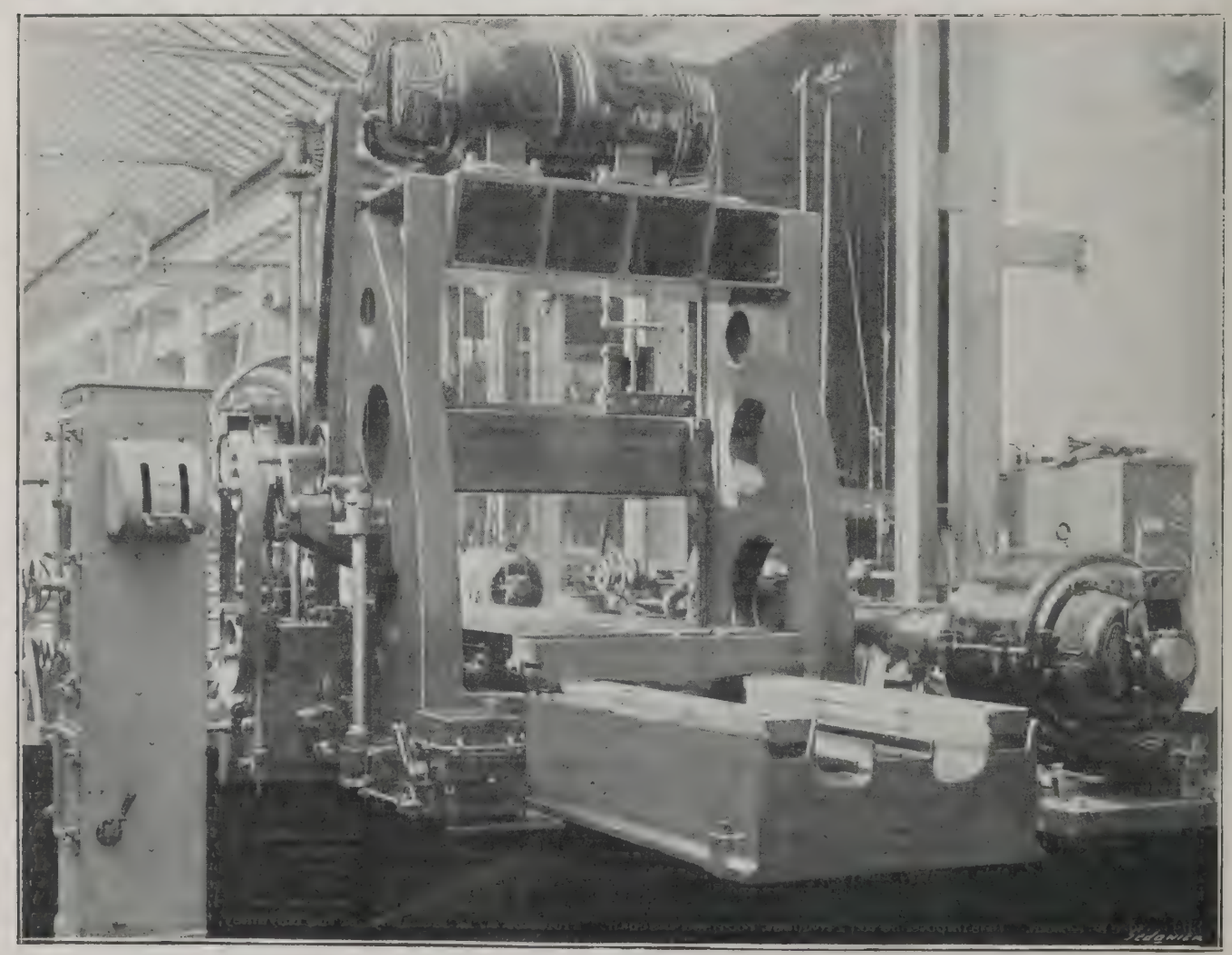


Fig. 9.

Figs. 8 and 9. Views showing Feed, Traversing, and Cross-Slide Raising-Gear for Buckton Planing-Machine.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" can be supplied direct from the Publisher post free, for twelve months, at the following rates, payable in advance:—

For the United Kingdom	£1	9	2
For Canada—			
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Thick ,,	£1	16	0 ($8.75)
For all other places abroad—			
Thin paper copies	£1	16	0
Thick ,,	£2	0	6

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

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We desire to call the attention of our readers to the fact that the above is our SOLE Address, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS—"ENGINEERING," LONDON.
TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With a Two-Page Plate of the JUNKERS MARINE OIL-ENGINES FOR A HAMBURG-AMERICA LINER.

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, November 24, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda:—1. "The Maximum Value of the Electric Stress Between Two Unequal Spherical Electrodes," by Dr. A. Russell. 2. "The Cubical Expansion of Fused Silica," by Mr. F. J. Harlow. 3. "On the Temperature Coefficient of Diffusion," by Mr. B. W. Clack. 4. "The α Particles Emitted by the Active Deposits of Thorium and Actinium," by Messrs. E. Marsden and T. Barratt. 5. "The Magnetic Transition Temperature of Cementite," by Messrs. S. W. J. Smith, W. White, and S. G. Barker.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH LOCAL SECTION.—Friday, November 24, at 8 p.m., in the Rooms, 207, Bath-street, Glasgow. Meeting to discuss the proposed new Articles of Association. The President, Mr. S. Z. de Ferranti, and one or more Members of Council, will come from London specially, and will attend the meeting for this purpose.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, November 24, at 7.30 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-upon-Tyne. Paper to be again discussed:—"The Relationship between Residuary Resistance Horse-Power and Forms of Vessels," by Mr. Ernest Saxton White, B.Sc. Paper to be read and discussed:—"Certain Aspects of Ship Resistance as Disclosed by the Performance of the Corrugated Sided Vessel 'Monitoria,'" by Mr. Arthur H. Haver, M.I.N.A., Member.

THE BRITISH FOUNDRYMEN'S ASSOCIATION: BIRMINGHAM BRANCH.—Saturday, November 25, at 7 p.m., at the Technical School, Suffolk-street, Birmingham. Mr. E. L. Joselin will read a paper on "Fans for Cupolas."

THE INSTITUTE OF MARINE ENGINEERS.—Monday, November 27, at 8 p.m. Paper on "Shipping on the Great Lakes," by Mr. A. E. Jordan, Member.

THE SURVEYORS' INSTITUTION.—Monday, November 27, at 8 p.m. The discussion on Mr. J. J. Dones's paper on "The Development of Building Land," adjourned from last session, will be resumed.

THE ROYAL SOCIETY OF ARTS.—Monday, November 27, at 8 p.m. Cantor Lecture. "The Carbonisation of Coal," by Professor Vivian B. Lewes. Lecture I.—"The Composition of Coal."—Wednesday, November 29, at 8 p.m. "The Efficiency of the Aeroplane," by Mr. A. E. Berriman. Mr. Dugald Clerk, F.R.S., M. Inst. C.E., Member of the Council of the Society, will preside.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 28, at 8 p.m. Paper to be read:—"Electric Lighting of Railway-Trains: The Brake-Vehicle Method," by Mr. Roger Thomas Smith, B.Sc., Assoc. M. Inst. C.E.—Students' meeting, Friday, December 1, at 8 p.m. Paper to be read:—"Brake-Lining Coefficients of Friction," by Messrs. James and Will Legg, Studs. Inst. C.E. Dr. W. C. Unwin, F.R.S., President, will occupy the chair.

THE JUNIOR INSTITUTION OF ENGINEERS.—Tuesday, November 28, at 8 p.m., at the Institution of Electrical Engineers, Victoria Embankment. Paper on "Modern Methods of Water-Softening and Purification," by Mr. J. J. Lassen (Member), of London.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 29, at 7.30 p.m. A paper will be read by Mr. J. S. Gillingham, R.C.N.C., M.I.N.A., entitled "The Evolution of the Modern Armour-Plate for Warships."

THE NORTHAMPTON INSTITUTE ENGINEERING SOCIETY.—Friday, December 1. There will be an open debate on "The Prospects of the Technical *versus* the Practical Man."

READING-CASES.—Reading-cases which will hold twenty-six numbers of "ENGINEERING" may be had of the Publisher or of any newsagent. Price 6s. each.

ENGINEERING.

FRIDAY, NOVEMBER 24, 1911.

PARLIAMENT AND THE RAILWAY AGREEMENT.

WEDNESDAY'S debate in the House of Commons has a wider significance than is involved in the immediate issue raised. It accentuates the difficulty which has always been experienced in connection with collective bargaining, and once more establishes the lack of authority of the trade-union leaders over the rank and file of their members. The railway strike in August last, and the negotiations in connection with it, afforded experienced leaders in the political arena and masters of administration in the Government departments an admirable opportunity of setting an example to labour organisers, not only in respect of precision in proceedings under arbitration, but in asserting power as recognised masters in their organisations. This opportunity was missed, partly owing to haste and anxiety to bring about a state of peace at home, when, as now appears, there were strained international relations. But even those responsible on behalf of the Government cannot escape criticism for the uncertainty which has since arisen as to agreement in the acceptance of the recommendations of the Railway Commission which was to be appointed as a result of the conference between the members of the Government, the railway companies, and their employees. Apart from this, there is a salient lesson to be learned by all interested in industrial affairs, owing to the attempt of the workers' representatives to establish now that there was no such agreement, although the railway companies formally ratified their intention to abide by the recommendations of the Commission.

It is this practice of refusing to accept the result of arbitration proceedings or other negotiations between employer and worker which is the cause of most of the prevalent labour unrest. Collective bargaining can only succeed provided those representing both parties agree to accept the decision mutually come to or established by the arbiter, and to enforce with all their authority the acceptance of the decision or award on the part of the men they represent. No opportunity should be lost of enforcing this condition, even in the interests of the labour organisers; and yet, what is the attitude of such an exacting leader as the Chanceller of the Exchequer? He stated:—"I certainly understood both parties were prepared to accept the recommendations of the Royal Commission. . . . We (the Government) feel that we have been just as much a party to that agreement as the railway directors and honourable gentlemen below the gangway (the Labour Party)." But notwithstanding this, Mr. Lloyd George objected to an official assertion in the resolution by the House of Commons that the parties to the agreement had agreed to accept the finding of the Commission, on the ground that the House must not make it difficult for the Labour leaders, who have their constituents (the railwaymen) to consider in ensuring amity and the acceptance of the agreement. But recalcitrancy is never cured by indecision, weakness, or tergiversation. Such is an undoubted incentive not only to leaders to repudiate agreements come to under collective bargaining, but to the men to rebel against decisions come to, as the result of negotiations conducted on their part, in the event of the issue being in any way unsatisfactory to them.

Moreover, there can be no longer any question that the workers agreed to stand by the agreement. It was pointed out in the course of the debate that Mr. J. H. Thomas, the Member for Derby, stated in evidence: "The railway companies are prepared to accept the finding of the Commission, even to the extent of recognition, and we on our part say the same." The Member for Derby was one of the union representatives during the negotiations. Another unionist, Mr. Charles, was asked by the Commissioners: "Is it a fact that whatever recommendation this Commission may make is to be accepted by both the companies and the men?" and he replied: "That is what our representatives tell us was the understanding on which they signed the agreement; if that was not the understanding, the strike would not have finished when it did." It is true that Mr. Thomas claimed during the debate that, as reported in a Derby paper, he, in September, had contradicted the assertions made in the Press, that the men had agreed to abide by the decision; and he seemed to think that this contradiction in a provincial town, recorded only in a local paper, should have been accepted by the railway companies in refutation of all the other evidence brought in favour of trade-union acceptance of the decision of the Commission. We have already indicated the view taken by the Chancellor of the Exchequer, who was one of the Ministers at the Conference. The Prime Minister, who was also present at most of the meetings, and was thoroughly conversant with all that took place, was perfectly clear in expressing the view that the men did agree to accept the finding of the Commission. Mr. Asquith stated that "the official minute at the time by the Board of Trade shows recorded their understanding of what took place. That minute was published in the Press, and discussed and canvassed throughout the length and breadth of the country, and, so far as I am aware—nothing that Mr. Ramsay Macdonald has said alters what I am going to say on that point—when the Commission assembled and during the progress of its proceedings, no protest, remonstrance, correction, or qualification of any kind was put forth to suggest that that was not the view taken." Mr. Macdonald had said that, after the signing, the Board of Trade produced a document, which was read, and which undoubtedly committed the men to the acceptance of the report. But he pleaded that, owing to the prolonged negotiations, the men, who were scattered about the room and were tired with the negotiations, should not be bound by the document, because it was an addendum to the signed terms of agreement. We say nothing about the mismanagement which did not include such a vital clause in the main body of the agreement which was signed, but, in any case, practically every Labour leader was forced, by the arguments adduced in the House, to accept at least moral obligation for the acceptance of the decision of the Commission.

The Labour leaders fought against any recording

of this mutual agreement or acceptance of the findings of the Commission in the resolution proposed, and calling for Government interference to bring about a further meeting of the railway directors and the men's representatives. This hesitancy in adopting a masterly declaration, whereby the authority of the leaders would be established, warrants the importance which we have attached to this part of the question, since it justified the railway companies in refusing to recognise trade unions, who do not represent the majority of the men, and do not loyally fulfil their agreements, by meeting them and opening out the whole subject of the recommendations of the Royal Commission. Mr. Ramsay Macdonald's motion was regarded as practically a vote of censure on the railway companies, and the Prime Minister said that it contained language "to which the Government cannot subscribe, and which must make any effort to bring the parties together almost impossible." The motion asked the House to express regret that the directors of the railway companies had refused to meet the representatives of the men, and to declare that such refusal was "contrary to the public interest, and to have no justification." The Government, after thus censuring the railway directors, were to ask them to meet the unions in conference without delay. Everyone in the House — everybody in the country—is anxious to find a *via media* for ending the present state of unrest. Mr. Asquith, after stating the fact that the men had agreed to abide by the report, and after paying well-merited recognition to the attitude of the railway directors, who had shown "a patriotic spirit, and a spirit which redounds to their credit, both as citizens and as men of business," pleaded with them for further discussion and conference, not on the main principles laid down in the report, but rather on strictly limited details. He, however, made it perfectly clear that there was to be no question of recognition other than the "recognition as determined by the terms of the report itself." Mr. Bonar Law was right in the view he expressed that the Government ought to have approached the railway directors in consultation before putting forward a proposal to the House in favour of a further conference, which, Lord Hugh Cecil pointed out, in view of the acceptance of the report, was only either "mischievous or superfluous." The leader of the Opposition had been himself in conference with the railway directors, and the view taken was that, as the Government had previously used strong pressure upon the railway directors to enter into a bargain, they had acceded because it was to be final, and would be accepted by both sides. They would therefore not now agree to further pressure to attend a conference upon the subject settled by the Commission. There was therefore a greater need for the Government insisting upon a definite declaration in the resolution that both parties had decided to accept the findings of the Commission, as a preamble to any recommendation of further negotiations as to details. If, as the Chancellor of the Exchequer said, the Government were themselves parties to this agreement, it behoved them to make such a declaration of the findings.

Sir Alfred Cripps moved as an amendment to Mr. Ramsay Macdonald that "the report of the Royal Commission, being agreed to by both parties, this House requests the Government to use its good offices with a view of arranging that the directors shall meet the representatives of the men in order to discuss questions of detail arising out of the report of the Royal Commission." As regarded the acceptance of the findings of the Commission, Mr. Ramsay Macdonald considered the word "accept" to be so ambiguous that it might lead to unfortunate results. But, as Mr. Bonar Law pointed out, the real objection to the word was "not because it was ambiguous, but because it was too clear." Political expediency again won: ultimately the House, after two divisions, accepted the Chancellor of the Exchequer's motion to the effect that "in the opinion of this House a meeting should take place between the representatives of the parties on whose behalf the railway agreement of August, 1911, was signed, to discuss the best mode of giving effect to the Report of the Royal Commission, and asks the Government to bring both sides into conference without delay." We quote the wording; we disclaim responsibility for its loose English.

The question that now arises is as to whether the railway companies will accept the invitation of the Government. The failure to make it clear beyond doubt whether the finding of the Commission was to be accepted by the unions, and their refusal to support completely the decision of a Commission established by themselves in face of recalcitrant workmen, naturally does not conduce to a large degree of confidence that the finding of this second conference will yield a lasting result, even although its purview is limited. The principal objection taken to the Commission's report is as to the degree of "recognition" granted to trade unions. Only 42 per cent. of the workers on the railways belong to unions, and the whole contention of the Labour Party is that the men should be met by the directors. The railway companies are willing to meet the men, but they must be their own men. They have acceded to the new recommendation of the Commission that the secretary of the Boards appointed by the men should be an official of the trade unions. This new conference is obviously devised in order that the unions may meet the directors. This would create a precedent to recognition, especially in national negotiations devised for the main purpose of facilitating national strikes. No greater menace to the interests of the nation can be conceived than such national strikes. Mr. Asquith's justification for the second conference is to obviate "the suspension of a service which is necessary to the prosperity, to the health, and even to the life of the community." The avoidance of such a calamity cannot be ensured by setting up and recognising an authority antagonistic to peace, discipline, and the economical working of an indispensable transport system, and representative of less than half the workers, in order that the unionists' demands in the case of a small section of the service may be enforced by a complete cessation of traffic throughout the country. Peace lies rather in the direction of carrying out the provisions evolved by the Royal Commission, which must be regarded as a reasonably liberal compromise in the interests of all the working men and of the railways.

THE EFFICIENCY OF THE GAS-TURBINE.

In a paper read this week at the Berlin meeting of the German Society of Naval Architects, Mr. H. Holzwarth, of Mannheim, describes a gas-turbine of 1000 horse-power, which has been constructed to his designs. The paper in question is interesting as a record of what has been done in this matter, but in other respects it leaves much to be desired. It consists in the main of comments on the advantages of turbines, of explanations of certain details of construction, and of a slight and imperfect sketch of the theory to which the machine has been constructed. We all know that a gas-turbine can be built to run, and also that a good gas-turbine would have enormous advantages, and hence at this date long-drawn generalities on such texts constitute very unattractive fare. Plain statements as to the gas consumed per kilowatt-hour are entirely missing from Mr. Holzwarth's paper; an omission from which our readers will draw their own conclusions.

On another page we reproduce a section showing the general arrangement of the 1000-horse-power machine, built for the inventor by Messrs. Brown, Boveri, and Co., at Mannheim. This machine has been under test for the best part of a year, and figures as to net results must be available. As will be seen, the author does give some so-called efficiency curves, but in the case of all heat-engines there are so many ways of estimating efficiencies that in the absence of a definite statement as to which is intended, the term has no meaning. For example, the thermal efficiency of one and the same steam-engine may be either 18 or 80 per cent., according to whether the estimate is based upon the proportion of the total heat turned into work, or on the proportion of the heat theoretically available which is utilised. It is exceedingly difficult to determine with certainty, from Mr. Holzwarth's paper, what the basis is on which the efficiency has been calculated. As far as we can gather, his total over-all efficiency is the ratio of the useful work actually done to the area of the theoretical indicator diagram, as calculated from the observed initial and final pressures. We cannot be quite certain on this point, as the author's statements in connection therewith seem to be wanting in lucidity, and in spite of our best efforts we may have misunderstood them. The actual over-all efficiency given is, however, in accord with what would be expected from the cycle chosen, and is, it will be seen, a very small fraction of the corresponding figure for a good gas-engine.

Briefly stated, the cycle adopted by Mr. Holzwarth is essentially as follows:—A charge of gas and air is compressed through a non-return valve into an explosion-chamber, communicating through a valve with nozzles discharging on to a turbine wheel. The compressed charge is exploded, the nozzle-valve opened, and the burnt gases expanded through the nozzles on to the wheel, driving it round. A scavenging charge next clears out the explosion chamber, and the nozzle-valve is then closed, and a fresh charge compressed into the chamber as before. The cycle is, therefore, an old one, and some experiments were made here with it a few years back, the inventor's idea being to build a turbine suitable for motor-car construction. The noteworthy feature in Mr. Holzwarth's scheme is the low compression used, which, as will be seen from Fig. 2, page 714, is only some 22 lb. to 24 lb. absolute. Such a low compression would in the case of an ordinary gas-engine involve a very high expenditure of gas per indicated horse-power developed, but such engines only expand down to the initial volume of the charge, and the toe of the diagram, which is theoretically capable of doing a considerable amount of work, is lost. Considerations of size and weight make it impracticable to utilise this toe in a gas-engine of the ordinary type, but a turbine is under no such disabilities. It can fully expand the gas down to its original pressure, and it is this fact that makes a high compression less essential than it is in the case of a reciprocating engine. There is, therefore, something to be said for the plan of using a low compression, as it reduces the negative work done in the cycle, and the weight and cost of the compressor. But though the compression may be low, the explosion pressure is always considerable, and it is therefore necessary to introduce a non-return valve between his explosion chamber and the compressor, which, of course, involves intermittent working. The velocity at which the products of combustion issue from the nozzle is thus a constantly varying one and the variation is through a wide range. The author remarks that the wheel in his turbine is working under the same conditions as a Parsons turbine operated with gust-governing; but if so, his losses are likely to be considerable. Experience has shown that the efficiency with gust-governing is practically the same as with throttle-governing, in which case the admission pressure is the mean of the extreme values obtained with gust-governing, so that if the analogy he advances holds, Mr. Holzwarth's turbine will have about the same efficiency as if supplied continuously with gases expanded from about half the explosion pressure.

If the explosion pressure of a gaseous mixture is calculated from the specific heats of the products of combustion, and the heat units liberated by the reaction, this calculated pressure is always much greater than that actually recorded by the indicator, and it is now known that a very large fraction of the defect is due to radiation losses. A knowledge of specific heats and of heats of reaction is therefore insufficient to afford a clue to the efficiency of the cycle under consideration. This, however, can be obtained from Mr. Dugald Clerk's classical experiments on "The Explosion of Gaseous Mixtures" (Minutes of the Proceedings of the Institution of Civil Engineers, vol. lxxxv.). It will be seen from Fig. 2, page 714, that the temperature attained in the best of Mr. Holzwarth's tests was about 1560 deg. Cent. absolute, the initial temperature of the mixture being 15 deg. Cent. From Mr. Clerk's experiments it appears that to attain this temperature the mixture must have had expended on it about 830 B.Th.U. per pound, which at an absolute pressure of 24 lb. per sq. in., and at a temperature of 15 deg. Cent., will occupy about 8.47 cub. ft. If we assume, which is, perhaps, doubtful, that the waste heat will be sufficient to drive the compressor, the net expenditure of energy will thus be 830 B.Th.U. per pound used. The pressure of explosion is 126 lb. per sq. in. absolute. If, in accordance with gas-engine experience, we assume that the pressure falls according to the law $P V^{1.3} = \text{constant}$, the final volume of 1 lb. after expansion to atmospheric pressure will be 44.22 cub. ft., and the mean effective pressure, if the gas were allowed to do work on a piston, would be about 24.1 lb. per sq. in. Hence the indicated work amounts to 24.1 ×

$(44.22-8.46)\times 144=124{,}524$ ft.-lb., or 159.8 B.Th.U. To obtain this the expenditure of heat has amounted to 830 B.Th.U., so that the maximum possible over-all efficiency appertaining to the cycle appears to be 0.193 Actually it will be less, since the 159.8 B.Th.U., above found, is the amount of energy which will, in the absence of nozzle friction, appear in the form of kinetic energy; of this the turbine will convert only a fraction into work. Mr. Holzwarth claims for his turbine an efficiency of 58 per cent., which appears high, considering the conditions of working and the type of turbine used; but accepting this figure, the over-all efficiency, taken as the ratio of useful work done to heat expended, comes out as 0.112. With good gas-engines values as high as 0.36 have been registered, so the future of the suggested cycle appears far from promising.

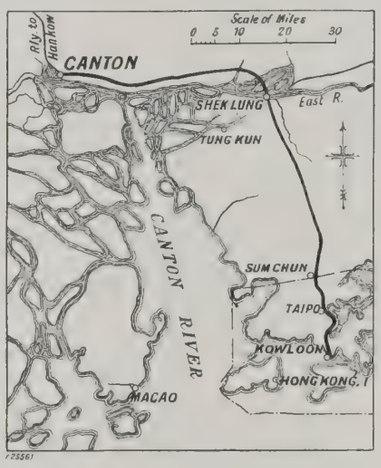
Other experimenters have been at work with the gas-turbine both in this country and in France. In one set of English experiments which we have in mind the nozzles were made of carborundum, as it was feared that ordinary cast iron or steel would melt. The compression used was fairly high, so that the temperatures were greater than in the Holzwarth machine. A regenerator was used to recover, as far as possible, the heat carried off by the waste gases. The experimental plant was well supported financially, but the size and relative inefficiency of the compressor needed led to the abandonment of further experiment. The most discouraging feature about the problem of the gas-turbine is, however, to be found in certain experiments made in France. Here it was proposed to use the turbines to drive torpedoes. The compressor difficulty in such cases does not exist, since the turbine has to compete with an engine which also has to have a supply of compressed air. In spite, however, of the fact that the turbine was without the handicap involved in driving a compressor, the best results obtained after prolonged experiment were markedly inferior to those easily secured with the reciprocating engines now fitted.

CANTON TO KOWLOON RAILWAY.

The latest papers from the Far East contain accounts of the official opening of the Chinese section of the Canton-Kowloon Railway on October 4, and the ceremony marks an important date in the development of communication between the East and the West. It may be a considerable time yet before it will be possible to take a railway-ticket at Kowloon (opposite Hong Kong) for Calais *viâ* Canton, Hankow, Berlin, and Paris, but the completion of the Chinese section of the Canton-Kowloon Railway brings the time appreciably nearer, and, if internal troubles in China do not prevent the development of railway construction, it may not be long before it is possible to make the journey from London to Hong Kong in fourteen days. The important line which has just been completed starts from Canton, the great commercial centre of South China, and after traversing nearly 90 miles of fertile country links up with the British section at the frontier of our leased territory, thus providing a continuous track of steel from Kowloon ferry to Canton itself. The results to South China following from the completion of this line are expected to be very great, as a very large population is brought into direct communication with Hong Kong, a great distributing centre with goods from all parts of the world. The importance of Hong Kong should thus be greatly increased, and when the line is extended northwards, and brought into direct communication with the Trans-Siberian Railway and with the railways of Europe, it is impossible to form an estimate of the developments which may take place. We may be sure that they will be very great. China is awakening rapidly, and when she is fully awake, and her resources are taken advantage of, she will become a factor in the world's trade and industry which will greatly change the position of its centre of magnitude.

It may be convenient to recall the fact that the island of Hong Kong became a British Crown Colony in 1843. It, however, soon became evident that the acquisition of territory on the adjacent mainland was essential to the existence of the colony, as the island was too small to allow of much development. In 1858 an arrangement was come to with the Governor of Canton whereby a perpetual lease of an area of 4 square miles in the Kowloon Peninsula was placed under British jurisdiction. Forty years later a further area was granted on a lease of ninety-nine years, and at the same time the British and the Chinese Corporation obtained a concession for the construction of a railway between Canton and Kowloon. Nothing, however, was done for some years beyond making a preliminary survey, but the changes which were taking place in other parts of China made it very evident that if Hong Kong was to remain the distributing port for South China, railway communication between the colony and Canton was essential. Accordingly, before the end of 1905 serious steps were taken to secure the early construction of this important line. The hand of the British authorities was forced when certain other countries suggested that a railway from Canton to the coast should be constructed outside British territory, a course which would have dealt a heavy blow to Hong Kong, and, what is more important, to British prestige in China generally.

We need not enter into the financial arrangements which were made in connection with the construction of the line; it is sufficient to say that by April, 1906, the loan was satisfactorily settled, the bonds being taken up at par, a circumstance which affords a sufficiently striking testimony to the value of the security presented by the undertaking. Work was at once commenced, and carried on under somewhat



serious difficulties. The line falls into two clearly defined sections for an estimated distance of about 100 miles. Between Canton and the boundary of the Kowloon territory the line runs through a country which is subject to Chinese control. At the Kowloon boundary, however, it falls within British jurisdiction. The British portion of the railway was built departmentally, under the auspices of the Crown Agents of the Colonies, by the Government of Hong Kong, and some of the work was exceptionally heavy, as in a total length of 22 miles there are five tunnels and forty-nine bridges. The lengths of the tunnels are 150 ft., 212 ft., 329 ft., 170 ft., and 923 ft. The longest of the bridges is 200 ft. It is formed of concrete and brick masonry in two spans of 60 ft. and two of 40 ft. Most of the other bridges are comparatively short, but considerable trouble was experienced with some of them owing to the failure of the foundations, several of which had eventually to be strengthened, and in a few cases even rebuilt.

The Imperial Government of China built the Chinese section of the line, 89 miles long. In May last about 35 miles were opened for traffic. The local administration of the railway is placed by the Loan agreement in the hands of a Chinese managing director associated with a British engineer-in-chief and a chief accountant, and these positions are at present filled by Mr. Chao Ching Hua, acting-managing director, Mr. Frank Grove, M. Inst. C.E., engineer-in-chief, and Mr. Ernest Hall, chief accountant. Mr. Grove was formerly connected with the Bengal-Assam Railway, previous to undertaking the position he has for some year occupied. Indeed, the Hong Kong-Canton line is also indebted to the Bengal-Assam Railway for Mr. E. S. Lindsey, M. Inst. C.E., the chief resident engineer of the British section, and both these gentlemen deserve great credit for the ability and energy which they have displayed in carrying out the work under great difficulties. Although the two sections of the line are distinctive in so far as they are under separate control and management, considerable uniformity exists in the works, and much of the plant is interchangeable. The Chinese section of the railway passes through a hilly and mountainous country involving heavy embankments. A feature calling for special note is a series of large bridges in the East River Valley, which is crossed between mile 32 and mile 41. In these 9 miles are the following bridges:—

Sien Tsun River Bridge	5 spans, 60 ft., skew
Shek Ha River Bridge	3 spans, 60 ft.
Shek Tan River Bridge	3 spans, 100 ft.; 2, 60 ft.
Pek Kong River Bridge	4 spans, 60 ft.
Kan Sui River Bridge	3 spans, 100 ft.
Sheklung, East River Bridge	3 spans, 224 ft.; 2, 60 ft.
Tung Kun River Bridge	4 spans, 244 ft.; 2, 60 ft.

Steel rails, 85 lb. per yard, have been supplied by the Hangyang Iron and Steel Works, Hanyang, near Hankow, also fastenings with the exception of fish-bolts, and the quality, as proved by analysis and physical tests, is up to a high standard. The type of locomotive adopted is outside cylinders, 19 in. by 24 in. stroke; double bogie tender for 3500 gallons of water and $5\frac{1}{2}$ tons of coal; weight of engine and tender loaded, $101\frac{1}{2}$ tons; maximum axle load, $16\frac{1}{2}$ tons; diameter of driving wheels, 5 ft.; manufacturers, the North British Locomotive Company, Limited, Glasgow. The first carriages in use were supplied, as to frames and bogies, by the Metropolitan Carriage and Wagon Company, Birmingham, the bodies being manufactured and erected by the Hong Kong and Whampoa Dock Company, Limited, of Hong Kong. Others have been built by the Tang Shan Works of the Imperial Railway Works of North China. They are all fitted with the most up-to-date appliances for the comfort and safety of the passengers.

The completion of the Canton-Kowloon Railway is a most important step in the development of the railway system in China, and when it is extended to Hankow it will open up great possibilities for trade not only with Hong Kong, but also with a very large district with an immense population.

THE CYCLE AND MOTOR-CYCLE EXHIBITION.

The popularity of cycling is amply evidenced by the display of machines exhibited at Olympia during the present week, where some hundred or so firms engaged in their manufacture are represented. The pedal cycle is well in evidence, but a noticeable feature is the large proportion of cycle firms now constructing motor-cycles. Several firms are exhibiting these for the first time at this Show, and few of the more well-known cycle-makers are unrepresented in this section. Pedal cycles would appear to have settled down to a more or less standard design, and though certain details are varied in the different makes, there would not appear to be any noticeable alterations.

In the motor-cycle, however, several new features are to be found; but, in spite of the years of practical experience, errors in design—or, rather, errors due to lack of design—are still perpetuated in some of the more popular makes. The construction of machines would appear to be largely controlled by fashion, and the average motor-cyclist takes up the sport with the idea that the troubles he will experience are not to be avoided, or even mitigated. In spite, however, of the difficulties that must arise in the attempt to provide so much power with strict limitations as to weight, no possible excuse can be offered for driving-belts which foul magneto covers and such like evils. Tyre troubles the motorist is more or less bound to have, and punctures must occur with the best of tyres. The repairs, however, might be considerably simplified by taking them into account in designing a machine and allowing for easier access to the tyres. Very few firms appear to have given much thought to this matter, and to have provided an easily detachable portion to the back mud-guard and carrier.

The lack of intelligent design is particularly noticeable in connection with the brake gear, which, considering the hill-climbing capacity and the high speeds attained, is one of the most important items in the machine. The impression gained from a survey of the exhibits is that a certain number of component parts have been assembled together in order to produce a motor-cycle. Having got to a certain stage, it has occurred to the builder that brakes are essential, but, on coming to add these, various other parts already in position prevent a direct connection being made from the operating lever to the brake. According to the progress made on the machine previously to the brake idea maturing, a greater or less number of bends are necessary in the brake-rod. An interesting example can be seen

MOTOR-CYCLE PETROL-ENGINE AT OLYMPIA.

CONSTRUCTED BY MESSRS. VELOCE, LIMITED, BIRMINGHAM.

Fig. 1.

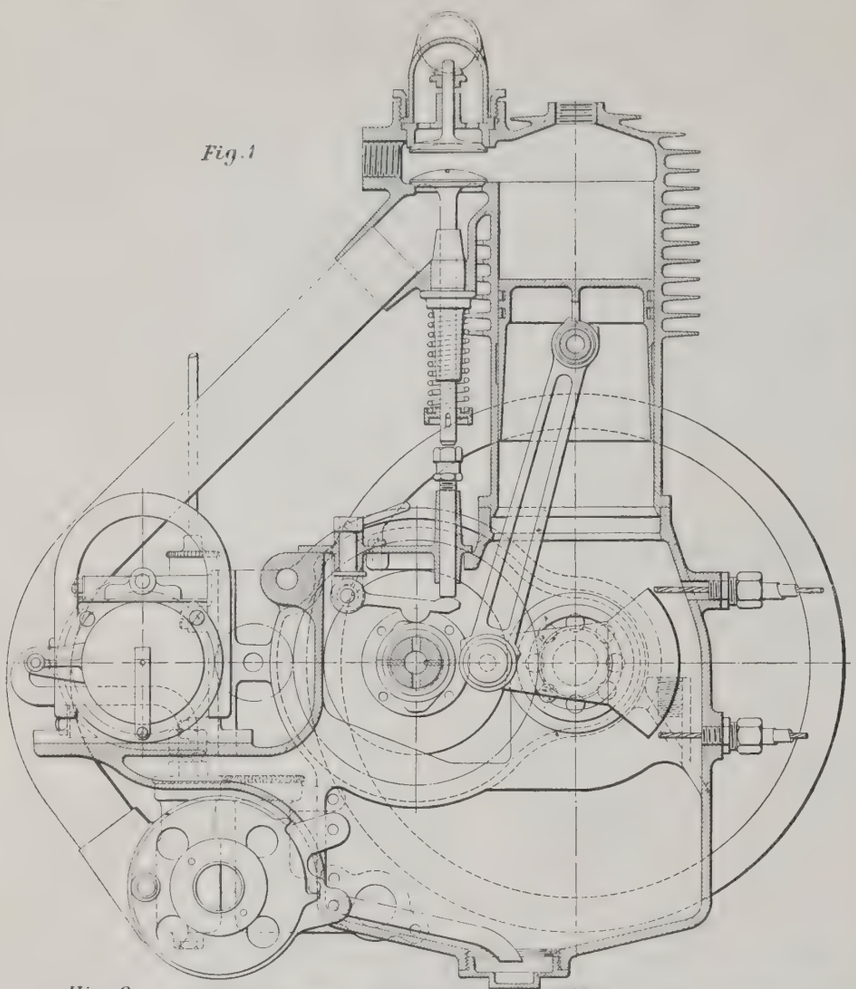
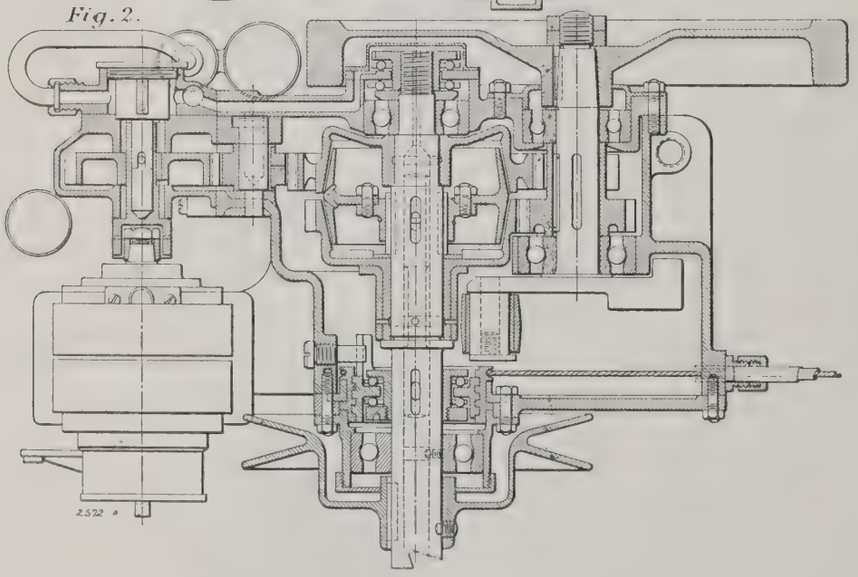


Fig. 2.



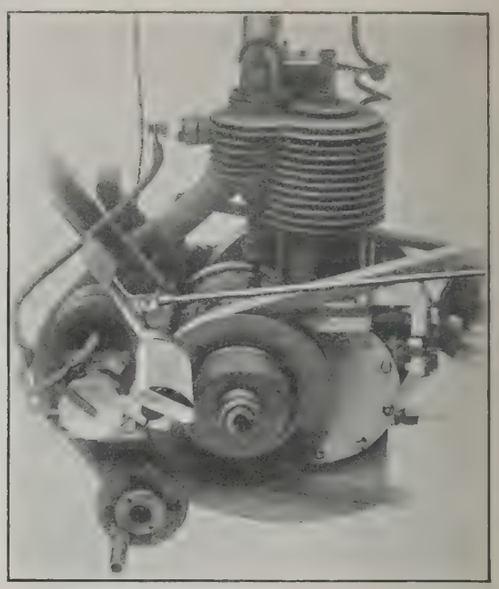


Fig. 3.

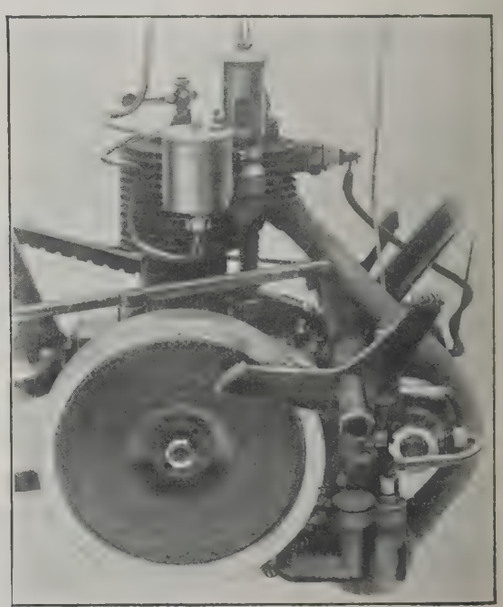


Fig. 4.

in which no less than six bends are made to clear existing obstacles, leading one to suppose that this machine was completed originally without brakes. Many systems of bent rods are to be seen, an attempt in one case being made to stiffen the bend by using a twisted rod of rectangular section, whilst many more or less satisfactory applications of the well-known Bowden wire are used. The practice of clamping brake-gear on to the frame still survives, but an improvement is gradually making headway in that lugs are brazed on to the frame.

The want of competent design is exemplified in one exhibit, however, in this connection. In this instance a lug is brazed on the lower back-stay to carry the brake-block link, the brake in this case operating on the inside of the driving-pulley. The brake rigging has a substantial appearance, adjusting-screws, &c., are eliminated, and mechanical strength is thus improved. The back wheel, however, is provided with adjustment for chain-tightening purposes, and thus, if the chain is tightened by this means, the brake gear is thrown out of adjustment, unless providentially the wear of the brake-block is in the right proportion to the stretch of the chain.

Comparatively few attempts are made to provide any adjustment for belts, in spite of the well-known troubles that occur with this type of driving, which still appears to be the popular method. Chain-drives are, however, offered by several leading makers, some of whom have, as yet, failed to realise the necessity of providing a friction drive on the pinion with this type of gear. This is more necessary when the engine is slowed down, as when riding in traffic. The variation of the cyclic speed then causes an undue shock on the chain at each impulse, unless some form of slip is provided. If this point be realised, very little trouble is found in chain-driving, and certainly less than is the case with belt-driving.

Although many machines are shown with change-speed hubs, their substitution by gear-boxes with chain drive from the engine is becoming popular. In spite of the successful operation of the geared hub, the new arrangement lends itself more readily to a mechanical job being made. On some machines a combined drive is provided, a chain being used

from the engine to a gear-box, and a belt to the driving-wheel, a selective clutch being used to operate the gears with a "free engine" position midway. As regards clutches, the designs shown include expanding, toothed and disc types, one of the latter being of the cork-studded variety.

In spite of the popularity of belt-driven machines, the more or less general absence of any belt-tightening arrangements would lead one to the impression that the average motor-cyclist is a long-suffering mortal. However, some makers have awakened to the desirability of such adjustments, and their designs may be considered among the novelties of the coming year. Several makes of variable-speed belt-driving are also exhibited which are new to this season's designs. In these an expanding pulley is fitted on the engine, having axially-moved sides to the V groove. The bottom of the groove is generally a ball-bearing sleeve, and thus the belt in its lowest position gives a "free engine"; on closing the sides of the pulley together the belt mounts up the groove and gives the varying gear ratios required in a very flexible manner. In order to maintain a uniform tension on the belt, when the gear is changed, several methods are shown. In one case a linked belt is employed with a jockey-pulley, but in a more popular design the back wheel is shifted by means of gearing interlocked with the pulley-expanding gear; in another instance, both pulleys are of the expanding type. In these gears the troubles due to belt-slip should be considerably mitigated.

As regards frame-design improvement may be found in some cases, and a more general introduction of an extra back-stay, to take the engine pull, is to be seen. An entirely new design of frame is shown by one firm, who exhibit a machine with a drop-frame built up of metal plates, having angle-iron stiffeners. The back wheel is carried in an independent tubular frame, which is hinged, about its forward end, to the countershaft, and supported on laminated springs fixed to the main framework. The machine is chain-driven from a chain-driven countershaft, and appears to be of very substantial design, though possibly a too bold departure from conventional ideas to meet with the universal favour of riders.

Spring-frame construction has afforded free play to the imagination of designers, and ladies' machines are to be found on the stands of some dozen or so of the leading makers.

In engine design a few new features are to be seen. In one case a compact skew-geared countershaft serves to drive the valves, magneto, and oil-pump. Another engine, constructed by Messrs. Veloce, Limited, of Birmingham, combines in its case a two-gear countershaft for the belt drive, and is to be particularly noticed on account of its compact and mechanical design. The construction of this engine will be readily seen from the engravings, Figs. 1 and 2, on the opposite page, which are respectively a sectional elevation and plan. The crank and fly-wheel are overhung at opposite ends of the engine-shaft, which has two fixed pinions, between its bearings, for the high and low gear drives to the countershaft. Two spur-wheels, free to revolve on the countershaft, run in mesh with these pinions, either of which wheels is made to drive by means of a double conical clutch sliding on feather-keys. The sliding action of the clutch is obtained by a screwed bush, working in a fixed nut, which is rotated by Bowden wires from a pedal. Engaging with the bush is a sliding-sleeve with double ball thrusts, and the motion of this sleeve is transmitted to the clutch by means of a spindle working in the hollow countershaft, to which both sleeve and clutch are fixed. The valves are operated by cams on the boss of the high-speed gear-wheel, as shown in Fig. 2, which figure also shows the arrangement of magneto drive. A complete and efficient system of lubrication is fitted, the oil being circulated from a sump in the gear-case by means of a rotary pump mounted on the magneto driving-spindle. From the pump the oil is led to the fly-wheel end of the hollow countershaft, along which it travels to the gear-wheel bearings, clutch, &c., by means of oil-holes drilled in the shaft; lubrication of the crank-pin is effected by a jet of oil from a hole drilled in the valve-cam. Two outside views of this engine are given in Figs. 3 and 4, opposite, which clearly show the compactness of design.

Automatic lubrication, either by pumps or by utilising the variation of pressure in the crank-chamber, is a feature of the most recent machines, adding to the comfort of the rider. Foot-starting mechanisms, by means of which the rider can start the engine without leaving the saddle, are also fitted by many makers, although a large number of machines still retain the pedal-drive.

Most makers follow the senseless fashion of fitting cut-outs on the exhaust silencers, and several elaborate designs are shown. Provided a suitable silencer is fitted, cut-outs are quite useless, and only provide means for ignorant riders to make themselves more objectionable than usual. In some cases, however, the makers have wisely omitted cut-outs, and have devoted their energies to the production of effective silencers.

It is satisfactory to find that more attention is given to protecting the magneto by placing it above or behind the engine, though many makers still place it in full range of the mud thrown up by the front wheel. The pedal control for ignition, fitted on several makes of machine, is another example of misplaced ingenuity, as also is the design of many of the crank-cases, which appear to be specially designed to retain dirt. A move in the right direction, however, is to be seen in the enclosing of valve spindles and springs, whilst the fitting of half-compression gear for starting the engine is an improvement fitted by several makers. Attention has also been given to the filling-caps of the oil and petrol-tanks, and many machines are provided with reasonably large openings; in some instances, however, strainers are omitted.

Among the other items of interest will be found a railway inspection car of very light construction, fitted with a 2½-horse-power engine; whilst an example of a very well-designed three-wheeled "runabout" is also shown, the details of which have been well thought out.

NOTE.

Oil-Engines for Torpedo-Boat Destroyers.

The application of the oil-engine to warships is pretty certain to be initiated in torpedo-boat destroyers, not only because these lend themselves easily to such experiments from the practical point of view, but because the financial and strategical risk involved is not so great as with larger craft. It is therefore interesting to have information as to the possible results from such application, even although they may be more or less hypothetical. Such data are given in a paper read at the meeting of the Society of Naval Architects and Marine Engineers, held in New York last week. Some measure of reliance may be placed on the comparison, as the author, Mr. G. C. Davison, states that the internal-combustion engine proposed corresponds exactly to that now being built for a foreign naval Power, and that complete plans and data were available. There is taken for the comparison an existing torpedo-boat destroyer, completed in 1900—the Paul Jones—250 ft. long, and 23 ft. 6 in. beam, with a coefficient of fineness of 0.41. On a mean draught of 7 ft. the displacement in sea-going trim is 470 tons. The reciprocating engines are of the four-cylinder vertical triple-expansion type, each of which develops about 4000 horse-power, supplied with steam from four Thornycroft water-tube boilers. The only variant is the type of propelling machinery. The ship has now four machinery compartments; a forward room has two Thornycroft boilers fired from a central stokehold; the second the starboard engine, with the condenser on the port side; the third compartment, the port engine, with the condenser on the starboard side; and the after compartment with two boilers, as in the forward boiler-room. In the new arrangement two Nurnberg two-cycle eight-cylinder engines driving wing-shafts are proposed for the forward engine-room, with a longitudinal bulkhead, while in the after room is a third engine driving a central shaft, with the auxiliaries in the wings. Thus the vessel becomes a triple-screw ship. The fuel-tanks are placed alongside the two engine-rooms. This oil machinery occupies about 40 ft. less of the length of the ship than does the steam plant. Each of the cylinders of the oil-engine has a diameter of 18.9 in., a stroke of 19.7 in., and the engine is designed to give 2500 brake horse-power at 350 revolutions. The length over all of each engine is 34 ft., the breadth 5 ft., the height 10 ft., and the weight 47 tons. The total horse-power is thus 7500, as compared with the 8000 in the reciprocating steam-engines. The three-engine arrangement has been adopted so that the middle engine alone may be used for cruising at speeds up to 16 knots; it is contended that there is tactical advantage in being able to increase from any fraction of full speed to the highest rate without delay. The comparison is tabulated as follows:—

Item.	Steam.	Oil.
Indicated horse-power	7,700	8,300
Shaft horse-power	7,000	7,200
Weight of main motive power machinery lb.	449,522	317,000
Weight per shaft horse-power ,,	64	44
Cruising radius at 16 knots, 180 tons of fuel miles	1,700	10,000
Fuel per horse-power-hour at 16 knots lb.	3.0	0.60
Cruising radius at 28 knots with 180 tons of fuel miles	630	2,950
Fuel per horse-power-hour at 28 knots lb.	2.34	0.50
Number of engineer's staff	54	21
Fuel consumed per annum, 20,000 miles cruising tons	2,100	360
Fuel consumed in port ,,	300	300
Annual total fuel consumption ,,	2,400	660
Cost of fuel on Pacific Coast £	3,840	924
Pay of engineer's staff per year ,,	4,500	1,920
Repairs, average annual ,,	2,000	400

The only auxiliaries separate from the main engines, according to Mr. Davison, are for such duties as coaling, heating, lighting, anchor-gear, steering-engines, &c., and these may either be driven by steam from a small donkey boiler using liquid fuel, or by electric motors provided with current from two auxiliary oil engines of 100 horse-power, connected direct to electrical generators.

NOTES FROM THE UNITED STATES.

Philadelphia, November 15.

During the past week orders were placed for 100,000 tons of steel rails. This is the season when estimates are made and when the placing of contracts begins. During the past two weeks the total placement by six railroads amounts to 180,000 tons, which does not include many pending estimates. The Pennsylvania and the New York Central Railroad are figuring on their requirements for 1912, and the most extravagant guessers place their requirements at a half million tons, but this may be considerably in excess of the actual figures. The standard price of 28 dols. for Bessemer prevails. To what extent the railway systems in general will place their orders is a matter of uncertainty. Nothing is to be gained by delay, and as far as can be seen no advantage in placing orders at this time. As regards pig iron there is a general delay until the prospective adjustment of the ore situation. It is a matter of uncertainty as to the ore prices for the coming year. A difficulty in the way lies in the fact that the over-production of ore for a long time, particularly in merchant ore, leaves immense stocks to be disposed of at the high prices heretofore prevailing. The excess of ore shipments for the current year over consumption is put at 8,000,000 tons. This is an important factor in the situation. The disturbing influences were not anticipated or dreamed of as possible. On the other hand, as regards finished products, the situation is more encouraging. Stocks of iron and steel all over the country are at a lower ebb than they have been for years. Jobbers have been extremely conservative. They and consumers generally feel perfectly safe because of the large percentage of unemployed capacity. It would require something unusual to precipitate a demand that would absorb the total capacity, but even such a possibility is not entirely lost sight of.

The German Navy.—The Kaiserin, ironclad, has just been launched at Kiel. She will form one of a division, the other members of which are the Kaiser, the Frederick the Great, and the King Albert. The launch for the German Navy of a small cruiser, named the Stralsund, may also be noted.

The Steam-Turbine: Errata.—On page 551 *ante*, col. 3, line 15 from top, the value of σ for semi-wing blades should be 1.6, in place of 1.1, as printed. On page 661, Table IX., line 18, for $\frac{h-c}{h+\sigma c} \cdot \frac{s}{32.2}\phi$, read $\frac{h-c}{h+\sigma c} \cdot \frac{s}{32.2} \cdot Q$. Same page, column 3, line 2 from top, for 10.102 read 1.0102; and on line 8 from top, for 10.03 read 1.003.

The Presentation of the Fritz Medal to Sir William H. White, K.C.B.—The naval architects of this country will appreciate the compliment paid to the profession in the presentation of the Fritz Medal to Sir William White at the dinner of the Society of Naval Architects and Marine Engineers in New York, on Friday evening last, the 17th inst. The presentation was made in acknowledgment of notable achievements in naval architecture. Sir William, who was present, having earlier in the course of the proceedings of the society read a paper which is reproduced in this week's issue, acknowledged the presentation, and gave expression to the respect which is entertained in this country for Mr. Fritz, who was present at the dinner, notwithstanding his advanced age.

INDUSTRIAL NOTES.

According to the monthly report of the United Society of Boiler-Makers and Iron and Steel Shipbuilders for November, the Society appears to have done well during the quarter which ended with September, having added nearly 15,000*l.* to the reserve funds, in addition to which there was a reduction of almost 5000*l.* in members' arrears. From the monthly returns for October it appears that at the end of that month there were 2404 members signing the book, against 2854 at the end of September. At the end of October there were 1170 members on the sick fund, against 1202 in September, while on the same dates there were respectively 2466 members and 2448 members on superannuation. There was a great decrease in the expenses in October as compared with September, the figures being 5948*l.* 16s. 3d. and 10,136*l.* 17s. 7d. respectively. There were, however, five weeks' expenses in September.

The monthly report of the Associated Blacksmiths' and Ironworkers' Society for the four weeks ended November 4 shows an income of 717*l.* 19s. 5½d., and an expenditure of 556*l.* 17s. 3d., or a net gain to the funds of 161*l.* 2s. 2½d. The total number of members was 3254, against 3250 in the previous month. The outlay per member on trade benefit, superannuation, sick, funeral, management expenses and grants was 3s. 8d. for the four weeks. The total income for the quarter ended September was 2232*l.* 5s. 10½d., which was a record for the Association. The total amount now standing to the credit of the Association is 19,929*l.* 15s. 2d. Attention is called to the large bill of arrears, amounting to 831*l.* 15s. 2d., and an appeal is made to all the well-wishers of the society to put an end to this as soon as possible.

The quarterly report of the Ship Construction and Shipwrights' Association for the three months ended September last, states that the income of the society for the quarter was 17,309*l.* 6s. 10½d., and the outlay 13,438*l.* 16s. 1d., showing a net surplus of 3825*l.* 10s. 9½d., which was 3086*l.* less gain than that showed for the June quarter. This was, however, accounted for by the fact that 2332*l.* 8s. 8½d. was spent on dispute benefit, and 1390*l.* on accident bonus claims. At the end of September the reserve funds had reached 95,280*l.* 16s. 9½d. There was a net gain in membership during the quarter of 431, bringing the total up to 22,711. Referring to the National Insurance Bill, it is pointed out that although it will have an important bearing on the trade-union and friendly society movement, yet, if these two great movements take hold of its provisions and utilise them, there is no reason why it should not be to their advantage, as well as to the strengthening of their respective organisations. The quarter referred to was one of full employment for the members of the society, both in new construction and in repair work, while the demands for labour were almost unprecedented. It is pointed out, however, that the picture will not always be so bright, and a reaction must sooner or later come. Men should, as far as they can, prepare for this.

A meeting of the executive committee of the Miners' Federation of Great Britain was held in London on Thursday in last week, at which Mr. Ashton, the secretary, was instructed to ask the employers to fix a date before December 20 on which the proposals for a minimum wage may be further discussed. Mr. Ashton stated after the meeting that the committee had put before Mr. Masterman at the Home Office certain proposed amendments to the Mines Bill, and on the whole they were very well satisfied with his promises.

The cotton-weavers at Accrington held a mass meeting last night, when it was stated by their secretary that the cotton manufacturers were making profits galore, and the weavers of the northern counties thought they could get an advance of wages. Before long they would, he said, be asking for an advance, and if the non-unionists did not join the union, they would miss getting an advance in wages of 1s. 6d. or 2s. a week.

The Bradford and District Machine Wool-Combers' Association and the Gas-Workers and General Labourers' Union have entered into an agreement which will, it is hoped, tend to make employment in Bradford more regular. In summer employment at the gas works is very slack, and the wool-combing industry suffers similarly in winter. Hitherto no gas-worker has been allowed to work as a wool-comber, nor have the wool-combers been allowed to do the work of the gas-workers. Under the new arrangement, however, the two unions will recognise each other's members, so that the gas-workers may obtain employment as wool-combers in the summer, and the wool-combers as gas-workers in winter.

The Standing Committee of the House of Commons, presided over by Sir D. Brynmor Jones, met again on Thursday in last week in order to finish their consideration of the unemployment provisions of the National Insurance Bill. Part II. of the Bill as amended was then ordered to be reported to the House. The following new clause was moved by the Solicitor-General:—"Where a workman is employed in a district the principal industry of which is agriculture, and the workman usually follows in that district some occupation in an insured trade occasionally only, contributions under this part of the Act shall not be payable in respect of the workman except in cases where the employer and the workman agree that contributions shall be payable notwithstanding this provision." It was proposed to leave out the words "is employed in a district the principal industry of which is agriculture, and the workman," so as to extend the operation of the clause to districts in which agriculture, though not the principal, was a large and important industry, and where men usually employed on the land found occasional employment in one or other of the insured trades. This amendment was, however, opposed by the Solicitor-General, and after a lengthy discussion was vetoed, the clause being added to the Bill. It was moved by Mr. Buxton to insert after Clause 77 "The Board may, if in any case they consider it desirable, by special order exclude from the occupations which are to be deemed employment in an insured trade for the purpose of this part of the Act—(*a*) Any occupation which appears to them to be common to insured and uninsured trades alike, and ancillary only to the purposes of an insured trade. (*b*) Any occupation which appears to them to be an occupation in a business which, though concerned with the making of parts or the preparation of materials for use in connection with an insured trade, is mainly carried on as separate businesses, or in connection with trades other than insured trades; and on any such order being made, the occupation to which the order relates shall not be treated as employment in an insured trade for the purpose of this part of the Act. Any special order made under this section may be made so as to cover one or more occupations." Mr. Buxton said that when the report stage was reached he would ask that the special orders to which this new clause had reference might be exempted from the general condition imposed by Clause 88, that special orders made by the Board of Trade under the Bill should lie on the tables of both Houses of Parliament for thirty days before they should become operative. The clause was added to the Bill.

The sixth schedule was then considered. It contains a list of the insured trades for the purposes of Part II. of the Bill relating to unemployment insurance, and these as agreed to now stand:—(1) Building; that is to say, the construction, alteration, repair, decoration, or demolition of any buildings, including the manufacture and structural fitting of wood, of the kind usually made in a builders' workshop or yard. (2) Construction of works: that is to say, the construction, reconstruction, or alteration of railroads, docks, harbours, canals, embankments, bridges, piers, or other works of construction. (3) Shipbuilding; that is to say, the construction, alteration, repair, or decoration of ships, boats, or other craft, or any part thereof, and of the tackle thereof, by persons not being members of a ship's crew. (4) Mechanical engineering, including the manufacture of ordnance and firearms; ironfounding, whether included under the foregoing heading or not. (5) The construction of vehicles; that is to say, the construction and decoration of vehicles, or any part thereof. On a motion of Mr. Buxton, an amendment was agreed to to bring in saw-milling, including machine wood-work, within the category of insured trades. In accordance with the intimation which he gave on the previous Wednesday, Mr. Buxton moved to amend the seventh schedule (rates and periods of unemployment benefit) so as to make the rate of unemployment benefit 7s. in all the insured trades, with the following proviso:—"Provided that, in the case of a workman under the age of eighteen, no unemployment benefit shall be paid while the workman is below the age of seventeen, and while the workman is of the age of 17 or upwards, but below the age of 18, unemployment benefit shall only be paid at half the rate at which it would be payable if the workman was above the age of 18. The amendments were agreed to and the schedule was passed. The eighth schedule, which fixes the contribution relating to unemployment insurance at 2½d. for both workmen and employers, was amended in consequence of the proviso added to the preceding schedule, and 1d. was substituted for 2½d. in the case of workmen below the age of 18. The schedule also lays it down that employment of less than a week shall be treated as if it were employment for a whole week." On a motion of Mr. Buxton the following words were added: "except that where the period of employment is two days or less, the contributions both of the employer and of the workman shall be reduced to 1d. if the period does not exceed one day, and to 2d. if it exceeds one day; and in such case in reckoning the number of contributions under Part II. of the Act and the schedules therein referred to, contributions at such reduced rates shall be treated as two-fifths or four-fifths of a contribution, as the case may require." Part II. of the schedule (rates of reduced contributions by the employer) was struck out. This schedule and also the ninth were passed, and with the formal motion that Part II. of the Bill as amended be reported to the House. This brought the Committee stage to a close.

After negotiations extending over months, and in their latter phase conducted under the auspices of the official mediator, some 2500 to 3000 concrete and earthwork hands in Denmark have gone out on strike, it being found impossible to bring about any fresh agreement. The hands in question are employed by several masters' unions, whereas those working under the Copenhagen and an adjoining municipality have continued work.

Unfortunately the negotiations between the iron-founders of Wexford and their employees, who have been locked out, came to an unsatisfactory conclusion on Saturday last, owing to the refusal of the employers to recognise the Irish Transport Workers' Union. For three months now as many as 600 men have been locked out, and the masters intend to import fresh workers immediately, and reopen the workshops. There were at the beginning of this week 300 policemen in the town.

It has been announced that the Lancashire and Yorkshire Railway Company, who recently granted advances in wages to clerks and porters, has now granted 1s. per week to cleaners, gas men, and greasers. This brings the wages of men of all grades over twenty-one years of age to a minimum of 1*l.* per week.

The question of the Railway Commission is dealt with in another column, but we may here note that at a meeting of railwaymen at Crewe last Sunday, Mr. Albert Fox, general secretary of the Associated Society of Locomotive Engineers and Firemen, told the men that their representatives (of whom he was one) in the August strike negotiations, while accepting the Royal Commission, did not say they would accept its findings. As a business man, however, he said it was understood that, having undertaken to allow the Commission to sit, they were morally bound to accept its findings. He was quite hopeful there would be no need to go to extreme measures. As to the Commission, he thought that no five men could have made a better attempt to meet the situation. They were not altogether satisfied with the Commission scheme, but the only thing missing was that it did not say to the companies in so many words, "You must recognise the trade unions." He pointed out opportunities in the scheme of getting recognition by electing trade-union secretaries to conciliation boards. He thought the scheme would bring a great improvement if the men would make the best of it. Those people who straight away condemned the scheme, he thought, were wrong.

At Manchester, however, there was on the same day a mass meeting of railwaymen, and a resolution was adopted strongly urging the men to vote solidly against accepting the report, and in favour of withdrawing their labour in order to secure recognition of the unions. At Bradford, also, about 600 men attended a mass meeting, and a resolution to the same effect was passed. A similar feeling among the men also exists at Nottingham.

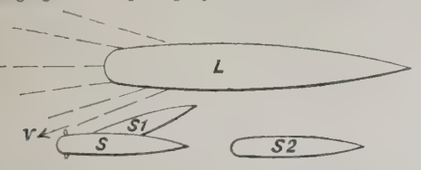
It has been announced that the directors of the London and South-Western Railway, who are still considering the pay of their staff, generally decided at their last meeting to introduce, as from December next, a revised and improved scale of salaries for the clerical staff. Other grades will be dealt with in due course. This railway company is the eighth important company that has announced the granting of important advances of wages to the men. It is understood that this action on the part of the London and South-Western Railway Company is not the result of representations made by the men, but has followed a careful examination of the position of the clerical staff. On this railway, during the strike in August last, the men, with only two exceptions on the whole system, remained at work, and the whole of the ordinary service of trains was maintained without interruption. The Port Talbot Railway Company have also announced a number of concessions to their employees, the following advances having been made:—Permanent-way men, 2s. weekly; signalmen, 1s. to 3s.; and hours reduced from 12 to 10 per day: guards, 1s. to 3s.; porters, 2s.; gangers, 2s. 6d.; shunters, 1s. to 4s.; and boys, 2s. to 3s. Concessions to the men have also been made by the Liverpool Overhead Railway.

On Monday the men and women employed by the Birmingham Small-Arms Company accepted the terms offered by the company, and have resumed work.

THE "HAWKE"-"OLYMPIC" COLLISION.

To the Editor of Engineering.

Sir,—It is possible that the following suggestion has a bearing on the recent collision between H.M.S. Hawke and the liner Olympic, and may be of public interest, as the effect described is undoubtedly, in certain circumstances, a risk in navigation. It is recognised that when a small vessel (S, in sketch below) overtakes a larger vessel L, say to port, the smaller vessel is to a certain extent liable to swing to port on account of the wake of the larger vessel impinging on the port propeller of the smaller, while



the starboard propeller rotates in comparatively still water; but it does not appear to be realised that if the speed of the engines of the larger vessel is increased, this effect is greatly increased during the interval that elapses before the larger vessel attains the speed corresponding to the change of power. So long as the engine speed of the larger vessel remains constant, the speed of the wake is unchanged, and the unbalanced thrust of the propellers on the smaller can be counteracted on the smaller vessel by a small angle of port helm. But as the larger vessel, on account of her mass, does not immediately respond to an increase of engine power, the rearward velocity of the wake is temporarily increased by an amount corresponding to the increase in power of her engines.

In other words, the total "slip" is equal to the initial slip plus the increase in speed of the propellers. The unbalanced thrust of the propellers of the smaller vessel depends on the velocity of this wake relatively to the comparatively still water on her starboard side, and it is clear that the stronger the current in the wake, the greater the tendency to swing to port. The spreading action of the wake, as well as its velocity, is increased when the propeller speed of the larger vessel is raised above that corresponding to her speed in knots, and the effect may be still further increased when the smaller vessel swings to the position S 1, which favours the spreading of the wake. The above suggests that the smaller vessel would tend to swing to port *strongly* when *overtaken* by a larger vessel which had previously been running alongside at the same speed as herself. So long as the smaller vessel is abeam of the larger (position S 2) this action of the propellers is not felt, although a certain suction, which may be counteracted by a small angle of helm, may be experienced. It is only when the smaller vessel reaches the wake of the larger vessel that she is subject to this tendency, which cannot properly be termed suction.

Without definite information as to the lateral distance between the two vessels it is not possible to say whether this effect was in reality the cause of the collision; but when the lateral distance is small, there can be no doubt of the danger incurred when any large vessel increases speed to pass a smaller vessel under way. The risk is minimised when the smaller vessel slackens speed to allow the larger vessel to pass, as the unbalanced thrust depends on the backward velocity of the wake of the larger vessel, and would then be a minimum.

I am, Sir, yours faithfully,
B. P. Haigh.

James Watt Engineering Laboratories,
The University, Glasgow, November 22, 1911.

"NEO-PHILISTINISM."

To the Editor of Engineering.

Sir,—You will, no doubt, remember Thoreau's admirable assertion that "all fables, indeed, have their morals, but the innocent enjoy the story." Whether I can be included in the category of the innocent it is not my province (and certainly not your privilege) to decide, but in the fable that usurps the position of "leader" in your issue of November 17, the little joy that the story gave me was more than eliminated by the pain that I received from its moral. That it is a fable in the proper acceptance of that term I have little doubt; "Mind and Matter" is its title, and it takes the form of a highly fictitious tale about something which is called "Matter" or "Mind," as the mood sways the teller, tagged with a "moral" that is as mediocre as it is meretricious.

When Matthew Arnold saddled Ignorance and Irresponsibility with the title-rôle of "Philistinism" it was hoped that a certain silence might have been assured. Vain expectation! To-day the Unwise have discovered a new shibboleth, and Mr. Campbell Swinton (I do not remember having read any of those masterpieces of imaginative literature for which he is so justly famous; but, no doubt, he is fully qualified to be didactic upon the artistic and the intellectual) pillories the "literary guilds," and prohibits the "humanities" as a preparation for "life."

It is unfortunate (for the Neo-Philistines) that the initial portion of the fable is composed of two very pregnant tales (of the Admiral and of the Cambridge Professor) both fundamentally *true*, that give the direct lie to the immoral moral that Mr. Campbell Swinton so insistently (and indecently) preaches—namely, that: "The really effective force in moulding humanity has been the *scientific imagination!*"

Does Mr. Campbell Swinton (and the fableist) honestly believe that "scientific imagination" (Heaven save the mark!) has advanced the human race by one iota? Does he conscientiously imagine that we have grown more charitable since 245 years ago an apple fell on the head of a scientific crank? Or that, because "science" has evolved machinery whereby modern warfare has become a veritable shambles, man will therefore be less likely to break the Sixth Commandment. Perhaps he has forgotten the rebuke of the Japanese Ambassador:—"For a hundred years we have flooded your markets with 'objets d'art,' and you called us 'barbarians;' to-day we have slain ten thousand men, and you say we are *civilised!*"

Let him look to Tripoli.

To quote the words of a great modernist:—

"Does any man seriously believe that the *chauffeur* who drives a motor-car from Paris to Berlin is a more highly developed man than the charioteer of Achilles, or that a modern Prime Minister is a more enlightened ruler than Cæsar because he rides a tricycle, writes his dispatches by electric light, and instructs his stockbroker through the telephone?"

Does Mr. Swinton?

"Enough, then, of this goose-cackle about progress."

But the fableist is not content with salutations to science; he must needs play gutter-boy to the Arts, particularly the art of writing. His pitiful ignorance of literature, however, is prejudicial to his mission. It is certainly somewhat of a shock to hear Pope (excellent journalist though he was) described as a "poet," let alone a "famous" one, and it is a little alarming to have so very hackneyed a quotation as "the *proper* study of mankind is man" changed into "the *noblest* study of mankind is man." But our fableist is even weaker (if it be possible) in logic than he is in the Arts. He points out that "economics is not one of the *exact* sciences," the inference being, presumably, that the "natural sciences" are. It would seem probable from this fundamental fallacy that the fableist has not yet grasped the difference between "deduction" and "induction," and the essential incompleteness of the latter form of reasoning. Surely it should hardly be necessary to point out that philosophy and metaphysics are deductive and "exact," while the natural sciences are inductive and insecure.

Does anyone now believe Boyle's Law to be universally true? How long a life, even, are you prepared to give to Van der Waals' Equation? It would seem that as great an ignorance is displayed upon Descartes and Mill as upon Pope and Platonism. I see that the reply of the French Republic to Lavoisier's famous (or infamous) defence against decapitation has been quoted. Let it be remembered that that reply was wholly commendable. The world has no need for *chemists;* or *engineers*! It has need of three classes of mankind only: Philosophers to make it think; Artists to make it happy; *men* to do its work! If Lavoisier had been more of a man and less of a chemist he might have made the reply that Fouquier Tinville made: "Will your bread be any cheaper when my head is off?"

Lastly, it is complained that the poet and the novelist are placed by the mob upon a higher intellectual plane than the physicist and mathematician. Then the mob have more common-sense than the Philistines. Does any ordinarily sane man pretend, for one moment, that even the *greatest* of the scientists could dare to aspire to the pinnacle of wisdom occupied by the humblest of the poets? Does Mr. Campbell Swinton propose that Huygens or Van't Hoff are the intellectual equals of even "B. V.," Thompson, or James Clarence Mangan? Let alone Goethe, Chateaubriand and Keats? Finally, I ask, in all humility, does the writer of this leader think that Carnot or Wöhler have benefited the human race in the remotest degree? And that Giotto and Guercino, Grieg, and Vogler, Gautier, Ibsen, and Zola, Molinos, "Father Ange" and St. Francis of Assisi have not done more to advance man than a legion of so-called "scientists?" I do not wish to dwell upon the evils that are the direct outcome of science. I do not know if Mr. Campbell Swinton is familiar with Chicago, but he could hardly dare to hold such a brief for science were he once to see what Messrs. Swift, Armour, and others have achieved with its aid.

If either "the fableist" or Mr. Swinton fully believe that the researches of Werner, for example, into the cobalt-ammonium compounds is going to raise the common conscience of mankind above its present level, I should suggest that he seek immediate relief at the hands of the Lunacy Commissioners.

I challenge Mr. Campbell Swinton to reply.

Yours faithfully,
Norman Davey.

Conaways, Ewell, November 19, 1911.

[Invective, misrepresentation, and assertion appear to constitute the bulk of our correspondent's letter. The first named we shall ignore, since it is a mere re-echo of what we have heard periodically ever since Matthew Arnold enriched, by the addition of the word Philistine, the verbal missiles of the literary clique. Epithets settle nothing, being commonly mere counters used to avoid the trouble of thought. The misrepresentation is another matter. Neither Mr. Campbell Swinton nor ourselves advocated the "prohibition" of culture studies. To quote from our own article: "No one, of course, advocates the abandonment of culture studies." Our plea has been solely for the establishment of a wider basis of education. Again, our critic's quotation concerning the chauffeur and the charioteer of Achilles can have no other object than to imply that we claimed an intellectual superiority for the first-named, a misrepresentation which it is difficult to justify in view of the following quotation from our article:—"Both the glory and the weakness of the engineer lie in the fact that his mental exercises afford occupation for hosts of mere manual labourers." We thus distinguished between the "mind" which thinks and initiates and the "hands" which can be taught to use tools and processes they are quite incapable of originating.

In asserting that we had made a misquotation from Pope, our critic has walked incontinently into a carefully set trap. Knowing the importance attached by the literary clique to "words" rather than "ideas," we felt certain that some one of them would once again illustrate this by calling attention to the substitution of the word "noblest" for "proper." If our correspondent will refer to our leader, he will see that quotation marks were of set purpose omitted. The supreme importance attached by him to "words" is again illustrated by his objection to our use of the term "exact sciences." Surely he must have come across W. K. Clifford's "Common-Sense of the Exact Sciences." This is concerned solely with a discussion of such conceptions as number, space, motion, and the like, which are involved in the application of mathematics, to those branches of science which can conveniently be treated in this way. The term was used in our article in its ordinary accepted sense, with the object of conveying our meaning in the simplest and most direct fashion. In fact, our critic clearly understood it himself. As to Philosophy being the only one of the exact sciences, this is true only in a very limited sense. No one nowadays disputes that our own thoughts are the only things of which we have direct cognisance; but so long as each generation of philosophers differs from its predecessor on almost every other point, the term "exact science" in the ordinary acceptation of the term is inapplicable, however technically defensible. Had our critic been in less of a hurry, he would hardly have asserted that "modern warfare has become a veritable shambles." Surely he has read of Cannæ and other ancient fights, at which the slaughter was out of all proportion greater than it ever is to-day.

Whether the poetic or the scientific imagination is the more important to the race could be easily settled by direct experiment. Let our critic imagine that he is to be marooned on a desert island, and is offered his choice of the works of the poets and philosophers he so highly appreciates, or alternatively the products of the scientific imagination of thinkers, for the most part dead for generations. These would comprise every implement for making fire, every weapon and every tool. It is easy, in the comforts of an outer suburban home, to affect to despise the mental labours of those dead and gone investigators, which alone give our critic the leisure for his favourite studies; but left naked face to face with Nature, we have absolutely no doubt as to what his choice would be, if the above alternatives were offered him. Further, history itself upholds the claim that the scientific imagination has had an enormous influence in advancing civilisation, in whatever sense the latter term be used.

It is not so long since the scientific worker ran the risk of being burnt or tortured by his literary brother. Bad old times they were and long they lasted, before the scientific man established his right to freedom of thought. Slavery was almost an unavoidable necessity. A belief in witchcraft was universal because the scientific mind had not yet established a belief in the orderliness of Nature. Inhuman punishments were the rule, since science had not produced modern facilities for tracking offenders. Wholesale massacres and barbarities of every kind excited little reprobation, mainly because scientific thinkers had not then established the present close intercourse between man and man. It would probably be not going too far to say that the only important thing in the world is thought, and the first essential for the race is that this thought shall be applied to the conquest of Nature. Art, literature, and philosophy will then be added in due course, but are inherently secondary. The only logical alternative to this conclusion is that life is a bad thing, a conclusion arrived at independently by certain Oriental sages, as well as European philosophers. With this view we have no quarrel, though we do not share it, but we admit that logically it is quite as defensible as the contrary opinion.

Of course, we do not expect to convince our critic, as from the impassioned note which characterises his letter he would appear to be one of that numerous class whose beliefs owe more to the warmth of their feelings than to the cold light of reason.—Ed. E.]

CASE-HARDENING.

To the Editor of Engineering.

Sir,—I have read with interest the article by Dr. Giolitti in your issue of November 10. He is, however, rather late in the field, for during the last ten years many firms have used my system of case-hardening with hot producer-gas in combination with a solid carburising material, under my patent of 1901. The operation is carried out with an inexpensive furnace, and the method is largely used by steel manufacturers and motor-car builders.

I should be obliged if you would insert this in your next issue.

I am, Sir, yours truly,
F. J. Clinch-Jones.

152, Stretford-road, Urmston, Lancs,
November 20, 1911

The "Mechanical World" Pocket-Diary.—This interesting pocket-diary and year-book for 1912 has just been issued. It is published at 6d. net by Messrs. Emmott and Co., Limited, 20, Bedford-street, W.C., the 1912 edition being the twenty-fifth. It contains, like the former editions, a very large amount of useful information, data and formulæ for the use of mechanical and civil engineers. The turbine section has been extended, and new sections deal with roller-bearings, helical springs, and other mechanical details. The usefulness of the book is enhanced by a very complete index.

THE KJELLBERG ELECTRIC-WELDING PROCESS.

In joining two pieces of metal together by means of so-called autogenous or fusion processes, their junction is produced by actually melting the points of contact, and at the same time adding molten metal to bring the "weld" up to full section. Provided such a process is carried out under certain conditions, there is no reason whatever why this method of welding should not give reasonably satisfactory results; in fact, it has been clearly shown that under proper circumstances actual welding will result at temperatures considerably below melting-point, and without the application of pressure to the pieces joined. In order to obtain a satisfactory result, however, in any form of weld, means must be adopted to prevent the inclusion of any impurities, such as slag, oxide of iron, or other foreign substance; and in this respect many of the blow-pipe and electric-arc systems have been found wanting. In the Kjellberg system, which has had considerable success in Sweden, an electric arc is employed, but metallic electrodes of a special character are substituted for the more usual carbon. These electrodes consist of a metal core encased in a surrounding coating, the constituents of which serve to prevent the inclusion of foreign matter in the weld. It further contains a practically non-fusible substance which forms, at the end of the electrode, a crater, in which the metal is fused out of contact with air, whilst an atmosphere of a reducing nature is produced, which surrounds the arc and prevents oxidation of the weld taking place. The success of the process in large measure would appear to depend upon the composition of this coating, though, by varying the nature of the metal core, different classes of weld are produced. In this country the system has recently been introduced by the Kjellberg Syndicate, Limited, of the Stowage, Deptford, who recently enabled us to see the process in operation. For its successful operation continuous current is necessary, the arc taking about 120 amperes with a voltage of about 100. The negative pole is connected to the work operated upon, and the positive to the electrode which is clamped in an insulated holder. The arc is started in the usual manner, by making contact between the work and electrode, and work proceeds as in other similar processes. During the process of the work the weld is hammered in order to squeeze out the slag which is formed, but this is stated not to be essential to successful results. As already mentioned, the coating of the electrode is the essential feature of the system; but, in addition to the points referred to, it enables the arc to be directed axially with the electrodes as required; thus welding can be done at the bottom of a groove without fear of the arc striking its sides. Another interesting feature is that the weld can be made from below the work, the molten metal apparently being projected upwards and adhering to the work. In preparing work for welding, the edges to be joined are bevelled off to form a V-shaped groove, and the weld is built up with fused metal in the usual way. In dealing with rusty or corroded plates it is not found necessary to resort to cleaning, though it is, of course, an advantage to remove as much rust as is possible by scraping.

Although the results of tests on this form of weld, made by the Swedish company, have been published, some data relating to tests actually done in this country will not be without interest. An interesting experimental weld, made on behalf of the General Steam Navigation Company, is shown in Fig. 4, above. A wrought-iron tip was made, and then welded on to a broken cast-iron propeller as shown. An attempt was then made to detach this wrought-iron tip by blows from a heavy hammer, the result being that, although the tip was bent somewhat, fracture finally occurred in the casting clear of the weld. In order further to demonstrate the soundness of the weld, we reproduce, in Figs. 1, 2, and 3, micro-photographs prepared by Mr. A. P. Strohmenger, which clearly show the structure at various points of the welded area. In Fig. 1 the complete junction of the cast iron to the fused metal is to be seen, together with the decarburising effect of the fusion on the original cast iron; Fig. 2 is taken from the centre of the fused metal, whilst Fig. 3 is taken at the junction of the fused metal with the wrought-iron tip. Two further photographs, Figs. 5 and 6, clearly show the perfect union which takes place in the case of wrought iron and steel, and the freedom from impurities of the added metal. The micro-photographs reproduced were taken with vertical illumination, with a magnification of 100 diameters (reduced to 80 in reproduction).

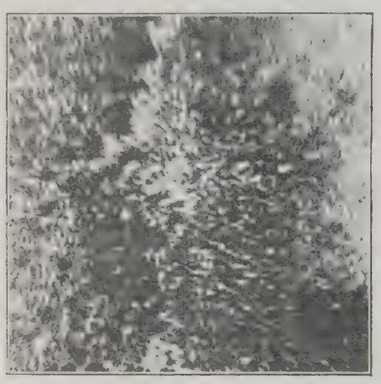


Fig. 1.

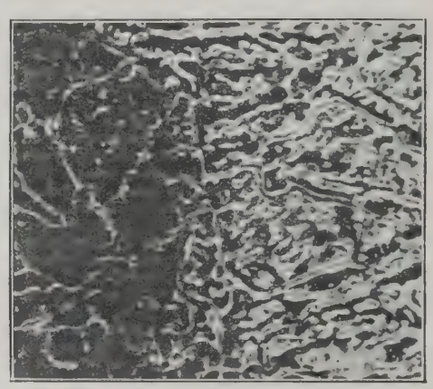


Fig. 2.

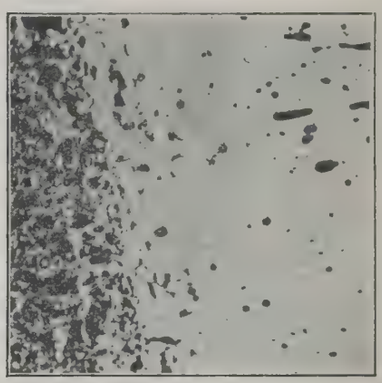


Fig. 3.

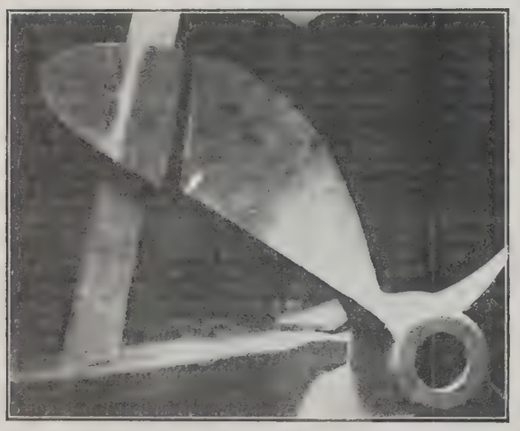


Fig. 4.

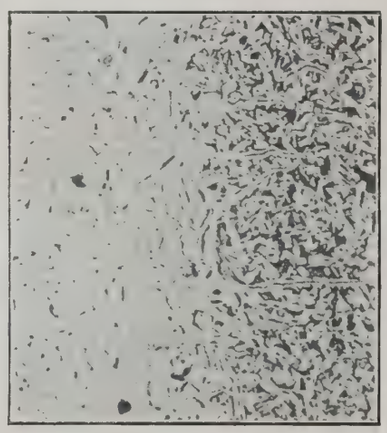


Fig. 5.

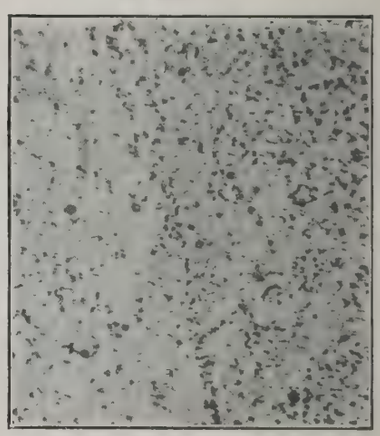


Fig. 6.

Table I.—*Results of Tests on Welds by Kjellberg System*

All Specimens of Rectangular Section.

Test No.	Area.	Yield-Point.	Breaking-Load.	Elongation. On 8-In.	Elongation. On 2-In. at Fracture.	Remarks.
	sq. in.	t. per sq. in.	t. per sq. in.	per cent.	per cent.	
33,986	0·732	16·01	18·25	5·4	7·7	Broke at weld: flaw at one side; fracture granular; some crystalline spots
33,987	0.714	16·22	17.06	3.9	7.7	Tore apart slowly at weld: a somewhat large flaw; fracture granular; some finely crystalline spots
33,995	0.5128	16.71	18.43	2.8*	6.5*	Broke through weld; fracture irregular, granular
33,996	0.5116	17.28	21.74	5·9*	12.5*	Tore across weld; fracture irregular; granular; some specks of crystal
			Original Material.			
33,988	0.710	17.20	25.37	24.1	36.3	Fracture silky; somewhat irregular
33,989	0.719	17.33	25.14	28.1	44.3	

* Owing to the irregular fractures, the extensions given above are in excess of the real value, the broken halves not fitting accurately.

Mechanical tests carried out on welds made by the Kjellberg process have given very good results. We hope to give a fuller account in more detail at a later date, but meanwhile we give in Table I. the results of some tests made by Messrs. Burstall and Monkhouse on welded steel boiler-plates, together with corresponding tests on the original material.

In the case of the first two tests given, the welds are stated to have been made with alternating current, which is quite unsuited for the process, and the lower results obtained are attributed to this fact. In the other welded specimens it will be seen that the breaking load exceeded that corresponding to the yield-point of the original material. The apparently low extension given by the welded specimens is accounted for by the fact that the extension of the metal in the actual weld, which is only about $\frac{3}{4}$ in. in length, is really a large proportion of the total extension measured, since the specimens broke at a load before extension of the original metal occurred.

It must further be mentioned that in this, as in any other method of welding, a considerable amount of practical experience is essential for the production of satisfactory work. In this particular system, too, it would appear that a considerable knowledge of the possibilities of the various types of electrodes is necessary, since it is claimed that metal of differing character can be introduced into the weld at will by a suitable selection.

AN EXPERIENCE WITH A LATHE.

By Henry Lea, M. Inst. C.E.

The lathe is a 5½-in. screw-cutting one, with a lead screw of 1¼ in. diameter and four threads per inch. The bed is 5 in. deep, and has a double flat top 5¾ in wide over all. It is a strong, stiff bed, as 5½-in. lathe-beds go, and has recently been re-planed all over and scraped true. The saddle is substantial and about 11 in. long. The slide-rest has ample surfaces carefully fitted together. Some time ago it was noticed that when a light finishing cut had been taken off, say, a gun-metal plug 4 in. long by 1 in. in diameter, the tool having been carefully and keenly sharpened, there were marks on the work ¼ in. apart—that is, of the same pitch as the screw. They were not helical, but consisted of very shallow hollows and ridges in alternate circles normal to the axis of the work. When a short, stiff straight-edge was rubbed longitudinally on the revolving work, the tops of the ridges were thereby slightly planished, and were rendered more easily visible. Fig. 1 is a photograph of the appearance. When a bush was bored to fit the turned plug, it was found to have similar hollows and ridges inside it, and when the plug was pushed into the bush, it was a tight fit when the ridges of the plug coincided with the ridges of the bush, and was a loose fit when the hollows of the plug coincided with the ridges of the bush, or *vice versâ*. Screws cut in this lathe must have had the same defect, though the hollows and ridges were not visible, as in the case of plain cylinders. It was concluded that the lead screw was not straight, and that its eccentric motion caused a very slight rocking motion of the saddle, whereby the tool was advanced towards and withdrawn from the work every ¼ in. Upon testing the lead screw, it was found to be not quite straight. A leading firm of engineers' tool makers straightened the screw as nearly as they could, and took a light cut over it. The same marks were, however, produced on the work as before. A new lead screw was then obtained from another well-known firm of makers, under a stringent condition that if it were not quite straight it would be of no use. The new screw produced the marks as before. Upon testing the screw resting in V blocks on a bench, it was found to be eccentric to the extent of about the $\frac{1}{1000}$th part of an inch, but the pressure of one finger on the screw was sufficient to bend the screw, and to cause as much movement in the testing spline or lever as was caused by the eccentricity of the screw. The testing arrangement was as shown in Fig. 2.

When the screw was rotated slowly, the end A of the spline moved up and down ¼ in. ¼ in. × $\frac{1}{4\frac{1}{2}}$ in. ÷ 2 = $\frac{1}{1000}$ in. = the eccentricity of the lead screw. It seemed impossible that the substantial saddle could be rocked sufficiently to cause marks on the work by an eccentricity of a lead screw which was so flexible that the pressure of the finger would bend the lead screw to an extent equal to the eccentricity, but such evidently was the case, unless the marks could be traced to some other cause. No other cause could, however, be thought of, and the subsequent experiments were therefore based upon an assumed screw error. The V strips of the saddle were tightened up so that the saddle moved stiffly upon the bed, and the tightness so obtained was uniform from end to end of the bed, showing a good close fit wherever the saddle might be situated on the bed. The next thing that was done was to remove the bearing bracket which carried the tail end of the screw, the tail end being thus left free to wobble about as much as it liked. A piece of wood was clamped to the bed to receive the end-thrust of the screw, while leaving the latter free to wobble. The result upon a plug at about 12 in. from the fast headstock was that the marks, now very faint indeed, were only just visible after being rubbed with the straight-edge. Here was clear proof that the screw, flexible as it was, was capable of influencing the tool and causing the hollows and ridges. But, upon skimming up a plug chucked as near to the fast headstock as it could be got, the marks were more distinct than at 12 in. from the fast headstock, though not nearly so pronounced as originally. Evidently, then, the bearing bracket near the fast headstock was holding the screw too firmly, just as the tail bearing-bracket did before it was removed. Both these brackets were then bored out $\frac{1}{200}$ in. larger than the screw, but the boss of the change-wheel quadrant, which also fitted the screw closely, but which only had a bearing on the screw for a length of ⅜ in., was not bored out. It was left unbored out in order to steady the change-wheel on the screw. It was thought that if the length of the bearing were only ⅜ in., instead of, as originally, about 4 in., sufficient freedom would be obtained. Another trial on the last-named plug showed that the marks were still there, though now still more faint. The quadrant was then eased out with a smooth file so as to allow the screw to wobble a little in the boss, without materially affecting the steadiness of the change-wheel. Another trial on the last-named plug showed that at last the defect had been removed, for there were no marks of the kind whatever, and the surface was clouded uniformly by the straight-edge (see Fig. 3). Another trial was then made at 12 in. from the fast headstock, the result being equally good (see Fig. 4).

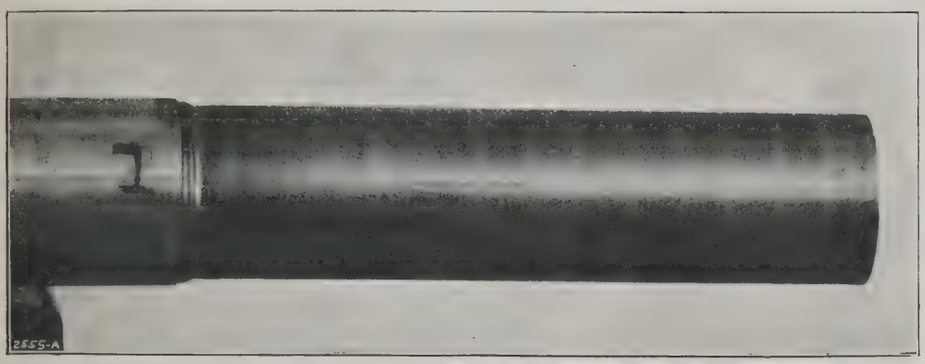


Fig. 1.

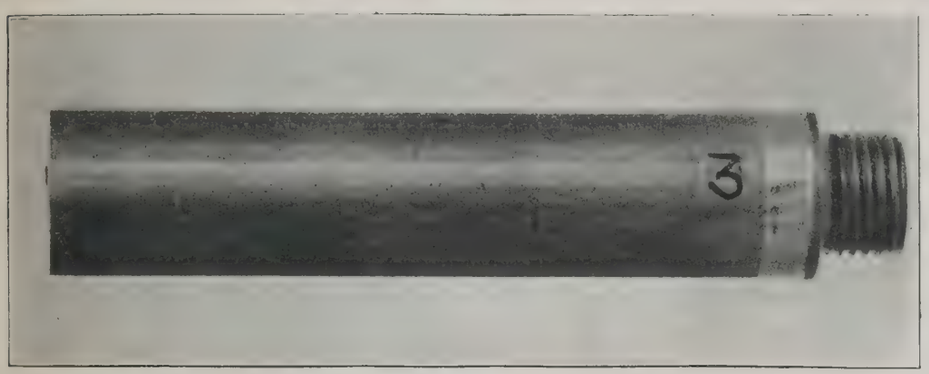


Fig. 3.

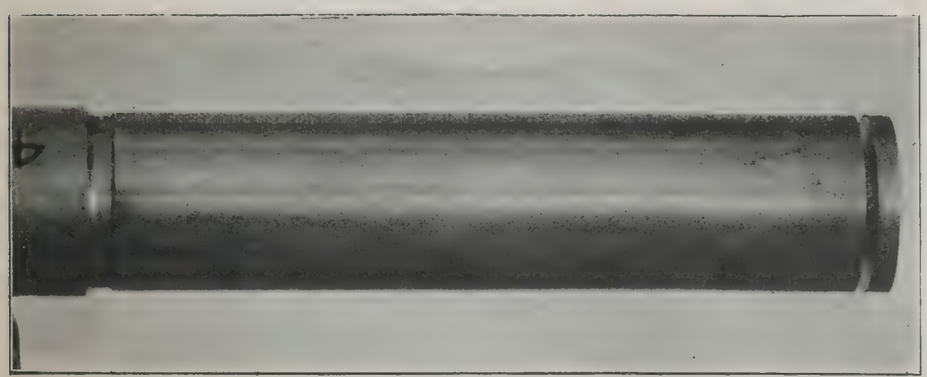
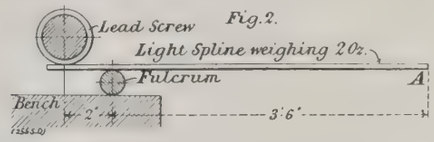


Fig. 4.



Another test in the earlier stages was made by placing a very sensitive spirit-level across the top of the slide-rest. The lathe being set into slow motion, the bubble of the spirit-level moved to and fro about $\frac{1}{10}$ in. at every revolution of the screw, showing that, rigid as the saddle appeared to be, and flexible as the screw had been proved to be, the top of the slide-rest was really rocked at every turn of the lead screw.

Two lessons were learned from the foregoing experiments:—(1) The extreme and quite unexpected flexibility of the parts of an ordinary and fairly strong 5½-in. lathe; and (2) the necessity of so fitting lead screws that they shall not be able to affect the saddle transversely. It is generally considered that it is impossible to make a lead screw absolutely straight. The removal of metal in cutting the screw relieves stresses within the structure of the metal bar, whereby the straightness of the screw is affected, and it can never be perfectly straightened if from any cause it has once become crooked.

A friend who was present remarked: "The search for perfect accuracy is almost as futile as the search for perpetual motion." It was also agreed that the lead screw of this lathe was being used for parallel turning, whereas there ought to have been a rack-and-pinion motion for that purpose. That may be true, but when the lathe is used for cutting screws, the lead screw must be used, and then the same defect will occur in the screw which is being cut as occurred in the plain cylinder, the only difference being that in one case the defect is visible, and in the other case it is not. In modern machine-shops the lathe is not much used for producing cylindrical work of extreme accuracy. For that purpose the grinding-machine has taken its place. In the latter we find an extremely massive construction, a grinding-wheel revolving at about 6000 lineal feet per minute, with a breadth of face several times the pitch of the lead screw, and a comparatively slender lead screw. The broad grinding-wheel, the high velocity, the light pressure on the work, and an abundant lubrication maintained by a pump, all combine to produce an accuracy unattainable with cutting tools in a lathe, and to finish the surface in much less time. The lathe superseded the grindstone; now the grindstone has superseded the lathe, a curious alternation in machine-tool history.

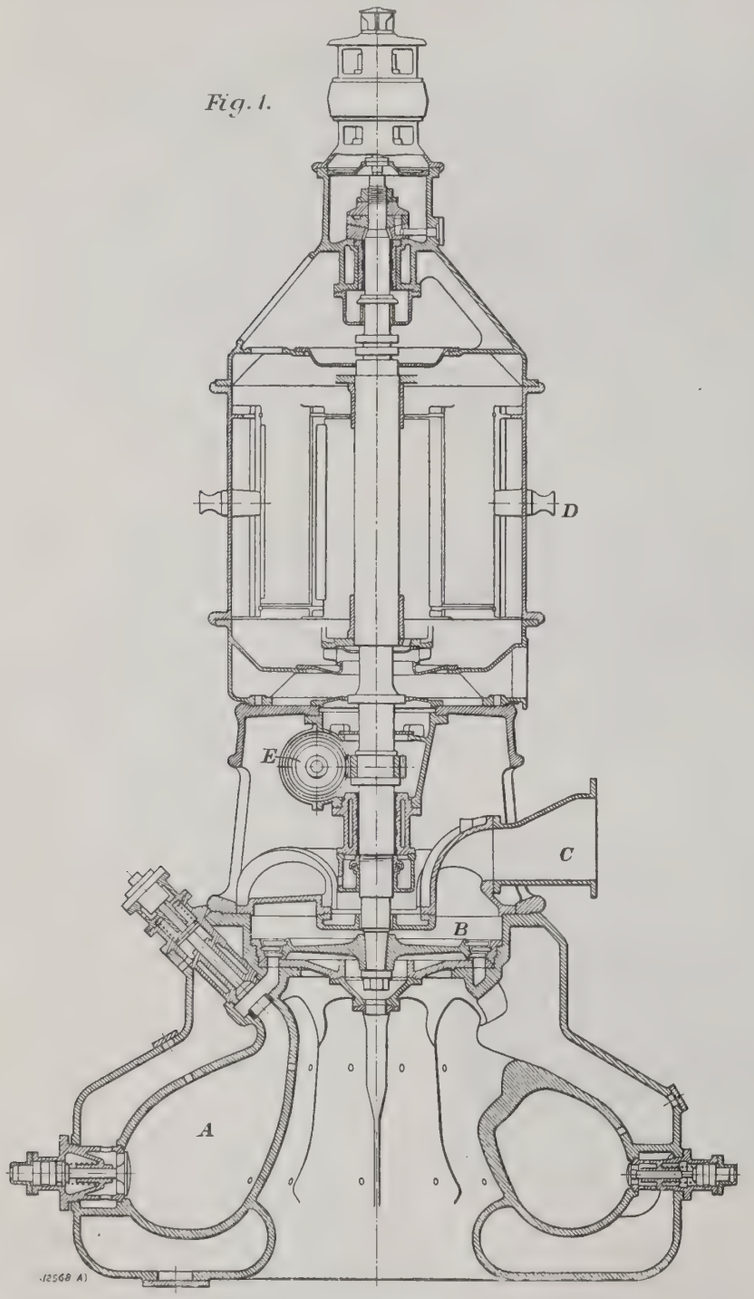
Electric Energy for Christiania.—A special committee appointed to consider the question of supplying Christiania with electricity has recently issued its report, and recommends the exploitation of the waterfalls belonging to the town, and the acceptance of an offer from the Vamma Power Company to supply, at a price agreed upon, 25,000 horse-power. The power transmission installations proposed are to have a capacity of 56,000 horse-power, and at the expiration of the contract time they will pass into the possession of the town, in the year 1948, for a sum of 4,800,000 kr., which sum the town will hand over to the Vamma Company free of interest until 1919, and after that time subject to an interest of 4½ per cent. It is estimated that the town's waterfalls in the River Glommen will yield 28,000 horse-power, and the aggregate cost of the entire installations will amount to about 14,000,000 kr.

THE GAS-TURBINE.*

By H. Holzwarth, Mannheim.

The turbine described is an explosion turbine. The combustion-chamber, marked A in Fig. 1, is intermittently filled with the gas and air mixture; then follow ignition, explosion, and increase in pressure of the burnt gases and their expansion through the nozzle, after which they act on the turbine-wheel marked B. The explosion-chamber is next effectively scavenged and cooled by fresh air. A number of similar explosion-chambers are arranged in a circle at the base of the turbine, and act one after the other. Any kind of compressor may be used in order to maintain the separate chambers, which surround the explosion-chambers on the outside, supplied with gas and with air at a low pressure, and a vacuum is maintained at

Fig. 1.



the exhaust C. Inlet valves allow the air and gas to enter the combustion-chamber one after the other. After the combustion-chamber has been filled with air, gas is driven in, the mixture of both being complete. While this is taking place the nozzle-valve remains closed; immediately upon ignition it is forced open by the pressure of the explosion, and the available energy in the gases is transformed into kinetic energy. As the pressure falls, due to the escape of the gases, the nozzle-valve is forced slowly down upon its seat, its action being regulated by an oil relay, so that the air for scavenging has sufficient time to clear out the combustion-chamber, and to effect a certain amount of cooling on the turbine wheel. The spring drives the valve hard upon its seat in the explosion-chamber, so that during the compression of a new charge into the latter no gas can escape. When ignition has taken place, oil under pressure enters beneath the valve-piston, and holds it up, keeping the valve open until scavenging is completed. Fig. 1 illustrates the first gas-turbine of the type built on a working scale. It works usually with suction producer-gas of 1100 to 1200 calories per cubic metre (123 to 134 B.Th.U. per cubic ft.), and has been designed for a maximum output of 1000 horse-power at 3000 revolutions. It drives a dynamo marked D. The turbine-shaft, as will be seen, is supported from above. On it is fitted the turbine-wheel and the dynamo rotor. From the very commencement smooth running was obtained at all speeds, although the temperature of the turbine casing rose to 500 deg. Cent. This was due to the fact that the system expands regularly and centrally with an increase in temperature. The base of the machine contains all the mechanism for the inlet and outlet of the gases and for their ignition. The material used is almost exclusively cast iron. The pressures are much less than in reciprocating engines—10, as against 30, atmospheres (147; 441 lb. per sq. in.); and there is no possibility of pre-ignition; the shape given the explosion-chamber is a more suitable one for withstanding the force of the explosions than that of ordinary cylinders, all which conditions combine to lead to a decrease in the thickness of the walls of the engine base (see Fig. 1). The air and gas-valves are of the mushroom type; they are operated by oil relays, the oil under pressure being supplied by a rotating oil-distributor. The turbine is provided with a horizontal governor shaft driven by screw gearing (see E, Fig. 1). On the shaft are keyed the main governor, an emergency governor for preventing ignition, a tacheometer, the gear for operating the vertical oil-distributor, and the ignition mechanism.

The action is the following:—

Directly before ignition takes place there is in the explosion-chamber a mixture of gas and air in the condition represented by p_0, v_0, T_0. On ignition taking place, the condition of the mixture becomes p_1, v_1, T_1, and it is presumed that when this reaction has taken place regularly, not violently, the total available heat becomes free during the explosion, and this addition of heat is made at constant volume. On reaching the p_1, v_1, T_1 condition, communication with the turbine is suddenly established. The gases are then expanded down through the nozzle to the condition p_2, v_2, T_2, and the available work they contain is transformed into kinetic energy, which in its turn is turned into work by the turbine. The variations in pressure, temperature, and in the heat contained in the mixture during the process, can be clearly followed in the entropy diagram, as set forth by Stodola in 1898, shortly after the appearance of the Diesel engine. The conditions in which this turbine works are, the author claims, the same as with the system of gust-governing used with the Parsons turbine. At the moment of complete combustion the explosion-chamber is filled with gases, which flow out with decreasing velocity until the pressure is that on the discharge side of the nozzle. Taking the turbine efficiency to be η, the total efficiency, he states, is

$$\eta_{\text{tot.}} = \eta \times \eta_{\text{exp}}$$

where $\eta_{\text{exp.}}$ denotes the efficiency of the explosion.

Fig. 2. NORMAL INDICATOR DIAGRAM.

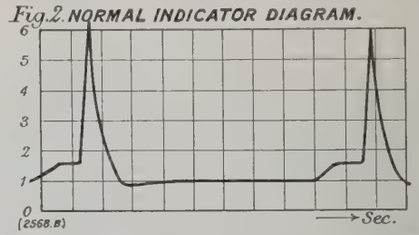
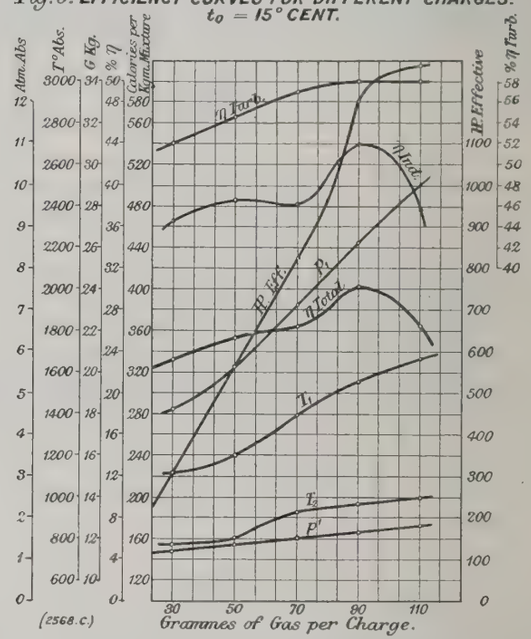


Fig. 3. EFFICIENCY CURVES FOR DIFFERENT CHARGES.
$t_0 = 15°$ CENT.



The experiments made with regard to scavenging, charging, compression, and regeneration may be summarised as follows:—

Air-scavenging is absolutely required in order to maintain the temperature of the mixture in the turbine space within reasonable limits (below 400 deg. Cent.). With a view to secure good economical scavenging and low heat radiation from the walls of the combustion-chamber it is necessary to have the nozzle opening as large as possible. In order to save fuel this opening must be closed when charging by means of a nozzle-valve. The work for air compression is obtained by utilising the waste heat; this has no influence upon the heat balance of the gas-turbine. The area of the regenerator necessary for regeneration is not greater than that of the surface-condenser of a steam-turbine of equal power.

The temperature of the mixture before ignition is important. On this depends the method of reaction, whether ordinary combustion or detonation; also the regularity of the process, and, above all, the explosive efficiency; it determines whether a pure mechanical process takes place, or undesirable heating. The paper includes a diagram illustrating what occurs when using carbon-monoxide gas, and states that should the temperature of the gas before ignition be 100 deg. Cent., then the combustion pressure will be 7.7 times the initial pressure. This will be reached in probably $\frac{1}{100}$ to $\frac{1}{1000}$ second by a regular development of the flame. Thus the pressure of detonation will not be reached, since, starting at 100 deg. Cent., its ratio to the initial pressure is 9.1. But should the initial temperature be, for example, 400 deg. Cent., detonation will occur after quiet combustion of one-half of the charge; the remaining half will detonate spontaneously, and thereby generate a shock having 5.7 times the initial pressure, whilst the pressure corresponding to quiet burning is only 4.3 times. At 200 deg., 14 times the value is reached as against the normal 6 times. This

* Abbreviated translation of a paper read in German before the meeting of the Schiffbautechnische Gesellschaft, held in Berlin, November 23 to 25.

unexpected and not always welcome increase in pressure does not result in an increase of power, as it merely gives an unsustained shock. The paper gives a gas-turbine diagram illustrating partial ignition by explosion wave, also a diagram with normal ignition. We reproduce the latter in Fig. 2.

The author lays stress upon the small space occupied by the turbine as compared with that of a reciprocating gas-engine of equal power. The areas occupied are as 1 to 3.28; the total weight as 1 to 4.2. The gas-turbine, like the steam-turbine, works without shocks or vibrations, and saves the expense of cylinder lubrication. Lubrication, as in the case of the steam-turbine, is more complete and more reliable than in that of the reciprocating steam-engine, since all movable parts are in oil-baths. On these grounds, the wear of the movable parts need not be expected to exceed that which obtains in steam-turbines. Notwithstanding the numerous experiments made, no wear in the nozzles and blades could be found. There being absence of water particles, the causes which make for wear in the steam-turbine are non-existent in the gas-turbine. Starting does not require an air-compressor plant, as in reciprocating gas-engines, but only a supply of steam for starting the air-compressors until the regenerator supplies the necessary steam for the latter.

A first, experimental, gas-turbine was built for tests in 1908. Then the one we illustrate was put in hand, and experiments with this were carried on during this present year, using producer gas from coke—*i.e.*, the gas which turned out poorest in hydrogen and in heat. The turbine, with its electric-generator, ran light, excited, as early as February last, at 3000 revolutions, 4000 volts, with only 250 cub. m. to 300 cub. m. (8830 cub. ft. to 10,595 cub. ft.) of gas per hour, corresponding to an indicated efficiency of over 20 per cent., "a certainly very satisfactory commencement for the efficiency curve, though only a transitory one." Then the temperature of the mixture rose largely above the value which, calculation showed, should have been the maximum reached. The total contents of the chamber soon detonated, next only a part of the charge burnt in the chamber, the other burning probably in the turbine space, not designed for that purpose. This showed how the degree of temperature before ignition influenced the ignition itself, and determined whether it occurred as combustion, or developed into an explosion wave; steps were therefore taken towards maintaining the walls of the explosion-chambers as cool as possible by water, and provision was made to take the air direct through the air-valves from outside. The conditions were thus improved. At the same time the method of ignition was improved, and the ignitions and combustions took place as perfectly as could be expected, allowing for the variations in the specific heat, and without explosive waves, not only for small, but also for the maximum gas charges. It is necessary, however, still to develop the engine in order actually to obtain the effect which may be expected from the calculations. With a small charge and low detonation pressure the efficiency reached was very close to that calculated. With higher charges and higher pressures, however, the increase in efficiency was not in the ratio which had been expected. The end to be aimed at in working the turbine is to obtain the curves which are shown in Fig. 3. With comparatively small charges, the end in view is already attained; further tests will lead to an equally satisfactory result, using larger charges. The curves in question, in their highest values, apply more especially to the first experimental gas-turbine, and therefore not generally to the turbine we illustrate. The efficiencies given in the curves may be improved—for example, by fitting much larger nozzle exhausts, by increasing the charge pressure, the highest explosion pressure, replacing the nozzle-valve by a flap, with unhindered direct through-flow of the gases, &c.

The first experimental gas turbine was built to the author's designs by Messrs. Gebr. Körting, A.-G., Hannover. The one we illustrate was built also to the author's designs by Messrs. Brown Boveri at their Mannheim Works.

Electric Railway in Moscow.—A concession has been granted for the construction of an electric railway, without State guarantee, from Moscow to Sergijew-Posssad, in the Government of Moscow, with branch lines to the stations Puschkino, Mitischtschi, and Lossinoostrowskaja, on the North Railway. The aggregate length is 69.5 versts.

Radiotelegraphy for Fishing Fleets.—Referring to a paragraph on this subject in one of our former issues (see Engineering, vol. xci., page 735), Dr. Erich F. Huth, Berlin, informs us that the cost of the radiotelegraphic apparatus had hitherto delayed their use on board the fishing smacks. He adds that the price of a wireless station, even of the smallest type, amounts approximately to half the cost of the whole fishing-boat, and is therefore quite beyond the means of the fishermen. It is true that the Deutsche Seefischerei Verein, which is under the German Emperor's care, assists the fishermen out of this difficulty; but the means at the disposal of this body are limited. To overcome this difficulty, Dr. Huth proposes to supply the fishermen, in the first place, with a receiving station only, and he manufactures this of a comparatively cheap and handy type, so that familiarity with its working may easily be procured. Dr. Huth's receiving station takes up no more room than a photographic camera, and does not cost any more; its use does not require any special knowledge of radiotelegraphy. Thanks to the enterprise of the Deutsche Seefischerei Verein, two fishing-boats have been equipped with this receiving apparatus; these are the fishing-boats Maria Klausine, of Blankenese, and Meta Margareta, of Finkenwerda. The antennæ do not interfere with the sails.

ELECTRIC TORSION DYNAMOMETER.*

By Fritz Lux, of Ludwigshafen-on-the-Rhine.

Apparatus for measuring and recording the torsion of propeller-shafts, by mechanical, optical, stroboscopical, and electrical methods, have been devised, notably by Bauer, Thaemer, Gümbel, Amsler-Laffon, Föttinger, Rambal, Frahm, and abroad by Denny and Hopkinson. In his endeavours to perfect these apparatus the author has particularly aimed at constructing a meter to record horse-power hours.

The principle of his instruments will be understood from the diagram, Fig. 1, which represents a torsion-indicator. An electric circuit is made and broken, once during every revolution, at one point of the shaft, and a spark is thereby produced at another point of the shaft—for instance, at its end; the position of the spark with regard to an arc encircling the shaft will indicate the angle of torsion. This angle may directly be read off, or graphically be recorded. In a third class of instrument the product of the factors, number of revolutions, coefficient of elasticity of the shaft, and angle of torsion is recorded, and the energy transmitted by the shaft can thus be read off directly.

Fig. 1.

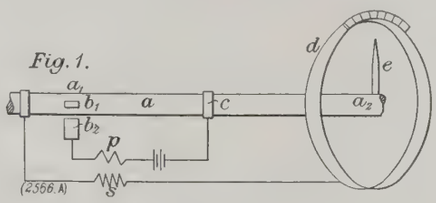


Fig. 2.

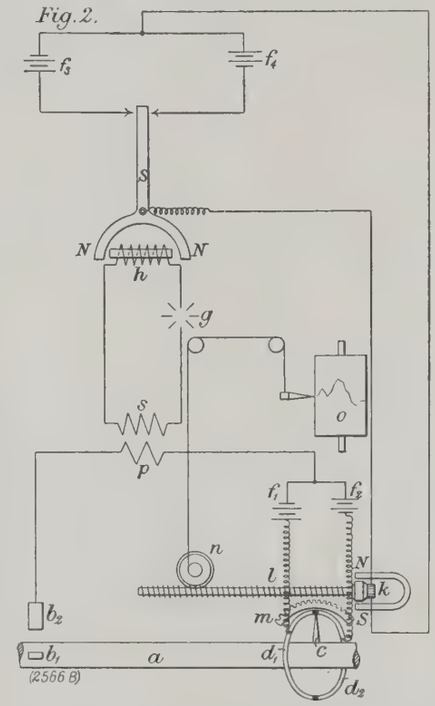
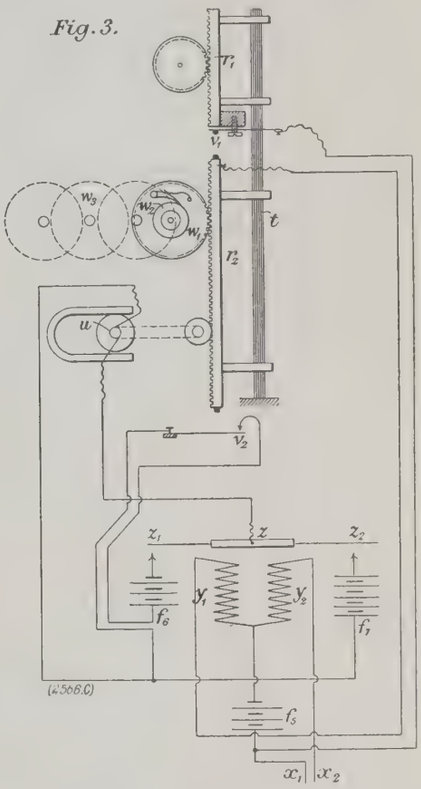


Fig. 1 illustrates the first instrument, the torsion-indicator, which marks the angle of torsion between the two points a_1 and a_2 of the shaft a. When contact is momentarily established between b_1 and the knife b_2, the primary circuit p of the battery is closed through the slip-ring c and the shaft a. A secondary current is then induced in the circuit, which comprises the graduated arc d, and a spark will pass from the pointer e, attached to the shaft, over to the arc. As long as the shaft is not strained, this spark will strike the arc at the zero of the angular scale; when the shaft is under torsion the spark will strike another spot, and the arc between the zero and this spot will measure the torsion. In order to facilitate the reading, especially at slow propeller speeds, several contacts b_1 b_2 and pointers e are provided, all at equal distances from one another; the angular distance between two successive contacts should be smaller than the maximum torsion, of course, not to complicate the readings. The provision of multiple contacts offers the further advantage that the observer can see whether the movement is uniform or torsional vibrations are set up. In order to increase the accuracy of the reading, especially for small torsions, the pointer e is replaced by a knife-edge, mounted parallel to the axis of the shaft, and the circular arc by a helix; the spark will pass on the plane where the knife crosses the helix, and the rate of magnification can be varied by altering the pitch of the helix.

Fig. 2 shows the recording electric torsion dynamometer. Contact is made between b_1 and b_2, and a spark produced as before, but the primary battery is split into f_1 and f_2, and the circular arc d is also split into two halves, d_1 and d_2, which are insulated from one another. The primary current will come from f_1 or from f_2, according as the pointer e slides over d_1 or d_2, the two currents flowing in opposite directions through the primary coil p. The currents in the secondary coil s and its circuit will hence also be either in the one or in the other direction, and the relay h will close the circuit of one of the two batteries f_3 or f_4. The spark-gap g in the secondary circuit has been inserted with the object of making the relay h respond only to the stronger current induced by the breaking of the primary circuit, not to the weaker current induced by its making. The batteries f_3 and f_4 send currents through the electric motor k, turning the armature and its worm-shaft l in the one or the other direction. The shaft engages with the toothed segment, which is coupled with the split circular arc d_1, d_2. One of the two semicircles d_1 or d_2 will be turned—namely, that one on which the pointer e is resting at the moment. That is to say, when, owing to the torsion of the propeller shaft a, the pointer e—which normally rests on the upper one of the two insulating blocks, separating d_1 from d_2—has been displaced with regard to the contact b_1, the toothed segment m will be rotated until the pointer e comes to rest again on its insulator. The angle through which the shaft has been twisted is read off on a pointer, directly or indirectly attached to the worm l. This pointer is not marked on the diagram. The diagram shows, however, how the rotational movement is registered by a style on the drum o, through the intermediation of the worm-wheel n and several pulleys.

Fig. 3.



The special devices, by the aid of which the recording torsion dynamometer is converted into a power meter, are indicated in Fig. 3. Two toothed racks, r_1 and r_2, slide up and down the standard t; r_1 is carried up or down by its wheel in accordance with the amount of the shaft torsion; the gearing for r_2 comprises the electric motor μ, from the armature of which a chain extends over to the toothed wheel of the rack. When r_2 moves up or down, it carries the wheel w_1 with it. This wheel w_1 rides loosely on its axle, while the wheel w_2, which is set with fine teeth, is fixed on the axle; w_2 and its pawl belong to the wheel train of the counter mechanism w_3. The movement of the rack r_2 is limited, above by the flat contact spring v_1, which is attached to the bottom of r_1, and below by the spring v_2.

The main leads from the contacts of the propeller-shaft whose torsion is to be determined are x_1 and x_2 (at the bottom of Fig. 3). The circuit is closed once during every revolution, or series of revolutions, of the shaft. The circuits comprise three batteries f_5, f_6, f_7, a split relay coil y_1 y_2, and its armature z, which makes contacts z_1 or z_2 on the right or left. When the circuit is closed by the propeller-shaft contacts, current passes through the battery f_5, and through one of the two coils, say y_2; the armature z will then make contact at z_2. Thus the battery f_7 is put in circuit, the current flows to the motor μ, and the rack r_2 travels upwards until it touches the flat spring v_1. The current is then diverted through the other coil y_1, the armature z is deflected, and the battery circuit f_6 is closed. The motor μ is therefore turned in the opposite direction, and the rack r_2 descends again. The motion downward will continue until r_2 strikes the contact spring v_2, and breaks the connection there, so that the motor μ comes to rest. This play will be repeated each time the circuit of the propeller-shaft contacts is closed. The

* Abbreviated translation of a paper read in German before the meeting of the Schiffbautechnische Gesellschaft, held at Berlin, November 23 to 25, 1911.

counter mechanism will therefore each time register a movement corresponding to the angle of torsion, and thus record the product of torsion and number of revolutions. When, further, the modulus of elasticity of the shaft is taken into consideration in fixing the gear ratio of the wheel train, the meter will directly indicate the torsional moments transmitted by the shaft, and hence register the horse-power hours.

A demonstration instrument of this kind is on the table, and it is possible to see how it works. The Imperial navy has promised to fix a torsion dynamometer, now under construction, on board the cruiser Ersatz Kondor. It is confidently anticipated that it will come up to expectations.

ROYAL METEOROLOGICAL SOCIETY.

The opening meeting of this Society for the present session was held on Wednesday evening, the 15th inst., at the Institution of Civil Engineers, Dr. H. N. Dickson, President, occupying the chair.

Mr. C. Harding read a paper on the abnormal weather of the past summer. He presented statistics showing the distribution of temperature, rainfall, and sunshine, week by week, in the various districts of the British Isles, and also made a comparison of the results with the Greenwich Records back to 1841. From the facts thus brought together, Mr. Harding showed that, as far as temperature is concerned, the summer of 1911 was unique. The maximum temperature of 100 deg. at Greenwich on August 9 is the highest recorded in the British Isles since the establishment of comparable observations. The mean temperature for the summer was also higher than for any similar period during the last 70 years. The maximum temperature of 96 deg. in July has only been slightly exceeded on two previous occasions, and the September temperature of 94 deg. has not previously been equalled during that month. So many hot days during the summer have never before been recorded. Mr. Harding further showed that the rainfall for the three summer months has only been smaller in three previous years during the period of seventy years, and also that the duration of bright sunshine was greater than in any previous summer since the introduction of sunshine-recorders in 1881. As a consequence of the exceptional weather, the harvest was everywhere commenced at an earlier date than usual, and was quickly concluded under the most favourable conditions. The effects of the drought, other than in relation to the water supply and vegetation, were very far-reaching. Sports of all description were but little interfered with, and the summer will long be remembered as having been exceptionally fine for holiday-makers.

A paper by Mr. W. Larden, describing some observations which he has made on solar halos, was also read.

International Table of Atomic Weights.—The new table of atomic weights for 1912, published by the International Committee, consisting of F. W. Clarke, W. Ostwald, T. E. Thorpe, and G. Urbain, suggests alterations in the atomic weights of calcium (Ca = 40.07, instead of 40.09, formerly accepted); erbium (Er = 167.7, instead of 167.4); iron (Fe = 55.84, instead of 55.85); mercury (Hg = 200.6, instead of 200); tantalum (Ta = 181.5, instead of 181); vanadium (V = 51, instead of 51.06); and admits niton (Nt = 222.4) as a new element. Niton is the gaseous emanation from radium, and is now recognised as an element of the nitrogen group, on the researches of J. W. Gray and W. Ramsay and of A. Debierne. The corrections made in the atomic weights of mercury and tantalum are large, and it is rather striking that half a unit should be added to so well-known an element as mercury; there was doubt about tantalum, as it is very difficult to purify. The recognition of niton is still more striking; we described the determination of its atomic weight by Gray and Ramsay (with the aid of the micro-balance) in our account of the Sheffield meeting of the British Association, 1910.

Early Matches.—Some interesting information about the history of the match industry was given in the first meeting of the Chemical Society of this season by Mr. E. G. Clayton in a paper on "The Characteristics and Chemical Composition of Some Early Matches." Chemical matches, compounds like sulphuric acid and chlorates, which would ignite on being mixed, were used more than a hundred years ago; a phosphorus compound, ignited by friction, is supposed to have been introduced by Derosne, of Paris, in 1816. Mr. Clayton spoke of matches which he had been able to analyse, and he considered many generally accredited statements to be inaccurate. Samuel Jones introduced his "Promethean" matches in 1828. They were chemical matches containing chlorate, sulphur, and lycopodium, and in the small glass tube sulphuric acid. He also made "friction lights" in 1832, containing sulphur, antimony sulphide, chlorate, iron oxide and gum, and called them "lucifers." But friction lights were previously made in 1826 by John Walker; these were coated with sulphur, and ignited by being drawn through sand-paper. Phosphorus matches, ignited by being struck on the box, so-called "congreves," were probably introduced by Sir W. Congreve, the inventor of the war rocket, early in the 'thirties. They were chiefly taken up under that name in Germany and in Austria, and contained, in addition to ingredients already mentioned, frequently nitrates, powdered glass, chalk, starch, and a blue dye. Phosphoric cigar-lighters came from Vienna early in the 'fifties. The chlorate, we may add, was, about 1835, replaced by lead oxide, which Preshel (Vienna) mixed with nitric acid and dried; strips of red phosphorus paper were manufactured by Böttger in 1848; but they did not find favour until reintroduced from Sweden.

WORKMEN'S COMPENSATION CASES.

County Court.

For many weeks the long vacation was a season of complete suspension of all legal business in the High Court. It is true that ordinary litigation, especially cases under the Workmen's Compensation Act, has occupied the county courts, but since our last notes it may be said that none of the reported applications presented any points of interest to workmen or employers, and rarely any of legal interest to the public.

The question "Is sunstroke an accident?" was a novel point which occupied the arbitrator at Preston, when the claim was heard on behalf of Margaret Wignal, the widow of J. R. Wignal, a carman in the employ of R. Watson, a hay and straw dealer. The deceased died as the result of sunstroke sustained while at work. It was contended that the cause of death was not an accident for which the employer was responsible. On the other hand, it was argued on behalf of the widow that sunstroke was common to all employments, and that danger was more or less present if a man worked hard or if he did not. Such cases are governed by the same principle as that which has been made clear in cases of frost-bite or heat apoplexy to which a man is peculiarly exposed by the nature of his employment. In every such case the particular circumstances must determine whether sunstroke is to be deemed an accident arising out of the man's work, and for which the employer is liable under the Workmen's Compensation Act. If in the employment there is nothing peculiar and different from that to which all workers are alike exposed, then there is no accident; but if the workman was doing something in the course of his employment which by reason of his employment exposed him to peculiar danger, then the injury, as by frost-bite or heat apoplexy, is an accident. In the case before the Court, the deceased was shown to have suffered by extreme heat, involving more than the ordinary risk to which carters are exposed. The deceased's death was incurred in the course of his employment, and as sunstroke is known to be brought on by undue exposure to the sun's rays, it did not arise in the ordinary course of natural causes, to which all men working in the sun are exposed. The judge, following the decisions, awarded the applicant 171*l.* 12s., being the aggregate of three years' wages. The fact that the deceased had carried seventy-two heavy trusses of hay in an hour and twenty minutes from the haystack to the lorry, on a hot summer day, exposed him to a danger that was not common, but peculiar to his particular employment at the moment. It was in justice an accident for which the employer was liable.

Employee's Disobedience of Instructions.—It is a well-known rule under the Workmen's Compensation Act that an applicant has no claim when it is proved he disobeyed orders. Some subtle differences were considered in the case at Rawtenstall County Court, when the mother of a carter on a farm claimed 150*l.* compensation for the death of her son, on whom she was dependent. The man met his death by drowning while watering his horses in a pond on the farm of his employers. The work was done in the course of the man's employment. The employer stated that in this particular case the carter was instructed to avoid the pond, which was often polluted, and to get the water from a well. Had the man obeyed instructions, the accident could not have happened. The man, for his own convenience, went to the pond, and in watering the horses he slipped into deep water and lost his life. In giving instructions the master made no mention of danger. The pond was the general watering-place for the horses, and, of course, there was no danger to the horses, who always refuse to drink polluted water. This, perhaps, was the carter's reason for disobedience of orders, as going for the well-water was more troublesome, and the pond-water on this occasion not so objectionable as to be the subject of special orders.

The arbitrator held the act of disobedience was proved. But it did not apply to the man's course of employment. He watered the horses, as was his duty. That he did not obey the strict orders to avoid the pond-water did not mean disobedience of general orders arising out of the man's employment. The fact that another carman had watered at the pond excused the deceased for not troubling about watering at the well. The carelessness of farmers and their employees is so frequent in respect of using polluted water instead of pure well-water, that it might, therefore, be unfair to assume that such carelessness of a farmer's ignorant carman is tantamount to gross disobedience of orders to water horses only at well-water. It is hard, however, in the case of a farmer giving distinct and reasonable instructions to avoid polluted water, because of the danger, that he should be penalised by payment of compensation to the careless workman's dependants. A High Court judgment making the law on such points more definite would be of great advantage to county court judges and to employers.

Court of Appeal.

Old and New Accidents not Contributory Causes of a Single Disablement.—The Workmen's Compensation Act, since it became law, has been the subject of conflicting public opinion, and employers and men of business, who are largely influenced by party bias, incline to follow their political leaders in their views as to whether the results of the working of the Act are beneficent and just to the interests of industry, or whether the Act has been on the whole extravagant and unfair—requiring drastic amendment. The Court of Appeal alone gives a guiding opinion which is free from party bias and is of real permanent value. An appeal which raised a question of importance has been decided. The applicant met with an accident while at work as a riveter in 1902; he was in receipt of weekly payments, and did not resume his employment until the County Court held he could do light work. The injured man carried on his work as a caulker without feeling any ill effects from his accident from 1903 to 1910, when a new foreman suggested he should use a heavy pneumatic hammer, which had the bad effect of inflaming the hand injured in 1902, and in 1910 he claimed compensation for the former injury.

This raised the question whether the accident was a contributory cause arising at different times. If the accident in 1910 was itself enough to cause the disablement, and the employer thus knew of the injury in 1902 being likely to contribute to the cause of the injury in 1910, would this enable the injured man to go against the employer of 1902, and leave the employer of 1910 untouched? The Master of the Rolls was of opinion that the employer of 1910 alone was liable, and that the accident of 1902 was not a contributory cause. The County Court Judge had misdirected himself, and the Court of Appeal reversed his judgment. It is not to be supposed that it may take two accidents at different times to make one disablement. The circumstances of the two accidents are, of course, independent, and have no relation to one another.

If the first employer be made responsible for a certain injury at a certain time, and his liability ends when the disablement is ended, then it is absurd to say that a predisposition to a similar injury arises out of a continuing incapacity, and that a similar accident years ago under an old employer is to be counted as part of the contributory cause of the second accident.

Sunstroke may be an Accident.—This question has now been settled in the Appeal Court. It has been held, as set forth in the previous case, that if, in the course of his employment, a workman is exceptionally exposed to the rays of the sun, the sunstroke is an accident within the meaning of the Act, and the employers are liable. Thus, where a man in his work is exposed to risk to which all workers in the sun are not equally liable, then the sunstroke is an accident arising out of the workman's employment. The case of Davies *v.* Gillespie, in which there was an appeal by the respondents from an award of the Salford County Court, raised the question whether an attack of sunstroke from which the applicant suffered was an accident within the meaning of the Act, and arose in the course of his employment. The applicant was a ship's officer on board the appellants' ship, who, while superintending the loading of cargo in the heat of a West Indian sun, suffered after five hours exposure one day an attack of sunstroke, which caused partial blindness.

It was argued that his duties did not expose him to an exceptional risk at his work. But the Court of Appeal held that any peculiar and exceptional exposure arising out of the man's work was an accident for which his employers were liable. Europeans would not be exposed to an Indian sun for hours on the steel deck of a ship without suffering an exceptional risk, and it was this which produced the attack of sunstroke, which, though not unusual in the tropics, was an accident to which a European is only exposed in the course of his peculiar employment, and is an accident in the course of his employment for which the shipowners were responsible under the Workmen's Compensation Act.

Warrington Bridge.—After having been under consideration for a long time, the reconstruction of the above bridge is to be be carried out, Royal assent having been obtained, the contract let, and a commencement made. The existing bridge is in good condition, and is a fine stone structure, but is much too narrow for the present traffic, especially as two tram-lines cross it. Widening of the existing bridge was considered, but rebuilding in reinforced concrete was decided on. The new bridge will be the fourth to be built over the Mersey at this point, the first of them being constructed in 1496 by the first Earl of Derby. The new bridge has been designed by Mr. John J. Webster, M. Inst. C.E., of Westminster, who adopted the Considère system of reinforcement. The bridge will consist of one arch span, 134 ft. clear between the abutments, with a width between the parapets of 80 ft. There will be a 60-ft. roadway and two 10-ft. footways. The arch will consist of eight main ribs and two outer ribs, vertical posts on the ribs supporting the main longitudinal and transverse beams of the roadway deck or flooring, upon which will be laid Jarrah wood blocks for the roadway and granolithic slabs for the footway. The ribs will be parabolic in form, their underside at the centre of the span being 17.42 ft. above low-water level, which is 9 ft. above ordnance datum. The centre line of the rib at the springing will be 5 ft. 6 in. above low-water level. The depth of the main ribs normal to the centre line at a point 5 ft. from the abutment is 3 ft., the width being 3 ft. 9 in., and the section at the centre 2 ft. 9 in. deep by 3 ft. 9 in. wide, the ribs having cross ribs at intervals. The whole of the structure will be monolithic, the reinforcement consisting throughout of steel rods of varying diameter. The abutments are built on Considère concrete piles, spiral reinforcement being adopted. The vertical steel reinforcing-rods of the piles are carried into the abutments. The top and bottom reinforcement of the main ribs consists of steel bars running longitudinally the whole length of the ribs, the diameter and number varying according to the stresses. The floor under the footpaths will be of special construction so as to receive three water-pipes, each 1 ft. 6 in. in diameter, three gas-pipes 1 ft. 6 in. in diameter, compressed-air pipes, telegraph and telephone cable ducts, &c. The cost of the bridge is estimated to be about 20,000*l.*, and it is to be completed within two years. The contractors for the work are Messrs. Alfred Thorne and Sons, Westminster.

WATER-POWER WORKS.

At the meeting of the Institution of Civil Engineers, held on Tuesday, November 14, the President, Dr. W. C. Unwin, occupying the chair, two papers on water-power works were read. Of these papers we subjoin abstracts :

The Loch Leven Water-Power Works.

By A. H. Roberts, M. Inst. C.E.

The Loch Leven Water-Power Acts were obtained in 1901 and 1904, authorising the construction of works to utilise the rainfall of the western slope of Rannoch Moor for power for industrial purposes. The scheme possesses a number of advantages, including large catchment area, heavy rainfall, and high head, all in proximity to the seaboard. The author refers to the usual water-works practice of reckoning only upon the mean rainfall of the driest three consecutive years, and suggests that in power schemes of this character it might often be possible to obtain a greater output of power with the same expenditure. This could be effected by installing extra units of power plant (turbines, &c.), making a reduction in the height (and therefore in the cost) of the storage dam, and arranging to work the extra power in wet seasons.

The catchment area for the Loch Leven Works is the basin of the River Blackwater, and is 55 square miles in extent, lying between Lochs Treig, Ossian and Rannoch and Glen Coe. Rain-gauges established in 1905 and 1906 have given average readings of over 70 in. for the Blackwater basin and 80 in. for Kinlochleven. No compensation water had to be supplied, this feature greatly increasing the available power. The site of the reservoir is favourably contoured for storage purposes, and the full reservoir is about 7½ miles in length and ½ mile in breadth. Its greatest depth is 75 ft., and it impounds over 20,000 million gallons of water. The Blackwater dam is 3112 ft. in length, with a maximum height of 86 ft., its top surface being 1068 ft. above Ordnance datum. About half its length is formed as a waste weir in six horizontal steps of 6 in. each. The foundation is of an exceptionally sound character; only a few feet of the surface beds had to be removed to obtain a satisfactory foundation. The plant and materials required for the construction were brought by sea to the wharf and carried thence to the dam, &c., by an overhead cableway and a overland railway of 3-ft. gauge, which latter included two rope inclines. The cableway was driven by a Pelton wheel at the foot of the Falls of Leven. The dam is built of large blocks of stone embedded in a matrix of ordinary concrete, with fine concrete facework. The bulk of the cement was of rotary-kiln manufacture, and exhibited certain characteristics, which are described. Cracks due to the contraction of the concrete appeared after the dam was built, traversing it vertically from top to bottom. Reference is made to the question of inserting contracting-joints in large dams. The valve-tower contains six valves of the three draw-off pipes, the spindles being carried up to the valve-house above top-water level. The draw-off pipes lead to the upper penstock-chamber, whence the water is delivered over a measuring-weir into the conduit.

Water is conveyed to the pipe-track by this conduit, which is 3½ miles in length ; it is of square section, 8 ft. by 8 ft., and is laid to a general gradient of 1 in 1000. The construction consists for the lower part of a channel excavated in the rock and lined with concrete, while the work above rock level is of concrete reinforced with expanded metal and round bars. Expansion joints are inserted in the walls at intervals of 64 ft. Contraction cracks, however, appeared midway between these joints, until the conduit was brought into use, after which they closed up entirely. The arrangements for the maintenance of the natural surface drainage are described, and also the methods of shuttering and concreting the work. Along the route of the conduit, and above the same, lies a catchment area of 3½ square miles, with a rainfall of about 75 in., the greater part of which is drained by three streams. These have been laid under contribution by collecting their water and turning it into the conduit. A description is given of their intake works and of the automatic valves for throwing off superfluous water. Electrical transmitters and recorders indicate to the valve keepers at the lower penstock chamber the changes taking place in the contribution of the side-streams, enabling them to take advantage of the extra water and reduce the draw-off from the reservoir, thus storing an equivalent quantity of water in the reservoir. The conduit discharges its water into the lower penstock-chamber of about 300,000 gallons capacity, where it is measured and delivered to the pipes as required.

From the penstock-chamber water is conveyed to the power-house in six welded-steel pipes, of 39 in. diameter. The track is 1¼ mile in length, and the fall of 935 ft. yields a normal static pressure of 406 lb. per sq. in. The pipes are laid upon concrete pedestals, and at the bends there are heavy concrete anchorages to resist the thrusts of the water and pipes. The pipes are made from one plate welded longitudinally, and vary in thickness from 10 mm. (0.394 in.) at the top of the hill to 22 mm. (0.866 in.) at the foot. With the exception of flange-joints in special positions, the whole line is jointed with a special "muff" joint, a form of spigot and sockets with joint-rings for securing the packing material. Expansion is thus accommodated at every joint. The pipes were brought to the site by an overland railway laid up the hill alongside the track, and were lifted into position by specially-adapted derrick-cranes. Water is distributed from the six main pipes to the various turbines by a system of pipes, comprising two omnibus pipes and six feeders, all of 39 in. diameter. Each "bus" pipe, with its three feeders, forms one complete system, the two systems being at different levels to enable branches to cross. One branch from each bus-pipe feeds each turbine. The main valves which control the supply of water to the distributing pipes are of ordinary sluice-valve type, but specially designed to meet the combination of large diameter and high pressure. They are hydraulically worked, and are fitted with operating gear and automatic closing appliances, together with a mechanical device for controlling the speed of closing. At the top of the pipe-track, immediately below the penstock chamber, automatic cut-off valves have been installed, of the usual "butterfly" pattern, to stop the flow of water in the event of a burst occurring on the main pipe-lines. At the summit of a slight elevation in the main-line air-valves have been fixed of a special design to allow large quantities of air to pass in or out, as required, when filling or emptying pipes. The tail-race is of concrete, the channel leading to an outfall in the River Leven.

The Company have constructed a wharf and a jetty, both of timber, in Loch Leven ; and have dredged a channel through the Loch Leven narrows. A domestic water supply has been installed for the village and factories of Kinlochleven. It comprises a storage reservoir with concrete dam in a neighbouring valley, pipe line, a service reservoir of reinforced concrete, and distributing mains. The dam at present is only carried up to half its ultimate height; this, when completed, will be 55 ft., and its length will be 440 ft. Contraction joints are provided, and have proved efficient in preventing the occurrence of cracks.

The works described in the paper have cost about 600,000*l.*, and are now the property of the British Aluminium Company. The electrical plant in the power-house forms the subject of another paper (see below). The construction was begun in August, 1905, and the factory commenced working in February, 1909. The engineers were Messrs. Thomas Meik and Sons, and Messrs. Kennedy and Jenkin, in collaboration with Mr. W. Murray Morrison, the manager and technical adviser of the company. The principal contractors were Sir John Jackson, Limited, and there were other subsidiary contracts. The author was resident engineer.

The Hydro-Electric Plant in the British Aluminium Company's Factory at Kinlochleven.

By F. B. Sonnenschein, Assoc. M. Inst. C.E.

This paper deals briefly with the plant erected in the power-house at Kinlochleven, other than that which is of standard design in England, and a detailed description of the tests made on the turbines and generators is given. The aggregate power installed is 30,660 horse-power at the generator couplings, the generators being capable of a maximum output of 21,088 kw. Nine main units and two exciter units are erected, each unit consisting of a turbine and two generators. The main turbines are of the Pelton-wheel type, with two water jets, and are designed to give 3200 brake horse-power as a maximum; each drives two generators coupled in parallel, and having an output up to 2200 kw. together. The two small exciter units are also of the Pelton-wheel type, each driving a pair of generators on one shaft. These consist of an exciter and lighting machine, capable of giving an output up to 550 kw., and a traction machine up to 94 kw. capacity. All the connections between the generators, furnaces, &c., are made of bare aluminium strip. The feeders and distributors for lighting and power in the village and on the railway and wharves are also made of bare stranded aluminium cables erected on poles, and this metal has been found to be perfectly satisfactory under all conditions.

Efficiency and governor tests were carried out on the main units, and governor tests on the exciter units, as follow :—An iron wire resistance was used for absorbing the electric energy, and was placed in the tail-race, being kept cool by the discharge water. Below the resistance a hook-gauge was suspended for measuring the head over a weir. A gate constructed in the tail-race could be closed at will, thus forming a reservoir to measure the quantity of water passing over the weir at varying heads. After the weir curve was known, measurements were taken of the output of the generators at varying loads, and from these figures the efficiencies were calculated. The results obtained showed that the turbines did not quite reach their anticipated output, and that their efficiency was slightly below that guaranteed by the makers. Further tests are described, in which the areas of the jets were increased in size. It is shown that the efficiency was improved about 2 per cent. by increasing the area of the lower jet, but keeping the top jet of the original size, and by this alteration the turbines were enabled to give the specified output at the guaranteed efficiency.

The governing tests are then described. The specified limits for the variations in water-pressure and speed are enumerated, and the natural conditions are given under which these results had to be obtained. It was found during the tests that the generators were liable to flash over if the voltage increased excessively, and that they were also liable to flash over if a circulating current flowed round the two armatures of the dynamos on the same shaft running in parallel, when load was thrown off. An electrical protective device was therefore designed and fitted to each pair of generators, which automatically breaks the field circuit when either of these two conditions arises.

Messrs. Escher Wyss and Co. supplied the turbines, and Messrs. Dick, Kerr, and Co. the dynamos. The author acted as resident engineer for Messrs. Kennedy and Jenkin.

A Canadian Canal Bridge.—The Canadian Pacific Railway Company has adopted a design of the Strauss Bascule Bridge Company, of Chicago, for a 336-ft. double-leaf single-track bascule for the United States ship canal at Sault Ste. Marie.

THE BOOTH PASSENGER LINER "AIDAN."

The steamer Aidan, built by the Tyne Iron Shipbuilding Company, Limited, Willington Quay, and engined by the Wallsend Slipway and Engineering Company, for the Booth Steamship Company, Limited, Liverpool, completed her trials on Tuesday, the 14th inst., off the Tyne, and proceeded to the Mersey to take up her station on the owners' passenger and cargo service from Liverpool to the Amazon, and thence to New York and back to Liverpool, a round voyage of approximately 15,000 miles. The vessel is of the shelter-deck type, with long bridge, and embodies the best present-day practice. The dimensions are :—Length over all, 390 ft. ; length between perpendiculars, 376 ft. ; breadth (moulded), 50 ft. ; depth (moulded) to upper deck, 26 ft. ; depth (moulded) to shelter deck, 33 ft. 9 in. ; load draught, 23 ft. 6 in. ; dead-weight capacity, 6300 tons ; gross tonnage, 4550 tons ; net tonnage, 2880.

There are two decks, a cellular double bottom right fore and aft, eight bulkheads, and five large holds, independent of refrigerating space of 2200 cub. ft. capacity. On the upper deck amidships are cabins for forty-six first-class passengers, and extensive public rooms, and aft accommodation for one hundred third-class passengers. The holds are designed for large and heavy units of cargo, and included in the handling plant is a 45-ton derrick. The water-ballast tanks have a capacity for 1500 tons, and the bunkers hold 2200 tons of coal, so that the vessel can carry fuel for the complete round voyage.

The propelling machinery consists of a set of triple-expansion engines of very substantial design. The cylinders are respectively 24 in., 40 in., and 67 in. in diameter, with a common stroke of 48 in. Piston-valves are fitted to the high-pressure and the intermediate cylinders, and a slide-valve to the low-pressure cylinder. The large forgings throughout have been supplied by Messrs. John Spencer and Sons, of Newburn-on-Tyne, and are of their hydraulic forged ingot steel. The propeller, which is of the built type, is fitted with four manganese-bronze blades. The condenser, constructed entirely independently of the framing of the engines, but secured thereto largely as a matter of convenience in erecting the machinery in the shops, is of Weir's "Uniflux" type, built of steel plates. The condensing plant is capable of maintaining a vacuum of 27 in. when the machinery is working at full power.

There is a complete installation of auxiliary machinery. Steam is supplied by two main boilers, 16 ft. inside diameter by 11 ft. 8 in. long, the working pressure being 180 lb. per sq. in. Each boiler is fitted with three furnaces of the Deighton type. The boilers are arranged to work under Howden's forced-draught system. The necessary air under pressure is provided by a double-inlet fan driven by two single-cylinder engines, one of which is capable of doing the whole of the work. The funnel is 90 ft. in height from the base of the vessel.

On the measured mile off Whitley a speed of over 12 knots was attained running light. This result was assumed to be amply sufficient to ensure a speed of 10½ to 11 knots loaded in service. During the trial the owners were represented by Mr. J. A. Fisher, and the engineering superintendent, Mr. W. Beckett ; the shipbuilders by Mr. G. F. Mulherton, general manager and secretary, and Mr. J. Bourn ; and the engine-builders by Mr. Andrew Laing, director and general manager of the Wallsend Slipway and Engineering Company, Limited.

English Purchases of Swedish Peat Deposits.—An English syndicate has recently bought the large Dumme peat deposits, near Jönköping, Sweden, for the purpose of utilising the peat for the manufacture of spirit, and since then the extensive Stora peat deposits and the Tynge peat deposits, both near Vernamo, have also been sold, likewise, it is understood, to an English syndicate.

Telephones and the Post Office.—The question of introducing a cheaper form of telephone service in sparsely populated rural districts has been under consideration by the Postmaster-General, and it is thought by this means, and with the aid of agricultural associations, to assist the agricultural classes without burden to other tax-payers. Arrangements have been made whereby telephone subscribers may have the advantage of reduced rates for trunk calls outside busy hours. The concession is made for half-hourly periods when the traffic is light, generally before 9 a.m., between 1 p.m. and 2 p.m., and between 5 p.m. and 6 p.m. on weekdays, excepting Saturdays. Provision is being made for the transfer of the staff of the National Telephone Company to the Post Office service, and the whole staff, except those in receipt of as much as 700*l.* a year, will be taken over on January 1, 1912, subject to certain conditions as to physical fitness, and in the case of those with less than two years' service, as to efficiency and conduct. During the year ending March 31 last the number of suggestions from Post Office servants brought to the notice of the Awards Committee increased by 60 per cent., and about one hundred of these suggestions have been adopted. Awards were given in 120 cases for suggestions made. The only telephone systems now existing which belong to local authorities and maintain an independent existence are those of Hull and Portsmouth, which belong to the Corporations of these towns, and the Guernsey telephone system. The licenses of Hull and Guernsey expire on December 31 next, but in the case of Portsmouth not until 1926. The Corporation of Portsmouth is said to be unwilling to sell its system to the Post Office, or to purchase from the Post Office the plant belonging to the National Telephone Company, and it may therefore be necessary for the Post Office to become a competitor of the Corporation, as the National Telephone Company now is.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a number of colonial and foreign engineering projects, further data concerning which can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Canada: According to the *Monetary Times*, Toronto, a scheme is on foot for the utilisation of a large portion of Lulu Island (Vancouver) for railway terminal facilities. The proposal is to reclaim some of the tide flats and construct a tunnel 5 miles long into the town of Vancouver. The *Monetary Times* also states that a charter has been granted to Mr. J. D. McArthur, Winnipeg, for the construction of a railway from Edmonton through the Pine River Pass to Port George.

South Africa: An extraordinary issue of the *Union Gazette*, contains the text of the Irrigation and Conservation of Waters Bill. This Bill provides for the establishment of an Irrigation Department for the Union, with powers to supervise, construct, and control irrigation works; and lays down regulations for the organisation and control of the use of water for irrigation and industrial purposes. It also provides for loans to be made by the State to individual owners of land, and to Irrigation Boards for the purpose of carrying out irrigation works. No such loan is to be made in respect of works to cost more than 30,000*l.* without the previous consent of the South African Parliament.

Australia: According to the *Age*, Melbourne, a Bill was passed in the Victorian Legislative Assembly on October 3 authorising the Government to raise a loan of 2,000,000*l.*, to be expended as follows:—Construction of railways and tramways, works on existing lines, and rolling-stock, 1,650,000*l.*; country water works, 300,000*l.*; other public works, 50,000*l.* H.M. Trade Commissioner also reports that a Victorian Royal Commission, appointed to consider the proposal to construct new railways on the western border of Victoria so as to make connections with the South Australian railway system, recommends in its report the construction of a line 59 miles long from Heywood (Victoria) to Mount Gambier (South Australia), at a cost of 204,600*l.*, and of a line 17 miles long from Murrayville (Victoria) to Pinnaroo (South Australia), at a cost of 45,700*l.* Similar recommendations have been made by a South Australian Royal Commission working in conjunction with the Victorian Commission. The recommendations will be brought before the Parliaments of the two States in due course, and it is anticipated that they will be adopted. The second reading was moved of the Water Supply Loans Bill, providing for the expenditure of 431,233*l.*, of which a large part is a re-vote from last year. Advances amounting to 79,931*l.* are to be made to thirty-six water trusts in different parts of the State, 15,005*l.* is provided for the irrigation trust at Mildura, 107,000*l.* for main channels leading from Goulburn Weir, &c., 210,000*l.* for various water supply and irrigation works, &c. The second reading was also moved of the Railway Loan Application Bill, providing for an expenditure of 3,358,145*l.* (of which 1,373,222*l.* is a re-vote from last year), including 1,220,166*l.* for additions and improvements to ways and works, 1,107,046*l.* for additional rolling-stock, and 865,237*l.* for railway construction.

Netherlands: The *Nieuwe Rotterdamsche Courant* notifies that the Stoomtrammaatschappij Breskens-Maldeghem has applied for powers to construct and work a section of light railway, 4½ miles long, from Oostburg to Cadzand. The Bill which has been submitted for the above purpose provides for various communal subsidies and a State subsidy of 60,000 gulden (5000*l.*), which represents one-third of the cost of construction.

Luxemburg: The *Reichsgesetzblatt*, Berlin, contains the text of an agreement between the respective legislative authorities of Germany and Luxemburg, under the terms of which a railway is to be constructed from Vollingen to Rümelingen *via* Oettingen.

Spain: The October number of the report of the British Chamber of Commerce for Spain states that, with the support of the Spanish Government, several Spanish capitalists are considering the construction of a large fishing port on the North-East Coast, with commercial entrepôts for the supply of provisions to the fishing-craft, repair-docks, and ice factories.

Brazil: The *Diario* publishes the following decrees:—No. 9046, opening, in favour of the Ministry of Communications and Public Works, a credit of 1,300,000 milreis (about 87,000*l.*) to meet the expenses in connection with the construction of a section of the Central Railway of Brazil—viz., from Sabará to Ferros. No. 9049, approving the plans submitted by Messrs. Florisbello Leivas, André Virissimo Rebouçâo, and João Baptista Garcez, for the construction of a section of railway, 33½ miles long, from Basilio, forming part of the railway from Jaguarão to Basilio. The cost of this section is estimated at 4,705,000 milreis (about 314,000*l.*).

Journal of the British Fire-Prevention Committee.—In the sixth number of this journal may be found tabulated results of fire-tests on floors carried out by the British Fire-Prevention Committee. They are given in such a way as to record the principal facts of each investigation in a concise form. Twenty-eight floor tests are dealt with, and are classified in accordance with the "Universal Standards" of fire resistance. The tables given, in the first place, are intended for the committee members and subscribers, but the information is, no doubt, of service to public authorities and professional societies outside the committee; and a limited number of copies will therefore be available for the public. They may be obtained from the British Fire-Prevention Committee, 8, Waterloo-place, Pall Mall.

CATALOGUES.

Moulding-Machines.—We have received from Messrs. J. W. Jackman and Co., Limited, of Caxton-House, Westminster, S.W., a pamphlet illustrating and giving some particulars of moulding-machines, with and without turnover pattern-plates, for hydraulic or hand-power. The pamphlet also deals with gear-wheel moulding-machines, jolt-ram, and vibrator moulding-machines, hydraulic and hand-power core-presses, and other foundry plant. Dimensions, weights, and capacities of the various machines are given in tabular form.

Engine Governors.—A catalogue of their well-known engine governors and governor-gear has come to hand from Messrs. Wilson Hartnell & Co., Limited, Volt Works, Leeds. These governors are suitable for controlling trip gears, expansion valves, or equilibrium throttle valves, on all kinds of steam engines, turbines, and internal-combustion engines; they can be constructed with any degree of sensitiveness. Particulars are given of the various patterns made, prices being stated in each case. Some notes on governing are also included in the catalogue.

Smiths' Tools, Forges, Blowers, Furnaces, &c.—We have received from the Alldays and Onions Pneumatic Engineering Company, Limited, Great Western Works, Birmingham, a copy of an illustrated catalogue of their manufactures for use in the motor-car and cycle trades. These include vices, portable forges and smiths' hearths, brazing hearths, blow-pipes, fans and blowers, smiths' tools, stocks and dies, &c. Particulars of case-hardening, annealing and tempering furnaces, fired with coal, coke, gas, or oil, are also given in this catalogue. Prices are stated for all the articles dealt with.

Revolving Shutters and Shop-Fronts.—Messrs. S. W. Francis and Co., Limited, 64, &c., Gray's Inn-road, W.C., have sent us a copy of their catalogue and price-list of steel, iron, and wood revolving shutters, and all kinds of fittings for shop-fronts. Several designs for complete shop-fronts are illustrated, and sections of brass-covered sash-bar mouldings, and brass stall-plates, are shown, as well as designs for metal caps and bases for pilasters and columns, letters for fascias, &c. Illustrations of portable grills for protecting shop windows, collapsible steel gates, and wrought iron fire-proof doors, are also included in this list.

Cranes.—Sir William Arrol and Co., Limited, Dalmarnock Iron Works, Glasgow, have issued a book illustrating examples of cranes, &c., constructed by them. The illustrations, which are reproduced from photographs, show large hammer-head cranes, tower-cranes, floating-cranes, shipyard derricks, gantry-cranes, locomotive-cranes, railway breakdown cranes, overhead travellers, traversers, capstans, &c. The book also shows examples of complete crane equipments for shipbuilding berths, Temperley grabs and transporters, overhead trolley-hoist transporters, and other plant for handling materials of all kinds.

Friction-Clutch.—A pamphlet illustrating and describing the Benn friction-clutch has been forwarded to us from the Unbreakable Pulley and Mill-Gearing Company, Limited, of West Gorton, Manchester. This clutch consists of a cylindrical chamber keyed on the driven shaft, enclosing a boss to which two annular friction-plates are secured by feathers. The boss is keyed on the driving-shaft, and the friction-plates can be moved axially in opposite directions by means of a toggle mechanism, so that they come into frictional contact with the ends of the chamber, and thus transmit the drive. Among the advantages claimed for this form of clutch, it is mentioned that its action is independent of centrifugal force, it has no projecting parts, is self-locking both in and out of gear, and is very easily adjusted for wear. This latter operation is effected by screwing in the plate which forms one end of the cylindrical chamber. The pamphlet gives full particulars, including dimensions, prices, and capacities of these clutches, and also deals with alternative arrangements of actuating gears.

Power-Transmitting Appliances.—We have received from Messrs. Croft and Perkins, Limited, of Thornbury, Bradford, a copy of their latest catalogue and price-list of appliances for power transmission. The book contains over 650 pages, measuring 5 in. by 7 in., and is bound in limp cloth covers. It is divided into fifteen sections and is provided with a thumb index, so that any of the sections can be very easily found; a complete index is also included. The first few sections deal with shafting, collars, couplings, universal joints, plummer blocks, hangers, brackets, wall-boxes, &c.; while those following give particulars of all kinds of pulleys and other appliances for belt and rope-driving. Later sections relate to gearing, friction gears, head-gear pulleys for mines, friction clutches and operating mechanism, speed-varying gears, right-angle drives for shafting, &c., and the book concludes with a number of useful tables and a glossary of foreign technical terms. Altogether this catalogue forms a very complete compilation of modern practice in mill-gearing, and the information it contains should render it of great assistance to all designers and users of plant for the transmission of power by mechanical means.

Railway Employment (Prevention of Accidents) Act, 1900.—The Board of Trade have made a rule in pursuance of the above-named Act with respect to the subject of brake levers on both sides of railway wagons, being the first of the matters specified in the schedule to the Act. Copies of the rule will be placed on sale at an early date. In the meantime a limited number of copies may be obtained at the Offices of the Board of Trade, 7, Whitehall-gardens, London, S.W.

ON THE MAXIMUM DIMENSIONS OF SHIPS.*

By Sir William H. White, K.C.B., F.R.S., D.Sc., LL.D., D.Eng., Honorary Member.

It has been thought desirable, during the present meetings, to initiate a discussion on probable growth in dimensions of ships, and I have been requested to introduce the subject. Having given close attention thereto for many years, I have acceded to this request, and have prepared the following notes, which may serve as a basis for discussion, although they do not profess to cover the whole ground which may be discussed. The subject is undoubtedly important; it has an interest for naval architects, shipowners, dock and harbour authorities, travellers, and all classes of engineers. What seem to be chiefly needed are reasoned replies to certain questions:—1. Is it probable that the dimensions of ships will continue to grow at the rapid rate which has prevailed in recent years? 2. Will an upper limit to the sizes of ships be reached? 3. What considerations, if any, are likely to determine such a limit, for either merchant ships or warships?

In view of the greatly accelerated rate of increase in dimensions which has occurred during the present century, and is indicated by Tables I. and II., one may well ask, Whereunto will this thing grow? Probably the most useful procedure will be to make a detailed statement of facts and principles, which will, for the most part, command general assent; and in doing so it may not be out of place for me to state my own conclusions on points of controversy.

I. It will be agreed that the law of growth in dimensions has operated hitherto on all classes of ships, and that its action has, on the whole, been beneficial. Members of this Society treat as axiomatic the statement that economy in propulsion and over-sea transport has been, and always will be, promoted by increased dimensions. The actual influence of such an increase has, in many cases, been masked or made less obvious by concurrent changes in other factors and features of ship construction, but it has been none the less felt. Stronger materials of construction have been made available; more efficient types of machinery and propellers have been devised, higher steam-pressures have led to greater fuel economy, and higher rates of revolution have favoured relatively lighter propelling apparatus. But after each such improvement has been introduced and utilised, the law of growth in dimensions has inevitably reasserted its claims on naval architects, and been again brought into operation in order to secure still further advantage in respect of speed, carrying power, or other features of ship design. Successive vessels belonging to each and every class have been made larger than their predecessors. Excellent illustrations of this general law may be found in the development of the smaller classes of war-vessels during the last twenty years. Submarines also furnish illustrations of the working of that law.† The same general law has been at work in the mercantile marine. Many small ships continue to be built, but there is a universal upward tendency in size.

II. It must be noted, however, that, notwithstanding the remarkable developments of the last ten years, the number of ships of extremely large dimensions is relatively few. These great ships naturally attract most attention; they are admittedly essential to the performance of special services; but the carrying trade of the world is mainly done by vessels of moderate dimensions. The British mercantile marine in 1910 owned 11,495 steel ships of 100 tons (gross) and upwards. Of these only 328 ships individually exceeded 7000 tons (gross), 107 exceeded 10,000 tons, and 20 exceeded 15,000 tons. The enormous preponderance in numbers of ships of moderate dimensions has resulted from the operation of purely commercial considerations, which have similarly influenced all mercantile marines. Whatever may be the future growth in size of the largest ships built for special services, the bulk of the maritime business of the world will always be done by ships of relatively moderate dimensions, and they will continue to be the largest contributors to the revenues of port and harbour authorities. This fact, as will be shown hereafter, may have an important influence upon the upper limit of dimensions of merchant ships.

III. Naval architects will agree that, provided the money is forthcoming for building still larger ships, their construction will be possible; and that considerably increased dimensions will present no serious difficulty, even if the materials for shipbuilding already available were not improved upon.

IV. Existing physical conditions in the seaports, harbours, and docks of the world necessarily impose limits on the draught of water of ships. Much has been done, at great cost, to improve accommodation and to provide increased depths of water; but it is well recognised that the increase in dimensions of ships above described has been chiefly in lengths, breadths, and moulded depths; the increase in draughts of water when fully laden has been relatively small. Since 1899 the lengths and depths of trans-Atlantic steamships have been increased about 30 per cent., breadths have been increased nearly 40 per cent., but deep load-draughts by only 10 per cent. This disproportionate increase in draught of water has imposed difficulties and disadvantages on the work of ship design which need not be dwelt upon. Shipowners find themselves debarred from loading many existing vessels to the full draughts to which they might be safely laden were there sufficient depths of water at terminal ports and were cargoes available. The

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* Abstract of paper read at the eighteenth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 16 and 17, 1911.

† See page 655 *ante*.

earning powers of ships are thus lessened, and in these circumstances it is natural that a demand should have arisen, and should still continue, for greater depths of water and better accommodation for ships of the largest size.

While shipowners and shipbuilders urge upon authorities and proprietors of harbours and docks the necessity for prompt and liberal action, the latter may well be pardoned if they do not immediately respond to the demand, but require evidence that the large expenditure which would be needed to carry out these great engineering works will be followed by a corresponding and adequate increase of revenue. The difference in point of view is natural and inevitable. It is idle for those who are interested in ship development to ignore or treat as unreasonable this attitude of dock and harbour authorities who are responsible for a return to investors on the enormous capital sums administered by them. Of course, there are some great works which may be and are properly treated as national rather than private or local enterprises. The Ambrose Channel at New York, the navigation of the St. Lawrence and the Kiel Canal furnish examples; but such enterprises are exceptional in character, and are avowedly undertaken for the benefit of the community as a whole, or for strategical reasons which lie outside the present discussion.

TABLE I.—Trans-Atlantic Steamships.

Line.	Name.	Date.	Length.	Breadth.	Depth.	Gross Tonnage.	Load Draught.	Load Displacement.	Horse-Power.	Sea Speed
			ft.	ft. in.	ft. in.		ft. in.	tons		knots
Cunard	Persia	1856	360	45 0	31 5	3,300	23 0	6,000	5,500	13.0
White Star	Germanic	1874	455	45 0	36 0	5,000	23 0	8,500	13,000	16.0
Cunard	Oregon	1883	500	54 0	40 6	6,900	23 0	10,500	20,000	18.0
White Star	Teutonic	1889	565	57 6	42 0	9,700	23 0	13,000	30,000	20.0
Cunard	Campania	1893	600	65 0	41 6	12,500	27 6	20,000	26,000	22.0
White Star	Oceanic	1899	685	68 5	49 0	17,274	30 6	26,400	38,000	20.75
North German Lloyd..	Kaiser Wilhelm II...	1903	678	72 0	52 6	19,360	29 0	26,000	75,000	23.5
Cunard	Mauretania	1907	760	88 0	60 5	31,938	34 0	39,000	13,000	25.5
White Star	Cedric .. .	1903	681	75 3	44 1	21,000	32 0	32,000	16,000	16.5
White Star	Adriatic .. .	1906	709	75 6	52 6	24,540	34 0	36,000	46,000	17.0
White Star	Olympic	1911	850	92 0	64 3	45,000	34 0	50,000		21.0
Hamburg-America ..	Imperator	Building	880	96 0	64 0	about	34 0	to	Not	22.0
Cunard	Aquitania	Building	885	95 6	..	50,000	34 0	55,000	stated	23.0

TABLE II.—*Armoured Warships.*

Navy.	Name.	Date of Order.	Length.	Breadth.	Load Draught.	Load Displacement.	Horse-Power.	Trial-Speed.
			ft.	ft.	ft. in.	tons		knots
British ..	Warrior ..	1859	380	58	26 0	9,000	5,500	14.4
British ..	Bulwark ..	1899	400	75	26 9	15,000	15,000	18.0
United States..	Maine ..	1898	388	72¼	25 6	13,500	16,000	18.0
German ..	Wittelsbach	1899	394	68¼	25 0	11,900	15,000	18.0
French ..	Suffren ..	1899	410	70	27 6	12,700	16,500	18.0
British ..	Lion ..	1910	660	88½	28 0	26,400	70,000	28.0
United States..	Wyoming ..	1909	554	93½	28 6	26,000	28,000	20.5
German ..	Moltke ..	1908	610	96¾	27 0	23,000	50,000	25.5
French ..	Jean Bart ..	1910	541	88½	29 6	23,100	29,000	20.0
Argentine	Rivadavia ..	1910	585	96	27 6	27,500	39,000	22.5

V. Up to the present time the response made to the appeal from shipowners for increased accommodation for larger ships by authorities of the great seaports of the world has been neither niggardly nor unsatisfactory. At the present moment extensive and costly works are in progress which will provide accommodation for the largest ships now building, and leave some margin for further developments. The Ambrose Channel to New York, and the new docks provided at that port for the great trans-Atlantic liners, furnish illustrations of the foregoing statement. At Liverpool and Southampton corresponding works are in course of performance, while still larger schemes are contemplated. From reports issued by the new Port of London Authority, it appears that the estimated outlay for making the dock and channel accommodation of the Port of London suitable for the existing trade, and for providing a proper margin to meet future developments, will be about 14½ millions sterling (over 72 million dols.).

VI. The marvellous growth of the world's commerce in modern times has enabled these great engineering works to be undertaken hitherto under conditions which have, in most cases, either yielded fair returns to investors in dock and harbour securities, or which have been considered by governments to be beneficial to the whole nation and worthy of adoption irrespective of the return upon capital expenditure. In many cases this question of dock accommodation has been treated by great corporations, such as railway companies, as parts of their schemes of operations rather than as independent undertakings. Modest returns have been accepted on large sums expended upon docks, because the existence of that accommodation has led to such an increase of earnings on the system considered as a whole as justified the expenditure on docks. The growth of traffic in most of the great seaports has also enabled earlier docks to be fully utilised by vessels of smaller dimensions than those for which the latest docks have been constructed. But while this has hitherto happened, it seems not improbable that a point may be reached beyond which dock and harbour authorities will not care to go in expenditure in order to meet further increase in dimensions and draughts in a relatively small number of the largest ships; and it is well understood that this consideration particularly applies to increase in draught of water, since the cost of dredging grows rapidly with increase of depth.

It is not my purpose to attempt any prediction of what the limit of depth of water will be in future. For the moment 40 ft. of water at low tide seems to be the maximum contemplated; and most ports are content with less, especially when there is a good rise of tide. Keen rivalry between great seaports has hitherto greatly influenced both policy and performance on the part of authorities, and has given shipowners and shipbuilders practically what they have demanded. In the end, however, commercial considerations must prevail, and dividends must be earned by docks and harbours as well as by ships. The advantages to be obtained by the whole community, and not the profit of a particular section, ought and will determine what is done eventually.

VII. The following brief summary of facts relating to the dimensions of locks and dock entrances recently constructed, or now in process of construction, may be of interest as indicating the outcome of inquiries set afoot by responsible authorities in regard to the provision of suitable accommodation for the largest ships likely to be built. On the Panama Canal the locks are 1000 ft. long, 110 ft. wide, with 40 ft. of water over the sills. On the reconstructed Kiel Canal the locks are to be 1080 ft. long, 147 ft. wide, with 36 ft. of water over the sills, but provision has been made in the structures for increasing this to 46 ft. if required hereafter. The new Gladstone Dock at Liverpool is to be capable of receiving the Cunard steamship Aquitania when she is completed, and still larger vessels; it is really part of a great scheme of dock extension. This dry dock will be 1020 ft. long, 120 ft. broad, with 44 ft. of water on the sills at high water of ordinary spring tides. On the Clyde a dock of nearly the same dimensions as the Gladstone Dock is now under construction with 36 ft. of water on the sills at high water; but the rise and fall of tide is less than at Liverpool. The Port of London Authority contemplates the construction of a dock 1000 ft. long, 120 ft. wide, with 40 ft. of water over the sills. At the new naval base which the British Admiralty are constructing at Rosyth (Firth of Forth) the plans originally provided for a lock 850 ft. long, 110 ft. wide, with 36 ft. of water at low tide, and for a dry dock of similar dimensions, except that it was to be 750 ft. long. It is understood that some increase in length and breadth is probable.

Approach channels have been deepened considerably. A depth of 40 ft. at low water is to be secured throughout the Ambrose Channel; at Southampton access is to be secured at all times for ships drawing 34 ft. to 35 ft. At Liverpool the minimum depth of water at low tide in the "cut" through the bar of the Mersey is maintained at 30 ft. On the St. Lawrence works in hand are intended to give a minimum depth of 35 ft. from Montreal to the sea—a marvellous change from the minimum of 10 ft. to 12 ft. formerly existing on that river during the greater part of the navigation season. On all sides there is and has been recognition of the need for ample depth of water.

VIII. When the foregoing particulars for locks, docks, and approach channels are considered in the light of dimensions of ships, the margins provided in most of the recent engineering works are not very great in regard to length and breadth, although they are expected to prove sufficient for many years to come, because of the commercial considerations above mentioned.

IX. It is a fact worth noting that ships of the maximum dimensions now built or building are not easily accommodated or moved in the largest docks and harbours. The vessels are wonderfully handy, as all who have seen the Lusitania or Mauretania approach or leave the docks at New York, or the landing-stage at Liverpool, will agree; but they necessarily require large spaces for their manœuvres, because they are so long and heavy, and in the busy waters of their terminal ports caution is required. It has been stated recently that the provision of suitable docks at New York for the latest trans-Atlantic liners will involve an encroachment on the fair-way of the Hudson River, which may prove disadvantageous to the general traffic of the port. Whether or not this statement is well founded, the general truth of the foregoing remark will be admitted. Ships of 900 ft. to 1000 ft. in length, weighing 40,000 to 50,000 tons when deep-laden, are not easily dealt with, especially when moving on restricted spaces and in tide-ways, wherein other vessels are under-way, and they themselves must necessarily move at low speeds. In many ports also the great draughts of water of the ships impose considerable restrictions on the water area which they can utilise with safety to themselves. Even in the terminal ports of the trans-Atlantic steamers difficulties are necessarily experienced, and although they have been overcome so far, they must be accentuated by any further increase in size.

X. For cargo steamers and warships no such fixed conditions of terminal ports exist. The former class are built to seek cargoes everywhere and to deliver them wherever desired. Consequently, experience has led to the adoption of relatively moderate dimensions and draught of water in order that their possible field of operations may be extended widely.

Warships are designed to operate from special bases, but they must find great advantage from being able to enter and utilise other harbours or sheltered waters where the depth of water is moderate. It is desirable also that they should be capable of proceeding to any place where an enemy can be found, and thus enlarge to the utmost their field of operations. Moderate draught of water is therefore an important feature of warship design; and the tendency in recent years to a considerable increase in the deep load-draughts of warships is, from this point of view, objectionable. The "sinkage" of modern warships (from normal to deep load-draught) is frequently 4 ft. to 5 ft.; and although this fact may be ignored in statistical returns, it must seriously affect the practical working range of action of the vessels in war-time. In respect of draught of water, the United States Navy formerly favoured shallowness—indeed, insisted upon it—although naval architects did not fail to point out the penalising influence of that restriction. It will be interesting to be told why this remarkable change of attitude has been made. It is notorious that some of the most recent capital ships added to war fleets cannot, when fully laden, find shelter in harbours which have been built primarily, and at great cost, to serve as naval bases, and they cannot be placed in many existing dry docks, in case of injury in action, because of their considerable load-draughts. It will not be disputed that one essential factor in framing a shipbuilding programme for any war fleet should be the consideration of the harbour and docking accommodation which will be available, in case of war, for the reception and repair of the largest vessels. For warships, as well as for merchant ships, expenditure on ships and armaments must be considered concurrently with that on harbours and docks, and in every well-devised programme the two things must be dealt with concurrently. This is a truism, no doubt; but past events prove that it may none the less be neglected in the excitement of a race to produce the "biggest warships," each carrying the greatest number of the heaviest guns.

XI. Enlarged dimensions, of course, enable certain advantages to be obtained, outside the fundamental gains of economy in sea-transport or increased speed. Amongst these advantages are: (*a*) Maintenance of speed at sea in rough weather, and increased uniformity of service between terminal ports. (*b*) Greater steadiness and good behaviour in rough water and increased comfort for passengers, if naval architects are left free to utilise fully the greater size of ships. Not infrequently they do not enjoy such freedom, because the conditions laid down impose limitations on their choice of dimensions and proportions. (*c*) Better and more spacious accommodation for larger numbers of passengers. (*d*) The attraction which many passengers have toward the "biggest ships afloat." Maintenance of speed in rough seas and storms is obviously affected by the relative dimensions of ships and waves. The Mauretania has averaged for a whole year, on thirty consecutive passages (fifteen voyages), westward and eastward in all weathers and under varying and uncontrollable conditions of service, a mean speed of 25.5 knots. The highest mean speed going west was 26.06 knots; coming east it was 25.89 knots; the lowest mean speed was 24.92 knots in both directions. This regularity of performance has been repeated during service in two following years, the average mean speed being 25.25 knots and 25.1 knots respectively. In the series of passages made between February and August this year the total number of revolutions of the screws during each passage varied only 2 per cent. above or below the number of revolutions per passage deduced from an average for all the passages. A closer approach to regularity of performance on the trans-Atlantic service can hardly be realised whatever may be the sizes of the ships employed. Experience proves also that in the Cunarders the limit of speed at which they can be safely driven in heavy seas is not fixed by their size, engine power, or general structural strength, but by considerations of the serious damage which might be done to fittings and navigational appliances, as well as to the officers and crew employed in navigating the ships, and of the safety of passengers if the ships were driven at high speeds against heavy seas. This will always remain true whatever the sizes of ships may be.

In regard to steadiness in a seaway, long experience has shown that ships of less size may be more free from heavy rolling in a seaway than much larger ships, if the latter are endowed with greater stiffness, and consequently move more quickly when rolling. In recent years increase in the proportion of breadth to draught of water has tended to shorten periods of oscillation. No doubt in modern passenger steamers the lofty superstructures tend to raise the centre of gravity, and so to diminish stiffness and lengthen periods of oscillation. The increased breadth of ships has also tended to lessen the "effective wave-slope," and so to diminish rolling. Apart from detailed calculation, no exact knowledge can be reached respecting the probable behaviour and period of oscillation for a new ship; but that fact in no way contradicts the general statement made above, that large dimensions are not necessary to secure moderate rolling and easy motion. In modern warships of the largest types, as I pointed out in the paper read last year to this Society, the periods of rolling oscillation are actually less than the corresponding periods for smaller ships which preceded them; and it is certain that, as a result, the larger ships must prove less steady gun-platforms than their predecessors under the influence of ocean storm-waves, such as are frequently encountered.

XII. In view of the foregoing statements, it becomes apparent that larger dimensions are not essential to good behaviour at sea, and that increase in length and weight

beyond the Mauretania is not necessary in order to secure maintenance of speed on long ocean passages. It would appear, therefore that the main determining factor in regard to maximum dimensions for future mercantile vessels must be found on the commercial side, and not on the technical. If ships cannot be made to pay dividends on the capital sums invested in them—after meeting working expenses and cost of upkeep, and making due allowance for insurance and depreciation—they are not likely to be built.

The first cost of trans-Atlantic passenger-steamers has been increased enormously during the last forty years. In 1874 a 15-knot steamer cost 200,000*l.*; in 1889 a 20-knot steamer cost 375,000*l.*; in 1893 a 22-knot steamer cost about 550,000*l.*; in 1899 the Oceanic, of 20.75 knots, with relatively good cargo capacity, cost 700,000*l.*; four years later a 23-knot steamer, of about the same dimensions as the Oceanic, cost 800,000*l.* For later ships authoritative figures have not been published, but certain statements indicate approximately the sums which have been spent upon them. The British Government granted to the Cunard Company a loan of 2,600,000*l.* towards the construction of the Lusitania and Mauretania, and it is understood that the actual cost of the two vessels exceeded that amount. The outlay on the Olympic has been put at about 1½ million pounds sterling by men who had exact knowledge of what she has cost. The Hamburg-America and Cunard steamships now building would, on this basis, represent an expenditure of about 1¾ million pounds sterling per ship. There can be no doubt that experienced men who guide the policy of these three steamship companies have reached the conclusion that even such huge expenditure as these figures indicate will, on the whole, prove advantageous to the owners, and lead to increased revenue.

It is not my purpose to attempt even the roughest estimate of earnings or working expenses for the new vessels. On the other hand, it may be well to call attention to certain facts and opinions which are already public property, and which bear on the subject. In 1902 a committee appointed by the British Government to consider and report on the employment of mercantile cruisers, and the subsidies proper to be paid for the services of such ships, expressed the opinion that commercial companies would require to be paid annual subsidies for swift steamships, in order to make good "the loss which would be sustained in peace time for running such vessels." For ships having a sea speed of 25 knots the Committee considered that the annual subsidy ought to be 15 per cent. of the first cost; for 23-knot vessels, 8.6 per cent.; for 20-knot vessels, 2.6 per cent. The essential point in this recommendation was that extremely fast vessels could not be worked without loss, and that if they were to be made available for use as auxiliary cruisers in war, annual subsidies should be paid. National sentiment was strongly in favour of recovering ownership of the swiftest ocean steamships for Great Britain; Parliament approved that action; an agreement was made with the Cunard Company to build the Lusitania and Mauretania; an annual subsidy of 150,000*l.* was arranged; and the loan above-mentioned was granted at 2¾ per cent., to be repaid in twenty years. Only the owners of these two vessels can know whether or not they have earned dividends, and it is their concern alone. It is noteworthy, however, that no attempt has yet been made to surpass these vessels in speed, and that the five ships of greater size, for which particulars are given in Table I., are intended to be slower than their predecessors. They may, in fact, be regarded as the latest developments of the "intermediate" type of trans-Atlantic steamships, rather than as additions to the series of "express" passenger-steamers, in which very little cargo is carried, of which the Cunarders are the latest examples.

The essential characteristics of the "intermediate" type of steamships are moderate speed in proportion to length and displacement, and the association of large passenger accommodation with a considerable cargo capacity. Moderate speed, of course, permits of relatively moderate engine-power, lessens the coal bill and engine-room expenses, makes less demands for space for engines, boilers, and fuel, and leaves free for other uses a larger proportion of the internal capacity than in express steamers. All these differences obviously tend to increase net earnings in vessels of the intermediate type relatively to express steamers of equal size, but much higher speed; provided that passengers and cargo can be obtained. On the other hand, if cargoes are obtained which utilise the full deadweight capacity of a very large steamer of the intermediate type, it may happen that the period of detention in port may be considerably in excess of that required for the passenger service and for re-coaling. As a consequence there may be so considerable an increase in the time spent in port—during which the capital is unproductive—as will seriously diminish the net earnings. Every one agrees that for large and costly ships a quick "turn round" is of vital importance to commercial success, and the shipment and discharge of large cargoes must interfere with that procedure.

Let it be assumed that the Mauretania and Olympic start at the same deep load-draught—34 ft. Allowing for differences in speed and engine power, the coal burnt for propulsion on a trans-Atlantic passage by the Olympic at 21 knots would be about 70 per cent. of that required for propulsion by the Mauretania at 25 knots. For other purposes the daily coal consumption of the Olympic would rather exceed that of the Mauretania, because of her larger size and greater number of passengers. The duration of the passage would be about 20 per cent. longer for the Olympic, and on this basis the deadweight cargo capacity of the Olympic at the load draught assumed for both ships would probably exceed that of the Mauretania (roughly) by 10,000 tons. This is obviously a potential source of larger earnings, provided cargoes can be secured and dealt with in port without objectionably long detention. It may be doubted whether this full cargo capacity would be frequently utilised, even coming eastward, and going westward there would be no prospect of its utilisation under the conditions of actual trans-Atlantic service. If not so utilised, the vessel could, of course, be worked at lighter draught, or could carry coal from England for the voyage out and home, or be otherwise dealt with. On the other hand, the under-water form would always remain that which was selected as appropriate to the carriage of a large dead-weight; and if the provision made for cargo had been less, it would have been possible to produce a vessel of smaller displacement and less cost having the same speed, with reduced working expenses and equal passenger accommodation. These remarks are made in no spirit of criticism. Those who were responsible for the construction of the Olympic are undoubtedly masters of all details of shipping and ship management, while I am only an outsider in mercantile affairs, and necessarily regard the problem from the point of view of a naval architect. Even that point of view should not be ignored, however, and it will have an influence on the future developments of mercantile steamships.

XIII. For warships other considerations than those of first cost and cost of maintenance must determine the maximum dimensions which should be adopted. Their case is, therefore, distinct from that of merchant ships and must be considered on its merits. Warships are intended to seek out and find an enemy wherever he may be. In order to secure success, therefore, each navy needs a considerable number of ships, and the draught of water of individual vessels ought to be moderate in order that their field of possible operation should be large. Warships are also exposed to special risks, and as a consequence it is essential to provide for considerable numbers as well as for individual power in the constitution of each fleet. It is admittedly a correct definition of the problems involved in the arrangement of an "establishment" for any navy to say that it must rest on a definite plan of campaign, the fulfilment of which requires the construction of a certain number of ships of various types suitable for various services, and ranging from capital ships—forming units in squadrons and fleets—down to the smaller classes of armed vessels and the fleet auxiliaries. For each fleet of capital ships it is necessary to arrive at a decision as to the best distribution of the total sums to be expended on construction and subsequent maintenance; and in reaching such a decision regard must be had to the special risks incidental to modern naval war, as well as to the necessities of naval operations which must demand the capability of either concentrating or distributing the force as the varying conditions of a campaign may require. Problems such as these naturally, indeed necessarily, give rise to different solutions, and there is room for various opinions as to the best possible arrangements in proportion to total expenditure. My personal opinions on the subject were expressed in the paper on "Armaments of Battleships," which appears in the transactions of this society for last year. It may assist the present discussion if they are briefly summarised.

(*a*) Multiplication of the heavy-gun positions in capital ships, and of the number of such guns carried by individual ships, has necessarily involved increase of lengths and displacements.

(*b*) Concurrently with this alteration of armament there has been an increase in speed and fuel supply: this has involved further increase of size.

(*c*) Modern capital ships—with heavy-gun armaments and great weights of armour placed high above water—must be endowed with considerable initial stability in order to possess a reasonable range of stability under ordinary peace conditions. Hence they have been made very broad in relation to their draughts of water, even after allowance is made for the increase in draught (deep laden), as compared with their predecessors.

(*d*) Their moderate range of stability (when intact) gives to these ships a less margin of safety when injured in action by gun-fire; and, in many instances, the distribution of the armour is of a character that adds to this risk, because it leaves without protection large areas of the sides which are reckoned as water-excluding in calculations of stability, although they can be rapidly riddled and destroyed by shell-fire with high explosives. In later designs the areas which are armour-protected have been considerably increased; but the addition to the weight of armour placed high above the water-line has necessarily been accompanied by a rise in the position of the centre of gravity of the ships. The breadths have been still further increased in proportion to the draughts, and even then the range of stability in the intact condition is very moderate.

(*e*) Modern warships, notwithstanding their greater size, are not, and cannot be, as steady gun-platforms as their predecessors, because their great initial stability causes them to have relatively short periods of oscillation. As a consequence, they are more likely to be set rolling by ordinary conditions at sea. Experience has shown them to be less steady in a seaway than ships of earlier date and smaller size. Some of these ships are so large in relation to the available dry-docks that their bilge keels are either very shallow or non-existent at the mid-ship portions of the length; and as a consequence the check upon rolling is greatly reduced.

(*f*) The development of under-water attack proceeds rapidly. Torpedoes are now larger, have greater charges, are much faster and can be used at much longer ranges. Submarine mines have been used with great effect in actual warfare, and will be used in future with greater effect. Submarines have been developed, and are now being made of dimensions, speed, and radius of action which probably enable them to act as auxiliaries to fleets over considerable areas of operation. Advocates of very large dimensions in warships admit that one successful under-water attack will probably put the largest warship out of action. It cannot be questioned that the increase in length and speed of recent ships will necessitate an increase in the intervals between successive ships in the line of battle, and the danger of successful under-water attack will be increased because both individual ships and the line of battle formed by a certain number of ships must be made longer.

(*g*) In view of the foregoing considerations it appears to be desirable to put a limit upon the size and cost of individual warships, and the concentration of so many guns in a single ship; because a single successful blow may bring about a serious proportionate loss to a fleet by one ship being put out of action. Moreover, the withdrawal of a single ship from a fleet, for temporary employment on detached service, would involve a serious loss of power, which with more numerous vessels would be avoided.

(*h*) Special dangers must be incurred by the multiplication of heavy guns and of magazines placed below them. Some of these magazines are necessarily in the neighbourhood of boiler-spaces or bunkers, where high temperatures are unavoidable. No doubt the dangers are lessened by fitting appliances for keeping magazines cool and by other devices; but although lessened, they are not absolutely overcome, and the risk of explosion—as sad experience proves—remains. The loss of the Liberté, which is universally deplored, following upon a previous accident to the Jena, demonstrate the possibility of possible and sudden destruction in this fashion of the largest ships, and furnishes a fresh argument against "putting too many eggs in one basket."

My personal conviction, based upon long-continued study of the problem, is that the wiser course in warship building would be found in a return to more moderate dimensions and a reduced unit cost for capital ships. Experience has established the fact that, without having resort to the extreme dimensions which have recently found favour, it is possible to produce capital ships which shall be powerfully armed, well protected, steady gun-platforms, capable of fighting their guns in all weathers when actions could take place, and able to maintain their speed in rough water. The value of high speed in capital ships has been much discussed, but it really opens up a separate field into which it would be undesirable to enter now. Suffice it to say that with equal speed a reduction in the number of heavy guns carried in a single ship, such as I advocated last year, would enable considerable reductions to be made in size and cost; and that, for a given total expenditure on the first cost of a fleet or squadron, a more formidable and flexible force could, in my judgment, be obtained, with greatly reduced risks from either gun-fire, under-water attacks, or magazine explosions. It would probably be true that the more numerous fleet would cost more for manning and maintenance; but the price which would have to be paid in this direction would be well earned by advantages in other respects, and, above all, by a greater prospect of success in the day of battle.

Cargo Fleet Iron Company, Limited.—In their report to be submitted to the annual general meeting of the shareholders, to be held at the works on Wednesday next, the 29th inst., the directors announce that the result of the year's operations has wiped out the debit balance of 8647*l.* 5s. 8d., brought forward from last year, and, after paying all preference charges, has left a credit balance of 32,572*l.* 10s. 7d. Of this amount, they recommend that 30,000*l.* should be placed to depreciation, and the balance of 2572*l.* 10s. 7d. carried forward.

Belgian Coal-Mining.—The production of coal in Belgium last year was 23,916,560 tons, showing an increase of 399,010 tons as compared with the output of 1909. The number of pits working last year in Belgium was 273 out of 329. The total of 23,916,560 tons representing the coal production of Belgium last year was made up as follows:—Hainaut, 16,950,470 tons; Namur, 825,430 tons; and Liége, 6,140,660 tons. The value of the coal raised in Belgium in 1910 was 13,955,074*l.*, giving an average of 11s. 7d. per ton. Of the Belgian coal output of last year, 21,615,840 tons were available for sale; the balance of the output was consumed by the collieries themselves. The number of persons engaged below ground in Belgian coal-mining last year was 103,443; of these, 13 were women. The number employed above ground was 8148; of these, 1548 were women and girls over twenty-one years of age, 3396 girls of from sixteen to twenty-one years' and 3204 girls of from twelve to sixteen.

Indian Bridge-Building.—New works upon the Bengal and North-Western Railway have made good progress during 1910-11. A bridge 6000 ft. long over the Ganges at Allahabad—forty spans of 150 ft. each—is expected to be completed in the course of 1912. The Manjhi Ghat bridge, over the Gogra, which is also in hand, comprises eighteen spans of 200 ft. each. All the piers of the bridge and fourteen spans of girders have been practically completed, and they stood the test of the monsoon of 1911 without being materially affected; the bridge should be opened early in 1912. The Bagaha bridge, over the Gundak, comprises fifteen spans of 150 ft. each; eleven piers have been completed, good progress has been made with the remaining four, and one span of girders has been erected. The Dhang bridge, over the Bagmatti, comprises fifteen spans of 100 ft. each; all the piers have been completed, and seven spans of girders have been erected, while works for guiding and controlling the river have been put in hand; the bridge is expected to be available for traffic in the course of 1912.

THE RISORGIMENTO BRIDGE, ROME.

By W. NOBLE TWELVETREES, M.S. Ing. Civ., France.

WITHIN the last few years a remarkable development has taken place in the construction of long-span ferro-concrete arches. In this country the most notable example is New John's Bridge, Kilkenny, with the clear span of 140 ft.; in the United States several bridges have been constructed with arches of from 200 ft. to nearly 300 ft., and on the Continent the progressive increase of arch-spans is shown by the following list, given in a recent paper read to the Canadian Cement and Concrete Association:—

Date.	Designation.	Engineer.	Span.	Rise.	Width.
			ft.	ft.	ft.
1907	Pyrimont, France ..	Hennebique	176.2	25.0	12.5
1904	Decize, France ..	Do.	183.5	15.3	34.9
1908	Kronstadt, Hungary ..	Zielinsky	196.5	71.8	—
1904	Grünwald, Germany ..	Mörsch	229.0	41.9	30.1
1908	Sitter, Switzerland ..	Do.	258.0	86.7	22.0
1911	Rome, Italy	Hennebique	328.0	—	—

The last structure mentioned is that forming the subject of the present article. A view of it is given in Fig. 1 herewith, while it is further illustrated in Figs. 2 to 11, on Plate LVIII., with this issue, and on pages 722 and 736. It crosses the River Tiber in a single span of 328 ft., the arch has a rise of 32.8 ft., equal to one-tenth the span, and a total width of 65 ft. 6 in., including a roadway 42 ft. 6 in. wide, and two footwalks, each 10 ft. 3 in. wide.

The work was projected by the Executive Committee of the Rome Exhibition, 1911, who decided that it was desirable to construct a bridge across the Tiber, to connect the Artistic and Ethnographic portions of the Exhibition, the former situated on the right bank of the river at the Piazza d'Armi, and the latter on the left bank in Vial Famina, near the picturesque Valley of Vigna Cartoni.

It was at first thought that the bridge would necessarily comprise three arches, as in most of the Roman bridges, and all the designs submitted in competition were in that form with the exception of the project by Signor G. A. Porcheddu, the Italian representative of Messrs. Hennebique, of Paris.

Signor Porcheddu proposed a single arch of 100 metres span and a rise of 10 metres, and after consideration by a Technical Commission, composed of Commander Engineer Cesare Ceradini, Commander Engineer Rinaldo Rinaldi, Signor Bentivegna, and Professor Parvopassu, the scheme was accepted at the contract price of about 50,000*l.*, the work to be completed within the period of sixteen months. The project was definitely approved by the City Council on July 31, 1909, and finally settled by the Ministry of Public Works on October 9, 1909, and work was commenced on November 11, 1909.

The data furnished by trial borings on the site proved to be by no means reassuring. Under the bed of sand and clay at the bottom of the river, soil of varied character was encountered, becoming less and less stable as depth increased, until at last the material was simply mud. Consequently, it was necessary to modify the nature of the foundations provided for in the original designs. This presented no difficulty, the necessary modification being left in the hands of Signor Porcheddu, whose company was to be responsible for the perfect stability and safety of the completed work. In these circumstances M. Hennebique recommended the adoption of the "Compressol" system of foundations, a method which has already been fully described and illustrated in ENGINEERING. Over an area of about 5520 sq. ft., M. Hennebique proposed to compress the subsoil by means of seventy-two concrete piers formed by ramming deep holes by the aid of specially designed falling weights, and filling the holes with concrete thoroughly rammed in a similar manner. The piers being symmetrically distributed over the foundation area, and having enlarged bases, literally constitute immovable roots for the foundations of the bridge abutments. Fig. 2, Plate LVIII., published with this issue, shows the arrangement of the piers, and the weight used for ramming them.

After the piers had been constructed, the abutments were moulded upon them in the form of ferro-concrete caissons of several compartments, constituted by partition-walls longitudinally and transversely to the axis of the bridge. Figs. 2, 3, and 4 indicate the general form and disposition of the abutments. The longitudinal partitions act as counterforts, to which are connected monolithically the vault of the arch, and the spandrel walls which are continued up to the decking. This type of arch bridge has already been adopted very largely, notably for the Via Cigna Bridge in Turin, built in 1908, and the Saint-Claude Viaduct, France, with a clear span of 205 ft. over the River Bienne. In the case of the Risorgimento Bridge, the calculations of the different parts demonstrated the practicability of adopting relatively small thicknesses for the various members and structural elements, as may be seen by the drawings now reproduced. The two exterior spandrel walls are chamfered at the bottom, as shown in Figs. 3 and 4, so that, measured from the angle at the intersection of the chamfer with the spandrels, the rise is only 26 ft. 3 in., instead of 32.8 ft. There are seven spandrel-walls in the width of the bridge, all of them being 8 in. thick, but prolonged into the abutments with the thickness of 12 in. (see Fig. 4), and there constituting the longitudinal counterforts previously mentioned.

The grillage formed by the counterforts and transverse partitions is not supported upon a foundation-raft, as usual in ferro-concrete practice, but only the counterforts, at the points of intersection with the transverse divisions, are connected with the "Compressol" piers. Consequently, the earth filling in the interior of the abutment caissons, which is carried up to road-level, rests on the natural soil. The filling is well rammed, and intimately connected with the earth below by means of twenty-four additional "Compressol" piers in each abutment, some of these being represented in Fig. 12, page 722, which gives a half plan of the abutments and piers. Thus the complete abutment, comprising counterforts, transverse divisions, piers, and compressed soil, form an exceptionally solid structure, capable of enormous resistance to vertical and horizontal forces. Behind the front wall of the abutments a passage has been left, 16 in. wide, as shown in Fig. 2. This permits examination of the interior of the bridge, and at the same time reduces the load on the front of the abutments.

FIG. 1. THE RISORGIMENTO BRIDGE OVER THE TIBER.

The seven spandrel walls of the arch are stiffened at intervals by wind-bracing formed by transverse partitions, 4 in. thick, pierced by openings to facilitate inspection. In the middle part of the arch the seven longitudinal ribs are 8 in. thick, and they are provided with secondary ribs, 4 in. thick, longitudinal and transverse to the bridge axis, and connected by the decking and the arch wall at the top and bottom respectively. At the crown of the arch the total thickness is 2 ft. 9½ in., made up as follows:—

Decking	8 in. thick
Arch vault	8 ,,
Space between decking and arch ...	17½ ,,

Under the footwalks the total thickness at the crown of the arch is 3 ft. 9 in. The small thickness of the arch gives remarkable suppleness to the work, while at the same time the proportions are more than adequate for the necessary resistance, and the calculations would have permitted further reduction of dimensions had it not been requisite to provide spaces for the accommodation of conduits under the footwalks. While the decking at the crown is 8 in. thick, it is only 6 in. thick in

other parts, with 7-in. by 10-in. secondary beams carried by the longitudinal ribs.

Work was very much simplified by the adoption, for purposes of reinforcement, of only two sizes of steel bars, approximately of 0.2 and 0.6 sq. in. sectional area respectively. The vertical partitions and walls were reinforced by vertical and horizontal bars, the arch proper being reinforced by large-diameter bars longitudinally, and small bars transversely. The arrangement of the reinforcement is plainly shown in Figs. 5 to 11, on Plate LVIII., and Figs. 12 and 13, subjoined. Fig. 8 shows the reinforcement of the spandrel walls, and Figs. 5, 9, 10, and 11 similarly show the reinforcement for the wind bracing, &c., at various points indicated in Fig. 2. Figs. 6 and 7 show the juncture of cross-members with the longitudinals. Fig. 12 shows in plan the reinforcement of the abutments and counterforts, and Fig. 13 gives a section at the line M N (Fig. 12).

The paving consists of small blocks of cement and asphalt moulded under heavy pressure, this form of block being a speciality of the Società Porcheddu. The decoration is shown by our view of the completed structure (Fig. 1), the surface finish of the concrete being very fine, so that in the abutments, parapets, and mouldings generally it can hardly be distinguished from cut stone. The roadway, with two lines of tramway track, has a gradient of about 1 in 55, and to facilitate traffic the roadway has been made 87 ft. wide at the approaches. All calculations for the resistance and stability of the work were made in accordance with the Hennebique method.

In order to protect the foundations against erosion on the left bank of the river, where the soil is of friable character, a curtain of ferro-concrete sheet piles 14 in. square has been formed along the face of the abutment, as represented in Fig. 2. These piles were moulded with a central hole to enable them to be sunk by water-jet, the subsoil being particularly suitable for this method. For the operation of sinking, pumping plant was installed, filling a reservoir placed 50 ft. above water-level. By the aid of large-diameter pipes, each with control valve, fixed at the head of the piles, water was forced to descend to the bottom of the latter with sufficient pressure to displace gravel and sand, thereby enabling the piles to sink gently and steadily. In this manner 130 sheet piles were sunk, forming a protecting curtain 10 ft. in front of the abutment, and 165 ft. long.

The level of the Tiber is very variable, and, as is well known, floods assume a serious character in spring time, while they are almost equally troublesome in autumn. Every year the water level rises rapidly to from 18 ft. to 24 ft. above the normal mark. Consequently it was most necessary for the contractors to make provision against damage to the works by water. With this object, Signor Porcheddu devised an original and novel form of staging in ferro-concrete, instead of employing timber, as customary, for support of the centering. As illustrated in Figs. 14 and 15, page 736, the staging comprises ten spans, each founded on sixteen ferro-concrete piles, driven by a steam pile-driver mounted on a barge. The pile-heads were connected by sills carrying bases for ferro-concrete columns, braced horizontally, the whole forming a very light and strong type of pier. A navigation opening 49 ft. 3 in. wide was left in the middle of the river. The main girders of the centering above the piers were of the bowstring type, conforming to the profile of the permanent arch, and very light relatively to their span. The other spans were provided with tie-beams, facilitating the construction of a light and economical form of scaffolding. Upon the ferro-concrete falseworks were erected the moulds and centering necessary for execution of the ferro-concrete permanent arch, all the timbering having been carefully levelled and aligned by means of wedges.

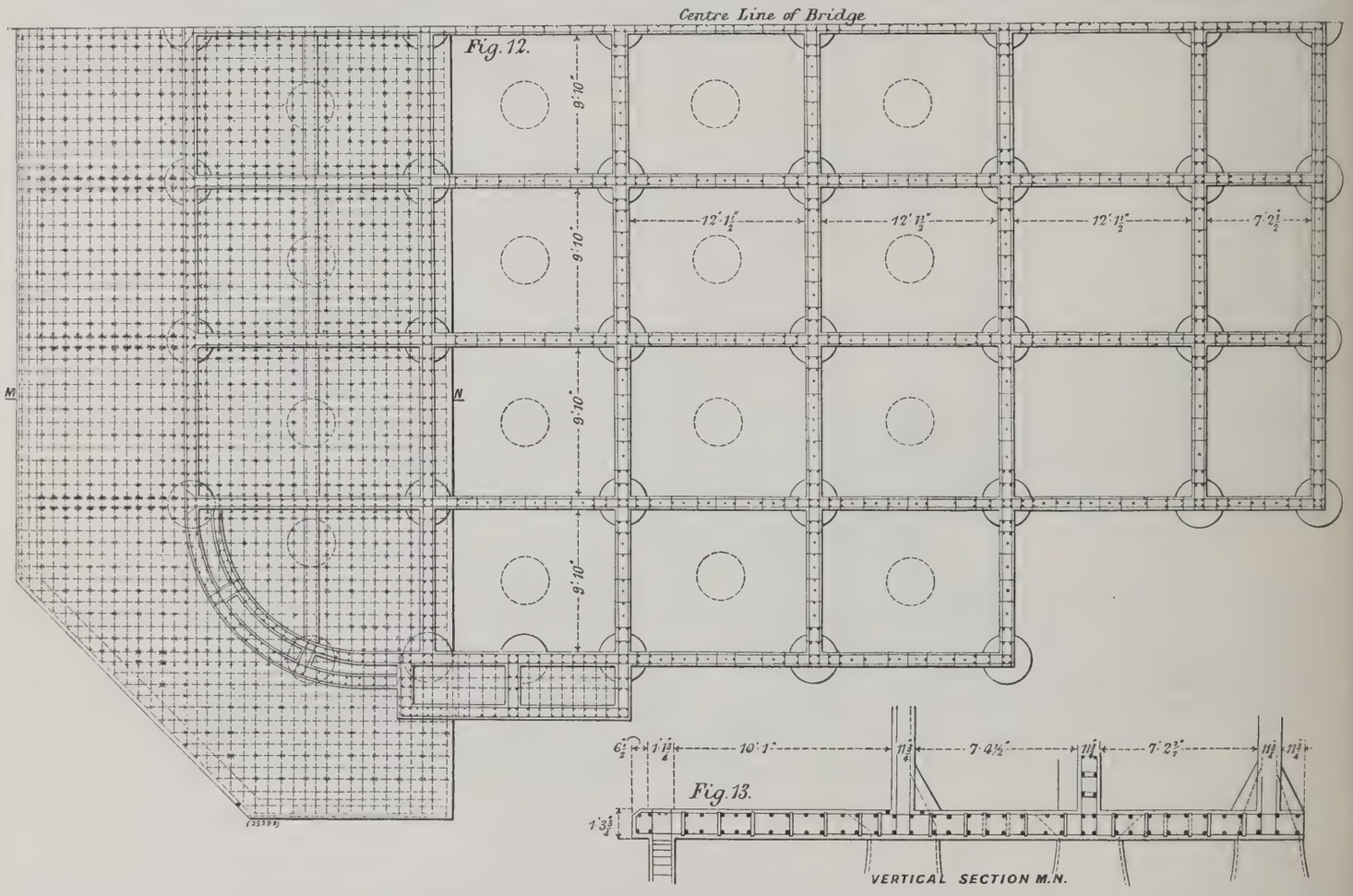
This type of staging obviated the employment of carpenters skilled in the erection of falseworks, and made it possible for the concrete workers to erect their own timbering as the work progressed. Thus there was a considerable saving in cost, while the time saved enabled the contractors to complete their work within the period specified. The solidity of the staging was practically demonstrated during the execution of the works by an accident which would have caused a serious disaster if the staging had been of the ordinary kind. On December 29, 1910, when the river was in flood, a steamship of the Società Navigazione Fluviale, descending the river, ran violently into one of the ferro-concrete staging piers, owing to the sudden breakage of a rudder-chain. So violent was the shock that three of the foundation piles were cut away and the bow of the vessel was seriously damaged. As half of the arch vault had been moulded only a few days before, the mishap might have had most serious results. But the staging was not disturbed as a whole, although part of it was thus unexpectedly converted into a cantilever with the projection of 10 ft. beyond the uninjured piles, which were thereby suddenly called upon to perform a double duty. This accident demonstrates once more the great strength of monolithic ferro-concrete structures.

For the vertical surfaces two kinds of shuttering were employed, designed to give satisfactory results both structurally and economically. In laying the centering for the deck-slab, a method was adopted which facilitated the rapid execution of work and diminished the number of props required. All the 7-in. by 10-in. secondary beams were moulded in advance, and fixed in place when the spandrels had reached the level where the beams had to be inserted. These beams were proportioned so as to be capable of carrying the timbering for the decking without other support. All concrete was mixed wet enough to flow readily into the moulds, and was prepared in the proportions of 5 cwt. of Portland cement per cubic yard of gravel and sand.

A view showing the counterforts during construction is given in Fig. 16, on page 736, while Fig. 17, on the same page, is a view showing an early stage of the construction of the arch.

The following is a brief account of the order in which the works were executed :—

The foundation and pile works, commenced in January, 1910, were finished in the succeeding August. The ferro-concrete staging was completed at the end of August, 1910, and the timbering and moulds for concrete were completed at the end of September in the same year. The abutments were commenced on July 27, 1910, and the arch on October 9, 1910. Work continued thenceforward regularly until February 27, 1911, when the decking, including that for the footwalks, was completed. At that date there remained nothing for execution but decora-



THE RISORGIMENTO FERRO-CONCRETE BRIDGE

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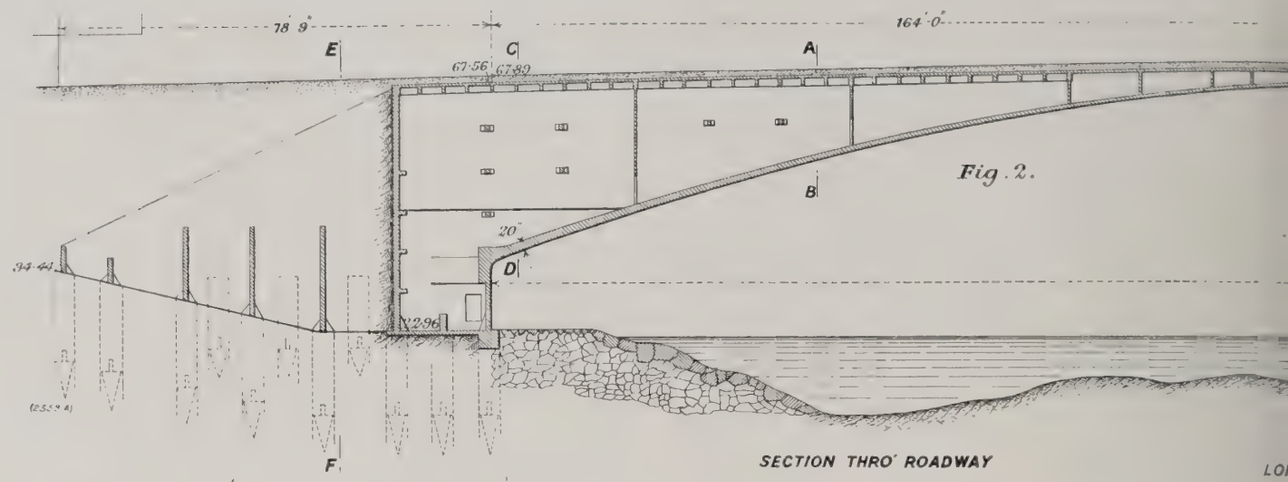
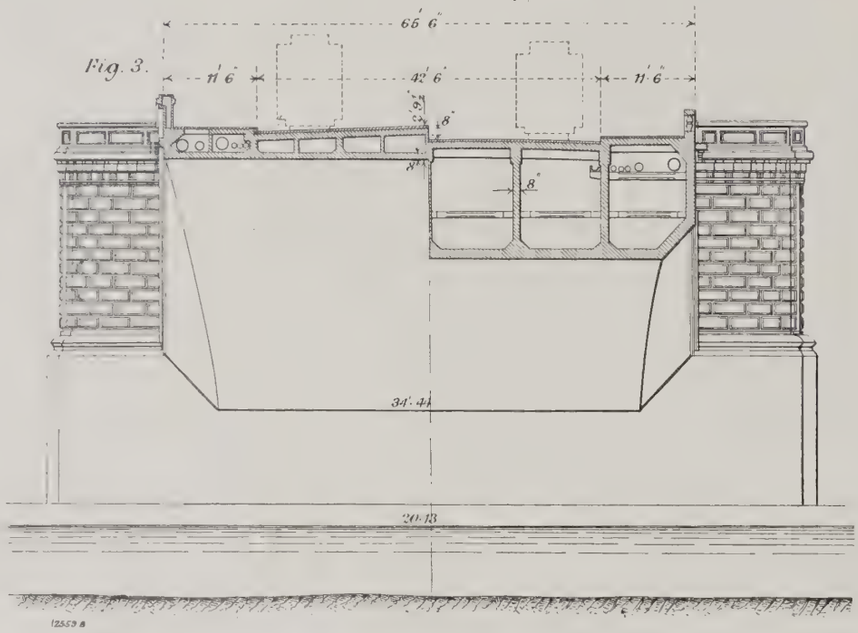


Fig. 2.

SECTION THRO' ROADWAY

LO

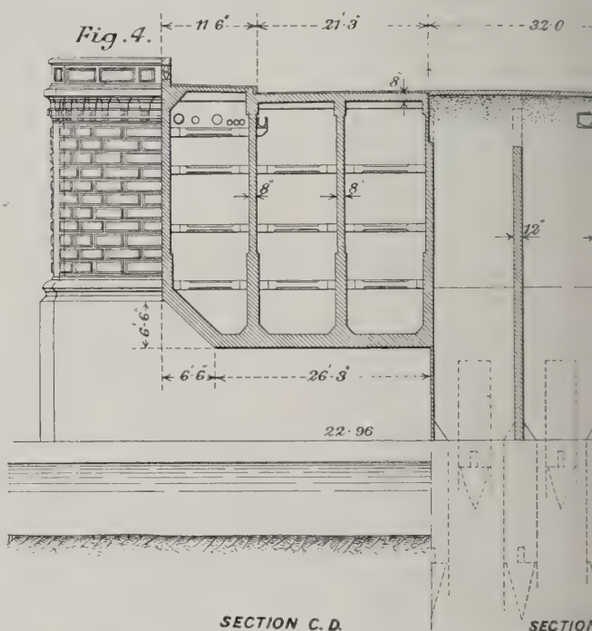
Fig. 3.



SECTION AT CROWN.

SECTION A.B.

Fig. 4.



SECTION C.D.

SECTION

Fig. 8.

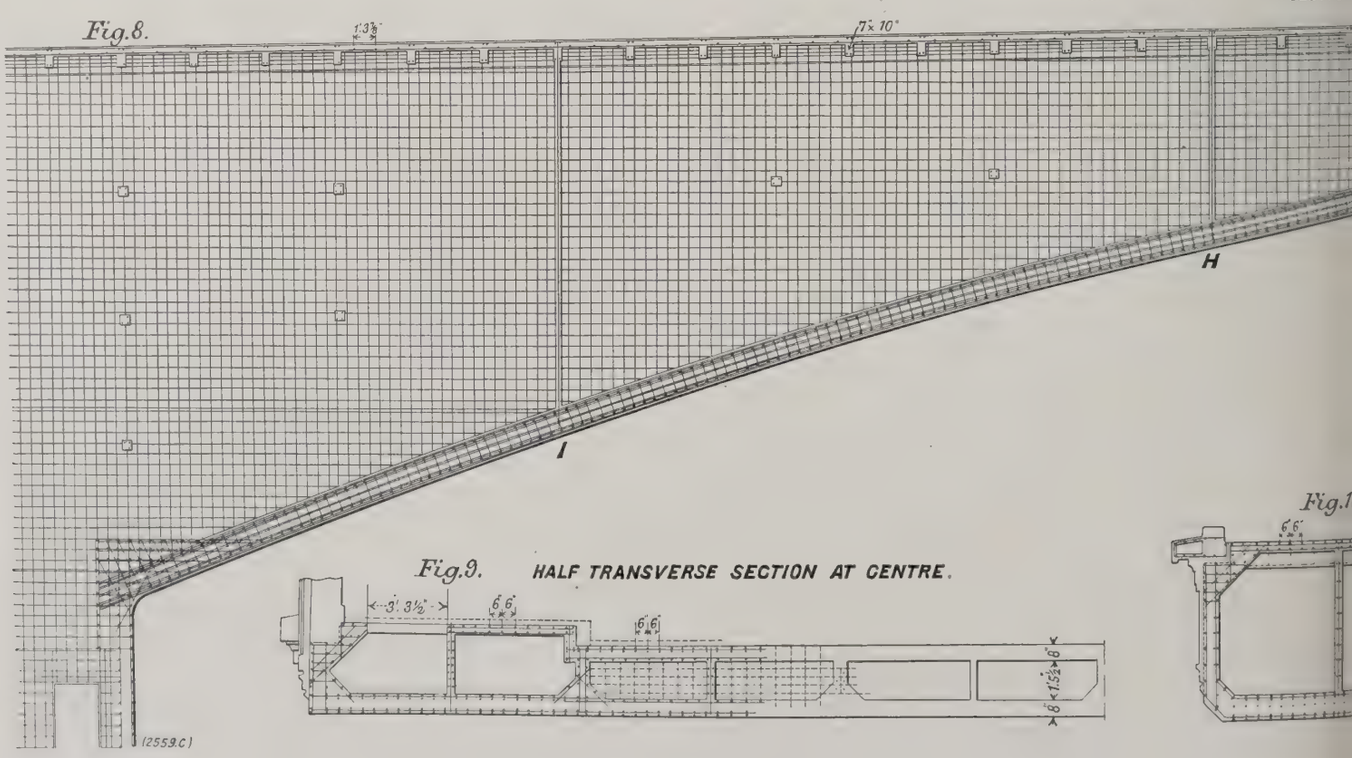
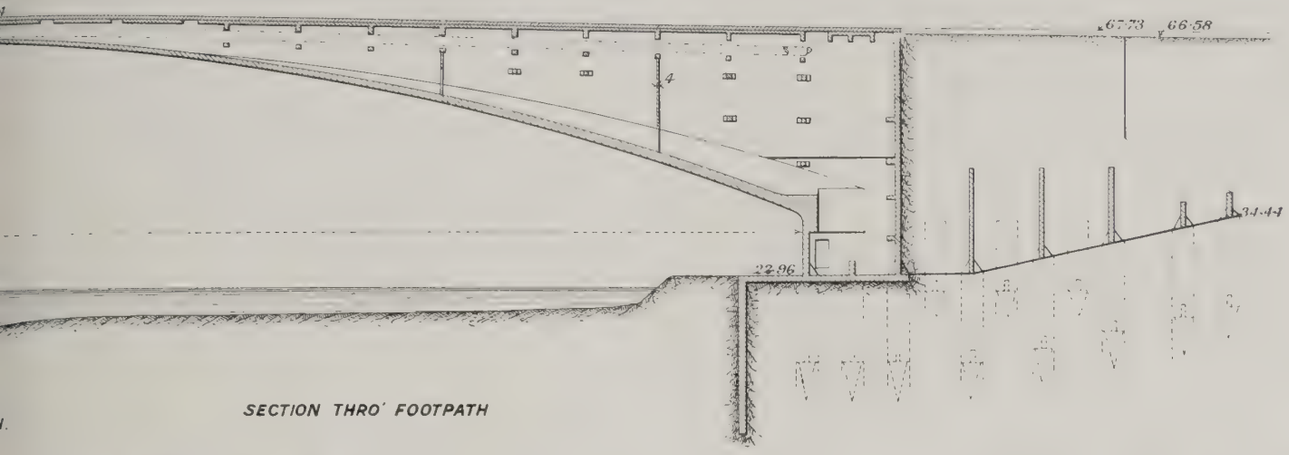


Fig. 9. HALF TRANSVERSE SECTION AT CENTRE.

Fig.1

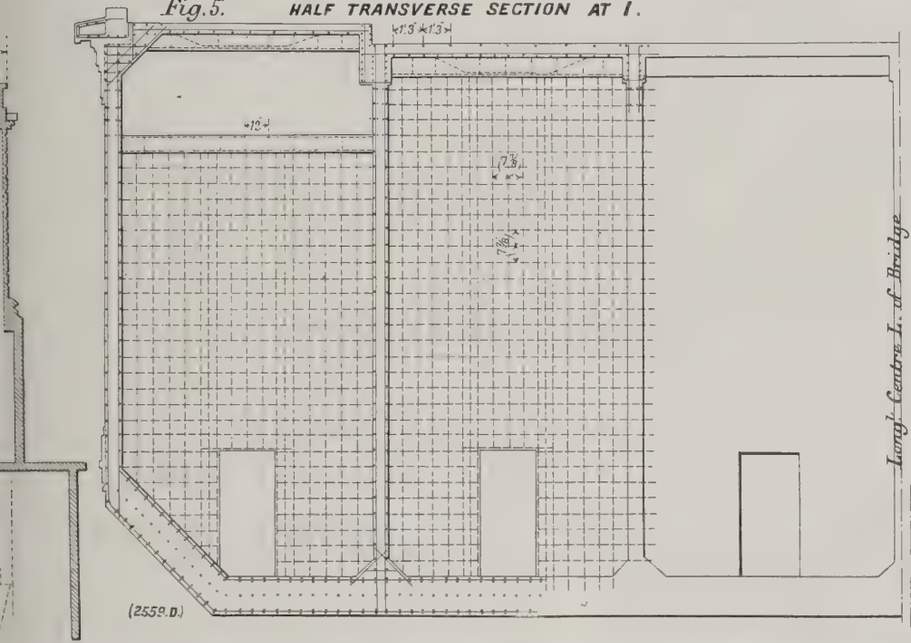
BIQUE SYSTEM), ROME, OVER THE RIVER TIBER.

ge 721.)



SECTION THRO' FOOTPATH

Fig.5. HALF TRANSVERSE SECTION AT *I*.



DETAILS OF BARS IN ARCH. LONGITUDINAL SECTION.

Fig.6.

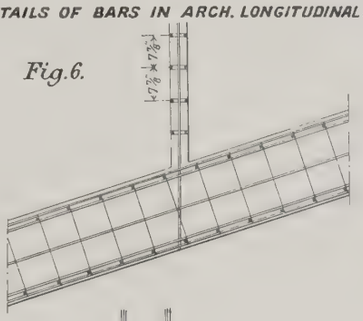
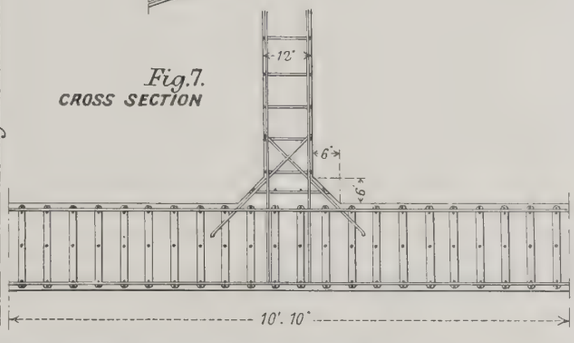
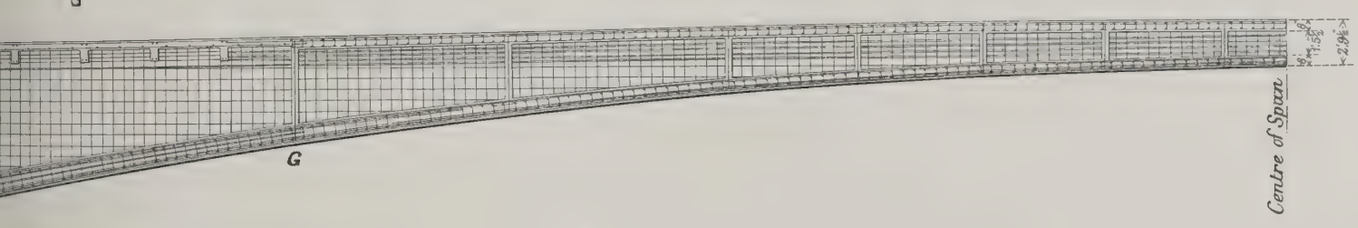


Fig.7.
CROSS SECTION





ERSE SECTION AT *G*.

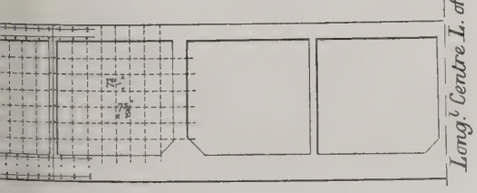
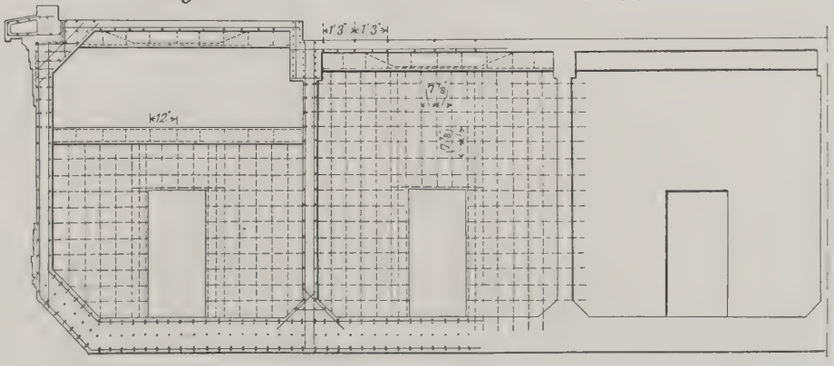


Fig.11. HALF TRANSVERSE SECTION AT *H*.



tive work, the paving of the roadway and footwalks, and the erection of the parapets. It was intended that the bridge should be completed before April 21, 1911, for the opening of the Ethnographic Section of the International Exhibition. From the early days of that month the contractors commenced to strike the centering, and completed the operation by the 11th of the month, when a steam roller of 19 tons passed over the bridge. A few days later, a very large tree trunk had to be taken across to the Exhibition, and advantage was taken of this to make a preliminary test of the bridge. A procession consisting of seven steam rollers moved across it, followed by the tree trunk on a special wagon drawn by sixteen horses. The maximum deflection at the crown of the arch under the rolling load of 150 tons, constituted as above, was only 3.5 mm. (less than $\frac{9}{64}$ in.). After this conclusive test, the contractors notified the authorities that the bridge was ready for the opening of the Exhibition on April 21, 1911, the view, Fig. 1, page 721, having been taken on that day.

The official tests conducted before the work was taken over from the contractors were held on May 8, 9, 10, and 11, under the supervision of a special Commission, consisting of Commander Engineer Ceradini, Director of the School of Engineers, Rome; Cavalier Guidi, Professor of the Course of Construction of the Polytechnic School, Turin; and Commander Engineer Rinaldi, Assistant-Director of the Italian State Railways. The specification clause relative to the tests is to the following effect :—"The tests shall be made according to the requirements of the Commission, and shall comprise static and dynamic tests, the former including the imposition of uniformly distributed loading on the bridge equal to 500 kg. per sq. m. (about 1 cwt. per sq. ft.), first over half of the bridge and afterwards over the whole length and width of the bridge. During the second of these tests three 15-ton steam-rollers shall be driven across the bridge simultaneously in both directions, while the footwalks remain under the load of 500 kg. per square metre. The maximum deflection permissible under the different loads shall be not more than $\frac{1}{1500}$th of the span of the bridge (67 mm.), and the permanent deformation shall be less than that allowed 'by the Ministerial Regulations.'"

On Monday, May 6, the roadway was levelled, and deflectometers of the Richard type were placed in position, three under the crown of the arch, one beneath the centre line of the roadway, and one under each footwalk, and two others under the centre line of the roadway, and at the distance of 75 ft. on either side of the arch crown. At 2.45 P.M., the same day, the work of loading was started between the crown and the left-hand abutment, the material employed being sand in a layer 3 in. thick, and gravel in a layer 10 in. thick. Owing to persistent rain during the operation, the sand and gravel were saturated with water, so that the actual static load was equal to 620 kg. per square metre. The loading was completed on the following morning at 11.30 A.M., when the deflectometers gave the undermentioned readings :—

	Deflection. Mm.
Crown of arch (mean of three instruments)	13.1
Right-hand haunch	1.00
Left-hand haunch	13.7

At 11.45 A.M. a theodolite of high precision was employed for the examination of a vertical line traced before commencement of the tests upon the left-hand spandrel, with the result that no variation could be detected in the direction of the line.

Next commenced the loading of the other half of the bridge between the crown and the right-hand abutment, an operation finished on Wednesday, May 10, at 6 A.M., the total load on the structure being 1240 metric tons. At 11.15 the same morning the deflectometers gave the following readings :—

	Deflection. Mm.
Crown of arch (mean of three instruments)	32.2
Right-hand haunch	16.2
Left-hand haunch	19.1

Then all the loading was removed from the roadway—a task completed by 6.30 A.M. on Thursday, May 11. Deflectometers of the Rabut type, as used in testing the cantilever extension of the Rue de Rome, outside the St. Lazare Station, Paris, and employed largely on the French State Railways, were placed one under the middle of the crown, and another under the axis of the left-hand haunch at 76 ft. from the crown. Six deflectometers of the Grist type were placed against the intrados of the arch under the footwalk curbs—two instruments at the crown, and the other four at 76 ft. on either side of the crown.

At 8.15 A.M. on the same day the dynamic tests were commenced with the aid of three steam-rollers —one of 13 tons, one of 16 tons, and one of 17 tons. These rollers were driven abreast four times across the bridge from one abutment to the other. After the first trip of the rolling load from the left to the right abutment, the deflectometer readings were :—

	Deflection. Mm.
Crown (mean of two instruments)	1.95
Right-hand haunch	0.65
Left-hand haunch	0.80

For the four trips of the rollers the Rabut instrument gave consistent diagrams, demonstrating the perfect elasticity of the construction, and showing clearly the absence of permanent deformation. The maximum deflections registered were as follow :—

	Deflection. Mm.
Crown	2.0
Haunches	0.9

Afterwards the unloading of the footwalks was undertaken and completed at 11.30 the next morning. At 3.10 P.M. the same day the readings were :—

	Deflection. Mm.
Crown (mean of three instruments)	16.7
Right-hand haunch	9.9
Left-hand haunch	7.6

At 7 P.M. on the same day the readings on the instruments were :—

	Deflection. Mm.
Crown (mean of three instruments)	16.0
Right-hand haunch	9.5
Left-hand haunch	7.4

The foregoing records are taken from the official *proces-verbal*, signed on behalf of the Commission by Professor Ceradini, Commander Engineer Rinaldi, and Professor Cavalier Guidi.

Briefly summed up, the tests demonstrated that, instead of being equal to $\frac{1}{500}$th of the span, or 67 mm., under the static load of 500 kg. per sq. m., the deflection was actually only equal to 1/3125 of the span, or 32 mm. under the static load of 620 kg. per sq. m. In other words, the maximum deflection was less than half the amount permitted by the terms of the specification, although the load had been increased by 25 per cent.

Vibration tests were conducted on July 14, 1911, with the double object of demonstrating the behaviour of the bridge under the influence of vibratory and temperature stresses. A regiment of 1100 men were caused to march across the bridge, changing step from "quick march" to "the double" during each passage of the bridge, the tests being conducted at times when the temperature presents the widest differences, one period being from 4 A.M. to 7 A.M., and the other from 4 P.M. to 7 P.M. They were conducted under the direction of Signors Ceradini, Guidi, and Rinaldi. Instruments for recording vibration were disposed at the crown and haunches as for the previous tests.

Companies of soldiers were marched across, the pace being increased until the maximum vibrations were obtained. With 1100 men marching at "quick step" the maximum deflection registered was 2 mm., and for the same number crossing the bridge at "the double" the maximum deflection was 2.5 mm. These figures are so striking that no comment is necessary.

It may be remarked, however, that in consequence of the resonance established throughout a structure of this class under the action of rhythmic shocks, the amplitude of the depressions and elevations constituting the phenomenon of vibration increase until the resistance opposed by the material to molecular deformation occasioned by flexure absorb the forces produced by each new shock. Hence to each augmentation of shock intensity corresponds a greater amplitude of vibration. Moreover, the vibratory displacements are materially affected by the nature of the design and construction, and it will be seen from the drawings reproduced as illustrations to this article that the elements of the Risorgimento Bridge are disposed so as to diminish the masses susceptible to resonance, and also to conduce to rapid dissipation of vibratory movements. In this respect the resistance of the work was shown by the tests to be as satistactory as its rigidity under static loading.

In conclusion, we may record the fact that His Majesty the King of Italy, who throughout evinced a great interest in the construction of this bridge, created Signor Porcheddu a Knight Commander of the Order of the Cross of Italy, an honour which is rarely accorded in such connections.

FOUNDRY PLANT AND MACHINERY.
No. XXXV.

By JOSEPH HORNER.

FIGS. 565 and 566, on page 724, illustrate a rather special design of heavy machine, using a non-turnover table. The pressing is done by the main central ram. Pressure is transmitted to the table through a heavy crosshead A working in guides, and the mass is counterbalanced by two weights B, B suspended from ropes which pass over pulleys to the crosshead. The extraction of the pattern is accomplished by turning the lever C from left to right, which, working on a cam attached to the crosshead A, operates the four lifting-pins a, a, a, a. The operation of extraction is assisted by the counterweights B, B, attached to the crosshead, so that with the largest machine no undue exertion is necessary to draw the pattern. The presser-head has horizontal movement by means of trolley-wheels. This machine is an example from the practice of the London Emery Works Company, of Tottenham, London, N.

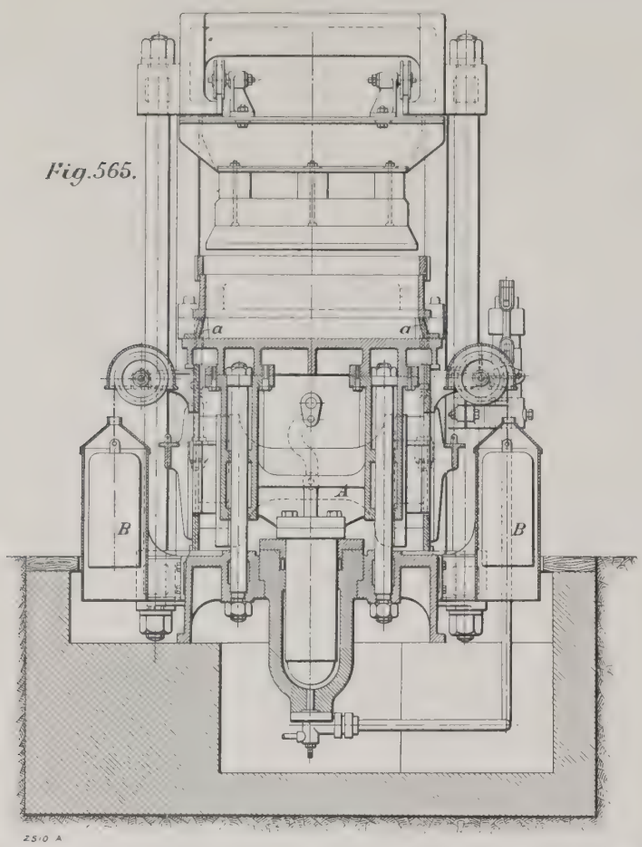
As the non-turnover table machines constitute so large a proportion in all dimensions, in the smallest, largest, and medium sizes alike, the methods of moulding adopted on them are often different from those which are available on machines with turn-over tables, as follow :—Two courses are open in the case of patterns which are jointed, leaving one half or portion in the bottom, and the other in the top. In one case two separate machines are used, one ramming bottoms, the other tops; or a certain number of tops are rammed, and then the plates are changed, and an equal number of bottoms are then done. The other way is to arrange both tops and bottoms on one board or plate exactly to right and left of a centre line, and ram top and bottom at once thus (or separate plates can be used, one carrying tops, the other bottoms). The pattern parts must be mounted absolutely accurate, otherwise the halves of the moulds will not match exactly. Many machines are built of extra length for this purpose.

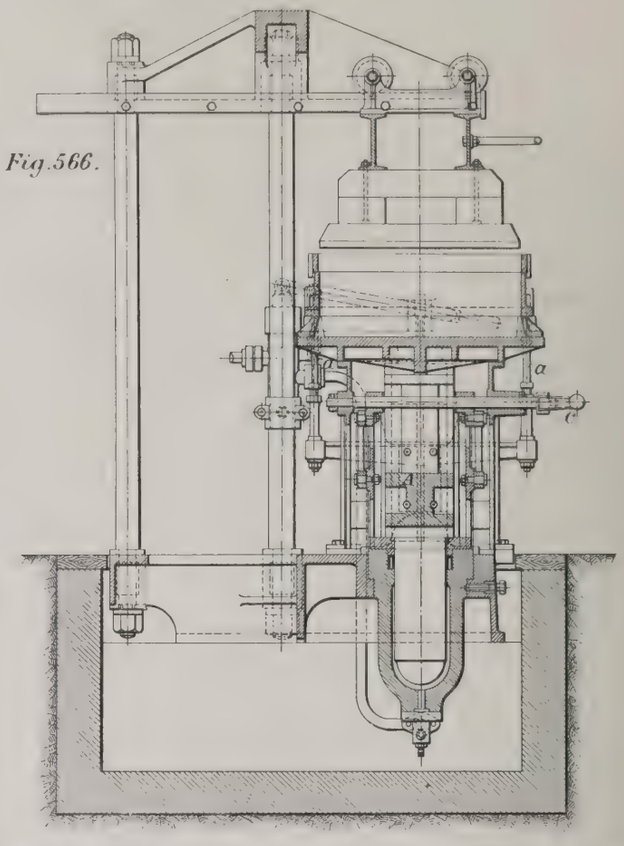
When patterns are mounted on odd sides, in which the patterns are fitted in recesses in a plate, these are moulded by pressing top and bottom simultaneously. When they are plated—*i.e.*, fitted on both sides of a plate—one side—the drag—is pressed first, and the box is turned over and the top put on, filled and pressed.

An example of an hydraulic machine for deep work, drawn through a stripping-plate, and with non-turnover table, is shown by Fig. 567. It is by the Maschinenfabrik Gritzner A.-G., of Durlach, Baden. Being deep, the machine is partly sunk into a pit, and its base A rests on a concrete foundation. The base receives two pillars B, B, on which slides the table C, to which the stripping-plate D is attached, through the supporting stools E, E. On the stripping-plate the moulding-box F lies, surmounted by its sand-frame. G is the presser-head, of wood, attached to a cylindrical body above. The height of the head is capable of adjustment for patterns of different depths, and it is locked by the lever H. The pressing apparatus is connected by cords that pass over pulleys above at J to a frame K below, which embraces the cylinder of the ram, and fits over ribs on the outside of the cylinder. When the ram moves upwards to bring the patterns to the proper height for ramming, the mass is counterweighted by the weight of the presser-head. The table slides up on the stools E, E. Then the pressure is put on, compressing the sand of the mould. The sand-frame is removed, and the sand in the box strickled. The pressure being released and the lever H unlocked, the table C descends by gravity, bringing the patterns away from the mould through the stripping-plate. The presser-head G ascends, leaving the mould on the stripping-plate. The lever H is then thrown in again, and the box with its contained mould removed.

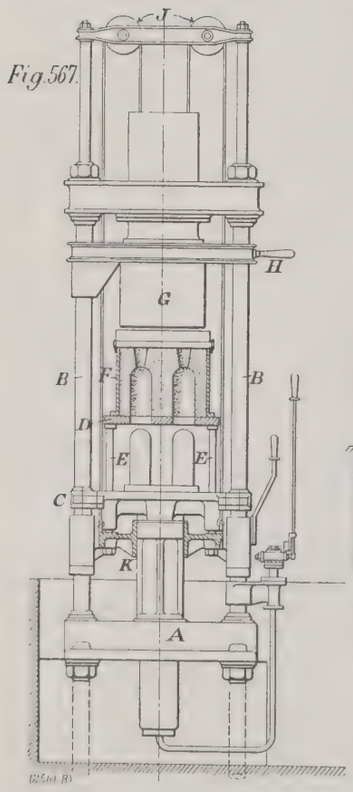
A good many hydraulic machines are made to ram top and bottom boxes simultaneously. In one of these, shown by Fig. 568, the movements of

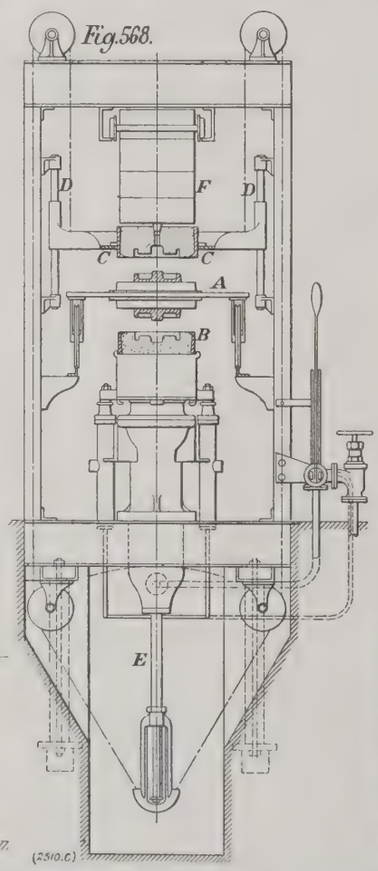
FOUNDRY PLANT AND MACHINERY.

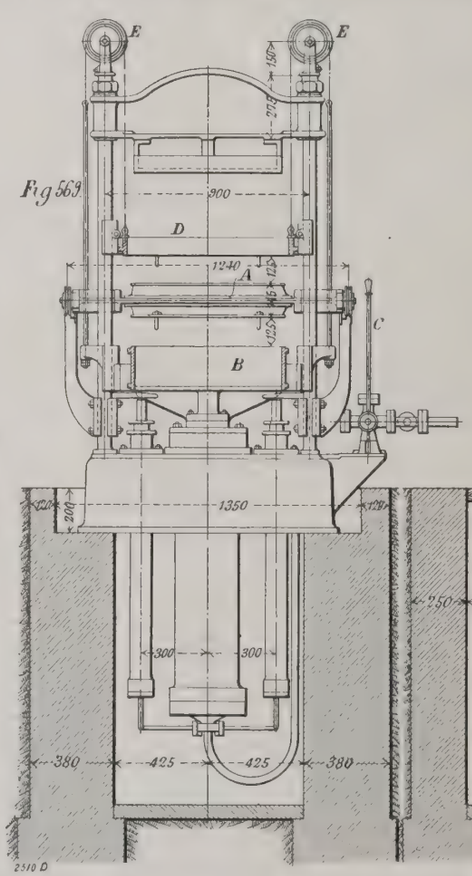




Figs. 565 and 566. Heavy Machine with Non-Turnover Table; The London Emery Works Company, Tottenham, London, N.







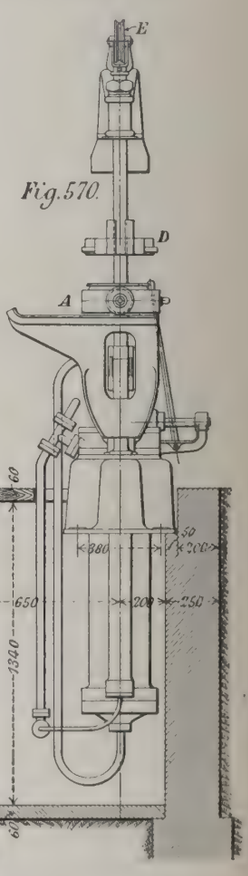
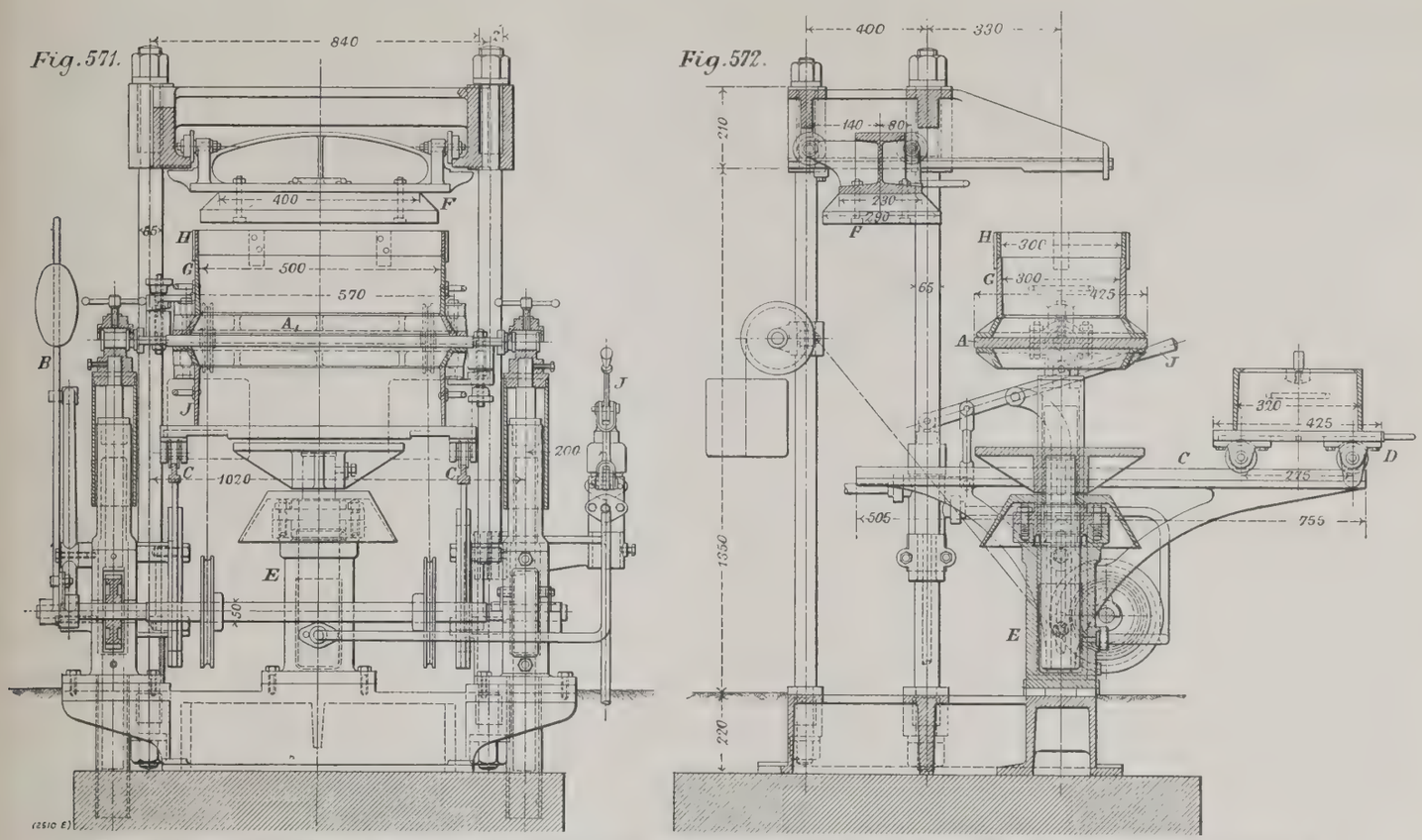


Fig. 567. Machine for Moulding Deep Articles; The Maschinenfabrik Gritzner A.-G., Durlach. Fig. 568. Machine in which Top and Bottom Flasks are Pressed Simultaneously; Bopp and Reuther, Mannheim. Figs. 569 and 570. Machine for Flaskless Moulds; The Badische Maschinenfabrik und Eisengiesserei, Durlach.

the boxes occur in unison, the operating mechanisms being connected by cords passing over pulleys. The table A is of the non-turnover type, and is carried on a trolley at a fixed height. The bottom box B is supported directly on the hydraulic ram. The top box C is carried on a frame which slides vertically on the pillars D, D. The cords which pass over the pulleys connect this frame with the movement of the ram through a stem E below, which is a prolongation of the ram. The upward motion of the ram thus causes the lower box B to rise, and the upper box C to descend. The descent

FOUNDRY PLANT AND MACHINERY.



FIGS. 571 AND 572. MACHINE FOR MOULDING DEEP PATTERNS; THE LONDON EMERY WORKS COMPANY, TOTTENHAM, LONDON, N.

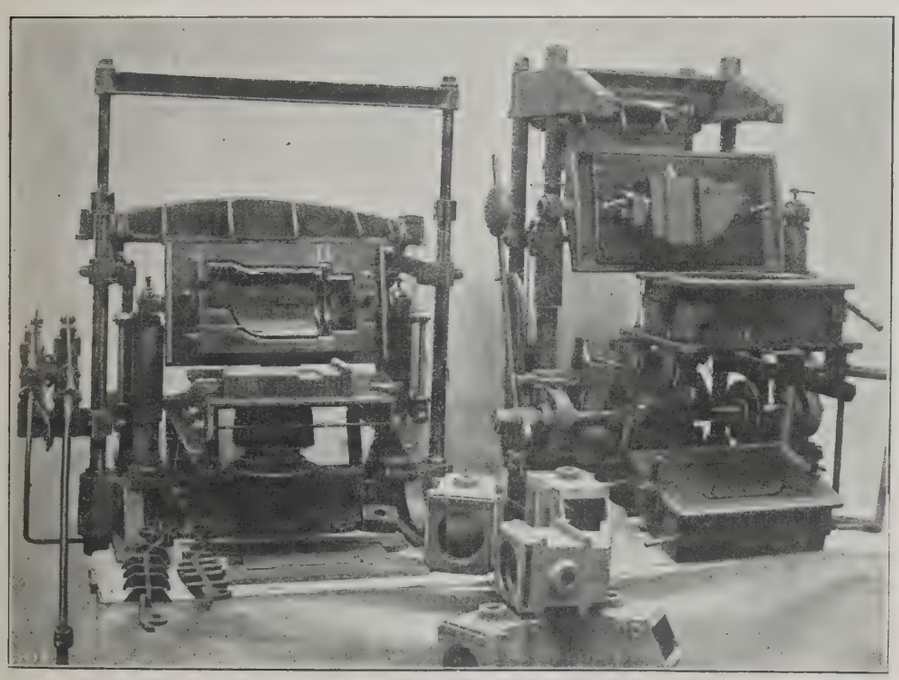


FIG. 573. MACHINE FOR MOULDING AXLE-BOXES.

of the ram moves the boxes away from each other. At the first the upward movement of the ram lifts the lower box B into contact with the lower side of the pattern-plate A. The top box C is then filled with sand, and the presser-head F brought along on its trolley-wheels over the mould, and the pressure put on, compressing the sand in both boxes. On the release of the pressure the ram descends, and both boxes deliver from the pattern-plate. The latter is then ran away, and the ram is again brought up to close the boxes, which are then taken away for pouring. This machine is manufactured by Messrs. Bopp and Reuther, of Mannheim.

An hydraulic machine for making moulds without flasks is illustrated in Figs. 569 and 570. Several types of these machines are built, and the design is many years old, having been introduced before the snap-flask methods were introduced. It is suitable for the same class of work as the snap-flasks—that which does not exceed from 16 in. to 20 in. square. In rapid repetitive work the saving in flasks is very great. Any type of pattern-plate can be used, with pattern parts mounted on opposite sides. It does not turn over for moulding, though it can be swung over for cleaning, but the mould parts are made in frames above and below.

In moulding, the pattern-plate A is first ran along out of the way, and the lower moulding-frame B filled with sand and the pattern-plate ran back. By the movement of the lever C the upper moulding-frame D is lowered and also filled with sand. The hydraulic pressure is then applied, forcing the moulding-frames with the pattern-plate between them against the presser-head, squeezing the sand. Then the pressure is taken off, leaving the frames free to rise and fall away from the pattern-plate. As the two frames are connected by the chains which pass over the pulleys E, E, they counterbalance each other without the employment of counterweights. The pattern-frame is now run out, and the top frame is lowered until its mould rests upon that in the bottom frame. The two mould parts are then thrust out of the frames upwards by slight hydraulic pressure, and removed from the top of the upper frame ready for casting. The Badische Maschinenfabrik und Eisengiesserei, of Durlach, build this machine.

Figs. 571 and 572 illustrate a machine by the London Emery Works Company, of Tottenham, N., which is built especially to take high patterns, though it is also adaptable for shallow ones. Two standards are carried on a base-plate. The standards enclose racks actuated by pinions, through which the pattern-table A is raised and lowered by means of the lever B. Two adjustable rail-brackets are bolted to the standards to carry the trolley D on rails Q. E is the hydraulic ram, located between the standards, and F is the movable rammer-head, the tracks for which are supported by four columns at the rear of the machine—a position which leaves the machine free for the manipulation of moulding-boxes.

In operation, both box parts are put on the pattern-plate, the bottom part G being uppermost, surmounted by a sand-frame H. The facing being thrown in next the pattern, the remainder of the box and frame is filled with floor sand. The presser-head is then ran along over the box, and the valve J opened, putting on the pressure and squeezing the sand. The valve is then closed, the presser-head ran back, the frame removed, and the excess of sand strickled off level with the edge of the box. The pattern-plate is then turned over, and the top box part treated in the same way as the bottom one. Then the bottom box is released from its fastenings, the plate rapped, and

the pattern lifted out of the box upwards by pulling the lever B. Twenty-eight sizes of this machine are made. The photograph, reproduced in Fig. 573, shows the machine operating on axle boxes, which come under the head of deep work, while Fig. 574, page 728, shows it in use on gears, work of average depth requiring a stripping-plate. Fig. 575 shows a stripping-plate and pattern-plates.

In several of the German designs the pressing apparatus is situated centrally on a track along which two carriages run, operated by two men, forming a duplex machine. One of these, by the Badische Maschinenfabrik und Eisengiesserei, of Durlach, is shown in Figs. 576 and 577, page 728. The pattern-tables are of the non-turnover type, delivery taking place in a downward direction, so that these machines are better adapted for shallow than for deep work. Being duplex, the pattern halves for cope and drag are located on separate travelling tables on the tracks, on each side of the central presser-head, under which the flasks are, when filled with sand, brought one after the other. The intention is that two workmen can be engaged on one machine, using one presser-head and one ram alternately. Each box part A and B is dealt with on its own pattern-plate, each on its separate carriage. These are seen in Fig. 577, each surmounted by its own sand-frame. They are brought along on the track to the presser-head C, the height of which is adjustable. The pattern-plate with its flask is raised by the central ram D and squeezed; when the pressure is released, the flask is held by two side-rails a, a, while the pattern-plate descends and delivers its pattern. The flask is then removed, for which purpose a swing crane is provided in the heavier machines (see Fig. 576), operated by the waste water used for compression.

This general design is amplified in various ways. The principal variation is in making the presser-head to travel to right and left instead of the pattern-plates and moulding-boxes. The latter then are each located over a separate pressing-ram. In another design with a travelling presser-head, the tables are made of double the usual length, the "length" being that taken transversely to the travelling movement of the presser-head. The advantage is that each oblong table will take two square flasks adjacent or one long one. When two are being used, the top and bottom of a mould can be pressed on each table, so that two men can be handling four box parts simultaneously. Each long table is operated by one central ram.

RECENT RESEARCH WORK ON THE PROPERTIES OF STEAM.

By C. A. M. Smith, M.Sc., and A. G. Warren, B.Sc. (East London College, University of London).

It sometimes happens that work which is done by the physicist or mathematician is published in such a manner that it is not easily accessible to the engineer. Further, there is such a vast amount of research work now being carried out in physical and chemical laboratories that the practical man may be pardoned for failing to keep closely in touch with all that is done in scientific circles. Thus it comes about that research, which is of interest to the man of applied science, and is often of consequence in engineering design, remains buried among the mass of other papers which appeal to the readers of transactions of scientific societies. Such a case was that of the contribution, by Mr. J. J. Guest, concerning the elastic breakdown of mild steel. This was published (in the Proceedings of the Physical Society) some ten years before it was discussed by engineers in the technical periodicals.

During the last decade physicists have given attention to certain problems connected with the properties of steam. Of practical importance is the result that engineers may now calculate and obtain accurate values of total heats and specific heats of saturated and superheated steam. Every confidence may be placed on the numerical results obtained by the aid of the research of the physicist and mathematician. The matter has been approached in a thoroughly scientific manner.

The authors propose to trace out the development of this new work on thermodynamics. In order to illustrate the contrast between the old and the new values, they will compare numbers taken from the well-known steam-tables of Peabody with those which they have themselves obtained by numerical substitution in formulæ developed from the equations provided by Professor H. L. Callendar in his paper read before the Royal Society in 1900. In order to arrive at these numerical results it has been necessary to make some thousands of calculations, which space renders impossible to set forth, and which would, indeed, probably be considered irksome by the reader. It is, however, hoped at some later date to fully publish in some fashion the mathematical work, which will enable engineers to follow closely the reasoning of Professor Callendar. Some of it is given later in this article, and doubtless many readers will be able to bridge over any gaps which appear by the aid of Professor Perry's "Calculus for Engineers," or some similar work.

The Old and the New Methods.—The story of the old and the new steam-tables is one that is well worthy of notice, for it illustrates in a striking fashion the difference between the research work of to-day and that of half-a-century ago. In the past various industrious individuals, including engineers so well known as Peabody, Thurston, and Macfarlane Gray, have compiled certain tables which give numerical values for latent, sensible and total heats of steam, entropies, &c. All of these men have worked from the fundamental assumption that a number of purely empirical formulæ, based entirely upon experimental data, formed a sufficiently accurate basis for their calculations. At that time no other method of procedure had been pointed out; formulæ were then built up entirely from the results of experiment, and there appeared to be no means of checking the accuracy of the latter, except, of course, by taking many observations.

The difficulty of determining exact values by experiment was greater in the days when these formulæ were built up than is now the case. One of the most critical measurements was that of temperature, and most engineers are aware of the advances which have been made in the last few years in the science of pyrometry. Many of the improvements have been entirely due to the brilliant work of Callendar in that field of research. During the last few years the platinum thermometer has been applied, with notable results, to various engineering experiments. In the days when Regnault did his classical work, which formed the basis upon which the compilers of the old steam-tables built, the methods of temperature measurement were less accurate. Indeed, it is remarkable, when we remember the disadvantages under which the exponents of the science of thermodynamics worked in those days of fifty years ago, that their results should approximate as closely as is the case to the latest figures obtainable. It speaks well for the extreme care and patience of the experimenters.

The Fundamental Relations.—The way in which Callendar approached the subject was entirely different to the method of Regnault. The latter fixed his attention upon experimental measurements only, and built up the formulæ upon those results. Callendar first attempted to establish, by the aid of the science of thermodynamics (and a full knowledge of advanced mathematics) definite relations between the various quantities. In this attempt he succeeded. He showed certain fundamental relations which exist between the various quantities. He took hold of existing evidence, and he argued with the skill of the natural philosopher that if this or that well-known phenomenon actually existed, then either A must be equal to B, or A must equal C. But he could prove that it was quite impossible for A to equal C, because of the existence of another well-known phenomenon. Whence it was clear that A must be equal to B. And so he established the fundamental relations of which we shall speak later. These were unrecognised by the earlier investigators. They had no check upon their experiments, and thus any errors which were due to their apparatus or observation were introduced, and the tables contained certain inconsistencies.

The great advantage of Callendar's method is that, provided the reasoning, the mathematics, and the calculations of the people who use them are all accurate, there can be no such inconsistencies. He worked out, very completely, the theory of the subject; he built up upon that basis a few fundamental formulæ connecting the various quantities; then he made his experiments in order to find the numerical value of certain constants which appear in the formulæ. Such a method of attack renders results, obtained by the aid of the implements provided, *consistent*.

The Science of Heat-Engines.—There are those who maintain, in spite of the evidence to the contrary, that all of the advances of the last half-century have been due to the unerring instinct of the engineers. They will tell you that a pound of practice is worth a ton of theory, and they will ride to death other time-worn idioms. But the development in heat-engines as prime movers may be traced back to the philosophy and the experiments of the physicist and the mathematician. It is perfectly true that their efforts would have been quite useless but for the practical men who took up their results and translated them into internal-combustion engines and steam-turbines. Let us have these things in their true perspective, and pause, for a moment, to see how the triumphs of to-day are founded upon the pioneers of the nineteenth century.

It was in 1843 that Joule made his classical experiments which established the doctrine of the conservation of energy and determined the mechanical equivalent of heat. These gave a tremendous impetus to, if they did not actually commence, the science of the theory of heat-engines. From that day men turned their thoughts to other working fluids, than steam, and in the Stirling, Ericsson, Buckett, and the other hot-air engines, we may trace the commencement of the experimental work which has produced the modern gas-engine. Although the doctrines established by Joule made some of the pioneers turn their attention to utilising air as a working fluid, others applied the new knowledge to determine the properties of steam. Regnault made his experiments in 1847. Clausius, Rankine and Thomson—better known to this generation as Lord Kelvin—worked on at the theory of subject. (The two latter worked in the University of Glasgow.) Can any other centre of learning show the record of three such men as Watt, Rankine, and Kelvin within a century? And the work on steam of Rankine remains immortalised by his suggestion of the well-known Rankine cycle, now the standard of efficiency for all steam-engine work. It almost appears that a period of stagnation ensued after this date, but Osborne Reynolds and others were turning their thoughts to thermodynamics as applied to the steam-turbine, and scientific men were evolving the theoretical cycles, and their practical application to external and internal-combustion engines.

Callendar's Work and the Specific Heat of Superheated Steam.—We must now pass on to the latest development of the thermodynamics of steam. In 1900 Callendar published his first paper on the subject. It is included in the Proceedings of the Royal Society for that year, and is entitled "On the Thermodynamical Properties of Gases and Vapours as Deduced from a Modified Form of the Joule-Thomson Equation, with Special Reference to the Properties of Steam." In that paper he developed the Joule-Thomson equation, and gave it such a form as to represent, accurately, the properties of steam, whether superheated or saturated. He made certain deductions, expressed in a convenient fashion by formulæ, some of which, it must be confessed, appear somewhat complicated to the practical engineer.

Perhaps the most important result of Callendar's researches is the determination of the properties of superheated steam. Hitherto it has been usual to assume that the value of the specific heat of superheated steam is, for all practical purposes, constant and equal to 0.48. This value is, according to results obtained by means of Callendar's equations, the lower extreme, and only occurs at very low pressures. The value of the specific heat of superheated steam rises rapidly with the pressure, and is a maximum near the saturation point.

Thus at 20 lb. per sq. in. pressure the specific heat at saturation is 0.508; at the same pressure and at 600 deg. Fahr. the specific heat is 0.482—*i.e.*, when there is 372 deg. Fahr. superheat. The average value over the range is 0.490.

For steam at 300 lb. per sq. in., the specific heat at saturation is 0.637; at 600 deg. Fahr. (*i.e.*, 183 deg. Fahr. superheat) the specific heat is 0.547. The average value over the range is 0.585. This is about 20 per cent. higher than the usually accepted value. A full table of these values is given later.

Saturated a Particular Case of Superheated Steam.—Callendar's equations apply directly to the case of superheated steam, for which his form of the Joule-Thomson equation holds. The case of saturated steam, which is of great importance, may be treated as a particular case of superheated steam, the amount of superheat being zero. The degree

of superheat, or the condition of saturation, may be defined by the relation between temperature and pressure. It will be shown later that the laws of thermodynamics require a definite relation between these two quantities.

The importance of this work was not fully realised by English engineers at the time of its publication. It is, indeed, very probable that it appeared to be almost incomplete, and it is certainly not an easy matter to follow the eminent physicist and mathematician through the maze when he gives such few sign-posts to guide us. Moreover, there were practically no numerical results published, and as the work involved in obtaining these values is far greater than appears at first sight, it is just possible that those English engineers who studied Callendar's work at the time of its publication waited in the hope of obtaining further numerical data from the same source. On the Continent, however, they were less patient.

The work of Callendar was taken up by Mollier (of Munich), who redetermined some of the constants, and published a set of steam-tables in metric units. Sir James Ewing, K.C.B., has included part of these tables of Mollier in the last edition (1910) of his well-known treatise on heat engines. (He has definitely adopted the pound-calorie, instead of the British thermal unit, as the unit of heat in this new edition of his book.) In an appendix he draws attention to the importance of the work of Callendar and Mollier.

The authors take this opportunity to gratefully acknowledge that the perusal of this appendix was their inspiration to look more deeply into the subject which is here discussed.

The numerical values in the tables of Mollier are on bases of temperature and metric pressures. It was considered that English engineers would find more useful tables having as bases temperature and pressure, the temperature being given both in Fahrenheit and Centigrade units, the pressures in pounds per square inch, and the quantities in both pound-calories and British thermal units. The authors have therefore calculated tables, some of which are given later, making use of Callendar's work and Mollier's constants. It is now proposed to give a brief account of Callendar's work, and then to illustrate its importance by comparing values calculated by his method with those to be found in existing steam-tables.

The Basis of the Old Tables.—Purely empirical formulæ, based entirely upon experimental results, were used for calculating the values given in the tables published previous to those of Mollier, and these are given below. They were founded on the work of Regnault and Rankine which has been already mentioned.

The total heat of saturated steam at T deg. Cent. is, in existing English tables, reckoned from Regnault's formula :—

$$H = 606.5 + 0.305\ T \quad . \quad . \quad . \quad (1)$$

The pressure (p) is calculated from the formula :—

$$\text{Log}\ p = a + b\ B^T + c\ C^T \quad . \quad . \quad (2)$$

The empirical constants were fitted in to the experimental results.

In the paper above referred to Professor Callendar says :—"It was proved by Rankine* that the rate of change of the total heat of steam at low temperatures, at which it very nearly follows the laws of an ideal gas on account of its low pressure and large specific volume, must be very nearly equal to the specific heat of the vapour at constant pressure. Therefore, either the specific heat of steam at low temperatures must be 0.305, increasing considerably with the temperature, so as to reach the value 0.48 between 100 deg. Cent. and 200 deg. Cent., or else the observations of Regnault must be wrong. In any case it is clear that the variation of the total heat should not be linear, unless we abandon the experimental evidence in favour of the constancy of specific heat of an ideal gas."

In the case of a perfect gas, the temperature, pressure, and volume are connected by the fundamental equation $p\ v = R\ \theta$. In practice all gases deviate from this. Joule and Thomson adopted a modification of this equation, which is

$$v = R\ \theta/p - \frac{a}{R\ \theta^2} \quad . \quad . \quad . \quad (3)$$

The final development of the equation, as given by Callendar, is

$$v - b = R\ \theta/p - c_0\left(\frac{\theta_0}{\theta}\right)^n = V - c \quad . \quad (4)$$

* Royal Society of Edinburgh Proceedings, 1850.

In such a form the equation may represent accurately the properties of steam whether superheated or saturated.

In addition to evolving this equation, Callendar demonstrated the thermodynamic relations which exist between the various properties, and he deduced accurate formulæ for the calculation of quantities which had previously been represented empirically.

Advantages of the New Method.—This method of attacking the problem has the great advantage that all of the quantities so obtained must be consistent. With quite a few experimentally determined constants the whole of the properties can be deduced from the application of pure thermo-dynamics.

The importance of such tables has been accentuated by the development of the steam-turbine. In nearly all work in which they are used small differences of large quantities are dealt with. It is therefore more important that the tables should be consistent than that the absolute values of the quantities should be exact.

It will be necessary, in order to explain the final form of the Joule-Thomson equation, to refer to the arguments used by Callendar when he suggested it.

If we take b as the minimum volume, or "co-volume" of Hirn and Van der Waals, the equation of a pluperfect gas becomes $p\ (v - b) = R\ \theta$. The quantity b is relatively small at ordinary pressures. It may probably be taken as the volume of the liquid at low pressures. Further, it is usual, in the kinetic theory of gases, to assume that the average total kinetic energy of the molecules is proportional to $p\ v$. Then, since the specific heat is proportional to $p\ v/\theta$, it follows that the limiting value of the specific heat at very low pressures must be constant. We may assume that the kinetic energy of the vapour is proportional to $p\ (v - b)$ at all stages. It then becomes necessary to assume that the index of the term $a/R\ \theta^2$, in the Joule-Thomson equation, is $n = J\ K_{v0}/R$, and not 2 (where K_{v0} is the limiting value of the specific heat at constant volume). The hypothesis of Clerk-Maxwell, with regard to the distribution of energy between the various degrees of freedom of a molecule, would suggest the value 3.5 for a tri-atomic gas such as steam. This was the value used by Callendar in his first paper. His own experiments had suggested a somewhat lower figure, about 3.3, but in deference to Clerk-Maxwell, and as a result of communications with Lord Kelvin (as well as a value of 3.8 obtained by Grindley) at about that time, he felt compelled to adopt the higher number. His subsequent experiments, by three independent methods, confirmed his original figure 3.3 or $\frac{10}{3}$. This was the value which he communicated to Mollier, who calculated his tables in the metric units. It is also the value which the authors have adopted in the calculations for their tables in English and pound-calorie units. The three methods employed by Callendar, in obtaining this value, were : (1) by means of throttling experiments ; (2) by adiabatic expansion, giving the ratio of the specific heats ; (3) by direct measurement of the specific heat. All of the latest evidence, therefore, seems to confirm the figure $\frac{10}{3}$ which has been used. The constant b is taken as 0.016 cub. ft. The value of R is determined by reference to the molecular weight of water, and is assumed to be 154.1.

(To be continued.)

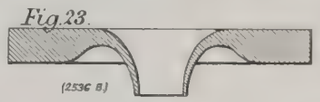
THE STEAM-TURBINE.

(Continued from page 663.)

THE theory of the impulse steam-turbine, whether in the shape of the De Laval wheel, or compounded on the Rateau system, is simple and generally known to all interested in the question. There are, however, a few points which may be worth consideration here.

Experiments on nozzle and guide-blade friction have not been wholly concordant owing mainly to the inadequate attention often given to the determination of the initial quality of the steam, and to providing it with an easy access to the nozzle. In Rosenhain's experiments, for instance, there is evidence that the steam contained at least 10 per cent. of moisture, but as this was not directly measured, the experiments give practically no indication as to absolute values of nozzle friction. If we assume, however, that the steam was of much the same quality in the different sets of experiments, some comparative results are deducible. Thus a nozzle with an entrance but slightly rounded appears from the experiments to have only some 94 per cent. of the efficiency of a nozzle with a thoroughly well-rounded entrance. This result is confirmed by comparing the results of Rateau and of Briling. The former found that with a convergent nozzle very fully rounded (see Fig. 23) the efficiency was unity at the critical velocity of discharge, whilst Briling, using

Fig. 23.

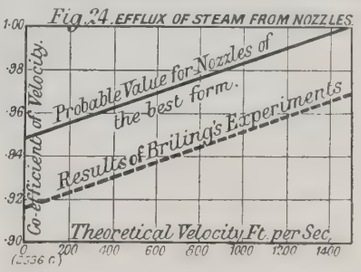


(2536 s)

a nozzle with but a slightly rounded entrance, found at the critical velocity an efficiency of 93½ per cent. only. Rateau's result is confirmed by Stodola's experiments with a convergent-divergent nozzle, the discharge from which was not measurably less than the theoretical value, thus showing that the convergent portion of the nozzle worked with unit efficiency. Both Rateau and Stodola carefully measured the initial quality of the steam they used, and their results are worthy of great confidence.

Briling, as well as Rateau, obtained evidence that the friction was relatively less the higher the steam speed, but in Rateau's experiments the actual velocity of flow was unknown save at the critical speed, since it is practically certain that at the lower velocities the jet contracted after clearing the orifice, so that the observed coefficient of discharge would require correction for this contraction before the coefficient of velocity could be deduced. On the other hand, with Briling's experiments a contraction of the jet after issue seems improbable in view of the slight taper of his nozzle, and hence his coefficients of velocity appear comparable *inter se*. These are plotted on the lower line, Fig. 24, whilst the upper shows the coefficients

Fig. 24. EFFLUX OF STEAM FROM NOZZLES.



which would probably have been reached with a nozzle of the best form.

Many experimenters on convergent-divergent nozzles have attempted to measure the efficiency by means of the reaction or pressure developed. This process is legitimate only when due precaution is taken to make sure that the whole of the pressure head is converted into velocity head before the jet clears the nozzle. If, as in many experiments, the nozzle has a divergent cone insufficiently long to fully expand the steam, part of the thrust measured is due to the excess of pressure still remaining at the point of discharge, and the velocity of flow calculated from this pressure is not a true velocity, and the efficiency of the nozzle as deduced from this calculated velocity is inaccurate, being too high.

Stodola's and Lewicki's experiments seem those most worthy of confidence, and from these it appears that the percentage loss in a well-designed convergent-divergent nozzle is about

$$6\left[\frac{u-45}{100}\right]^2$$

where u denotes the available heat expended.

Thus with $u = 145$ B.Th.U. the loss is 6 per cent., whilst with $u = 45$ it is zero, this being nearly the value which gives the critical velocity.

The curve, Fig. 25, page 729, has been prepared from this formula. It applies only to nozzles having thoroughly well-rounded entrances. In the case of nozzles only slightly rounded at the entrance the losses are materially higher.

Rateau, by actually measuring the force exerted in a bucket by a jet issuing from a divergent-convergent nozzle, proved that there was little or no loss involved in using a nozzle which, at its discharge end, was a little too small ; whilst if, on the other hand, it was a little too large, the loss was considerably

FOUNDRY PLANT AND MACHINERY.

(*For Description, see Page* 723.)

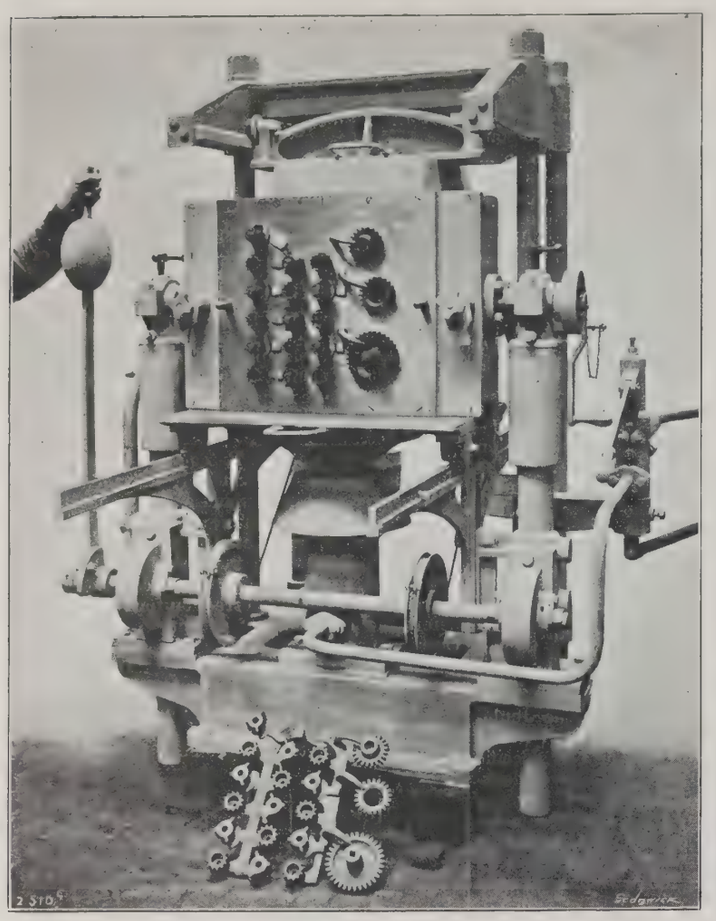


Fig. 574. Machine for Moulding Gears; The London Emery Works Company, Tottenham, London, N.

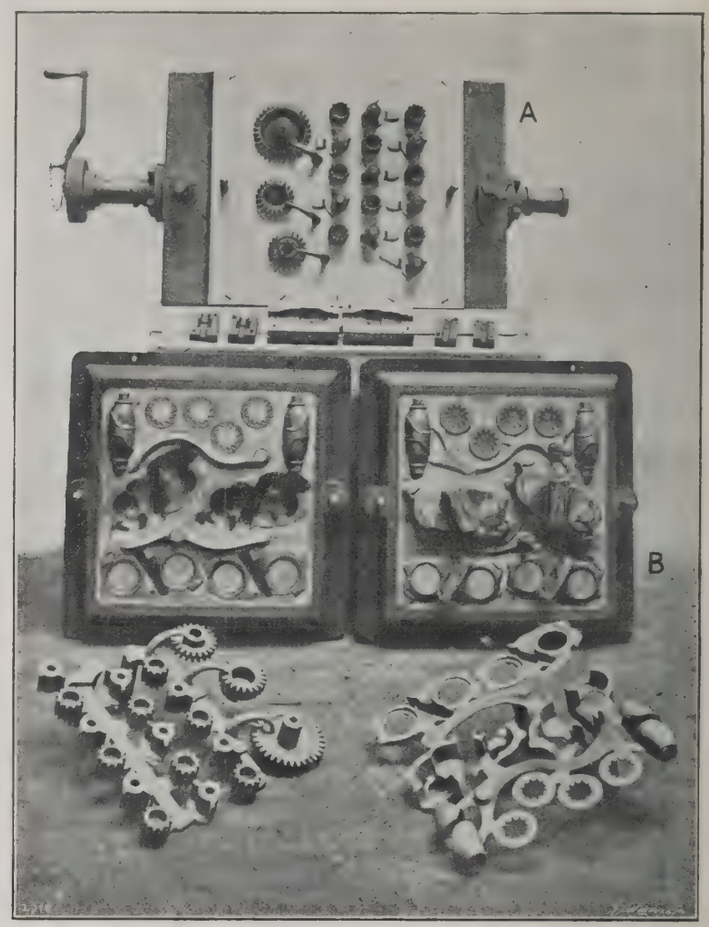
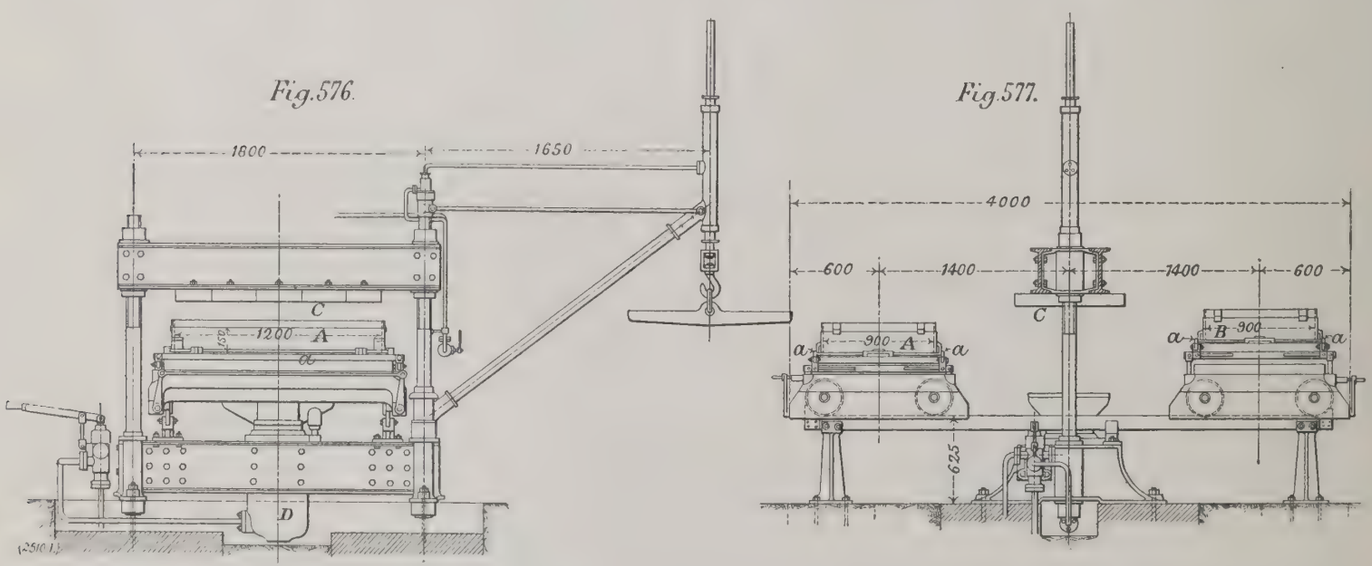


Fig. 575. Stripping-Plate and Pattern-Plates; The London Emery Works Company, Tottenham, London, N.



Figs. 576 and 577. Duplex Moulding-Machine with Central Presser-Head; The Badische Maschinenfabrik und Eisengiesserei, Durlach.

increased. It is thus a good plan to design nozzles a little smaller at the discharge end than theory would indicate. Two different nozzles were tested by Rateau. Of these, the one corresponding to the curve A, Fig. 26, page 729, was so proportioned that the flow would exactly fill the mouth when the inlet pressure was 3.68 kg. per sq. cm. The corresponding point on the curve is denoted by M. The other, corresponding to the curve B, was designed for an inlet pressure of 6 kg. per sq. cm.

In drawing the velocity diagram, Fig. 27, page 729, of an impulse wheel, it is best to draw the velocity of discharge from the bucket above instead of below the base line—that is to say, to represent it by the heavy line E C instead of by the dotted line C D. In this diagram A B denotes, of course, the velocity v of the steam as it issues from the guide-blades, C B the blade speed, and A C the relative velocity of the steam to the bucket at entrance. At one time great importance was attached to making the bucket angle at entrance equal to the angle A C F. A departure from this condition was said to result in losses by hydraulic shock. Actual experiment has, however, shown that considerable departures from this condition are as likely as not to be favourable to efficiency, and it is now common to make the bucket angle at entrance 3 deg. to 8 deg. larger than A C F.

The relative velocity of the steam on discharge from the bucket is represented by E C, and in impulse turbines E C is always less than A C owing to bucket friction. The ratio $\frac{E C}{A C}$ is known as the

velocity coefficient, and may be represented by ψ. Its value has been the subject of some direct experiments, but these have been mostly confined to cases in which A C did not exceed 1200 ft. to 1600 ft. per second. Amongst the best of such experiments are those of Rateau and Briling.

Within the range common to the two sets of experiments the values of the velocity coefficient found by Rateau and by Briling agree remarkably well, both as to the absolute value of the coefficient and as to the fact that it increases with increasing velocities. It is this fact, it may be noted in passing, which alone makes it possible for impulse steam-turbines of large size to compete with similar units of the reaction type. If, as is usually assumed, friction losses increased directly as the square of the velocities, theory shows that the reaction turbine should possess considerable advantages over its rival. It can be shown that if the loss at each drop of pressure is $k\,q$ (where q is the available heat corresponding to the change of pressure) then the over-all efficiency of the turbine

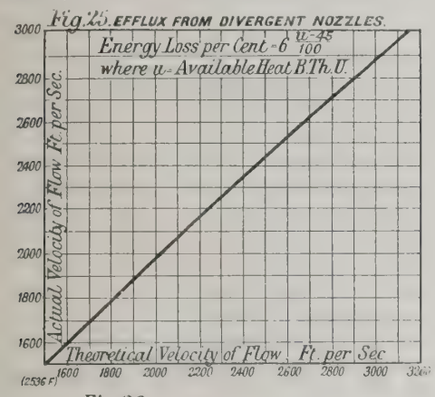
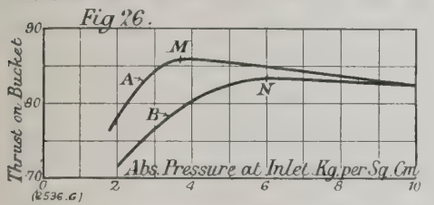
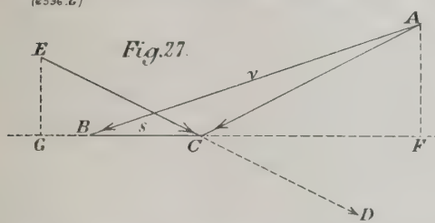


Fig. 25. EFFLUX FROM DIVERGENT NOZZLES.
Energy Loss per Cent. = 6 u-45/100
where u = Available Heat B.Th.U.
Actual Velocity of Flow Ft. per Sec.
Theoretical Velocity of Flow Ft. per Sec
(2536 F)





s nearly directly proportional to $(1-k)$. Now, in a reaction turbine there is only one friction-producing element for each drop of pressure, whilst in an impulse turbine there are at least two—viz., the guide-blades and the moving blades. Briling found, however, that the coefficient varied with the width of the bucket; but in Rateau's experiments there was not the slightest evidence of such an effect. Briling also investigated the interdependence of the velocity coefficient and the angle through which the fluid is deviated. He obtained the result that if ψ denotes the coefficient of velocity, it can be expressed in the form

$$\psi = \psi_0 - 0.000432\,\theta^{\frac{3}{2}},$$

where ψ_0 ranges from 0.95 to 0.99, and θ denotes the angle of deviation.

In practice with simple impulse turbines θ commonly lies between 120 deg. and 135 deg., and no correction for curvature is generally required. In Rateau's experiments the highest velocity reached was about 1600 ft. per second. The writer is not acquainted with any direct measurements of ψ made with higher steam speeds than this. Stodola, deducing nozzle efficiencies from the results of his own experiments, found that in a test of a De Laval turbine, made by Delaporte, ψ had the value 0.83, the relative speed of the steam to the bucket being about 2530 ft. per second. It is also possible to deduce values of ψ from Rateau's experiments on bucket reaction, the results of which are recorded in Fig. 26. The bucket used was of the Pelton type, having discharge angles of about 20 deg.

The measured impulse in the first experiment, using steam at 3.68 kg. per sq. cm., was 0.855 of the maximum theoretically possible. The nozzle efficiency, from the formula already given, was 97.2 per cent. Hence we may write

$$\frac{0.972\,(1+\psi\cos 20)}{2} = 0.855.$$

Whence $\psi = 0.809$ for an actual velocity of outflow equal to 2116 ft. per second.

Similarly, in the second experiment, the nozzle, when using steam at a pressure of 6 kg. per sq. cm., had a calculated efficiency of 95.1 per cent., whilst the combined efficiency of nozzle and bucket as measured from the curve was 0.83. Hence we get

$$\frac{0.951\times(1+\psi\cos 20^\circ)}{2} = 0.83,$$

and thus $\psi = 0.793$ for an actual velocity of flow of 2460 ft. per second. These values have been plotted in Fig. 28, and, as will be seen, fit in quite fairly with the earlier portion of the curve, and with Stodola's value for a velocity of the same order.

Using the values of the velocity coefficient taken from the curve in Fig. 28, the full-line curve in Fig. 29 has been drawn, the abscissæ being the

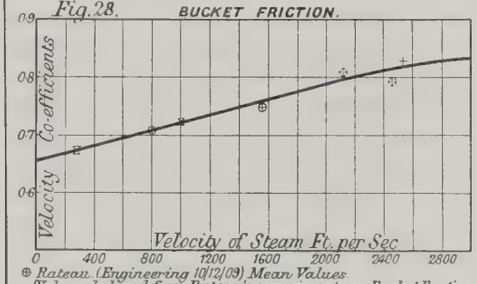


Fig. 28. BUCKET FRICTION.
Velocity Co-efficients
Velocity of Steam Ft. per Sec
⊕ Rateau. (Engineering 10/12/09) Mean Values.
* Values deduced from Rateau's experiments on Bucket Reaction; Congrès International de Mécanique Appliquée 1900.
Σ Brilings Experiments with 20°m. Buckets (Engineering 29/4/10).
+ Stodola 'Steam Turbines' deduced from Delaporte's Test of a de Laval Steam Turbine.
(2536 D)

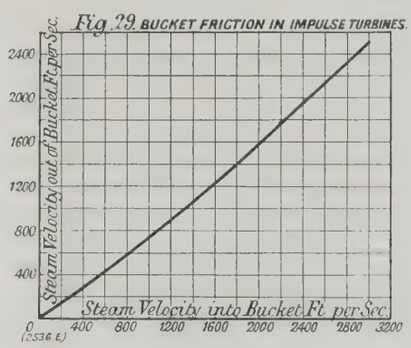


Fig. 29. BUCKET FRICTION IN IMPULSE TURBINES.
Steam Velocity out of Bucket Ft. per Sec.
Steam Velocity into Bucket Ft. per Sec.
(2536 E)

relative velocity of the steam at entrance to the bucket, and the ordinate the corresponding velocity at discharge. The efficiency of a turbine of the Rateau or De Laval type calculated from these curves agrees well with what is actually realised in practice.

In Fig. 27 A B has a known value, as also has C B, the bucket speed, so that A C can be found graphically. The direction of E C is the same as that of the tangent to the bucket at discharge, and its length is given by the relation E C $= \psi$ A C, where ψ is taken from Fig. 28, or the product ψ A C may be read direct from the curve in Fig. 29. The line E B represents the absolute velocity of the steam as finally discharged.

The efficiency of the wheel is obtained very simply from this diagram by dropping the perpendiculars E G and A F. If, then, η denotes the diagram efficiency of the wheel, we have

$$\eta = \frac{2\,s\,.\,\mathrm{G\,F}}{\mathrm{A\,B^2}}.$$

The proof is as follows:—Each pound of steam enters the wheel with a velocity A C $= v$. This velocity can be resolved into two components: one, F B, is directed along the line of motion of the bucket, and the other, A F, perpendicular to the plane of the wheel. The former may be called the "tangential component" of the velocity of the fluid on entrance. The line E B, as already stated, denotes the absolute velocity of the steam at discharge. Its "tangential component" is, it will be seen, equal to G B, which is oppositely directed to F B. Hence, in passing through the wheel, each pound of steam passed per second has had its tangential momentum altered by the amount represented by G F. To effect such a change in one second, a force equal to $\frac{\mathrm{G\,F}}{g}$ must have acted, and since action and reaction are equal and opposite, this also represents the tangential component of the force which has acted on the buckets. The quantity $\frac{\mathrm{G\,F}}{g}$ is commonly called the "impulse" on the wheel. The driving force on the bucket being thus known, the useful work done per pound of steam passed per second is found by multiplying this force by s, the bucket speed. Hence we find that the useful work done per pound of steam passed per second

$$= \frac{s\,.\,\mathrm{F\,G}}{g}.$$

The kinetic energy entering the bucket per pound of steam passed per second is, of course, equal to $\frac{v^2}{2\,g}$, and hence the efficiency of wheel is equal to

$$\frac{s\,.\,\mathrm{F\,G}}{g} \div \frac{v^2}{2\,g} = \frac{2\,s\,.\,\mathrm{F\,G}}{v^2}.$$

For this quantity Mr. Jude has suggested the excellent term "diagram efficiency." The stage efficiency is found by multiplying the diagram efficiency by the nozzle efficiency.

With pressure-compounded turbines the energy expended in friction is returned to the steam as heat, and in consequence the steam, at every successive stage, is drier than it would have been were the turbine friction free. In a perfect turbine consisting of N stages the heat available in each compartment would be $\frac{u}{\mathrm{N}}$, where u denotes the "available heat" as measured in the ordinary way from the well-known Mollier diagram. If, however, the first compartment of an actual turbine is designed to account for $\frac{u}{\mathrm{N}}$ units of heat, then more heat than this will be available in each of the succeeding compartments, since each delivers, to the next, the steam in a drier condition than it should do were there no frictional losses. Hence, if the first compartment is designed to account for $\frac{u}{\mathrm{N}}$ units of steam, it will deliver less power to the shaft than each of its successors. To get an equal partition of energy between the compartments the first should be designed to account for $\frac{\mathrm{U}}{\mathrm{N}}$ heat units, where $\mathrm{U} = r\,u$, r being known as the re-heat factor. Where the number of compartments is large $r = \frac{\epsilon}{\eta}$, where ϵ denotes the efficiency ratio and η the hydraulic efficiency of the turbine. Curves showing the relation between ϵ and η have already been given on page 374 *ante*.

Thus, if the turbine is to operate with steam at 170 lb. absolute, and at a temperature of 520 deg. Fahr., expanded down to $1\frac{1}{2}$ lb. absolute, the Mollier diagram shows the value of u to be 331 B.Th.U., and a perfect turbine would, it also appears, deliver the steam 83.4 per cent. dry. If the efficiency ratio of the turbine is 70 per cent., 30 per cent. of u will be expended in drying the steam, instead of in effecting useful work. Hence the actual condition of the steam on discharge will be 92.9 per cent. dry, and its specific volume on final delivery will be therefore $92.9 \times 227.3 = 211.2$ cub. ft. per pound.

From the curve (Fig. 10, page 374 *ante*) the reheat factor

$$r = \frac{\epsilon}{\eta} = \frac{70}{65.6} = 1.067;$$

so that

$$\mathrm{U} = 1.067 \times 331 = 353.2\ \mathrm{B.Th.U.}$$

If, then, there are twenty compartments, each may be designed to account for

$$\frac{353.2}{20} = 17.66\ \mathrm{B.Th.U.},$$

and the velocity of issue from the guide-blades will be the same in each. The theoretical velocity is $224\sqrt{17.66} = 940$ ft. per second, and the actual from the curve in Fig. 29 will be about 921 ft. per second.

The area required through the guide-blades in each compartment will then be proportional to the specific volume of the steam when it gets there. The initial value V_0, corresponding to a pressure of 170 lb. absolute and a temperature of 520 deg.

Fahr., is 3.346 cub. ft. per pound. The final value has already been found to be 211.2 cub. ft. per pound. If one intermediate value can be determined, all the others can be found with practical accuracy by logarithmic interpolation in a manner to be presently explained.

An exact method of finding the reheat factor, corresponding to any degree of expansion, was described in our issue of January 13, 1905; but the resulting equation is complicated. By comparing the results of an application of this exact method, a simple empirical rule was discovered giving practically the same results.

Thus let $U_1 = \frac{\epsilon_1}{\eta} \cdot u$ be the total amount of heat which becomes available in a turbine, taking into account the fact that at each stage the steam is drier than it should be. In this expression ϵ_1 denotes the over-all efficiency ratio. Then for a heat expenditure equal to $\frac{1}{2} U_1$ we have the empirical relation that $\epsilon_{\frac{1}{2}} = \frac{\epsilon_1 + \eta}{2}$.

Hence the first half of the turbine under discussion has an efficiency ratio

$$\epsilon_{\frac{1}{2}} = \frac{70 + 65.6}{2} = 67.8 \text{ per cent.}$$

Hence

$$u_{\frac{1}{2}} = \frac{65.6}{67.8} \cdot \frac{U_1}{2}$$

$$= \frac{65.6}{67.8} \cdot \frac{353.2}{2} = 170.9 \text{ B.Th.U.}$$

The pressure corresponding to the value $u_{\frac{1}{2}} = 170.9$ is found from the Mollier diagram to be 21 lb. absolute, and the dryness fraction for adiabatic expansion is 95.0 per cent. Actually, $170.6 \times (1 - 0.678) = 54.9$ B.Th.U. have gone to dry the steam, so that its actual condition at 21 lb. pressure is 97.6 per cent. dry, and thus its specific volume is $19.03 \times 0.976 = 18.57$ cub. ft. per lb.

We have thus got three values of V, viz.:—

$V_0 = 3.346$ its value at entrance,
$V_{\frac{N}{2}} = 18.57$ its value in compartment 10,
$V_N = 211.2$ its value on final discharge.

If we take the logarithms of these values, viz.:—

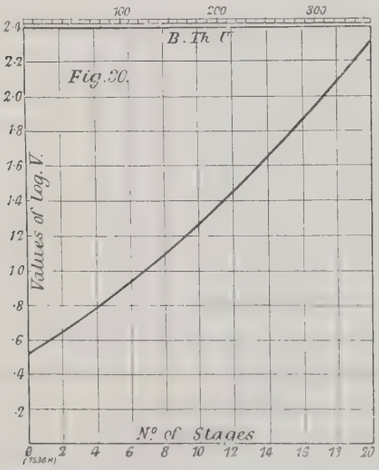
$y_0 = \log. V_0 = 0.5245,$
$y_{\frac{N}{2}} = \log. V_{\frac{N}{2}} = 1.2688,$
$y_N = \log. V_N = 2.3247,$

we can find all intermediate values with sufficient accuracy by interpolation. Thus

$$y_{\frac{N}{4}} = \frac{6\, y_{\frac{N}{2}} + 3\, y_0 - y_N}{8} = 0.8575.$$

$$y_{\frac{3N}{4}} = \frac{6\, y_{\frac{N}{2}} + 3\, y_N - y_0}{8} = 1.7575.$$

By again applying the formula in similar fashion, we could further interpolate between any three



consecutive values of the five values of y now known; but it is handier to complete the interpolation graphically, plotting down the five values of y against the corresponding stages, as in Fig. 30. The logarithms of the specific volume at each stage can then be read from the curve, and we thus get finally the following values of the specific volume of the steam at each stage:—

Stage No.	Specific Volume of Steam.
0	
1	3.88
2	4.49
3	5.22
4	6.12
5	7.24
6	8.61
7	10.33
8	12.47
9	15.14
10	18.6
11	22.9
12	28.5
13	35.7
14	45.0
15	57.2
16	73.1
17	94.4
18	122.5
19	160.3
20	211.2

By effecting the final interpolation graphically the difficulty which might arise when $\frac{N}{2}$ was fractional is avoided. Thus, if in the case just taken there had been nineteen stages instead of twenty, $\frac{N}{2}$ would be $9\frac{1}{2}$, whilst $\frac{N}{4} = 4.75$; whilst what is wanted is the value of V for integral values of N. By plotting down the calculated values of y against the corresponding fractional values of N, the values corresponding to each integral value of N can be read from the curve.

An equal partition of energy between the different compartments of a turbine is not always desirable, nor, indeed, always practicable, on account of the excessive volume of steam at high vacua. This often makes it difficult to provide the requisite area for flow without both increasing the velocity of the steam and the guide-blade angles. The difficulty is frequently minimised by proportioning the turbine on the basis of a moderate vacuum and then estimating its output with higher vacua from correction curves. At the high-pressure end again, where partial admission is used, the steam flow can be spread over a larger arc of the wheel by diminishing the guide-blade angle, which has in some cases been made as small as 13 deg. in the case of the first compartment. On the other hand, the guide-blade angle at the final stage is frequently 30 deg. Some builders, too, prefer to have a specially large pressure drop at the first guide-blades. This has the advantage that the maximum pressure and superheat introduced into the casing of the turbine proper is reduced, and the loss from the fact that the first wheel is then underspeeded is reduced by utilising as much as possible of the "carry over." The moving blades are generally shrouded in order to avoid "spilling" over the tips of the blades.

The method above set forth of determining the value of the specific volume of steam by logarithmic interpolation is based on the fact that in certain limiting conditions—viz., that of so-called "isothermal" expansion—the value of log V plotted against N gives a straight line, and that in all conditions the curve obtained is a very flat one, which can consequently be treated as a parabola without any error of consequence.

The device is, moreover, equally applicable to cases in which there is not equal partition of energy between the different compartments; but in that case log V should be plotted against U in place of against N, where, as before, U denotes the "available" heat multipled by the reheat factor. This total quantity of energy can be distributed amongst the different compartments in any fashion desired.

We thus get values of U_0, U_1, U_2, &c., up to U_N, and the corresponding value of log V can be read from the curve. U_0, of course, has the value zero, and $U_1 - U_0$ is the energy expended in the guide-blades of compartment No. 1. Similarly $U_{N-1} - U_n$ denotes the energy expenditure in the guide-blades of compartment No. n. The velocities of inflow are, therefore, known, and log V_n being scaled from the curve, the requisite area needed through the blading can be deduced.

(To be continued.)

Cement Manufacture in the Ural.—The Ural district, where there is a considerable market for cement, has hitherto been compelled to draw its supply from St. Petersburg, Riga, and other distant parts, at comparatively high prices. A group of local consumers has now decided to erect a cement manufactory in the Ural, where the natural conditions are considered favourable. A large German machine firm is aiding the new venture.

THE LATE MR. ALFRED HOLT.

We regret to have to record the death, which occurred suddenly on Monday night, the 27th ult., at his residence, Crofton, Sudley-road, Aigburth, Liverpool, of Mr. Alfred Holt. Mr. Holt, who was in his eighty-third year, had been for a very long period one of the leading figures in the commercial life of Liverpool. He was a son of the late Mr. George Holt, the founder of the well-known cotton firm bearing his name, and was brought up to the profession of a civil engineer. He invented a number of improvements in marine engines, and founded, in 1852, the Ocean Steamship Company, since known as the Blue Funnel Line, which is engaged in the Australian passenger service. Mr. Holt retired from active participation in business a few years ago, but he continued to take a keen interest in the welfare of the company. He served a few years ago on the Mersey Docks and Harbour Board, and acted as chairman from August, 1889, down to December, 1890. He actively advocated at various times a number of schemes which he believed would improve the trade of the port; but finding that he failed to carry his colleagues with him in certain proposals for improvements he had put forward, he decided to give up his membership of the board. He had advocated, among other schemes, one for the laying of a road plate-way from Liverpool to Manchester, with a view to facilitate transit between the two centres; this, however, was not carried by the board, and a few years later the Manchester Ship Canal was decided upon and commenced. Mr. Holt was the first and most earnest advocate of the construction of the Liverpool Overhead Railway, and one of the founders of the Liverpool Crematorium, at Anfield. He contributed generously to a large number of charitable institutions.

"MOTION STUDY."

To the Editor of Engineering.

Sir,—I have read with interest your editorial on Mr. Gilbreth's article on "Motion Study," and note that you consider his claims excessive, and feel that he has attributed to motion study many results which you claim are simply "concerned with the economy both in time and labour of production which may be brought about by the use of suitable tools and labour-saving appliances. There is nothing new in this latter point." From an academic standpoint, I should be inclined to agree with you in this statement, but from a practical standpoint there is much that is new in Mr. Gilbreth's presentation of the subject.

In the past detailed study of motions or operations has not been considered important, while that of designing machinery has been given great attention. The consequence of this is that many well-designed and constructed machines are operated very inefficiently, the presumption on the part of the designer or constructor having been that if the tools were provided, anybody could use them satisfactorily. This has not proven to be the case, for in the past 24 years, during which time I have been engaged in the study of operations, I have seldom found that the same skill was exerted in industrial work which we found in cricket, tennis, golf, baseball, or football, nor is the usual skill in industrial operations comparable with that of a good marksman or fencer.

Further, you state that the development of labour-saving appliances which Mr Gilbreth refers to as the result of motion study is only the natural development which is taking place everywhere.

I will grant you that there is a natural development of labour-saving appliances taking place everywhere, but in many cases these appliances are developed from theoretical considerations, and when put to the test of proper motion study are many times found to be lacking. It is coming to be well recognised to-day *that proper labour-saving appliances do not precede, but follow, motion study.* In other words, they are designed by men who have a practical working knowledge of what requirements are instead of a superficial or academic knowledge, which has been so often the basis of development in the past.

The great efficiency in naval gunnery to-day, and the changes which have come in the sights and gun-carriages, have not been devised so much in the engineer's office as they have been by capable engineers studying the performance at the guns themselves. As a matter of fact, in the Navy of the United States, and I have no doubt in that of Great Britain, many devices which were designed to promote efficiency have been discarded since a thorough study has been made of the real elements of efficiency in this art.

Referring to your contention that such careful instructions make machines of men, because they lose initiative and enthusiasm, does not stand the test of experience. It is an old argument, which you will not use a few years hence. As a matter of fact, it has just exactly the reverse effect, *for skill invariably inspires confidence and stimulates initiative.* This result has followed wherever the methods explained by Mr. Gilbreth have been inaugurated; but the most convincing argument of all is that men who a few years ago wrote editorials breathing the same spirit that yours does, are now the most enthusiastic supporters of the system.

We believe that a study of these methods is of the greatest possible importance in Great Britain, where the labour conditions are so unsatisfactory, and where the methods in vogue in the past have seemed only to make the situation more and more hopeless.

To illustrate the growth of the sentiment in the United States in favour of such methods, I have but to say that

while a few years ago it was necessary for everybody who spoke on this subject to defend himself against the critics who would rise in the audience, such is not the case to-day, for there are always present in such audiences people who have made at least a partial study of these methods, and have seen what benefits can be derived from them. Such men are quick to take up the cudgels in their behalf, and show how their studies have invariably benefited both the employer and employee.

Yours very truly,
November 7, 1911. H. L. GANTT.

TO THE EDITOR OF ENGINEERING.

SIR,—We in America cannot "write a letter to the *Times*" when we are peeved, but we have a way of looking upon ENGINEERING as the *Times* of the profession, and it grieves us indeed when our grievance comes from the "Thunderer" itself.

In the last paragraph of your editorial review of Mr. Gilbreth's "Motion Study," page 358, September 15, let me suggest a few slight alterations. Imagine (never mind anachronisms) that Mr. Watt has just introduced his steam-engine, and that this is the subject under discussion. Then proceed:

"Mr. John Ruskin, representing the wine and cellerage trade, took the attitude that if the adoption of the new machine would increase the productivity of labour, the only result would be that the employers would be able to do their work with fewer men, and that labour would obtain no advantage from the arrangement. Mr. Thomas Carlyle, of Chelsea, thought that labour would not profit by the steam-engine, and that it was doubtful if the employer would either. Professor Matthew Arnold condemned the whole of the proposal as rank Philistinism, and suggested that one might as well chain men to galleys at once. . . . Those who believe in the steam-engine have years of work before them . . . those who have no faith in it need have little fear that we are on the eve of a revolution in our industrial methods."

The workmen of Great Britain had to accept the steam-engine in spite of their unwillingness to believe that increased output does not restrict employment. Your workmen and ours will have to accept (I venture to hope) the more business-like effort toward individual efficiency which preachers like Mr. Gilbreth are making. Perhaps we can convince them (the workmen) of their economic heresy first: that were a good thing to do, a highly necessary thing. But, after all, the big job for engineers of this generation is to quit puttering, and show what they can do when they really put their minds to it.

That is all that "Scientific Management" or "Motion Study" proposes—that we put our minds to our work.

I am, yours very truly,
WILLIAM D. ENNIS.

The Polytechnic Institute, Brooklyn, New York,
November 13, 1911.

"NEO-PHILISTINISM."

TO THE EDITOR OF ENGINEERING.

SIR,—After your Editorial Note it scarcely seems necessary for me to reply to Mr. Norman Davey; but perhaps I may be allowed to point out that had it not been for the invention of writing, itself a notable product of the scientific imagination, Mr. Davey would not have been able to put his remarkable ideas into permanent form. Further, had it not been for another important achievement of the scientific imagination—namely, the invention of printing—Mr. Davey's writings could not have been disseminated through your columns. Lastly, had it not been for the invention of weapons by man in the early stages of his existence, it is highly improbable that either Mr. Davey would be here to write, or anyone else to read his lucubrations: this for the reason that the human race would have perished ages ago, overborne by the beasts of prey, who are so much better equipped by Nature with means for survival than is man, except in regard to that scientific imagination which Mr. Davey affects to despise.

Yours faithfully,
A. A. CAMPBELL SWINTON.

66, Victoria-street, London, S.W., November 25, 1911.

TO THE EDITOR OF ENGINEERING.

SIR,—I have been much entertained by reading the articles which have appeared in the last two issues of your journal, in reference to the respective values of the literary and scientific minds; and, if you will grant me the courtesy of your columns, I should like to relate my impressions.

My mind is still thrilling with the echo of a statement made in the first article of this interesting controversy, which said that anyone can talk generally upon literature and history. Now, Sir, have you ever heard two engineers involved in literary discussion, or endeavouring to express views on historical questions? Well, I have.

Also, you yourself have written a paragraph which filled me with amazement. It starts thus:—"Whether the poetic or the scientific imagination is the more important to the race could be easily settled by direct experiment." Now, Sir, I ask you plainly, is it possible to experiment upon the value of the poetic imagination? Surely you must see that experiments belong to the school of Science, and not to the Arts.

You endeavour to bear out your statement by relating a particular case of a person marooned upon a desert island, and infer that, because his desires would lie in the direction of those articles produced by the aid of science, the poetic imagination must for all time take a secondary place in comparison with the scientific mind. This arguing from the particular to the general is surely not the method of procedure of the engineering mind.

May I suggest that the position in which your arguments place you is settled upon somewhat thorny ground? You have drawn dangerously near discussing the utility of Art, and there, Sir, I must beg to leave you.

Yours faithfully,
JOHN COX.

The Engineering Laboratories, Cambridge,
November 25, 1911.

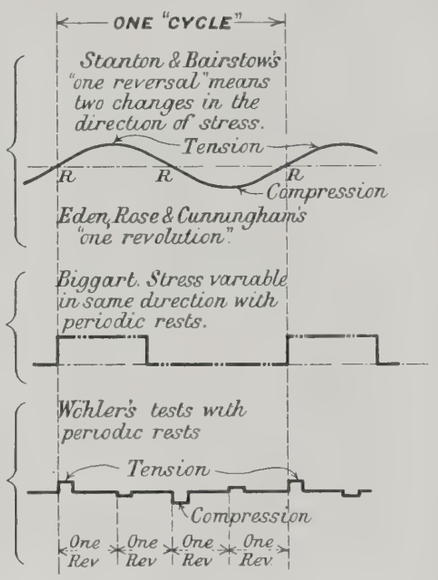
[Our correspondent must have been singularly placed if his experience does not bear out our statement that everyone "with little or no training can speak and argue on such subjects with absolute self-confidence." His amazement at our suggested experiment is in itself amazing. A race could conceivably exist without poetic imagination (it might not be a nice race), but not without the scientific. Finally, is he absolutely certain that in the ultimate, the value of poetry, art, and philosophy is not really utilitarian? If such pursuits do not, directly or indirectly, tend to preserve a race, it is hard to perceive their function. In many cases, indeed, the utilitarian value is directly obvious: a common religion, a common history, and a common stock of poetry have tremendous unifying effects. This is not to say, however, that the artist, the poet, or the philosopher is to aim consciously at utilitarian ends.—ED. E.]

"THE ENDURANCE OF METALS."

TO THE EDITOR OF ENGINEERING.

SIR,—I see that in your very accurate report of my remarks at the Institution of Mechanical Engineers last Friday, a slip has been recorded which I had intended to correct. There was no bending in the Stanton and Bairstow tests. In the last column on page 694, line 25 from the bottom *et seq.* should read, therefore, as follows:—

"When those authors spoke of '*a reversal*' they meant a change from tensile to compressive stress and back again from compressive to tensile stress (really two reversals), corresponding to the effect of one revolution of the rotating beam described in the paper under discussion. In Fig. 1 thousands of double bends were plotted along the horizontal. These, in the authors' case, were thousands of revolutions of the specimen, and thousands of *pairs* of



Various meanings of a Cycle
(2580)

tensile and compressive stresses in Dr. Stanton's case." In Mr. Biggart's tests a cycle meant one passage of the rope over the pulley, in which it was bent once and straightened again. Here there was no reversal of stress until the elastic limit was passed. A "cycle" may be defined diagrammatically as above, from which it will be seen that the rope fibres rested, both when bent and when straight, for a period which is not recorded.

In two experiments by Wöhler the stress was relaxed during three-fourths of the time which would be occupied by the rotation of a continuing revolving specimen, and applied during the remaining one-fourth. X in the diagram indicates the period when the direction of bending on a given "fibre" was at right angles to that producing maximum tensile or compressive stress.

As the results of Wöhler's experiments, though not conclusive, are certainly interesting, I reproduce the figures from page 350, vol. xi., of ENGINEERING. (From page 244 it appears the ultimate tensile strength was from 47,080 to 48,150 lb. per sq. in.)

Maximum Stress (in Pounds per Square Inch) Applied to the Outer Fibres.	Number of Complete Revolutions Made before Fracture when the Motion was	
	Intermittent.	Continuous.
29,960	170,900	183,145
25,680	610,000	909,810

It will be seen that the effect of the rests was to reduce the number of cycles required to produce fracture by 6½ per cent. when the maximum stress was 29,960 lb. per sq. in., and by nearly 33 per cent. when the maximum stress was 25,680 lb. per sq. in.

I am, Sir, yours faithfully,
C. H. WINGFIELD.

28, Victoria-street, Westminster, November 24, 1911.

WEAR OF RAILWAY TYRES.

TO THE EDITOR OF ENGINEERING.

SIR,—With regard to the above article, published in ENGINEERING of November 10, my experience is that sharp flanges are seldom to be found on both sides of a pair of wheels. The cutting action usually takes place on one wheel only; moreover, after replacing a worn pair of wheels, the sharp flange reappears on the corresponding wheel of the new pair.

In order to prolong the life of leading wheels, which commence to "run sharp," it is customary to change them round right to left before the wear becomes serious. For the above reasons I am inclined to think that the cause of sharp flanges may be sought for in the engine itself rather than in the curvature of the road.

Yours faithfully,
Tanta, November 22, 1911. W. KNIGHT.

CANADIAN IRRIGATION.—The results attained by the Canadian Pacific Railway Company from its irrigation system in what is styled the "Eastern Block," have been gratifying. The great dam at the Horse-Shoe Bend of the Bow, south of Bassano, is completed; and by the close of the year upwards of 6,000,000 cubic yards of material will have been moved in making ditches. The whole work is expected to be completed within the next two years, and before the expiration of that period some of the land proposed to be treated can be served with water.

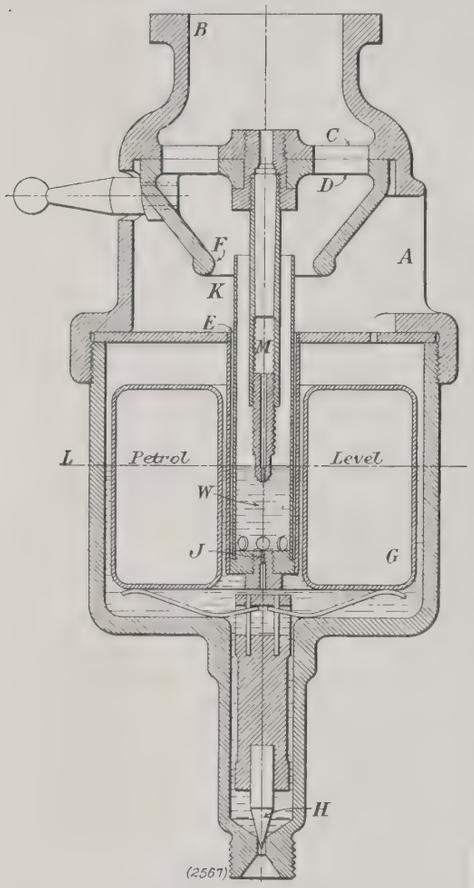
A RECORD YEAR AT THE ROYAL MINT.—The annual report of the Royal Mint, 1910, which has just been published, gives an account of the enormous operations of this department during the past year. No less than 371 tons of gold were melted during the twelve months, this amount being more than double the average of the ten years 1899-1908. A large quantity of nickel is melted at the Mint for coinage for East and West Africa. The quantity of gold, silver, bronze, and nickel melted during the year amounted to the prodigious total of 1251 tons, and even then the demand for coinage was so great that 250 tons of bronze blanks had to be purchased from contractors. The total number of coins struck during the year was 158,204,241, the value of these amounting to 28,040,217*l.*, which is the highest record for the Royal Mint. Some very important changes have been made in the methods of melting the various metals used for coinage. Preliminary experiments on the use of gas and oil, instead of coke, have been in progress since early in 1909, and these experiments have involved the preparation of many designs for furnaces of various sizes, and the testing of a number of burners for obtaining high temperatures, some specially designed, and others of patterns already in use in various trades. Electric furnaces were also experimented with. In connection with these experiments a number of visits were made to factories both in London and the provinces where oil or gas was used for melting purposes, and the superintendent was directed in January, 1910, to visit the United States and Canada, where oil is largely used, in order to collect data which were likely to be of assistance in arriving at a decision. Oil-furnaces burning both petroleum and creosote oils were tested under very varying conditions, and with air at pressures varying from 2 lb. to 25 lb.; but it was finally decided that liquid fuel was unsuitable. In the experiments with ordinary town gas a variety of systems was tested, involving the use of gas at ordinary and high pressures, combined with variations in the pressure of the air, and the burner ultimately adopted was made by Mr. S. N. Brayshaw, of Manchester. For the Brayshaw burners in use at the Mint the gas is taken at the ordinary pressure in the main (about 3 in. of water), and mixed with air from a powerful blowing-engine at about 2 lb. pressure. With care the noise of these burners can be reduced sufficiently to be unobjectionable, the furnace linings compare very favourably with those hitherto used for coke in regard to endurance, and the crucibles used for gold are found to last longer (each crucible serving for an average of eighteen heats, as against twelve when coke is used). The adoption of gas as a fuel in place of coke has been accompanied by several incidental economies, and it is interesting to note that the present charge for fuel averages about 4½d. per cwt. of standard gold bullion, as against 7d. when coke was used. It should be added that in this statement the fuel needed to warm up the furnace in the morning has been eliminated; but, including this, the cost rarely exceeds 5d. per cwt. on a day's work. During 1910 the Mint installed sixteen gas-heated furnaces, each capable of taking a 400-lb. crucible, and fired with Brayshaw gas-burners. These sixteen furnaces have a maximum capacity of 2⅜ tons of sterling silver, or 2¼ tons of bronze per melt, and four melts of silver, or three of bronze, can be made in an ordinary working-day (8 a.m. to 6 p.m.). Also, five furnaces similarly gas-heated, but of a smaller size, are in use for melting gold. Considering the large quantity of metal melted at the Mint, it will be seen that a very substantial saving in cost of fuel alone has been effected for the nation by the use of gas. The incidental economies are, however, still greater. The cost of carting and handling both coke and clinker is saved, and the room formerly required for the storage of them is set free. The expenditure on crucibles, which is a large item, has been reduced by 33 per cent. The work of melting is less laborious, the loss of metal is much reduced, and the bars cast are better and more uniform.

WARE CARBURETTOR.

Among the simplest of the carburettors shown at the recent Motor Show was that known as the Ware, now used on the Straker-Squire cars, and exhibited at Olympia by Messrs. Straker and Squire, Limited, 75, Shaftesbury-avenue, London, W.

In this carburettor, which we illustrate herewith, the regulation of the mixture is obtained without any automatic valves or multiple jets. The throttle and choke-tube are concentric with the float-chamber, and are placed above it. The throttle consists of two discs, D and C, pierced with four holes, which are opened and closed by rotating the lower disc D. Combined with this is the choke-tube F. A is the passage for the incoming air, and B the outlet to the induction pipe of the engine.

Petrol enters the float-chamber through the needle-valve H, and is maintained at a constant level L by the annular float G in the ordinary way. In the centre of the float-chamber is the well W, communicating with the float-chamber by the jet J. Inside the well is a tube K extending up into the choke F, and perforated with holes at the bottom. A tube M



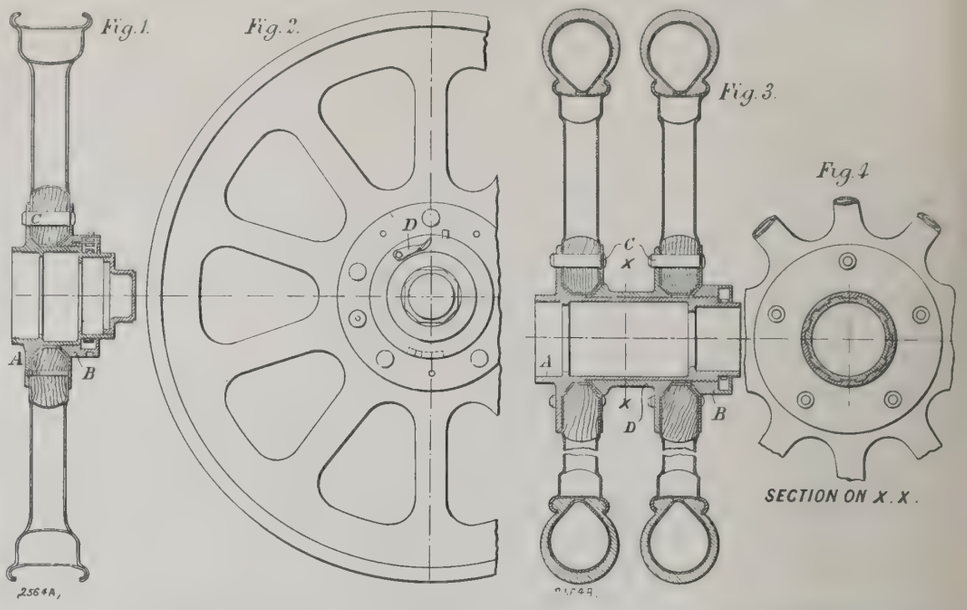
extends from the space above the throttle to a little below the normal petrol level. The action is as follows:—For starting, the engine is turned with the throttle shut when enough petrol is sucked up the tube M to ensure starting without flooding. On the engine starting, the level of the petrol in the well falls below the end of the tube M, as the vacuum in the tube M is much greater than that in the well. Air as well as petrol are therefore drawn up the tube M, and this provides enough mixture to keep the engine just turning round. If the throttle is opened, a vacuum is created in the well, and the flow of petrol through the jet J is therefore increased, and a larger amount of petrol is drawn up the tube M to mix with the air drawn through the throttle. When the throttle is full open, part of the petrol is drawn straight up the tube K into the choke.

An annular space is provided between the well and the tube K. This space fills with petrol when the engine is at rest or running slowly, but on the throttle being opened the petrol is drawn into the tube K. It is stated that this gives rapid acceleration when the throttle is opened.

Two means of adjustment are provided for this carburettor. In order to adjust the supply of petrol when the engine is running at full power, the jet J is varied, jets with different sized holes being provided for the purpose. In order to vary the mixture when the engine is running throttled, the nozzle at the end of the tube M is screwed up or down so as to vary its depth below the level of the petrol in the float-chamber. This carburettor is thus extremely simple.

THE SANKEY WHEEL.

CONSTRUCTED BY MESSRS. JOSEPH SANKEY AND SONS, HADLEY, SALOP.



Two of the interesting features of the recent Motor Show at Olympia were the increasing use of detachable wheels and the use of twin tyres for the back wheels of very heavy cars.

Among the most interesting of these is the Sankey wheel, made by Messrs. Joseph Sankey and Sons, Castle Works, Hadley, Salop. This can either be used as an ordinary detachable wheel, or can be mounted as a twin wheel for use on the back axle, and appears to have several advantages. We illustrate the ordinary form in Figs. 1 and 2, and the special arrangement for twin wheels in Figs. 3 and 4.

The peculiarity of the Sankey wheels is that while they have the same appearance as the ordinary wood wheel, they are made throughout of thin steel, the spokes and rim being hollow. The wheel is made of two main pieces, each stamped out of a sheet of steel and welded down the middle, a suitable rim for the tyre being incorporated. They can, of course, be used as fixed wheels if desired, but are more usually made detachable. In the latter case the arrangement is as in Figs. 1 and 2, where A is the fixed part of the hub, B the nut which holds the wheel on, and C are studs fixed in the wheel and entering into holes in the flange on the fixed hub A. These studs take the driving stress. On the nut B being unscrewed the wheel slides off. A suitable locking pawl D is provided, so arranged that when the nut is screwed up the spanner cannot be removed unless the pawl is properly locked. As compared with the wire wheel it is claimed :—

Firstly, that the appearance is much better and that it is much easier to clean.

Secondly, that it is very much narrower over the hub.

Thirdly, that the fixed part of the hub can be made lighter than for the wire wheels.

These are all points of importance. The narrowness of the hub enables two wheels to be carried quite easily in the usual place without excessive space being taken up. The fact that the hubs are so narrow lends itself to a very convenient arrangement of twin wheel. We illustrate this in Figs. 3 and 4, where A, B, C are the fixed hub, nut, and driving-studs as before. D is a distance-piece which slides on to the hub and is kept from revolving on it by the feathers shown in Fig. 4, and which therefore drives the outside wheel through the studs C. On removing the nut B the outside wheel can be removed, then the distance-piece, and then the inside wheel, the whole operation taking a very short time to accomplish as compared with most arrangements, such as detachable rims.

The distance-piece can, of course, be made of any length, and in this way suitable for any sized tyres. The wheels themselves are of the same pattern as the wheels for single tyres, and are therefore interchangeable. Thus the front wheels of a car may be single and the back wheels twin, and the same pattern spare wheel fits both.

Harbour Surveying.—At the meeting of the Liverpool Engineering Society, held on Wednesday, the 29th ult., Lieutenant F. W. Mace, R.N.R., F.R.A.S., A.I.N.A., read an interesting paper having the above title, in which he reviewed the methods followed in marine surveying, dealing with the measurement, extension, direction, and bearing of the base, plotting, coastlining, and so forth, and laying stress upon the registering of tidal conditions.

The "Orion."—The super-Dreadnought Orion returned to Portsmouth on Saturday from her final acceptance trials, which included a non-stop run of 24 hours.

The Royal Society of Arts.—At the ordinary meeting of the Royal Society of Arts, held on Wednesday last, Mr. A. E. Berriman read a paper on "Aeroplane Efficiency." In this paper the author first considered the value of the thrust-lift ratio, or the coefficient of flight, and pointed out how deadweight affected this factor. He then passed on to the consideration of the resistances offered by aeroplanes, by their surfaces, body forms, &c., finally deducing expressions for lift and resistance of the machine. The expression arrived at for the lift was $\frac{V^2 \tan \beta}{200}$, and for the total resistance $\frac{V^2(0.000018 + \tan^2 \beta)}{400}$, the latter being based on Dr. A. F. Zahm's formula for air resistance, and β being the angle of deflection. The ratio of these two gave the coefficient of flight, and was equal to $\frac{(0.000018 + \tan^2 \beta)}{2 \tan \beta}$, which, with an angle of deflection of 5 deg., had a value of about 0.085. The coefficient was independent of velocity, because the absolute resistance and the absolute lift were both proportional to V^2. If the speed be doubled, the lift and resistance would be both quadrupled.

Personal.—The greater part of Messrs. Siemens and Co.'s office staff at Caxton House has been removed to new offices at their Woolwich works. All future communications relating to insulated wires and cables, telegraph and telephone apparatus, line materials, measuring and testing apparatus, batteries, railway signalling, publications, and accounts, should be addressed to the company at Woolwich.—The Submersible Motors, Limited (W. R. Macdonald's Patents), 23, St. Swithin's-lane, Lombard-street, E.C., have taken over the works and business of "The J—L Manufacturing Company, Limited," of Johnson-street, Southall, as from August 11 last. Mr. T. L. Reed-Cooper, managing director of the J—L Manufacturing Company, Limited, has been appointed managing director of this company, and the whole of the J—L Manufacturing Company's staff has been retained. The name of the company will be altered at an early date to: "Submersible and J—L Motors, Limited."—Messrs. Alfred Herbert, Limited, of Coventry, announce that Messrs. Oscar Harmer, Joseph Pickin, John Milburn, W. H. Herbert, P. V. Vernon, and Thomas Woof, all of whom have for many years been actively associated with the management of the company, have been appointed departmental directors. Mr. Alfred Herbert continues as chairman and governing director.—Mr. H. R. Witting, of 9, Southampton-street, Holborn, W.C., will, on the 8th inst., remove his offices to more extensive premises at 41, Berners-street, Oxford-street, London, W.—Mr. K. Schall, scientific-instrument maker, opened on last Wednesday his enlarged new premises at 75, New Cavendish-street, W., and gave some interesting demonstrations with new electro-therapeutical apparatus on this occasion. An instantaneous photograph of a heart in the human body was taken, the subject standing in front of the Röntgen bulb, and holding the encased photographic plate before his chest.—Mr. A. Hoffmann informs us that from December 1 he resigns his position as managing director of United Motor Industries, Limited, for the purpose of devoting himself entirely to the expanding business of Ivel Agricultural Motors, Limited, of which company he has acted as manager since the Ivel motor was first placed on the market—about nine years ago. After December 16 the head office of the company will be at the works, Biggleswade, Beds, where all communications should be sent.

SHORT-STROKE WORK ON PLANING-MACHINES.

DURING the last two years the driving of planing-machines by reversing motors has been vigorously advocated, and many planers are now running at speeds that were impossible with the belt-drive. The reversing motor alone, and the reversing motor in conjunction with a motor generator, have both been utilised, and planers equipped with these systems reverse fairly accurately at the end of the cutting stroke, but often overrun considerably at the end of the return stroke. This excessive overrun is not so detrimental at the end of the return stroke as it would be at the end of the cutting stroke, because it does not affect the cut, which has often to be done up to a given line, but it occupies time and limits short-stroke work on the planer.

The cause of this overrun is not due to excessive power required by the planer, because the maximum demand occurs directly after the reversal at the end of the cutting stroke, and in accelerating the table up to the return speed. It must therefore be due to the kinetic energy in the heavy armature of the motor. Tests have been made by Messrs. Cecil E. Lugard and Co., Chester, on two planing-machines of identical construction, measuring 11 ft. 8 in. between the housings, each driven by a motor of 50 horse-power, one fitted with a reversing motor, and the other with a continuous-running motor, the reversals being done by a magnetic clutch. The machine fitted with this clutch gear is illustrated in Fig. 1 on this page. This clutch is of the "Vulkan" pattern, fully described and illustrated in vol. xci. of ENGINEERING, page 722, and its operation will therefore be clear without further description. The method of application shown in Fig. 1 herewith is slightly different from that previously dealt with, belt-drives to the clutch taking the place of gears. In Fig. 1 herewith the motor drives direct the upper shaft of the two in the foreground. This by belt to the clutch drives the planer on the reverse stroke. By gear the lower shaft shown in the foreground is driven at reduced speed, the drive being transmitted to the clutch by belt for the cutting stroke.

The planing-machine fitted with the reversing motor has a cutting speed of 33 ft. 10 in. per minute, and a return speed of 54½ ft. per minute, the revolutions of the motor being 588 and 900 respectively. The machine fitted with the magnetic clutch has a cutting speed of 26 ft. 7 in. per minute, and a return speed of 67 ft. 4 in. per minute, the revolutions of the clutch being 164 and 415 respectively.

The kinetic energy in the clutch armature from 164 revolutions per minute (cutting speed) to rest is 1041 ft.-lb., and from 415 revolutions per minute (return speed) to rest is 6632 ft.-lb., whereas in the reversing motor from 588 revolutions per minute (cutting speed) to rest is 17,605 ft.-lb., and from 900 revolutions per minute (return speed) to rest is 41,445 ft.-lb., or 16.9 and 6 2 times greater than the clutch-drive. If it be assumed that the reversing motor is capable of running the planer at the same speed as the clutch-drive—26 ft. 7 in. per minute and 67 ft. 4 in. per minute—the speed of the motor would be 438 revolutions per minute and 1110 revolutions per minute, and the kinetic energy 9837 ft.-lb. and 62,917 ft.-lb., or 9.4 and 9.5 times greater.

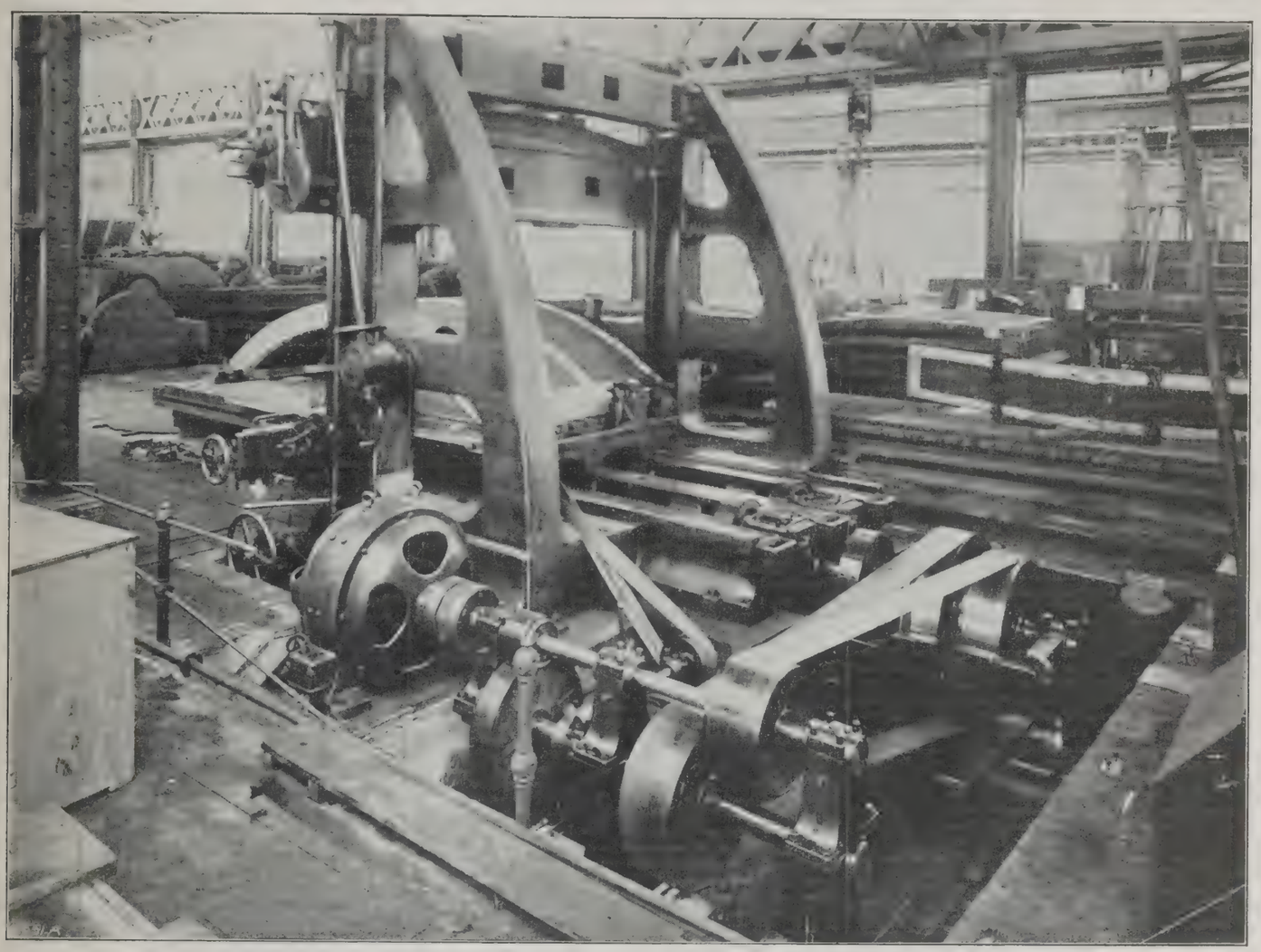
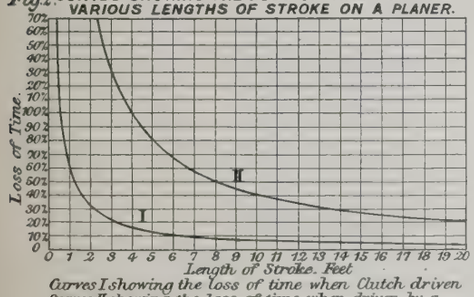


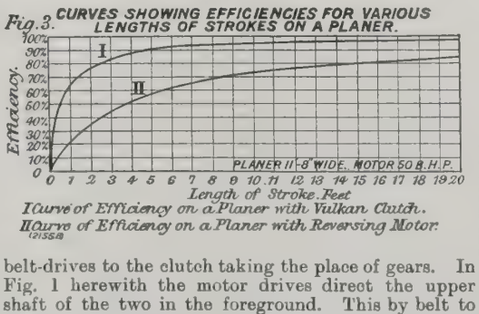
FIG. 1.

Fig. 2. CURVES SHOWING THE LOSS OF TIME FOR THE VARIOUS LENGTHS OF STROKE ON A PLANER.



Curves I showing the loss of time when Clutch driven. Curves II showing the loss of time when driven by a Reversing Motor.

Fig. 3. CURVES SHOWING EFFICIENCIES FOR VARIOUS LENGTHS OF STROKES ON A PLANER.



I Curve of Efficiency on a Planer with Vulkan Clutch. II Curve of Efficiency on a Planer with Reversing Motor.

As it is impossible to run the motor up to 1110 revolutions per minute, it is necessary to adjust the speed of the reversing motor so as to get a comparison under the same theoretical running time—namely, a stroke of 39.3 in. in 10.34 seconds, regardless of the time needed for reversal. The speeds of the motor will then be 558 revolutions per minute and 712 revolutions per minute, and the kinetic energy 15,985 ft.-lb. and 25,930 ft.-lb., or 15.3 and 3.9 times greater.

It will thus be seen that under any conditions the kinetic energy is an important consideration, and that it governs the overrun and time of reversal. It is further evident from this that short strokes with a reversing motor are undesirable, if not impossible. The loss of time for various lengths of strokes is clearly shown in Fig. 2, which gives the time required for reversal expressed in per cent. of the theoretical running time. The efficiency for various lengths of stroke is shown in Fig. 3. This gives the ratio between theoretical running time and actual running time.

In addition to the kinetic energy produced in the clutch or motor-armature, there will be the power required to stop the table, gears, &c.; but this need not be taken into account, since is will be the same for both types of drive, but the clutch-drive is more able to deal with it, as it is not overloaded with its own energy.

With the reversing motor, as it is necessary to break comparatively heavy currents repeatedly, the switch-gear requires very careful design if it is not to give trouble. The reversing motor in conjunction with a

motor-generator is easier on the switch-gear, but the electrical efficiency due to having to employ three machines in tandem will be very low, probably about 40 per cent.

The machine fitted with the magnetic-clutch drive, shown in Fig. 1, is one of six machines which have been running satisfactorily for eighteen months. Nearly 300 planers and slotting-machines have been fitted with this "Vulkan" clutch drive during the past six years; this is fair testimony to the reliability of the system.

Reading-Room in Berlin.—The Dean-Mayer Company, advertising contractors, of 1, Schellingstrasse, Berlin, W. 9, have arranged conference, reading, and writing-rooms for the benefit of their friends and for English engineers visiting Berlin. These rooms can be used free of charge for appointments, interviews, &c.

The late Mr. George Bower.—We regret to have to record the death, which occurred on the 29th inst., of Mr. George Bower, the well-known gas and water engineer, of St. Neots, Huntingdonshire. Mr. George Bower put down water works and gas works in many countries, and invented also a number of improvements in gas-lighting apparatus. He was eighty-five years of age.

Contracts.—One of the largest contracts that of recent years have been placed in connection with machinery for hydro-electric power installations has, after a very keen competition of English, Continental, and American manufacturers, been awarded by the Tata Hydro-Electric Power Supply Company, Limited, through the medium of their consulting engineers, Messrs. Alfred Dickinson and Co., to the following successful tenderers:—Messrs. Escher, Wyss, and Co., for the hydraulic machinery, turbine, and pipe-lines; Messrs. Siemens Brothers Dynamo Works, Limited, for the generators; the General Electric Company (of New York), Schenectady, for the transformers; and the Felten Guilleaume Cable Works for the transmision line. The equipment comprises four 9600-kw. generators direct-coupled to high-pressure tangential water-wheels of the impulse type. The turbines will be designed for a head of 1740 ft., and will have a speed of 300 revolutions per minute. The regulation is effected by automatic oil-pressure governors. Instead of making use of pressure regulators, the turbines will be fitted with nozzles of the deflecting type (Escher, Wyss, and Co.'s patent). The pipe-line is one of the most important of its kind, both with regard to length and diameter, as well as to difficulties entailed in its construction. Over 6000 tons of steel pipes are required, not taking into account the weight of the anchorages and auxiliary apparatus. The capacity of the plant (Khopole power-station) will be about 38,000 kw., but can be increased to 76,000 kw. at any time. For the excitation two separate aggregates are to be installed, each of 600 kw. output, and driven by water-turbines of the same type as the main turbines.—The Worthington Pump Company, Limited, London and Newark-on-Trent, has recently booked a large number of orders for pumping and condensing plants complete, for collieries, railways, various works and corporations, both in this country, the Continent, and distant lands. They have also secured a large number of orders for their well-known duplex pumps, including over 150 for marine service, also power-pumps, vacuum-pumps, air-compressors, water-meters, &c.

The French Navy.—The number of vessels now in course of construction, or in contemplation, for the French Navy is 39, as compared with 54 twelve months since. There is, accordingly, a falling off of 15, or rather more than one-fourth. The number of vessels now remaining to be completed is 18; the number to be continued is 11; and the number still to be commenced is 10. The vessels to be completed in 1912 comprise eight torpedo-boat destroyers, nine submarines, and one mine-layer. The vessels to be continued in 1912 comprise four ironclads, five torpedo-boat destroyers, and two submarines. The vessels still to be commenced comprise nine submarines and one transport ship. Of the vessels to be continued next year, three torpedo-boat destroyers are being built in Government arsenals and five by private firms, while nine submarines remain to be completed in Government arsenals and one mine-layer by a private firm. Of the vessels to be completed next year, two ironclads are in hand in Government arsenals and two in private yards, three torpedo-boat destroyers are in hand in Government arsenals and two in private yards and two submarines are in hand in Government arsenals. Of the vessels still to be commenced, nine submarines are proposed to be taken in hand in Government arsenals, and one transport is to be built by a private firm. Among vessels which are to proceed with their trials in 1912 may be mentioned eight torpedo-boat destroyers—viz., the Henri, the Herbert, the Bisson, the Capitaine Mehl, the Dehorter, the Francis Garnier, the Commandant Bory, the Commandant Rivière, and nine submarines—viz., the Foucault, the Euler, the Franklin, the Coulomb, the Arago, the Cuny, the Le Verrier, the Clorinde, and the Cornélie. Eight of the submarines in hand are numbered at present from Q 94, to Q 101. They have a displacement of 410 tons each, and are 179¾ ft. long by 17 ft. beam. Their engines work up to 1300 horse-power, and their surface speed is to be 15 knots. Another submarine, known at present as the Q 102, will have a displacement of 520 tons, and will be 200 ft. long by 18 ft. beam. Her engines are to work up to 2100 horse-power, and they are to give her a surface speed of 17½ knots. Two other submarines, the Gustave Zédé and the Néréide, are to have the still larger displacement of 797 tons; they are 246 ft. 4 in. long by 20 ft. beam, and their engines are to work up to 4800 horse-power, and give an estimated surface speed of 20 knots.

NOTES FROM THE UNITED STATES.

Philadelphia, November 23.

Railroad buying has become quite a feature in the market during the past week. The railroad companies have been holding back for months and are now coming forward. Car orders made a larger total for the week than for many months, the figures being 13,000 cars, besides several large inquiries which are being figured on. Orders for rails for the week figure up to something over 100,000 tons. Most of this business is, of course, for next year's delivery. Some mills are almost bare of orders. In a general way prices are about the same as they have been. Crude iron is selling in a fair way, and iron-pipe makers are in the market for large blocks. Foundry irons are under some active inquiry, though the actual orders are of not much consequence.

In finished products there is also greater activity, especially in those lines connected with railroad supplies. This applies particularly to plates and shapes, and the aggregate of orders for these products foot up about 100,000 tons; the most of these has been taken by Western mills. If the present rush should continue, a hardening of prices is regarded as quite probable. Eastern shape and plate-mills have not as yet shared very freely in this improvement. A moderate volume of business is flowing to them. Another reason is that Eastern plate-mills have not dropped their price to the low level prevailing in the West. Competition in steel billets is active, and is keeping prices at the low level. In bar and merchant iron further activity is mentioned. Tin-plate mills have not recovered beyond a 50 per cent. output of total capacity. For two weeks the total of car orders foots up 31,200 cars, as announced to-day. During three weeks more car orders were booked than for the four months preceding.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was quietly steady, and 4000 tons of Cleveland warrants were done at 48s. cash, 48s. 4d. and 48s. 3½d. one month. Closing sellers quoted 48s. 0½d. cash, 48s. 4d. one month, and 48s. 10½d. three months. Buyers of hematite offered 62s. 10½d. one month. In the afternoon there was little doing, but Cleveland warrants remained steady. The turnover consisted of 1500 tons at 48s. cash, 48s. 4d. one month, and 48s. 9½d. three months, and at the close sellers quoted 48s. cash, 48s. 3½d. one month, and 48s. 10d. three months. Hematite was firmer, with cash sellers at 63s. 6d., and one month buyers at 63s. On Friday morning Cleveland warrants were easier, and 3500 tons changed hands at 47s. 10d. cash and 48s. 8d. February 3. The closing quotations became firmer, with sellers at 47s. 11½d. cash, 48s. 2½d. one month, and 48s. 9½d. three months. The afternoon session was quiet, and 2000 tons of Cleveland warrants were dealt in at 47s. 11d. cash and eight days, with cash sellers over at that figure. For the other positions the quotations were 48s. 2½d. one month, and 48s. 9½d. three months sellers. On Monday morning weakness prevailed, and only 1000 tons of Cleveland warrants were done at 47s. 11½d. four days, and 48s. 3d. one month, and closing sellers quoted 47s. 10d. cash, 48s. 1½d. one month, and 48s. 8½d. three months. Hematite was steady and 500 tons changed hands at 63s. cash, with buyers over at 63s. 4d. one month. In the afternoon with Cleveland warrants being offered the prices fell away, and the business amounted to 4500 tons at 47s. 8½d. and 47s. 8d. cash, 47s. 8½d. nine days, 47s. 8d. four days, and 47s. 11½d. one month. Sellers' closing quotations were 47s. 9d. cash, 48s. one month, and 48s. 7d. three months. Hematite was unchanged at 63s. 4d. one month buyers. The market was the turn firmer on Tuesday morning, when 10,000 tons of Cleveland warrants were put through at from 47s. 9½d. to 47s. 9d. cash, from 48s. 1d. to 48s. one month, and from 48s. 7½d. to 48s. 7d. three months. At the close there were sellers over at 47s. 9d. cash, 48s. 0½d. one month, and 48s. 7½d. three months. In the afternoon the tone was easier, and the dealings consisted of 3500 tons of Cleveland warrants at from 47s. 8d. to 47s. 7½d. cash, and at 47s. 11½d. one month, and 48s. 6d. three months, with sellers over at the last two figures, and 47s. 8d. cash. When the market opened to day (Wednesday) weakness prevailed, and Cleveland warrants fell off from 47s. 8d. to 47s. 5½d. cash, and the turnover of 9000 tons included dealing at 47s. 9d. one month, and 48s. 4½d. three months. At the close of the session sellers quoted 47s. 5½d. cash, 47s. 9d. one month, and 48s. 3½d. three months. In the afternoon there was little doing, and Cleveland warrants were a shade firmer. The business consisted of 1500 tons at 47s. 5½d. and 47s. 6d. cash, and closing sellers quoted 47s. 6½d. cash, 47s. 9½d. one month, and 48s. 4½d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 62s. 6d.; Gartsherrie and Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 65s.; Shotts (at Leith), 63s.; and Carron (at Grangemouth), 64s.

Sulphate of Ammonia.—A quieter tone has ruled in the sulphate of ammonia market during the past few days, and the demand is not quite so brisk. The price has eased off slightly, and is now quoted at 14*l.* 5s. per ton for prompt shipments, Glasgow or Leith. The amount exported from Leith Harbour last week was only 20 tons.

Scotch Steel Trade.—The Scotch steelmakers report quite a healthy trade during the past week, and as specifications for plates and angles have been plentiful, the output of these has been large. New business is still being fixed up very slowly, but, all the same, a fair amount of new orders have lately been booked. The demand for light sheets and thin plates and structural sections generally is again very good, and these departments are fully employed. The export trade is satisfactory, and a lot of material is going through. Owing to the adoption of the rebate scheme, the Scotch steel-makers have made an application to the Board of Conciliation and Arbitration for a reduction of 2½ per cent. in the wages of the mill-men and steam-men. At present the wages of the mill-men and steam-men are regulated by the minimum prices fixed from time to time by the makers, while the wages of melters vary in accordance with realised selling prices. The makers are anxious to bring about uniformity in the sliding scale, and propose to alter the basis for mill-men and steam-men to that by which the melters' wages are arranged.

Malleable-Iron Trade.—No change has taken place in the malleable-iron trade of the West of Scotland since last report, except, perhaps, that makers are busier and the various establishments are running full. Specifications are plentiful, but prices are no better than 6*l.* to 6*l.* 2s. 6d. per ton, less 5 per cent. for crown bars. Foreign competition is less active, but the local competition is still as keen as ever.

Scotch Pig-Iron Trade.—A fairly good business continues to be done in Scotch pig iron, both locally and with consumers in the South. The shipping trade is also very fair. Makers' prices are firm, and the recent advanced rates are being obtained. Hematite is still quoted firm at 65s. per ton; and although buyers are only purchasing sparingly, a fair amount of material is going through.

Shipbuilding.—The Greenock and Grangemouth Dockyard Company, Grangemouth, have received orders from Messrs. Hendry, McCallum, and Co., Glasgow, to build a passenger and cargo steamer for Australian owners.—Messrs. John Reid and Co., naval architects, Glasgow, have just given out orders for three tug-boats. They have placed orders for two of them with Messrs. George Brown and Co., Greenock, while Messrs. Alley and McLellan, Limited, Polmadie, have received the order for the third. The latter firm also report having contracted to build two steel lighters, each of 150 tons, for foreign owners.

Steel-Blade Hydrometer.—In a meeting of the Société Scientifique de Bruxelles, held last April, Felix Leconte described an "areometer without meniscus." In the ordinary hydrometer for the determination of the densities of liquids the observations are disturbed by the adhesion of the liquid to the rod or tube of glass. Now, water does not adhere to steel, and, according to Leconte, no meniscus is formed in liquids in which water predominates when a flat strip of steel is inserted into the liquid; that is to say, the line of contact between liquid and steel is straight and in the plane of the surface level. The blade is made of blue steel, which is not likely to rust when it is wiped after each use. The calibration marks are chemically engraved in the steel. Leconte thought that the steel might galvanically be coated with copper and then with gold to avoid all chances of rusting. But he had not tried whether this galvanising might not lead to the formation of a small meniscus.

The Institute of Metals.—The London meeting of the Institute of Metals will be held at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W., on Tuesday, January 16, and Wednesday, January 17, 1912. The meeting will commence on Tuesday afternoon, when the President-designate (Professor W. Gowland, F.R.S.) will deliver his inaugural address on the subject of "Copper and its Alloys in Early Times." The whole of Wednesday, January 17, will, if necessary, be devoted to the reading and discussion of papers on extremely interesting subjects, amongst which may be mentioned the following:—"Properties of Certain Copper Alloys at High Temperatures." by Mr. G. D. Bengough, M.A.; "Further Experiments on the Inversion, at 470 deg. Cent., in Copper-Zinc Alloys," by Professor H. C. H. Carpenter, M.A., Ph.D.; "The Influence of Oxygen on Copper containing Arsenic or Antimony," by Mr. R. H. Greaves; "The Nomenclature of Alloys," by Dr. W. Rosenhain, B.A.; "Poisoned Brass, and Its Behaviour when Heated in Vacuo," by Professor T. Turner, M.Sc.; and a paper by Dr. Carl Benedicks, of the University of Stockholm, dealing with some novel experiments on a zinc-antimony alloy. The last-named paper, the second to be contributed by a foreign member of the Institute in the past three months, will be unique in the literature of British learned societies, as it will contain illustrations in colour reproduced by autochrome (natural colour) photography. From the above it would seem that a capital programme has been arranged, including, as it does, papers of an essentially practical as well as of a theoretical character. There have recently been received so many applications for particulars of membership conditions of the Institute, that the Council has decided that there shall take place shortly a special ballot, so that new members can be elected in time for them to be present as full members at the annual general meeting. The necessary membership application forms can be obtained from Mr. G. Shaw Scott, M.Sc., Secretary of the Institute of Metals, Caxton House, Westminster, S.W. The last date for the receipt of membership application forms in connection with this ballot is December 6.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Midland Iron.—The factors which have retarded prosperity in the iron trade during many months of the present year were detailed at the annual meeting of the Midland Iron Company. For the first few months, up to May, the company did very well. Then the extreme heat of the summer reduced outputs, and trade was further unfavourably affected by the railway strike and the general labour unrest. Otherwise, the chairman said, he thought they would have had a better statement to present, as the figures on the balance-sheet were, on the whole, more satisfactory than last year. As to the future it was difficult to speak with confidence on account of the situation in the labour world, but at present the iron trade was certainly in a very much better condition than it had been for a considerable time.

South Yorkshire Coal Trade.—There is the inevitable falling-off in shipments of steam coal owing to the closing of the Baltic ports, so that the hard-coal market is not now quite so strong. On the other hand, the industrial demand shows no decrease, and although lower prices are being taken in some instances, collieries which are well booked up are asking good figures for supplies for the open market. Railway companies are still buying in the open, but their contracts expire at Christmas, and there is considerable speculation as to what terms they will obtain. Previous quotations were 8s. 9d. a ton, and it is said that the colliery companies are asking a substantial advance on that figure. Gas-coal, both for shipment and inland works, is in steady demand. Slacks are better, and prices have strengthened along with the improving inquiry. Coke is steady. The house-coal position has not changed much, but colder weather has had an improving effect, and things are moving a little more freely. Of course, there are still considerable stocks both at pits and dépôts, but price reductions are being made very cautiously. Last week's official prices, quoted on the local Exchange, were:—Best hand-picked branch, 14s. 6d. to 15s. 6d.; Barnsley best Silkstone, 12s. to 13s.; Silkstone, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. to 11s.; Derbyshire large nuts, 9s. to 10s.; small nuts, 6s. to 7s. 6d.; Yorkshire hards 9s. 3d. to 10s. 3d.; Derbyshire hards, 7s. 9d. to 8s. 9d.; washed nuts, 8s. to 9s.; rough slacks, 5s. 6d. to 7s. 6d.; seconds, 4s. 6d. to 5s. 6d.; smalls, 2s. to 3s.

Iron and Steel.—Pig iron has made a big improvement during the last week or two. The exceptionally active condition of the steel trades has necessarily resulted in a very heavy consumption of iron, and the benefits of this are being appreciated. Prices have moved up all round. Hematites are stronger than they have been for a very long time. Sales of Derbyshire irons have been on a large scale, and Lincolnshire makers are quoting premiums on the Association's figures. The following are the new official quotations:—Hematites, West Coast, 74s. to 76s.; East Coast, 69s. to 70s.; Lincolnshire No. 3, 50s. 6d.; forge, 49s. 6d.; Derbyshire No. 3, 53s.; forge, 50s. Bars are selling at 7*l.*, and sheets from 9*l.* to 9*l.* 10s. Very small stocks only are held of forge and foundry irons. Basic iron is being consumed in large quantities locally, and the furnaces are being extended. Steel scrap has not improved. The march of prosperity in Sheffield trades goes forward without any check. Indeed, every week sees a greater volume of work in the hands of the manufacturers, and that notwithstanding the exceptionally heavy ordering which has been going on now for a couple of months. There is no cessation of activity in the armament departments, and the outputs in the various branches of the heavy trades form a phenomenal aggregate. As illustration of the position of the armament houses, it may be pointed out that the collapse of the big scheme of naval construction in Canada, although it means considerable loss on preliminary work done by the three Sheffield houses, is not such as to interfere with the steady progress of these firms. Inquiries from shipbuilders and engineers are on a big scale; consequently the foundries and forges are fully occupied, and there is great activity amongst the file and engineers' tool-makers. Some of these branches are busier than they have ever been before, and it is satisfactory to note that a fair weight of orders has been received from the Continent, showing that Sheffield-made tools and appliances more than hold their own against the cheaper foreign products. A good deal of inconvenience is still caused to manufacturers by railway delays, which have the effect not merely of delaying delivery of finished goods, but causing urgently needed raw materials to be held up, which is particularly aggravating when makers are working under extreme pressure.

OUR RAIL EXPORTS.—The exports of rails from the United Kingdom do not show any advance during the ten years ending with 1910 inclusive. The movement and value of the shipments during each of the ten years were:—

Year.	Tons.	Value. £
1901	466,607	2,736,264
1902	583,543	3,173,203
1903	604,076	3,212,700
1904	525,371	2,544,289
1905	546,569	2,731,854
1906	460,328	2,591,363
1907	429,161	2,806,096
1908	452,521	2,769,344
1909	580,215	3,357,010
1910	482,327	2,825,504

It will be observed that last year's shipments were below those made in 1902, 1903, 1904, 1905, and 1909. The stagnation observable in the exports is, no doubt, attributable to the German and American competition which has now to be faced.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—After the recent heavy buying in Cleveland pig iron there is a lull. Purchasers of Cleveland are once more indisposed to operate, and values are easier. The downward movement, however, is not due to any adverse influences in the legitimate market, but is in consequence of a fall in warrants caused by holders having decided to take their profits and selling out rather freely. This speculative movement is not expected to keep prices of makers' iron down; nevertheless, for the time being it checks business, as genuine buyers of pig will not, in a falling market, place more orders than are necessary to meet early requirements. Producers as a rule quote 48s. for early f.o.b. delivery of No. 3 g.m.b. Cleveland pig, but buyers are not prepared to pay any such figure. Second hands have accepted as low as 47s. 9d. for small odd lots, and even that figure might now be shaded. No. 1 is 51s. 6d. to 51s. 9d.; No. 4 foundry, 47s. 3d.; No. 4 forge, 47s.; and mottled and white iron, each 46s. 9d.—all for early delivery. The hematite branch of the staple industry continues steadily to improve. There are no hematite warrants to hamper this branch, and so good has been the demand of late that makers' stocks are said to have almost disappeared. Mixed numbers of East Coast hematite are up to 62s. 6d. for early delivery. Foreign ore is firm, and promises to be dearer. Market rates are based on fully 21s. ex-ship Tees for best Rubio. Coke is in good request, with a continued heavy local consumption. Average blast-furnace kinds stand at 15s. 3d. delivered here.

Stocks and Shipments of Pig Iron.—It is understood that makers have now practically no stocks of pig iron. Those of hematite are said to have been cleared out, and the only stock of Cleveland is the 558,000 tons in the public warrant stores. During November Cleveland pig has been withdrawn from the public warrant stores at the rate of about 750 tons per working day. Shipments of pig for November come up to expectations, averaging 4000 tons per working day. For the previous month the daily average was 4420 tons, and for November last year 4110 tons.

Manufactured Iron and Steel.—Very satisfactory and encouraging reports continue to be given of all branches of the manufactured iron and steel industries. Not only have firms made excellent contracts, but orders are still coming in. Values are not quotably changed, but advances are anticipated. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 7s. 6d. to 6*l.* 10s.; iron ship-angles, 7*l.*; iron girder-plates, 6*l.* 15s.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel boiler-plates, 7*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel strip, 6*l.* 10s.; steel joists, 6*l.* 7s. 6d. to 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 24 gauge, in bundles, 11*l.* 5s.—sheets less 2½ per cent. f.o.b., railway material net, and all other descriptions less 2½ per cent. discount.

Ironworkers' Wages.—According to the accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England, the average net selling price of iron rails, plates, bars, and angles for the two months ending October 31 last was 6*l.* 5s. 3.25d. per ton, as compared with 6*l.* 6s. 5.63d. for the previous two months; and, in accordance with sliding-scale arrangements, finished-iron workers' wages for December and January will be the same as prevailed during the preceding two months.

TIN-PLATES.—This year has witnessed a great falling off in the demand for British tin-plates in Canada. In the last nine months of 1910 the imports were 429,697 tons, or 47,744 tons per month. In the seven months ended July 31, this year, they declined to 170,757 tons, or 24,394 tons per month. While this decrease has been taking place in the imports of tin-plates from Great Britain, American deliveries have largely increased.

THE "NATIONAL REVIEW" OF CHINA.—At this time, when public attention is being directed towards developments in China, the issue of a special number of the *National Review* of China, published at Shanghai, should prove particularly opportune. The present movement is mainly one for reform from the inside, with a view to greater progress along the lines of modern civilisation. The probable future developments, if this reform movement is successful, can to some extent be gauged by the wonderful changes that have taken place in recent years, in spite of all hindrances. In 1896 China possessed but 370 miles of railway. To-day she has nearly 6000 miles in operation, while schemes in prospect or under construction amount to 14,000 miles more. Thus, within a short space, China will probably have produced a railway system of a size similar to that which it occupied India no less than forty-three years to build up. The special October issue of this review is devoted to China's railways, and will well repay study by those interested in such development. In various articles the systems are surveyed, and articles are also devoted to the special undertakings, such as the Imperial Railways of North China, the Tientsin-Pukow Railway, the Shanghai-Nanking Railway, and others. An inset takes the form of a railway map of China, showing the existing lines, as well as those under construction and proposed. The review is procurable from the Far Eastern Advertising Agency, Limited, Craven House, Kingsway, W.C., at 2s., post-free.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The position of the steam-coal trade has been improved by substantial tonnage arrivals, but there are now complaints that loading facilities are not sufficient to provide for current requirements. Cardiff tippers have decided not to proceed with a threatened strike, and this, of course, has given satisfaction to all engaged in the coal trade; some anxiety is still felt, however, as to the course likely to be taken by local railway men. The best Admiralty large steam-coal has made 17s. to 17s. 3d. per ton; secondary qualities have ranged between 15s. and 16s. 9d.; best bunker smalls between 8s. and 8s. 6d.; and cargo smalls between 6s. and 6s. 9d. per ton. The house-coal trade has shown scarcely any change; the best ordinary qualities have made 14s. 6d. to 16s. 6d.; No. 3 Rhondda large, 17s. to 17s. 6d.; and smalls, 9s. 9d. to 10s. per ton. No. 2 Rhondda large has been quoted at 12s. 3d. to 12s. 6d.; and smalls at 6s. 3d. to 6s. 9d. per ton. Foundry coke has made 17s. 6d. to 20s.; and furnace ditto 15s. 6d. to 16s. 6d. per ton. As regards iron ore, Rubio has brought 19s. 6d. to 20s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

More Welsh Coal.—The "black vein" seam of coal has been struck at the Bedwas Navigation Colliery, at a depth of 780 yards. The seam is about 7 ft. in thickness, and of excellent quality. Mr. Ivor Williams, formerly of Bargoed, had charge of the mechanical operations, and Mr. F. Piggott (Caerphilly) carried out the sinking contract. The new shafts are 21 ft. in diameter. The total area of the takings extends to over 2000 acres, and the ground taken up for an engine-house and other surface arrangements is about 36 acres. An important development is reported in the Llanelly coal-field. For the past three years Mr. Evan Jones, Penmount, has been carrying on sinking operations at the Crown Colliery, Pwll. Mr. Jones persevered, and a few days ago his efforts were rewarded by the finding of the Cwmmawr seam. Sinking operations carried on at the Trane pit, Gilfach Goch, recently acquired by Mr. D. A. Thomas and Mr. Leonard W. Llewelyn, have resulted in the discovery of the 6-ft. seam, at a depth of about 400 yards, in the same shaft where a few weeks ago the Foot-foot seam was won.

Tredegar Iron and Coal Company.—The directors of the Tredegar Iron and Coal Company, Limited, have decided to pay an interim dividend of 2½ per cent., or at the rate of 5 per cent. per annum, on the "A" and "B" shares, The shareholders in the Tredegar Company are being offered at par 150,000*l.* 5 per cent. first mortgage debentures, which the company is issuing in connection with the development of the Oakdale Navigation Collieries. The debentures will be secured on the uncalled balance of the ordinary shares, amounting to 152,000*l.*, and also upon the whole of the Oakdale property, comprising 2900 acres of minerals, upon which the sinking of three pits has been completed.

New Cruiser for Pembroke.—The keel-plates of a new unarmoured cruiser of the Boadicea class have been laid down at Pembroke Dockyard. The new ship will be the seventh ship of the Boadicea class built at Pembroke, the preceding vessels having been the Bellona, the Blanche, the Blonde, the Active, and the Amphion. The first vessels carried a main armament of six 4-in. breech-loading guns, which has been greatly augmented in later ships. The new ship will also have two 22-in. torpedo-tubes, while the earlier vessels had two 18-in. tubes. The turbine-propelling machinery of the new cruiser will be of 18,000 horse-power, and the estimated maximum speed of the ship is 25 knots. The principal dimensions of the new cruiser will be:—Length between perpendiculars, 385 ft.; extreme breadth, 41 ft. 6 in.; displacement, 3360 tons.

ANKER MILL, NUNEATON, BOILER EXPLOSION.—The formal investigation ordered by the Board of Trade to be held in this matter is fixed for hearing in the Court-room, Police Court, Nuneaton, on Tuesday, December 12, at 11 a.m.

THE AIR RESISTANCE OF WIRES AND ROPES.—With reference to the article in our issue of October 20, page 548, entitled "Communications from the Göttingen Model-Testing Institute," the author, Dr.-Ing. Otto Föppl, asks us to add that the results of experiments on the air resistance of wires and ropes, given in the *Zeitschrift für Flugtechnik*, are only to be considered in the light of a provisional abstract. The complete data concerning the results of tests with wires are published in the *Jahrbuch der Motorluftschiff-Studien-Gesellschaft*, 1910-11 (Julius Springer, Berlin), which appeared in July, 1911.

AMERICAN CONTRACTS.—Some important American contracts have been let for 1912. One of these relates to the main arch and two approach-spans of the New York Connecting Railroad Bridge, which will involve the use of 36,000 tons of steel. Other approach-work will also require 54,000 tons. The connecting-bridge will be a monumental work, it being in the nature of a gateway to Long Island Sound. The bridge is a connecting-link between the New York, New Haven, and Hartford Railroad and the Pennsylvania Railroad. The link line will be 12 miles in length, and the steel viaduct forming the bridge part is to provide for four tracks of rails laid on stone ballast so as to diminish noise. A Pennsylvania mill will furnish plates for five American Hawaiian steamers to be built at Sparrow's Point, Maryland. Recent car orders have brought business to the plate and structural mills, and an Indiana car plant has been started up.

THE RISORGIMENTO FERRO-CONCRETE BRIDGE (HENNEBIQUE SYSTEM), ROME, OVER THE RIVER TIBER.

(*For Description, see Page* 721.)

Fig. 14. Completed Ferro-Concrete Staging.

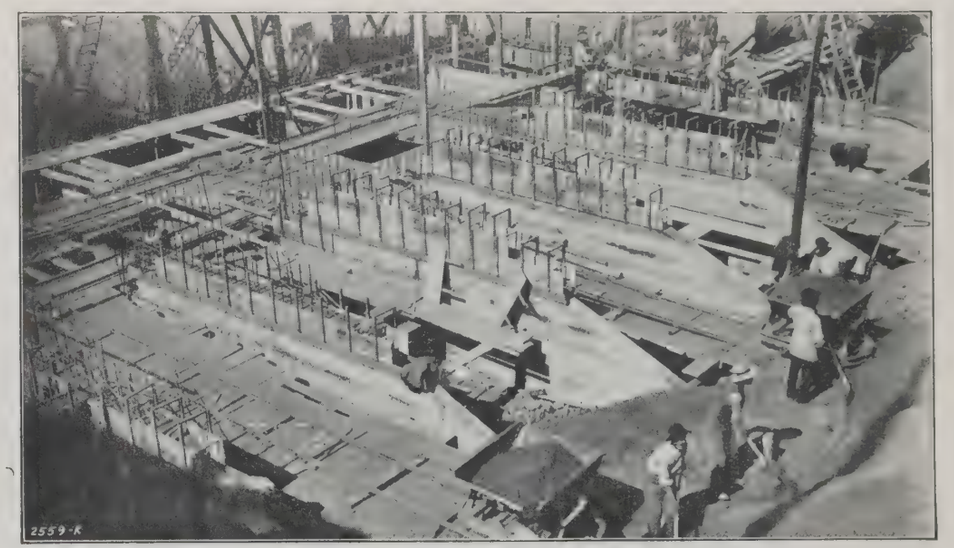


Fig. 16. Haunch under Construction.

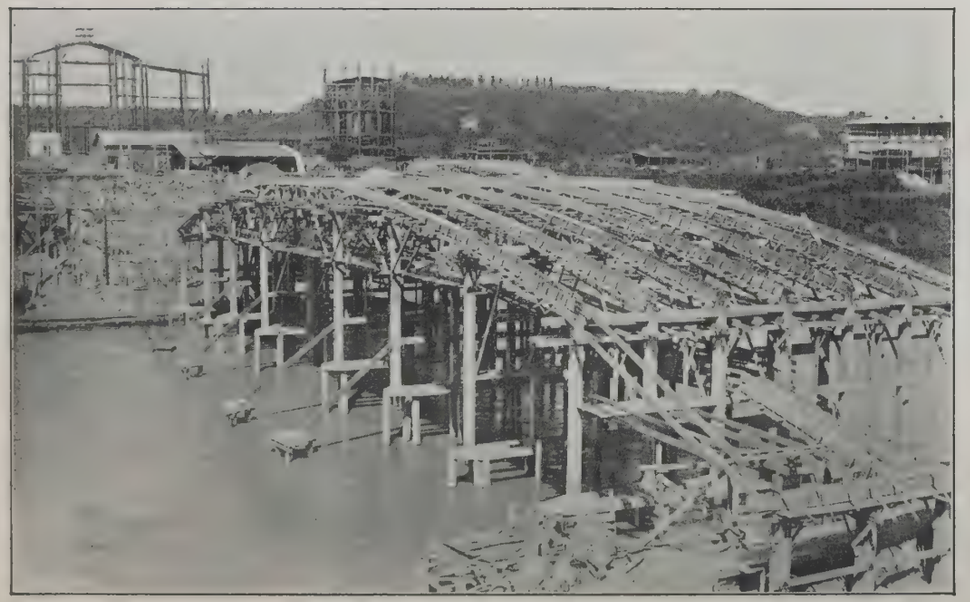


Fig. 15. Ferro-Concrete Staging under Construction.

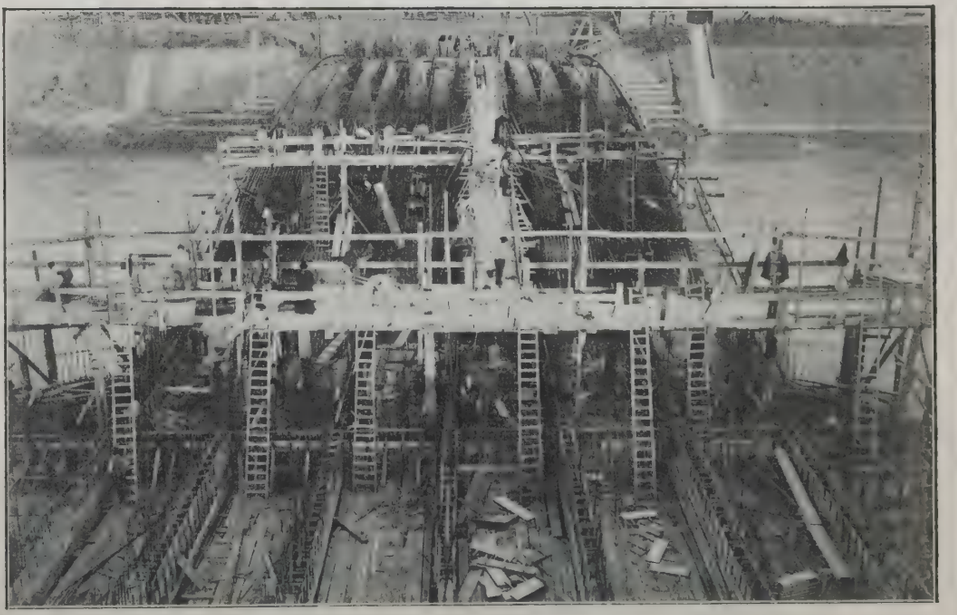


Fig. 17. Arch under Construction.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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For all other places abroad—			
Thin paper copies	£1	16	0
Thick ,,	£2	0	6

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

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NOTICES OF MEETINGS.

THE GEOLOGISTS' ASSOCIATION, LONDON.—Friday, December 1, at 8 p.m., at University College, Gower-street, W.C., when the following paper will be read:—"Note on a Maxilla of Triconodon from the Middle Purbeck Beds of Swanage," by Mr. Arthur Smith Woodward, LL.D., F.R.S., Sec. G.S. The following lecture will also be delivered:—"On Prehistoric Paintings and Drawings in the Caverns of Northern Spain," by Mr. Arthur Smith Woodward, LL.D., F.R.S., Sec. G.S. The lecture will be illustrated with lantern views.

THE ROYAL INSTITUTION.—Monday, December 4, at 5 p.m., General Meeting.

THE ROYAL SOCIETY OF ARTS.—Monday, December 4, at 8 p.m. Cantor Lecture. "The Carbonisation of Coal," by Professor Vivian B. Lewes. Lecture II.—"The Methods Employed in the Destructive Distillation of Coal."—Wednesday, December 6, at 8 p.m. "British Guiana and its Founder, Storm van's Gravesande," by Mr. J. A. J. de Villiers, Hon. Secretary of the Hakluyt Society. Lord Reay, G.C.S.I., G.C.I.E., will preside.

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, December 4, at 7.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. A paper will be read on "The Design of Tall Chimneys," by Mr. Henry Adams, M.I.C.E., M.I. Mech. E., M.I.E.E., Past President of the Society of Engineers and of the Civil and Mechanical Engineers' Society.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 5, at 8 p.m. Paper to be further discussed:—"Electric Lighting of Railway-Trains: The Brake-Vehicle Method," by Mr. Roger Thomas Smith, B.Sc., Assoc. M. Inst. C.E.—Students' visit, Wednesday, December 6, to the Liverpool-street Extension Works of the Central London Railway.

THE RÖNTGEN SOCIETY.—Tuesday, December 5, at 8.15 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. Paper by Professor W. H. Bragge, M.A., F.R.S., The University, Leeds, "The Energy of the X-Ray."

THE FARADAY SOCIETY.—Wednesday, December 6, at 8 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. The following papers will be read;—"A Redetermination of the Density and Coefficient of Linear Expansion of Aluminium," by Mr. F. J. Brislee, D.Sc. "The Solution Volumes of Nitric Acid," by Mr. V. H. Veley, F.R.S. "The Influence of the Physical Condition of Metals on Cathodic Over-Voltage," by Mr. J. N. Pring, D.Sc., and Mr. J. R. Curzon, B.Sc. "Notes on Thermostats," by Professor Hugh Marshall, D.Sc., F.R.S. "Notes on Two Thermo-Regulators," by Mr. W. R. Bousfield, M.A., K.C. "Notes on Thermostats and Devices Used in Connection with Thermostats," by Mr. A. C. Cumming, D.Sc.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 7, at 8 p.m. Ordinary general meeting:—"Notes on National and International Standards for Electrical Machinery," by Dr. R. Pohl.

THE BRITISH FOUNDRYMEN'S ASSOCIATION: LONDON AND DISTRICT BRANCH.—Friday, December 8, at 8 p.m., at Cannon-street Hotel, E.C. Mr. Thomas Turner, M.Sc., Assoc.R.S.M., F.I.C., Professor of Metallurgy, University of Birmingham, will read a paper on "Solidification of an Iron Casting in the Mould."

THE INSTITUTION OF WATER ENGINEERS.—Friday and Saturday, December 8 and 9, in the Rooms of the Geological Society, Burlington House, W. The following papers have been promised for reading and discussion, in addition to the other items on the programme:—1. "Water-Works Management," by Messrs. Easton Devonshire and William Matthews. 2. "Portland Cement on Public Works," by Mr. Gerald Thornhill Edwards. 3. "The New Water Works for Skegness," by Mr. Percy Griffith. Friday, December 8, at 4 p.m., a report on "Future Water Legislation and the Position of the Institution in Regard Thereto," prepared by the Water Areas and Statistics Committee, and approved by the Council, will be read, and, after discussion, submitted for adoption by the members. Saturday, December 9, at 10.30 a.m., reading of papers and discussions thereon.

ENGINEERING.

FRIDAY, DECEMBER 1, 1911.

COMPROMISE IN ENGINEERING.

EXCEPT in morals, ethics, and justice, compromise is always commendable, and even in these three departments of life it cannot often be neglected. For instance, justice without mercy may work more harm than it cures. In all problems of life and activity compromise is a factor which affords and yields the most beneficial and acceptable solution, while the rejection of it generally entails incomplete success in material matters and often discontent in personal affairs. So accurate and far-reaching is this statement that examples will crowd upon the reader's mind. The multiplicity of cases which provide illustrations of the penalties which follow non-compliance with the condition proves that there is an ever-pressing need for enforcing the desirability of compromise. In life, as the philosopher has put it, "we have to deal with good principles that cannot be pushed to their full logical results—with varying standards which cannot be brought under inflexible law." How true this is, for instance, of the Insurance Bill of the Government, and how illuminating the example it affords, in the attitude of the promoters, of the lack of recognition of necessary limitations. The failure to practise compromise, even where "good principles" are involved, may defeat the realisation of a great and beneficent scheme. Then there are also the difficulties of the relations of capital and labour, where "different kinds of interests not only blend but also modify, and in some degree counterbalance, each other," so that there become necessary "constant compromises in which the lines of definition are seldom very clearly marked, and in which even the highest interest must not altogether absorb or override the others." As matter of fact, labour difficulties are only overcome eventually by compromise, and it is matter for regret that in most cases this spirit is not fully awakened before time is lost, wages forfeited, capital laid idle, and relationships embittered.

In following engineering practice the same need exists for compromise. In this fact, indeed, one finds some justification for the appointment of laymen as the responsible authorities in the management of engineering and other works engaged in the production of highly specialised manufactures. "Men of affairs," by reason of their detachment from purely scientific pursuits, are often able to take a broader view, and to embrace commercial considerations more fully in their scheme of control. It is accepted that the temperament which characterises an inventor, and his continuous search for improvements, may be inimical to business prosperity. Many men could be named whose material reward has been in inverse ratio to their great services to science. The cause is often to be found in this conflict in character. The striving after perfection or of the highest efficiency induces the pure scientist to delay commercial manufacture or repeatedly to alter designs or processes, and thereby indefinitely to postpone reward to capital and inventor. Moreover, he becomes engrossed in design to the disadvantage of workshop supervision. We have known of a case of serious delay in an Admiralty contract due to the obsession of the manager in the design of a special machine-tool and the consequent neglect of the work in progress in the shops. Where, however, the engineer combines the two important elements in manufacturing success—originality in technique and design and commercial capacity—the result is better than where the experience is one-sided. The important point is that neither element must be cultivated to the exclusion of the other, in other words, there must be compromise.

There is the greatest need for the necessity of compromise being constantly kept in view in the case of youth, when enthusiasms are most intense. Encouragement must not be withheld, because without it initiation can scarcely survive, but success is, nevertheless, dependent largely upon the subjection of enthusiasm to reason—in other words, to a broader, common-sense view than is possible where the motive is purely scientific.

For this reason, Mr. J. R. Richmond, of the firm of Messrs. Weir, of Cathcart, did useful service in enforcing the importance of compromise when delivering the presidential address to one of those societies of young engineers which is doing useful work in stimulating enthusiasm and study. He himself combines in well-balanced measure technical and commercial knowledge, and was therefore able to enforce his argument from the standpoints of both fields of activity, and many of his illustrations were most apt. At the present time much is being done in order to increase the thermal efficiency of engines by the use of feed-heaters, superheaters, and the like. We must not for a moment be considered as depreciating the efforts made in such direction when we agree with his enforcement of the view that the gross result from the financial point of view must be considered along with, or, indeed, in preference to, the net result in thermal efficiency. What must be considered is not alone the economy in fuel realised, but also the effect of the additional units of machinery, and the greater care and complication involved in manufacture, with their consequent additional prime cost and maintenance charges, and also the need for higher-paid supervision. He mentioned the case of a Continental type of engine fitted with a tubular feed-heater, superheater and poppet-valves running on test at a consumption of steam per indicated horse-power per hour which looked most attractive when compared with the British standard stationary-engine steam consumption, more than twice as great. But, as he pointed out, the simpler machine for ordinary work may in the end give the most satisfactory and commercially sound compromise, particularly as the Continental engine reaches its high efficiency only when all the contributory elements are respectively working at their most effective loads; otherwise any inefficiency involves a rapid decrease in economy. Thus the high-grade combination must be pronounced as less elastic.

Another instance is to be found in the present tendency towards exceptionally high vacua in ordinary steam-engines. With the coming of the steam-turbine, it was recognised that high vacua

yielded a sound financial economy, and there arose a tendency to seek for the same result without the most important variant, the great range of expansion of the low-pressure turbine, and without considering whether the extra cost was balanced by, or gave a surplus in favour of, the over-all economy. Mr. Richmond points out that the usual proportions in the passages and valve ports of the ordinary commercial engine will not permit of any advantage being taken in the low-pressure cylinder from the higher vacuum ; but even assuming that the eduction path of the steam is increased as far as practicable, the additional condensation, due, firstly, to additional surface, and, secondly, to the greater temperature difference, introduces a qualifying factor of a negative kind. Consideration has also to be given to the increased volume of circulating water required, and to the larger circulating-pump and increased driving power for the same. Moreover, increased vacua necessitates a low hot-well temperature. This, again, raises the question as to whether there is sufficient surplus of auxiliary exhaust steam to heat the feed-water of the hot-well to the temperature corresponding to the hot-well in the case of low vacuum. All these considerations, it will be seen, point to the importance of collateral questions being very carefully considered.

Indeed, the marine steam-engine of to-day is what it is owing to the influence of compromise, guided, of course, by experience. For instance, purely theoretical considerations pointed to the gain in economy from very high boiler pressures and large ranges of expansion in successive stages in multiple cylinders, but the consideration of difficulties due to weight of material and cost in boiler construction, as opposed to the measure of financial gain realisable, has resulted in moderate pressures being adopted—more moderate even than those advocated ten or fifteen years ago. Nor has the steam-turbine involved any departure from the middle course already accepted. In connection with this latter, a compromise of another nature has had to be introduced—namely, in reference to revolutions. The highest efficiency with the turbine is only attained when the blade speed approximates a definite and known ratio to the velocity of the steam. To reduce the rate of revolution of the propeller satisfactorily without affecting the blade speed of the turbine would have involved many objectionable features. For instance, the greatly increased diameter of the turbine to give efficient blade speed with a favourable rate of revolution would have added enormously to weight, space occupied, and prime cost. Thus a compromise has been made, and the result is a good combined efficiency. Those responsible for the design of turbines and propellers are nevertheless tackling the problem from a new standpoint, and, as is known, Sir Charles Parsons is working on experiments on a large scale in order still further to increase the combined efficiency of the turbine and propeller.

In other departments of engineering the same spirit of compromise is essential, and in none more than in organisation. Mr. Richmond devoted a large part of his address to "motion study" and "the principles of scientific management." Into this question we do not propose to enter specially in this connection, but he found support for his view as to the need of compromise in the extreme views of the advocates of these systems. Beyond a definite point, economic loss ensues through the multiplication of costly supervision and expert skill. The new system indeed "represents pretty much what every wide-awake shop manager has been doing for years past, but the main ideas are carried beyond the limits of practical application, and hold out to the young engineer promises which cannot be fulfilled." Similarly with the cost department, there is a tendency to excess in forms and cards and multiplication of data. We have heard, for instance, of a case where a new system was devised, resulting in the destruction in the workshop boiler of 7 tons of printed material—cards, &c. The question which naturally arises has reference to the economic advantage from such change, particularly as it involves the education of all workmen, as well as experts. As Mr. Richmond points out, the initial purpose of a costing system is to give the cost of the product as a whole, and this may be developed into giving costs of component parts, and so indicating lines of investigation and of improvement in shop methods. But even in the best system compromises are constantly made, and must continue to be made. To weigh, for example, the cuttings, borings, and turnings of individual pieces of a brass-finishing department, in order to credit each with the cost of such turnings and cuttings, would obviously occupy so much time, labour, and handling as would make the actual accuracy and utility of the data disproportionate to the cost of obtaining them. In reference, again, to the routeing and tracking of material through successive shops, elaboration may be reduced by taking account, not of the bulk of the work, but only of those particular items of contracts about which information is immediately required. Another case where compromise is introduced is in connection with the charging of draughtsmen's wages against a job. There are classes of work in which the advantage of this is infinitesimal compared with the labour necessary to attain it. In the same way, in the foundry, where the product is of a uniform character, it is of little value to know the cost of separate castings when there is available the cost of the total output per hundredweight. Indeed, there is practically no limit to the instances which might be given of the value of compromise, in methods of costing and of organisation, and particularly of resisting the temptation to ride a hobby-horse to the neglect of other profitable pursuits. Enough, however, has been said to guide thought in a direction which is attractive because of the breadth of view which is presented, and of the efficacy of the result, reflective as well as direct.

THE DIMINISHING ARTESIAN WATER SUPPLY OF AUSTRALIA.

The great artesian basin of Eastern Australia is said to be the largest at present known in the world. Its supply furnishes a considerable portion of the water required in the north-west of New South Wales and the west of Queensland for stock-raising in ordinary times, and is indispensable during the periodical droughts which occur owing to scanty direct rainfall. As tillage in the Eastern Australian States is gradually moving westwards to meet the increasing demands of the world's wheat supply, and as irrigation from artesian sources in the comparatively dry west has been expected to supply the means, a decrease in the quantity of flow, which has lately been observed, has given rise to some anxiety.

In order that the situation should be understood, it is necessary that an outline of the topographical conditions of the basin should be given. Its area, which covers about 570,000 square miles, is in form a very roughly shaped equilateral triangle, with its apex to the north, this apex being extended in a narrow tongue about 600 miles long, and 50 to 100 miles wide right up to Cape York. The north-eastern side of the triangle is approximately parallel to the Pacific Coast and about 100 to 200 miles from it, this rainy coastal belt forming the chief of the intake beds. The base of the triangle runs from Dubbo, in New South Wales, generally westerly to meridian 133 deg. west longitude in South Australia, while the north-west side runs in very zigzag fashion to near Cloncurry, in Queensland. There are 376,000 square miles in the latter state, 90,000 in South Australia, 20,000 in the Northern Territory which is now administered by the Commonwealth Government, and 84,000 in New South Wales. It is in the latter, however, that the greatest amount of water is being drawn, and it is the Government and scientific authorities of the mother-state who have principally raised the question of diminishing supply, and have, so far, dealt with it.

The first actual discovery of artesian water in the basin was in 1879, in the north-west of New South Wales, a supply being obtained at a depth of 140 ft., which rose in pipes to a height of 26 ft. above the ground ; but the Kerribee bore, in the Bourke district, 1073 ft. deep, yielding 350,000 gallons per day, was the first to demonstrate the success of artesian boring on an extensive scale. Since then a large amount of this sinking has been done with successful results in that State and in Queensland, both by Government and by private effort. In one bore at Boomi, in New South Wales, where the depth is over 4000 ft., the discharge amounts to 1,428,640 gallons per day, the temperature of the water being 132 deg. Fahr. The deepest bore is in Queensland, at Bimerah, reaching 5045 ft. ; while the well yielding the greatest volume of water is at Charleville, in the same State, where over 3,000,000 gallons flow per day. We have not heard whether, as to these particular wells, these figures, which are, we believe, the latest on record, have suffered diminution more recently, in harmony with the observed decrease elsewhere, which has given occasion to investigation.

This decrease has been especially noted in the Coonamble district of New South Wales, while, some years ago, similar symptoms began to show themselves in parts of Queensland. As far back as October, 1906, a perceptible diminution was noted, and in a paper read before the Sydney University Engineering Society, Mr. Percy Allan, M. Inst. C.E., principal assistant engineer, Water Conservation Department, N.S.W., accounted for the check in the flow as due "to the water-bearing strata before tapping being in a fully charged condition, with an impeded flow under high pressure, which, when released, gives off its maximum quantity with a gradually decreasing flow and pressure until the discharge becomes a question of the velocity with which the water from the drainage area within the influence of the bore will travel through the interstices of the water-bearing strata." Hence, Mr. Allan argued that the flow would soon become normal and continue so.

Recent facts, however, do not appear to admit of this explanation. For example, in the Coonamble district 130 bores that had originally a flow of 62,000,000 gallons daily now only have an output of 38,500,000 gallons. Professor David, Sydney University, and Mr. L. A. B. Wade, M. Inst. C.E., Chief Engineer for Irrigation, New South Wales, were accordingly deputed to investigate. Pending this action, an application to Government was made for permission to sink six new bores in the Coonamble district for the purpose of irrigation. Hitherto, except on a very small scale, the bores in New South Wales have been used for watering stock only. The result of the professor's evidence in the latter inquiry, as well as that of the one already started—and in both he is supported by the Government Geologist, Mr. E. F. Pittman—was that there was no need of serious apprehension that the artesian basin was other than permanent. Doubts had been expressed originally by Professor Gregory, formerly occupying the chair at Melbourne, but now in Glasgow, as to the character of the supply. He argued in his book, "The Dead Heart of Australia," from the nature and amount of minerals dissolved in artesian water, and from the water's temperature, that it was derived, not from soakage, but from geyser springs which came up from great depths. Such water he termed "plutonic," to distinguish it from rain water.

We might remark, *passim*, that some of the water of very high temperature met with in the piercing of the Simplon Tunnel was deemed to be plutonic, water that had never seen daylight. (See Minutes of the Proceedings of the Institution of Civil Engineers, vol. clxviii.) Professor Gregory argued that, as the result of the flow underground of such springs for hundreds of thousands, possibly millions, of years, the porous strata had become saturated with this plutonic water, which was forced to the surface by the expansion of compressed gas when the bores were put down. The discovery of a remarkable tide affecting the water of a sub-artesian well at Urisino, in New South Wales, seemed to him to support his argument, as he considered that the tide was due to the alternate formation and condensation of steam at a depth in connection with the deep-seated geyser. Elsewhere in the same book Professor Gregory points out that as the basin has only a narrow shallow lip to the north, the deep central waters are old accumulations, which are not inexhaustible. Mr. Pittman, on the other hand, argues that any accumulation of water, whether underground or on the surface, must eventually become salt unless it has an outlet, since the water will continue to dissolve saline matter from the rocks or soil. It is reasonable to conclude, therefore, he says, that all artesian wells from which potable water is obtained must have leakage either direct to the ocean or through valleys of denudation which have cut through the overlying strata and exposed the porous beds. It follows, therefore, that such basins must be of the character called hydraulic, rather than hydrostatic.

As to the question of tides, Professor David showed that tidal phenomena in artesian basins were not unknown elsewhere in areas where it had never been suggested that the source of the water was other than that of local rainfall. It

was further shown that, as to the wells, there was a definite hydraulic grade in a south-westerly direction—that is to say, away from the chief intake. The height to which the water rises in the bores gradually decreases from about 1400 ft. above sea-level, in Queensland, to 700 ft. at points between Coonamble and Bourke, in New South Wales. Close to the shores of the Gulf of Carpentaria, at Normanton, artesian bores yield plentiful supplies of perfectly fresh water. Inasmuch as these porous sandstones, which are there some 2000 ft. below sea-level, continue out a great distance under the sea, they must sooner or later pass upwards into the sea floor; and were there not a continuous flow through these strata of fresh water forced through them by the pressure of the head of water in the high-lying intake beds, the sea-water would flow back into these porous beds, and so saturate them for some distance inland with salt water. In evidence of this, Dr. R. L. Jack, former Government geologist of Queensland, had called attention to the fact that a marked difference had been observed in the appearance of the sea many miles out from the shores of the Gulf of Carpentaria. A bucket was lowered into the sea, and the water brought up was found to be practically fresh. The conclusion was that this was due to the waters rising from openings coming from the outlet beds of the artesian basin in the floor of the gulf.

The weight of geological fact and opinion seems, therefore, to be against the plutonic theory of the origin of the water, and as ordinary artesian conditions prevail, the decline in supply seems to point, as Messrs. David and Wade imply, to local obstruction at the outfalls. Some time ago it was found that the steel casings of many of the bores were becoming seriously corroded, a condition which would, no doubt, affect the discharge, and the Government accordingly made inquiries as to the desirability, from this point of view, of substituting casings of other material, especially of what is called American ingot iron, which is more or less proof against corrosion. But a more likely cause of obstruction has been suggested by Mr. Wade, who thinks that the pores in the artesian sandstone may have gradually become plugged up as the result of the flow of artesian water into the pipes at the bottom of the bore for a long period of time. Also, it is thought that the slots, by means of which the water is admitted into the pipes from the artesian beds, may have become choked with rock débris.

As to the effect of corrosion, it has been made known that in the few instances where the casing has been renewed in bores in which a decline has been noted, the yield has not been increased as a result of re-lining. Professor David has suggested, as a test of the correctness of Mr. Wade's theory, that a new bore should be sunk not far from one in which a falling off had been noticed, and a measurement taken to see if the flow from the new one was, or was not, equal to the original flow of the first bore, the latter being plugged during the trial.

The question of gas pressure as an agency in the velocity and amount of the outflow has been raised and is being now specially investigated by Mr. Wade; but in this regard the following quotation may be made from a paper read before the Royal Society of New South Wales on "Irrigation Geologically Considered, with Special Reference to the Artesian Area of New South Wales," by Messrs. E. F. Pittman, Assoc. R.S.M., and T. W. Edgeworth David, B.A., F.R.S., July 20, 1903:—

"A distinguishing feature of the artesian water obtained from bores in New South Wales is a strong odour of sulphuretted hydrogen, which is very noticeable in the water when it first issues from the bores, but which speedily passes off after exposure to the atmosphere. Mr. Hamlet, Government analyst, however, states that, after visiting a number of the bores and subjecting the water to careful tests, he was unable to obtain any reaction for that gas or for free sulphuric acid. With the exception of the Ballimore bore, near Dubbo, which yields a flow of carbonated water, none of the bores in this State are known to evolve free carbon oxide. We have, therefore, at present, no evidence to show that gas pressure plays a part in the rise of the artesian water of New South Wales."

Much information on the geological and other features of this great basin is to be obtained from this lengthy paper, which is to be found in vol. xxxvii. of the Society's Transactions.

Assuming artesian conditions, the enormous quantity of water available, with reasonable deductions, from the intake, as compared with the yield at its highest, precludes any idea of the multiplication of the bores affecting the supply to any appreciable extent. There is, however, an undoubted diminution of flow, and to account for it we have the two hypotheses of release of gas pressure, and local impediments to flow. Whether any of the causes suggested in this article for the decline in the flow prove to be correct or otherwise, engineers having to deal with artesian supply will look forward to the solution of the problem with considerable interest, and this more especially as the increased utilisation of a large amount of highly fertile country in providing more food, from the British Empire, for us and other nations, is in question.

MAGNETIC PROPERTIES OF HEUSLER ALLOYS.

THE accidental discovery by Dr. Heusler in 1901 that certain manganese alloys, composed of copper, manganese, and aluminium were magnetic, led to a general investigation of their properties. Some time after the original discovery, it was found by Dr. Heusler, W. Stark, and E. Haupt, that a copper-manganese alloy was not magnetic, but when zinc, arsenic, antimony, bismuth, or boron were added, it gained a certain amount of magnetism; while the addition of aluminium produced a good ferro-magnetic alloy. It was also found that the most magnetic alloy was formed when the manganese and aluminium were in the proportion of their atomic weights—namely, manganese, 25 per cent.; aluminium, 12.5 per cent.; and copper, 62.5 per cent. It was not till after 1904 that these alloys received much attention in this country, but since then several experimenters have been at work upon them, and up to the present time some specimens having especially good and uniform mechanical properties have been made. It was first made certain that the materials used were quite free from iron, cobalt, and nickel, although there was some carbon. In some tests carried out last year at the University of Illinois, Urbana, Illinois, U.S.A., an account of which is given by E. B. Stephenson in Bulletin No. 47 of the University, much care was taken in the casting and preparation of the specimens. The melting crucible was a new clay-graphite one, and the manganese and copper were put in first, the aluminium being added when they were thoroughly fused. The pouring of the metal into vertical moulds was quickly done, twelve specimens being prepared, each 35 cm. long and 1 cm. in diameter. These specimens were tested magnetically as cast and again after grinding, which latter process had no effect on their magnetic properties. A variety of tests were carried out, particulars of which we cannot here give in full. The results of these tests are, however, summed up as follow:—(1) The best specimen had the manganese and aluminium in the proportion of their atomic weights, and it gave a maximum value of B = 4000, and M = 57, for H = 70, but had not reached saturation. (2) Heating to various temperatures, cooling in air, and testing at room temperature, gave for H = 50 a practically constant value for the permeability from room temperature to 300 deg., a rapid drop between 300 deg. and 600 deg. to about one-sixth its former value, and beyond 700 deg. a rapid rise to more than the original value at 900 deg. This series of changes was reversible for at least three times. (3) The largest values of B and M were obtained when the specimen was quenched in water from near its melting-point. (4) A series of cooling curves gave melting-points between 910 deg. and 970 deg. Cent., and curves characteristic of solid solutions. The curves for the two magnetic specimens showed transformation points, with evolution of heat at 615 deg. Cent. Specimens quenched from this temperature are non-magnetic when tested at room temperature. (5) It seems evident that there is an allotropic form of the alloy, or at least of the magnetic constituent of the alloy, which has a non-magnetic molecular arrangement at about 600 deg. Cent. (6) A series of photo-micrographs showed differences in the crystalline structure due to previous history, but no simple relation could be established between the magnetisation and the presence of certain crystals.

Other important contributions to this investigation have recently been published. E. Take, of Marburg, communicated the first results of his researches to the Deutsche Physikalische Gesellschaft last December. He experimented with forged specimens of an alloy containing copper, 17 per cent. of manganese and 9 per cent. of aluminium; other cast samples contained 18.1 per cent. of manganese and 9.7 per cent. of aluminium; both alloys were almost free from iron. The magnetism of these alloys vanishes at a certain critical temperature, and Take found that this temperature went higher and higher with each heating if the specimen had not previously been aged. In his experiments he heated the specimens up to 600 deg. Cent. before quenching, or even to 800 deg. Cent. when he wanted to cool slowly, and he baked at temperatures ranging from 80 deg. up to 350 deg. Cent. The complicated results show that the temperature influence upon the susceptibility, permeability, and critical temperature depends upon the strength of the field. When the specimen has been quenched at red heat, the magnetic susceptibility will go on increasing with continued ageing, provided that the magnetic test-field be strong; in weak fields a maximum is reached by baking for four hours at 209 deg. Cent., and the susceptibility then diminishes again asymptotically if the ageing is continued. When a soft material is aimed at, the quenching should be sudden, and the ageing be effected at low temperatures. A certain amount of ageing takes place even at ordinary temperatures. In explanation of the phenomena Take suggests, partly in accord with Heusler, that two structural changes take place in the alloy. In the first instance molecular magnets are formed, in the second instance these molecules unite to complexes of the type ($Al M_3$), where M stands for manganese and partly also for copper. These complexes are less free to move than the molecular magnets, so that the coercitive force increases as their formation proceeds. When the cooling is very slow, the complexes have time to form during the cooling period, and the subsequent ageing has hardly any influence.

Another research was published by A. A. Knowlton, of Utah University, in the *Physical Review* of last January. Knowlton prepared his alloys by adding aluminium (13 per cent. maximum) to fused copper and manganese (maximum 29 per cent.) re-melted several times without the use of a flux, which would cause the metals to eat into the graphite crucible. He kept the alloy in the molten condition, poured it into moulds, and allowed it to cool there to 250 deg. Cent., when he quenched it in hot water. The resulting specimens were of good mechanical quality and malleable. Prolonged and short annealing at different temperatures had different effects. Annealing should take place at the upper limit of transformation, not at the lower, and be followed by quenching; the transformation temperature depends upon the composition. A metallographic examination of etched specimens showed white, dark grey, and black crystals, and Knowlton concludes that it is the molecular groups of the white crystals which become magnetic under suitable temperature conditions.

ENGINEERING SCHEMES IN PARLIAMENT.

THE private Bills to be presented to Parliament during the ensuing session constitute a very humdrum programme. This, no doubt, is in part due to the fact that promoters have at length realised that investors have resolutely closed their pockets in connection with home schemes until the present socialistic craze has expended itself, and until they can appraise the effect that social legislation is likely to have upon industrial profits. Recent legislation has already been responsible for much of the unemployment so generally deplored. It is inevitable that a democracy should make mistakes, and we can only await the time when it will realise that the dearest thing in which to economise is brains.

RAILWAYS.

The London and North-Western Railway propose to lay down in North Wales a new curve into Holywell Station from their Holywell branch now in course of construction. The real interest of their Bill centres, however, in their proposal to electrify the North London line and the North and South-West Junction Railway. In order to facilitate a junction between the electrified North London Railway and the new Watford local line at Chalk Farm, the plans of the latter have been modified, and the proposed deep tunnel from Kilburn to Euston replaced by shallower works. The railway

company obviously intend to have their own power-station, which will be of large size, having to supply current to some 80 miles of single track. The company also seek powers to supply current to factories, subject to the consent of local electrical undertakers. In addition to a number of colliery connections and the like in South Wales, the Great Western Railway propose to undertake widenings at Paignton, Bourton, Solihull, Mynyddyslwyn, Ogmore, Ealing, Ruabon, Churston, Devonport, Banbury, Ammanford, Lapworth, Shrewsbury, Birmingham, Oldbury, Crosskeys, Griffithstown, and Abersychan. In Cornwall, the existing Ponsandane Viaduct, on the West Cornwall railway, is to be replaced by an embankment. In connection with the Rhondda and Swansea Bay Railway it is proposed to construct new junctions with that line at Neath and Briton Ferry.

Probably the most important of all the railway Bills is that in which the Midland Railway Company seek powers to acquire the London, Tilbury, and Southend Railway. In a second Bill the Midland Railway Company propose the construction of a number of short lengths of line in the neighbourhood of Brynamman and Pontardawe, with the object of improving their connections with Swansea. The North-Eastern Railway proposals are of very little interest, comprising merely junctions with the Great Northern and Great Central Railways at Thorpe (West Riding), and also at the same place with the No. 1 Railway authorised by the Hull and Barnsley Act of 1909. The Great Central Railway Company seek powers to construct a branch from the Midland Railway's Grimethorpe branch at Brierley to Shafton, and also to widen their existing lines round Doncaster, from Kilnhurst to Mexborough, from Swinton to Hexthorpe, and from Doncaster to Stanforth. Another widening proposed is that of their main line at Woodhouse station, near Rotherham. In Lincolnshire the company's line between Wrawby and Brocklesby is to be widened. A considerable amount of work is proposed by the Great Eastern Railway, though none of it involves extensions of the system, being for the most part intended to improve the existing means of access to popular resorts on the East Coast. Thus the Cromer line is to be widened from North Walsham to Northrepps, the Clacton branch from Thorpe-le-Soken to Clacton, and the Felixstowe branch from Ipswich. The company's main line to Cambridge is, moreover, to be widened at Whittlesford. At Beccles and St. Olaves it is proposed to construct new swing-bridges over the Waveney in substitution for the existing structures. These will improve the access to Yarmouth. At Lowestoft the company propose to construct new river-walls on Lake Lothing, and to extend the existing breakwater. One clause of the Bill will empower the electrification of the East London line.

The Metropolitan Railway Company seek powers to widen their line from Neasden to Finchley-road, and to establish at Hammersmith a junction with the No. 3 Railway of the Great Western Act of 1905. At King's Cross authority is sought for extending the existing subway into the London Electric Railway Station. The company also seek power to construct a branch from Rickmansworth to Watford.

In the Melton Mowbray district the Great Northern Railway Company propose to construct a new connection between their main line at Great Ponton and their Waltham branch. The company's main line is also to be widened at Rossington in connection with a branch to Rossington Colliery.

The London Electric Railways Company have a scheme for a junction at Willesden with the London and North-Western Railway electrified lines, towards which the company last named is to contribute 1½ millions. The other work scheduled consists of some subways at the Elephant and Castle.

The Metropolitan District Railway Company seek powers to widen the Wimbledon and Fulham line of the London and South-Western Railway Company from Wimbledon Station to Craven Villas-road, Wandsworth. They are also taking powers to supply electricity from Lot's-road to the North Metropolitan Electric Power Supply Company, and to the Richmond Electric Light and Power Company.

The Taff Vale Railway Company's proposals appear of little importance. They include a short branch line from Sully Station, and the construction of a footbridge over the company's Rhondda Fawr branch and adjoining lands. The Barry Railway Company propose an extension of their lines at Barry by a new one to the eastern breakwater of the company, which is in substitution of a line authorised in 1907.

The only important proposal which appears in the *Edinburgh Gazette* is made by a company which proposes to construct a new line from Leith Harbour to the Preston Links Colliery, Prestonpans, and thence to Newcastle. Another branch is to commence in a junction with the Caledonian Railway at Leith and terminate in the city of Edinburgh.

Light Railways, Tramways, and Trackless Trolley Proposals.

It is proposed to construct a light line, about 10¼ miles long, along the Conway Valley, commencing in a junction with the London and North-Western Railway at Conway, and terminating in a junction with the same company's Llandudno and Blaenaw Festiniog line.

The North Staffordshire Railway Company apply for powers for a light railway commencing in a junction at Trentham with their Trentham Park line, and passing through Newcastle-under-Lyme to a junction at Silverdale with their Apedale branch line.

In North Yorkshire a private promoter seeks powers to construct a light railway from Richmond Station to Reeth, a distance of probably some 10 miles. Another proposed line in the North Riding is one from Haxby, on the North-Eastern Company's York and Scarborough branch, to Bransby. The Southwold Harbour Company have a proposal to construct about a mile of new light line to connect up the existing light railway with the Southwold Harbour. The East Kent Light Railways Company propose two extensions of their lines already authorised. Of these, one, 3½ miles long, will carry the rails from Wingham to Wickhambreux. Another 1½ miles of line will extend the No. 11 line, of the company's Order of 1911, to Sutton.

Coming to tramway work, the most notable feature of the proposals is the absence of any grandiose scheme promoted by the London County Council. The latter is the only great local authority which has not the power to prohibit competition with its tram undertakings by other motor vehicles. Such cities as Glasgow, Manchester, and Birmingham are able to protect their tramways against the march of improvement, and their citizens must be content to put up with their existing systems of traction, whatever better alternatives may be offered in the future. The principal proposal of the London County Council is to extend the tramway from its present termination at Catford to Southend, a distance of rather over a mile. The other important provision in the Bill is a clause demanding the right to run trailer-cars, in spite of the strongly adverse opinions expressed by the police authorities. The London United Tramways Company seek for an extension of time for the construction of their proposed lines in Richmond, and for powers to abandon their line along Kew-road, in case of failing to come to an agreement with the Corporation of Richmond. Very little work is proposed by the Metropolitan Electric Tramways Company; merely some short junction lines at Hornsey and Stoke Newington. The West Ham Corporation are clearly not downhearted at the steady migration of manufacturing firms into less highly-rated areas. They seek powers to construct 1½ miles of new line, and also to run a trackless trolley system to Leyton. A number of new junction lines are to be built by the Corporation of West Hartlepool, and a good deal of work of a similar character is proposed at Sheffield. Extensions to existing systems are proposed at Burry, Dewsbury, and Swansea. The Bingley Urban District Council ask for a Provisional Order for the construction of about 3 miles of line, to constitute an extension of the existing line at Shipley, which is leased to the Bradford Corporation.

Many proposals are made to adopt the trackless trolley system. Thus the Urban District Council of Ramsbottom propose to work such a system between Holcombe Brook railway station and Ramsbottom railway station. In the London district a company has been formed to establish a service of this character between Uxbridge-road and Twickenham, passing through Heston. The Brighton, Hove, and Preston United Omnibus Company, Limited, propose to adopt this system over the route now worked by their motor-omnibuses; but the Corporations of Brighton and Hove are seeking powers of a similar kind. The Corporation of the latter borough transferred their electric-light station to a company; but in connection with their trackless trolley proposal they propose to re-establish a generating-station and sell current both for light and power purposes at Shoreham and Portslade. In the Middlesbrough district a company has been formed to work a trackless trolley line between Ormesby, Normanby, and Eston.

Other local authorities seeking powers for the establishment of trackless trolley services are Keighley, Barry, Stockport, and Sheffield.

The Falkirk and District Tramways Company seek powers to construct a line, about 3 miles long, from Falkirk to Grangemouth. This will involve a considerable amount of road widenings. The County Council of Lanark propose about 8 miles of tramway extensions. The longest branch is to connect up the Glasgow Tramways and Holytoun, *via* Thorniewood, Muir Park Rows, Bellshill, and Mossend. Another line, nearly 2 miles long, is to be constructed in Bothwell, and will connect the above-mentioned line with the lines of the Lanarkshire Tramways Company. In addition to this it is proposed to construct in Bothwell another long branch. The Glasgow Corporation seek power to construct a large number of short junction lines and spurs as improvements to their existing system.

Electricity, Power, and Lighting.

The most significant feature of the applications to be made to Parliament this session is the number of cases in which local authorities are seeking authority to transfer their undertakings to more capable hands. In the enthusiasm prevalent a few years ago, many authorities, in applying for Provisional Orders, failed to include a clause authorising such transfers. Actual experience has, however, now shown even the most enthusiastic of municipalisers that small, isolated generating-stations cannot be profitably worked, and that it is far better to convert them into substations, either purchasing current from some power company, or preferably to transfer the whole to the latter, which can give to the economical operation of the system an attention undistracted by a necessity of securing votes at November elections. A large consolidation of small electrical undertakings is, we observe, being effected in the West Riding by the Electrical Distribution of Yorkshire Company. Either new orders or transfers are sought by or for this company at Wath-on-Dearne, Rothwell, Burstall, Ardsley, Darton, Hoyland, Greetland, and Goole. The Pontefract Corporation is to transfer its order to the Yorkshire (West Riding) Electric Tramways Company.

The Urban District Council of Abercarn proposes to transfer its undertaking to the South Wales Electric Power-Distribution Company. On the other hand, the Doncaster Corporation ask powers to extend their limits of supply so as to include Wheatley, and the Burnley Corporation to extend theirs to Reedley Harrows, whilst that of Keighley are seeking powers to supply in bulk. In addition to the places already named, Provisional Orders are sought for Radcliffe, Bognor (two proposals), Glastonbury, Aylesbury, Goole, Newton-in-Makerfield, Great Harwood, Abingdon, Dorchester, Wimborne, Sherborne, Holmforth, Burnham, and Bingley. Extensions of existing limits of supply are also sought at Altrincham and Llanelly.

A company has been organised to construct a hydro-electric power plant, deriving its water from Loch Ericht, the River Ericht, the Allt Glas, and other lochs connected therewith. The level of the loch is to be raised by an embankment, which will submerge lands in the parishes of Laggan, Kingussie, and Insh in Inverness-shire, and in that of Fortingall, in Perthshire. Provisional Orders for Linlithgow, Rathgate, Armadale, and district, and for the Falkirk district are sought by a private promoter.

Gas.

It is long since gas projects have been of a character to excite interest. Almost the only notable feature in the proposals made is an amazing proposal by the Corporation of Salford. This body, it appears, has speculated on the supply of gas to outside areas, and is apparently now in some doubt as to whether this venture is going to be permanently profitable. They propose, therefore, that should their works become unprofitable, through a cessation in the demand for gas, that

any deficit shall be made up by a *pro rata* assessment on their own rate-payers and on their outside customers. The other noteworthy feature in the gas-works proposals is the number of cases in which powers are sought to institute systems of co-partnership and to provide benefit funds.

The York United Gas Company seek to extend their limits of supply to include the area within a 7-mile radius of the Ouse Bridge. The other undertakers seeking similar extensions are those at Houghton-le-Spring, Cambridge, Cleethorpes, Tendring Hundred, and Annfield Plain. Powers to extend works, with or without reconstruction of the company, are sought at Conisbrough, Fleetwood, Welwyn, Ashern, Knottingley, Woking, Swansea, and West Kent. At Bawtry the local company propose to take over the undertakings of the Gringley and District Company and the Tickhill Gas-Light, Coal, and Coke Company. The Brodsworth Company similarly seek to acquire the undertaking of the Ashern Gas-Light Company. Purchase Bills are promoted at Ashbourne, Sidmouth, Bedwellty, and Bala.

Water Supplies.

No large and important water scheme is foreshadowed in the *Gazettes* received to date. The Derwent Valley Water Board seek powers, subject to maintaining a minimum flow over Yorkshire Bridge Weir, to divert water from the River Derwent into the Derwent and Howden reservoirs. At Egremont, Cumberland, the Urban District Council propose the construction of an impounding reservoir across the Wormgill Beck, together with a settling-tank and service reservoirs. A company has been formed to supply water to the districts of Sutton-on-Sea, Trusthorpe, Maltby, Theddlethorpe, and Bilsby, obtaining a supply in bulk from the North-East Lincolnshire Water Company. New wells and pumping-stations are proposed by the water authorities at Tendring Hundred and Scunthorpe, and by the Staffordshire Potteries Water Company. The Mid-Kent Water Company propose to erect a new pumping-station at Charing and at Pluckley, Wrotham, and Eastry, whilst new service reservoirs will be constructed at Halling, Mereworth, Wrotham, and Wootton. Purchase Bills are promoted by the Felixstowe and Walton Urban District Council, as well as by those of Tavistock and Bedwellty.

Powers to extend their limits of supply are sought by the Henley-on-Thames Water Company, the East Surrey Water Company, and the Wimborne Minster Water Works Company.

The Corporation of Dunbar seek powers to construct a new reservoir in the parishes of Spott and Stenton, to impound the waters of the Rottenraw and the Cauld Burns.

Harbours, Piers, and Docks.

A company has been formed to construct a deep-water dock at Canvey Island, in the Thames estuary, where it is proposed to build a wharf 1500 ft. long, having rail connections with the London, Tilbury, and Southend Railway at Benfleet. Powers are taken to work the dock lines and connections electrically, and to supply current in bulk to other users. The Blyth Harbour Commissioners seek powers to build a new pier and jetty, together with a tidal basin, at Bedlington, and to extend the existing breakwater and seawall. The construction of a new breakwater, 1000 ft. long, is proposed by the Brixham Urban District Council. At Lowestoft, the Coast Development Company are proposing to widen and extend the existing south pier. Private promoters are seeking authority to build a new pier at Hove, commencing about a quarter of a mile east of Hove-street.

Sewerage and Drainage.

The Halkyn District Mines Drainage Company have a Bill authorising new tunnels and cuttings at Coleshill Fawr and Northrop, Flintshire, to drain into the Swinchiard Brook. It is further sought to sell water for power purposes. Application to constitute a Rhymney sewerage board is made by the Urban District Councils of Gelligaer, Bedwellty, Rhymney, and Mynyddislwyn, together with the Rural District Council of St. Mellons. The Bill provides for the compulsory adhesion to the scheme of Caerphilly, so far as the Rhymney portion of that area is concerned. The works comprise intercepting and outfall sewers discharging into the sea near Peterstone Wentlloog Church. The Swansea Corporation propose to construct two new intercepting, and three new outfall, sewers.

The Town Council of Macduff, N.B., propose to improve their harbour by the construction of a pier, 450 ft. long, and to increase the length of their quays by about 500 ft. of new work.

In Ireland private promoters seek power to construct a pier and quay at the mouth of the Glyde and Dee Rivers, Annagassan.

Miscellaneous.

A reconstruction of the Lambeth Bridge is proposed by the London County Council. A new bridge over the Ribble, to accommodate tramways as well as other road traffic, is to be erected at Penwortham by the Lancaster County Council. At Hull the Corporation propose to construct a new opening bridge in substitution for the existing North Bridge. A curious Bill is that promoted by the Cheshire County Council, intended to prohibit the pumping of brine to points outside the county boundary. The City Corporation seek powers to construct new subways at Cannon-street and Queen Victoria-street.

NOTES

The Metallurgical Industry in Italy.

We have received from the Iron and Steel Institute a copy of an illustrated hand-book having the above title, which describes the metallurgical industries of Italy. This hand-book was kindly prepared by the Italian Association of Iron-Masters for presentation to the members of the Institute on the occasion of their proposed visit to Italy. The first fifty pages contain an illustrated description of the places of interest through which the members were to have passed on their tours through the country. The second part, covering 430 pages, gives illustrated descriptions of fifty-nine Italian metallurgical engineering and shipbuilding works. These descriptions state the extent of the various works dealt with, their situation, their equipment, the number of men they employ, their manufactures and specialities. The internal views of ships and of launches, the illustrations of work carried out, and so forth, are most excellent. The book gives a very complete insight into the activity displayed by the Italian industries in all their numerous branches. The various shops, including the foundries, which only too often have a very neglected appearance in many large works, are light and are admirably equipped with modern machine-tools and other plant. The establishments described include not only those which have acquired a world-wide reputation in iron and steel specialities of all kinds, such, for example, as the Terni Works, the Orlando Yard and Engineering Works, the Vickers-Terni Ordnance Works, the Armstrong-Pozzuoli Company, the Fiat San Giorgio Company, the Savona Iron Works, and many others, but also a number dealing with the extraction and working up of antimony and other metals and chemical products, and works manufacturing turbine and electrical plants. The book contains further a very clear map of that portion of Italy embracing the districts which the members were to visit.

The Training of Engineers.

The inaugural meeting for the present session of the Institution of Civil Engineers of Ireland, took place a week earlier than the corresponding meeting of the Institution of Civil Engineers in London. It was occupied by a very suggestive and interesting address of the President, Mr. P. C. Cowan, M. Inst. C.E., who expressed the opinion that too much value had been assigned to workshop training for engineers. Probably in giving this view Mr. Cowan had in mind the requirements of those engaged in the civil branch of the profession, and though even there workshop knowledge is useful, it must be recognised that few men can spare the time necessary to give them at once workshop experience, experience in the field, and a sound knowledge of theoretical principles. Something must be sacrificed, and for those who do not intend to pursue mechanical engineering, it may well be that the shops can be omitted, with fewer drawbacks than would follow an attempt to crowd training in all three directions into an inadequate space of time. In such case Mr. Cowan contends that the college training should precede practical work, and here we have no doubt that he is right. In the case of those who intend to take up mechanical engineering, however, we believe that in general it will be found best to take at least three years in the shops before proceeding to college. A lad of 16 to 18 views with less repugnance the soiling of his hands and clothes than the young man of 20 or 21. In discussing the qualities necessary for success as an engineer, Mr. Cowan quoted with approval the distinction drawn by the late Dr. Burdon Stoney between an engineer and a craftsman, the latter being defined as one who executes mechanically the designs of others without introducing any new application of scientific principles, whilst the engineer moulds matter into new forms suited to the special object to be attained. All our readers will thank him for emphasising this point. The claim of the engineer to be a professional man ought to be made confidently. It is an important part of the training of the young that they should have a high opinion of the career before them, and should be prepared themselves to fulfil its obligations, both scientific and moral. A presidential address affords an excellent opportunity for enforcing this point, and Mr. Cowan made good use of it.

The Port of London.

Early in the present year, it will be remembered, the Port of London Authority issued particulars of a programme of port improvements recommended by its chief engineer, Mr. F. Palmer, M. Inst. C.E. These proposals were dealt with in our issue of February 3, when we gave maps showing the several projects, &c. It was proposed that the whole scheme, involving the expenditure of some 15 millions sterling, should be taken up as three different programmes, of which the first, considered to include work urgently necessary, would cost about 3,896,700*l*. The largest individual project in this urgent programme was the construction of a new dock, to be called the South Albert Dock, the estimate of cost for this being 2,339,000*l*. In the recently issued annual report of the Authority it is stated that the construction of this dock has been approved, the preliminary estimate of the sanctioned work coming to 2,156,000*l*. The dock will be 4600 ft. long by 600 ft. wide, with a depth of 38 ft. The entrance lock will be 800 ft. long by 100 ft. wide and 45 ft. deep on the sills. The work as sanctioned does not quite conform to the chief engineer's scheme, which suggested a dock depth of 44 ft. 6 in., with the entrance 850 ft. long by 110 ft. wide by 48 ft. deep on the sills. The dock as proposed will probably suffice for vessels of the size likely to come so far up the river as this, for some years to come, and as the chief engineer's proposals embodied the suggestion for the construction later of a new North Albert Dock, with 1000-ft. entrance locks, the Authority is perhaps justified in not adopting the dimensions originally suggested for the present undertaking. The purchase of the land for the proposed new North Albert Dock has also been sanctioned. That dock, it is suggested, should be 7400 ft. long by 700 ft. to 1000 ft. wide, and 45 ft. deep, with an entrance lock 1000 ft. by 120 ft. by 52 ft. depth on sills. The engineer's estimate for this work was 4,350,000*l*. A large dry dock will be provided at the South Albert Dock. During the past year two other new works of some magnitude were commenced. One of these is a double-storey reinforced-concrete shed, with crane equipment, &c., at the North Quay of the London (Western) Dock, the estimated cost of which is placed at 54,000*l*. The other is a new pumping-station, estimated to cost 43,000*l*., at the entrance to the Royal Victoria and Albert Docks, for raising the water level of these docks 2½ ft., in accordance with the chief engineer's proposals. The plant will be electrically driven, and capable of dealing with 17,000,000 gallons of water per hour. During the year covered by the last report, some 2½ million cubic yards of material were removed from the navigable channel of the river. It is stated that the original alignment selected for the Yantlet Channel has been abandoned owing to silting, and a new alignment chosen. This will involve the removal of about two million cubic yards of material from the new site. The Authority's proposals as to deepening and widening the channel from London Bridge downwards was described in the article above referred to. The amount of material to be removed to give effect to this scheme (exclusive of the Yantlet Channel work) is 20,000,000 cubic yards, and for this purpose a quantity of dredging plant, costing 426,650*l*., and capable of removing five

million cubic yards per annum, has been ordered. This plant includes two 27-cub.-ft. bucket dredgers, each capable of removing 765 cubic yards per hour when working at a depth of 55 ft. below water-level; eight 1000-cubic-yard steam hopper-barges; two 10-cub.-ft. bucket dredgers, each capable of removing 300 cubic yards of material per hour at a depth of 45 ft.; seven 500-cubic-yard steam hopper-barges; and one steam tender. A new dredger capable of removing 430 cubic yards per hour is also under construction, for dredging within the dock area, which, when completed, will bring the plant so engaged up to a capacity sufficient to handle 1,200,000 cubic yards per annum.

THE WORK OF THE REICHSANSTALT IN 1910.

The brief account of the work of the Physikalisch-Technische Reichsanstalt in 1910, which we give in the following lines, in accordance with our custom, is based upon the official report presented by the President of the Reichsanstalt, Professor Warburg, to the curatorium of that institution. An official abstract of the report is every year published in the *Zeitschrift für Instrumentenkunde*. This abstract merely refers to some of the many researches, however, details of which have already appeared in scientific and technical journals, which we have consulted in preparing our account. Our diagrams are reproduced, by permission, from the just-mentioned journal, whose editor, Professor S. Lindeck, member of the Reichsanstalt, died a few weeks ago. The grants for the Reichsanstalt for the year 1911 comprise a sum of 5575*l.* for erecting a new magnetic laboratory on Telegraph Hill, near Potsdam, where disturbances by electric currents are not to be feared, and of 14,170*l.* for a new strong-current laboratory. We deal with the subjects under separate headings, without observing the distinction made in the report between work done in the Physical Department and in the Technical Department (the latter under Director Hagen), and we add the names of the respective investigators in brackets.*

Thermal Expansion and Elastic Properties of Metals (E. Grüneisen).—An analysis of the experiments of Holborn and Day, Henning, Scheel, and Heuse, and of new experiments made by Grüneisen with many metals, shows that the thermal expansion of metals is in general in close agreement with the exponential formula of Thiesen, especially for low temperatures; the range of experiments was −190 deg. to +100 deg. Cent. Zinc, cadmium, and tin behave abnormally, and the abnormal behaviour may be ascribed to discontinuous changes in the structure of these metals. In general the total expansion from absolute zero to the melting-point seems to be a function of the atomic volume; but the experimental data are not sufficient for extrapolations to temperatures in the neighbourhood of absolute zero. It had previously been found that the ratio of the coefficient of linear expansion a to the specific heat Cp is nearly independent of the temperature in the case of the metals Al, Fe, Ni, Cu, Pd, Ag, Ir, Pt; in the case of Pb the a, and in the case of Sb and Bi, the Cp seems to increase more rapidly with rising temperature than it should according to this rule, which metals of large atomic volume do not follow so well as those of small atomic volume. The atomic volume is obtained by dividing the atomic weight of an element by its density; the alkali metals (not referred to in these researches) are characterised by very high atomic volumes. The ratio of the expansion coefficient to the specific heat is also nearly independent of the temperature, and the variation of the specific heat of metals with temperature could therefore also be expressed by Thiesen's formula.

The effect of temperature on the compressibility of metals has been investigated by experimenting on tubes of Fe, Cu, Ag, Pt, Al, Sn, Pb by the application of internal pressure, on Mallock's method, as has been explained in previous reports; the temperature limits are −190 deg. and +165 deg. Cent. Hard metals and metals in the hard condition (*i.e.*, at temperatures much below the melting points) vary their volume and linear moduli very nearly as the temperature, so that Poisson's ratio approaches a constant, characteristic for each metal. Soft metals and metals in the soft condition show an increase of Poisson's ratio with rising temperature.

Gas Volumes. Gas Thermometers (K. Scheel and W. Heuse).—Since the volume of the mercury meniscus introduces an error, which must not be neglected, into the accurate measurement of gas volumes, the volume of this meniscus has been determined for tubes ranging in internal diameter from 13.9 mm. up to 23.7 mm.; and T. Lohnstein has found that the table based on these observations is in fair agreement with a theoretically deduced formula.

The comparison between platinum thermometers and gas thermometers between 0 deg. Cent. and 450 deg. Cent. has been resumed with Jena 59^{III} glass tubes and quartz tubes, and with the aid of oil and nitrate baths. The quartz tubes are preferable to the glass tubes, among other reasons, because a gas occlusion and re-liberation by the glass became apparent during the repeated experiments. The gas used for charging the tubes was generally nitrogen, sometimes hydrogen, helium, or argon; helium proved unsuitable, some of this gas being lost at higher temperatures.

In the re-determination of the saturation pressure of aqueous vapour between 50 deg. and 100 deg. Cent. (L. Holborn and F. Henning), electric heating is applied, as in the experiments at higher temperatures.

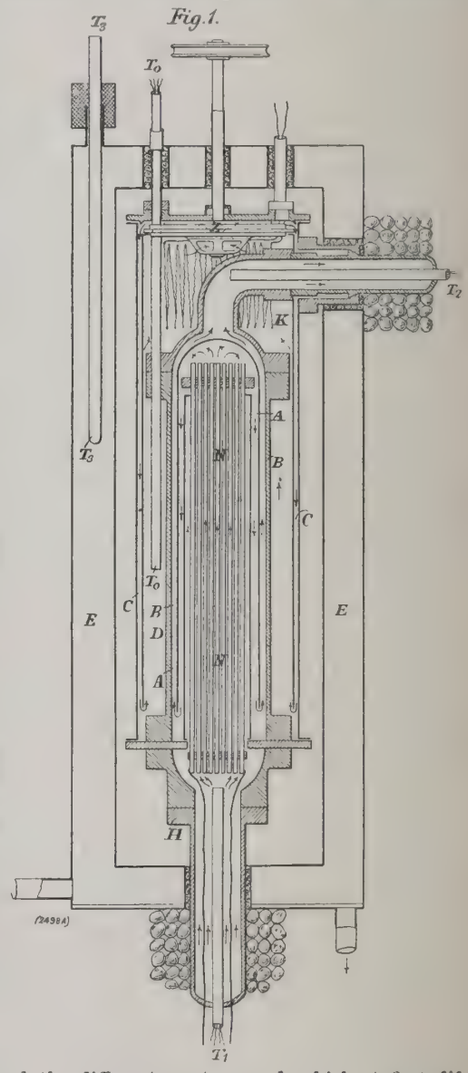
The apparatus for the investigation of argon (Holborn, H. Schulze) at temperatures ranging from − 80 to + 400 deg. Cent., and pressures of 200 atmospheres, is built up of steel and glass vessels, steel capillaries, and seven steel valves. The 30 litres of argon required were prepared after the method of Fischer and Ringe—by absorbing the oxygen and nitrogen of the air with the aid of a mixture of calcium carbide and 10 per cent. of calcium chloride, such as is used in the technical manufacture of cyanamide; the last traces of nitrogen are removed after the method of Maquenne, and the separation from neon and helium is effected by means of charcoal with the aid of the apparatus of S. Valentiner and K. Schmidt.

Specific Heat of Gases (Holborn, A. Baumann, M. Jakob).—The apparatus for determining the specific heat of gases at pressures up to 400 atmospheres is nearly completed; the compressor has not been installed yet, as the whole apparatus will have to be fixed in another room. Fig. 1 is a diagram of the calorimeter. The gas enters the heater H, which is made of nickel steel, from below, flows upward through the electrically-heated nickel tubes N, and leaves after having been circulated through the jackets A and B, which are separated by a thin partition. The platinum thermometers T_1 and T_2 at the entrance and exit of the gases are mounted in tubes in which they can be shifted. The heater vessel H is wholly surrounded by an oil-tank divided by a partition into two compartments, C and D; a small centrifugal pump Z keeps the oil in circulation through these compartments, and the oil is heated, if necessary, by the constantan ribbon K. The whole apparatus is placed within the double steam-jacket E, which is built up of welded sheet-iron, and in which a temperature of 100 deg. Cent. is maintained. The electric energy sent to the resistances K and N is measured. In order to test the apparatus, the specific heat of air has first been determined at pressures of 1 and 13 atmospheres; up to 10 kg. of air are passed through the calorimeter per hour.

The simultaneous experiments on the specific heat of gases at low temperatures (Scheel and Heuse) are made with a different apparatus, a diagram of which is reproduced in Fig. 2. The method is also that of Callendar and Barnes. The gas passes in a continuous stream through an apparatus in the interior of which it receives a measured amount of electric energy. The apparatus is constructed of glass. The gas enters from below at a constant temperature, measured by the thermometer Pt_1, through a glass spiral, which is only added to allow the apparatus to adapt itself to temperature changes, into two compartments B and C, forming jackets, and into the calorimeter A, in which it is heated by the resistance H; Pt_2 is the second thermometer, which has a length of 5 mm. only. D is a vacuum jacket of glass, and the whole apparatus is kept in a bath at constant temperature. The concentric jackets B and C, through which the gas flows in opposite directions, were added because it was found that, in spite of the vacuum outside, the calorimeter lost some heat by radiation; this would not matter if it were possible to push the thermometer Pt_2 close up to the heater H, but some space must be left to allow the gas layers to mix well. On average, about 5 litres of gas pass through this calorimeter per minute at temperatures down to that of liquid air. In the first experiments with dry atmospheric air, free of carbon-dioxide, the velocity of the air current was varied within wide limits, and it resulted that the specific heat of air is, at −183 deg. Cent., 5 per cent. higher than at + 15 deg. Cent. That the air had a higher specific heat when near its condensation point than at ordinary temperature had already been noticed by Witkowski, who experimented at − 183 deg., − 102 deg., and + 15 deg. Cent.; air would thus behave as steam does according to the most recent determinations of Knoblauch, Jakob, and Mollier.

Masonry Pillars (Scheel).—The masonry pillars for supporting scientific instruments have continued to increase in height during the sixth year (in two cases the fifth year) of observation. The increase amounted in most of the pillars to about 0.015 mm., and the different mortars used, which at first differed as to their expansion, now behave similarly; the cement pillar, however, showed a larger increase, of 0.3 mm. The comparison was originally made against cast-iron columns; later, three rods of Atlas steel were added, and these iron and steel columns have not varied in their height, so that the alterations in the heights of the mortar and cement pillars would appear to be real.

Fig. 1.



Radiation. Spectrum Analysis. Anode and Cathode Rays.—The examination of the structure of the very fine lines of the spectrum, with the aid of vacuum arcs and Wehnelt cathodes, has been continued (L. Janicki). Refractory metals cause considerable difficulties, because these metals frequently contain some carbon, so that the cathodes burn through under the high current intensities. The spectrum lines differ, moreover, in their intensity from those of ordinary arcs, and the impurities render the identification of the very numerous lines very difficult. Molybdenum, palladium, uranium, tungsten, silicon, tellurium do not show many satellites, however.

* For our report of last year, see ENGINEERING, vol. xc., pages 672 and 727.

The study of anode rays (E. Gehrcke and O. Reichenheim) induces Gehrcke to support a suggestion thrown out by E. Pringsheim that the eruptive solar prominences are produced by positive ions. The sun is regarded as an incandescent body surrounded by gases at very high rarefaction. The sun should, therefore, like every substance glowing in a vacuum, emit cathode rays (negative electrons) and, becoming positively charged, should under suitable conditions also emit positive rays which would be accelerated in the electric field and acquire the fluctuating, often enormous speeds of prominences. This, Gehrcke and Pringsheim consider, would be in accord with Hale's observation that a sun-spot (negatively charged) is formed at the point of origin of a prominence. The rays of the corona, which extend much further out from the sun, would, on this view, be cathode rays.

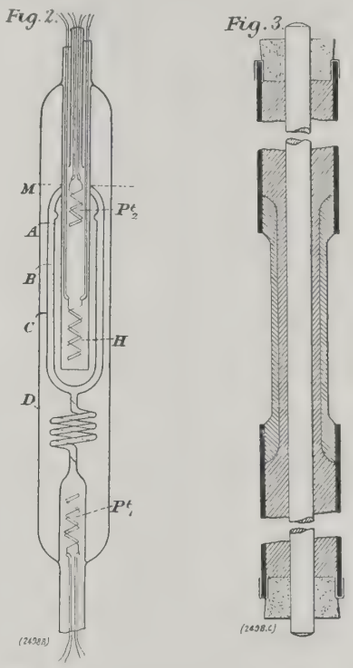
It has, so far, been assumed that incandescent bodies lower the discharge potential in tubes filled with gases. O. Reichenheim has recently observed, however, that the resistance of the gases is increased by the presence of glowing platinum, which may be anode or cathode, or not connected with the poles, when moist vapours are also present.

As regards the elements concerned in canal (positive) rays, J. J. Thomson has found evidence of the presence of two kinds of positively-charged hydrogen ions—apparently hydrogen atoms and hydrogen molecules, since the e/m ratios were 10^4 and 0.5×10^4 (or 5×10^3)—in all tubes, no matter what gas the tube had originally been charged with; only in helium tubes some rays of $e/m = 2.5 \times 10^3$ were observed in addition, apparently helium atoms carrying a unit charge. This agreed with previous observations of W. Wien, who had, however, isolated oxygen-atom rays by magnetic deflection in oxygen tubes. Gehrcke and Reichenheim now also find, in oxygen tubes at high vacuum, rays ascribed to oxygen atoms, in addition to the hydrogen rays mentioned, and they have not succeeded in suppressing the hydrogen rays in helium tubes, in which, moreover, sometimes radiations corresponding to higher atomic weights have been observed. They are further inclined to ascribe the Doppler effect in hydrogen radiations, for which J. Stark had accounted on Planck's theory of light entities (quanta), to diverse, originally present, particles of these kinds. For the determination of the e/m in cathode rays a very exact measurement of the intensity of the magnetic field and great constancy are required, and Gehrcke and M. von Wogau have wound a coil, 1.50 m. in length and 10 cm. diameter, for this purpose, which gives a field of constant intensity over a length of 8 cm.

Radiation of the Black Body.—The continued determinations of the constant c of the Wien-Planck law, formerly in the hands of L. Holborn, has been taken up by E. Warburg and G. Leithäuser at temperatures of the melting point of gold and above, with the aid of prisms of quartz and of fluorspar. The values for c, so far found in these re-determinations, lie between 14,200 and 14,600; the fluorspar prism gave the highest value, the Stefan-Boltzmann law the lowest. In order to avoid the effect of astigmatism in the mirrors of the spectrometer, in adjusting the slit for the bolometer, the reflection from the first mirror is made to take place in the horizontal plane, and that from the second mirror in the vertical plane.

Metrology (A. Leman, Blaschke, and A. Werner). *Steel Gauges.*—The twenty sets of end-measures of hardened steels, 10, 25, 50, and 100 mm. in length, have shown no further alterations in length after four years of observations; only in a few cases further alterations amounting to fractions of a micro-millimetre could be determined. The temper tests of 38 end-measures of 100 mm. lengths have also been completed. Comparative tests were made with other specimens of different shapes and dimensions, comprising discs up to 150 mm. in diameter and 27 mm. in thickness, made of hardened or non-hardened steel and copper. The results of these tests are to be published. The continued examination of three samples of test-rods, cut from the surface layers and the core of a boiler-plate, which seemed good in the cold, but which was very brittle at 400 deg. Cent., has led to the design of an apparatus for the convenient testing of metals against quartz glass; the report speaks of temperatures up to 300 deg. Cent. only, however, while the brittleness in the case mentioned was observed particularly at 400 deg. Cent.

Electrical Researches. Silver Voltameter and the Weston Normal Cell (W. Jaeger).—We have mentioned on other occasions that on the basis of the common experiments made by the representatives of the national laboratories of the United States, England, France, Germany, in the Bureau of Standards at Washington, in April and May, 1910, the electromotive force of the Weston normal cell has been fixed at 1.0183 volt at 20 deg. Cent., and that this value has been adopted since January, 1911. The calculations were based upon measurements with various silver voltameters, the mean of the British and German standard resistances, and upon the mean electromotive force of the Weston cells of the four nations. The four secondary manganin resistance standards of the Reichsanstalt have kept almost constant for eighteen years; three of them are now kept in rooms at a constant humidity of 50 per cent. The two mercury standards of 1 ohm in quartz tubes have so far proved satisfactory. Fifteen Weston cells were taken over to Washington; four were left there; the other eleven showed no change after their return to



Charlottenburg. The twelve cells sent by Professor Haga, of Gröningen, to Charlottenburg, are of the Reichsanstalt pattern and agree with those cells. When the silver anodes of the voltameters, the recent experiments confirm, are wrapped with filter paper, too much silver is deposited; sheaths of silk may be used; the presence of organic compounds also favours the formation of too heavy deposits.

The late F. Kohlrausch, formerly President of the Reichsanstalt, had continued his researches on the conductivity of aqueous solutions; the data are being collected by E. Grüneisen and H. von Steinwehr.

New Switchboards and Rectifiers (Orlich, G. Schulze, and Schering).—The new switchboard for the alternating-current distribution consists of an iron grid frame into which panels of marble with bus-bars, all made to standards, are being fitted as required. The Westinghouse Company supplied in January, 1910, seven mercury-vapour rectifiers for charging 120-volt batteries from three-phase generators. Each rectifier takes currents of 10 amperes, and to maintain this intensity, two iron resistances, so-called variators, of the Allgemeine Elektricitäts-Gesellschaft, are inserted in parallel into each rectifier circuit. Each variator can throttle from 10 to 40 volts, and keep the current at 5 amperes. The rectifiers are divided into two groups, so that two batteries can be charged at the same time; when the battery is fully charged, the rectifiers go out. The rectifiers waste current, of course, but the plant does not require any attendance, running day and night.

Transformer Oils. Junction-Boxes.—In the insulation tests (Schering) of transformer oils, ball electrodes of 10 or 15 mm. diameter, and sometimes point electrodes are used; the points are apt to give discordant results, and, when a spark has passed, too high a breakdown voltage is observed the next time. The device used in testing the compounds of junction-boxes is illustrated in Fig. 3. Iron pipes are made, 15 mm. internal width, 10 cm. in length, provided with thickened ends; a cardboard tube (black in the diagram) is pushed over the pipe, and a brass rod is placed in the pipe and centred with the aid of two corks. The compound is then poured into the tube through a perforation in the upper cork, so as to form a layer of uniform thickness, 3 mm., around the brass rod. Four tests are made as a rule, and the compound is then burnt out, so that the iron pipe can be used again.

Capacity. Self-Induction. Dielectrics (E. Orlich, E. Giebe, H. Schultze).—In order to suppress the residual capacity in large resistances, the resistance is wound in opposite directions in two portions, with a gap between the inner and outer portion; a certain amount of self-induction is thereby introduced, but the inner capacity can be suppressed for all frequencies. The effects of distributed capacity in standards of self-induction at high frequencies (up to 5000 per second) have been investigated by Giebe by comparing his bridge method (all the arms screened by shields) with the resonance method as used by Lindemann and by A. Campbell; the bridge method gives results in agreement with M. Wien's formula. In testing the energy losses in dielectrics (Schering, Schmidt) condensers are built up of ten plates of the dielectric alternating with copper foil and inserted in the one bridge arm. Low frequencies (nine and more periods) are produced with the aid of Rubens vibration galvanometers, the needle being replaced by thin sheet-iron. For high frequencies (up to 2000) a vibration galvanometer of Duddell was constructed; another galvanometer of this type, with two chords, 1 m. in length, can be regulated for frequencies ranging from 25 up to 100. These determinations require high resistances devoid of capacity and induction, and on Nernst's suggestion solutions containing 121 grammes per litre of mannite and 41 grammes of boric acid, together with a very small amount of potassium chloride (0.06 gramme, added to compensate for the temperature coefficient), have been tried; these solutions cannot be kept long, however, as they attack the glass vessels.

The energy losses in stranded cables (R. Lindemann), and the increase in the resistance observed in "ideally" wound cables, when under high-frequency currents,* have further been investigated. It results that there is, in addition to the skin effect, an energy loss in the insulation material of the strands, which is dependent upon the frequency, but can also be expressed by a formula. The resistance of relatively short wires (1 m. in length) under direct and under high-frequency currents is being tested with the help of an apparatus which permits of throwing the wire quickly into the one or the other circuit. A thermo-couple is soldered to the middle of the wire, and the current intensity is so regulated that an equal rise of temperature is observed in the two cases; the resistance ratio is then calculated from the current ratio. The wire should quickly assume a steady temperature, and is for this reason stretched in a glass tube, 3 cm. in diameter, which is filled with hydrogen.

(To be continued.)

WINTER TOURS TO PORTUGAL, MADEIRA, AND SOUTH AMERICA.—The Booth Steamship Company, Limited, have issued illustrated pamphlets stating the conditions for a number of tours to the above countries. The information includes particulars of their ships, and general data on the main towns on the tours in question.

RAILS IN ITALY.—The imports of rails into Italy in the six years ending with 1910 inclusive were as annexed:—

Year.	Tons.	Year.	Tons.
1905	8,303	1908	31,262
1906	21,063	1909	12,895
1907	31,268	1910	16,575

Practically no rails are exported from Italy.

THE "OLD STRATFORDIANS'" DINNER.—The eighth annual reunion dinner of the past and present members of the Locomotive Department staff of the Great Eastern Railway was held at the Liverpool-street Hotel on Friday last, the 24th ult., and was largely attended. Mr. A. J. Hill, the works manager at Stratford, occupied the chair, and in addition to Mr. S. D. Holden, the locomotive superintendent, and a number of prominent members of his staff, there were present, amongst others, Mr. James Holden, the late locomotive superintendent, Mr. W. F. Pettigrew, the locomotive superintendent of the Furness Railway, and Mr. W. Pickersgill, locomotive superintendent of the Great North of Scotland Railway. The gathering was in every way most successful.

* Compare last year's report; ENGINEERING, November 25, 1910, page 729.

INDUSTRIAL NOTES.

If we are to judge by what is reported in the daily papers, there appears to be a very general determination among the union railway men throughout the country to vote in favour of a general strike, in order, if possible, to obtain recognition. This, however, does not mean, even should the ballot show a majority, that there will be a general strike, because, after all, it would only be the expression of the majority of a minority of the railwaymen. It is only the union men who are giving trouble in order that they may be flattered by full recognition by the railway companies. We do not believe for one moment that the majority of the railwaymen wish for a general strike, even though a majority of the union men may decide that they do. There is also a wide difference between expressing an opinion that there ought to be a general strike and actually bringing one about. The union men are fond of being in evidence, and making themselves heard, but that is no reason why they should always be getting what they want. They are now demanding to be brought into conference with the railway companies, as they say, "to discuss the best mode of giving effect to the report of the Royal Commission." And what if such a conference with the railway companies should be held? There is no guarantee whatever that these men will loyally keep to any agreement that may be come to if, later, it should suit them not to do so. Their methods are conducive of waste of time, and we cannot wonder if the companies decline to hold further conference with them. Had the companies behaved as the unionists are now doing, there would have been a most emphatic protest from the unionist ranks. It certainly looks as though there might be another attempt by the Government to put pressure on the railway companies, in which case there is great danger that the crisis will only be postponed unless the railway companies are willing to yield themselves altogether to the trade unionists. The matter has to be settled on its merits. There will be no lasting peace until it is, and nothing satisfactory will be accomplished until the men learn to keep their agreements.

It is stated that a meeting of the Council of the Railway Companies' Association will be held at 2.15 p.m. to-day at the offices of the London and North-Western Railway Company in Parliament-street, Westminster, to consider a communication from the Board of Trade with reference to the resolution passed by Parliament after the recent debate on the report of the Royal Commission. The resolution passed by the House was to the effect that in the opinion of the House a meeting should take place between the representatives of the parties on whose behalf the Railway Agreement of August, 1911, was signed to discuss the best mode of giving effect to the report of the Royal Commission, and the Government should be asked to use its best offices to bring both sides into conference without delay. It is, of course, quite impossible to forecast the result of this meeting, but there seems to be a feeling that the railway companies may be willing to accept an invitation from the Government to meet the representatives of the unions for the purpose stated in the resolution, provided it is clearly understood that the findings of the Commission are accepted in principle and in substance by all parties.

At a mass meeting of railwaymen on Sunday last at York a resolution was unanimously adopted urging the North-Eastern men to abstain from voting on the first question on the ballot-paper (concerning the acceptance of the Commission's report), on the ground that it does not affect them. Added to the resolution was the following:—"We are not in favour of withdrawing our labour except upon a programme which is drawn up by representatives of the North-Eastern Railway, and submitted to the company through the joint executive." At Leeds also a resolution was passed declaring that the North-Eastern men did not intend to record their votes in the ballot; and at West Hartlepool the Amalgamated Society of Railway Servants decided on Sunday last not to take part in the ballot, on the ground that they already possess recognition on the North-Eastern Railway. At Glasgow, on the other hand, the Buchanan-street branch of the Amalgamated Society of Railway Servants, at a meeting held on Sunday last, appeared to possess a large majority who were not in favour of accepting the Commission's report, and were in favour of a general strike.

According to the *Times*, numerous inquiries have been received at Lloyd's during the last few days for terms at which insurance could be effected against the risk of another strike among the workers on the home railways. The idea that a strike on Christmas Eve is a possibility has evidently gained a footing, though whether it is justified is doubtful. Inquiries have, however, come from persons who think that they would be especially affected by such an occurrence. The risk named has in some cases merely been "a railway strike," and a proposition couched in such general terms has not been considered by the underwriters. It has been suggested that the risk should be narrowed down to "a railway strike of 75 per cent. of the workers," though this was thought to involve serious difficulties, and was not regarded as an altogether satisfactory solution. The plan so far generally adopted has been to quote a rate indemnifying the proposer to the extent of the falling off in the traffic receipts of any railway for each week as against the previous or the corresponding week of last year, provided there is a falling off of 50 per cent. in the earnings. This plan might be regarded as satisfactory to a proposer living in a town served by only one or two railways; but, if applied to London, it would appear to mean that, to be really effective, the risk of a strike on several great lines would have to be covered separately. The amount that has been usually quoted for insurance for six weeks is 5*l.* per cent., to take effect in the last week of the year.

An agreement between the Warwickshire colliery owners and the miners has been come to with regard to the minimum wage question. This result has not been arrived at without much consideration. The arrangement is that stallmen shall receive 7s. per day; daymen, 6s. 1d.; and loaders, 5s. 4d. per day. Tools, lights, and explosives will be found by the employers. The question of boy labour was decided upon a basis which has obtained generally for some years past. The arrangement appears to have given satisfaction to the miners. In the Cannock Chase and Pelsall district the coalowners and the men's representatives resumed their conference at Birmingham on Friday last. Amended proposals on behalf of 30,000 miners were submitted to the employers, counter proposals being put forward by the latter. The result was a further adjournement of the meeting, but the miners' agent stated that he hoped a satisfactory settlement would be arrived at.

It has now been definitely decided by the Associated Coal-Owners that they meet the Miners' Federation in conference to discuss, on national lines, the question of a minimum wage for all miners, and it is understood that the meeting will be held early in the week beginning December 11. It is stated that the miners of the Dean Forest Labour Association have decided by a large majority not to join the Independent Labour Party.

On Thursday in last week the oil-millers' strike at Hull came to an end. It was decided on the ballot, there being 803 votes in favour of a return to work on the conditions offered by the Seed-Crushers' Association, and 180 against. There has been an increase of wages in the lower grades of as much as 2s. a week in some cases, and in others 1s. a week, and the agreement is that union and non-union men are to work peaceably together. In order to deal with future grievances a joint board has been established. Work was resumed last Friday.

Another instance of trade-union oppression is announced from Lancashire by a Blackburn correspondent of the *Times*. It appears that the Weavers' Association at Great Harwood, having reduced the number of non-unionists working there from several hundreds to eighteen, and increased the membership of the Association to 5000, decided to serve notices, on behalf of 200 weavers at Park View Mill, last Wednesday, unless three members of one family employed there joined the union. Attempts to persuade the three seem to have failed. Should the notices become operative, several of the employers will, it is said, support a general closing policy. At Boxenden also a number of union weavers have decided to tender notices unless three operatives join their association.

On Monday last the representatives of the National Conference of Friendly Societies and the General Federation of Trade Unions held a meeting after they had had a private conference with Mr. Lloyd George at the Treasury. They passed a resolution to the effect that the committee of the National Conference of Friendly Societies and the General Federation of Trade Unions unanimously agreed in requesting the Chancellor of the Exchequer to withdraw any proposed alternative to the first three days' sick-pay [which he is unable to grant] other than the payment of full pay for six months in lieu of thirteen weeks as provided by the Bill; and further recommended that the Bill should become operative on July 8, 1912, in order that the benefits of the Bill may be administered from the first Monday in January, 1913. They also passed a resolution drawing the serious attention of Members of the House of Commons to the probable disastrous effects to the friendly societies and trade unions by the creation of separate funds and separate bodies of Commissioners in the four parts of the United Kingdom; as it would appear, as a result of amendment of the Bill, that friendly societies and trade unions with members or branches in the four countries (as now obtains in all the affiliated societies and trade unions) are to be dismembered, and four separate societies are to be created instead of one, with heavier cost of administration to the society and with a probability of the creation of irksome difficulties and the setting up of anomalies between one country and another.

The Norwegian Employers' Union have prepared a report on the results of the great lock-out. The conflicts, which have been settled, comprised those with the mining industry, at the Christiania nail manufactory, and at the electrical installation firms, as well as the building conflict in Stavanger. As far as the law is concerned the result was practically the same as the terms offered by the employers as early as May. The arrangement at the nail manufactory was virtually on the basis of the employers' last offer, but some of the reductions demanded by the employers will take place gradually, according to a sliding-scale, instead of all at once. The electrical fitters originally demanded a minimum pay of 50 öre (6⅞d.) per hour for skilled hands; the employers offered 37 öre (5d.), and the result of the mediation was 40 öre (5½d.). The employers accepted the 40 öre. Other clauses in the agreement were drawn up in accordance with the masters' offer.

As regards the mining industry, there was no offer from the employers prior to the agreements about the shop hands at the Sulitjelma and Foldal mines. It is therefore impossible to ascertain whether the conflict resulted in advantages to the men which they could not have obtained by peaceful negotiations. The men, however, had to reduce their claims very considerably. They asked 52 öre (7d.) minimum pay per hour for skilled hands. The result of the mediation was 40 öre (5⅛d.). For helpers above eighteen years they asked for a minimum pay of 37 öre (5d.) and 42 öre (5⅝d.) after a year's practice; the result of the mediation was 33 öre (4½d.).

The joint agreements within the mining industry, in all essential points, were in accordance with the masters' offer. The provisional minimum rates at all mines except Salangen and Stordö were practically fixed according to the masters' last offer. In a few cases the reduction has been divided, but it is a reduction all the same. In spite of the special conditions existing at Salangen and Stordö the separate agreements were negatived, and the two concerns were included in the joint agreement, except as to some minimum rates previously agreed to, which, however, were reduced.

Canadian Peat Bogs.—Canada appears to possess peat bogs of considerable size among her natural possessions, to judge from figures given by the *Canadian Engineer*, for it is stated that they cover an area of approximately 36,000 square miles, from which about 28,000,000,000 tons of air-dried peat could be produced, said to be equal to some 14,000,000,000 tons of coal. In order to encourage the utilisation of these resources a peat bog of 300 acres, with an average depth of 8 ft., has been acquired by the Canadian Government at Alfred, near Caledonia Springs, Prescott County, Ontario. About five miles of ditches have been dug, and a storage shed to hold 300 tons of air-dried peat has been erected, as well as a blacksmith's shop and an office. It is estimated that the erection of a peat plant capable of producing 30 tons of air-dried peat daily should not cost very much, and since workable peat bogs are scattered throughout the farming regions of Ontario and Quebec, the most economical plan for utilisation of this fuel would be the erection of a number of plants at convenient points, to be operated in the interests of the neighbouring communities.

Responsibility for Bridges over Railways.—Perthshire Highland District County Council Committee have had under consideration the question of responsibility for improving bridges on the public road crossing the Highland Railway at Pitlochry and Tighnageat, which have been declared unsafe for traction-engine traffic. At a meeting of the Committee at Logierait on Saturday, November 25, the clerk (Mr. H. Mitchell, solicitor) reported that he had attended a meeting of County Council delegates in Edinburgh to discuss the matter with the managers of the Scottish railway companies. The position taken up by the railway companies was that they were only bound to make the bridges sufficient for traffic at the time they were built, and if traffic increased so as to make the bridges unsafe, that was a matter for the District Committee. On the other hand, it was admitted that the District Committee had no power to meddle with a railway bridge, and that therefore the responsibility of keeping up a bridge and making it safe lay with the railway company, so that while the railway company were under no legal obligation to maintain a bridge for heavy traffic, nobody else had the power to touch it. The suggestion was made that a non-contentious Bill should be introduced in Parliament to enable district committees to contribute towards the cost of putting over-line bridges in a proper state for the traffic of the district. Auditors have generally intimated that they were prepared to pass expenditure of this sort, as being absolutely necessary in connection with district wants, and it was agreed to contribute the sum of 300*l.* towards the cost of the proposed improvements.

COMBINED STOP AND ISOLATING VALVE.

CONSTRUCTED BY MESSRS. T. SUGDEN, LIMITED, ENGINEERS, LONDON.

Fig. 1.

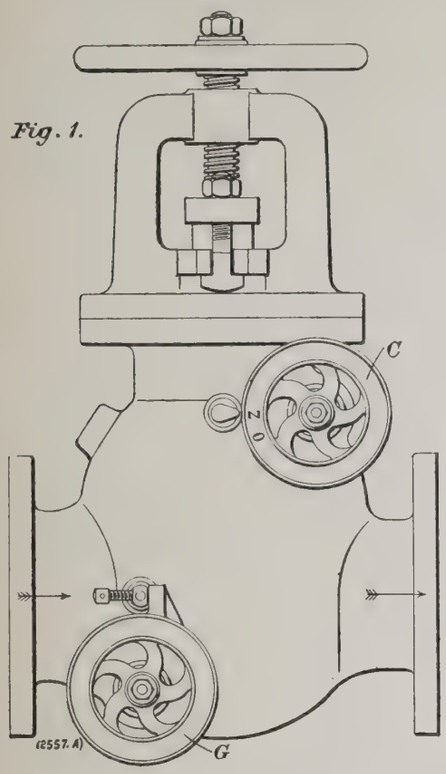
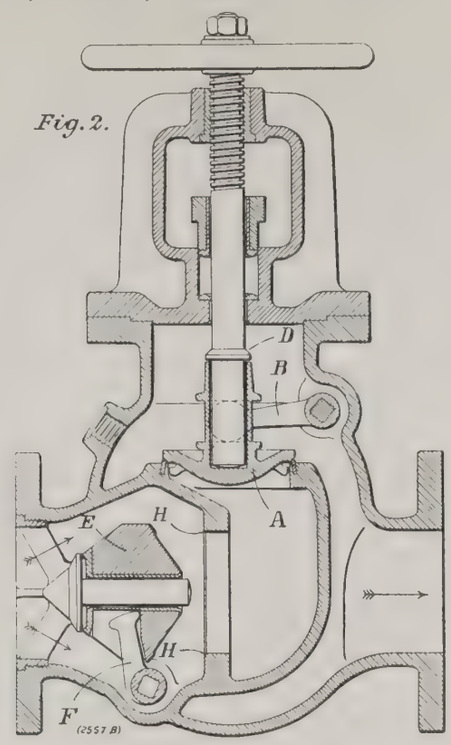


Fig. 2.



We illustrate above a form of steam-valve which is manufactured by Messrs. T. Sugden, Limited, 180, Fleet-street, London, E.C., and which has been designed to act both as a stop-valve and as an isolating-valve. We described some years ago a similar type of valve made by the same firm, but the one we now illustrate is a modification of that, several alterations and additions having been introduced with a view of improved action. One of these alterations consists in fixing the valve in a horizontal position. This may at first sight appear a very simple matter, but it is one on which the makers place much importance. Hitherto it has been found difficult to make any kind of isolating-valve which will meet varying conditions of work, for although the vertical type of valve is found to answer exceedingly well under normal conditions where the supply of steam is constant, it is not so suitable where there is a variable load, and where constant excessive demands are made for steam, such as obtain in connection with large colliery winding-engines and large rolling-mill engines. In these cases the arrangement of the valve should be less sensitive than where there is a steady demand for steam, although the valve still acts in a reliable manner when an accident occurs through the fracture of a steam-pipe. The new form of horizontal valve, which we illustrate, has now, we understand, been very thoroughly tested, and has been found satisfactorily to meet the duties required of it. It serves a three-fold purpose. In the first place the upper valve serves as an ordinary stop-valve; in the second place it closes immediately in case of an accident to the boiler, and will thus isolate the boiler to which the accident has occurred from the rest of the battery. In addition to this the valve will automatically couple up the boiler, in which steam is being raised, to the other boilers at work as soon as the steam pressure on both sides of the valve is the same. In case of a steam-pipe fracture, the lower valve closes, due to the high velocity of the steam which arises when an accident occurs.

The construction of the valve will be better understood on reference to our illustrations. These are respectively a side elevation, Fig. 1, and a longitudinal section, Fig. 2. The arrows indicate the direction in which the steam flows. The combined arrangement consists of two separate valves A and E, as will be seen by Fig. 2, both of which are loose on their spindles. When the former of these is screwed down it acts as an ordinary stop-valve and shuts off the boiler. When the spindle is raised the valve is opened by the flow of steam. As the valve is loose on its spindle, it acts as a non-return valve, and immediately closes in case an accident happens to the boiler, and so prevents the passage of steam from other boilers. The valve E, which is placed horizontally, is also free to move on its spindle, which, however, is a fixture, as shown in Fig. 2. Its action is the opposite to that of the valve A, for it comes automatically into operation in case the steam-pipe fractures, or other mishap occurs on the outlet side of the valve, for it at once moves along its spindle, until it comes in contact with the seating H. Under working conditions this valve is open, in which position it can be placed from the outside by means of the lever F, which is actuated by the hand-wheel G. Under ordinary conditions also there is a certain amount of pressure of steam tending to keep the valve back from its seat, owing to a partial vacuum formed by the flow of steam past the valve, whereby a suctional action is caused in the space between the valve and the spindle, and between the seating on the spindle and the back of the valve. When an accident takes place, and the automatic valve E is closed against its seat H, it is held there by the pressure of steam until the stop-valve A is closed. When this is done, the steam-pressure on both sides of the valve E is equalised by a small quantity of steam passing to the right-hand side of the valve through the space between the valve and spindle, and the valve can be returned to its normal position. The valve can be set to close at any desired difference in pressure by the adjusting-screw shown in Fig. 1. When once adjusted by the hand-wheel C, a padlock or seal may be applied to prevent anyone tampering with the valve.

Hand-wheels for testing are connected by means of spindles to the levers B and F, and by means of these the valves can be kept in working order from the outside. The valves can operate independently of the testing-gear until nearly closed, and at this point the force of the steam easily overcomes the friction of the testing-gear. The spindle for the valve A has formed on it a small facing D, which, when the stop-valve is full open, comes in contact with a seating in the cover above, immediately below the stuffing-box. This forms a joint and protects the packing, and also allows new packing to be put in while the valve is under full steam. The valve-casing is made entirely of steel, and the valves and seatings are arranged for superheated steam.

The number of accidents (continually taking place) which are really preventable by the use of appliances like that we have described should offer an inducement for the adoption of these valves; in fact, the makers state they know of more than 120 cases in which these valves have actually prevented serious damage, and probable loss of life.

POCKET-DICTIONARY OF THE ENGLISH AND RUSSIAN LANGUAGES.—We have received a copy of this dictionary, which forms part of Hossfeld's educational series, is edited by Mr. S. W. Linden and Dr. Th. Kawraisky, and is published at the price of 7s. 6d. net by Messrs. Hirschfeld Brothers, Limited, 263, High Holborn, W.C. The English portion contains 460 pages, and the Russian portion has 445 pages. This is a well-produced and very complete dictionary of words of general use.

FOREIGN ENGINEERING PROJECTS.

We give below a series of foreign projects, for several of which tenders are asked. Further data concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Holland: H.M. Consul at Rotterdam states that tenders are invited by the Colonial Office at The Hague, up to December 5, for the supply and delivery of the following:—Ironware with appurtenances for the roofing of the sheds at Madioen and at Sourabaya-Goebeng (Contract No. 555); galvanised materials for telegraph and telephone poles (Contract lit. M 17); 200,000 mild-steel hook-bolts (Contract lit. N 17); sleepers, washers, and bolts with nuts (Contract lit. O 17); mild steel (Contract lit. P 17). Specifications may be obtained from Mart. Nijhoff, Lange Voorhout 9, The Hague, on payment of 7.50 fl. (12s. 6d.) for Contract 555; 2.50 fl. (4s. 2d.) for lit. M 17; 1.50 fl. (2s. 6d.) for lit. O 17; and 1 fl. (1s. 8d.) for lit. N 17 and lit. P 17.

Denmark: The Danish *Licitationen* states that tenders will be opened on December 5 at the offices of the harbour authorities at Stubbekobing ("Havneudvalget, Stubbekobing") for the carrying out of various harbour works.

Spain: The *Gaceta de Madrid* contains a decree issued by the Ministry of Fomento, authorising the authorities to proceed with the construction of the new dock at Tarragona. It appears that this work has been suspended for some time owing to the necessity for introducing certain alterations in the original plans. The *Gaceta* also notifies that Don Rafael Adell y González has applied for a concession for the construction and working of a secondary railway from Calasparra to Caravaca, and that the matter is being considered by the Ministerio de Fomento in Madrid.

Mexico: H.M. Consul-General at Mexico City reports that, according to a published statement of the President of the National Railways of Mexico, new construction work is to be deferred till the spring of 1912, but proposals are being considered for the construction of two branch lines of considerable length from points on the main lines, the one to the Pacific Coast and the other to the Gulf of Mexico.

Brazil.—The *Diario Official* notifies that tenders will be opened on April 18, 1912, at the offices of the Ministerio da Viação e Obras Publicas, Rio de Janeiro, for the carrying out of extensive harbour works at Paranaguá, State of Paraná. This work will include the construction of wharves, warehouses and administration buildings, dock railway lines, and a reinforced-concrete bridge, and also the carrying out of paving operations and kindred works. The cost of the work is estimated at 4,731,724 milreis (about 315,000*l.*). A deposit of 50,000 milreis (about 3300*l.*) is required to qualify any tender, and this amount will have to be doubled by the successful tenderer on the award of the contract. The work must be completed in four years after the signing of the contract. It would be necessary for foreign contractors to have a duly qualified agent in Brazil possessing full powers for carrying on the enterprise. Local representation is necessary for tenderers.

Peru.—El Peruano contains a decree authorising Dr. Aníbal Maurtua to conduct surveying operations in connection with the proposed construction of a railway between Supe and Huallanca, with a branch to Recuay. Twelve months are allowed for drawing up the plans.

RUSSIAN RAILWAYS.—The aggregate revenue of the railways of Russia last year amounted to 961,984,636 roubles, or 65,270,015 roubles more than the amount collected in 1909. The working expenses last year were 629,608,267 roubles, or 10,172,521 roubles less than in 1909. The net revenue last year was, accordingly, 332,376,369 roubles, or 75,442,536 roubles more than in 1909. The State Railways realised a profit last year of 207,596,735 roubles, or 49,433,909 roubles more than in 1909.

THE JUNIOR INSTITUTION OF ENGINEERS.—A number of members of this Institution, with the kind permission of the chairman and directors, visited the works of the Tottenham and Edmonton Gas-Light and Coke Company on Saturday afternoon, November 18. Under the guidance of Mr. A. E. Broadberry, engineer, assisted by members of the staff, they were shown No. 1 retort-house, containing eighteen beds of eights, 22 in. by 16 in. through retorts, with regenerative heating—total, 144 retorts—which are operated by a Fiddes-Aldridge machine, and the coke is removed by a De Brouwer hot-coke conveyor. A setting of verticals is now on order, and when complete the total capacity of the house will be 3,000,000 ft. per diem. No. 2 retort-house, containing at present twenty-four beds of tens, 22 in. by 16 in., through ⌂-retorts, with regenerative heating. The charging and discharging is effected by De Brouwer's projectors and pushers. The coke arrangements are similar to No. 1 house. The total capacity of the house is 3,750,000 ft. per day. The water-gas plant was first put in operation in 1894, when Beckton was the only other works in England using the system. The two original sets have been scrapped, and one larger set (1¼ millions) put in their place. The plant now consists of:—Two sets, 500,000 ft. each—1,000,000 cub. ft.; two sets, 1,000,000 ft. each—2,000,000 cub. ft.; one set, 1,250,000 ft. each—1,250,000 cub. ft. The growth of the output since Mr. Broadberry received chief control in 1899 has been from 575,658,000 cub. ft. to 1,687,811,000 cub. ft. in 1910, and clear indications show that this year's output will be at least 1,770,000,000 ft. At the conclusion of the visit the members were entertained to tea, and the chairman, Mr. Walter T. Dunn, expressed their appreciation of all that had been done to render the occasion so interesting and enjoyable, Mr. Broadberry responding.

SOME HACK-SAW TESTS.

The introduction of high-speed steels effected a wonderful revolution in the ease and rapidity with which metal could be cut in the lathe and in other machine-tools. The consequent remarkable reduction in the cost of roughing cuts has repeatedly been the theme of papers and articles dealing with the operations of the workshop. Great as has been the increase thus rendered possible in cutting speeds, it is perhaps doubtful whether it is not fully equalled by the introduction of the modern type of hack-saw, the enormous advantages of which were not the result of metallurgical improvements, but merely of a common-sense application of well-known facts to materials already existing. Those of us whose experience at the fitter's bench dates back a quarter of a century or more well remember how formidable a job was the cutting in two of a 1-in. or 1½-in. bar by means of a hack-saw. The teeth of the latter were soft enough to file. The saw-blades were, moreover, relatively expensive, and it was usual, therefore, to repair a broken blade by hard soldering it and re-shaping by a file the teeth affected. Such saws, after a few strokes on iron, lost the whole of their keenness, and hence, as already stated, the cutting of even a 1-in. bar meant the expenditure of much time and elbow grease. The modern saws, for the introduction of which we are indebted to our American cousins, have revolutionised the sawing of metals in the cold. Armed with them a workman will not hesitate to cut by hand a 10 by 8 I-beam of some 20 sq. in. of cross-section, and in the hands of a real expert the time taken is astonishingly small. A large round bar is an even worse proposition, since the principle of always cutting "on a corner" is less easily applied, yet in demolishing the Great Wheel at Earl's Court the 3½-in. bars forming the suspension-rods were commonly cut through in about two and a half hours, although the situation in which the men had to work made it impossible to tackle the job to the best advantage. The remarkable cutting properties of the modern hack-saw have, of course, been recognised for some years, and for long past the old type of saw has been used only for special jobs, such, for instance, as the cutting of electric-power cables, where the diversity of the materials to be divided is likely to lead to numerous breakages, if really hard saws are used. So far as we know, however, little accurate experimental work has been done on the cutting powers of modern blades. Our readers will therefore be interested in the following figures, giving the results of experiments on different brands of saw, carried out by Messrs. David Kirkcaldy and Son on behalf of Messrs. F. M. Frye and Co., of 46, Upper Thames-street, E.C., to whom we are indebted for copies of the reports made. In all cases the saws were used in a machine, thus eliminating the human factor, which may well have a preponderating influence in any test of a hack-saw made by hand.

Most of the tests were made with a "Miller's Falls" machine, but in some a Herbert eccentric sawing-machine was employed. The tests showed that different makes showed considerable differences in cutting powers. The "Enox" saw is a production of Messrs. Frye and Co., and the other saws were different well-known brands. It will be seen that the saws are all machine, and not hand, saws. In the first series of tests, the most noteworthy point is the way in which the saws in tests No. 357 and No. 261 maintained their sharpness. The time taken to make the twentieth cut of the 1½-in. bar was only about 12 per cent. more than on the first cut. When cutting tool-steel stock, of course, a more rapid deterioration of the cutting power is to be expected, as much injury being caused by some three or four cuts in such material as in fifteen or twenty made on ordinary mild steel.

A machine test is, of course, a very fair one, since with hand-saws so much depends on the skill of the operative. The latter, if a good man, will generally beat most types of machine in the matter of time occupied; but a less skilful one will soon destroy the sharpness of the teeth, and is, moreover, likely to prove expensive in the matter of broken saws. The cuts made on 4-in. bars, which are grouped together in Table II., really show very good work. Compared with experiments Nos. 357 and 261, about 5½ times the area was cut through in about 3½ times the time. The brand numbers attached to all the saws, save the "Enox," are, we should add, fictitious, since the makers of these had no direct share in the conduct of the experiments, the saws tested having been bought in the open market.

TABLE I.—TESTS OF HACK-SAW BLADES ON MILLER'S FALLS MACHINE.

Test No.	Description.	Strokes per Minute.	Material Cut.	Time occupied in minutes for the following cuts. 1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	12th.	13th.	14th.	15th.	16th.	17th.	18th.	19th.	20th.	Remarks.
TT																								
356	Brand "Enox," 12 in. long, ⅜ in. wide, 14 teeth per inch, 21 I.W.G.	54	Tool-steel bar, 1 3/16 in. dia.	7	8	9	13	17½	23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Test discontinued. (Saw ceased cutting.)
357	Ditto Ditto	54	Tough-steel bar, 1½ in. sq.	12½	12½	12½	12½	12½	12½	12½	12½	12½	12½	12½	12½	12½	12½	12½	12½	13½	13½	14	14	Test discontinued.
359	Brand 1, 12 in. long, ⅜ in. wide, 14 teeth per inch, 21 I.W.G.	54	Tool-steel bar, 1 3/16 in. dia.	10	11	15	27 half way through	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Test discontinued. (Saw ceased cutting.)
358	Ditto Ditto	54	Tough steel bar, 1½ in. sq.	12	12	12	12	12	12	12	13	13½	13½	13½	13½	14	14	15	15½	16	16	16	17	Test discontinued.
SS																								
452	"Enox" saw, 12 in. long, 1 1/16 in. wide, 16 teeth per inch, 22 I.W.G. thick, packet labelled: "Enox saws, 12 in., 16 teeth"	55	Tough steel bar, 1½ in. sq.	8	9	9	9	10	11	11	11	13	13	13	14	14	14	14	14	—	—	—	—	
453	Brand 2, 12 in. long, ⅜ in. wide, 14 teeth per inch, 22 I.W.G. thick, packet labelled: Brand 2.	55	Ditto	11	11	13	13	13	13	13	14	14	15	17	18	18	19	19	20	—	—	—	—	
452	"Enox" saw } same saws as above; test continued	55	Tool-steel bar, 1 3/16 in. dia.	5	8	14	21	—	—	—	—	—	—	—	—	-	—	-					—	
453	Brand 2 .. }	55	Ditto	7	14 (only half-way through)	..	..	..	..	..	..	..	..	..	..	..	..	..		..	..	..	..	Saw ceased cutting.
TT																								
259	Brand 3, 12 in. long, ¾ in. wide, 15 teeth per inch, 21 I.W.G.	54	Tough-steel bar, 1½ in. sq.	12	12	12	12	12	12	12	12	12	12	12	12	12	13	13½	15	15	..	..	..	Test discontinued.
260	Ditto Ditto	54	Tool-steel bar, 1 3/16 in. dia.	7	16	26	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Test discontinued. (Saw ceased cutting.)
261	Brand "Enox," 12 in. long, ¾ in. wide, 14 teeth per inch, 21 I.W.G.	54	Tough-steel bar, 1½ in. sq.	12½	12¼	12½	12½	12½	12½	12½	12½	12½	12½	12½	12½	12½	12½	12½	12½	12¼	12½	13	13	Test discontinued.
262	Ditto Ditto	54	Tool-steel bar, 1 3/16 in. dia.	7	9	19	20	21	23	28	42	..	..	..	..	..	..	..	..	..	..	..	..	Test discontinued. (Saw ceased cutting.)
2450	Brand "Enox," 12 in. long, ⅜ in. wide, 14 teeth per inch, 21 I.W.G.	54	Tool-steel bar, 1 3/16 in. dia.	7	8	10	13	18	24	32	..	..	..	..	..	..	..	..	..	..	..	..	..	Test discontinued.
2451	Ditto Ditto	54	Ditto	5	6	9	13	18	24	28	..	..	..	..	..	..	..	..	..	..	..	..	..	Saw ceased cutting when about halfway through 7th cut.
2452	Brand 4, 12 in. long, ¾ in. wide, 14 teeth per inch, 22 I.W.G.	54	Ditto	6	25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Saw ceased cutting when two-thirds way through 2nd cut.
2453	Ditto Ditto	54	Ditto	7	25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Saw ceased cutting when about half-way through 2nd cut.
2956	Brand "Enox," 12 in. long, ⅜ in. wide (full), 14 teeth per inch, 18 I.W.G.	54	Tool-steel bar, 1 3/16 in. dia.	6	9	11	19	25	30	44	..	..	..	..	..	..	..	..	..	..	..	..	..	Test discontinued
2957	Ditto. "Enox"	54	Ditto	6	8	11	15	22	32	40	..	..	..	..	..	..	..	..	..	..	..	..	..	Saw ceased cutting when about half-way through 7th cut.
2958	Brand 5, 12 in. long, ⅜ in. wide (bare), 10 teeth per inch, 18 I.W.G.	54	Ditto	8	13	44	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Test discontinued.
2959	Ditto Ditto	54	Ditto	8	10	13	43	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Ditto

TABLE II.—TESTS OF HACK-SAWS ON HERBERT'S ECCENTRIC SAWING-MACHINE.

SS		(Length of stroke, 5½ in.)																						
2571	17-in. long, 1 in. wide, 18 I.W.G. thick, 10 teeth per inch. Brand 6	64	Steel bar, 4 in. dia.	43	48	54	68	62	65	67	67	72	75	..	..	..	..	..	..	..	..	..	..	Test discontinued.
2571	Ditto. Brand 5	64	Ditto	43	46	50	55	59	60	66	67	68	73	..	..	..	..	..	..	..	..	..	..	Ditto
2572	17 in. long, 1 in. wide, 18 I.W.G. (tight) thick, 10 teeth per inch. Brand "Enox"	64	Ditto	48	51	52	52	53	54	56	60	63	67	..	..	..	..	..	..	..	..	..	..	Ditto
2572	Ditto. Brand "Enox"	64	Ditto	49	52	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Saw broke by accident when half-way through third cut.

Fire-Prevention Congress in Russia.—An International Fire-Service and Fire-Prevention Congress will be held at St. Petersburg and Moscow from May 25 to 30, 1912 (new era), to be organised by the Imperial Fire-Brigades' Federation of Russia, and held under the auspices of the Council.

COMBINED RECIPROCATING ENGINES AND TURBINES IN SHIPS.*

The Best Arrangement for Combined Reciprocating and Turbine Engines on Steamships.

By G. W. DICKIE, Member of Council.

IT is by invitation of the Committee on Papers that I am presenting to the Society what I think should be the best arrangement of combined reciprocating and turbine engines on steamships. In accepting this invitation I am well aware that the opinion I have reached, after much thought on the subject, is at variance not only with the opinion, but also with the practice, of some very eminent engineers, whose experience is much wider than mine. It is to be expected, therefore, that what I have to present will be challenged, and declared entirely untenable. If I thought the members of this Society would agree with me in regard to anything I might present before them, I would not take the trouble to present this paper.

It so happens that both types of steam-engine have an economical and a wasteful end. I have just been trying to compare the data on a set of indicator-cards from a triple-expansion marine engine, the aggregate horse-power being 5600, divided as follows:—High-pressure cylinder, 1886 horse-power; intermediate-pressure cylinder, 1874 horse-power; and low-pressure, 1840 horse-power—these are sufficiently close to say that the power is divided equally among the three cylinders—with data from a marine-turbine set, consisting of a central high-pressure and two wing low-pressure turbines giving 5500 shaft horse-power, also practically divided evenly between the three shafts. No superheating in either case.

In the reciprocating engine, the first stage, or one-third of the total horse-power, is obtained by a drop in the pressure from 180 lb. absolute to 70 lb. absolute, being a drop of 110 lb., corresponding to a drop in temperature from 372.9 to 302.9, or 70 deg.

In the turbine engine, the first stage, or one-third of the total horse-power, is obtained by a drop in the pressure from 175 lb. absolute to 35 lb. absolute, being a drop of 140 lb., corresponding to a drop in temperature from 370.8 to 259.3, or 111.5 deg.

In the reciprocating engine, the second stage, or one-third of the total horse-power, is obtained by a drop in the pressure of 70 lb. absolute to 25 lb. absolute, being a drop of 45 lb., corresponding to a drop in temperature from 302.9 to 240.1, or 62.8 deg.

In the reciprocating engine the third, or last, stage is obtained by a drop in the pressure from 25 lb. absolute to 2 lb. absolute, being a drop of 23 lb., corresponding to a drop in temperature from 240.1 deg. to 126.26 deg., or 113.84 deg. The aggregate drop in pressure for the second and third stages, or two-thirds of the total horse-power, is from 70 lb. absolute to 2 lb. absolute, a drop of 68 lb., corresponding to a drop in temperature from 302.9 deg. to 126.26 deg., or 176.64 deg.

In the turbine the second, or last, stage, or two-thirds of the total horse-power, is obtained by a drop in the pressure from 35 lb. absolute to 1 lb. absolute, being a drop of 34 lb., corresponding to a drop in temperature from 259.3 deg. to 102 deg., or 157.3 deg.

These pressures and temperatures are not given for the purpose of making any comparison between the economic performance of the reciprocating engine and the turbine, for, as a whole, their economy was practically the same. The consumption of fuel of like quality was practically the same per horse-power, with the advantage in favour of the turbine, as between shaft and indicated horse-power, the volume of steam passing through the cylinders was practically the same as that passing through the rotors, yet 1886 horse-power, slightly over one-third of the total, was developed with a drop of pressure of 110 lb., corresponding to a drop in temperature of 70 deg.; consequently the mean temperature of the high-pressure cylinder, with its small surfaces, would be about 35 deg. below that of the entering steam. In the second stage, 1874 horse-power, slightly more than one-third, was developed with a drop of pressure of 45 lb., corresponding to a drop in temperature of 62.8 deg., consequently the mean temperature of the intermediate-pressure cylinder would be about 31.4 deg. below that of the entering steam. In the third stage, however, 1840 horse-power, 26 less than one-third, was developed with a drop of pressure of 23 lb., corresponding to a drop in temperature of 113.84 deg.; consequently the mean temperature of the low-pressure cylinder would be 56.92 deg. below that of the entering steam, which, taken in connection with the larger surfaces, accounts for the great loss in the last stage. The intermediate cylinder, being steam-jacketed, would indicate that considerable re-evaporation took place in that cylinder.

It is unfortunate that, if the exact point was known in the expansion of steam, where on the one side the economy would be with the reciprocating engine and on the other with the turbine, yet that point might not be the best place to make the division. There are other matters, such as manœuvring, with reciprocating engines, propeller design, and desirable arrangement in the available engine-room space, that may render the best arrangement for steam economy not the best for general economy.

I believe that the best result in steam consumption could be gained from having the terminal pressure for the reciprocating part of the engine power at or about 30 lb. absolute, or a little above the usual low-pressure receiver pressure in triple-expansion engines. This is very far from that usually adopted as the best arrangement, everything considered.

The arrangement that has found favour with those responsible for the most important installations of power on board ship, where the two types of engine have been combined, has been that in which the steam has been expanded in the reciprocating engine down to a pressure of 9 lb. or 10 lb. absolute. This would give a drop in temperature in the low-pressure cylinder of about 62 deg., say a mean of 31 deg. below the temperature of the entering steam. This, I think, is far below the line where the economy of the turbine is superior to that of the reciprocating engine, and is undoubtedly the result of accepting as best the arrangement of two sets of reciprocating engines and one exhaust turbine between, the new White Star liners being notable examples of this arrangement.* For very large installations of power there are several important advantages that attach to this arrangement. The size of the reciprocating engines is thus kept within reasonable limits. The manœuvring power is 80 per cent. of the total. A breakdown of the turbine engine leaves the whole manœuvring power intact, while a breakdown in one of the reciprocating engines still leaves 75 per cent. of the propelling power intact, and 40 per cent. of the manœuvring power available. There would also be what advantage can be claimed for twin-screws for manœuvring.

Notwithstanding these important advantages claimed for the arrangement of two reciprocating engines and one turbine, I believe that better results, with installations up to 20,000 horse-power, can be secured by having one reciprocating engine on the centre line delivering steam to a turbine on each side at about 30 lb. absolute. This is slightly below the pressure that, in the regular three-turbine set, the steam is usually delivered to the low-pressure turbine. This would admit of the centre-line engine developing about 40 per cent. of the total power, and, when exhausting straight to the condenser, at least 60 per cent. of the full power. The largest and most effective propeller would be on the centre line, where its efficiency would have the best propelling effect. The smaller side propellers would not require so wide projections from the side of the ship, and would thus cause less disturbance to the water in the after run. With the large propeller in the centre, the side propellers could be run at a higher number of revolutions than would be advisable for the centre propeller were it turbine driven. This would permit of the turbine rotors and casings being of a moderate diameter. In a 20,000-horse-power set of engines, with the centre line-shaft making, say, 78 revolutions, I would have the side shafts running about 400 revolutions, which would give a diameter of about 8 ft. to the rotor. This would enable the turbines to be placed alongside the reciprocating engine in any merchant ship having that amount of power.

With the reciprocating engine closing its work with a terminal pressure of 30 lb. absolute, a simple compound engine would give satisfactory results. Where the total power was to be above 8000, I would make the reciprocating engine with two high and two low-pressure cylinders, the high-pressure cranks being 180 deg. apart, and the low-pressure cranks 180 deg. apart, each pair being

Fig. 1.

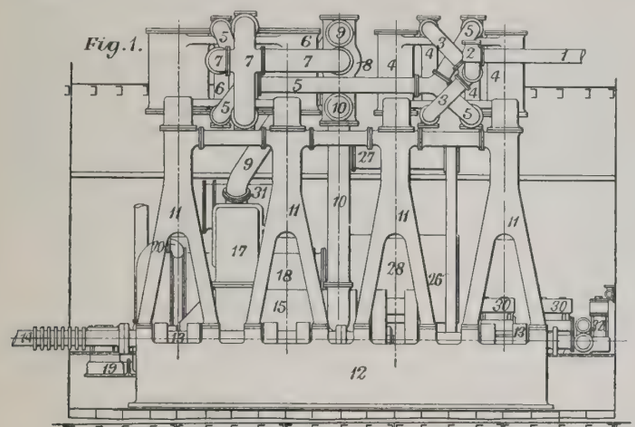


Fig. 2.

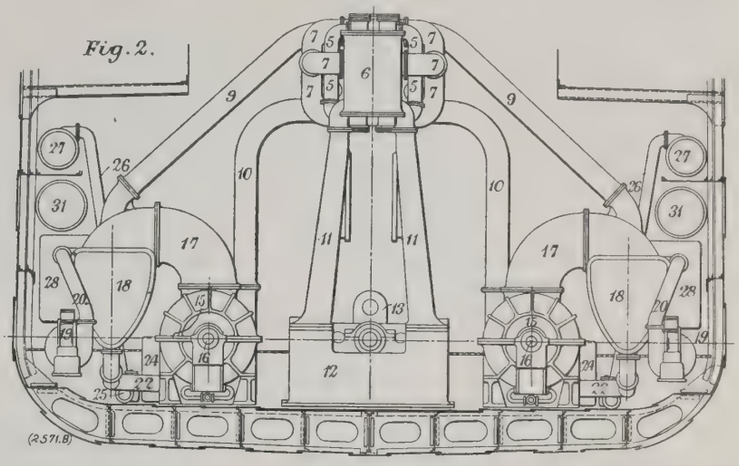
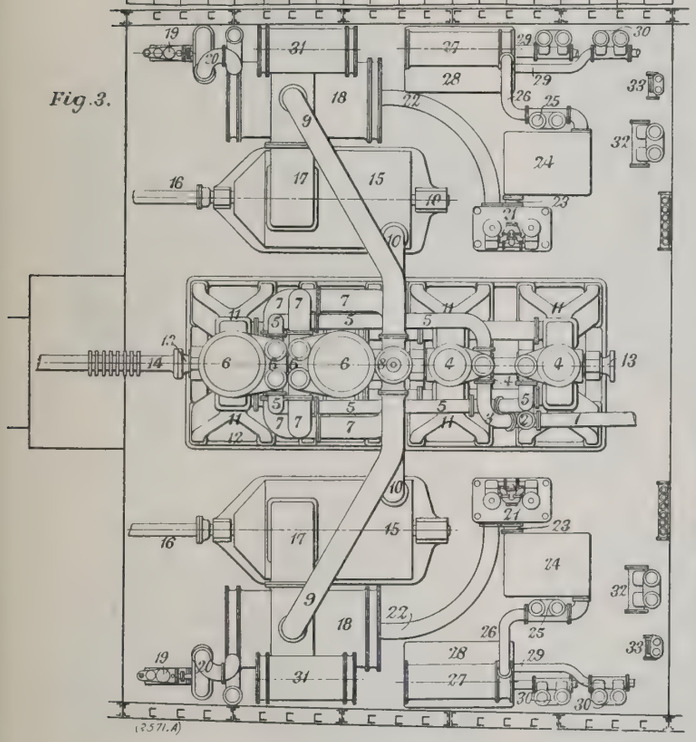


Fig. 3.



REFERENCES.

1. Main steam-pipe from boilers.
2. Main throttle-valve for h.-p. cylinders.
3. Steam-pipe connection to after h.-p. cylinder
4. H.-P. steam-chests and cylinders.
5. Steam-pipe connections from h.-p. steam-chests to l.-p. steam-chests.
6. L.-P. steam-chests and cylinders.
7. Exhaust-pipes from l.-p. steam-chests to change-valve.
8. Change-valve.
9. Exhaust-pipes from change-valve to condensers.
10. Exhaust-pipes from change-valve to l. p. turbines.
11. Reciprocating engine framcs.
12. Reciprocating engine bed-plate.
13. Crank-shaft.
14. Thrust-shaft.
15. Low-pressure turbines.
16. Low-pressure turbine-shafts.
17. Main exhausts from turbines to condensers.
18. Main condensers.
19. Main circulating-pumps.
20. Circulating water-pipes.
21. Main air-pumps.
22. Suction-pipes from condensers to air-pumps.
23. Discharge from air-pumps to hot-well and filter-tanks.
24. Hot-well and filter-tanks.
25. Hot-well pumps.
26. Discharge-pipes from hot-well pumps to surface-heaters.
27. Surface-heaters.
28. Main feed-tanks.
29. Suction-pipes from main feed-tanks to main feed-pumps.
30. Main feed-pumps.
31. Auxiliary condensers—pumps underneath.
32. Bilge-pumps.
33. Sanitary-pumps.

* Abstract of paper read at the eighteenth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 16 and 17, 1911.

* See ENGINEERING, vol. xc., pages 564, 620, and 693.

90 deg. apart; this would produce a well-balanced engine. Both pairs of cylinders would have piston-valves, the valves for each pair being arranged so that one would take steam on the outside of the valve, and the other on the inside. This would enable the valves for each set of cylinders to be operated by one valve-gear, making an exceedingly simple marine engine. By a proper arrangement of exhaust from the low-pressure cylinders, only one change-valve would be necessary. This would be operated by a direct steam cylinder, controlled by an hydraulic cylinder and piston, so that the movement might be as slow as required. No steam jackets would be needed on the cylinders. The exhaust-pipes, however, from the low-pressure cylinders to the turbines might be jacketed with advantage.

In such an arrangement there need be no objection to operating the air-pumps, of which there would be two, through levers worked from the crossheads of the low-pressure cylinders. These pumps would be placed so that the foot-valves would be as low down as possible, the channel-way being in line with the lower face of the bed-plate so as to be below the lowest part of the turbine-casings, it being important to have them thoroughly drained. The dry air-pumps should be operated in the same manner as the wet air-pumps, being placed above the operating levers in a direct line with the wet pumps. The writer, however, would prefer to have the air-pumps independent, as shown on the sketch arrangement illustrating this paper, which would simplify the main engine and enable the turbines to be run without the reciprocating engine being in use. The feed-pumps would be operated independently and thus remove another source of trouble from the main engine. In nearly all cases there would be room to instal the main condensers on the outboard side of the turbines, so placed as to have the exhaust passage in the middle of the length of the condenser. The channel ways or connections to the wet air-pumps would pass through the lower part of the turbine casings, and connect direct to the lower chambers of the pumps. As the turbines would not be as long fore and aft as the reciprocating engine, there would be plenty of room for all engine-room auxiliaries.

An outline of how such an arrangement would be installed for, say, 20,000 horse-power will accompany this paper. The dimensions of the various parts have not been worked out to meet any specific conditions, or to any refinement of accuracy, but are near enough to show how such an arrangement when perfected would look in place, the ship having a moulded breadth of 66 ft.

This arrangement admits of a cooler engine-room than can be obtained where the hottest parts of the machinery are in the wings, and, in most cases, under deck. In the arrangement proposed by the writer, the hottest parts of the machinery are directly under the casing that leads up through all the decks to the open air above.

There are certain objections which will be brought against my arrangement, and some of these are important, and have been carefully considered. It may be asked, Why sacrifice the manœuvring power of two propellers on reversing engines for that of one? In reply to this it is claimed that the advantage of a simpler and cheaper arrangement with the most effective propeller on the centre line of the ship, and the promise of better economy, should outweigh any possible advantage for manœuvring that the twin-screw has over the single-screw ship. It is quite possible that this advantage may be over-rated.

The writer, from his office window, has the opportunity to watch the docking of two steamships once a week. They are sister ships in every respect except that one is a single screw while the other has twin screws. Each vessel is of 5000 horse-power and 400 ft. long on the water-line. The dock that these vessels land at is across the tide, which runs either one way or the other with the flood or ebb. The writer is interested in these vessels, both having been built under his supervision, and yet after careful observation, extending over three years, he has not been able to observe any marked advantage that the one has over the other in making a landing at the dock; no assistance is ever required by either of them. Two days ago he timed the single-screw vessel and found that the time consumed from being abreast of the end of the dock to being moored alongside was just 6.5 minutes. In a larger ship, the turning effect of running the screws in opposite directions would be still less than in the ships mentioned above. The backing power of the single large propeller on the centre line when the engine exhausts to the condenser would be ample for all purposes.

Another objection that might be raised to the arrangement advocated by the writer, is that a breakdown of the reciprocating engine would deprive the ship of any backing power. This objection must be admitted, yet from the simple construction of the proposed reciprocating engine, a breakdown involving the stopping of the engines for good seems rather a remote possibility, and, if it should happen, the turbines could keep the vessel going ahead until she could arrange by wireless for assistance in making port.

These are the two principal objections that can be advanced against the arrangement that the writer proposes, while, if he is right in the claim that the turbine can show a higher efficiency than the reciprocating engine to a point much higher in the expansion curve than 9 lb. or 10 lb. absolute, then the arrangement he proposes would give a better combined economical result and be simpler and less expensive. The chances for air-leaks, where the reciprocating engine delivers the steam to the turbines at 30 lb. absolute, is reduced to one stuffing-box at the condenser end of the low-pressure turbines, while, in the case of two sets of reciprocating engines exhausting to one turbine at 9 lb. or 10 lb. absolute, there are always possible air-leaks at both ends of the turbine and at the stuffing-boxes of both low-pressure cylinders of the reciprocating engines.

In one arrangement proposed by the writer the air-pumps, both wet and dry, are operated from the low-pressure cylinder crossheads. This might be objected to as not providing any means for maintaining a vacuum should the reciprocating engine be disabled. The object in making the air-pumps part of the main reciprocating engine is simply one of first cost, and some advantage in economy of steam and of work in caring for the pumps. The writer has forestalled this objection, and prefers the independent pumps as an additional security against any failure of the reciprocating engine. Of course, independent air-pumps can be installed, in which case they should exhaust into the turbine steam-chests. Our sketch plan shows this arrangement.

In a paper read by Mr. A. C. E. Rateau at the Jubilee Meeting of the Institution of Naval Architects, July 5 of this year, there seems to be something that would indicate that the arrangement proposed in this paper had been considered by Professor Rateau. He says that "In 1906 we fitted the French destroyer Voltigeur with an improved arrangement of engines. The power is distributed on three shafts (centre-shaft reciprocating engine, with turbines on wing-shafts). Up to a speed of 20 knots the reciprocating engine exhausts into the turbines, but above that speed the engines become independent. We could therefore have realised a perfect engine up to a speed of 20 knots if the reciprocating engine and the turbines had been designed solely with the view of obtaining better results by working by stages; but instead of this, they were designed more particularly with the object of obtaining the maximum efficiency at full power." In other words, the Professor, by providing a third condenser for the reciprocating engine to exhaust into at full power, added to the power developed at the expense of the lost economy in the low-pressure end of the reciprocating engine, and in the high-pressure end of the turbine, and even when exhausting from his reciprocating engine into the turbines, he lost in economy by using low-pressure steam in turbines designed to be operated by steam direct from the boilers.

In utilising the expansion in reciprocating engines down to a pressure of, say, 9 lb. absolute, we must have cylinders of large dimensions subject to marked changes in temperature every revolution, involving large losses due to condensation combined with large frictional losses, causing a great curtailment in the theoretical gain due to the expansion; on the other hand, by turning the steam over to the turbines at a pressure and temperature that ensures a more economical continuation of efficiency in the power developed, we thereby succeed in obtaining the very best possible out of each type of engine.

All this, of course, has been considered by the able engineers who have designed the important installations of combined reciprocating and turbine engines that have been fitted to equally important additions made lately to the great steamships of the world. The writer thinks, however, that the desire to hold on to the advantage claimed for the twin-screw ship in manœuvring, and the ability to continue a voyage with one engine disabled, may have had much to do with determining the arrangement of these great combinations of reciprocating and turbine engines. The installation on the Olympic, for instance, can hardly be called a combination of reciprocating and turbine engines, but rather a splendid example of reciprocating engine practice, with a turbine in the exhaust to utilise the last stage of expansion which the low-pressure cylinder could not manage with any efficiency.

In the arrangement proposed in this paper there is no sacrifice of go-ahead power with either the reciprocating engine or the turbines disabled, but only a sacrifice of backing power should the reciprocating engine be out of commission. The question is one that ought to form a good subject for discussion by this Society.

MICROGRAPHIC EXAMINATION OF FAILURES.*

By J. S. Glen Primrose, A.G.T.S.

The "Metallographic Examination of Engineering Materials" has been so enormously developed within recent years that it has given experts an extremely valuable insight into the internal structure of most alloys, of which iron and steel are the most important, and shows that in many cases the proximate composition, as revealed by the microscope, is of more importance than the chemical composition. Metallography has emerged from the stage of doubt and uncertainty in which it for a time existed, and has now attained a position of practical importance in no way secondary to physical testing or chemical analysis, so that practically every steel works of note possesses a photo-micrographic equipment, and many engineering shops are following suit. The engineer himself may not have the time available during his training to devote to a study of practical metallography, and, even in practice, be unable to perform a microscopical examination for himself; but he should at least have sufficient knowledge of the rudiments of the art, that he can comprehend the report and illustrations of an expert metallographist, and understand how it is possible to arrive at a fairly accurate idea of the life history of the materials with which he has to work, and also ascertain their fitness for any particular purpose.

The chief advantage of metallography over the ordinary methods of chemical analysis is that it is much more rapidly performed, and can deal with portions of metal much too small for analysis, and, further, it reveals the mode of arrangement of the constituents, whose presence only is detected by the analysis. Unlike the ordinary methods of mechanical testing, it can be carried out without destroying or even injuring the test-piece, which for micrographical purposes need not be detached from the work. The microscopical examination cannot only be done before putting the material into service, but it can also be applied in the case of a failure, and the metal right up to the place of fracture can be inspected.

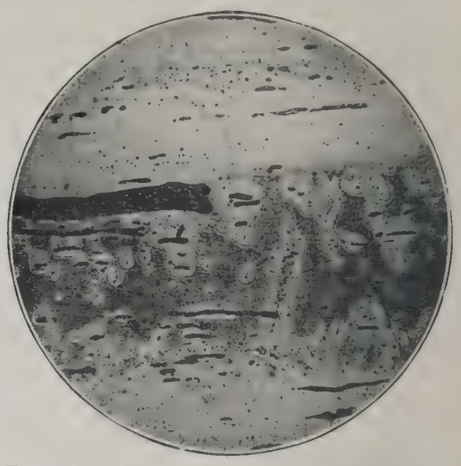


Fig. 1.—Wrought-iron angle-bar, showing phosphide segregation in ferrite ground mass and black areas of slag. Magnification, 120 diameters

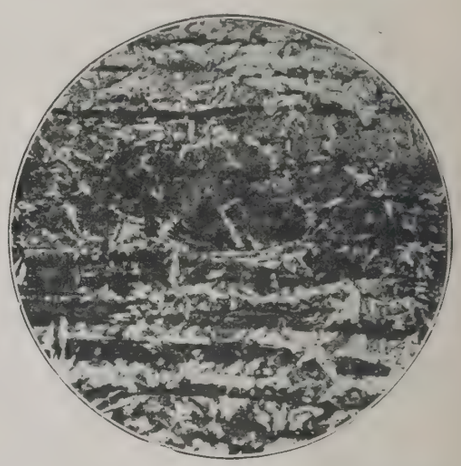


Fig. 2.—Wrought iron, showing carbide inclusion as a dark band of pearlite in ferrite ground mass and black slag patches. Magnification, 60 diameters.

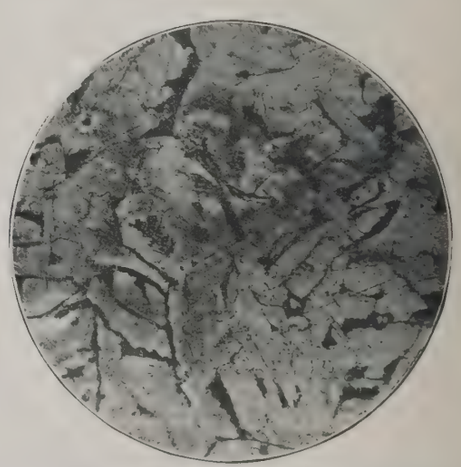


Fig. 3.—Mild-steel plate, showing irregular arrangement of pearlite in the ferrite ground mass and two circular phosphide segregations. Magnification, 120 diameters.

After pointing out the limitations of the art, the author described the most modern methods of work applied in a systematic metallographic examination, as also the latest forms of microscopes and the influence of using different methods of illuminating the carefully-prepared and polished specimens or micro-sections. The chief micrographical constituents of iron and steel were copiously illustrated by a series of original micrographs, showing the effect of increasing carbon content, also that of mechanical and heat treatment on the structure, as shown

* Abstract of opening lecture delivered to the Glasgow University Engineering Society on November 9, 1911.

by the various magnifications obtained with the metallurgical microscope.

INVESTIGATION OF FAILURES.

The general method adopted in examining a case of failure was stated as first consisting in making a chemical analysis to determine faults due to incorrect composition or segregation of impurities. Static or dynamic tests follow to show up the defects arising from incorrect working of the material; and, as a final word, sections are examined microscopically to discover if wrong heat treatment or fatigue has been put upon the metal. Each method can afford independent evidence, but conclusions drawn from the combined results usually give the true solution.

From the slides shown to illustrate some of the failures investigated by the lecturer photo-micrographs are reproduced on pages 748, 749, and 750. Fig. 1 shows the micrograph made from a portion of a wrought-iron angle-bar, the failure of which caused a serious boiler explosion, attended with fatal results. The actual fracture, which happened to be carefully preserved, showed quite a silky appearance, but a streak about $\frac{1}{8}$ in. in from the bend, and parallel to it, exhibited quite a large crystalline structure much whiter than the remainder. The micro-section was taken across this, and shows in the figure quite a marked phosphide segregation running through the ferrite ground mass, and surrounding the elongated slag enclosures. As picric acid was employed in etching, the phosphide showed up highly coloured in the actual specimen, although it only appears as a half-tone area in the reproduction. The quality of the metal was not inquired into at the subsequent inquiry, but the analysis gave an average value of 0.34 per cent. of phosphorus, which was much too high, even apart from the embrittling manner in which it had segregated as phosphide. Clearly such metal should not have been employed in the position it was.

Another example of brittle wrought iron on investigation showed the fault to be due to the incomplete removal of the carbon, which did not appear unduly high on analysis, but the micro-section (Fig. 2) shows that the rolling had extended it into a flat plate, in which the carbon percentage would approximately be half of 1 per cent., and thus the tubes rolled from this material split, with disastrous results. The micrograph shows the central dark band of pearlite, and on either side the white ground-mass of ferrite with the slag extended longitudinally through it.

The micrograph reproduced in Fig. 3 was taken from a mild steel plate which fractured very badly on bending, although the test-piece had come up to specification tests. The structure shows a very elongated and irregular arrangement of the pearlite through the ferrite ground-mass, indicating that the metal had been finished at too high a temperature, and either not afterwards annealed, or annealed at too high a temperature. In addition to the brittle effect thus produced, there are two well-defined phosphide patches in the section, which, although coloured in the sample, only show as dark circular stains in the ferrite. The section was taken from a portion of the plate close to the fracture, and the chemical analysis showed 0.14 per cent. of carbon and 0.08 per cent. of phosphorus.

A rail steel of medium-carbon content, which broke under the drop-test, showed the reason for failure very distinctly under the microscope, the micrograph being

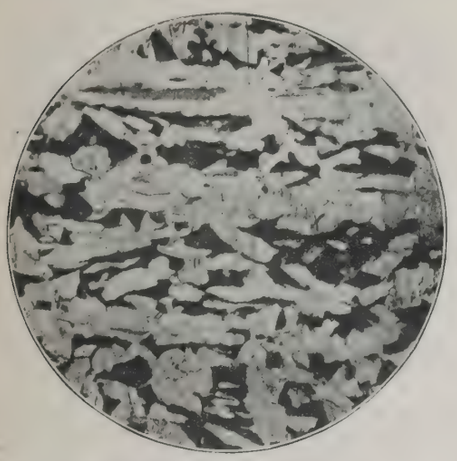


FIG. 4.—Medium carbon rail steel, showing white "ghosts" of ferrite with slag inclusions in them, and pearlite in irregular patches. Magnification, 120 diameters.

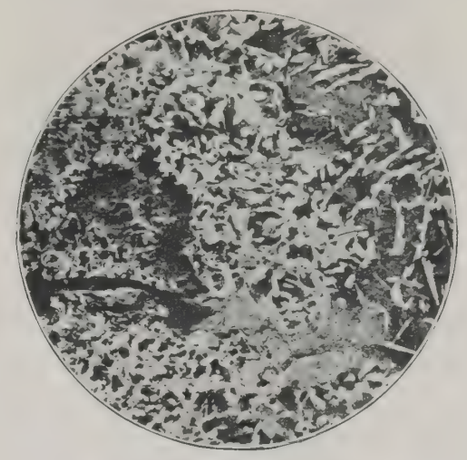


FIG. 5.—Sulphide pock-mark in a test-bar which failed.

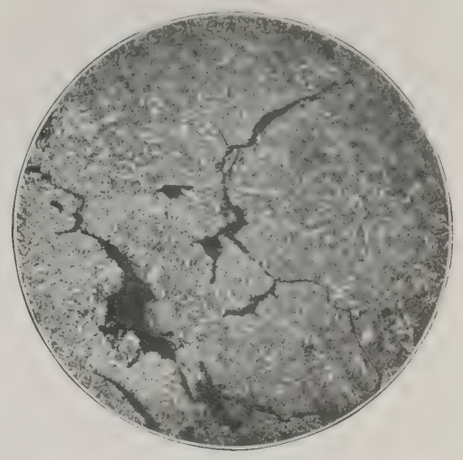


FIG. 6.—Sample of mild steel which had been overheated and burned. Very low magnification.

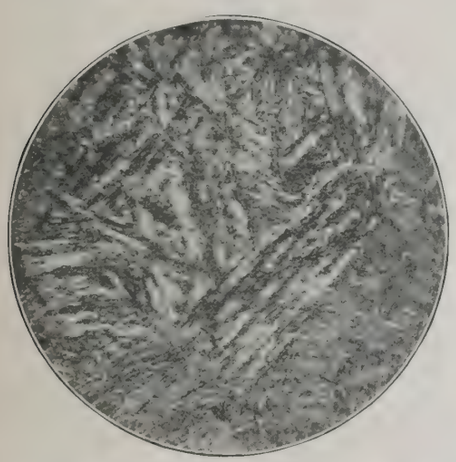


FIG. 7.—Brittle nickel-steel plate showing martensitic structure due to sudden cooling. Magnification, 60 diameters.

FIG. 8.—Fractured locomotive axle, with large-grain structure showing elongated slag enclosures in ferrite ground mass (high power).

FIG. 9.—Fractured locomotive axle, with large-grain structure (low power).

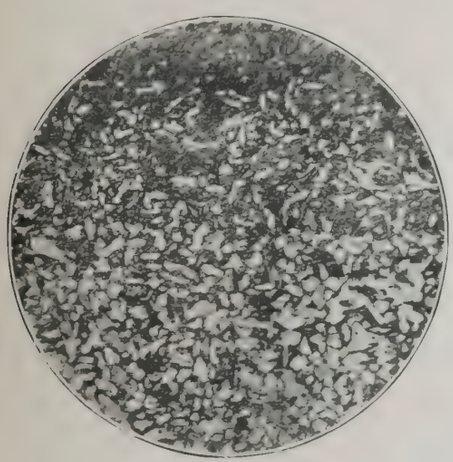


FIG. 10.—Cross-section of case-hardened motor-car steering-rod. Low magnification.

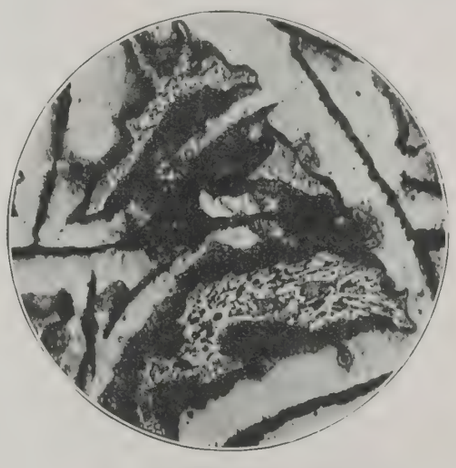


FIG. 11.—Sample of cast iron in which the carbon had separated in large flakes.

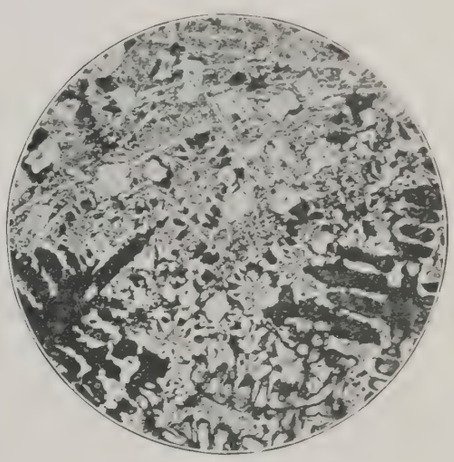


FIG. 12.—"Shot corns" found in grey iron castings.

THE MICROGRAPHIC EXAMINATION OF FAILURES.

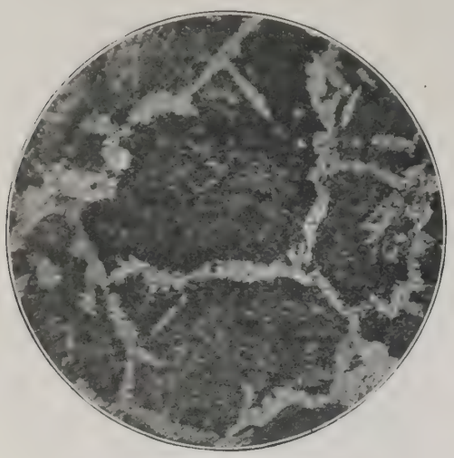


Fig. 13.—Motor-car axle before annealing.

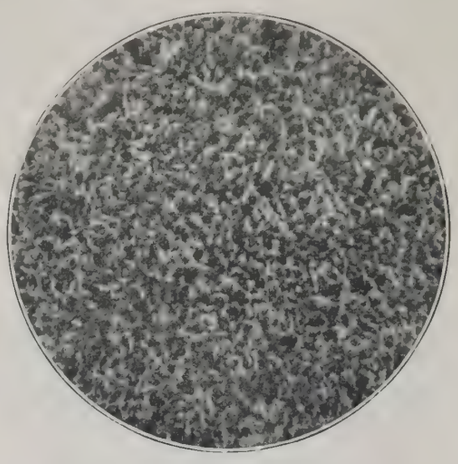


Fig. 14.—Motor-car axle after annealing and fairly rapid cooling.

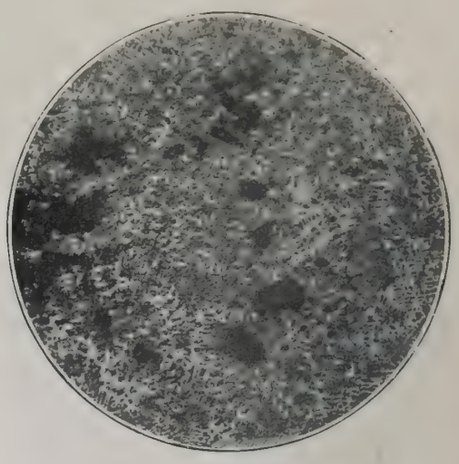


Fig. 15.—Section of cast-iron water-pipe, with blow-holes.

given in Fig. 4. This shows the much elongated bands of ferrite, free from carbon, and known as "ghosts," in which has been entangled quite a considerable amount of slag. This is seen to be grey in shade and quite distinct from the irregular pearlite areas, which under a higher power were seen to be well laminated (indicating that the metal had been left to cool slowly from an overheated condition), and not sorbitic in character, as it would be in a properly-finished rail. The carbon-content was slightly low at 0.3 per cent., but the weakness was undoubtedly due to the structure being traversed by the weak ferrite bands, and also to the slag inclusions which increase the tendency for the metal to split along the "ghosts."

Failure is not commonly due to the presence of sulphur in the form of sulphide segregations, but when these occur the metal is found to be not only "red short," but also to develop brittleness when cold, and fail by fracture under even moderate stresses. Fig. 5 shows the micrograph of a sulphide "pock-mark" noticed in a test-bar which failed to come up to standard. The chemical analysis did not indicate any marked segregation, but close to those parts of the bar at which the skin had puckered in testing the appearance was found to be very much altered, as seen in the lower part of the micrograph. In this portion both manganese and iron sulphides were recognised, and embedded with these in the ferrite were considerable masses of scoriaceous or slaggy matter.

A very general fault in annealing is to raise the temperature too much, and this gives rise to too large a crystal growth, readily recognisable under the microscope, and even in extreme cases to what is called "burning."

Fig. 6 shows the appearance under a very low power of a piece of over-heated mild steel which has also been "burned." The ferrite ground mass not only shows the large crystal structure and irregular distribution of the pearlite, but heat cracks have made their way into the mass from the edge of the billet and left the characteristic track of oxide film, showing up as a black inclusion. Whilst for over-heating the remedy is proper annealing and rolling or forging, for the defect of "burning" produced in this way there is no remedy, short of remelting the material, if the oxide films have penetrated to any considerable depth.

A somewhat unusual type of brittleness was shown by a consignment of nickel-steel plates, which were unfortunately scrapped before the micrographic examination was made. Along one edge the plates were almost glass-hard, and had considerably damaged the shears employed to cut them. The carbon content was only 0.33 per cent., so that the structure under normal conditions should have been pearlitic; but Fig. 7, under a high power, shows the appearance, which is a strongly martensitic or triangular structure. This brittleness could only have arisen by a drastic quenching, and inquiry elicited the fact that some of the plates, whilst on the cooling bank, had been exposed to the action of a heavy snowfall, which sudden cooling was practically equivalent to quenching. This defect could therefore have easily been rectified by a suitable annealing.

One of the most interesting cases of failure investigated by the author was that of a locomotive axle which fractured while the engine was travelling at express speed, but fortunately without serious result. In the summing up of the inquiry blame was largely thrown upon the design of the built-up axle, and yet the two micrographs reproduced in Figs. 8 and 9 clearly show that the metal was in itself distinctly faulty, even although it had passed specification tests. The chemical analysis gave the carbon content as 0.43 per cent., and the sulphur and phosphorus were well within the limit; but on testing the material for tensile strength it broke at an ultimate stress of 30½ tons per sq. in., and gave an extension of only 6½ per cent. on the 3-in. test-piece, which was the largest size available. The low-power micrograph (Fig. 9) indicates from the large size of the grain structure that the metal had been left after manufacture in a brittle or overheated condition, possibly due to incomplete mechanical working, or the finishing of this at too high a temperature. The strongly marked lattice-work arrangement of the ferrite around and through the pearlite is characteristic of brittle and untrustworthy material. The higher magnification (Fig. 8) shows a further source of weakness by reason of the presence of elongated slag enclosures in the ferrite ground mass, and both of these defects had evidently given rise to the conditions favourable to developing "fatigue" of the metal from which it finally fractured.

Such metal could undoubtedly have been restored to a proper condition by a suitable annealing and fairly rapid cooling before being put into use, and instances were quoted to show how motor-car axles which developed serious brittleness had been heated and oil-quenched to produce the necessary reduction in the grain size and uniform distribution of the pearlite to give exceedingly durable material (Figs. 13 and 14).

The failure of a motor-car steering-rod, due to fracture, was shown to be due to the imperfect case-hardening of the material. Fig. 10 shows the micrograph of a cross-section near the point of fracture, and shows, even at the low magnification, the very sharp line of demarcation between the martensitic structure of the outer edge (shown at the top) and the mild-steel centre containing the ferrite ground-mass with small quantities of pearlite. Evidently a small heat or surface crack had penetrated the hardened skin, which, not being well cemented to the core, had yielded under the stress of a sudden twist.

Cast iron is not usually called upon to withstand heavy stress put upon it, but hydraulic castings occasionally fail in a way which may appear mysterious without the aid of the microscope. One peculiar case of the failure of a heavy casting while in service was investigated, the test-bar having given entirely satisfactory results. It had cooled at a much quicker rate than the metal in the casting, which was rather high in silicon for the thickness employed, with the result, as shown in Fig. 11, that the carbon separated in very large flakes, which were without doubt the cause of fracture. The metal was also weakened by the considerable degree of segregation of the iron phosphide, which appears as the eutectic mass enclosed within the dark pearlite areas.

Sometimes even grey iron castings fail on account of the separation within them, of minute "shot corns" or bullets of a very hard material, often attributed to chilled metal. In nearly every instance of such defects investigated by the author these were shown to be due rather to eutectiferous segregation of iron phosphide. These bullets are often much too small for analysis, but the microscope reveals the characteristic eutectic structure, as shown in Fig. 12, which not only illustrates the peculiar manner in which the pearlite areas are affected, but indicates how the iron phosphide can separate out in lozenge-shaped crystallites when above the eutectic proportion. This makes the portion of metal extremely hard and brittle to shock.

Blow-holes in castings are responsible for many failures, particularly in instances where the metal is desired as hard and close in the grain as possible. Fig. 15 illustrates the micro-structure of a water-pipe which failed badly under pressure, owing to the defective manner of casting, which had evidently produced too sudden a cooling. The ground mass had been converted into the cementite characteristic of a white iron, and the large amount of contraction had led to the formation of unsound patches in the interior of the metal, indicated by the dark holes scattered throughout the pearlite areas.

The lecturer claimed that there were many cases in which the microscopical examination of metal before use would prove of great service to the engineer, particularly in preventing the use of faulty material unsuited for the purpose to which it was to be put.

Finsbury Technical College Old Students' Association.—The sixth annual dinner will be held at the Trocadero Restaurant, Piccadilly-circus, on Saturday, December 9, at 7 for 7.30 p.m., when the chair will be taken by Mr. Reginald J. Wallis-Jones, M. Inst. C.E., M.I.E.E., President of the Association.

ELECTRIC LIGHTING OF RAILWAY-TRAINS; THE BRAKE-VEHICLE METHOD.*

By Roger T. Smith, B.Sc., Assoc. M. Inst. C.E.

The method of train-lighting considered is that in partial use on the Great Western Railway, where axle-driven dynamos and batteries controlled by an automatic regulator are installed on brake-vehicles only. The lamps throughout the train are supplied from these equipments, which work in parallel with each other, the brake-vehicle equipments and the lamp wiring in the coaches dependent on them being connected electrically by through wiring coupled between coaches. There is consequently an appreciable reduction in initial cost and upkeep of plant, and, what is of chief importance from the railway point of view, increased reliability. Mr. William Langdon's paper, read before the Institution in 1891, describes his, the first, attempt to light electrically passenger rolling-stock in general, in place of lighting set or block trains which were never broken up in traffic. Mr. Langdon's final method provided one axle-driven dynamo in the block part of a main-line train, and a battery on each of the other coaches. All coaches were electrically coupled, and when uncoupled the lighting of each coach was continued during its branch journey by means of the charged battery. For any method of electric train-lighting applicable to all passenger rolling-stock the alternatives are either some such method as proposed by Mr. Langdon, or that every coach is "self-lit;" that is to say, provided with its own axle-driven generator and battery. Other methods are either not applicable to passenger stock as a whole, or unsuitable for English railways.

The first aim of any method of train-lighting should be to light passenger rolling-stock adequately and with reliability. Measurement and experience lead to the provision of an illumination, measured on a horizontal plane at eye-level, of 2 foot-candles in third-class, and 2½ foot-candles in first-class compartments. Glare or dazzle can be minimised, if not entirely prevented, by keeping lamps out of the line of sight, by providing a white background behind the glowing filament, or by reducing the intrinsic brilliancy of the filament by enclosing the lamp in a diffusing globe or holophane globe, the latter at the same time improving distribution. The tungsten train-lighting glow-lamp now replaces the carbon glow-lamp, its most economical efficiency with present train-lighting lamps being 1.3 watts per candle. On the average, tungsten glow-lamps, with a useful life of 850 hours, now have to be changed only once a year in the electrically-lit coaches on the Great Western Railway, where lamp-voltage is regulated within ± 2½ per cent.

Any axle-driven system must, in the first place, provide a lead cell or other accumulator, so that the lamps are lit whether the train is standing or moving throughout its range of speed. In order to draw proper attention to the importance of the accumulator in train-lighting, it is both convenient and useful to look upon the accumulator as the essential element, and on the dynamo as a device for making the output of the accumulator continuous throughout the hours of lighting. As typifying the accumulator the lead cell alone is considered. The two extremes among methods of charging lead cells are charging at constant voltage and charging at constant current: but a method of charging which combines the advantages of both extremes, while avoiding their disadvantages, is recommended, the charge being completely under the control of an automatic regulator set to give the proper compromise. The arrangement consists in starting with a heavy charge and gradually reducing it until, after proper gassing has taken place so as to mix the electrolyte, the charge is stopped when the cells are full, or the battery is left floating on the load while lights are on. Automatic regulation is necessary to secure a long and healthy life for the lead cell, and to reduce maintenance it is essential; when properly arranged, 10 per cent. per annum of the initial cost of the whole cell will provide

* Abstract of paper read before the Institution of Civil Engineers, Tuesday, November 28, 1911.

for both maintenance and renewals of the plates and boxes.

The train-lighting dynamo is of secondary interest as compared with the battery, the essential element being some means of keeping the voltage constant at all speeds while permitting of its automatic variation by the regulator when required. The suspension and driving of the dynamo and the reduction of belt losses and renewals are among the chief factors in success. The automatic cut-in cut-out switch for connecting or disconnecting the dynamo from the battery should be actuated electrically, since the voltage of the latter may vary 25 per cent. from that of the former at any given speed. It is desirable that this switch should also act as an instantaneous automatic reverse-current circuit-breaker. The problem of automatic regulation has not attracted the British inventor as compared with other inventors on both sides of the Atlantic. The functions of an ideal regulator, combining in one or two instruments battery and lamp-voltage regulation, may be defined briefly as the following:—First, it must control the lamp-voltage within $\pm 2\frac{1}{2}$ per cent. of the rated voltage of the lamps, and, within reasonable limits, must do so independently of lamp-load and entirely independently of battery voltage. Secondly, when lamps are off, the regulator must control the generator field so as to provide the full output of the dynamo for charging an empty battery; and when lamps are on, the balance of the full output must be available for charging. As charging proceeds the regulator must control the inherent regulation of the dynamo so that its voltage only rises sufficiently to give a diminishing charging current. Thirdly, with a fully charged battery and lamps off, the regulator should reduce the charging current to zero. Fourthly, with a fully-charged battery and lamps on, the dynamo output must be adjusted to equal the lamp load, leaving the battery in a floating condition with current neither entering nor leaving it. The foregoing requirements can to-day be obtained combined in one piece of apparatus.

To reduce the initial cost of electric train-lighting, it is of first importance to reduce the number of battery-cells, since within train-lighting limits it is the number of cells to be maintained, and not their size, which counts. The number of dynamos and regulators may be reduced in the same proportion. With the exception of through coaches transferred from main to branch lines, every train on the Great Western Railway has at least one brake-vehicle controlling it for traffic purposes, and all coaches which leave or join a main-line train *en route* are either brake-vehicles themselves, if detached or attached as single vehicles, or, if two or more coaches are detached or attached, they are controlled by a brake-vehicle. If every brake-vehicle is equipped with a generator and battery, the remaining coaches being wired only, while through wiring and couplers, designed to connect all vehicles together electrically, are provided on every coach, a less costly method of lighting trains is assured, as compared with the equipment of every coach as a self-lit vehicle. In addition, much greater reliability is secured by working two or more dynamos and batteries in parallel. This arrangement of equipment it is proposed to call the "brake-vehicle" method, because under ideal circumstances only brake-vehicles need be equipped. On the assumption that all Great Western passenger rolling-stock might be equipped for electric train-lighting, the percentage of brake-vehicles would be 27, of dependent coaches 40, and of self-lit coaches 33, for main-line working, while for local and suburban traffic the percentage of brake-vehicles would be 39, and of dependent coaches 61. If the ratio of brake-vehicles to dependent coaches were as 1 to 3, and there were no self-lit coaches, the initial cost of equipping an entire rolling-stock of some thousands of coaches would be reduced by about 35 per cent. as compared with self-lit equipments, and the working costs would be reduced about 40 per cent. The increased reliability due to a higher percentage of generator coaches is, however, of greater importance to the railway than reduction in cost. In addition to the electrical requirements already specified for the ideal equipment, others are specially needed for the brake-vehicle method. It is of primary importance that the dynamo should be capable of running with its brushes short-circuited, while in addition its output must be capable of being quickly altered by a simple adjustment to suit altered traffic conditions.

An experimental six-coach train lit on this method was run nearly continuously for two years in all sorts of traffic, varying from fast main-line services to slow, stopping, local services. Two brake-vehicles, equipped with 45-ampere dynamos, regulators, and 180-ampere batteries, light themselves and three dependants. A self-lit detachable coach completes the train. The Leitner system provided the only available apparatus able to meet the special conditions. All the equipments are in parallel, coupled through cables throughout the train providing for this. For the lighting circuits the through wiring and method of coupling is arranged on the loop-positive system, one regulator controlling the lamp-voltage on each side of the loop. The same looped-positive brake-vehicle method nas been applied to two trains running on South Wales services, to two new trains specially built for the Cunard boat service between Paddington and Fishguard, and to two new trains used for Birmingham local services, and it is being further applied. The bus-bar system of through wiring, a simplification of the looped-positive system, is now being adopted. By the bus-bar system greater simplicity and increased reliability are secured as compared with the looped system, but at greater cost.

The total annual cost of lighting a six-coach train on the looped-positive brake-vehicle method is as follows:—The cost of the initia lequipment would be 761*l.*, inclusive of all carriage-work charges; adding working costs, extra cost of locomotive power—determined experimentally—and capital charges, the total annual cost becomes:—

	£
Working costs	45
Power to drive dynamos, 1½ per cent. on 875*l.*	13
Haulage of extra weight, 1.7 per cent. on 875*l.*	15
Interest on 761*l.* at 4 per cent.	30
Reproduction of capital in twenty years at 3 per cent.	23
Total annual cost of lighting a six-coach train	126

With regard to the safety of electric train-lighting, although at 22 volts an arc can be formed between any of the metals employed in train-lighting, this arc will not persist. Provided the ordinary precautions necessary with electric circuits are taken, and suitable fuses are used and properly maintained, it is believed that complete immunity from fire risks can be ensured.

CATALOGUES.

Diamond Tools for Dressing Abrasive Wheels.—We have received from the Carbon Tool Company, Albany-road, Coventry, a copy of a four-page pamphlet containing some notes on the selection and use of diamonds, which they supply for various industrial purposes. The pamphlet illustrates and states prices for various forms of diamond tools, for hand and machine use, suitable for dressing and truing abrasive wheels and other work.

Machine-Tools.—We have received from Messrs. A. A. Jones, Pollard, and Shipman, Limited, Church Gate, Leicester, a copy of their latest catalogue of machine-tools, including several new models; many of the original types have also been improved. The catalogue deals with upright, radial, and sensitive drilling-machines; milling-machines; centering-machines; drill, tool, and cutter-grinders; emery-grinders: hack-sawing machines; and internal gear-cutters. Prices are stated and specifications given for all the tools listed.

Heating Boilers.—A pamphlet giving prices and particulars of "Eau-sho" heating boilers has reached us from Messrs. Robert Jenkins and Co., of Rotherham. These boilers are horse-shoe shaped in plan, and have flat horizontal water-spaces at the top and bottom. Another water-space, triangular in cross-section, connects the legs of the horse-shoe about midway between the top and bottom. The grate is situated below this water-space, and fuel is fed in through an opening above it. The fire is thus almost completely surrounded by water-spaces, so that very little heat is lost by radiation. The boilers can be used for supplying hot or boiling water as well as for heating buildings. They are made in thirteen sizes, the capacities of which range from 210 ft. to 720 ft. of 4-in. piping. Boilers without a water-space at the bottom, but otherwise similar to those above described, are also listed.

Arc-Lamps.—A pamphlet relating to "Multax" flame arc-lamps has recently been issued by the Globe Electric Company, Limited, 11, Farringdon-avenue, E.C. These lamps employ flat carbons, the cores of which are dumb-bell shaped in section. The makers claim that the burning hours are increased 150 per cent. by the use of these carbons, and by the method of enclosure adopted. The pamphlet illustrates a new type of light distributor, consisting of a hollow glass ring, triangular in cross-section, and silvered inside. It is placed in the bottom of the outer globe, so that the light falling on the inclined surface is reflected at an angle of about 30 deg. with the ground. The arrangement is particularly useful for the illumination of streets and large open spaces. Prices are stated for lamps in two patterns, which burn for 25 and 40 hours respectively; both patterns are made for use on alternating-current and direct-current circuits. Prices for line resistances, auto-transformers, globes, &c., are also stated.

Steel Pipes.—Messrs. Stewarts and Lloyds, Limited, of 41, Oswald-street, Glasgow, have sent us a copy of their catalogue, Section W., giving standard dimensions and prices of steel pipes and accessories for gas, water, and air-mains. These pipes are made of Siemens-Martin steel plates, lap-welded, and can be supplied in lengths up to 40 ft., and up to 48 in. in diameter. They were originally made for foreign and colonial use, particularly in places were transport was difficult and costly, but are now being largely employed by engineers and municipal authorities in this country. The catalogue contains fully illustrated notes on joints and fittings, and also points out the superiority of these welded pipes over riveted-steel and cast-iron pipes. A method of nesting pipes of different diameters in order to economise space, and so effect a considerable reduction in shipping rates, is also illustrated. Some useful tables showing the discharge of water from pipes of various diameters at different degrees of inclination, are included; other tables given enable the capacity of gas and air-mains to be easily calculated.

Commercial Motor Vehicles.—From Leyland Motors, Limited, of Leyland, near Preston, we have received a copy of their latest catalogue of steam-wagons and petrol-motor vehicles for commercial purposes. The steam wagons are made in two types with gear and chain drive for the road wheels respectively; a specification of both types is included. The gear-driven wagons are made for loads of 3 and 6 tons, and the chain-driven type for loads of 5 and 6 tons. The petrol-driven vehicles are made in eight sizes for loads ranging from 1½ to 6 tons. In the four smallest sizes a worm-gear drive is employed for the back axles, while bevel gearing is used in the heavier wagons. A specification of each type of chassis is given, and numerous illustrations are included to show the varied nature of the work for which they have been employed. Both steam and petrol-wagons are largely used for collecting house-refuse, street-watering, and other municipal work, as well as for ordinary commercial purposes. Some examples of motor fire-appliances, omnibuses and char-a-bancs, and of petrol-driven tramcars are also illustrated. Prices are clearly stated in the catalogue, and some particulars of working costs for both steam and petrol-wagons are included.

Forging and Planishing-Hammers.—From the Alldays and Onions Pneumatic Engineering Company, Limited, Great Western Works, Birmingham, we have received a catalogue of pneumatic-power forging-hammers. The catalogue first deals with hammers of the guided-tup type for general forging work, arranged for driving by belt or by an electric-motor. The construction of these hammers is illustrated and described, and dimensions and capacities are given; six sizes, from 1 cwt. to 10 cwt., are listed. Particulars are also given of the "Perfecta" pneumatic-power hammers. These hammers are run continuously at high speeds, the force of the blow being varied as required by hand or by a foot-lever. Planishing-hammers for sheet-metal working are next dealt with, particulars being given of hammers operated by hand, foot, and pneumatic power. The catalogue also gives particulars of friction drop-stamps, a spring-type double oliver, and a spring-power hammer. Prices are stated, and shipping particulars given of all the machines listed.

Vibration-Indicator.—An interesting instrument for indicating and recording the vibrations caused by machinery in buildings, steamships, motor-cars, &c., is illustrated and described in a pamphlet which has reached us from Messrs. Siemens Brothers and Co., Limited, Caxton House, Westminster, S.W. The instrument, which is called the "Vibragraph," consists of a light and easily portable box, containing a mercury cup in which floats a mirror. A beam of light from a small electric lamp falls on to this mirror, and is reflected on to a photographic plate or a ground-glass screen. If the mercury is at rest, the spot of light is stationary, but any vibrations will set up ripples on the surface of the mercury, so that the resulting movements of the mirror cause the spot of light to trace out a line or a closed figure on the plate. The dimensions of this figure used in conjunction with calibration curves enable the actual movements of the object on which the instrument is placed to be accurately determined. A set of three mercury cups, with different degrees of sensitiveness, is usually provided with the instrument, which can thus be used in all cases where it is desired to measure vibrations. For instance, it would give valuable evidence in law-suits relating to alleged nuisance caused by vibrations to residents near power stations or underground railways. Several interesting records are reproduced in the pamphlet.

BRITISH TRADE COMMISSIONER'S OFFICE, CAPE TOWN.—We are informed by H.M. Trade Commissioner in South Africa that a Commercial Information Bureau is now attached to the British Trade Commissioner's office, Cape Town, for the purpose of supplying information, free of charge, to those interested in British trade. The object of the bureau is to assemble under one roof as much commercial information as possible dealing with the trade of the United Kingdom and South Africa. If at any time information is required that is not on record, H.M. Trade Commissioner states that he will be very glad to take the necessary steps to obtain it, if possible, provided that such information is associated with British trade interests.

BRITISH STANDARD SPECIFICATION FOR HARD-DRAWN COPPER WIRE.—The fifty-fifth report of the Engineering Standards Committee, which has recently appeared, is devoted to experiments on hard-drawn copper and bronze wire. Certain funds were provided by the General Post Office and the National Telephone Company, the two largest users of telegraph and telephone wire, for the Engineering Standards Committee, for the purpose of carrying out experiments at the National Physical Laboratory, the object being to obtain some independent data regarding the breaking stress of hard-drawn wire of small diameter when used for telegraph and telephone purposes. Much ground has been covered by these experiments, which included an investigation into the variation of mechanical properties of these wires due to differences of make, diameter, length, and temperature, as well as variations of strength caused by the kinking of the wire, this kinking having apparently more influence on the strength than has hitherto been appreciated. The testing arrangements are described in the report, and several very complete tables and curves are given which show the total extension and the breaking load for different wires. The influence of kinks on the moduli of elasticity of the material is clearly shown by the figures given. A comparison between the modulus of elasticity as calculated on 50-ft. lengths and as calculated on a short length is very distinctly brought out. It is suggested that wire-makers would do well to study the report carefully, and it is pointed out that wire of this class would benefit by being wound in coils of larger diameter than is usual, in order to minimise the weakening effect of sharp bends, as the matter is an important one where the erection of long lengths of wire is concerned. The report is published for the Committee by Messrs. Crosby Lockwood and Son, 7, Stationers' Hall-court, Ludgate Hill, E.C., and 121A, Victoria-street, S.W., and may be purchased from any bookseller or direct from the offices of the Committee, 28, Victoria-street, Westminster, S.W., price 10s. 6d. net.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

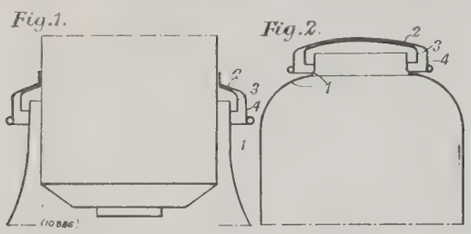
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

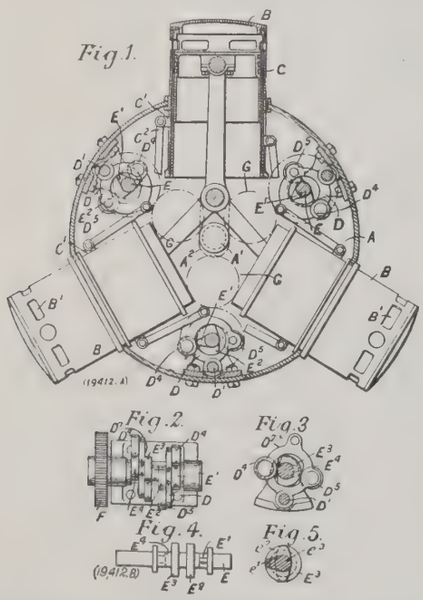
10,886/11. Korting and Mathiesen Aktiengesellschaft, Leipzig, Germany. Arc-Lamps. [2 *Figs.*] May 6, 1910.—The usual method of permitting the egress of the products of combustion in an arc-lamp consists in an annular sleeve surrounding the lamp-case, the fumes passing up between the case and sleeve. Surrounding this sleeve is a cover or hood so disposed that rain cannot directly enter the space between the sleeve and case. It has been found that, in stormy weather, rain is driven into the space between the sleeve and case, and that this defect is obviated if the cover or hood be formed with two or more downward pointing rings, of which, at least, the two outer rings terminate below the edge of the sleeve, the outer ring preferably projecting further down than the inner



ring. With this arrangement, the rain is driven into the air space between the two rings; the effect of the two rings is to cause a stagnant air space or eddy, so that the rain-drops impinge on the inner ring and drop thence downwards without being driven into the ventilating space between the sleeve and case. Fig. 1 shows diagrammatically one form of lamp ventilator made in accordance with this invention, while Fig. 2 shows a modified form. Two concentric rings on the hood are shown; Fig. 1 illustrates the method of bottom or side ventilation, Fig. 2 that of top or cap ventilation. The ventilating sleeve 1 is covered by a hood 2 fitted with two concentric rings 3 and 4 spaced a distance apart so that there is an air-gap between the two rings. Both rings cover roofwise and project below the mouth of the ventilating sleeve. (*Accepted October* 4, 1911.)

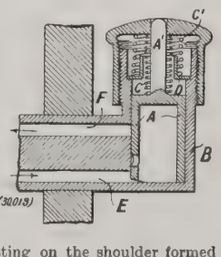
GAS ENGINES, PRODUCERS, HOLDERS, &c.

19,412/10. C. B. Redrup, Cardiff. Internal-Combustion Engines. [9 *Figs.*] August 18, 1910.—This invention relates to valve-gear of the type wherein for each valve there is provided a rocking-frame controlled by a pair of cams, whereof the portions at greatest distance from the centre of the cam-shaft on each are both on the same side of the shaft, and co-operate with staggered portions of the frame, or parts carried thereby, that lie on opposite sides of the cam-shaft. By making half, or more, of such a cam concentric with the axis of its shaft the long



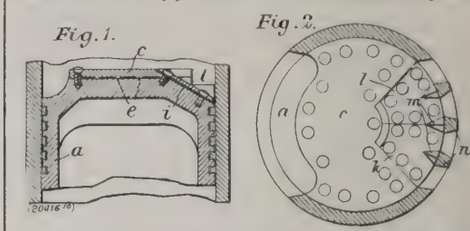
dwell desired, and then the rapid movement of the rocking-frame required for opening the valves, can be obtained. According to this invention, as applied to an engine having three cylinders radially disposed around and projecting partly into the crank-case, the rocking-frames and their double cams are provided in pairs, and disposed one pair between each two cylinders. The two pairs of cams are carried on a shaft common to both, and each shaft has on it a toothed wheel. These wheels mesh with other wheels arranged round the crank-shaft of the engine, and meshing in turn with a wheel thereon. All this mechanism is enclosed within the crank-chamber, and the rocking-frame of one pair of cams is connected to a valve belonging to one cylinder, and the rocking-frame belonging to the other pair of cams on the cam-shaft is operatively connected to the valve of the cylinder on the other side of the gear. Preferably half-sleeve valves are employed, each cylinder having two such valves for controlling the inlet and exhaust respectively. The engine has a crank-case A, radiating from which are three cylinders B. Within the walls of the cylinders are mounted half-sleeve valves C, which control ports B^1 near the head end of each cylinder. The valves are free to slide towards the head end and back towards the crank-chamber end first, to cover and then to uncover the ports. Each valve C has a lug C^1 that projects through an opening in the outer portion of the cylinder wall, and these lugs are connected by links C^2 to rocking-frames D. Each frame is pivoted at D^1 to the wall of the crank-chamber, and its opposite end is connected to the link C^2 by a pin. On each rocking-frame are rollers D^4, D^5. These rollers are placed on opposite sides of a central space provided in the frame, and they are staggered relatively to each other, one being on one face of the frame and the other on the opposite face. Extending through the space in the frame is a cam-shaft E, whereon double cams E^1, E^2 are mounted. The portions e^1, e^2 of the cams that are furthest from the centre of the cam-shaft are both on the same side of the shaft and are placed centrally in relation to each other; moreover, the part e^2 of the cam E^2 and a part e^3 of the cam E^1 extend more than half-way round the cam-shaft and are concentric therewith. The cam E^1 co-operates with the roller D^4, and the cam E^2 with the roller D^5. It will be observed that one cam is wide and the other narrow, and the relative proportions are such that as the two cams rotate both rollers are kept constantly in contact, or approximately in contact, with their respective cams throughout the whole rotation of the cam-shaft. Only one pair of cams E^1, E^2 has thus far been described, but the cam-shaft E carries a second pair E^3, E^4 that co-operate with rollers on a rocking-frame D^7. These cams and their frame are exact duplicates of those already described, but they are set at an angle to the other cams, so that when one pair of cams is moving its frame to the right the other pair will be moving its frame to the left. Each cam-shaft has mounted on it a toothed wheel F which gears with one of a series of toothed wheels G that are mounted round the crank-shaft A^1 of the engine and mesh with a toothed wheel A^2 thereon. Each pair of double cams, with their rocking-frames, are mounted on a base-plate providing bearings for the cam-shaft, and these plates are secured to the crank-case between each two cylinders. One rocking-frame thus serves one valve for one cylinder, and the other rocking-frame one valve for the adjacent cylinder. This arrangement enables the parts to be got conveniently into the crank-chamber. The operation of the gear is as follows:—The crank-case and shaft may both rotate in opposite directions, and the relative motion causes the intermediate gear-wheels G to be rotated about their supporting pins, which communicate motion to the cam-shafts E. The two pairs of cams on each shaft will thus be carried round with the shaft, and one pair being set, as already explained, at an angle to the other, will cause the rocking-frames D and D^7 to rock in opposite phase, thereby imparting movement to their respective valves. The long concentric portions e^2, e^3 of the cams allow the valves to be stationary during the compression and firing strokes, which is an important feature, as these valves being of the half-sleeve type, they are under pressure during these periods, so that any movement would result in considerable friction. As soon, however, as the valves are to be opened, these concentric portions of the cams pass from their respective rollers, and the rocking-frames are almost instantly brought over to the limit of their movement for opening the valves, thus throwing them wide open at the commencement of the exhaust or inlet strokes. (*Accepted September* 27, 1911.)

30,019/10. W. F. Rainforth and D. Napier and Son, Limited, London. Forced-Lubrication Apparatus. [2 *Figs.*] December 24, 1910.—In forced-lubrication apparatus for internal-combustion engines, it is the practice to deliver lubricant under pressure to certain of the moving parts by a pump operated by one of them and drawing its supply from a sump. Other of the moving parts require, under certain circumstances, what may be termed emergency lubrication. For instance, the pistons of an engine may be given more than the normal supply of lubricant—that is to say, may be given emergency lubrication, when the engine is started, and also at times when the speed may be exceptionally high. According to this invention, there is combined with the forced-lubrication main pipe a valve, which may be an indicating valve, and is loaded for more than the normal pressure of oil in the pipe; from this pipe there leads what may be termed an emergency branch controlled by that valve and so situated at its entry into the valve-casing that it is opened to the main by the pressure of the lubricant, at such times only as the normal pressure is exceeded. A hollow piston A moves in the casing B and is provided with an extension A^1 projecting through the upper portion of the casing and serving as an indicator of the position or movement of the valve. The valve is loaded by a spring C. The internal diameter of the upper portion of the casing B is enlarged,



and normally resting on the shoulder formed by this enlargement is a movable abutment D. A heavier spring C^1 is disposed between the abutment D and the underside of the upper portion of the casing. Communicating with the casing B is a pipe E, which is a portion of the main oil-pipe from the lubricating-pump. Above this pipe is a second pipe F communicating with the portion of the apparatus requiring extra lubrication at such times when the pressure in the lubricating system is caused to rise above its normal value. The operation of the valve is as follows:—Oil from the pump is delivered along the pipe E, and through an orifice enters the interior of the piston. When the engine is not running the piston is in the position shown, but on starting the engine the normal oil pressure in the system will raise the piston against the action of the spring C until it engages with the movable abutment D, the position of the extension A^1 indicating that oil is circulating in the system. A further increasing pressure of the oil moves the piston and the movable abutment D against the action of the heavier spring C^1. The orifice is then brought into alignment with the pipe F, and the oil is allowed to flow through this pipe F under pressure to the part requiring excess lubrication. After this point, if desired, the relief-valve may be allowed to come into operation to reduce too great an excess of pressure in the system. (*Accepted October* 4, 1911.)

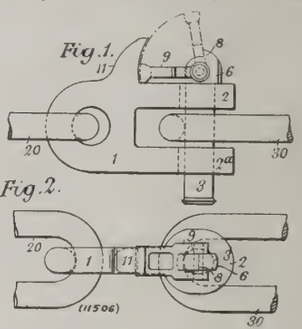
20,416/10. F. H. Tanner, Bristol. Pistons. [2 *Figs.*] March 1, 1911.—This invention consists in covering the surface of the piston of a Diesel engine over which the gases pass to the exhaust port or ports with a metal plate insulated from the piston, and provided with projections which are highly heated by the passage of the exhaust gases to said port or ports, one of the projections being preferably extended so as to project into the fuel spray at the moment of injection. The upper flat surface of the piston *a*, which is formed with an inclined exhaust face, has secured to it a covering plate *c* of metal. The plate *c* is formed with shallow, and comparatively wide, concentric channels, thus providing the plate *c* with a number of concentric ridge-like projections adapted to abut against the face of the piston *a*. These channels conveniently provide the insulation between the piston *a*



and the plate *c*, but an insulating pad or sheet of asbestos, or other non-conducting material, may be employed in addition. The inclined exhaust face *i* is machined to form part of a frustum of a cone, and is protected by means of two plates *k*, *l*, accurately machined to fit this surface, and insulated therefrom. The plates *k*, *l* are provided with ridges or projections *m* shaped to guide the exhaust gases to the exhaust-ports, and past the exhaust-port bridges *n*, in order to prevent the latter from becoming overheated. The exhaust cavity on the piston becomes extremely hot, and forms a very suitable combustion space, and, in order to facilitate ignition, one of the projections *m* is prolonged sufficiently so that it will just enter the fuel spray when the piston is on the inner dead centre, thereby ensuring prompt ignition. (*Accepted October* 4, 1911.)

MINING, METALLURGY, AND METAL-WORKING.

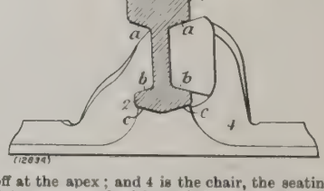
11,506/11. D. J. Davies and L. Roderick, Abercrave, Colliery Corves. [4 *Figs.*] May 12, 1911.—This invention relates to couplings for corves provided with a safety-pin for preventing accidental disconnection by the displacement of such pin from any cause. 1 is the coupling secured to the vehicle by the link 20 in the ordinary way. The forward end of the coupling 1 is bifurcated to receive the coupling-pin 3, which is capable of vertical movement in relation to the arms 2, 2*a* to permit of the insertion and withdrawal of the end of the draw-bar or the end one of the links 30 serving to connect the couplings of adjacent corves, the opening in the lower arm 2*a* being large enough to permit of the slightly enlarged end of the pin 3 passing through the same, while the opening in the upper arm 2 is, preferably, made smaller to prevent the passage of the said end therethrough and the consequent entire removal and possible loss or misplacement of the pin 3. The parts, as above set forth, are of similar construc-



tion to that hitherto employed. The upper end of pin 3 is provided with an enlargement constituting a head 6 of such size as to support the pin in its lowermost or operative position, as shown in Fig. 1. The head 6 is, at its upper end, provided with a projecting portion 8, constituting a stop or abutment for a catch 9, which is pivoted to said head. The arm 2 has a horn 11 projecting upwards from its top surface. The free end of catch 9 extends across from side to side of arm 2, and is provided with an opening constituting a handle for raising pin 3 by an upward pull thereon, after having been turned to its raised position. The outer, or free, end of catch 9, when in its lowered position, rests on the upper face of the arm 2, and in such position any upward movement of pin 3 will bring such outer end into contact with the inner surface of the horn 11, and by jamming against same effectually prevents the continued upward movement of said pin to an extent requisite to permit of the end of the draw-bar or the connecting-link 30 clearing the lower end of the pin, and so disconnecting the corves to which the couplings are applied. (*Accepted October* 4, 1911.)

RAILWAYS AND TRAMWAYS.

12,834/11. F. J. Hadfield, Beccles. Rail-Chairs. [1 *Fig.*] May 29, 1911.—According to this invention, a bull-headed rail is furnished with a shallow V-shaped foot designed to form an additional pair of fishing planes, the counterpart chair seating being formed to allow such rail-foot to bed firmly thereon. 1 is the rail formed with a shallow V-shaped foot 2, slightly



rounded off at the apex; and 4 is the chair, the seating of which is grooved to correspond with, and form a seating for, the V-shaped rail-foot. *a*, *a*, *b*, *b* indicate the usual fishing planes of the rail, and *c*, *c* the additional fishing planes formed by the V-shaped rail-foot; the rail thus presents three fishing planes *a*, *b*, *c* on each side, all disposed at equal angles to the rail-web, instead of only two—viz., *a*, *b*, as heretofore. (*Accepted October* 4, 1911.)

LITERATURE.

Navy League Annual. Edited by ALAN H. BURGOYNE, M.P. London: John Murray. [Price 2s. 6d. net.]

THIS annual, which was founded by Mr. Burgoyne, now makes its fifth annual appearance, and it continues to deserve the high degree of popularity it has attained by reason of the great care with which its records of the development of all navies are prepared and the data tabulated. The progress of almost every ship in course of construction for each Power is set forth, and note is taken of the development in *personnel* and other matters. It is the fate of writers of annuals that events move quickly between the date of proofs going to press and the book reaching the reader, and events have been unkind to the editor of the book under notice in respect, for instance, to the appointment of Sir William Smith as a successor to Sir Philip Watts, since Mr. Burgoyne dismissed his chapter on the British Navy; it is unfortunate, moreover, that in the discussion of probable successors Sir William's name is not mentioned.

Following upon the review of the world's fleets is an analysis of the comparative naval strength of different Powers. As to battleships of the Dreadnought era, it is stated that at the end of March next we shall have 20 out of a total of 46 then in commission, of which Germany will only have 9. At the corresponding date in 1913 we shall have 27 out of a total of 71 in commission, of which Germany is credited with 17 and the United States with 8. At the same date in 1914 we shall have 32, while Germany is credited with 21, the United States with 10, and the total completed will be 101. Our preponderance in ships of the pre-Dreadnought era is equally marked now, but in two or three years our fleet will begin to fall below the combined fleets of Germany and the United States, the two next greatest Powers. In armoured cruisers our position is not quite so secure; we possess 34, while France has 21, the United States 15, Italy 10, Germany 9, and Japan 9. Including armoured ships of high speed—namely, over 23 knots—we have a still greater preponderance—26 against 14 by the next five powerful nations. In protected cruisers and scouts possessing a war value, we have 96 as compared with 88 by the next five powerful nations. In light cruisers, destroyers, and submarines, we do not compare quite so favourably; in view of the immense extent of our floating commerce, these vessels must be of great value in time of war, and we ought to make up our deficiencies.

The second part of the annual has articles on a number of subjects of popular interest. This is as it should be, because the aim of the book is to educate the public. These subjects deal with the Declaration of London, the strategic importance of inter-imperial telegraphy, sensitive points in British sea power, the menace of armed merchantmen, the future of Russia as a naval Power, French naval progress, possible features of a North Sea campaign, the evolution of the capital ship—a somewhat speculative article, the permanent functions of the fleet, aeroplanes in naval warfare, and the development of the Dreadnought type, all by capable writers.

The tables, which form the third part of the work, giving the fleets of the Powers, are this year arranged according to the alphabetical order of the nations, which is much better than the former arrangement of grouping the countries according to the alliances. Under each head the ships, again, are arranged according to their age and class, and not alphabetically.

Tables of Physical and Chemical Constants and some Mathematical Functions. By G. W. C. KAYE and T. H. LABY. London: Longmans, Green, and Co. [Price 4s. 6d.]

THE tables of physical constants compiled by Messrs. Kaye and Laby will unquestionably fill a void in British scientific literature. Works of compilation have, however, somewhat unfortunately, little attraction for the generality of British physicists, who will accordingly be all the more grateful to the authors for undertaking the ungrateful task. The volume consists of 153 pages in all, of which the first 43 are devoted to general physics and astronomy, in which is included a short discussion of the dimensions of the different units, the principal results being grouped into a couple of short tables. In the section on heat we observe no reference to the work of Messrs. Knoblauch and Jakob on the specific heat of superheated steam, which they have shown to be a function of the pressure as well as of the temperature, and not of the latter only, as indicated.

The values of the specific heat for nitrogen are given on the authority of Holborn and Henning, but, unless we are mistaken, serious doubts have been thrown on the accuracy of these results by the British Association Committee on Gaseous Explosions. The section on optics is, of course, mainly of interest to physicists, and the same remark applies to many of the tabulated data on radioactivity. Electrical engineers will, however, find useful many of the electrical tables, as the information needed might otherwise involve a long and tiresome search through papers scattered over numerous scientific and technical journals. A collection of mathematical tables concludes the volume, which, we may add, is excellently printed. The work, we learn, was started in the Cavendish Laboratory, and the authors express in the preface their acknowledgments for help received to Dr. G. A. Carse and Mr. G. F. C. Searle.

BOOKS RECEIVED.

Industrial Drawing and Geometry: An Introduction to Various Branches of Technical Drawing. By HENRY J. SPOONER, C.E. London, New York, Bombay, and Calcutta: Longmans, Green, and Co. [Price 2s. 6d.]

Die Bedeutung der Kolloide für die Technik. By Professor Dr. KURT ARNDT. Zweite Verbesserte Auflage. Dresden: Theodor Steinkopff. [Price 1.50 marks.]

"Hütte" des Ingenieurs Taschenbuch. Herausgegeben vom AKADEMISCH VEREIN HÜTTE, E.V. 21 Auflage. Bande I. and II. Berlin: Wilhelm Ernst and Sohn. [Price: Leinen, 13 marks; Leder, 15 marks.]

"Hütte" des Bauingenieurs. Herausgegeben von AKADEMISCHEN VEREIN HÜTTE, E.V. Sonderausgabe des III. Bandes der "Hütte" des Ingenieurs Taschenbuch. 21 Auflage. Berlin: Wilhelm Ernst and Sohn. [Price: Leinen, 9 marks; Leder, 10 marks. Komplatte Ausgabe, Band I., II., III., Leinen, 18 marks; Leder, 21 marks.]

Handbuch der Militärischen Sprengtechnik für Offiziere aller Waffen. Von BRUNO ZSCHOKKE. Leipzig: Veit and Comp. [Price 14 marks.]

Motoren und Winden fur die See- und Küstenfischerei, nach dem Preisausschreiben des Deutschen Seefischerei-Vereins. Von DITTMER, LIECKFELD, and ROMBERG. Erster Teil. Herausgegeben von dem Deutschen Seefischerei-Verein zu Berlin. Munich and Berlin: R. Oldenbourg. [Price 5 marks.]

Die Finanzielle Überwachung der Gasverksunternehmen. Von Dr.-Ing. FRIEDRICH GREINEDER. Munich and Berlin: R. Oldenbourg. [Price 3.60 marks.]

Neue Theorie und Berechnung der Kreiselräder, Wasser- und Dampfturbinen, Schleuderpumpen und -Gebläse Turbokompressoren, Schraubengebläse und Schiffspropeller. Von Dr. HANS LORENZ. Zweite, neubearbeitete und vermehrte Auflage. Munich and Berlin: R. Oldenbourg. [Price 11 marks.]

Practical Mathematics and Geometry: A Text-Book for Advanced Students in Technical and Trade Schools, Evening Classes, and for Engineers, Draughtsmen, Architects, Surveyors, &c. By EDWARD L. BATES and FREDERICK CHARLESWORTH. Part III.—Advanced Course. London: B. T. Batsford. [Price 3s. net.]

Heat and Steam; Notes and Examples on Steam-Engines and Turbines for Engineers and Engineering Students. By Engineer-Lieutenant S. G. WHEELER. London: Edwin Arnold. [Price 4s. 6d. net.]

The Electric Propulsion of Ships. By H. M. HOBART. London and New York: Harper and Brothers. [Price 5s. net.]

Die Dampfturbinen als Schiffsmotor. Von Dr.-Ing. KARL BESIG. Berlin: Julius Springer. [Price 3 marks.]

Die Grundlagen der Lahnradbearbeitung unter Berücksichtigung der Modernen Verfahren und Maschinen. Von Dr.-Ing. CURT BARTH. Berlin: Julius Springer. [Price 3.60 marks.]

The Steam-Turbine. The Rede Lecture, 1911. By Sir CHARLES A. PARSONS, K.C.B. Cambridge: University Press. [Price 1s. 6d.]

Power. By CHARLES E. LUCKE, Ph.D. New York: Lemcke and Buechner; London: Henry Frowde. [Price 8s. 6d. net.]

Marine Steam-Turbines. (Forming the Supplementary Volume to *Marine Engines and Boilers.*) By Dr. G. BAUER and O. LASCHE, assisted by E. LUDWIG and H. VOGEL. Translated from the German and edited by M. G. S. SWALLOW. London: Crosby Lockwood and Son. [Price 10s. 6d. net.]

Power-Plant Testing: A Manual of Testing Engines, Turbines, Boilers, Pumps, Refrigerating Machinery, Fans, Fuels, Materials of Construction, &c. By JAMES AMBROSE MOYER, S.B., A.M. New York: The McGraw-Hill Book Company; London: The Hill Publishing Company, Limited. [Price 17s. net.]

Practical Thermodynamics: A Treatise on the Theory and Design of Heat-Engines, Refrigeration Machinery, and other Power-Plant Apparatus. By FORREST E. CARDULLO, M.E. New York: The McGraw-Hill Book Company; London: The Hill Publishing Company, Limited. [Price 15s. net.]

Gabriel Lippmann; Biographie, Bibliographie Analytique des Écrits. By ERNEST LEBON. Paris: Gauthier-Villars. [Price 7 francs.]

Practice before the Comptroller of Patents. By CARROL ROMER, M.A. London: Sweet and Maxwell, Limited. [Price 10s net.]

Taschenbuch für Bauingenieure. Herausgegeben von MAX FOERSTER. Berlin: Julius Springer. [Price 20 marks.]

The Second Irish Road Congress: Record of Proceedings Dublin, 1911. Dublin: Cahill and Co., Limited.

Dénivellations de la Voie et Oscillations des Véhicules de Chemins de Fer. Par GEORGES MARIÉ. Paris: H. Dunod et E. Pinat. [Price 3 francs.]

Limites de Flexibilité des Ressorts et Limites de Vitesse du Matériel des Chemins de Fer. Par GEORGES MARIÉ. Paris: H. Dunod et E. Pinat. [Price 2 francs.]

A Course of Elementary Workshop Arithmetic. By HENRY A. DARLING, A.M. Inst. C.E. London: Blackie and Son, Limited. [Price 1s. 6d.]

Der Brückenbau Lehr- und Nachschlagebuch für Studierende und Praktiker. Von M. STRUKEL, I. Teil, 2 Heft, enthallend: *Hölzerive Brucken (tellweise) und Eiserne Brücken.* Leipzig: A. Twietmeyer. [Price 18 marks.]

Der Panamakanal, die Bedentung des Kanalbaues Seine Technik und Wirtschaft. Von Dip.-Ing. MAX D. FIEGEL. Berlin: Dietrich Reimer (Ernst Vohsen). [Price 4 marks.]

The Gas Works Directory and Statistics, 1911-12. London: Hazell, Watson, and Viney, Limited. [Price 10s. 6d. net.]

The Water-Works Directory and Statistics, 1911. London: Hazell, Watson, and Viney, Limited. [Price 10s. 6d. net.]

Transactions of the Institution of Naval Architects. Vol. LIII. Part I. Edited by R. W. DANA, M.A., M. Inst. C.E., Secretary of the Institution. London: Offices of the Institution and Henry Sotheran and Co.

The Law Relating to Engineering: A Course of Six Lectures Delivered before the Society of Engineers and the Junior Institution of Engineers. By L. W. J. COSTELLO, M.A., LL.B. London: Published by the Societies.

Oil-Fields of New Zealand, with Some Critical Notes on the Colonial Oil Situation of To-Day. By J. D. HENRY. London: Published by the Author, 4, London Wall Buildings. [Price 15s.]

FEED-WATER HEATING AND SUPERHEATING ON LOCOMOTIVES.—No. VIII.

HIGH-FEED TEMPERATURES COMBINED WITH MODERATE, AND HIGH-DEGREE, SUPERHEAT.

WHATEVER process of superheating be adopted, owing to the comparatively high temperature of superheated steam and the inevitable difference of temperature between the steam and the heating agent, the waste gases, after passing over superheating surface, will still contain a large amount of heat. In the case of the waste-gas heater superheating to about 90 deg. Fahr., the final temperature of the gases, allowing for no temperature difference, cannot, with 180 lb. pressure, under any circumstances be below about 470 deg. Fahr., while, if high-degree superheating on the smoke-tube system be adopted, as was shown in Article III., page 277 *ante*, the smoke-box temperatures will differ only slightly from those normally recorded for ordinary engines of the same class. Hence it is evident that in either case there still remains in the waste gases, after superheating, heat which is utilisable, provided that a sufficient temperature head will allow of it being abstracted and transferred to the working medium at some suitable stage of the process. Feed-water heating offers the opportunity of accomplishing this, and by this means high feed-water temperatures may be secured in conjunction with either moderate or high-degree superheating. We will consider first the combination of high feed temperatures and moderate superheating.

Experiments in this direction have been conducted by Mr. F. H. Trevithick on the Egyptian State Railways, during the course of the work of which we have previously given account. These experiments consisted in an extension of the principle adopted by Mr. Trevithick in his system of feed-water heating by exhaust steam with moderate superheating, described in Articles IV. and VI., pages 445 and 617 *ante*. This system, it will be remembered, embodies, in the smoke-box, a drum-shaped tubular heater, through which the smoke-box gases are drawn by the induced action of the enclosed blast. At the same time the feed-water is heated to temperatures of between 206 deg. and 210 deg. Fahr. by part of the exhaust steam from the cylinders. In order to carry the feed-heating into the second stage, and to abstract more heat from the waste gases than is possible by superheating alone, a water-heater may be arranged in tandem with the steam-heater in the smoke-box. Obviously, in order to secure the greatest transfer of heat, the first heater must provide for the transfer of heat to the steam, since the temperature of the waste gases is then sufficiently high above that of the steam for the transfer to be effective, while the temperature difference between the gases leaving this heater and that of the feed-water, even after

preliminary heating to 206 deg. to 210 deg. Fahr., is still sufficient to result in the transfer of a considerable amount of heat to the feed. If the process were reversed, and the waste gases first brought in contact with heating surface backed by the feed, though the transfer of heat would be efficient, so great would be the reduction of temperature that insufficient head would remain for any effective transfer subsequently to steam. The water-heater in the tandem arrangement therefore must be interposed between the steam-heater and the blast-chamber.

Several arrangements of tandem smoke-box heaters have been tried, giving various proportions of steam and water-heating surface and different degrees of superheat and feed-water temperatures. None, curiously enough, has shown superiority over the simpler system of moderate feed temperatures and moderate superheat, which, as far as experiments have gone, appears therefore to have some advantages over the tandem arrangement. Particulars of the four tandem combinations tried are given in Table XVI. herewith.

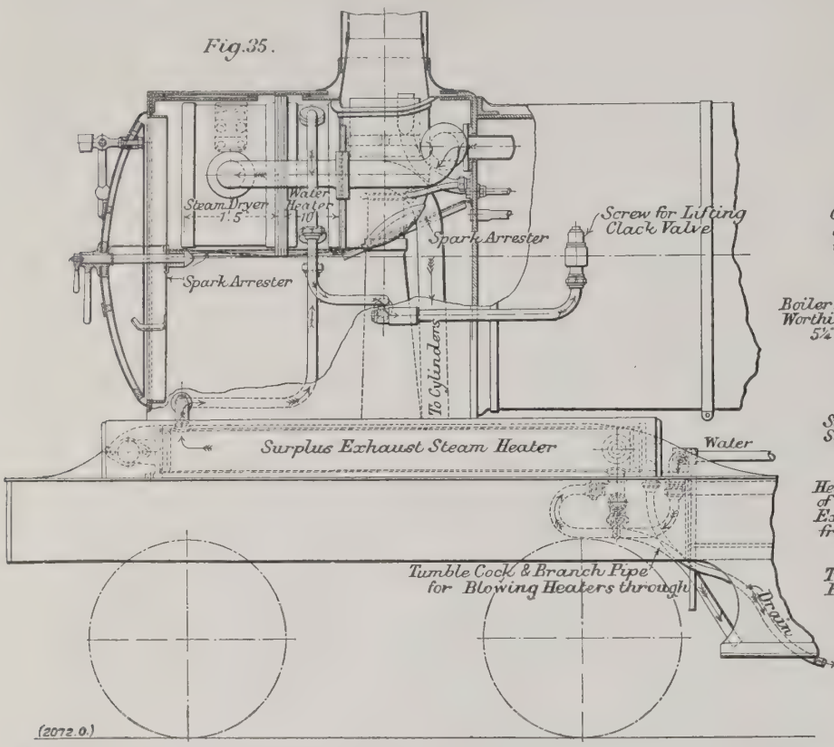
The theoretical advantage of high degrees of feed-heating with moderate superheat was briefly touched upon in Article IV., page 445 *ante*, the diagram then given (Fig. 12) indicating by the line *a' b'* the calculated coal consumption per draw-bar horse-power hour of an engine in which steam was superheated by 65 deg. Fahr., and the feed heated to 269 deg. Fahr. The calculated coal consumption for such a combination works out at less than that for the system, giving feed temperatures of 206 deg. to 210 deg. Fahr., and superheat in the neighbourhood of 90 deg. Fahr., with which we have been concerned until now. Nevertheless, so far, these theoretical indications have not been substantiated in practical applications of the tandem system.

The first engine on which this tandem arrangement was applied was No. 694. As recorded in the above table with this apparatus, after preliminary heating by part of the exhaust steam, the feed-water temperature was raised to 251 deg. Fahr. before entering the boiler, and the steam temperature obtained was equivalent to 65 deg. Fahr. superheat. The single smoke-box heater system applied to this engine gave steam superheat of 76 deg. Fahr., and feed-water temperatures of 208 deg. Fahr., with a final temperature for the waste gases escaping to the chimney of 514 deg. Fahr. In the tandem arrangement the final waste-gas temperature was no more than 432 deg. Fahr., and yet the coal consumption worked out at 0.0888 lb. per ton-mile for the single-heater system, and 0.1043 lb. per ton-mile for the tandem system. The chief cause to which this discrepancy can be traced is the lengthened cut-off necessary with the tandem system (31.8 per cent., against 28.5 per cent. with a rather heavier train). In order to maintain the same smoke-box vacuum (3 in. to 3.5 in.) in both systems, the vacuum in the blast-chamber had to be no less than 8 in. for the tandem arrangement, as against 5.7 in. for the single-drum steam-heater. To obtain this higher vacuum either a longer cut-off had to be used or the blast-pipe top had to be reduced. The latter would have resulted in greater back-pressure, so that either of these expedients tends to uneconomical operation. The resistance offered by the greater length of tube in the tandem arrangement was thus clearly detrimental.

The experiment was, therefore, repeated with engine No. 612. Two tandem arrangements were tried with this engine, denoted in the table by 612 (A) and 612 (B). In both of these the total tube length was considerably reduced, while the same aggregate flue area was preserved. The tube diameter was, however, reduced to $\frac{3}{8}$ in., instead of $\frac{1}{2}$ in. In the arrangement denoted in Table XVI. as 612 (A), both the steam-heater and the water-heater were 17 in. long between tube-plates. This apparatus gave superheat of 62 deg. Fahr. and a feed temperature of 260 deg. Fahr., but again, as regards coal consumption, the engine so fitted

Table XVI.—*Particulars of Steam and Water Waste-Gas Heaters arranged in Tandem.*

Engine	694.	612 (A).	612 (B).	696.
Internal diameter of heaters in.	$23\frac{7}{16}$	$25\frac{5}{8}$	$25\frac{5}{8}$	$30\frac{1}{2}$
Number of tubes	798	1404	1404	1216
Internal diameter of tubes in.	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{2}$
Flue area (aggregate) ..sq. in.	157	155	155	239
Length between tube-plates, steam-heater .. .. in.	$24\frac{3}{4}$	17	17	18
Length between tube-plates, water-heater .. .. in.	18	17	10	18
Heating surface, steam-heater sq. ft.	253	260	260	298.4
Heating surface, water-heater sq. ft.	184	260	107	298.4
Superheat obtained deg. F.	65	62	62	59
Feed temperature obtained ,,	251	260	250	269



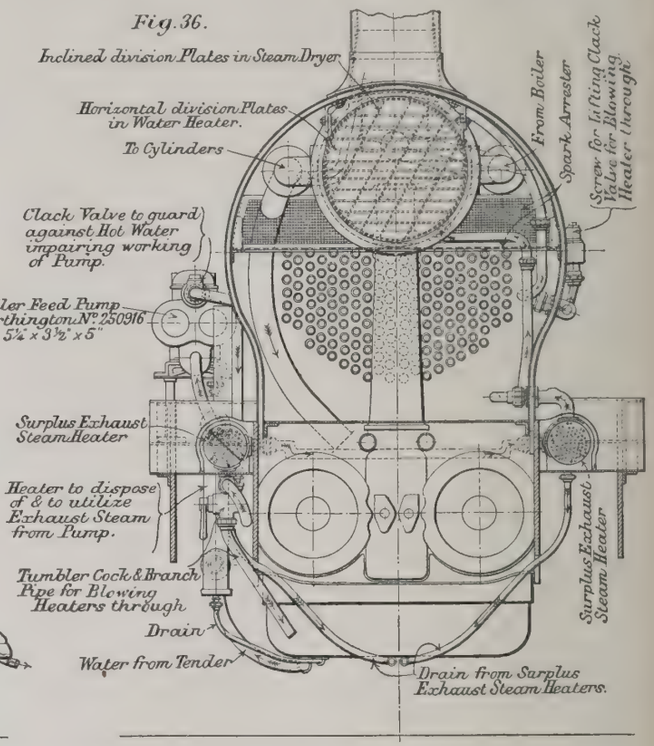
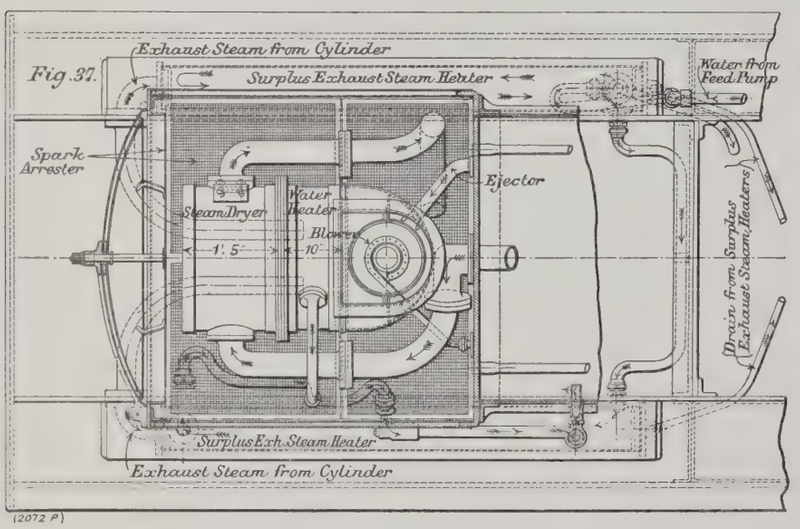


Fig. 36.
Inclined division Plates in Steam Dryer
Horizontal division Plates in Water Heater.
To Cylinders
From Boiler
Spark Arrester
Screw for lifting Clack Valve for Blowing Heater through
Clack Valve to guard against Hot Water impairing working of Pump.
Boiler Feed Pump Worthington No. 250916 5¼ × 3½ × 5"
Surplus Exhaust Steam Heater
Heater to dispose of & to utilize Exhaust Steam from Pump.
Tumbler Cock & Branch Pipe for Blowing Heaters through
Drain
Water from Tender
Surplus Exhaust Steam Heater
Drain from Surplus Exhaust Steam Heaters.



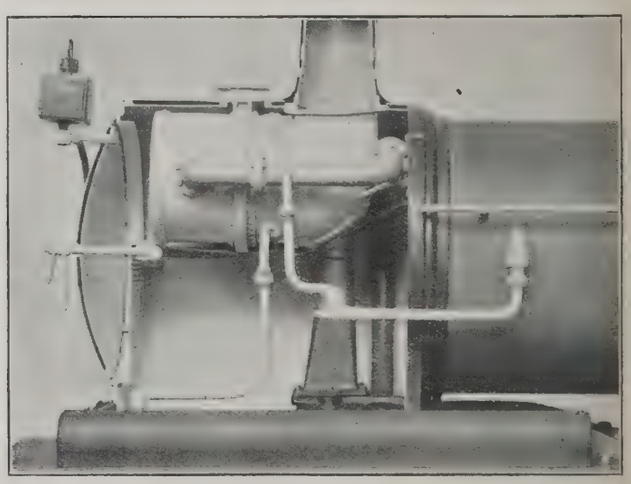


Fig. 38.

was not quite so good as when the single steam-heater was installed in the smoke-box, as in the Upper Egypt tests, and illustrated on page 447 *ante*. The same may be said for the second modification, 612 (B), represented in Figs. 35 to 38, page 754. This apparatus was similar in all respects to the preceding, except that the water-heater was 10 in. in length instead of 17 in. The feed temperature obtained in the apparatus illustrated in Figs. 35 to 38 was 250 deg. Fahr. The illustrations make the arrangement clear, arrows denoting the course of the water and steam through the heaters and connections. In both these cases the coal consumption was about 3 per cent. more than with the apparatus fitted to the same class of engine and used in the tests* on the Upper Egypt Division of the railways. It is noteworthy that, in both the 612 (A) and the 612 (B) experiments, the heating surface of the superheater of the tandem arrangement was practically the same as that of the superheater of the Upper Egypt engines. The superheat obtained, however, was rather lower. This loss, and that due to the increased resistance offered by the heaters in tandem, was not off-set by the much higher feed temperature.

The most recent trial of the tandem system has been made on engine No. 696, the particulars of the apparatus fitted to this engine being also given in Table XVI., page 754. Superheat of 59 deg. Fahr. with feed temperatures averaging 269 deg. Fahr. were obtained in this instance. The temperature of the waste gases was reduced no less than 340 deg. Fahr. in passing through these tandem smoke-box heaters, while the ordinary blast-pipe for engines of this class, $4\frac{1}{2}$ in. in diameter, was enlarged up to $4\frac{7}{8}$ in., which was $\frac{1}{8}$ in. larger than that used on engine No. 706, &c., fitted with the single smoke-box heater. In spite of this the consumption still ran out slightly greater than that for the simpler arrangement fitted to engine No. 706, &c., though in this instance there was very little to choose between the two. This, it must be admitted, is rather difficult of explanation, for with the final temperature of the waste gases 60 deg. lower, and the blast-pipe $\frac{1}{8}$ in. larger in the one case than the other, conditions would appear to be favourable for a reduction in coal consumption. As between the tandem system and the simple superheating appliances in the smoke-box, in favour of the former are the following points:—(1) Final temperature of waste gases, 60 deg. Fahr. lower; (2) blast-pipe $\frac{1}{8}$ in. larger in diameter; (3) feed temperature 60 deg. Fahr. higher. In favour of the latter there are but (1) superheat 30 deg. Fahr. higher; (2) lower resistance offered to passage of gases. The last item cannot in this instance be of much moment, since in the tandem system a blast-pipe larger by $\frac{1}{8}$ in. is suitable. Though this reduces the back pressure, it should be recognised that a still larger blast-pipe might be used with such high feed temperatures if the heaters in tandem offered a lower resistance to the flow of the gases than they do. The most important difference between the two systems is that one has the advantage of feed 60 deg. Fahr. higher in temperature than the other, while the latter has the benefit of 30 deg. Fahr. higher superheat in the steam than the former. On the face of it, it would be expected that the former would prove the more economical, since the 60 deg. Fahr. higher feed temperature represents, per 1 lb., 60 B.Th.U., while the 30 deg. Fahr. superheat represents, per 1 lb., only about 16 B.Th.U. There is thus a balance in favour of the tandem-heater system of about 44 B.Th.U. more absorbed per pound from the waste products than in the other engine. This is the cause of the lower final waste-gas temperatures in this system, and the greater economy should apparently result from this. Contrary to expectation, however, very consistent running for some months with engine No. 696 does not confirm this, and the indirect advantage of reducing initial condensation to a greater extent with 30 deg. more superheat is apparently about equivalent at this stage to the additional thermal value of the higher feed temperature. The two systems are thus, as regards consumption, on about an equal footing. In view of the greater simplicity of the single steam smoke-box heater, and of the lower cost, both of the apparatus and of the labour of fitting, the balance is rather against the tandem apparatus than in favour of it, so far as experiments have proceeded at present.

* See pages 447 and 517 *ante*.

With regard to the combination of high-degree superheat and high feed temperatures, it is very clear that nothing but practical considerations can be raised against the combination of high-degree superheaters of the smoke-tube type and waste-gas heaters used for feed heating, of which those embodying the principles utilised by Mr. Trevithick for smoke-box heaters prove suitable in this connection. Such heaters may be used either with or without preliminary feed heating by part of the exhaust steam from the cylinders. Reverting for the moment to the coal-consumption diagram, Fig. 12, page 445 *ante*, the line *d e* represents, it will be remembered, consumptions for degrees of superheat ranging between 100 and 220 deg. Fahr., obtained with the smoke-tube system. Heating the feed to 206 to 212 deg. Fahr., the limit with exhaust steam unless the back pressure be considerable, reduces these consumptions by amounts represented by ordinates below the line *k p*, bringing the actual consumption line down to *q r* instead of *d e*. If feed-heating be continued, reductions possible are represented by the height of points on the line *s t* above the base, and the consumption line is then further lowered to *v w*, this representing calculated consumptions based on feed temperatures of 260 deg. Fahr., with different degrees of superheat. Higher feed temperatures than this are possible, for there is no reason why the water should not be raised in temperature in this system by an amount approximately equal to that in the arrangements previously described, except for the fact that the reduced steam consumption means a slightly lighter draught and lower temperature of the smoke-box gases.

The manner in which high-degree superheating and high-temperature feed have been combined on the Egyptian State Railways is illustrated in Figs. 39 to 43, on pages 756 and 757 herewith. Figs. 39 and 40 give two reproductions of photographs of the smoke-box end of engine No. 712 converted in this way, while Figs. 41, 42, and 43 are respectively cross, longitudinal, and plan sections. The smoke-tube superheater calls for little comment. It is of the usual Schmidt type, and, as explained in Article VI., was supplied by Messrs. Henschel and Sohn, Cassel. The form of damper necessitated keeping any other appliance placed in the smoke-box low down, so as to be out of the way of the superheater header and case. The feed is dealt with in the preliminary manner described on a former occasion, there being a small pump exhaust-heater and two main exhaust-heaters. The latter are $7\frac{1}{2}$ in. in internal diameter and 7 ft. long between tube-plates. Each contains eighty-two tubes of $\frac{3}{8}$-in. bore, and together they provide 150 sq. ft. of heating surface. These heaters are supplied with part of the cylinder exhaust, and the feed passes through both in succession.

For the reason above mentioned the waste-gas feed-heating apparatus was placed low down in the smoke-box, and fairly far forward. It consists of two tubular heaters placed with their axis across the smoke-box, and arranged on either side of the centre line of the engine, as shown in Figs. 39, 41, and 43. Each heater is of $19\frac{3}{8}$ in. internal diameter, the shell being $\frac{5}{16}$ in. thick. The length between tube-plates is 25 in. Each contains 465 tubes of $\frac{1}{2}$-in. bore, the tube-plates being $\frac{3}{8}$ in. in thickness. The total heating surface of the two heaters is 339 sq. ft., and the aggregate flue area 182.5 sq. m. The two heaters are joined together by the horizontal member of a large inverted T-shaped uptake continuous with the chimney. Into this uptake the blast ejects, thus preserving the principle of the enclosed blast utilised in the Trevithick system previously described. In order to arrange for this, with the heaters so low down, the ordinary straight or curved blast-pipe usually standing on the top of the cylinder casting has been replaced by a pipe taking the form of a large elbow (Fig. 42), and fixed to the front of the cylinder casting between the piston-valve covers. The supply pipes for the main exhaust heaters branch out of this elbow exhaust-pipe.

The heaters, as will be seen in the illustrations, project through the smoke-box sides, and they are enclosed in cylindrical extensions forming part of the smoke-box sides, the ends of the casings being fitted with doors fastened after the manner of smoke-box doors. One of these is shown open in Fig. 40. These casings are considerably larger than the heaters, and they contain, fixed to the doors, spark-arresters taking the form of sieves of mesh which fit on to the outer tube-plate of each heater, as shown in Fig. 40. These spark-arresters being fitted to the doors, are swung out when the latter are opened, as in Fig. 39, the heater then being left clear for work at the tube-plate, or for withdrawal through the door in the smoke-box side, should occasion necessitate this. Each heater contains five diaphragms to make the water circulate thoroughly among the tubes. In the uptake a petticoat is fitted some few inches above the blast-pipe top, which only just protrudes into the blast-chamber. This ensures the draught being well distributed over the lower and upper tubes, and makes the interior absolutely self-clearing, which it would not be if the blast-pipe projected further into the chamber, and no petticoat were used. The two heater-drums are coupled, as regards water connections, in series, and also in series, of course, with the exhaust-steam heaters, which are also shown in the drawings and half-tone engravings herewith.

The action of the blast is exactly the same as explained in former connections. It draws the gases away from the smoke-box tube-plate and through the heaters. In this case the gases are drawn equally to either side of the smoke-box, through the sieve-shaped spark-arresters and into the heaters. Contact with the spark-arresters causes the large cinders to fall, and, shoots being provided below, as shown in Figs. 40 and 41, instead of accumulating near the netting, the cinders are carried off to ash-hoppers outside the frames. Each hopper is fitted with a door at the back, one being shown open in Fig. 40. The hopper floor slants steeply from below the shoots down to the door, so that the hopper is easily cleared. To expedite the raising of steam a flue-door is provided in the uptake as in previous arrangements. This door is opened during lighting up, and gives the heavy smoky gases direct access to the chimney.

This apparatus gives feed temperatures of no less than 294 deg. Fahr., and its use concurrently with high-degree superheating results in very large savings in coal. The two heaters provide ample flue area, some 182.5 sq. in., and it has been again possible to enlarge the blast-pipe top above that necessary when superheated steam only is employed. The engine has been running under these conditions for some months very steadily on a consumption which works out at 0.0798 lb. per ton-mile, or 27.7 lb. per mile, for trains averaging 346.8 tons tare behind the tender. This figure includes lighting-up coal, &c. Engine No. 706, described in Article VI., page 617 *ante*, and fitted with the combination of moderate feed-heating and moderate superheat, has averaged during the same period, with trains of almost exactly the same weight, 0.1005 lb. per ton-mile, so that engine No. 712, as now fitted, is 20.6 per cent. better as regards coal consumption than No. 706.

These heater engines are now regularly worked in a link, in which the trains have become too heavy for the ordinary engines of the same class, and are run against large De Glehn compounds and six-coupled passenger engines. It has not been able to obtain a direct comparison, therefore, between engine No. 712, as now fitted, at its best loads, and the ordinary sister engines, because the time lost by the latter on these schedules rendered their use prohibitive. The attempt was made, but, for traffic reasons, had to be discontinued. An indirect comparison is possible, however, by means of the trials conducted last spring, when for a time non-heater engines were run on these heavier trains. In those trials engine No. 706 proved itself 30 per cent. more economical than the non-heater engines. Engine No. 712 in its present form would therefore appear to be about 44 per cent. more economical than the ordinary engines at these loads. While these heater engines are capable of handling the increased loads of recent years, the ordinary engines of the same class, not long since fully capable of handling the heaviest traffic on these railways, have been relegated to lighter schedules.

With the object of securing a direct comparison engine No. 712 has recently been run for some time in the same link as these other engines, and has shown against them an economy of 37.7 per cent. (viz., 0.952 lb. per ton-mile for No. 712, and 0.1528 lb. per ton-mile as the average for engines Nos. 715, 723, and 716). This is for link working on trains giving average loads of 262 tons tare behind tender for No. 712, and 256 tons as the average for the other engines. The advantage to the railways is therefore apparent. Not only has engine No. 712 with combined high superheat and high feed temperature

FEED-WATER HEATING AND SUPERHEATING ON LOCOMOTIVES

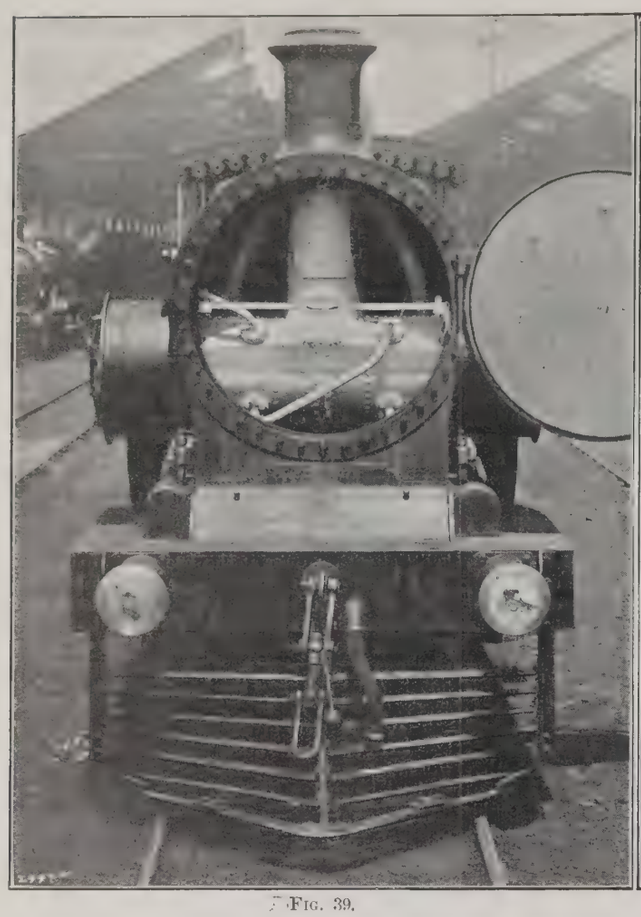


Fig. 39.

Fig. 40.

proved itself far more economical than ordinary sister engines in their own schedules, but it is capable of handling very economically traffic of greater weight than they can touch.

As with the previous smoke-box installations used on the Egyptian State Railways, the smoke-box cinders are greatly reduced in quantity in the case of engine No. 712. The cinders accumulating in the smoke-box proper and in the side hoppers have been collected and weighed for a number of trips, and it is found that about 43 per cent. of the total are deposited in the smoke-box proper, and about 29 per cent. in each of the hoppers. The total collected figured out to only 0.26 lb. per mile, while the amount collected in the non-heater engine smoke-boxes on the same schedules worked out to no less than 2.4 lb. per mile, thus showing that a large part of the saving is directly due to a reduction in the waste of unburnt fuel.

The figures for coal consumption given above cover all coal used in ordinary service, including lighting-up, &c. Supposing that no other benefit accrued than that of coal-saving, and that the value of this were no more than the 37.7 per cent. shown above on the light loads, on the basis of the calculations made in Article VII. the value of the coal saved annually per engine would amount to about 332*l*. If the more than ample rate of 28 per cent. on cost be put on one side for depreciation and repairs, allowing interest at 5 per cent., the expenditure of over 1000*l*. per engine would, under these circumstances, be warranted in the installation of the superheater and feed-water heaters. If the installation cost anything below that figure, there would be a clear profit after setting aside a very liberal amount to cover interest, depreciation, and repairs. It is quite clear that in the case of new engines the expenditure involved would amount to only a portion of this sum, and a clear return on such an investment is practically assured under many conditions as regards yearly mileage, cost of coal, &c. In the case of existing engines there are, undoubtedly, also circumstances in which such conversion would be warranted, but in such cases the ultimate financial saving realised would be greater with the simpler system described in Articles IV., V., and VI., of combining feed-heating by exhaust

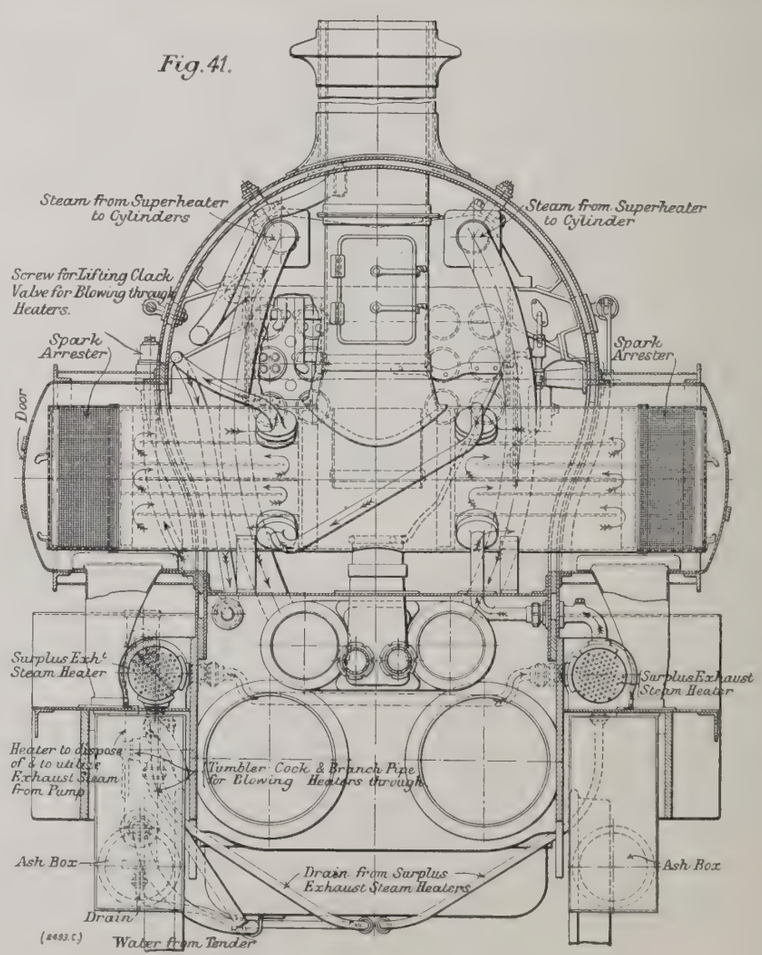


Fig. 41.
Steam from Superheater to Cylinders
Steam from Superheater to Cylinder
Screw for Lifting Clack Valve for Blowing through Heaters.
Spark Arrester
Spark Arrester
Door
Surplus Exh.t Steam Heater
Surplus Exhaust Steam Heater
Heater to dispose of & to utilise Exhaust Steam from Pump
Tumbler Cock & Branch Pipe for Blowing Heaters through
Ash Box
Ash Box
Drain from Surplus Exhaust Steam Heaters
Drain
Water from Tender
(2493 C.)

Fig. 42.

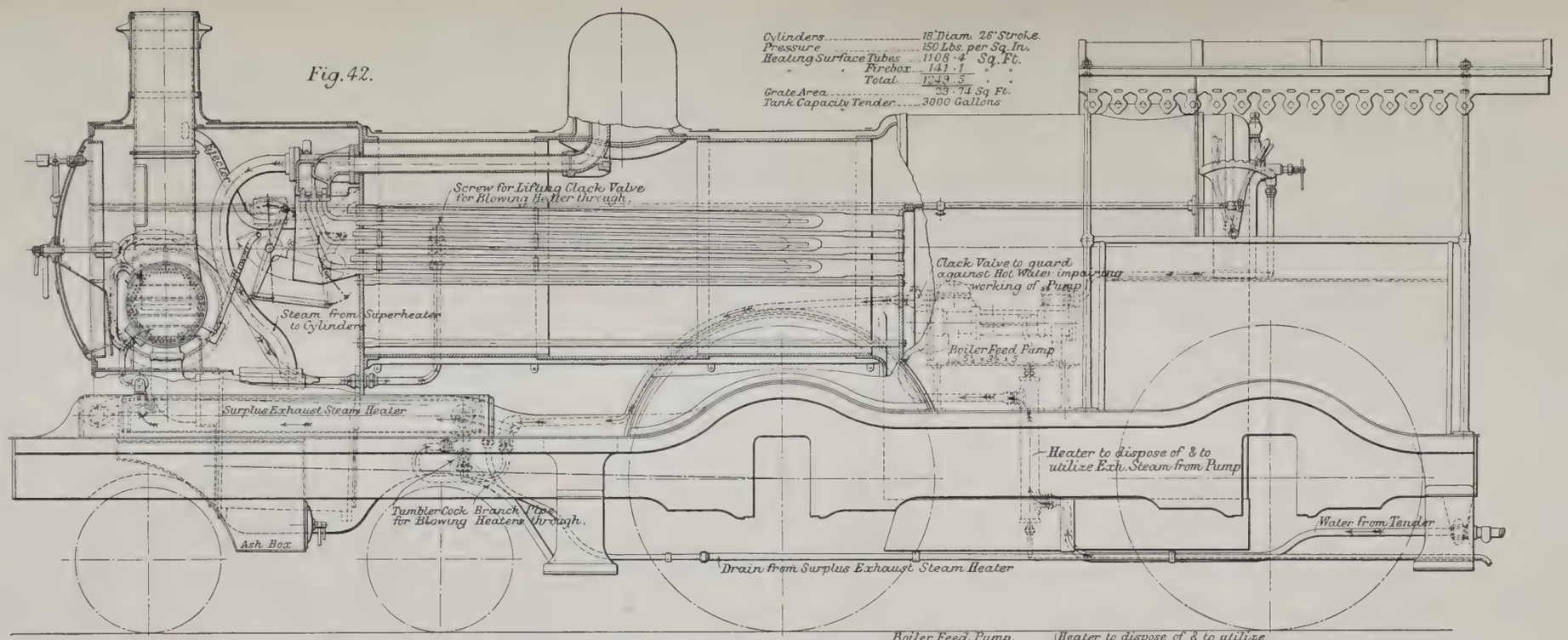
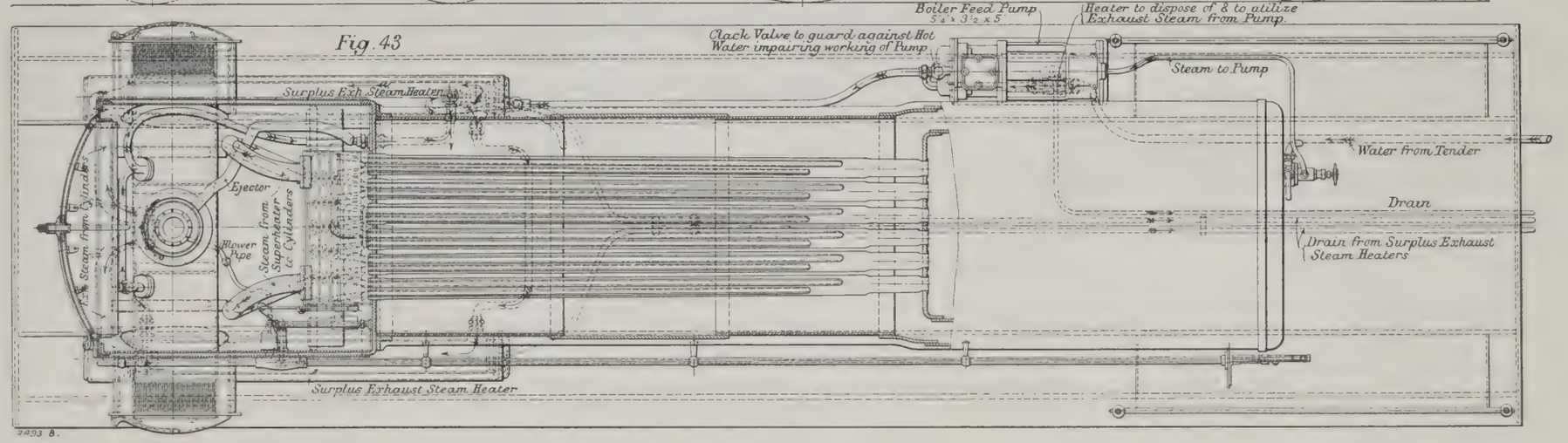

Cylinders 18" Diam. 26" Stroke.
Pressure 150 Lbs. per Sq. In.
Heating Surface Tubes 1108·4 Sq. Ft.
" Firebox 141·1 " "
" Total 1249·5 " "
Grate Area 23·71 Sq. Ft.
Tank Capacity Tender 3000 Gallons
Ejector
Screw for Lifting Clack Valve for Blowing Heater through.
Clack Valve to guard against Hot Water impairing working of Pump
Steam from Superheater to Cylinders
Boiler Feed Pump
Surplus Exhaust Steam Heater
Heater to dispose of & to utilize Exh. Steam from Pump
Tumbler Cock Branch Pipe for Blowing Heaters through.
Ash Box
Water from Tender
Drain from Surplus Exhaust Steam Heater

Fig. 43.


Boiler Feed Pump 5¼ x 3½ x 5
Heater to dispose of & to utilize Exhaust Steam from Pump.
Clack Valve to guard against Hot Water impairing working of Pump
Steam to Pump
Surplus Exh. Steam Heater
Water from Tender
Ejector
Steam from Cylinders
Blower Pipe
Steam from Superheater to Cylinders
Drain
Drain from Surplus Exhaust Steam Heaters
Surplus Exhaust Steam Heater

2493 B.

steam and moderate superheating. For improving existing engines therefore the combination of moderate superheat and feed-heating by the exhaust appears to be full of promise, while for new stock very considerable clear saving on present practice can be assured by the introduction of high-degree superheating in conjunction with high-degree feed-water heating, a combination which we have shown above to be perfectly practicable.

"Factory Accounts; Their Principles and Practice."—We have received a copy of the sixth edition of this hand-book for accountants and manufacturers, which is edited by Mr. Emile Garcke, managing director of the British Electric Traction Company, Limited, and by Mr. J. M. Fells, incorporated accountant, and formerly general manager of the Salt Union, Limited. It is published by Messrs. Crosby Lockwood and Son, 7, Stationers' Hall-court, Ludgate Hill, E.C. This is both a guide for the systematic drawing-up of factory accounts, determining costs and industrial book-keeping, and an admirable reference-book for settling a great variety of items connected with accounts, and with the formation and the working of industrial concerns, &c., upon which doubts might be at first entertained. For this latter purpose the very complete index and the glossary of terms used, which complete the book, will be found of special value. The organisation of factories from the points of view of labour, plant, and capital, and their successful working, are the subjects dealt with; they are gone into very fully.

RECENT RESEARCH WORK ON THE PROPERTIES OF STEAM.

By C. A. M. Smith, M.Sc., and A. G. Warren, B.Sc.
(East London College, University of London).

(*Concluded from page 727.*)

The Thermodynamics of Steam.—Since the state of a gas is completely defined by two of the three variables, we have, during any small addition of heat d H.

$$d\,H = A\,d\theta + B\,dv \quad . \quad . \quad . \quad (5)$$
$$= C\,d\theta + D\,dp \quad . \quad . \quad . \quad (6)$$
$$= E\,dp + F\,dv \quad . \quad . \quad . \quad (7)$$

where A, B, C, D, E, and F are functions of the state of the stuff.

If I is the internal energy, ϕ the entropy, j the reciprocal of Joule's equivalent, we have

$$d\,I = d\,H - j\,p\,dv \quad . \quad . \quad . \quad . \quad (8)$$

and

$$d\,\phi = d\,H/\theta = \frac{A}{\theta}\,d\theta + \frac{B}{\theta}\,dv \quad . \quad . \quad (9)$$

$$= \frac{C}{\theta}\,d\theta + \frac{D}{\theta}\,dp \quad . \quad . \quad . \quad . \quad (10)$$

Thermodynamics tells us that both d I and $d\,\phi$ are complete differentials. Making use of this fact we may readily obtain the two equations

$$\left(\frac{d\,A}{d\,v}\right)_\theta = j\,\theta\left(\frac{d^2\,p}{d\,\theta^2}\right)_v \quad . \quad . \quad . \quad (11)$$

and

$$\left(\frac{d\,C}{d\,p}\right)_\theta = -\,j\,\theta\left(\frac{d^2\,v}{d\,\theta^2}\right)_p \quad . \quad . \quad . \quad (12)$$

From these two equations Callendar has derived the whole of the properties of steam. It will be noticed that, in a constant volume change of state, $A = d\,H/d\,\theta$. That is to say, $A = K_v$.

Similarly,

$$C = K_p.$$

Applying equation (12) to equation (4) we obtain

$$-\,j\,\theta\left(\frac{d^2\,v}{d\,\theta^2}\right)_p = \frac{n\,(n+1)\,c\,j}{\theta} = \left(\frac{d\,C}{d\,p}\right)_\theta. \quad . \quad (13)$$

Integrating, we have

$$K_p = C = K_{p0} + \frac{n\,(n+1)\,c\,j\,p}{\theta}. \quad . \quad . \quad (14)$$

where K_{p_0} is the constant of integration, and is the limiting value of K_p when the pressure is zero.

In a similar manner, applying equation (11) to equation (4), we obtain

$$K_v = K_{v0}\left\{1 + \frac{n\,c}{V}\right\} \quad \left\{1 - \frac{c}{V}\right\} \quad . \quad (15)$$

The value of c may be calculated, for any temperature is known for one, since $c = c_0\left(\frac{\theta_0}{\theta}\right)^n$.

Both c and n may be determined experimentally by observation of the fall in temperature and pressure when steam passes through a restricted orifice. Such a process is one of constant total heat, for which it may readily be deduced that

$$K_p\left(\frac{d\,\theta}{d\,t}\right)_{H_t} = \theta\,j\left(\frac{d\,v}{d\,\theta}\right)_p - j\,v \quad . \quad (16)$$

which, when applied to equation (4), becomes

$$K_p\left(\frac{d\,\theta}{d\,t}\right)_{H_t} = j\,(n+1)\,c - j\,b \quad . \quad (17)$$

whence n and c can be found by experiment.

As before stated, n is taken as $10/3$; c_0 is taken as 1.2014 cub. ft. Since $K_{v0} = n\,j\,R$, it follows that $K_{v0} = 0.367$, and $K_{p0} = 0.477$.

Changes of State.—Any change of state may be considered as made up of an isothermal change, together with a constant pressure change. Any quantity which is a function of the state of the stuff can be determined by such a method.

Isothermal Change from a Pressure p_0 to a Pressure p_1 at a Temperature θ_0.—We have

$$d\,\phi = \left(\frac{d\,\phi}{d\,p}\right)_\theta d\,p.$$

For an isothermal change

$$d\,\phi = \frac{D}{\theta}\,d\,p,$$

whence

$$\left(\frac{d\,\phi}{d\,p}\right)_\theta = -\,j\left(\frac{d\,v}{d\,\theta}\right)_p \quad . \quad . \quad (18)$$

This gives us

$$d\,\phi = -\,j\left(\frac{R}{p} + \frac{n\,c_0}{\theta_0}\right)d\,p \quad . \quad . \quad (19)$$

Whence

$$\phi_1 - \phi_0 = R\,j\log_\epsilon\frac{p_0}{p_1} + \frac{n\,c_0\,j}{\theta_0}(p_0 - p_1). \quad (20)$$

The heat added is

$$H_1 - H_0 = \theta_0\,(\phi_1 - \phi_0)$$
$$= R\,j\,\theta_0\log_\epsilon\frac{p_0}{p_1} + n\,c_0\,j\,(p_0 - p_1) \quad . \quad (21)$$

The work done

$$W = \int_{v_0}^{v_1} p\,d\,v \text{ ft.-lb.}$$
$$= R\,j\,\theta_0\log_\epsilon\frac{p_0}{p_1} \text{ lb.-calories.}$$

The change of internal energy is therefore

$$I_1 - I_0 = n\,c_0\,j\,(p_0 - p_1) \text{ lb.-calories.}$$

Constant Pressure Change from a Temperature θ_1 to a Temperature θ_2 at a Pressure p_1.—The heat added

$$H_2 - H_1 = \int_{\theta_1}^{\theta_2} K_p\,d\,\theta$$
$$= K_{p0}\,(\theta_2 - \theta_1) + (n+1)\,j\,p_1\,(c_1 - c_2) \quad . \quad (22)$$

The work done

$$W = \int_{v_1}^{v_2} p_1\,d\,v = p_1\,(v_2 - v_1)$$
$$= R\,(\theta_2 - \theta_1) + p_1\,(c_1 - c_2) \text{ ft.-lb.} \quad . \quad (23)$$

Whence change of internal energy,

$$I_2 - I_1 = K_{v0}\,(\theta_2 - \theta_1) + n\,j\,p_1\,(c_1 - c_2) \quad . \quad (24)$$

The change of entropy,

$$\phi_2 - \phi_1 = \int_{\theta_1}^{\theta_2} K_{p0}\,\frac{d\,\theta}{\theta}$$
$$= K_{p0}\log_\epsilon\frac{\theta_2}{\theta_1} + n\,p_1\left(\frac{c_1}{\theta_1} - \frac{c_2}{\theta_2}\right) \quad . \quad (25)$$

For a general change of state from $p_0\,v_0\,\theta_0$ to $p_2\,v_2\,\theta_2$ we have

$$I_2 - I_0 = K_{v0}\,(\theta_2 - \theta_0) + n\,j\,(p_0\,c_0 - p_2\,c_2) \quad . \quad (26)$$

and

$$\phi_2 - \phi_0 = K_{p0}\log_\epsilon\frac{\theta_2}{\theta_0} - j\,R\log_\epsilon\frac{p_2}{p_0}$$
$$- n\,j\left(\frac{p_2\,c_2}{\theta_2} - \frac{p_0\,c_0}{\theta_0}\right) \quad . \quad . \quad . \quad (27)$$

Measuring both the internal energy and the entropy from 0 deg. Cent., we may conveniently write these expressions

$$I = K_{v0}\,T - n\,j\,p\,v + \text{const.} \quad . \quad . \quad (28)$$

and

TABLE I.—Specific Heats of Superheated Steam at Various Temperatures (Fahrenheit) and Pressures.

Temperature.	Pressures in Pounds per Square Inch.															Temperature.
	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	
227.8	0.508	—	—	—	—	—	—	—	—	—	—	—	—	—	—	227.8
230.0	0.507	—	—	—	—	—	—	—	—	—	—	—	—	—	—	230.0
240.0	0.506	—	—	—	—	—	—	—	—	—	—	—	—	—	—	240.0
250.0	0.504	—	—	—	—	—	—	—	—	—	—	—	—	—	—	250.0
260.0	0.503	—	—	—	—	—	—	—	—	—	—	—	—	—	—	260.0
267.1	..	0.525	—	—	—	—	—	—	—	—	—	—	—	—	—	267.1
270.0	0.501	0.524	—	—	—	—	—	—	—	—	—	—	—	—	—	270.0
280.0	0.500	0.522	—	—	—	—	—	—	—	—	—	—	—	—	—	280.0
290.0	0.498	0.519	—	—	—	—	—	—	—	—	—	—	—	—	—	290.0
292.5	..	..	0.539	—	—	—	—	—	—	—	—	—	—	—	—	292.5
300.0	0.497	0.517	0.536	—	—	—	—	—	—	—	—	—	—	—	—	300.0
310.0	0.496	0.515	0.533	—	—	—	—	—	—	—	—	—	—	—	—	310.0
311.8	..	..	..	0.551	—	—	—	—	—	—	—	—	—	—	—	311.8
320.0	0.495	0.513	0.530	0.548	—	—	—	—	—	—	—	—	—	—	—	320.0
327.6	..	..	..	..	0.562	—	—	—	—	—	—	—	—	—	—	327.6
330.0	0.494	0.511	0.527	0.544	0.561	—	—	—	—	—	—	—	—	—	—	330.0
340.0	0.493	0.509	0.524	0.540	0.556	—	—	—	—	—	—	—	—	—	—	340.0
340.9	..	..	..	..	..	0.572	—	—	—	—	—	—	—	—	—	340.9
350.0	0.492	0.507	0.522	0.537	0.552	0.567	—	—	—	—	—	—	—	—	—	350.0
352.7	..	..	..	..	..	..	0.581	—	—	—	—	—	—	—	—	352.7
360.0	0.491	0.506	0.520	0.534	0.548	0.563	0.577	—	—	—	—	—	—	—	—	360.0
363.2	..	..	..	..	..	..	..	0.589	—	—	—	—	—	—	—	363.2
370.0	0.491	0.504	0.518	0.531	0.545	0.559	0.572	0.586	—	—	—	—	—	—	—	370.0
372.7	..	..	..	..	..	..	..	..	0.597	—	—	—	—	—	—	372.7
380.0	0.490	0.503	0.516	0.529	0.541	0.554	0.567	0.580	0.593	—	—	—	—	—	—	380.0
381.6	..	..	..	..	..	..	..	..	..	0.605	—	—	—	—	—	381.6
389.7	..	..	..	..	..	..	..	..	..	..	0.611	—	—	—	—	389.7
390.0	0.489	0.501	0.514	0.526	0.538	0.550	0.561	0.574	0.587	0.599	0.611	—	—	—	—	390.0
397.2	..	..	..	..	..	..	..	..	..	..	..	0.618	—	—	—	397.2
400.0	0.489	0.500	0.512	0.523	0.535	0.547	0.558	0.569	0.581	0.593	0.604	0.616	—	—	—	400.0
404.2	..	..	..	..	..	..	..	..	..	..	..	..	0.624	—	—	404.2
410.0	0.488	0.499	0.510	0.521	0.532	0.543	0.554	0.565	0.576	0.587	0.598	0.609	0.620	—	—	410.0
410.9	..	..	..	..	..	..	..	..	..	..	..	..	..	0.631	—	410.9
417.0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.637	417.0
420.0	0.488	0.498	0.508	0.519	0.530	0.540	0.551	0.561	0.572	0.582	0.593	0.603	0.614	0.624	0.635	420.0
440.0	0.487	0.496	0.505	0.515	0.525	0.534	0.544	0.553	0.563	0.572	0.582	0.591	0.601	0.610	0.620	440.0
460.0	0.486	0.494	0.503	0.512	0.520	0.529	0.538	0.546	0.555	0.564	0.574	0.581	0.589	0.598	0.607	460.0
480.0	0.485	0.493	0.501	0.509	0.516	0.524	0.532	0.540	0.548	0.556	0.563	0.571	0.579	0.587	0.595	480.0
500.0	0.484	0.491	0.499	0.506	0.513	0.520	0.527	0.535	0.542	0.549	0.556	0.563	0.570	0.577	0.585	500.0
520.0	0.484	0.490	0.497	0.503	0.510	0.517	0.523	0.530	0.536	0.543	0.550	0.556	0.562	0.569	0.576	520.0
540.0	0.483	0.489	0.495	0.501	0.507	0.513	0.519	0.525	0.531	0.537	0.544	0.549	0.555	0.562	0.567	540.0
560.0	0.483	0.488	0.494	0.499	0.505	0.510	0.516	0.521	0.527	0.532	0.538	0.543	0.549	0.555	0.560	560.0
580.0	0.482	0.487	0.492	0.497	0.502	0.507	0.513	0.518	0.523	0.528	0.533	0.538	0.543	0.548	0.553	580.0
600.0	0.482	0.486	0.491	0.496	0.500	0.505	0.510	0.515	0.519	0.524	0.529	0.533	0.538	0.542	0.547	600.0
620.0	0.481	0.486	0.490	0.494	0.499	0.503	0.507	0.512	0.516	0.520	0.525	0.529	0.533	0.537	0.542	620.0
640.0	0.481	0.485	0.489	0.493	0.497	0.501	0.505	0.509	0.513	0.517	0.521	0.525	0.529	0.533	0.537	640.0
660.0	0.481	0.484	0.488	0.492	0.495	0.499	0.503	0.506	0.510	0.514	0.517	0.521	0.525	0.528	0.532	660.0
680.0	0.480	0.484	0.487	0.491	0.494	0.497	0.501	0.504	0.508	0.511	0.514	0.518	0.521	0.524	0.528	680.0
700.0	0.480	0.483	0.487	0.490	0.493	0.496	0.499	0.502	0.506	0.509	0.512	0.515	0.518	0.521	0.525	700.0
720.0	0.480	0.483	0.486	0.489	0.492	0.495	0.498	0.501	0.504	0.506	0.509	0.512	0.515	0.518	0.521	720.0
740.0	0.480	0.482	0.485	0.488	0.491	0.493	0.496	0.499	0.502	0.504	0.507	0.510	0.513	0.516	0.518	740.0
760.0	0.480	0.482	0.485	0.487	0.490	0.492	0.495	0.497	0.500	0.502	0.505	0.508	0.510	0.513	0.515	760.0
780.0	0.479	0.482	0.484	0.487	0.489	0.491	0.494	0.496	0.499	0.501	0.503	0.506	0.508	0.511	0.513	780.0
800.0	0.479	0.482	0.484	0.486	0.488	0.490	0.493	0.495	0.497	0.500	0.502	0.504	0.506	0.509	0.511	800.0
820.0	0.479	0.481	0.483	0.485	0.487	0.489	0.492	0.494	0.496	0.498	0.500	0.502	0.504	0.506	0.508	820.0
840.0	0.479	0.481	0.483	0.485	0.487	0.489	0.491	0.492	0.494	0.496	0.498	0.500	0.502	0.504	0.506	840.0

TABLE II.—AVERAGE SPECIFIC HEATS OF SUPERHEATED STEAM FROM SATURATION TO THE TABULATED TEMPERATURES (FAHRENHEIT) AT VARIOUS PRESSURES.

Temperature.	Pressures in Pounds Per Square Inch.															Temperature.
	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	
227.8	0.508	—	—	—	—	—	—	—	—	—	—	—	—	—	—	227.8
240.0	0.507	—	—	—	—	—	—	—	—	—	—	—	—	—	—	240.0
260.0	0.505	—	—	—	—	—	—	—	—	—	—	—	—	—	—	260.0
267.1	..	0.525	—	—	—	—	—	—	—	—	—	—	—	—	—	267.1
280.0	0.504	0.524	—	—	—	—	—	—	—	—	—	—	—	—	—	280.0
292.5	..	..	0.539	—	—	—	—	—	—	—	—	—	—	—	—	292.5
300.0	0.502	0.521	0.538	—	—	—	—	—	—	—	—	—	—	—	—	300.0
311.8	..	..	..	0.551	—	—	—	—	—	—	—	—	—	—	—	311.8
320.0	0.501	0.519	0.535	0.549	—	—	—	—	—	—	—	—	—	—	—	320.0
327.6	..	..	..	..	0.562	—	—	—	—	—	—	—	—	—	—	327.6
340.0	0.500	0.517	0.532	0.545	0.559	—	—	—	—	—	—	—	—	—	—	340.0
340.9	..	..	..	..	..	0.572	—	—	—	—	—	—	—	—	—	340.9
352.7	..	..	..	..	..	..	0.581	—	—	—	—	—	—	—	—	352.7
360.0	0.499	0.515	0.529	0.542	0.555	0.567	0.579	—	—	—	—	—	—	—	—	360.0
363.2	..	..	..	..	..	..	..	0.589	—	—	—	—	—	—	—	363.2
372.7	..	..	..	..	..	..	..	..	0.597	—	—	—	—	—	—	372.7
380.0	0.498	0.513	0.526	0.539	0.552	0.563	0.574	0.584	0.594	—	—	—	—	—	—	380.0
381.6	..	..	..	..	..	..	..	..	..	0.605	—	—	—	—	—	381.6
389.7	..	..	..	..	..	..	..	..	..	..	0.611	—	—	—	—	389.7
397.2	..	..	..	..	..	..	..	..	..	..	..	0.618	—	—	—	397.2
400.0	0.497	0.511	0.524	0.536	0.548	0.559	0.569	0.579	0.589	0.599	0.608	0.617	—	—	—	400.0
404.2	..	..	..	..	..	..	..	..	..	..	..	..	0.624	—	—	404.2
410.9	..	..	..	..	..	..	..	..	..	..	..	..	..	0.631	—	410.9
417.0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.637	417.0
440.0	0.495	0.508	0.520	0.531	0.542	0.552	0.561	0.570	0.579	0.588	0.596	0.604	0.613	0.621	0.629	440.0
480.0	0.493	0.505	0.516	0.526	0.536	0.545	0.553	0.562	0.570	0.578	0.586	0.593	0.601	0.608	0.615	480.0
520.0	0.492	0.503	0.513	0.522	0.531	0.539	0.547	0.555	0.563	0.570	0.577	0.584	0.591	0.597	0.604	520.0
560.0	0.491	0.501	0.510	0.519	0.527	0.534	0.542	0.549	0.556	0.563	0.569	0.576	0.582	0.588	0.594	560.0
600.0	0.490	0.500	0.508	0.516	0.523	0.530	0.537	0.544	0.550	0.556	0.562	0.568	0.574	0.579	0.585	600.0
640.0	0.489	0.498	0.506	0.513	0.520	0.526	0.533	0.539	0.545	0.551	0.557	0.562	0.567	0.572	0.577	640.0
680.0	0.489	0.497	0.504	0.511	0.517	0.523	0.530	0.535	0.540	0.546	0.551	0.556	0.561	0.566	0.570	680.0
720.0	0.488	0.496	0.503	0.509	0.515	0.521	0.527	0.532	0.537	0.542	0.546	0.551	0.556	0.560	0.564	720.0
760.0	0.487	0.494	0.501	0.507	0.513	0.518	0.524	0.529	0.533	0.538	0.542	0.546	0.551	0.555	0.559	760.0
800.0	0.486	0.493	0.499	0.505	0.510	0.515	0.521	0.526	0.530	0.534	0.538	0.542	0.546	0.551	0.555	800.0
840.0	0.486	0.492	0.498	0.503	0.508	0.513	0.518	0.523	0.527	0.531	0.534	0.538	0.542	0.546	0.550	840.0

$$\phi = K_{p0} \log_\epsilon \theta - jR \log_\epsilon p - \frac{njpc}{\theta} + \text{const.} \quad (29)$$

Similarly

$$H = I + jpv = K_{p0} T - jp\left\{(n+1)c - b\right\} + \text{const.} \quad (30)$$

For the expression $j\left\{(n+1)c-b\right\}$ Mollier substitutes Y, and for $\frac{ncj}{\theta}$ he uses Z.

The constants of integration can be found from a few well-known values. For instance, when T = 100 deg. Cent., then H = 639.6 lb.-calories for saturated steam.

Also

$$\phi_s = 1.759 \text{ Ranks.}$$

We then obtain

$$v = 154.1 \frac{\theta}{p} - c + 0.0160 \quad (31)$$

$$H = 594.7 + 0.477\,T - Y\,p \quad (32)$$

$$\phi = 0.477 \log_\epsilon \theta - 0.1101 \log_\epsilon p - Z\,p - 0.217 \quad (33)$$

$$I = 564.6 + 0.367\,T - \frac{10}{3} c\,p\,j \quad (34)$$

$$K_p = 0.477 + \frac{13}{3} Z\,p \quad (35)$$

The internal energy of water may be calculated sufficiently accurately from Regnault's formula

$$i = T + 0.00002\,T^2 + 0.0000003\,T^3 \quad (36)$$

The total heat of water $h = i + jpb$, where b is the volume of 1 lb. of water.

The specific heat of water $S = dI/dT$. Also

$$\phi^c = \int_\theta^S \frac{S\,d\theta}{\theta} = 2.4319 \log_{10} \frac{\theta}{273} - 0.0002057\,T + 0.00000045\,T^2 \quad (37)$$

The latent heat

$$L = H - h = \theta(\phi s - \phi w) \quad (38)(39)$$

Equations (38) and (39) define the relations between the pressure and temperature for *saturated* steam. The relation is, however, so involved that it cannot be practically applied. The method used is to assume the relation between the pressure and temperature, to calculate the quantities and make the necessary adjustments to bring these two relations (38) and (39) into line.

The formulæ determined above apply to steam at any degree of superheat, the degree of superheat being defined by the temperature and pressure. The case of saturated steam, with which we are more often concerned, may be looked upon as the particular case in which the superheat is zero. Applying this condition, values of the quantities can be calculated. Having once determined the relation between the temperature and pressure at saturation, some modification in calculation becomes possible. For instance, the entropy ϕ_s may be taken as $\phi_w + \frac{L}{\theta}$, and, further, the entropy of superheated steam may sufficiently accurately be taken as $\phi_s + k_a \log_\epsilon \frac{\theta_1}{\theta}$, where k_a is the average specific heat of superheated steam at the given pressure over the temperature range θ_2 to θ_1, θ_2 being the temperature of saturation, and θ_1 the temperature of superheat.

Tables derived by the method indicated exhibit striking contrasts with those generally employed previously. It has already been pointed out that previous tables have been calculated on the assumption of the existence of a linear relation between the total heat H and the temperature. This necessitates a relation, practically linear, between the latent heat and the temperature. The actual relations are far from such. The following values given exemplify this point :—

Temperature (Deg. Fahr.)	H (Peabody).	H (Smith and Warren)	L (Peabody.)	L (Smith and Warren)
80	1106.3	1093.0	1058.2	1045.0
120	1118.5	1111.5	1030.4	1023.3
220	1149.0	1154.6	960.1	965.5
260	1161.2	1169.7	932.0	939.9
360	1191.7	1200.5	859.9	867.6
400	1203.9	1209.8	830.2	835.0

An examination of this table reveals some essential differences. Considering Peabody's figures, the differences between the total heats at 80 deg. Fahr. and 120 deg. Fahr., at 220 deg. Fahr. and 260 deg. Fahr., and at 360 deg. Fahr. and 400 deg. Fahr., are equal to 12.2 and constant. That is to say, $\frac{dH}{dT} = \frac{12.2}{40} = 0.305$, and is independent of the temperature. Referring now to the figures calculated by the authors the differences over the same three ranges are respectively 18.5, 15.1, and 9.3. That is, the value of $\frac{dH}{dT}$ over the range 360 deg. Fahr. to 400 deg. Fahr. is only about one-half of the value over the range 80 deg. Fahr. to 120 deg. Fahr. For the values of L similar discrepancies exist. The two sets of values are thus contrasted below.

Temperature Range.	$\frac{dH}{dT}$ Average Value (Peabody).	$\frac{dH}{dT}$ Average Value (Smith and Warren).	$\frac{dL}{dT}$ (Peabody.	$\frac{dL}{dT}$ (Smith and Warren
Deg. Fahr.				
80 – 120	0.305	0.4625	0.695	0.5425
220 – 260	0.305	0.3775	0.7025	0.640
360 – 400	0.305	0.2325	0.7425	0.815

Approximate Formulæ.—The internal heat of water (i) has been calculated from Regnault's equation :—

$$i = T + 0.00002\,T^2 + 0.0000003\,T^3 \quad (40)$$

To this the quantity $j\,p\,v$ must be added to give h. The quantity $j\,p\,v$ represents the work required to pump the water into the boiler against the pressure p lb. per sq. in.

Above 100 deg. Cent. the following equations, evolved by the authors from the numerical data obtained by the use of Callendar's fundamental equations :—

$$h = T + 0.00001\,T^2 + 0.0000004\,T^3 \quad (41)$$

$$H = 589 + 0.602\,T - 0.00096\,T^2 \quad (42)$$

$$L = 588 - 0.375\,T - 0.00114\,T^2 \quad (43)$$

$$p\,v^{1.0676} = 491 \quad (44)$$

$$\log_{10} p = A - \frac{B}{\theta} - \frac{C}{\theta^2} \quad (45)$$

where

$$A = 6.10405$$
$$\log_{10} B = 3.1821693$$
$$\log_{10} C = 5.0772011$$

In the above equations (41 to 45) H is the total heat of saturated steam, L its latent heat, p its pressure in pounds per sq. in., V its specific volume in cubic feet, T the temperature in degrees Centigrade, and θ the absolute temperature in degrees Centigrade.

A modification of the constants of equation (45) allows of its use for temperatures below 100 deg. Cent. For such conditions

$$A = 6.18123$$
$$\log_{10} B = 3.1977522$$
$$\log_{10} C = 5.0392819$$

Referring to equations 42 and 43—

$$H - L = 1 + 0.977\,T + 0.00018\,T^2 \quad (46)$$

This should equal h (equation 41), and will be found to do so very closely over practical ranges.

Adiabatic Expansion of Steam.—The condition of adiabatic expansion of steam is often expressed by the equation $P\,V_p = C$. Over a range of working pressures (say 200 lb. per sq. in. to 40 lb. per sq. in.) the index n varies with the initial dryness of the steam, and may be taken as tabulated.

Initial Dryness Fraction	1 0.	0.9.	0.8.	0.7.
Value of n in equation $P\,V^n = C$ ..	1.144	1.133	1.120	1.102

The accompanying Table I. gives the values of the specific heat of superheated steam at various temperatures and pressures. Table II. gives the *average* specific heat from saturation to the tabulated temperatures at various pressures. From these it will be seen that the average value of the specific heat of superheated steam is very much greater than 0.48, the value generally accepted. The experimental values obtained by various investigators are, of course, known to be nearer the above figures. But the experimental values are not very consistent.

FRENCH GUNPOWDER FOR EXPORT.—We read in *Le Moniteur de la Flotte* that a Bill has now been placed before the French Parliament with a view to authorise private companies to manufacture gunpowder for export.

ELECTRIC WINDING GEAR AT THE WEST RAND CONSOLIDATED GOLD-MINES.

THE BRITISH WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, MANCHESTER, CONTRACTORS.

Fig. 1. Pit-Head Gear and Engine-House.

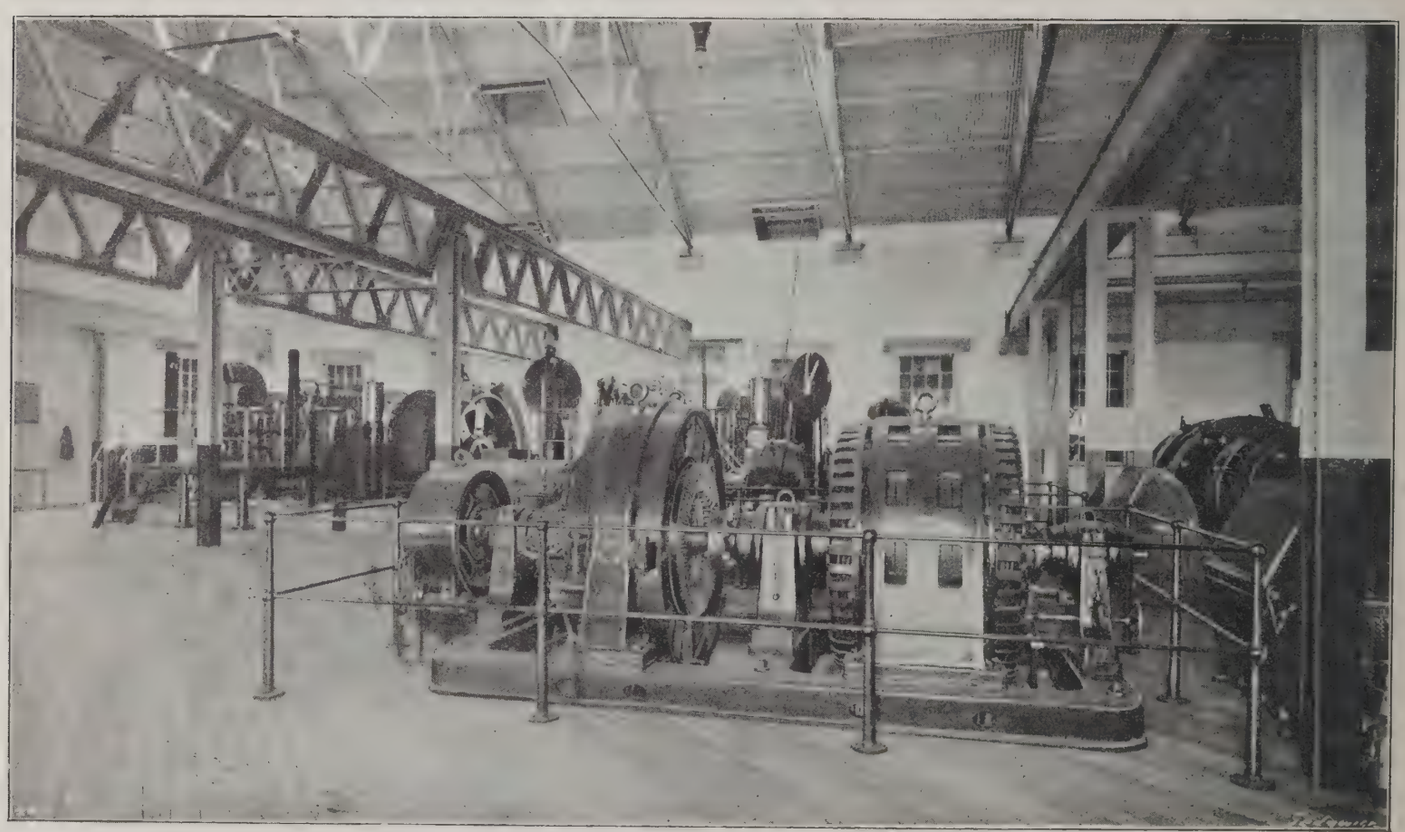


Fig. 2. 650-Kw. Motor Generator Set.

Gold-mining on the Rand has long passed the stage when mines, or, rather, claims, were exploited under false pretences, with no chance of return to the unlucky shareholders. The position and quality of the gold-bearing reef are much better known than formerly, and it has been recognised that, in order to make gold-mining pay under the conditions prevailing on the Rand, it is necessary to deal with large quantities of ore. To this end "consolidations" have been formed, so that many claims could be worked as one mine. This naturally reduces capital outlay and working costs, and enables the use of the most modern equipments for winning the ore and recovering the gold.

One such concern is the West Rand Consolidated Gold-Mines, Limited, who are at present working one shaft (the East shaft) and sinking a second on an estate of nearly 2000 claims, situated near Krugersdorp, about 20 miles from Johannesburg. The crushing capacity at the end of 1909 was about 30,000 tons per month, and in 1910 about 70,000 tons per month, and with the completion of the new shaft this capacity will be again augmented.

The West shaft of this mine, which is at present in course of sinking, is a seven-compartment shaft, and is being driven downwards at an angle of 50 deg. to the horizontal for an estimated distance of 3000 ft. Sinking was commenced by means of a temporary head-gear and two small steam sinking-engines, and at the same time an order was placed for two double-drum electric winding-engines—one suitable for a 6-ton useful load, and the other for a 3-ton useful load.

By the time the electric winding-engines were installed the permanent head-gear was completed, and the shaft had been sunk to a sufficient depth to permit of economical hoisting with the electric hoists. The permanent head-gear, which is built entirely of steel, is shown, together with the winding-engine house, in Fig. 1, above. The engine-room is remarkable, as it is built of brick, and is very commodious, whereas the usual engine-room on the Rand is of corrugated iron construction. The interior of the engine-room is shown in Fig. 2, indicating the positions of the two

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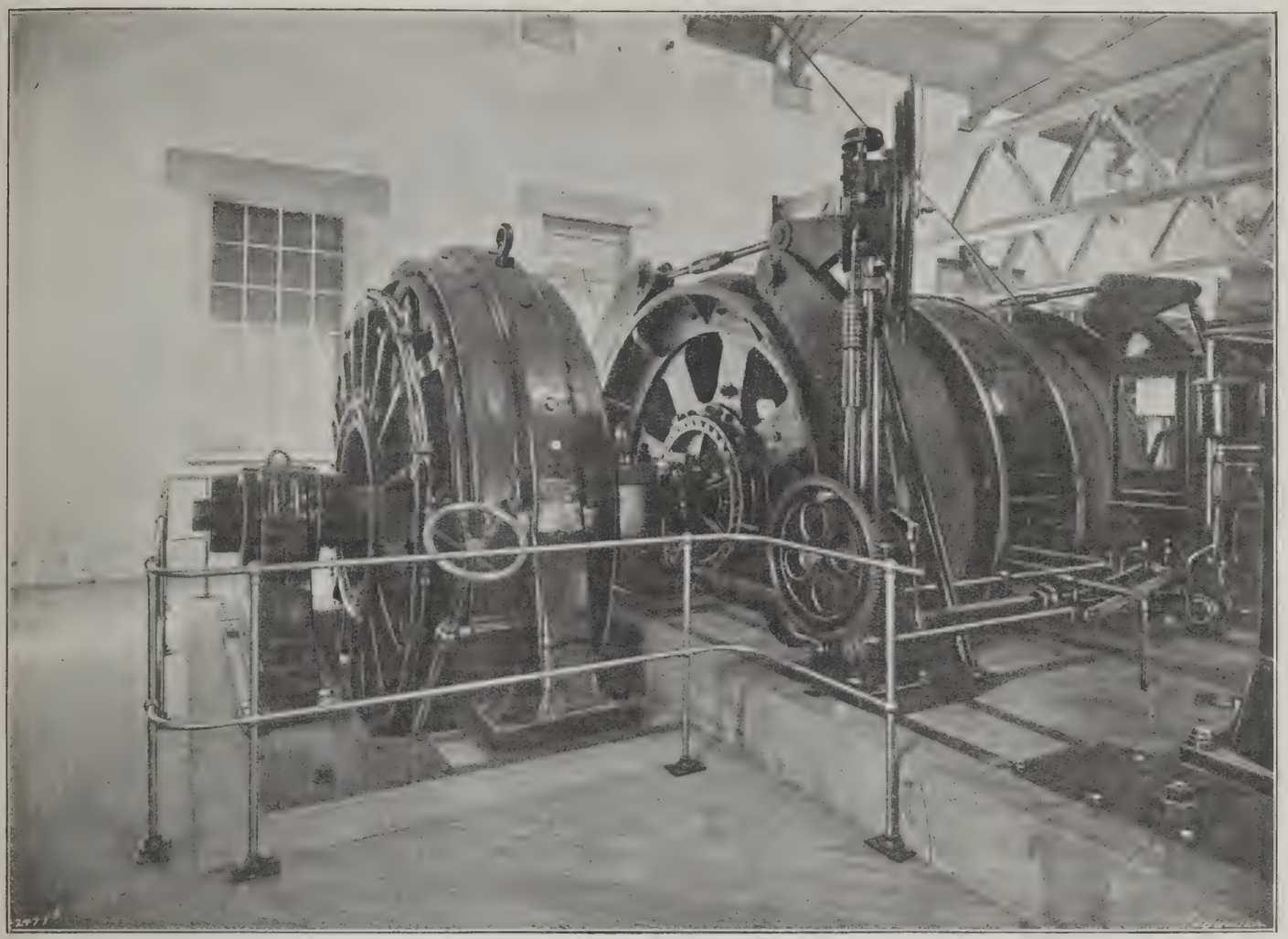


Fig. 3. Electric Winding Gear.

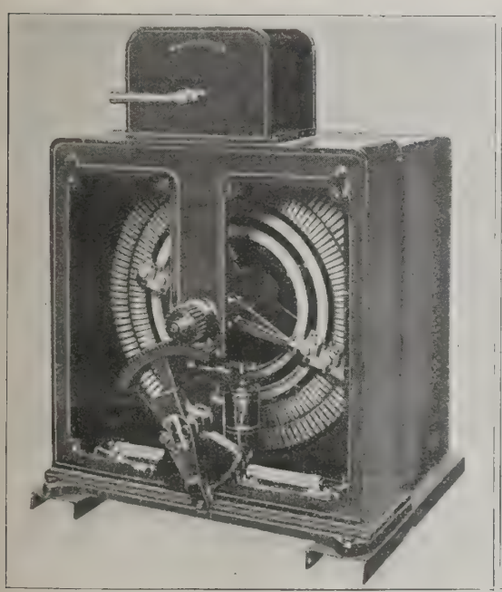


Fig. 4. Face-Plate Controller.

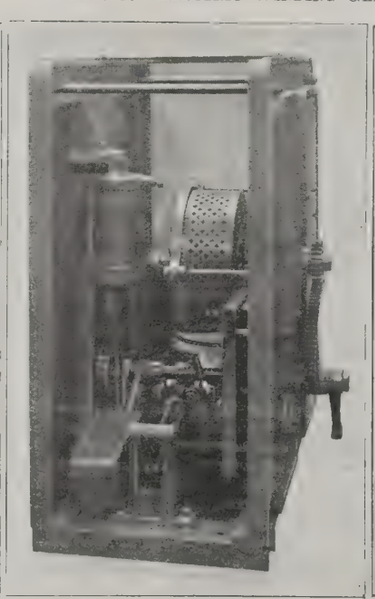


Fig. 5. Emergency Gear.

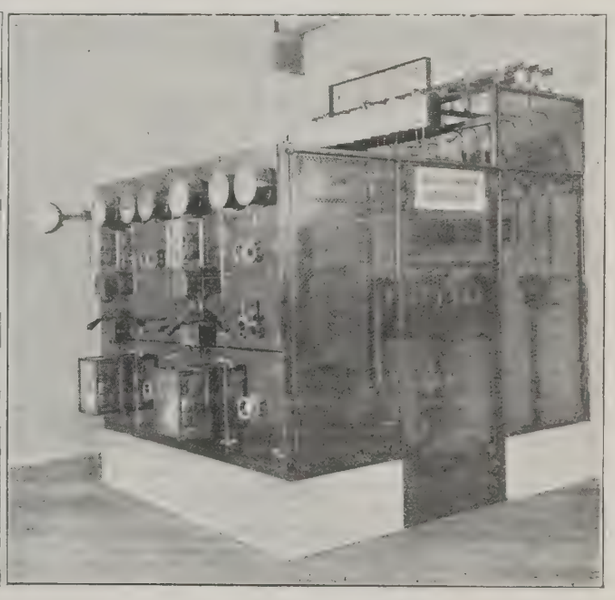


Fig. 6. Switchboard.

hoists and one motor elevator. The large space to the left of the picture is reserved for a third electric winder, to be installed when the shaft is finished and the mine partly developed. Power for the winding motors is obtained from two motor-generator sets, arranged so that either hoist may be driven by either motor-generator, provision also being made for the third equipment in contemplation. Each motor-generator set comprises a 2000-volt three-phase 50-period slip-ring induction motor, directly coupled to a direct-current generator and an exciter. The arrangement of the set for No. 1 hoist may be seen in Fig. 2. The alternating-current supply for driving the motors of the motor-generator sets is purchased from the Victoria Falls and Transmission Power Company, Limited.

The winding-engines were supplied complete and their erection supervised by the British Westinghouse Electric and Manufacturing Company, Limited, who purchased such parts as drums, brakes, drum-shafts, and bearings, from the Dingler'sche Maschinenfabrik

A.-G., under the terms of the order. The mechanical equipments of both hoists are almost identical, in spite of the difference in the load. The services for which these hoists are designed are :—

	Hoist No. 1.	Hoist No. 2.
Inclination of shaft to horizontal ... ... deg.	50	50
Length of shaft ... ... ft.	3,000	3000
Hoisting speed ... ft. per min.	2,000	2000
Weight of rock per wind lb.	12,000	6000
Weight of skip ... ... ,,	7,500	5500
Weight of rope ... ... ,,	8,500	6000

Each hoist is equipped with two drums, 10 ft. in diameter by 3 ft. 9 in. wide between flanges, running loose on the drum-shaft, and driven by multi-tooth clutches sliding on hexagonal sections of the shaft. The clutches are operated by hand-wheels on the driver's platform. Post brakes are provided on each drum, of the segmental type, supported in the centre, and applied by weights. Compressed-air engines, with "Iversen" valve gear, are used for releasing the brakes. Interlocks are provided so that the brakes cannot be released on a drum that is not clutched to the main shaft. Compressed air for operating the brakes is obtained from a small compressor, driven through gearing by a 16-horse-power three-phase 50-period 500-volt squirrel-cage induction motor, fitted with automatic starting and stopping gear, controlled by the air pressure. The position of each cage in the shaft is indicated by two dial depth-indicators, driven one from each drum through gearing. Each indicator has two points, one moving slowly during the entire travel of the skip, and the other moving very rapidly during the final part of the wind so as to increase the accuracy of stopping. Automatic devices are provided which bring the skips to a dead slow speed at the tip, and stop the hoist dead should the skips pass the tip, irrespective of any action on the part of the driver.

The electrical equipment is designed for operation on the now well-known Ward-Leonard system. The winding motors are directly coupled to the drum-shafts, and in each case operated at 60 revolutions per minute. On hoist No. 1 the motor is an 800-brake-horse-power 600-volt direct-current motor, provided with commutating poles. Fig. 3 shows this motor, together with some of the mechanical parts. Hoist No. 2 is provided with a 480 horse-power direct-current Westinghouse motor, together with the drum, driver's platform, and other gear.

In the Ward-Leonard system the speed and direction of rotation of the winding-engine are controlled entirely by altering the strength and direction of the current of the direct-current generator in the motor-generator set. This is carried out by means of a special face-plate controller, illustrated in Fig. 4. By means of this controller any desired speed may be obtained up to full speed in either direction, the speed corresponding closely to the position of the driver's lever, irrespective of the load. These controllers are fitted with stops, controlled electrically from the bank, so that half-speed cannot be exceeded when men are being raised.

An emergency device is provided for each hoist, illustrated in Fig. 5, arranged and connected so that the hoists are quickly stopped in case of :—

1. Overwinding.
2. Failure of power supply.
3. Failure of exciting current.
4. Overloads.
5. Failure of air-supply.
6. Operation of driver's emergency lever.

There is thus a safeguard against practically any danger that may arise.

A four-panel switchboard, illustrated in Fig 6, is used for controlling the supply of power to the two winding-engines, and is arranged to permit extension when required. The switchboard is equipped with one alternating-current and one direct-current panel for each hoist, the former for the alternating-current motor, and the other for the fields of the various direct-current machines.

Although the Ward-Leonard system may be readily adapted for use with a fly-wheel, so that no peaks are reflected on to the mains, no attempt has been made to equalise the load of these winding-engines, since the stations of the Victoria Falls and Transmission Power Company are large enough to be untroubled even by the heavy peaks of the large winding-engines in use on the Rand.

In conclusion, thanks are due to the engineers of the General Mining and Finance Corporation, who permitted the taking and reproduction of the photographs.

Arabic Self-Taught.—We have received from Messrs. E. Marlborough and Co., 51, Old Bailey, E.C., the publishers, a copy of the method entitled "Arabic Self-Taught (Syrian)," by Mr. A. Hassam, enlarged and revised by the Rev. N. Odeh, late chaplain to the Right Rev. G. F. P. Blyth, D.D., Bishop of Jerusalem. The price is 2s. If this book is equal to those for European languages published in the Self-Taught Series, its study will doubtless result in a workable acquaintance with the language.

INDUSTRIAL NOTES.

A resolution was proposed by some of the militant members at a meeting of the Bradford branch of the Amalgamated Society of Railway Servants, held on Sunday last, that, in the event of a strike, workers should be armed, so that they might be better able to meet the troops, if necessary, on equal terms. Such wild resolve is, of course, exceedingly pernicious, and only shows the kind of feeling that animates a section of the trade-union members. It is all foolishness. If anything of the kind were to be attempted, the very sternest measures would, of course, have to be taken with anyone following such a recommendation, and any culprit would find that he would meet with scant consideration from the public.

Yesterday a conference between the representatives of the railway companies and of the railway unions opened at the Board of Trade, under the presidency of Sir George Askwith, the Chief Industrial Commissioner, who represents the department. This conference is the outcome of the recent resolution of the House of Commons, recommending a meeting between the parties to discuss the best mode of giving effect to the report of the Commission of Inquiry. The Board of Trade, in their letter inviting the leaders of both sides to meet, made it quite clear that there was no intention to revise the recommendations of the Commission, because they stated that the invitation was issued "on the understanding that the findings of the Royal Commission were accepted in principle and in substance." It is true that while the directors of the railway companies also specified this proviso, the representatives of the men, when accepting the invitation, in their reply modified the clause, but not to any serious extent; but even apart from this, their acceptance of the invitation is acknowledgment of the finding of the Commission. The railway companies are represented by Mr. G. H. Claughton, Sir Guy Granet, and Mr. Sam Fay, with Mr. Walker as secretary. The unions are represented by Mr. J. E. Williams, Mr. J. H. Thomas, M.P., Mr. A. Bellamy, Mr. A. Fox, Mr. T. Lowth, and Mr. S. Chorlton, all of whom, like Mr. Claughton and Sir Guy Granet, signed the August agreement which ended the strike.

Pending the issue of the conference it would be a mistake to enlarge either upon its significance or upon its possible result. All hope that some arrangement may be made to overcome any objection which the representatives of the men entertain regarding the details of the machinery whereby the findings of the Royal Commission are to be carried into effect. To this extent some measure of future peace may be ensured. At the same time the acceptance of the invitation to confer is indication of the desire of the directors to come to an amicable settlement, so that the result of the ballot of unionists throughout the country, which is likely to be announced next week, loses a large part of its significance, and there seems reason for hoping that the desire for a general strike, if not also the general state of unrest prevailing, may give place to more amicable relationships in the immediate future.

The companies are taking measures to protect themselves as far as possible against the consequences of another strike. These preparations have been made quietly and unostentatiously, the object being to maintain a modified, but sufficient, passenger service, and to safeguard the transport of milk, meat, vegetables, fruit, and other articles of food, as well as coal. This will be done by united action, if not by an amalgamation of the various train services and competitive trains, and the interchange of traffic will be eliminated. Of course, it is anticipated that the authorities will afford ample protection for the loyal workers who may refuse to come out on strike when told to do so by the unions. Special constables will be sworn in locally, and will supplement the efforts of the military and the regular police. There will also be the volunteer police force. Food and lodging will be provided for the workers at the different railway stations. The places of those who have gone out on strike will be filled as far as possible. In addition to the above organisation, men from other railway occupations are being given some actual experience of the work of drivers, firemen, signalmen, and shunters, so that they may be allotted to those positions should necessity arise. The union leaders are well acquainted with these matters, but profess that the efforts of the companies as will make little difference when the strike occurs. Mr. Arthur Henderson, M.P., speaking at Toft Hill, near Bishop Auckland, last Tuesday night, referred to the situation as follows :—There were some people who thought that matters would not be put right until there was a stand-up fight with capital. That was not his view, and he was not going to encourage it. When he undertook a stand-up fight with capital he was going to be satisfied that both teams were sufficiently developed in the art of fighting, and that they were somewhat equally matched. That was not the case with some of the industries talking about fighting to-day. The strike last summer resulted in adding tens of thousands to the wages of the workers.

The monthly report of the Associated Ironmoulders of Scotland for December contains a statement of the working transactions of the society from October 21 to November 18, 1911, and shows that a satisfactory state of things exists with regard to membership, &c. The net income for the time stated was 2838*l.* 12s. 4d., outlay 1913*l.* 10s. 6½d., representing a gain on the funds of 925*l.* 1s. 9½d., which when added to capital account brings the funds up to 50,213*l.* 17s. 3½d. The total membership in November was 8080, against 8041 in October. An appeal is made to members to be more active in exerting their persuasive powers on non-members in order to induce them to join the ranks of the union.

At the end of October last the members of the Society of the Amalgamated Toolmakers had added to their numbers as many as 1379 members since the same time last year. The actual membership now stands at 5851. There has, however, been an increase in the number of the unemployed, for there were in this section, at the end of last October, 127, against 91 at the end of October, 1910. In the same time the reserve fund grew from 18,000*l.* to 23,700*l.*, a very satisfactory result. The report calls attention to the considerable increase there has been in the price of provisions since 1898. It is shown that where, in 1898, an "average weekly family grocery order," would have cost at wholesale prices about 5s. 4d., could only have been bought for a fraction over 6s. in 1910; and whereas 1*l.* sterling in 1898 would have purchased over 80 lb. weight of these groceries, in 1908 its command would have been limited to 73½ lb., and in 1910 to 71¼ lb. "The average order" first mentioned is supposed to consist of 1 lb. bacon, 2 lb. butter, ½ lb. cheese, 12 lb. flour, ½ lb. lard, 1 lb. meal, 4 lb. sugar, and ½ lb. tea. Coal also has advanced in price, for whereas in 1898 the price of house coal at the pit-mouth was 9s. 11½d. per ton, it was 13s. 3d. in 1910. Of course, these figures would vary in different localities, but they are given as being derived from carefully selected average prices.

The monthly report of the National Union of Boot and Shoe Operatives for November announces a somewhat improved state of trade in October. Returns from firms employing 66,597 workpeople in the week ending October 28 showed an increase of 0.6 per cent. in the number employed, and of 1.2 per cent. in the amount of wages paid compared with a month ago. Compared with a year ago there was an increase of 2.2 per cent. in the number employed, and of 5.2 per cent. in the amount of wages paid.

On Thursday in last week, at a meeting of the Council of the London Chamber of Commerce, a report from the Special Committee on Labour Unrest was adopted. Among the recommendations were the repeal or amendment of sections 2, 3, and 4 of the Trades Disputes Act, 1906; the enlargement of the powers of voluntary boards of conciliation and arbitration, under the Conciliation Act, so as to prevent lock-outs and strikes without due notice; effective provision for the protection of persons willing to work; and the securing of freedom of labour and commerce, as well as the protection of life and property. It was also urged that the statutory monopoly now enjoyed by a privileged class of watermen and lightermen in regard to the navigation of barges and similar craft on the Thames should be repealed.

The Swansea dock strike ended on Sunday last. The strike was the outcome of the visit of Messrs. Houlder Brothers' steamship Valhalla to the port, and was organised by the men as an act of sympathy with their comrades at Newport in their dispute with Messrs. Houlder Brothers. Those who took part numbered about 5000. The vessel left on Sunday for South American ports with a general cargo of 800 tons, which had been put on board by imported non-union labour. When these imported men began work on Friday, the whole of the Swansea dock-labourers ceased work, and for two days the trade of the port was paralysed. The men in charge of the dock-gates did not wait to close them properly, with the result that there was very nearly a disaster to the dock. In the terms of the settlement the men's leaders undertook to instruct the men that, in the case of any similar dock strike those in charge of the electric and hydraulic power stations should not cease work without giving proper notice.

At the eleventh annual ordinary general meeting of the shareholders in Messrs. Richardson, Westgarths, and Co., Limited, the effect of labour troubles on the affairs of the company was brought to light by the chairman, the Right Hon. Lord Furness, who stated that throughout the whole of this year labour troubles had been neither slight nor sectional. On a basis of 52 working weeks of 53 hours per week, no less than

30 per cent. of that time was affected by the shipyard dispute, whilst holidays, sickness, and miscellaneous causes accounted for a further 10 per cent., which in itself is equal to closing the entire works for five weeks. Of the entire year, therefore, no less than 40 per cent. was disturbed by strikes, or rendered ineffective through stoppages of one kind and another.

SPECIFICATIONS FOR STEAM PLANTS.

To the Editor of Engineering.

SIR,—I have noticed lately that the boiler insurance companies are endeavouring to compete with consulting engineers, and that where they have been asked to report on an insured plant they have in some cases persuaded the owner to permit them to specify and arrange for a new plant.

Now, a consulting engineer is supposed to act entirely in the best interests of his client; but, from the specifications I have seen lately issued by the different insurance companies, this aspect of a consulting engineer's duty seems to have been entirely lost sight of. The specifications are issued to a limited number of manufacturing engineers, presumably chosen on account of the reputation of their engines or boilers. On examining the specifications, however, it would seem that these manufacturers are not considered capable even of knowing what is good for their engine, but have to equip it with Mr. Smith's stop-valve, which has to be fitted with Mr. X's drain-tap, Mr. Brown's lubricator, Mr. Jones's steam-traps, Mr. Robinson's relief-valves, and that all the valves about the plant are to be Mr. X's, and the catalogue numbers of these are given. Mr. Y's piston-rings and Mr. Z's patent packing are also to be fitted. Surely this is not in the best interests either of the customer or the insurance companies themselves. By doing this they are impugning their own impartiality, and preventing competition; further, in the case of accidents or dissatisfaction with any of these specified adjuncts, the contractor is asked to be responsible. Should the customer be dissatisfied with the plant, and it not prove suitable for its work, he could not call the insurance company in to report; and if he was insured with them, how could they make an unbiassed report on their own delinquencies? They endeavour to avoid this by inserting in the specification a clause that the contractor is to be responsible for the plant being entirely suitable for the work it has to perform, and that everything is to be supplied to their satisfaction; further, he is to make it complete in every respect, whether specified or not, and, in fact, they disclaim any responsibility. The contractor does not know the conditions under which the plant will be employed, has never seen the site or the purchaser, and has not obtained his requirements, while the insurance company, who have done this, and know all the particulars of environment and site, and who are paid for their advice, endeavour to escape responsibility in this fashion.

The customer has to pay pretty stiffly for the enormous detailed specifications, which are supposed to set forth his requirements, but are in reality specifications of a lot of things for which the insurance company seek to make the contractor responsible. The customer has further to pay a very much higher sum for his complete work than if it were entrusted to a competent consulting engineer, or if he asked for tenders from several firms, and asked such an engineer to adjudicate on them.

Yours faithfully,
M.I. MECH. E.

CASE-HARDENING.

To the Editor of Engineering.

SIR,—I have noticed the letter of Mr. Clinch-Jones published in your issue of November 24.

I fully admit that a rapid perusal of my paper published in your issue of November 10 may leave the impression that there is some analogy between some parts of the furnace therein described and those of other furnaces already used for case-hardening.

But my paper above referred to only contains a very short description (not sufficient to give a clear idea) of the new case-hardening *processes* based upon the use of carbon bioxide and carbon protoxide under well-determined conditions of chemical equilibrium; by which processes it is possible to obtain cemented zones in which the carbon has a *determined concentration and a determined distribution.*

I feel sure that if Mr. Clinch-Jones will read my previous publications (some of which are mentioned in my paper above referred to) he will at once convince himself that the new processes (for which patents have been granted in the principal countries, including Germany) are substantially and totally different from all other case-hardening processes so far used in the industry, not only for the methods followed and substances used, but also and especially in the totally different and much superior results thereby obtained.

I should be very obliged to you if you would publish this letter in your next issue.

I am, Sir, yours faithfully,
FEDERICO GIOLITTI.

Genoa, November 28, 1911.

"NEO-PHILISTINISM."

To the Editor of Engineering.

SIR,—I have no wish (believe me) to burden Neo-Philistinism with more ridicule than it can bear. Were I to make no further reply to the Corinthian casuistry of my critics, I would attain that dignity to which only the magnanimous can aspire; but I should do so at too great a cost to the cause of truth.

Dignity to the dogs, then! while I claim, of your courtesy, permit to reply: since my one letter has been faced with *three* Philippics from the Philistines; while I step out from the Elysian Halls of Wisdom into the dust and din of the market-place to chastise the Sophists sitting there.

First, Sir, a word in reply to the elusive epilogue that succeeds my letter in your issue of November 24.

You accuse me of "invective," and pillory me with Matthew Arnold; you do me an honour for which I am duly grateful; perhaps we may eventually survive your censure.

You charge me with "misrepresentation;" but I never asserted that either you or Mr. Campbell Swinton suggested the "prohibition" of so-called "culture-studies." However, if it makes you at all happy, I am quite ready to suggest it *myself.*

Thirdly, you talk of "assertion." Do you, then, seriously suppose that it is possible to write a letter in which the writer is to assert *nothing*? An eventuality that would curtail the exchange of ideas sadly.

I will pass over your kind-hearted proposal that I should be left naked upon a desert island, since the matter has been already dismissed by another pen than mine; though I might add, in passing, that what a "Crusoe" feels the need of most, is *not* the comforts of a so-called civilisation, but a "Friday," to "tell him stories."

Now to answer Mr. Swinton.

I wish that he had replied to my letter, instead of confining himself to a fallacious argument, which, in a few moments, I shall proceed to annihilate. My letter consisted almost entirely of a series of questions, not one of which has been directly answered. My modesty forbids me providing an obvious explanation of this omission. The matter of Mr. Swinton's all too brief reply is this:—Without the printing-press we can have no literature worthy of the name, and, he is naïve enough to add, my letter would never have been written. *Surely!* But even a greater apotheosis than *that* would have been achieved: the leader of November 17 would never have been perpetrated, and no one would have been called upon to talk of the decadence of modern civilisation.

Surely Mr. Campbell Swinton does not imagine that literature is dependent for its existence on the printing-press. Or, perhaps, Mr. Swinton prefers the post-Caxton half-penny daily to Plato's *Republic* of a pre-Caxtonian era. Will any man dare to assert that we, as a nation, are more intellectual or more artistic than Greece in the 4th century B.C. Let us have no more of this "printing-press Pharisaism."

Finally, we are told that without the "scientific imagination" the human race would long ago have perished. Is Mr. Swinton under the delusion that the transition from the Stone Age to the Bronze Age was in any way a *self-conscious* change on the part of humanity—that the discovery of the use of metallic arrow-heads was other than the fortuitous finding (probably) of some prehistoric colonel? For countless centuries the world has been run upon a system of "trial and error;" it is only within the last few generations that a conscious "scientific imagination" has footed the stage of human endeavour, and humanity, as a whole, is as yet by no means prodigal of applause.

Here, Sir, is the end (absolute and unconditional) of what Mr. Campbell Swinton calls my "lucubrations" (I like the word); in the grip of "the white passion for truth" I have given away my dignity with both hands. I hope that you will appreciate the sacrifice.

One more gift (*timeo Danaos . . .!*) I have for you: a reiteration of the warning that my one comrade in arms has already given you. *You have drawn dangerously near discussing the utility of Art.*

I will conclude by parodying a notorious epigram:—"You have endeavoured to vindicate a false position: that is *your* tragedy. It necessitated a reply: that is *mine.*"

Yours faithfully,
NORMAN DAVEY.

Conaways, Ewell, Surrey, December 3, 1911.

To the Editor of Engineering.

SIR,—Will you be kind enough to allow me to say a few words on the subject of "Neo-Philistinism," in reply to your note at the end of my first letter on page 731 of your issue of December 1.

I should like, first, to point out that my name was misprinted as "Cox," instead of Case. Perhaps I write badly.

In my first letter I did not deny that people with little or no training can speak and argue upon literature and philosophy with absolute self-confidence; my suggestion was that I had heard engineers discussing such themes; the tone of the voices raised in altercation was supremely self-confident, whilst the substance of their remarks was perfect nonsense.

That some individuals can exist without poetic imagination, or, rather, remain unmoved by the beauties of art and poetry, common observation will prove; yet I maintain that no single race or nation, from the time it was worthy of that name, has ever passed through a period of which it could be said that the people composing that nation were entirely uninfluenced by art, and had not shown, perhaps only in some crude form, a desire and appreciation of the beautiful.

No, Sir, I am far from certain that the ultimate value of art (whatever that may mean) is not utilitarian; but I insist that the effect is so great and far-reaching that it does not permit of estimation. For example:—Can you tell me the force that Chopin's music has had in the world, or estimate for me the value and influence of Shakespeare's plays? On the other hand, I have no doubt that you could write a big book on the benefits which have accrued to the human race from the invention of the steam-engine, and wax eloquent upon the soaring effects of the coming perfection of the aeroplane.

Again, I should like to quote a portion of your note, for it contains the germ of a grievous misapprehension:—"This is not to say, however, that the artist, the poet, or the philosopher is to aim consciously at utilitarian ends." Let me say, in conclusion, that if any one of these should consciously aim at utilitarian ends, he immediately ceases to be an artist, poet, or philosopher. The artist is not concerned about regenerating the world; he has ideals, but his work lies with the emotions.

Yours faithfully,
JOHN CASE.

The Engineering Laboratories, Cambridge,
December 5, 1911.

[We are unable to apprehend the exact position occupied by our critic—viz., whether he denies that the emotions, and what pertains thereto, have a utilitarian value, or whether he merely means, to quote that eminent *littérateur* Mr. Silas Wegg, that it is difficult "to work it into money" or its equivalent. With the latter view we agree, but that such an emotion as love of offspring, for example, has a high utilitarian value is, we consider, indisputable. We regret the typographical error in the signature to Mr. Case's former letter.—ED. E.]

THE INSTITUTION OF CIVIL ENGINEERS.

To the Editor of Engineering.

SIR,—May I crave a little of your space to raise a strong protest against the absurd manner in which the discussion at the Institution of Civil Engineers was brought to a close on Tuesday last. After devoting two nights to the discussion on Mr. R. T. Smith's interesting paper on "Electric Train Lighting," the author was compelled, by the ruling of the chair, to defer his reply to the next meeting. Such treatment, in my opinion, is grossly unfair to the author, who should have been given the opportunity of replying to his critics while the members interested in railway work were present. Many such men had come up from the country to attend that meeting, and a number of these will, doubtless, not consider themselves justified in coming up again on Tuesday next to listen to a short reply by Mr. Smith prefacing the lengthy consideration of a subject in which they may have little interest. Many town members will hesitate to attend for similar reasons. The Institution is not a clockwork mechanism, and members have a right to expect something in the way of intelligent anticipation of their wishes, or steps to be taken to ascertain what these wishes may be. The 9.30 fetish is too blindly worshipped. As for the coffee and biscuits, their quality has by no means the same relish as a good reply from an author to a good discussion, and many members would willingly forego them for the latter. If the Institution *must* be closed so early, and coffee and a chat are essential, there are innumerable places outside to which members may adjourn subsequently, where both may be enjoyed in greater comfort than in Great George-street.

Yours truly,
RAILWAY MEMBER.

THE INSTITUTE OF CHEMISTRY.—We have received from the secretary a list of contributors to the Institute's Buildings Fund. The lease of the present premises—30, Bloomsbury-square—expires at Michaelmas, 1914, and this provides a suitable opportunity for the acquisition of more commodious and permanent headquarters. It is estimated that the building and fittings will cost about 15,000*l.*, and an appeal to Fellows and Associates of the Institute has already resulted in the receipt of contributions and promises amounting to over 8000*l.*, or more than half the sum required. A further appeal is now made, which, it is hoped, will result in completing the necessary amount.

THE INSTITUTION OF CIVIL ENGINEERS: STUDENTS' MEETING.—At the students' meeting, held at the Institution on Friday, December 1, at 8 p.m., Messrs. J. and W. Legg read a paper entitled "Brake-Lining Coefficients of Friction." The chair was taken by the President, Dr. W. C. Unwin, F.R.S. The paper gave detailed results of the authors' experiments on the relative value of several brake-lining materials, and the variation of the coefficient of friction between cast iron and the material, with the intensity of pressure and the relative velocity of the two substances. The results obtained were illustrated by numerous lantern-slides and diagrams. The discussion was opened by Mr. T. J. Taplin, and was continued by Messrs. R. W. Brims, C. T. B. Donkin, G. A. Clark, H. V. Hutt, and (at the President's request) Professor E. Wilson.

THE "DAILY MAIL" YEAR-BOOK, 1912.—London: The Associated Newspapers, Limited, Carmelite House, E.C. [Price 6d.]—As usual, this year-book contains a very great variety of information on home and foreign matters. The field covered is much too large to review in the space at our disposal. It includes comments on all the important topics which have been to the fore in the past year, and, in addition, on many a subject on which it is difficult to get concise information without wading through long records and accounts or tables of statistics. More directly concerned with our own sphere, it has summaries on such subjects as railways, aeronautics, marine and naval matters, &c. Under the heading of "railways," a slightly biased summary is given in one connection which would be as well avoided. A summary giving some objections to the nationalisation of the railways of this country is contributed by Mr. E. A. Pratt, and one in favour thereof by Mr. G. J. Wardle.

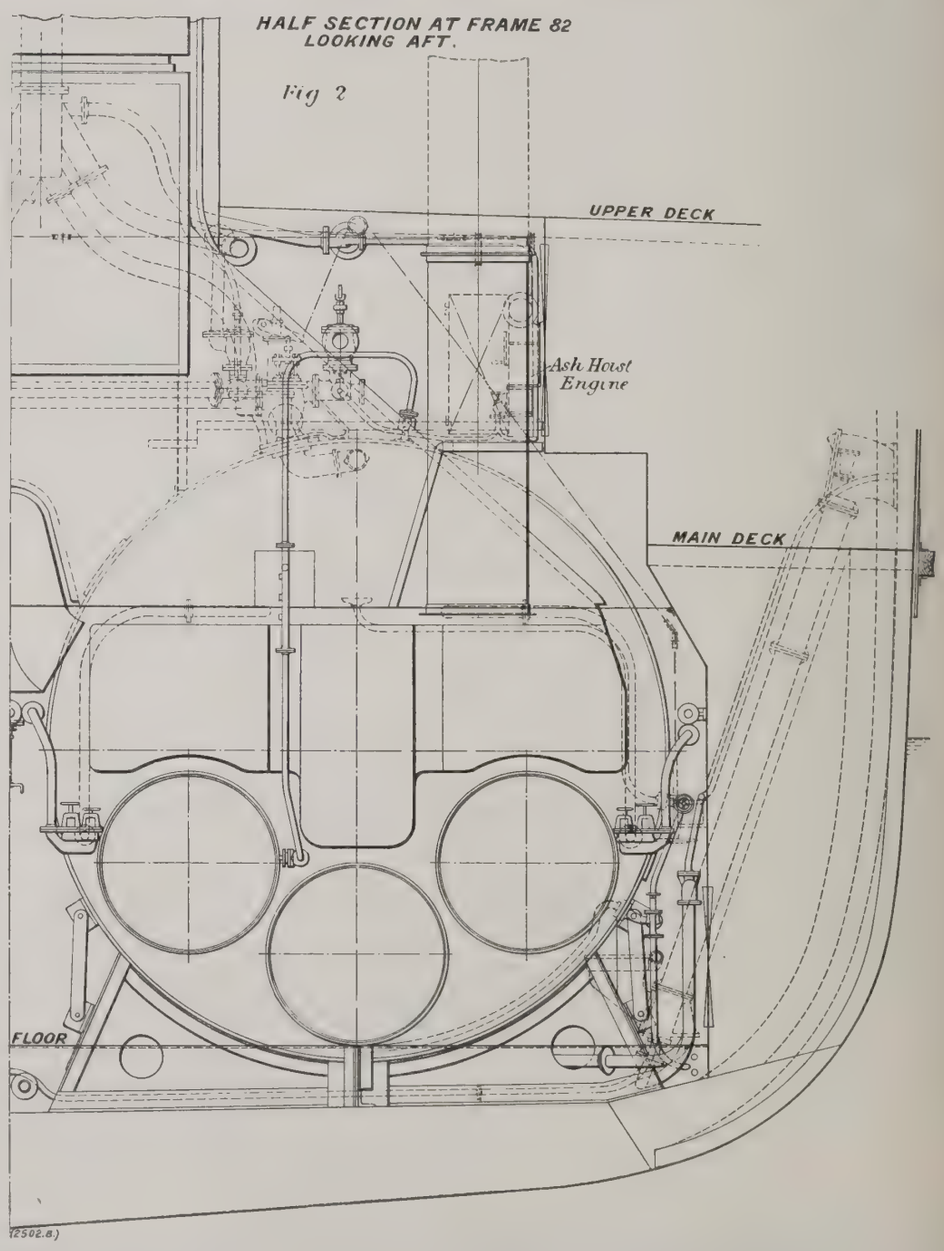
THE CANADIAN PACIFIC RAILWAY'S OIL-FUEL-BURNING T.-S.S. "PRINCESS ALICE."

BUILT BY MESSRS. SWAN, HUNTER, AND WIGHAM RICHARDSON, LIMITED, WALLSEND-ON-TYNE.

Fig. 1.

We illustrate on this page and on pages 765 and 768 the twin-screw steamer Princess Alice, which has just been completed for the Canadian Pacific Railway Company, and is the first of this fleet to be fitted with oil-burning apparatus. The vessel has been built by Messrs. Swan, Hunter, and Wigham Richardson, Wallsend-on-Tyne, and the steam installation and all the propelling machinery have been constructed by the Wallsend Slipway and Engineering Company, Limited. The vessel is 290 ft. long, has a 46-ft. 2-in. beam, and has been designed to carry her passengers and cargo on a draught of 12 ft. 6 in. As shown in the perspective view of the ship, which was taken on her trial, when oil fuel was being used, and when the absence of smoke was particularly noticeable, the vessel is typical of passenger steamers used in coasting and river traffic on the American Continent. Consequently there is a considerable range of superstructure; the half-section through the boiler-room (Fig. 2) will enable the reader to follow the general arrangement of the midship section and of the decks. On the promenade-deck there is an observation-room forward with a smoking-room aft, both fitted with plate-glass windows in order that an uninterrupted view of the scenery passed may be had by the passengers. Mahogany is used in the observation-room, fumed oak in the smoke-room, and in both cases there are hammered copper panels depicting the ancient "totem" poles of the North American Indians and specimens of the agricultural and horticultural products of Canada. A wide corridor, also of polished mahogany, with inlaid panels, extends between the observation and smoke-rooms, and gives communication with the state-rooms on each side. The corridor is particularly spacious, and a fine effect is contributed by the roof being of the clerestory type. From this corridor companion-ways lead down to the upper deck, where also there is arranged a series of first-class state-rooms, with special suites of rooms, and two social halls or music-rooms. On the main deck aft there is the dining-saloon, which is panelled in Italian walnut, and has specially large plate-glass windows. The pantry is still further aft, and the galley is in the stern of the ship, a great advantage from the point of view of ventilation. Under the dining-room deck there is a first-class saloon where refreshments *a la carte* are served.

The boilers are four in number, single-ended, of 15 ft. 7 in. external diameter and 12 ft. long, and constructed for a working pressure of 180 lb. They are arranged in one boiler-room, of which a half-section is given in Fig. 2. They are worked under forced draught on the closed-stokehold system, the air being supplied by two double-inlet fans by Messrs. M. Paul and Co., Dumbarton. The feed draught and other features are shown in Fig. 2. The firing of these boilers is so arranged that either coal or oil may be used, and the oil-burning installation is illustrated by Figs. 3 and 4, on page 765. The method used in burning the oil is the well-known Wallsend-Howden patent system, the manufacturer and licensee of which is the Wallsend Slipway and Engineering Company, Limited. This vessel is one of a large number fitted in recent years with this system, ranging from small tug-boats of 50 horse-power to large liners of over 14,000 horse-power. The liquid-fuel pumps are by Messrs. G. and J. Weir, Limited, and the remainder of the fittings, such as heaters, filters, burners, &c., are by the Wallsend Slipway and Engineering Company, Limited. The disposition of the oil-fuel apparatus is clearly indicated in Figs. 3 and 4, on page 765. The two liquid-fuel pumps are of the vertical "Simplex" type, and each is of such a size as to be able to deal with all



OIL-FUEL-BURNING APPARATUS OF THE CANADIAN PACIFIC RAILWAY COMPANY'S T.-S.S. "PRINCESS ALICE."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

Fig. 3.

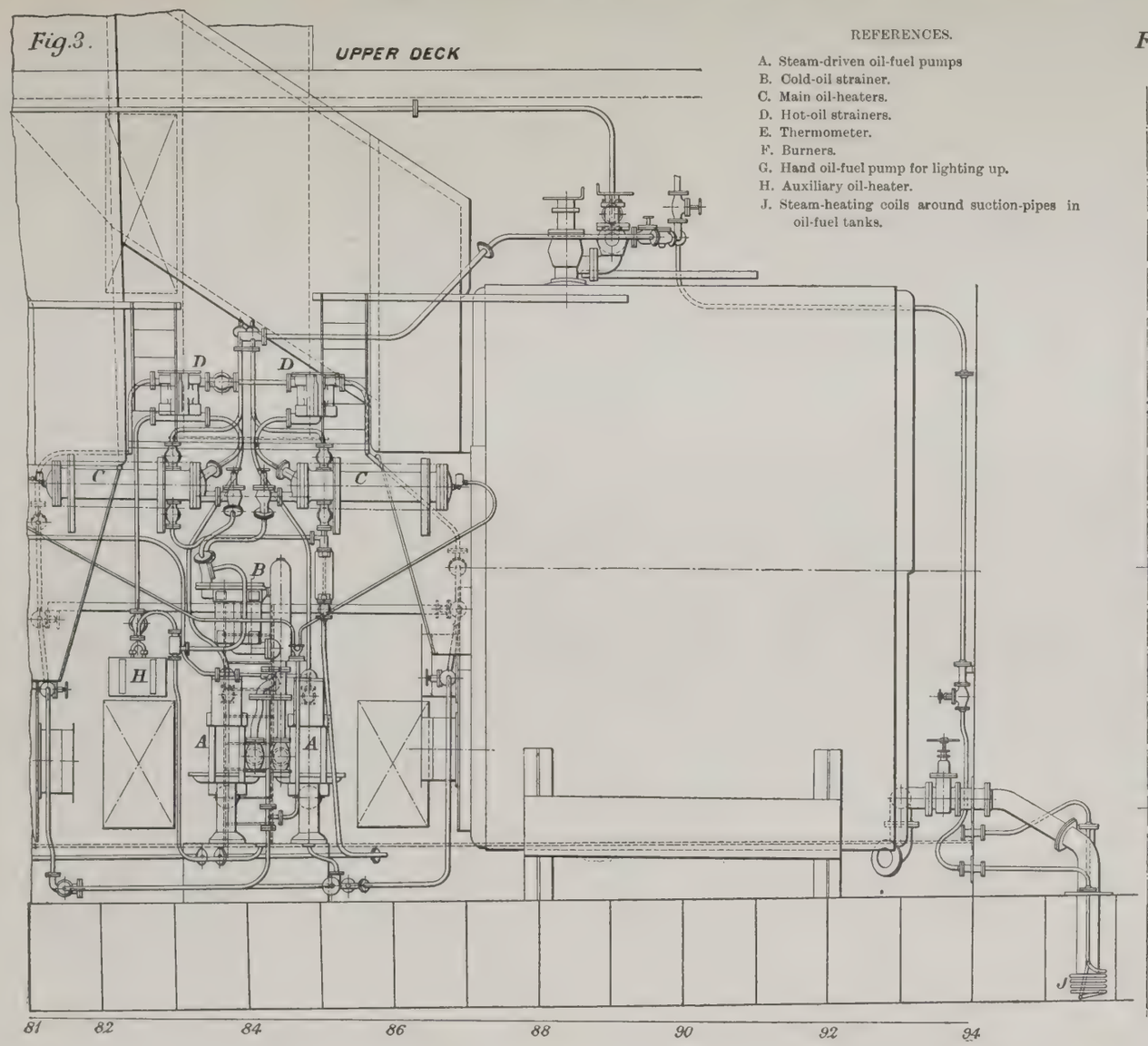
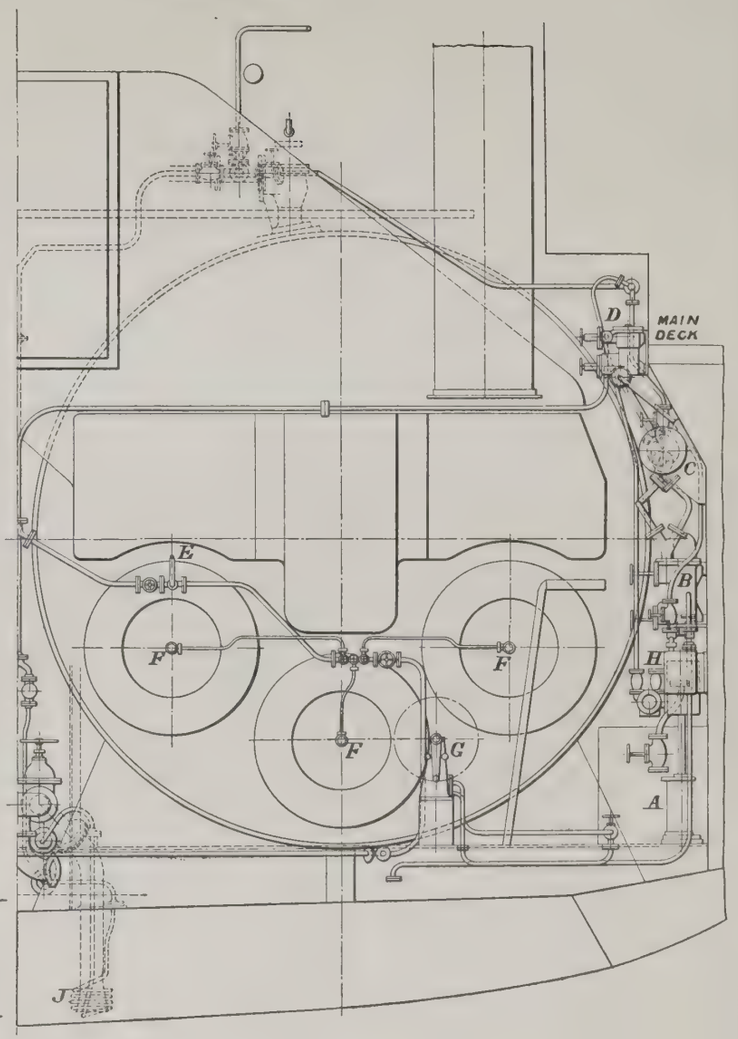


Fig. 4. SECTION AT FRAME 82 LOOKING FORº



the oil consumed at full power. The oil is stored in the double bottoms and deep tanks, and the pumps draw the liquid fuel from the various compartments, and deliver it through the duplex filters, in which the oil is thoroughly cleansed; thence it passes to large heaters, in which the oil is raised to the correct temperature. These heaters are fitted in duplicate. Each heater is of very ample capacity; one heater therefore acts as a stand-by in case the other heater requires overhauling. From the heaters the liquid fuel is conveyed to the various furnaces. Attached to each furnace is a patent distributor of the Wallsend-Howden design, and in this distributor the liquid-fuel spray and air is intermixed so as to produce perfect combustion. One of the great advantages in connection with this system of oil-burning is that the furnaces are absolutely clear of brickwork. On the Princess Alice a small auxiliary installation is fitted, consisting of hand-pump and auxiliary heater, so that steam may be raised on any boiler without the use of coal, wood, or any other combustible beyond the liquid fuel itself. This, it will be realised, is also a great advantage.

The liquid fuel to be burned on the Princess Alice is Californian oil; and the Wallsend Slipway and Engineering Company, who have had considerable experience with this class of oil, have designed the installation to suit its peculiar properties.

The funnel fitted is of an oval design, of dimensions 11 ft. by 8 ft., with an outer casing. The main steam-pipes are of wrought iron, lap-welded, and fitted with the necessary expansion joints. These pipes were manufactured by Messrs. Stewarts and Lloyds, Limited, Glasgow.

The propelling engines consist of one set of four-crank triple-expansion engines balanced on the Yarrow-Schlick-Tweedy system, so as to reduce vibration to a minimum, and drawings of them are reproduced on page 768. The cylinders are of the following dimensions:—27 in., 42 in., 48½ in., and 48½ in. in diameter, with a common stroke of 39 in. Each cylinder is fitted with a separate liner, and the pistons are of cast steel, except that of medium pressure, which is of cast iron. Each cylinder is carried on two cast-iron columns of box form, the back column of each

engine being fitted with a guide face for the piston-rod shoe. The bed-plate is of cast-iron, of box form and specially strong design, and attached to and forming part of this bed-plate is the thrust-block.

The condenser is entirely independent of the framing of the engines. It is of the Weir's "Uniflux" type, and is built up of steel plates. This condenser works in conjunction with an air-pump of the "Dual" type, also supplied by Messrs. G. and J. Weir, Limited. The condensing plant is capable of maintaining a vacuum of 26 in. when the machinery is working at full power. No pumps whatever are worked from the main engines.

The valve-gear is worked by means of the usual double eccentrics and link motion, the reversing being accomplished by means of one of Brown's combined steam and hydraulic engines. The starting and handling gear is concentrated on one column.

Each propeller is fitted with four manganese-bronze blades.

A complete installation of auxiliary machinery is fitted on board to work in conjunction with the main machinery. One centrifugal circulating-pump is fitted for supplying the circulating water to the main condenser. This pump is driven by an enclosed engine, and is of Messrs. Matthew Paul and Co.'s make. The main feed-pumps consist of one pair of Messrs. G. and J. Weir's independent duplex automatic pumps, with float-tank attached for regulating it. These pumps work in conjunction with a surface heater, also by Messrs. Weir. One of Messrs. Railton and Campbell's filters is fitted in the feed delivery-pipe to the boilers. There are two bilge and sanitary pumps, of Messrs. A. G. Mumford's make. Besides the above auxiliaries there are also installed on board ballast, fresh-water, general service, and ash-ejector pumps (all of Mumford's make), ash-ejector by Messrs. Trewent and Proctor, and one of Messrs. Alley and McLellan's steam ash-hoists.

On the trials, which were successfully carried through, a speed of 18 knots was easily realised.

The vessel was constructed under the direction of Captain H. Mowatt, marine superintendent for the Canadian Pacific Railway Company.

Personal.—The South Durham Steel and Iron Company, Limited, Stockton-on-Tees, have appointed Mr. Geo Marrs, 20 and 21, Laurence Pountney Lane, E.C., their sole agent for London and district, for the sale of their manufactures. Mr. Marrs was for 35 years with Messrs. G. Bailey, Toms, and Co.—Mr. T. Murphy, Hon. Secretary of the British Foundrymen's Association, London and District Branch, states that his address is now 54, Rosebery-avenue, E.C.—The Pullman Company, Limited, announce that on and from the 11th inst. their address will be Victoria Station (S. E. & C. R.), Pimlico, S.W.

London County Council Trade Scholarships for Boys, 1912.—By means of these scholarships boys may secure free education (with maintenance grant) at day technical schools, where they will receive such instruction as will prepare them on leaving school to take up either apprenticeships or employment in skilled trades. About 166 scholarships will be awarded in 1912. Full particulars of the course of study followed by the scholarship-holders at the various schools are set out in the "Scholarships Hand-Book, 1911-12," which may be obtained from Messrs. P. S. King and Son, 2 and 4, Great Smith-street, Westminster, S.W., price 1d., or by post 3d. Forms of application (T2/258) may be obtained from the Education Officer, London County Council, and must be returned not later than Saturday, January 20, 1912.

The Copper Market.—In their monthly report, dated the 1st inst., Messrs. James Lewis and Son state that copper had advanced materially during the past month. From 55*l.* on the 1st ult. cash Standard rose to 59*l.* 5s. on the 27th, when 60*l.* was paid for three months prompt. After receding to 58*l.* 17s. 6d. and 59*l.* 12s. 6d. respectively on the 29th, closing values were 59*l.* 1s. 3d. and 59*l.* 16s. 3d. This enhancement of prices was due to several causes. Consumers and speculators realised the steadily increasing strength of the statistical position. This again was followed by large purchases on the part of manufacturers in the United States and also in Europe, which had enabled American producers to market not only the chief part of their available stocks, but also to sell freely for forward delivery. Large quantities of electrolytic were disposed of at 13 cents per pound in New York, while the interest shown in the favourable prospects of this metal led to extensive purchases of Standard, the total quantity of the latter which had changed hands during the month amounting to about 45,000 tons. The more favourable outlook for the iron and steel market in the United States, and the large sales that had recently been made, induced a belief that the home consumption demand for copper would soon reduce the falling-off of 30,000 tons shown for the first ten months of this year, as compared with the same period of last year. European consumption continued as large as ever, and it was evident that a further considerable reduction would take place in the stocks held on both sides of the Atlantic, showing the extent to which consumption generally exceeded the production. The decrease in European stocks during November amounted to 6279 tons.

NOTES FROM THE UNITED STATES.

Philadelphia, November 29.

Another of those sudden turns in the United States iron and steel industry has just precipitated itself in an exceptionally active demand for several lines of material. Pig iron at last is sharing in the general improvement. Foundry iron is leading, and Bessemer has developed at least temporary activity. Very large purchases have been made at Southern furnaces for iron for cast-iron pipe purposes. The actual figures are not mentioned, but were over 100,000 tons. Considerable tonnages for the first quarter are pending, and first-half contracts and demand for January shipments of both Bessemer and basic have given the market a distinctly improved tone, which, it is predicted, will continue. Merchant furnaces are making no effort to put up prices at this time, and are still willing to contract into first quarter at about present prompt prices. The Republic Iron and Steel Company took a considerable tonnage of Bessemer iron from the Ohio merchant furnace, which proved to be a conversion deal, iron for ore, on the basis of 14.25 dols. for the iron, and the official 1911 price for the ore. One of the recent large contracts for structural material calls for 20,000 tons for the Continental Bank building at Chicago, and another 12,000 tons for an insurance building in Cincinnati. A gas-holder is to be built near Pittsburg which will take 8000 tons of riveted plates. A mill in that city is working on a 9500-ton order for an aqueduct to connect Los Angeles on the Pacific Coast with the nearest mountain range. The contemplated completion of the Panama Canal is stirring shipbuilding enterprise, and the shipyards along the Atlantic Coast are crowded with work, and are booking contracts for delivery all through the coming year. There are schemes for shipbuilding lines being worked up, and there is some sort of opposition shown to them in financial circles.

Contracts.—The Underfeed Stoker Company, Limited, have recently sold ninety-nine of their stokers of the various types, for use in different installations in this country, the colonies, on the Continent, and in distant lands.

The Physical Society's Annual Exhibition.—This Exhibition, which is to be held on Tuesday, the 19th inst., at the Imperial College of Science, South Kensington, will be open in both the afternoon (from 3 to 6 p.m.) and in the evening (from 7 to 10 p.m.). Professor the Hon. R. J. Strutt, F.R.S., will give a discourse at 4.30 and again at 8 p.m. on "Electric Discharge and the Luminosity which Survives it." Some thirty firms will be exhibiting. We understand that invitations have been given to the Institution of Electrical Engineers, the Faraday Society, the Optical Society, and the Röntgen Society. Admission in all cases will be by ticket only, and therefore members of the societies just mentioned (including also the Physical Society) desiring to attend the Exhibition should apply to the secretary of the society to which they belong.

Explosibility of Gaseous Mixtures.—Mixtures of an explosive gas, like methane, with air or with oxygen will not necessarily explode on ignition; the oxygen contents must not be too small or too large. The limits of explosibility depend also upon the method of ignition. In recent experiments E. P. Perman, of University College, Cardiff (see *Nature* of September 28, 1911), ignited the mixtures by means of incandescent platinum wires, and observed wider limits of explosibility than are usually assumed. He found that mixtures of the following percentages were explosive, the figures in brackets indicating the limits given by Clowes:—Methane, 2.5 to 24 per cent. (5 to 13); coal gas, 4 to 28 per cent. (6 to 29); hydrogen, 3 to 75 per cent. (5 to 72). The interest lies chiefly in the observed explosibility of very dilute mixtures. Perman also confirmed the explosibility of mixtures of coal-dust and air, free from other gases, which Garforth (British Coal-Dust Commission) and others have established.

Treating the Forest as a Crop.—There are now said to be 16,000,000 acres of Dominion forest reserves in Canada, besides great areas of non-agricultural land that may in future be set aside for forest cultivation in Western Canada, and on the Forestry Branch of the Department of the Interior depends, more than upon any other organisation, the future of the forests. This Forestry Branch, according to the *Canadian Engineer*, besides looking after Dominion lands, is now being asked by Eastern landowners to furnish advice as to the best means of securing at the earliest possible date a profitable crop of timber on waste land or wood lots. In order that the new Rocky Mountain Forest Reserve may be administered according to the latest scientific knowledge and best experience, the Forestry Branch is now making detailed studies of the habits of the merchantable species of trees on the eastern slope of the Rockies in Alberta. One of the men in charge of the work has been sent to study the systems of forest management practised during the past few years by the highly-developed United States Forest Service in the National Forests of Montana. The Canadian Forestry Branch will in this way benefit greatly from the experience of a country that has spent large sums of money in developing plans of lumbering which do not inconvenience the lumbermen, and which ensure the protection and reproduction of the forests.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was fairly steady, but the business was limited to 1000 tons of Cleveland warrants at 47s. 6½d. cash and 47s. 7d. eight days. At the close there were sellers at 47s. 7½d. cash, 47s. 11d. one month, and 48s. 6d. three months. Cash buyers of hematite quoted 62s. 11d., and sellers 1d. more, and sellers of copper quoted 60*l.* three months, with buyers at 5s. less. In the afternoon Cleveland warrants were firmer, and 6000 tons were done at 47s. 8d., 47s. 9d., and 47s. 8½d. cash, 47s. 11d. and 48s. one month, and 48s. 7d. three months, with sellers over for the latter position, and at 47s. 9d. cash and 48s. 0½d. one month. Hematite was quoted 63s. 1½d. cash sellers. On Friday morning the market was strong, and buyers were in evidence. The turnover amounted to 14,000 tons of Cleveland warrants at 48s. and 47s. 11½d. cash, 48s. 3d. and 48s. 3½d. one month, and 48s. 9d. and 48s. 10d. three months, and closing sellers quoted 48s. cash, 48s. 3½d. one month, and 48s. 10½d. three months. Hematite—500 tons—changed hands at 63s. 1½d. cash, with sellers over at 63s. 3d. The afternoon session was also active, when 11,000 tons of Cleveland warrants were dealt in at 48s. 1d., 48s. 0½d., and 48s. 1½d. cash, 48s. 4d. and 48s. 4½d. one month, and 48s. 11d. and 48s. 11½d. three months. At the close sellers quoted 48s. 2d. cash, 48s. 5d. one month, and 48s. 11½d. three months. Hematite was stronger, with sellers at 63s. 6d. cash and 63s. 9d. one month. On Monday morning activity again prevailed, but Cleveland warrants were easier. The turnover consisted of 11,000 tons at 48s. 0½d., 48s. 1½d., and 48s. 0½d. cash, 48s. 5d., 48s. 4½d., and 48s. 5d. one month, and from 49s. to 48s. 11½d. three months, and the closing prices were 48s. 0½d. cash, 48s. 4d. one month, and 48s. 11½d. three months sellers. Hematite was quoted at 63s. 4½d. cash and 63s. 9d. one month sellers. In the afternoon the market was quiet, and easier, and 3000 tons of Cleveland warrants were done at 48s. 0½d. cash, 48s. 10d. February 29, and from 48s. 11½d. to 48s. 10½d. three months. At the close sellers quoted 48s. cash, 48s. 3½d. one month, and 48s. 10d. three months. On Tuesday morning Cleveland warrants continued on the downward grade, and the business totalled 6500 tons at from 47s. 10d. to 47s. 10½d. to 47s. 10d. cash, 48s. 1d. one month, and 48s. 9d. three months. Closing quotations were 47s. 10d. cash, 48s. 1d. one month, and 48s. 8½d. three months sellers. In the afternoon the market was fractionally easier for Cleveland warrants, and 5500 tons were done at 47s. 9d. cash, 48s. and 48s. 0½d. one month, and 48s. 8d. three months sellers; closing prices were called at 47s. 9½d. cash, 48s. 0½d. one month, and 48s. 8d. three months. One month hematite was quoted at 63s. 6d. sellers. When the market opened to-day (Wednesday) the tone was quiet, and the business did not exceed 3000 tons of Cleveland warrants at 47s. 8d. and 47s. 7½d. cash, 47s. 11d. one month, and 48s. 6d. three months. At the close sellers quoted 47s. 8d. cash, 47s. 11d. one month, and 48s. 6½d. three months. In the afternoon the market was quietly steady, and Cleveland warrants were put through at 47s. 8d. cash and 47s. 11d. one month. The turnover was 3500 tons, and closing sellers' quotations were 47s. 8d. cash, 47s. 11½d. one month, and 48s. 6½d. three months. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 62s. 6d.; Gartsherrie and Summerlee, 63s.; Langloan, 63s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 65s.; Shotts (at Leith), 63s.; and Carron (at Grangemouth), 64s.

Sulphate of Ammonia.—The demand for sulphate of ammonia is perhaps not quite so pressing at the present moment, but, nevertheless, the amount being shipped continues on a fairly large scale. The current quotation is 14*l.* 5s. per ton for prompt lots, Glasgow or Leith, and the exports from Leith Harbour last week totalled 251 tons.

Scotch Steel Trade.—The Scotch steel works turning out heavy material continue very busy, and in most of the establishments the specifications are sufficient to keep the plant running full. New business, however, is rather slow, but order-books are at present so well filled that steady employment is assured for some months to come. With regard to new contracts it is said that buyers are holding back their orders, and also that material amounting to a considerable tonnage has recently been bought from firms in England outside the associations. Prices all round are very firm, and an official advance is probable in the near future. The export trade is good, and a healthy demand exists for angles, plates, and general sections for Australia, Japan, and South America. For black sheets the demand is reported to be greater than ever, and early delivery of new orders is quite out of the question.

Malleable-Iron Trade.—The malleable-iron makers in the West of Scotland continue to be well employed, and specifications are fairly plentiful. The main trouble at present is the low price going for crown bars, and although raw material has risen, the basis price is no better than from 6*l.* to 6*l.* 2s. 6d. per ton, and the latter figure is only secured with difficulty.

Scotch Pig-Iron Trade.—The Scotch pig-iron trade has been rather more active of late, and considerable buying has been done, both locally and on the part of consumers in the South. Another feature at the moment is the desire to book forward requirements, and even at the advanced prices demanded by sellers a fair business has been put through. The export inquiry is also good. Hematite is in better demand, and prices are firmer. Dealing has been reported at 66s. 6d. per ton, with sellers firm round that figure.

Scotch Shipbuilding.—With the announcement of the shipbuilding returns for November speculation as to what will be the ultimate figures for the full year always takes place, and on this occasion the position is indeed interesting. Since the commencement of this year considerable activity has prevailed, and more especially on the Clyde, where order-books have been very full, and about the only trouble has been the scarcity of suitable labour. That trouble still exists in the lower reaches, with little prospect of improving. The output for the different districts for the month of November was as follows:—

	Vessels.	Tons.
The Clyde	26	44,389
The Forth	1	450
The Dee	4	750
Total	31	45,589

The Clyde total given above brings up the output for the year to date to 535,793 tons, which, although not a record, has only once been bettered, and that was for the corresponding eleven months of 1906, when the total amounted to 550,878 tons. The prospects of a new record tonnage being established this year are very good, as the total to date is only 84,126 tons behind the record year of 1907, when the figure was 619,919 tons. The difference may seem too large to make up in one month, but several launches have still to be reported, and the final total will include a number of vessels built here and then taken down and shipped abroad. Several new contracts have recently been booked. Messrs. Caird and Co., Greenock, have contracted to build and engine a twin-screw steamer of 11,000 tons for the Peninsular and Oriental Steam Navigation Company.—Messrs. Alex. Stephen and Sons, Linthouse, have secured the order to build two new steamers for the Royal Holland Lloyd Company. These vessels will be 560 ft. in length, 66 ft. in breadth, 49 ft. in depth, and of 14,000 tons gross. The builders will supply engines of 11,000 indicated horse-power, to give a speed of 17 knots. They are for the company's South American trade, and the style and get-up of the passenger accommodation will leave little to be desired.—Messrs. Dunlop, Bremner, and Co., Limited, Port Glasgow, have received an order from Messrs. Thos. Wilson, Sons, and Co., Limited, Hull, for a steamer of 3800 tons for the Baltic trade.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

A Book on Steel.—A book which should prove of immeasurable value to manufacturers, and, in fact, all those engaged in the making of steel, and thus of particular interest to Sheffield, is "The Heat-Treatment of Tool Steel," by Mr. Harry Brearley, just published. It deals scientifically, but without the excessive use of technical terms, with the structure and classification of steel, and processes in the production of tool steel, with special attention to the use of pyrometers. This scientific side of steel-making is one which has received a great impetus in Sheffield during the last few years, largely owing to the highly important work done by the Applied Science Department of the University. The knowledge and capability of the Sheffield workman gained in generations of practical experience, which were inclined to make him hostile to the introduction of scientific methods, have proved, once he has been converted, of the highest value. The co-ordination of the instinct for the right method, with scientific accuracy, is undoubtedly a very important factor in the pre-eminence enjoyed by Sheffield's manufactured steel products.

Universities and Industry.—At a complimentary dinner given to Professor McWilliam, of the Sheffield University, who has just been appointed head metallurgical adviser to the Indian Government, Sir Robert Hadfield referred to the great part metallurgists had played in modern progress. Without such universities as Leeds, Manchester, and Sheffield, which recognised a wider need with regard to technical science, he asked where England would be to-day. It was impossible for us to continue competing with other nations without such universities. Technical science was becoming more complex, which meant more aid from the universities.

Professor F. W. Hardwick.—An honour has been paid to Sheffield and to Sheffield's University by the appointment of Mr. Francis William Hardwick, M.A., Professor of Mining in the Applied Science Department, as President of the Midland Institute of Mining, Civil, and Mechanical Engineers. Mr. Hardwick, who came to Sheffield University in 1891, has had experience in Spain and Canada, and he has done much for the development of the scientific study of mining both in Yorkshire and Derbyshire. He is an Associate Member of the Institution of Civil Engineers, and a member of the American Institute of Mining Engineers.

South Yorkshire Coal Trade.—The position in the steam-coal market has been steady for the past few days. Shipments are of about the usual quantity for the time of the year, but there is a very good inquiry for industrial consumption, and collieries hold practically no stocks. Consequently official prices have been maintained. As regards railway contracts, it is believed that coal-owners will hold out for advances of over 1s. Consumers are still stocking gas-coal, and there is a very big output of this class of fuel. Slacks are strongly held, and for contract renewals collieries are able to obtain small advances. Coke is in good request. Although house coal does not improve very quickly, there is a stirring in the market, and orders have been more frequent of late. It is anticipated, however, that collieries will get rid of a good deal of their stock within the next week or so, as merchants will be preparing in the event of a sudden demand which may come with a declaration of the result of the railwaymen's ballot. Wagons are still scarce. The quotations on the Sheffield Exchange last week-end were:—Best hand-picked branch, 14s. 6d. to 15s. 6d.; Barnsley best Silkstone, 12s. to 13s.; Silkstone, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. to 11s.; Derbyshire large nuts, 9s. to 10s.; small nuts, 6s. to 7s. 6d.; Yorkshire hards, 9s. 3d. to 10s. 3d; Derbyshire hards, 7s. 9d. to 8s. 9d.; washed nuts, 8s. to 9s.; rough slacks, 5s. 6d. to 7s. 6d.; seconds, 4s. 6d. to 5s. 6d.; and smalls, 2s. to 3s.

Iron and Steel.—The iron trade has shown further improvement during the week. Both hematites and common irons have been bought in considerably larger quantities, and prices all round have an upward tendency. A quantity of West Coast hematite has been taken by German merchants. The Lincolnshire makers, whilst still retaining the official figures for forge and foundry sorts, are asking premiums varying between 1s. and 2s. There is a good demand for the outputs of the Derbyshire producers. At their meeting on Monday the South Yorkshire Bar-Iron Association decided to advance prices a further 5s., so that the official quotation is now 7*l.* 5s. This is eloquent testimony to the improvement in the bar trade, which has brought welcome activity at all the mills. Prosperity in armaments is being well maintained. Further home orders have been received for battleship machinery, and it is reported that orders have come to Sheffield for shells. In all the departments of the local trades there is a constant stream of orders, some of them, it is true, not of much individual importance, but aggregating an imposing total, and sufficing to keep all the steel firms thoroughly well occupied. In this direction the brisk demand for special steels is noticeable, particularly the foreign and colonial inquiry for mining and drill steels. Further evidence of trade prosperity is afforded by the building of new Siemens-Martin furnaces at some of the large East-End works. The file manufacturers, and tool-makers generally, are fully employed, and there are several instances of extensions to plant having to be made. The making of special parts for motor-cars is proving to be an important minor branch of local industrial activity, and the demand for these special steels and forgings is growing steadily. There are still indications of the strike fear in the extra precautions being taken by manufacturers to safeguard themselves.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—A downward movement in warrants, due, it is said, to holders selling out and taking their profits, has caused values of Cleveland pig to ease, but the general tone of the market is still cheerful, and a fair amount of business is going on. Makers' iron is not being pressed on the market. The statistical situation is very satisfactory, and promises to improve, for present production does not fully meet requirements, with the result that, to satisfy needs, stocks have to be drawn upon. The quantity of Cleveland pig in the public warrant stores is now little over 550,000 tons, and it has so far this month been reduced at the rate of some 800 tons per working day. Several sales have this week been recorded at 48s. 3d. for early f.o.b. delivery of No. 3 g.m.b. Cleveland pig; but business has also been done at 48s., which is now the recognised market rate. No. 1 is 51s. 9d. to 52s.; No. 4 foundry, 47s. 6d.; No. 4 forge, 47s. 3d.; mottled and white iron, each 47s.; and mixed numbers of East Coast hematite pig, 62s. 6d., all for early delivery. There is very little hematite to be obtained for this year, and for forward delivery makers, all of whom are much better placed than they were a little while ago, are inclined to hold out for higher rates. Foreign ore is very stiff. Sellers, having made very large contracts, are not at all keen to make further sales at present. They ask 21s 6d. to 22s. ex-ship Tees for best Rubio, and other ores are in the usual proportion. Coke is in good demand for local use, and values are moving upward. Very little furnace coke is to be had for early delivery, and business over the first half of next year cannot well be done under 16s. 6d. for average sorts.

Manufactured Iron and Steel.—All departments of the manufactured iron and steel trades are fully employed, and producers generally have contracts made which will keep them very busy for many months. Principal market quotations stand:—Common iron bars 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; steel ship-plates, 6*l.* 15s.; steel ship-angles, 6*l.* 7s. 6d.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and galvanised corrugated sheets, 11*l.* 5s.—sheets less 4 per cent. f.o.b., railway material net, and all other descriptions less 2½ per cent.

Shipments of Iron and Steel.—Shipments for the eleventh month of the year came quite up to expectations. Those of pig iron averaged 4258 tons per working day, the total despatches reaching 110,717 tons, 101,159 tons of which went from Middlesbrough, and 9558 tons from Skinningrove. The total loadings of pig for the previous month reached 115,003 tons, or a daily average of 4423 tons, and the clearances during November, last year, were returned at 106,858 tons, or an average of 4110 tons per working day. Of the pig sent from Skinningrove during last month, 9049 tons went to Scotland, and 509 tons to Temeuzen. Of the pig loaded at Middlesbrough during November, 70,485 tons went abroad, and 30,674 tons to coastwise customers. Scotland was, as usual, the largest receiver, taking 20,276 tons, whilst Japan imported 15,983 tons; France, 8390 tons; Italy, 7586 tons; Belgium, 7497 tons; Germany, at one time the largest customer, 6383 tons; Sweden, 6045 tons; and Denmark, 4728 tons. Of the 11,693 tons of manufactured iron dispatched during November, 4882 tons went to foreign ports, and 6811 tons coastwise; India, with an import of 3385 tons, being the largest buyer. Steel shipped during the month reached 50,980 tons, 44,094 tons of which went abroad and 6886 tons coastwise. India was also the largest receiver of steel, importing 11,155 tons. Other good customers of steel were the Argentine, 7040 tons; Victoria, 5594 tons; Canada, 4669 tons; and Japan, 3767 tons.

Colossal Casting.—One of the largest castings ever manufactured on Tees-side was made this week at the works of Messrs. Richardsons, Westgarth, and Co., Limited, Middlesbrough — namely, the main frame and bed-plate in one piece for the largest set of gas-blowing engines which they are building for the Cargo Fleet Iron Company, Limited. The casting weighs about 42 tons. The operation was most successfully managed, and great credit is due to Mr. Buchanan, the foreman. There are already seven large gas-blowing engines built by Messrs. Richardsons, Westgarth, and Co., Limited, in operation at the Cargo Fleet Iron Works, but the engine now in course of construction is about twice the size of the existing engines, and is also of the very latest design, embodying all the most recent improvements.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade is considered to be growing stronger, consumers of coal pressing for supplies with prompt delivery. Statements have been current as to further Italian Government purchases of steam coal, but these reports require confirmation. All descriptions of large steam-coal have been harder. Monmouthshire coal has also shown an upward tendency. The best Admiralty large steam-coal has made 17s 3d. to 17s. 6d. per ton; secondary qualities have ranged between 15s. and 17s.; best ordinary bunker smalls between 7s. 9d. and 8s. 3d.; and cargo smalls between 6s. and 7s. per ton. House-coal has shown firmness, but prices have exhibited little change; the best ordinary qualities have made 15s. 6d. to 16s. 6d.; No. 3 Rhondda large, 17s. to 17s. 6d.; and smalls, 9s. 9d. to 10s. per ton. No. 2 Rhondda large has brought 12s. 9d. to 13s.; and smalls 6s. 3d. to 6s. 9d. per ton. Foundry coke has been quoted at 17s. 6d. to 20s.; and furnace ditto at 15s. 6d. to 16s. 6d. per ton. As regards iron ore, Rubio has made 20s. to 20s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Coal-Seams Worked Out.—The Ely Rhondda Coal Company, Limited, has reluctantly decided to close down its Dinas Isaf Colliery. The colliery, which is situated half way between Penygraig and Trebanog, gave employment to between 90 and 100 men; and although the seams are almost completely worked out, the output has been about 100 tons per day.

Great Western Rolling-Stock.—Orders for 3000 new wagons, with a stipulation for early delivery, have recently been placed by the Great Western Railway Company. There has also been an increased turn-out of new stock from the company's own works at Swindon.

Mr. H. J. Taplin.—Mr. H. J. Taplin, son of Mr. C. Taplin, Post Office telegraphs engineer, Newport, has died, at the age of forty-eight, in Johannesburg General Hospital. He joined the service of the Cape Telegraphs in 1882, and assisted in the construction of the Warrenton and Mafeking line, afterwards serving in Sir Charles Warren's expedition. He became chief constructional engineer to the late Transvaal Government, and under his supervision most of the main lines of telegraphs from Pretoria to Johannesburg were constructed.

Dowlais.—The works have been fairly busy, and the production of the mills has been slightly above the average. The Goat Mill is still engaged upon steel sleepers, tin-bar, and steel rails, while the Big Mill has had a good turn-out of light-weight colliery material, such as angles, curves, tram-rails, &c.; some deliveries of fish-plates have also been made. It is reported that the Dowlais Works have obtained an order for 12,000 tons of steel rails from the London and South-Western Railway Company.

TRAILING SUCTION-CUTTER HOPPER DREDGER.—Messrs. William Simons and Co., Limited, Renfrew, launched, on October 26, complete with all machinery on board, a Simons twin-screw trailing suction-cutter hopper dredger built to the order of the High Commissioner for New Zealand, for the Lyttelton Harbour Board. This vessel is fitted with suction and self-discharging pumps capable of raising and discharging 2000 tons of material per hour. The main centrifugal pumps are connected to the suction frame fitted in the central well at stern, and powerful water-jets are arranged on the nozzle at the bottom of the suction frame, for dealing with soft material. When it is proposed to deal with harder material the nozzle is substituted by a spiral rotary cutter driven through a line of shafting, fitted on the upper side of the suction frame, and machine-cut steel gearing actuated by a set of powerful independent compound engines. The vessel was designed under the direction of Mr. Cyrus J. Williams, engineer-in-chief to the Lyttelton Harbour Board, the construction being carried out under the direction of Messrs. Carruthers and Elliot, consulting engineers, London.

TRIPLE-EXPANSION ENGINES OF THE CANADIAN PACIFIC RAILWAY COMPANY'S T.-S.S. "PRINCESS ALICE."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(*For Description, see Page* 764.)

Fig. 5.

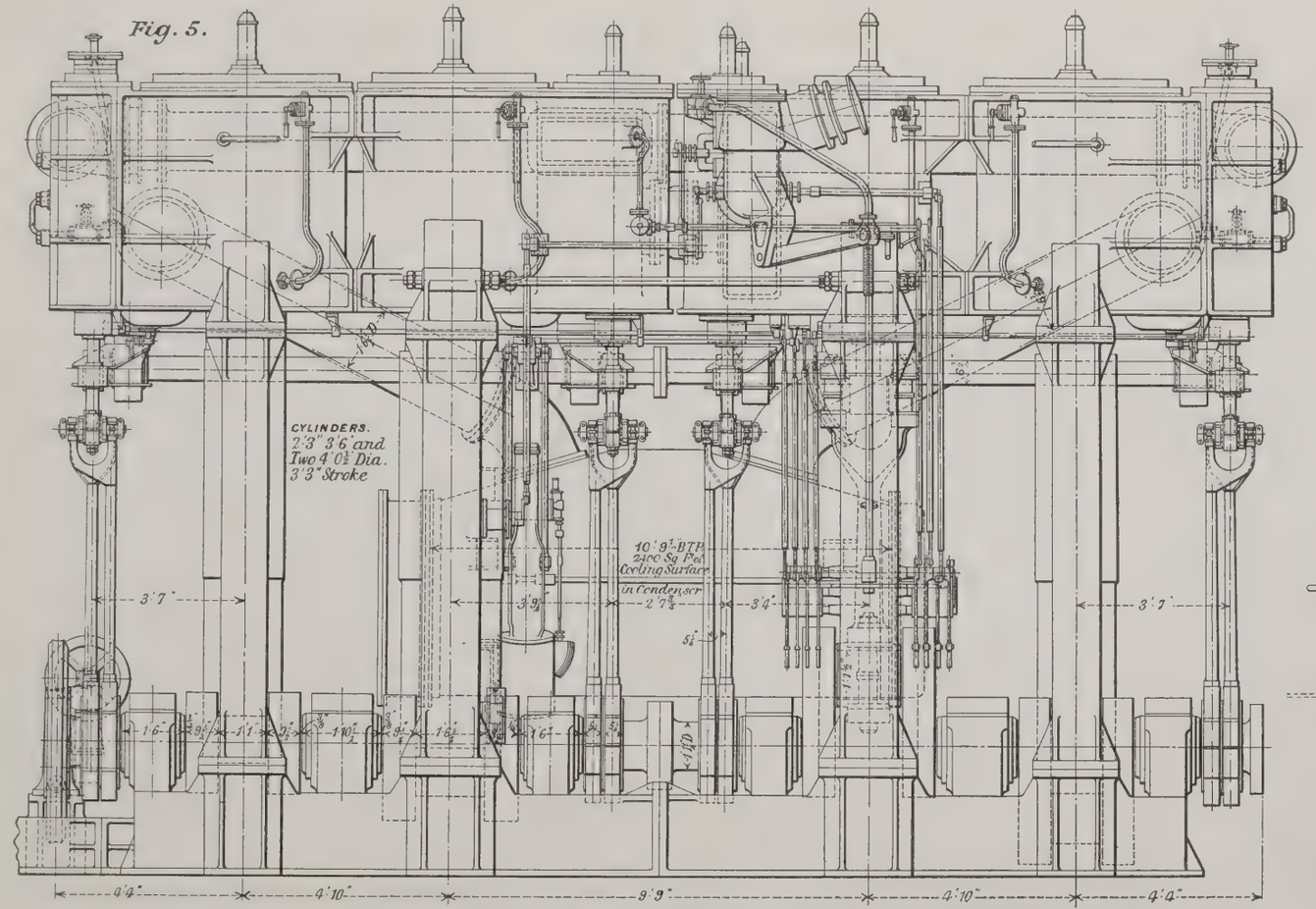
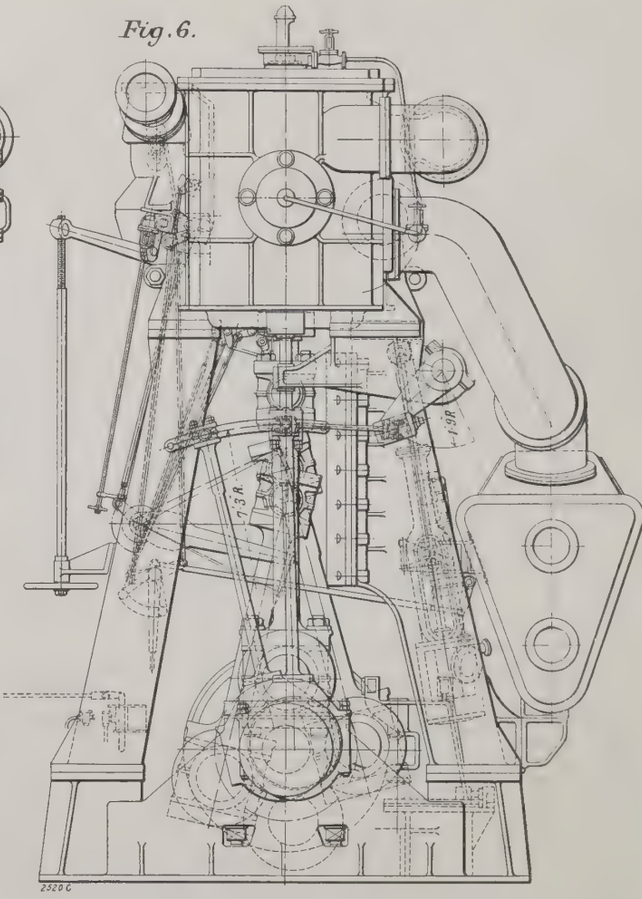


Fig. 6.



MOTOR FIRE-ENGINES. — Amongst the recent purchasers of self-propelled fire-engines may be mentioned the suburbs and towns of Tottenham, Finchley, Harrow, Willesden, Bromley, Chislehurst, Dartford, Merton, Heston, Isleworth, Penge, and Mitcham, who have selected the Merryweather petrol-driven motor fire-engine with "Hatfield" reciprocating pump.

SCIENTIFIC MANAGEMENT.—A trial, extending over some three years, has been made with what has come to be known as "Scientific Management," at the Watertown Arsenal of the United States War Department, and a recent report by Brigadier-General William Crozier states that the results have been highly gratifying and full of promise. The methods which have been tried are those which have been associated with the name of Mr. F. W. Taylor, and with one aspect of which we dealt in a recent article on "Motion Study." Although the results are so far satisfactory, the matter is still considered to be in an experimental stage, and further trials are to be made at Watertown before any attempt is to be made to apply the system at other United States arsenals.

CHANGES IN AGRICULTURE AND PRICES IN THE LAST TWENTY YEARS.—A comparison of the condition of British agriculture in the first decade of the present century and the last decade of the nineteenth century, together with a comparison of prices and supplies, is made in the reports to the Board of Agriculture and Fisheries accompanying Parts I., II., and III. of the Agricultural Statistics for 1910. The figures show a reduction in the cultivated area of about half a million acres in twenty years, a loss of about 1½ million acres of arable land as against an increase of one million acres under grass. The area of land devoted to the cultivation of fruit has increased to a noteworthy extent, the area of potatoes slightly, but the area under corn has been considerably reduced. The average of the crops during 1901-1910 was a good deal above the average of 1891-1900. Whilst the number of cattle increased, in relation to the increase of population the result was a serious decline. The same may be said about sheep. The value of nearly all British farm produce appears to have been greater in the first decade of the twentieth than in the last decade of the nineteenth century. The home production of wheat represents about 20 per cent. of the whole supply.

LAUNCH OF A JAPANESE CRUISER.—On October 3 the launch of the cruiser Yahagi took place from the Mitsu Bishi Yard at Nagasaki, and in spite of unfavourable weather everything passed off most successfully according to programme. The Yahagi is a protected cruiser, second-class, very similar in tonnage and speed to the British cruiser Newcastle, which is now visiting Japan. Her dimensions are as follows:—

Length	475 ft.
Breadth	46.6 ,,
Depth	28.6 ,,
Draught	16.7 ,,
Displacement	5000 tons
Horse-power	25,000
Speed	26 knots

The engines are Parsons steam-turbines. The keel of the vessel was laid on April 6, 1910, so that she was eighteen months on the stocks. Boilers, engines, and funnels were placed in position before the launch, so that it should not belong before she is ready for commission. Two sister-ships, the Chikuma and the Hirado, have already been launched at Sasebo and Kawasaki respectively. In replying to the toast of the Imperial Navy, Baron Saito eulogised the work of the Mitsu Bishi Dockyard, and proposed success to the company. The works have a very interesting history, being founded by the "Shogun" Government in 1856. Dutch engineers were employed, and the necessary machines and gear for commencing the works were imported from Holland. At the Restoration the works came under the control of the Public Works Department, and in 1871 No. 1 Dock was constructed. In 1884, on the abolition of the Public Works Department, the establishment and the various subsidiary works connected with it were purchased by the Mitsu Bishi Company, and additions have since been constantly made, and every department is now very complete. A recent addition is a ship model experimental tank, the design and arrangement of which were entirely placed in the hands of Dr. Archibald Denny, Dumbarton. It is practically a reproduction of the tank belonging to his firm, with the improvements evolved from experience since the construction of that tank. The Japanese are not content to become acquainted with merely practical construction, and miss no opportunity of investigating the conditions which arise in the construction of any new ship they are required to build.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" can be supplied direct from the Publisher post free, for twelve months, at the following rates, payable in advance:—

For the United Kingdom	£1	9	2
For Canada—			
Thin paper copies	£1	11	6 ($7.65)
Thick ,,	£1	16	0 ($8.75)
For all other places abroad—			
Thin paper copies	£1	16	0
Thick ,,	£2	0	6

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

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We desire to call the attention of our readers to the fact that the above is our SOLE Address, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS—"ENGINEERING," LONDON.
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With Four One-Page Plates of the BELFAST MUNICIPAL TECHNICAL INSTITUTE.

NOTICES OF MEETINGS.

THE BRITISH FOUNDRYMEN'S ASSOCIATION: LONDON AND DISTRICT BRANCH.—Friday, December 8, at 8 p.m., at Cannon-street Hotel, when a lecture will be given by Professor Thomas Turner, M.Sc., A.R.S.M., F.I.C., of the University, Birmingham, entitled "The Solidification of an Iron Casting in the Mould" (illustrated by lantern-slides).

THE BRITISH FOUNDRYMEN'S ASSOCIATION: BIRMINGHAM BRANCH.—Saturday, the 9th inst., at 7 p.m., at the Technical School, Suffolk-street, Birmingham, the following foundry difficulties will be discussed:—(1) Cavities, shots, and blow-holes in iron castings. (Useful information on the above will be found in the *Foundry Trades Journal*, June, 1911, page 337.) (2) Drop-bottom *versus* solid-bottom cupolas. (3) The best metal and design for annealing pans. Other questions may be introduced if time permits.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, December 9, at 2 p.m., in the Wood Memorial Hall, Newcastle-upon-Tyne. The following papers will be open for discussion:—"The Advantages of Freezing as a Method of Sinking through Heavily-Watered or Difficult Ground," by Mr. William Brumwell Wilson. "Experiments on Liquid Mixtures for Laying Coal-Dust," by Professor W. M. Thornton, D.Sc., D.Eng. "The Holmes-Ralph Gas-Detecting Portable Electric Lamp," by Mr. George J. Ralph. "The Microscopical Examination of Coal, and its Use in Determining the Inflammable Constituents Present Therein," by Mr. James Lomax.

THE ROYAL SOCIETY OF ARTS.—Monday, December 11, at 8 p.m. Cantor Lecture. "The Carbonisation of Coal," by Professor Vivian B. Lewes. Lecture III.—"The Thermal Conditions Existing During the Carbonisation of Coal." Wednesday, December 13, at 8 p.m. "Continuous Service in Passenger Transportation," by Mr. W. Yorath Lewis, M. Am. Soc. M.E., A.M.I. Mech. E., A.M.I.E.E. Thursday, December 14, at 4.30 p.m. Indian Section. "The Fisheries of Bengal," by Mr. J. Travis Jenkins, D.Sc., Ph.D., Superintendent of the Lancashire and Western Sea Fisheries. Sir Steuart Colvin Bayley, G.C.S.I., C.I.E., Vice-President of the Society, will preside.

THE SURVEYORS' INSTITUTION.—Monday, December 11, at 5 p.m. A paper will be read by Mr. W. A. Haviland, entitled "The Burden of Upkeep on Rural Estates, and its Relief under Section 69 of the Finance Act, 1910."

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (METROPOLITAN CENTRE).—Monday, December 11, at 6 p.m., at the Institution of Electrical Engineers. "Distribution by Means of Parallel Cables," by Mr. E. A. Pink.

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—Monday, December 11, at 8 p.m. A paper entitled "The Printing Press and Kindred Machines" will be read by Mr. R. H. Briggs, Graduate, of London. Chairman: Mr. L. A. Legros, M.I. Mech. E.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 12, at 8 p.m. Paper to be read:—"Experiments on the Strength and Fatigue Properties of Welded Joints in Iron and Steel," by Mr. Thomas Ernest Stanton, D.Sc., M. Inst. C.E., and Mr. John Robert Pannell. Students' meeting, Friday, December 15, at 8 p.m. Paper to be read:—"Tests on Reinforced Concrete," by Mr. E. F. Hunt, B.E., Stud. Inst. C.E. Mr. John J. Webster, M. Inst. C.E., will occupy the chair.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, December 13, at 8 p.m., at St. Bride's Institute. A paper will be read by Mr. George Wilkinson, M.I.E.E., M.I. Mech. E., and Mr. J. Rendell Wilkinson, B.Sc. (Lond.), on "Methods of Dealing with Losses in Steam Plant Due to Condensation." Mr. Frank Bailey, M. Inst. C.E., will occupy the chair.

THE INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, December 13, at 7.30 p.m., in Room 167, Technical School, Suffolk-street. Paper on "Automatic Starting of Asynchronous Motors," by Mr. N. Pensabene-Perez, Associate Member, and a paper entitled "Some Notes on the Circle Diagram," by Mr. T. F. Wall, M.Sc., Associate Member. To be followed by an oscillograph demonstration of above starting apparatus, and a demonstration by Dr. Kapp of a magnetic apparatus for testing the endurance of metals under often-repeated stresses.

THE MINING INSTITUTE OF SCOTLAND.—Wednesday, December 13, at 5.30 p.m., at the Institute, 39, Elmbank-crescent, Glasgow. The following papers will be discussed:—"An Outburst of Coal and Gas at Valleyfield," by Mr. Henry Rowan. "Wire Ropes as Applied to Mining," by Mr. Dugald Baird. "The Microscopical Examination of Coal, and its Use in Determining the Inflammable Constituents Present Therein," by Mr. James Lomax. Paper to be read, illustrated by lantern views:—"Description of an Aerial Ropeway from the Shale Mines to the Oil Works at Oakbank, Mid-Calder," by Mr. James B. Sneddon. Mr. John Paul will describe "Overwinding Prevention Gear for Colliery Winding-Engines, Fitted on the Mary Pit of the Lochgelly Iron and Coal Company, Limited."

THE JUNIOR INSTITUTION OF ENGINEERS.—Wednesday, December 13 at 8 p.m., at the Institution of Electrical Engineers, Victoria Embankment. Lecture on "Steel Specifications Considered Commercially," by Major H. B. Strange, R.A. (ret.), of Sheffield.

THE CONCRETE INSTITUTE.—Thursday, December 14, at 8 p.m., at Denison House, 296, Vauxhall Bridge-road, Westminster, S.W., Mr. G. C. Workman, M.S.E., will read a paper entitled "Some Recent Works in Reinforced Concrete."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, Dec. 14, at 8 p.m. "Residence Tariffs," by Mr. A. E. Seabrook, member.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 15, at 8 p.m., in the meeting hall of the Institution, discussion upon "Double-Cutting and High-Speed Planing Machines," by Mr. J. Hartley Wicksteed, Past-President, of Leeds. Paper to be read and discussed (if time permits): "Oil-Burning Locomotives on the Tehuantepec National Railway, Mexico," by Mr. R. Godfrey Aston, Graduate, of Mexico.

ENGINEERING.

FRIDAY, DECEMBER 8, 1911.

THE QUEBEC BRIDGE.

IN a series of articles recently contributed to the *Engineering News*, Mr. Gustav Lindenthal, the well-known bridge engineer, sets forth a highly interesting and detailed criticism of the design of the late Quebec Bridge, and of the scheme which has been accepted by the Canadian Government to replace the wrecked structure. Mr. Lindenthal is particularly well qualified for such a task, as he is thoroughly conversant with the whole of the circumstances, and we find no little satisfaction in noting that on many points his judgment, written after a very careful and prolonged study of the subject, coincides with the views expressed in our columns immediately after the disaster, and before many of the particulars since published were available.

One point on which he rightly lays great emphasis is the absurdly small sum which the promoters of the original project were prepared to pay for engineering advice. The fee paid to Mr. Cooper was fixed at about 760*l.* per annum, a ridiculously inadequate amount. Had a reasonable fee been paid, a larger staff would have been employed, the weights, Mr. Lindenthal points out, would probably have been thoroughly checked in the consulting engineer's office, and the serious underestimate of the dead load detected before the work of construction had been begun. This view is probably correct, but since the consulting engineer passed the defective design of strut, it is at least possible, it seems to us, that the payment of an adequate fee might actually have led to a disaster still more serious than that which actually occurred. Had these weights been more closely estimated, it is conceivable that the bridge might have survived completion, to fail ultimately when crowded with traffic. Inadequate provision for engineering expenses is a fair excuse for the underestimate of weight, but little or none for the adoption of such an unmechanical design of compression members. Writing immediately after the accident, we drew attention to the utterly bad design of these, but some American bridge engineers objected to our criticisms. Nevertheless, Mr. Lindenthal holds quite as strong views on the subject as any expressed by us, and he also supports the contention we made at the time—that the excuse made by some American engineers to the effect that sufficient data did not exist for the satisfactory design of large compression members, was ridiculous. This absurd plea received some countenance from the Commission of Inquiry. As Mr. Lindenthal points out, because two columns have the same ratio of length to radius of gyration, it by no means follows that they will carry the same stress. This is a frequent error with computers, and he quotes the case of the failure of the steel columns supporting a gas-holder at Hamburg (see ENGINEERING, vol. xci., page 858) as another instance of the tendency of computers to rely too exclusively on formulæ. He shows that by rearranging the metal of the Quebec Bridge chord members the strength, with the same area of cross-section and the same radius of gyration, could have been very nearly doubled.

In one other point his views are again in accord with those expressed by us at the time of the accident. We then pointed out that bridge failures were almost invariably due to weakness in the struts. Mr. Lindenthal confirms this by stating that no failure due to weakness of the eye-bars of a bridge is on record. A small eccentricity in the loading of compression members spells failure, whilst no particular harm results from the eccentric loading of a tie. Curiously enough, however, American text-books have in the past insisted strongly upon the necessity of avoiding eccentric loading in the case of tension members, but have hardly touched on the supreme importance of such considerations in the case of struts. Thus in one very well-known American text-book the author works out (inaccurately, it may be said, but at great length) the increase of stress in an eye-bar due to its own weight. The result reached is wholly erroneous, but the matter is practically unimportant any way, while it is, as stated, enlarged on at considerable length, whereas the really important effect of eccentricity on the safety of compression members is wholly neglected.

The sole satisfactory feature in the whole of the business connected with the Quebec Bridge has been the report of the Commission of Inquiry into its failure. As Mr. Lindenthal remarks, this Commission would have been excellently qualified to have drawn up general regulations and specifications for the new structure, but the Canadian Government appointed instead a committee of three engineers, who lived thousands of miles apart, and who had to work under such unsatisfactory conditions that the English member resigned. In the name of this Board an official design was issued which represented 2½ years' work, and is said to have cost about 100,000*l.* The general specifications when issued appeared to have been drawn up with a view to preventing the proposal of any satisfactory alternative design, although competitors were, *in words*, invited to submit such. Only

4½ months was, however, allowed for the preparation of these, and apparently to make the acceptance of the official design doubly sure, the contract for its foundations was let forthwith. In spite of this apparent determination to secure the selection of the official design against all alternatives, those fathering it were not prepared to take the responsibility for its adequacy, since the contractor was required to assume "the entire responsibility not only for the materials and construction of the bridge, but also for the design, calculations, plans, specifications, and for the sufficiency of the bridge for the loads therein specified." We commented on this extraordinary provision when the specifications were published, and, as Mr. Lindenthal well remarks, "One may wonder why, under such conditions, the Board should consist of engineers at all."

Perhaps the most interesting part of Mr. Lindenthal's paper is a remarkable comparison he makes between the Forth Bridge, the bridge which failed, and the new cantilever bridge now in course of construction.

He finds that if the bridge had been designed on the same lines as the Forth Bridge, but to take the floor load of 8000 lb. per lineal foot, which was that adopted for the design that failed, the average stress on the metal would have been about 18,700 lb. per sq. in., and the total weight 34,000 lb. per foot-run. In the design which collapsed the amount of steel used for the main members was the same as in the Forth Bridge design, as above modified, but the average stress on a weaker steel and on badly designed struts was 21,700 lb. Mr. Lindenthal concludes that had portions of the collapsed bridge been of nickel steel, correctly dimensioned, the compression members of rational form, and the bridge of somewhat greater width, it would have been possible to have built a satisfactory bridge for the same total weight of metal as was actually employed. Coming to the Board's design, on which tenders were called for, Mr. Lindenthal's analysis shows that a structure on the lines of the Forth Bridge, to carry the same loads as the official design, would have taken 24,000 lb. of nickel steel per lineal foot, and 14,000 lb. of ordinary mild steel. The corresponding figures for the official design were 35,700 lb. per lineal foot of nickel steel, and 14,600 lb. of ordinary carbon steel. The difference, which on the whole structure amounts to about 16,000 tons (all of high-priced nickel steel), is due, he states, in part to the low height of the towers, and in part to the inferior design of the web system. No reason has so far been vouchsafed for the low towers adopted in the official design. In the case of small span structures a somewhat low ratio of height to span has some advantages, as the consequent increase in the quantity of metal needed may often be more than compensated for by the increased durability of the bridge under heavy rolling loads, but no such considerations could apply to a structure of about 1800 ft. span. The specification of such low towers tended to bar out any effective competition from designs for stiffened suspension structures, since the greater the ratio of span to dip the greater the distortions due to temperature changes and to the live load. At the same time, of course, the weight of the cables is also increased when the dip is a small fraction of the span.

Mr. Lindenthal gives in his articles pretty complete general particulars of a stiffened suspension design for Quebec which he worked out last year. The estimated weight and cost of this bridge proved to be considerably less than that of the official design. Since compression members are the weak points in all bridges, there is, he points out, an advantage in avoiding them as far as possible. Of course, their use cannot be dispensed with in the stiffening system, but a failure there merely means a temporary inconvenience, whilst in a truss or cantilever bridge it commonly results in the collapse of the structure. Struts, he states, often broke in the stiffening girders of the old Niagara bridge, and were invariably easily repaired without stopping the traffic. The bridge he proposed was designed to meet the conditions imposed by the Board's specifications, and does not, therefore, represent the best that could have been done had designers been accorded a freer hand. The design is of the braced chain type, the links being composed of nickel-steel eyebars which were proportioned for a working stress of 25,000 lb. per sq. in., or one of 27,500 lb. per sq. in., allowing for the bending stresses induced in the bar by its own weight. The braced chains are "hinged" at the centre and abutments, so that the stress is everywhere statically determinate, and the shape of the chains was chosen so that the bracing under the dead-load of the bridge is free from strain. This bracing is of the single diagonal type, each diagonal having, therefore, to take alternately both tension and compression, and this is perhaps the point of design most open to criticism. With riveted connections there is no objection to a reversal of stress, but pin connections necessarily mean loose fits, in which case alternate tension and compression spell hammer action. On a small bridge this might be serious, but the matter is, perhaps, of less importance when the individual member in question weighs 100 tons or so. Moreover, in accordance with the requirements of the specifications, the structure was designed to take impossibly high live loads. Engineers, like the rest of the world, are too often creatures of habit, and because certain train-loadings are specified for spans of 300 ft. to 400 ft., which may be completely covered by a heavy train, apply too often the same specifications to very long spans, where there is no possibility of the bridge ever being loaded from end to end with heavy traffic. Comparing his suspension design with the Board's design, Mr. Lindenthal finds that the former would require 18,300 lb. of nickel steel per foot-run and 29,000 lb. of carbon steel, the corresponding figures for the official scheme being 35,700 lb. of nickel steel per lineal foot and 14,600 lb. of carbon steel. The total weights per lineal foot are not vastly different, mainly because a heavier floor system was provided for in the suspension scheme, but the saving in the high-priced steel is very nearly 50 per cent. An arch bridge, Mr. Lindenthal remarks, would have been still more economical in metal, but the cost of erection might more than offset any saving thus effected.

As is well known, the Board's scheme has been abandoned, the whole of the twenty-four tenders and eight alternative designs submitted having been rejected in favour of a plan proposed by a local company, who, by dispensing with the roadways and footpaths originally proposed, have been able to reduce the weight of the structure to a total of about 29,000 lb. per lineal foot, of which total 17,400 lb. are nickel steel.

METROPOLITAN TRAFFIC.

One of the most valuable of the publications issued by the Board of Trade is the report of the London Traffic Branch, which is drawn up under the direction of Sir Herbert Jekyll. No other city in the United Kingdom enjoys the advantage of an analysis of its traffic conditions prepared by officials at once competent and independent of the favour of local politicians. The report just issued is the fourth since the establishment of the department, the previous one having been published last February, and fully analysed in our columns at the time. That report contained the results of a census of London traffic, the results being, for the first time on record, treated on rational lines. But little real information as to the density of traffic is afforded by merely enumerating the number of vehicles passing certain points. The effective density depends really on two factors, of which the number of vehicles forms one, the other being the comparative degree of obstruction caused by each. As the result of careful observation and comparison, the conclusion arrived at by the Board of Trade was that taking the tram-car as 10 units of obstruction, then a motor-omnibus was equivalent to 3 units, a horsed cab to 2, and a taxi to 1. With this basis of comparison, the density of traffic is estimated by the number of units which pass per minute per 10-ft. width of available carriageway. In the new report, just issued, the results are given of a census taken during the past summer. These show that the volume of road traffic is greater in 1911 than it was twelve months ago, the increase being most marked in the N.W., S.W., and S. divisions. Westminster Bridge carried the greatest number of vehicles—viz., 14,618 in the 12 hours between 8 A.M. and 8 P.M.; but Blackfriars Bridge was a close second with 14,067, and London Bridge third with 13,771. In each case the figures given should be increased by the barrows and cycles which passed, but the relative position of the three is unaltered by including these. In traffic units, however, the density was greatest at the Tower Bridge, where at the hour of maximum traffic the figure amounted to 27.9, as against 27.4 for London Bridge, 22.5 for Waterloo Bridge, and 23.8 for Westminster Bridge. Nearly as high densities were recorded at Commercial-road, E., and at Bow Bridge; whilst at Brentford, on the Kew Bridge-road, and on Chiswick High-road values of 30.9 and 31.2 have been recorded, though the total traffic is not much more than one-third of that over Westminster Bridge.

As the requirements of the future must be largely dependent on the growth of population within the metropolitan area and the district immediately surrounding it, Sir Herbert Jekyll devotes considerable space to an analysis of the recent Census returns. These, for the first time on record, show a decrease of population in the Administrative County of London, where the number recorded was 4,522,961, a reduction of 13,306 on the returns of 1891. On the other hand, the population in the outer ring has increased during the same period by 685,000; and by comparing births and deaths within the county the report shows that most of this appears to be attributable to a migration from the more central districts rather than from the provinces. The total population of Greater London is put at 7,182,843, and the returns show that the habit of travelling is increasing faster than the increase in population.

The journeys by rail, tram, or omnibus averaged 218.5 per head per year, and, moreover, the average length of the trips is increasing. During the last decade, it is stated, the supply of transport facilities was in excess of the demand, and competition was carried to such lengths that commercial profits could not be made. The highest return on the share capital of any of the local railways is 3 per cent. only; and one is unable to meet its fixed charges; "few of the tramways have so far made any real profit;" and the omnibuses are only just commencing to pay. The opinion is expressed in the report that it is doubtful if tramway systems can be extended much further without imposing on them financial strains they are unable to bear. The receipts per car-mile show a tendency to diminish, whilst the cost of working is now just about 6½d. per car-mile, as against earnings of 11¼d. The motor-omnibuses earn about 10½d. per mile run, and the cost of working has been reduced to 8½d., and will, it is anticipated, be still further diminished. With respect to the complaint made by the London County Council that their trams had to pay rates which the motor-omnibus escaped, the report remarks that the petrol tax paid by the omnibuses is equivalent to 0.009d. per seat-mile, whilst the contribution of the trams is 0.008d. per seat-mile, so that the latter are really in a favoured position.

The astonishing growth of the motor-omnibus traffic is illustrated by the fact that a count made in 1910 showed that 162 omnibuses passed Lancaster Gate Station in four hours. In 1911 this figure had increased to 205, carrying 5200 passengers. At certain hours of the day eight omnibuses going East pass Oxford Circus Station per minute. So far, the report remarks, the omnibus competition has hardly affected the tramway receipts, since the routes chosen are for the most part free from trams; but as these become fully developed it is probable that competition may become acute. In this the omnibus will have many advantages, because the number of vehicles can be adjusted to the traffic, in a way impossible with tramcars, since an increase in the numbers has little effect on the speed. With the tramway service, on the other hand, the service cannot be increased beyond certain limits without giving rise to delays at crossings and junctions, which are the more objectionable in that they occur at the very times at which it is most important to maintain a high average speed so as to diminish the congestion of traffic.

The report remarks that the point-to-point speed of motor-omnibuses has of late been increased, although the maximum speed is the same as before. This is due to the fact that the frequency of the service provided diminishes the number and duration of the stops, and the new omnibuses being lighter than the old, can, moreover, be more rapidly accelerated.

On some routes there is already competition between the trams and the omnibuses. On the run from Aldgate Station to Bow Bridge, a distance of 2.7 miles, the motor-omnibuses average 9.53 miles per hour, and the trams 8.74. From Whitechapel High-street to Poplar Station, a distance of 2.6 miles, the trams average 8.35 miles per hour, and the omnibuses 8.83. On the run from Shoreditch Station to Ball's Pond-road (1.3 miles) the omnibus speed is 10.05 miles per hour, and that

of the trams 9.74. From Walworth-road to Camberwell Green (1.4 miles) the omnibuses are run at 10.13 miles per hour, and the trams at 8.16. Another interesting comparison of the relative efficiencies of the two services is afforded by the long-distance competition between Westminster Bridge and Rye-lane, Peckham, a journey of about 3¾ miles. The omnibuses in this case run a different route, and average 8.93 miles per hour over the whole distance, as against 7.87 miles per hour in the case of the trams. The London General Omnibus Company, it is stated, consumes about 30,000 gallons of petrol per day. The tramways are, of course, handicapped by their workmen's car services, every mile of which is run at a loss.

Commenting on the trackless-trolley proposals, the opinion expressed in the report is that the system appears to be most applicable where the promoters are seeking an outlet for surplus electric energy, and where there is a prospect of sufficient traffic being ultimately developed to justify the laying of rails at some subsequent date. In other conditions it is doubtful whether the system offers any advantages over a service of self-propelled vehicles.

Coming to the question of railways the report draws attention to the steady development of the outer suburban area. Some business men, it is stated, live as far out as Oxford. Many come in daily from Southend, a distance of 36 miles, and there is every prospect that this outer suburban area, which, speaking generally, may be taken to extend to a radius of 30 miles from St. Paul's, will develop considerably during the next decade; a development which will be accentuated by a more general adoption of electric traction.

Within the Metropolitan area the electric railways pretty uniformly show an increase of traffic and a diminution of the working ratio. For its length the Bakerloo line carried the heaviest traffic of any, the average traffic between each pair of stations for the second half of 1910 being 154,000 passengers. The Metropolitan and District lines are continuously increasing the facilities they offer to passengers, and the District Company is now engaged in arranging its automatic signalling system, so as to allow of fifty trains per hour being run from Earl's Court to the Mansion House, and this figure, the report states, may be exceeded in the future, though this may involve a widening at Victoria Station.

Great as are the improvements effected and prospective in the railway service, the report expresses the view that road traffic must steadily develop in the future, and that every effort should be made now in the outer suburban areas to lay out new roads so as to accommodate this increase. Already the large retail houses are delivering goods by motor-van to points within a 30-mile radius of London. The Post Office goes further, and has motor services to Birmingham (109 miles), Bristol (120 miles), Ipswich (67 miles), Portsmouth (84 miles), Dover (87 miles), and to Leicester, Eastbourne, and other places. The roads, therefore, are certain to come into more general use for goods traffic. How little this has so far been touched by the commercial motor is proved by the census already referred to. Of the trade vehicles enumerated, 94 per cent. were horse-drawn, whilst of the passenger vehicles all but 13 per cent. employed mechanical traction. In order that the system of road transport should be unobstructed in its development, it is essential that early steps should be taken to lay down building lines in the outer ring. At present this could be done relatively cheaply, but the cost will increase with the lapse of every year. It is argued accordingly that such funds as may be, or become, available should, in the first instance, be applied thus, rather than in metropolitan improvements, which, however badly needed, will cost little or any more in 10 or 20 years' time than if effected at present. In discussing the last report we reproduced maps showing the location of the new roads and improvements considered desirable. Owing to the subsequent acquirement of fuller data some minor modifications in the scheme then set forth are now proposed, and the present report contains a revised map, showing the recommendations now made.

CEMENT.

The two lectures on "Cement," which Mr. Bertram Blount, F.I.C., delivered before the Institute of Chemistry at King's College, W.C., on October 26 and December 1, marked a new departure of the Institute. Lectures on professional practice for the benefit of advanced students were specified as one of the objects of the Institute, which was founded in 1877, when it was incorporated by Royal Charter in 1885. But the Institute had not discharged its duties as a teaching body before Dr. G. T. Beilby, F.R.S., in his presidential address of last year, reminded the members of the need of providing for a closer connection between the academical and the practical training. Mr. Blount was selected to inaugurate this new series of lectures. Owing to the illness of Dr. Beilby, Professor J. Millar Thomson, of King's College, took the chair at the first lecture, and Professor R. Meldola, of Finsbury Technical College, at the second.

Mr. Blount said, in opening his first lecture, that work abroad had left him little time to prepare for his discourses, which he would confine to calcareous cements, and more in particular to Portland cement. The Portland cement industry was essentially chemical and should, in the interests of the manufacturer and consumer, be controlled by the chemist. The world-production of Portland cement rose from 2½ million tons in 1886 to 25 million tons in 1910, valued at about 35 million pounds. England produced 1 million tons in 1890 and 3 million tons in 1910, Germany 1½ million tons in 1890 and 5 million tons in 1910. The earliest form of calcareous cement was probably calcium sulphate, sufficiently dehydrated to form plaster-of-paris, which was, however, liable to attack by water and which lacked plasticity.

Calcareous cements proper resisted the action of water and hardened. Their discovery had probably been made by accident in almost prehistoric ages. Lime (calcium oxide), as Mr. Gillett, Mr. Blount's assistant, demonstrated, formed a hardening paste when mixed with water and sand; the oxides of strontium and barium (metals closely related to calcium) gave harsh, unsuitable mixtures, which would not set. Leaving the further consideration of the chemistry of setting to the second lecture, Mr. Blount emphasised that it was a common fallacy to attribute the setting of a lime mortar to the action of the lime on the sand. There was no such direct union. Silicates found in mortars had originally been present in the limestone or in the aggregate, or had been formed by mutual reactions. Limestone was hardly ever free from silica and clay. That certain substances—notably the pozzolanas—made good aggregates for mortar was known to the Romans. A pozzolana was anything silicious that would combine with lime without the application of heat; its usefulness was due to its containing hydrated silica or attackable silicates ready to react with lime, and to form compounds more or less resistant to water. Similarly, it had been known that certain limestones offered special advantages for producing mortars. But there was no record of the deliberate selection of a limestone for its hydraulic qualities before 1756, when Smeaton chose a blue lias limestone from Aberthaw for building the new Eddystone Lighthouse. Mr. Blount showed by lengthy quotations from Smeaton's diary that Smeaton was endowed with the true spirit of the original scientist. Smeaton and his "consulting" chemist, Cookworthy, ascertained not only that this stone was highly hydraulic, but also that it could further be improved by mixing it with trass, a pozzolanic material,* which reached England *via* the Rhine and Holland.

Having referred to the compositions of various pozzolanas, and stated that analyses were not sufficient to decide upon their value, the lecturer passed to Roman cement, which, he said, was a crude form of Portland cement, made by burning nodules of a clayey limestone containing a good deal of alumina (about 7½ per cent. was best); that industry dated from about 1796. Starting with the notion of imitating Roman cements, the originators of the Portland cements had arrived at the idea that when chalk and clay were mixed and burned, an hydraulic material was produced which, when ground, would form a sound cement.

The lecturer then turned to the starting of new works, and the functions of the resident chemist (he preferred this term to works' chemist) and the consulting chemist, on which he dwelt at length. The suitability of the site, the nature and quantity of the raw materials, supply of labour, transport facilities, and disposal of the products, and other features had to be considered. Samples of the material—chalk, clay, limestone, shale, marl—should be submitted, plentiful and of generous dimensions; they should be analysed, made into slabs, burned, ground, and tried; Mr. Blount showed how this could be done with the aid of a very simple furnace built up of bricks. Far too little attention was paid to proper sample taking, and ridiculously small samples were not rarely offered. If the material proved patchy, commercial success might be impossible. The proportions of the ingredients were settled more by rough estimates than by algebraic equations. Mr. Blount concluded the first lecture by making a few remarks on the manufacture of Portland cement which he explained with the aid of a diagram, acknowledged to represent an obsolete type. The acids and bases in the material began to combine after the water of hydration and the carbon dioxide had been given off. The material in that state was a bad cement. It was further heated until it clinkered into a sticky mass, but it should not fuse nor attack the acid lining of the furnace.

Passing in the second lecture to testing, Mr. Blount said that physical and mechanical tests were necessary, since, owing to our limited knowledge of the chemistry of cement, the almost obligatory chemical tests were not conclusive, while the other tests were, from their nature, more or less arbitrary. The history of testing showed many changes of opinion, but the British Standard Specifications were satisfactory, and had remained practically unaltered since 1904; some rules, however, had been made more stringent. Mr. Gillett demonstrated the making of briquettes for mechanical tests, by mixing a given weight of cement with a given weight of water, working the mixture into a paste with the aid of two trowels, and filling the mould with the paste, while knocking the mould on an anvil so as to secure a solid pat free from voids. This gauging, Mr. Blount remarked, looked very simple, but required great skill. He had in vain tried to abolish this neat cement test; when the cement was tested mixed with sand, the question of the fineness of the sand arose, and it was a fact that the standard sand, which differed from the aggregate afterwards used, gave lower values than ordinary sand. Since cement was not deliberately used under tension, compression tests were alone held proper in Germany; but all the tests were merely comparative, there were inherent errors in compression tests, and tension tests had given excellent results.

The determination of soundness, or of constancy of volume and value, was of paramount importance. It was sought in two ways. In the first (the Bauschinger test) a bar of cement of known length was measured with the aid of special callipers, day by day, against a bar of wood; there might be some difficulty with the fiducial points at the ends of the bar, at which small brass plates were fixed, if the cement were unsound. To avoid this trouble it was advisable to fix the plates with a cement known to be sound. The other test of Le Chatelier, which was vigorously opposed in America and Germany, but accepted here, made use of a ring of sheet-brass (better of nickel) about 1 in. in diameter, forming a cylinder of about the same height, which was split in an axial line; on each side of this line was fixed a steel needle (knitting-needle, several inches in length), and the two needles were normally in contact at their far ends. The cylinder was carefully filled with the cement, kept until fully set, and then placed in boiling water, to accelerate the soundness test. A sound cement would not expand much; an unsound material would dilate, and would make the needles open out. For the demonstrations Mr. Blount had purposely prepared some unsound cements, remarking that most cements now supplied were sound, and the observed dilatations ranged from 2 mm. up to 28 mm. The abridged British specifications of 1886 and 1910, which the lecturer had put on the wall, but which he did not explain, allowed (1910) an expansion of 10 mm. after 24 hours, and of 5 mm. after 7 days' aeration. The tensile strength demanded was, for neat cement, 1 in. by 1 in., 400 lb. after 7 days and 500 lb. after 28 days; for 3 parts of sand and 1 part of cement slabs of the same section, 150 lb. after 7 days and 250 lb. after 28 days.

Turning to the future, Mr. Blount said that additional criteria might be found, and that a revision

* A trachytetuffa found in the valley of the Brohl River, joining the Rhine from the Eifel Mountains on the left of the Rhine between Coblenz and Bonn.

of the tests on totally different lines was required. Two things ought to be determined, the proximate composition and the time of setting. The composition was so complex that chemists did not attempt to determine it, and the setting time was connected with the composition. An extraordinary ignorance prevailed as to these features. He did not himself know what was meant by "free lime," and how it was reliably to be determined.

The introduction of the rotary kiln had so much reduced the cost of production of Portland cement that it was now largely used where hydraulic cements had formerly been demanded; the chief thing was that the cement proved strong. The chemical reactions were slow, and the setting might require a few minutes or hours. After the setting, a cement should not alter. But no cement could bear the action of water continually renewed. If water could get through, a cement or concrete structure was doomed. They had also to consider that it was not easy to make a concrete free from voids. Blocks of cement would contain 14 per cent. of voids filled with air. The specific gravity of the cement at works was to be 3.15, after delivery 3.10, according to the British specification. But in bulk the average density was 2.6, and a dam was therefore deficient in weight, which was important, as the strength of a dam depended also on its weight.

Theoretically, concrete should weigh about 162lb., in practice it rarely weighed more than 140 lb.; it would hence be possible to increase economy in construction by making the concrete denser. The denser material would also be less pervious to water. Where concrete was exposed to water, imperviousness could be secured by the use of cement; the employment of substances of the pozzolana class, which would combine with the hydrated lime set free during the setting of the cement, was not so common. In the selection of a suitable aggregate the texture, and also the possibility of chemical action that the aggregate might exert in the concrete, had to be taken into consideration. Débris containing sulphates or easily decomposible silicates was unsuitable. As regards magnesia, there had been confusion. The magnesium salts of sea-water acted on cement; but the magnesia which had been found in cement structures that had failed in sea-water had been liberated in the cement, and had not been originally present in it, as had sometimes been supposed. The British specification did not allow more than 3 per cent. of magnesia in a cement.

Reverting to the training of the cement expert, the lecturer demanded a broad elementary education, a sound general knowledge of chemistry, supplemented by some mechanical and engineering training, before proceeding to a post-graduate training in the chemistry of cement. This should be gained in a laboratory within easy reach of accessible works.

Referring, in conclusion, to the chemistry of cement, Mr. Blount pointed out that the importance of the tricalcium silicate had, at different periods, been maintained and opposed, because it could not directly be prepared by fusing silica with lime, though it could be prepared by the fusion of lime with silicates. He paid a high tribute to the valuable researches of Le Chatelier of 1886. A cement would contain this tricalcium silicate ($3\,CaO\,.\,Si\,O_2$) in addition to mono- and dicalcium silicate and further analogous aluminates ($3\,CaO\,.\,Al_2O_3$, &c.), in addition to oxides of iron and magnesium, &c. He showed that, starting from about 25 per cent. of silica, 5 (or 2) per cent. of alumina and about 72 per cent. of lime (CaO), different combinations were possible in a hypothetical cement.

The tricalcium silicates (not the mono- and disilicates) set with water by passing into monosilicate and free calcium hydrate $Ca(OH)_2$; this free lime acted further on the aluminates. The three aluminates also reacted with water under liberation of lime, and the initial setting (during the gauging) was, according to Le Chatelier, primarily due to this reaction. According to the recent view, the hydrating compounds formed gels, a kind of cements within the cement, not the saturated solutions of the older view; but Mr. Blount said he had never seen anything in cement of the nature of a gel. The whole subject of the chemistry of cement still required the best power of the chemist, who would have to be able, among other things, to watch the effects of slight temperature changes at temperatures above 1500 deg. Cent.

THE SMITHFIELD SHOW.

The annual exhibition of the Smithfield Club was opened at the Agricultural Hall, Islington, on Monday last, and, as usual, there are on show some fine examples of agricultural machinery, though there is little, if anything, exhibited in the way of new departures of importance.

Of steam-engines, however, there is always a fine display. Messrs. Marshall, Sons, and Co., amongst their engines show a highly finished compound steam-tractor fitted with a Belpaire fire-box and a tubular feed-heater. This we illustrate on the opposite page. Such tractors find a field where the standard types of heavy engines are quite impracticable, and over the petrol and paraffin motors have the advantage that no special skill is required to discover the cause of a breakdown or to effect a repair. Special attention has been paid to the question of lubrication, so as at once to ensure efficiency and economise oil. The cylinder is steam-jacketed and fitted with mechanical lubrication. Wrought-iron guards are fitted to shield the working parts from dust, and to preserve the drive from accident. A winding-drum is fitted, and carries 50 yards of steel-wire rope. At the back end the tractor is mounted on laminated steel springs, while at the front the weight is also spring-mounted, thus rendering the engine very "easy-riding." The gears are of crucible cast steel, machine-cut, and two speeds of $2\frac{1}{2}$ miles per hour and 5 miles per hour respectively are provided for. In addition to the ordinary water-tank on the tender, the engine has an additional tank fitted under the boiler, thus enabling relatively long journeys to be made without stoppage for water. A similar tractor, fitted with roller-wheels, is constructed by the firm for direct traction ploughing. Another interesting exhibit at this stand is the firm's new fire-box, having the crown corrugated so as to dispense with roof-stays. This type is gradually being made the standard for all sizes of Messrs. Marshall's portable engines.

The exhibit of Messrs. John Fowler and Co., Limited, of the Steam Plough and Locomotive Works, Leeds, consists entirely of steam-engines, the principal exhibit being a compound ploughing-engine rated at 10 horse-power nominal. This is fitted with road-wheels 6 ft. 6 in. in diameter by 20 in. wide. The makers are now, when desired, fitting these engines with superheaters, experiments in this direction having been commenced some six years ago. The exhaustive trials since made enable the firm to recommend the system with confidence. The superheater is fixed in the smoke-box in such fashion as not to prevent easy access to the ordinary boiler-tubes. The steam is delivered from the superheater at a temperature of 608 deg. Fahr., and the consequent reduction in coal consumption is stated to amount to 20 to 25 per cent.

The principal object of interest at the stand of Messrs. Richard Garrett and Sons, of Leiston, is one of the semi-fixed engines described by Mr. W. J. Marshall in a paper read at the last meeting of the British Association at Portsmouth. These are designed to work with highly superheated steam, and have shown a remarkably low fuel consumption. Mr. Marshall's paper was reprinted in our issue of September 15 last.

A number of fine traction-engines and tractors are shown at the stand of Messrs. Clayton and Shuttleworth, Limited, of Lincoln, amongst them being a compound tractor fitted with a Belpaire fire-box similar to that for which the builders were awarded a Grand Prix at the recent Turin Exhibition. Messrs. J. and H. Maclaren, of Leeds, show one of their standard 8-horse-power traction-engines, but not the new type which they have recently introduced for direct traction ploughing. The exhibit of Messrs. Ruston, Proctor, and Co., Lincoln, consists of a 7-horse-power traction-engine, a 4-ft. 6-in. thrashing-machine, and a 7-horse-power horizontal oil-engine. All are notable for the high finish usual with the makers, but did not embody any new departures. A large stand is, as in past years, occupied by Messrs. Ransomes, Sims, and Jefferies, Limited, of the Orwell Works, Ipswich. Amongst the exhibits is a light compound steam-tractor, built to comply with the Motor-Car Acts, and capable of hauling loads of from 5 to 8 tons, according to the character of the roads. Two full-sized traction-engines are also shown, of which one is of the compound type, with the back-axle spring mounted.

A fine road locomotive is shown by Messrs. Aveling and Porter, of Rochester, of the type with which their name has long been identified. They also show a light steam-tractor, in which are embodied the results of their long experience with the heavier class of engine. Traction engines or tractors are also shown by Messrs. William Allchin, Limited, of Northampton; Messrs. Charles Burrell and Sons, Limited, of Thetford; Messrs. Brown and May, Limited, of Devizes; Messrs. Wallis and Steevens, Limited, of Basingstoke; and Messrs. Wm. Foster and Co., of Lincoln.

Mann's Patent Steam Cart and Wagon Company, of Leeds, show a steam-tractor designed for direct-traction ploughing. This is fitted with a side-fired locomotive boiler, designed for a working pressure of 200 lb. per sq. in. The compound-engine is completely enclosed, and is capable of developing 21 horse-power on the brake. A large water-tank, carrying a four hours' supply, is arranged over the hind wheels, the top of the tank being also intended to serve as a platform for carrying goods.

The most notable feature, perhaps, of the Exhibition is the evidence afforded of the steady growth in popularity of the small petrol motor. Where a large power is required, or where the work is of a reasonably constant character, the oil-engine shows, of course, lower running costs; but for intermittent work, requiring only a small power, the handiness of the petrol-engine much more than compensates for the relative costliness of its fuel. Messrs. R. A. Lister and Co., of Dursley, show small engines of this class, similar to those exhibited at the Norwich Show. Other builders of the type are Messrs. E. H. Bentall and Co., of Malden, the Bristol Wagon and Carriage Company, and the Eagle Engineering Company, of Warwick; whilst American-built engines of the same class are shown by the International Harvester Company, of 80, Finsbury Pavement, E.C., and by Messrs. Fairbanks, Morse, and Co., of 37, Southwark-street, S.E. The engines shown by the latter are noteworthy in having fan-cooled cylinders. Messrs. Rd. Hornsby and Sons, Limited, of Grantham, also show a small petrol-motor, though their principal exhibit consists of their well-known oil-engine. These are now made up to 270 brake horse-power, and are successfully running on every kind of oil fuel in every part of the world.

A new pattern of gas-engine is exhibited by Messrs. Fielding and Platt, Limited, of Gloucester. This engine, which is rated at $19\frac{1}{2}$ to 23 brake horse-power, is fitted with throttle-governors. The governor valve is, however, entirely distinct from the admission valve. The latter has a fixed time for opening and closing, and the strength of mixture is regulated by a supplementary set of valves of the piston type, which work in a cylindrical chamber cast in one with the cylinder breech-piece. Of these governor valves there are two, both on the same spindle, one being for air and the other for gas. The supply of air and gas can further be regulated by hand cocks provided with indicators, which are fitted for this purpose on the openings into the mixing-chamber. A suction-producer is exhibited with this engine, and at the same stand are also to be found a 3-horse-power and 10-horse-power oil-engine of the firm's standard pattern.

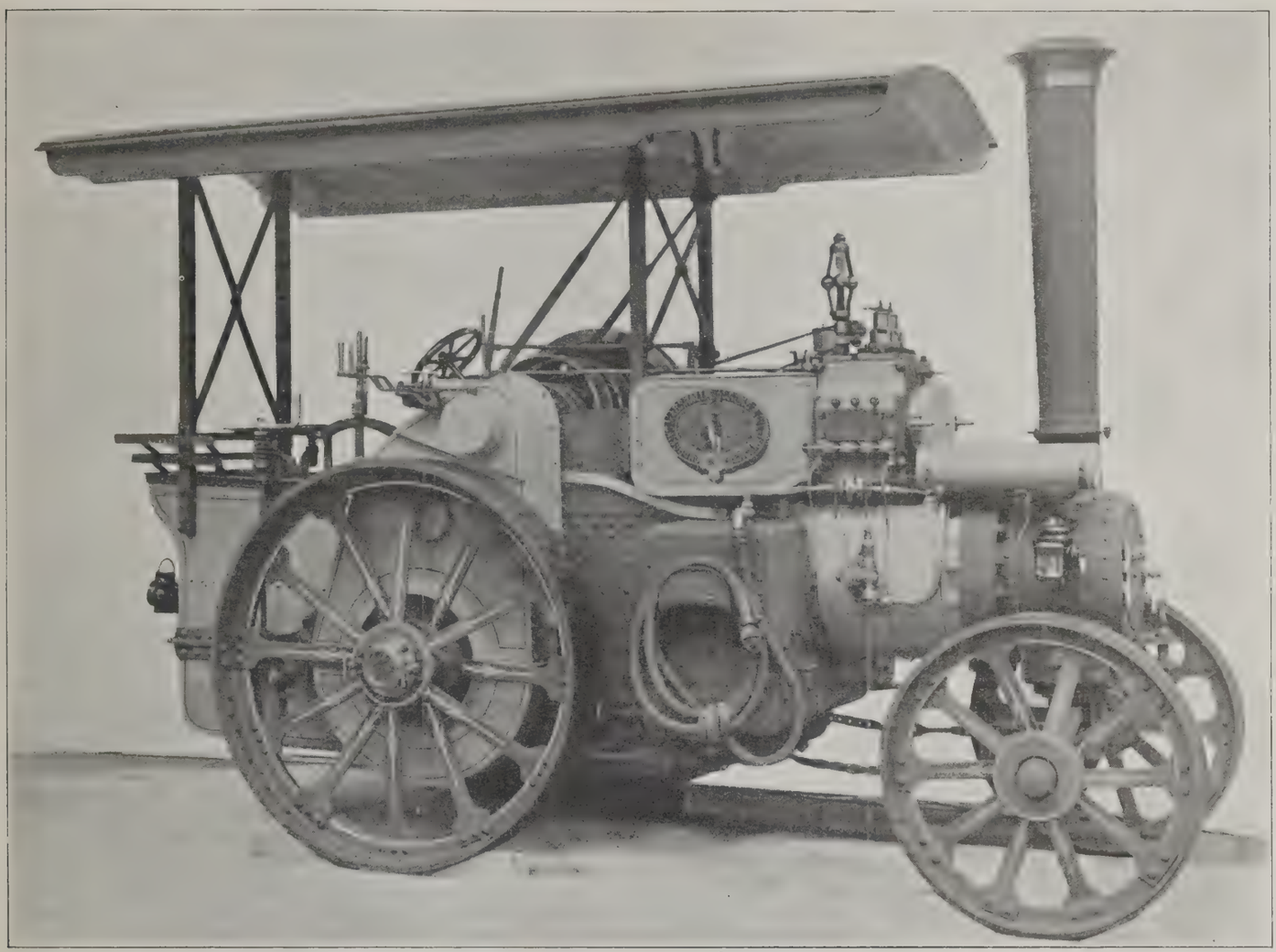
The exhibit of the Campbell Gas Engine Company, Limited, of Halifax, includes a suction-gas plant and engine rated at $11\frac{1}{2}$ brake horse-power, an oil-engine of about the same capacity, and a small $1\frac{3}{4}$-horse-power oil-engine and geared pump. These are all standard productions, but the gas-engine is now fitted with high-tension magneto-ignition.

Portable and stationary oil-engines are exhibited by Messrs. Blackstone and Co., Limited, of Stamford, who have recently considerably enlarged their works in correspondence with the growing demand for their crude or residual-oil engine. The latter has been described in detail in Engineering, vol. lxxxvii., page 756. It will work with any kind of residual oil and requires no water injection. Larger sizes are now being made, as much as 150 to 200 brake horse-power being generated with two cylinders.

Messrs. Davey, Paxman, and Co., Limited, of Colchester, show a suction-producer and gas-engine designed to develop 32 to 36 brake horse-power, similar to that which obtained a Grand Prix at the recent Franco-British Exhibition. These engines are now built to develop 500 horse-power in two cylinders. The firm, we learn, have now in use producers operating successfully on sawdust. As a marketable commodity, sawdust has for some time past been steadily diminishing in value, and

COMPOUND STEAM-TRACTOR.

CONSTRUCTED BY MESSRS. MARSHALL, SONS, AND CO., LIMITED, ENGINEERS, GAINSBOROUGH.



some means of utilising it for power production has long been a desideratum. One difficulty to be overcome lies in the facility with which the light dust can be drawn over with the gas, unless special means are taken to prevent it. On the other hand, the plants have the advantage that the tar collected is of considerable value.

Messrs. Petters, Limited, of Yeovil, show a new type of oil-tractor. This is fitted with one of their standard enclosed oil-engines, rated at 30 brake horse-power. The radiator used consists of a coil of pipe fitted with radiating fins, past which air is drawn by a horizontal fan driven by the engine. The loss of water averages about 3 gallons on a 12 hours' run, and the tank capacity provided is 20 gallons. The weight of the tractor is 5 tons, and when used for road haulage it will take an 8-ton load practically anywhere. The fuel consumption is stated to be 1 gallon of oil per hour. The tractor is specially intended for direct haulage of ploughs—a method which is growing into increasing favour, particularly in certain foreign countries where the furrows are often 1 or $1\frac{1}{4}$ miles long. The machine has one speed forward and a reverse, the backward motion being obtained by an epicyclic gear.

A 12-horse-power oil-engine is also shown by Messrs. Alexander Shanks and Son, Limited, of Arbroath, and a small combined oil-engine and pump is on view at the same stand. Here also the firm show samples of malleable castings, of which they claim to be the largest producers in Scotland, having ten annealing-ovens continually at work, largely for export.

Messrs. E. R. and F. Turner, Limited, of Ipswich, who have only recently taken up the manufacture of oil-engines, show at their stand two sizes—one rated at 5 and the other at 8 brake horse-power. In the case of internal-combustion engines it is not uncommon to fix the horse-power rating at the maximum which can be maintained for 15 or 20 minutes, but Messrs. Turner have adopted the plan of rating their engines at the load which they can maintain on long continuous runs.

Messrs. Saunderson and Gifkins, of the Elstow Works, Bedford, exhibit a 50-brake-horse power agricultural oil-tractor, with which a very complete series of tests were recently carried out by Mr. W. Worby Beaumont. Three acres of land were ploughed during the test to a depth of $5\frac{1}{2}$ in. to $6\frac{1}{2}$ in. at a fuel cost of $9\frac{3}{4}$d. per acre, and a total cost (exclusive of depreciation) of 1s. 8d. per acre. The average time taken was 34 minutes per acre. A similar machine has recently made a trip from railhead in Zululand for a distance of 100 miles, over a district devoid of roads. The tractor is fitted with a four-cylinder engine, and operates with ordinary paraffin. A special form of carburettor is used, the fuel-tube being jacketed by the exhaust gases. For starting up, when this tube is cold, petrol is used. The tractor is provided with very wide tyres, which reduce the weight per inch width to that of an ordinary farm-cart unladen. This increase of width has proved a great advantage in Canada, where, after the prairie is once broken up, the soil is said to resemble in consistency a mass of black ashes. The tractor in question has also been used in Hungary and Russia, where the soil is very sandy, a fact which has led the makers to encase carefully all bearings. The radiator consists of a number of copper tubes first flattened and then corrugated. These expose a large surface, and the cooling is very effective.

An agricultural tractor is also shown by Ivel Agricultural Motors, Limited, of Biggleswade. This is essentially the same as exhibited last year, but the two-cylinder engine is now fitted with high-tension magneto-ignition.

Royal Institution.—The following are the lecture arrangements at the Royal Institution, before Easter:—Dr. P. Chalmers Mitchell, a Christmas course of six illustrated lectures on "The Childhood of Animals," adapted to a juvenile auditory:—1. "Introductory." 2. "The Duration of Youth." 3. "Colours and Patterns of Young Animals." 4. "Young Animals at Home." 5. "The Feeding of Young Animals." 6. "The Play of Young Animals." Mr. W. Bateson, Fullerian Professor of Physiology, R.I., six lectures on "The Study of Genetics." Professor E. G. Coker, two lectures on "Optical Determination of Stress and some Applications to Engineering Problems." Dr. T. Rice Holmes, three lectures on "Ancient Britain." Professor A. W. Bickerton, two lectures on "The New Astronomy." Professor A. M. Worthington, two experimentally illustrated lectures on "The Phenomena of Splashes." Mr. M. H. Spielmann, two lectures on "The Portraiture of Shakespeare." Mr. F. A. Dixey, two lectures on "Dimorphism in Butterflies:"—1. "Seasonal Dimorphism." 2. "Sexual Dimorphism." The Rev. John Roscoe, two lectures on "The Banyoro: A Pastoral People of Uganda:"—1. "The Milk Customs." 2. Birth and Death Customs." Sir Alexander C. Mackenzie, three lectures on: 1. "Russian Music of To-Day," with the kind assistance of the Hans Wessely Quartet. 2 and 3. "Franz Liszt (Centenary)" (with musical illustrations). Professor Sir J. J. Thomson, Professor of Natural Philosophy, R.I., six lectures on "Molecular Physics." The Friday evening meetings will commence on January 19, when Professor Sir James Dewar will deliver a discourse on "Heat Problems." Succeeding discourses will probably be given by Professor Bertram Hopkinson, Dr. J. Mackenzie Davidson, Dr. J. A. Harker, the Right Hon. Sir John H. A. MacDonald, Mr. G. K. B. Elphinstone, Dr. W. J. S. Lockyer, Mr. F. Soddy, Professor D'Arcy W. Thompson, Professor Sir J. J. Thomson, and other gentlemen.

NOTES.

Peat-Gas Plant in Ireland.

A peat-gas plant has been working in Ireland since September last, with results which are reported to be quite satisfactory. The plant is installed at the factory of Mr. H. Robb, at Portadown, and has replaced a Mond-gas plant by which power was formerly provided. The plant utilises peat which is simply air-dried, cut from the boglands at Maghery, and stacked for the summer. As cut the peat contains about 85 per cent. of moisture, and during an average season this can be reduced by air-drying to 26 per cent. In exceptional years, such as that experienced this last summer, peat can be dried in this district to about 19 per cent. moisture. The plant is guaranteed to work with peat containing up to 45 per cent. moisture. It consists of two producers of 200 brake horse-power capacity each, with coke-scrubber, tar-extractor, sawdust-scrubber, exhauster and expansion-box. The air-dried peat is fed in block-form, as cut, into a hopper above the producer, whence it falls into the producer itself as combustion proceeds. The gas is drawn off through the coke-scrubber and washer to the tar-extractor, where the tar is extracted under centrifugal action. It then passes on to the sawdust scrubber, and is delivered to the gas-holder by the high-speed fan which draws it through the plant. The gas produced has a value of about 140 B.Th.U. It is similar to that produced from Welsh anthracite, but contains slightly less hydrogen. The peat used has been found to have a proximate analysis of 18.98 per cent. water, 55.17 per cent. volatile matter, 24.75 per cent. fixed carbon, and 1.10 per cent. ash. The ultimate analysis showed: carbon, 44.6 per cent.; hydrogen, 5.42 per cent.; nitrogen, 0.97 per cent.; ash, 1.10 per cent.; moisture, 18.98 per cent.; and oxygen (by difference), 28.93 per cent. The tar produced was found to contain the following:—Water, 49.7 per cent.; light oils distilling below 230 deg. Cent., 5.8 per cent.; middle oils distilling at 230 to 270 deg. Cent., 8 per cent.; heavy oils distilling above 270 deg. Cent., 19.4 per cent.; coke left after distillation, 10.3 per cent.; loss, 6.8 per cent. As originally designed, the coke-scrubber became clogged with tar, and it was therefore modified so that the greater part of the coke was removed, and a water-shower introduced, against which the gas passes upward. The cost of the peat delivered at the works is 6s. per ton, and with an average load of 275 brake horse-power on the plant the consumption is found to be slightly under 20 tons, costing thus 6*l*. There is a ready market for the tar at 35s. per ton, and about 5 per cent. of this by-product is recovered from the plant, or about 1 ton per week. The net expense for fuel is 4*l*. 5s. per week. On the other hand, the anthracite used by the Mond-gas plant (8½ tons per week) cost 13*l*. 16s. 3d. The plant has not been running sufficiently long to ascertain definitely whether or not a slight increase in labour may be necessary; but allowing 40*l*. per annum for such a contingency under these conditions at a factory of 500 looms, employing from 500 to 600 hands, a saving in the fuel bill of about 438*l*. would result. The operation of the plant is reported to be very simple, and after overcoming in the early stages one or two rather unexpected difficulties, of which one was due to sand becoming mixed with the peat during a long dry summer, no further trouble has been experienced. The plant was designed and constructed by Messrs Crossley Brothers, Limited, Openshaw, Manchester, to a specification by Mr. H. V. Pegg, of Messrs. T. L. Miller, Wilson, and Pegg, Belfast.

The Deformation Due to Press-Tool Working.

Mr. Henry Lea, M.Inst.C.E., has contributed the results of an interesting experiment in press-tool work to the discussion of the paper on "Pressed Steel for Automobile Construction," which was recently read by Mr. L. A. Legros, the President, before the Institution of Automobile Engineers Mr. Lea's communication will duly appear in the Proceedings of the Institution, but in the meantime we are enabled to give an account of the matter with which it dealt. The experiment consisted in pressing a circular steel blank into the form of a shallow circular pan, the blank having been previously marked, all over one side, with a series of ½-in. squares, so that after the formation of the pan the distortion of the metal could be seen over the whole of its outer surface. The material used was tinned steel, and the dimensions of the blank and pan were as follow:—

Diameter of blank	9.5	in.
Thickness of blank	0.012	,,
Diameter of pan	6.5	,,
Depth of pan	1.75	,,
Bottom corners of pan	0.25	,, radius

It will be found from these figures that the diameter of the pan was 68.3 per cent. that of the blank, so that the rim of the pan must have been compressed 31.7 per cent.; and that the perimeter of the pan was 9.78 in., measured up one side across the base and down the other side, as compared with the 9.5 in. diameter of the blank, so that the total metal was stretched 3 per cent. The sides of the pan, plus the corners, compared with the corresponding part of the blank, show a stretch of 8 per cent. The general distribution of the distortion of the metal is well shown in Fig. 1 herewith. A measurement of a "square" near the rim of the pan shows that its width has been reduced by

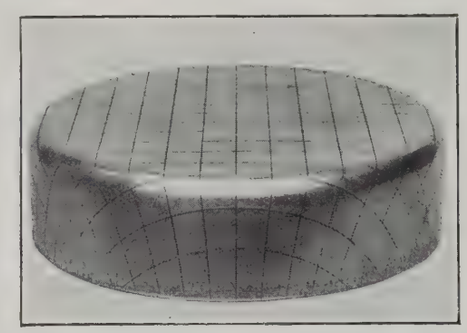
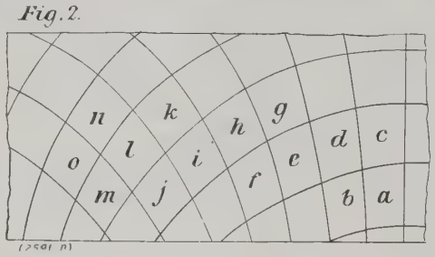


Fig. 1.

Fig. 2.



34 per cent., and its depth increased by 24 per cent. The squares on the bottom of the pan were found to be undistorted. Mr. Legros has developed the curved surface of the pan, and Fig. 2 herewith shows the forms of the curves on the development. A measurement of the areas of the squares, which are lettered in the figure, gives the following results, the figures referring to areas in square inches:—

a = 0.230	f = 0.240	k = 0.250
b = 0.217	g = 0.253	l = 0.245
c = 0.250	h = 0.250	m = 0.225
d = 0.247	i = 0.240	n = 0.255
e = 0.243	j = 0.207	o = 0.237

It will be seen from the figures that these areas have been slightly increased, to the extent of 2 per cent. as a maximum, at the base of the vertical side of the pan, but that as the distortion increases the area diminishes. Area b is only 87 per cent. of the original size, and area j 83 per cent. Mr. Legros explains this diminution by the slight wrinkling which takes place owing to the pressure of the presser-plate not being quite sufficient to ensure perfect shearing of the metal plate in its own plane.

Pioneers in Shipbuilding.

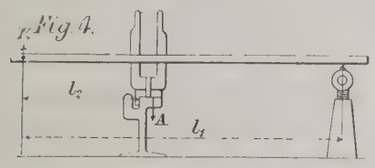
The story of early shipbuilding is ever of engrossing interest, and a further contribution is made in the brochure, published this week, on the early work of Messrs. Barclay, Curle, and Co., Limited, Glasgow. This book is issued *à propos* of Mr. James Gilchrist's jubilee connection with the firm. This company had its origin about 1818—six years after the advent of the Comet. The founder, Mr. Robert Barclay, leased ground at Stobcross, now in the heart of the city, but then a suburb, and there constructed two berths, with a slipway which proved of great advantage to the American clippers frequenting the Clyde, as the firm were able to overhaul or renew the copper sheathing. Repairing was, indeed, a lucrative part of the business. Many ships were built at this establishment, and by 1848 ships of 500 tons were being completed. One of the early transactions, of far-reaching effect, recalls the story of the indigent tramp seeking help by requesting that a shirt should be sewn on a button he had found. Barclay bought as a bargain a ground tackle outfit, and, finding no market, decided to build a ship for it, which ultimately became the first of a large fleet owned by the Curries of Leith, who, it is needless to say, have exercised a great influence on shipping in many seas. The 'forties saw the business increasing rapidly, and Mr. Robert Curle, who had gained experience as a shipbuilder at Troon, joined the firm as manager, and a few years later, in 1845, he, with Mr. James Hamilton, of the commercial department, became partners. Two years later the firm took up iron-shipbuilding. Mr. John Ferguson, who had been trained in iron shipbuilding by Smith and Rodger, the predecessors of the existing London and Glasgow Engineering and Iron-Shipbuilding Company, became manager, and an iron-shipbuilding berth was added to the others at Stobcross. The size of the ships steadily increased, and many American river steamers were built and shipped in sections to America. In 1855 the firm purchased the site of their existing yard at Whiteinch, and some time afterwards decided to add a marine engineering department, their machinery hitherto having been built by Messrs. A. and J. Inglis, another of the historical firms of the Clyde. About the same time Mr. John Ferguson became a partner as well as Mr. Maclean (afterwards Sir Andrew Maclean), of the commercial department, and also Mr. Arch. Gilchrist, who, at that time, was manager in the engineering department of Messrs. Todd and McGregor, a firm who had done much of the engineering work for the early Atlantic ships. The engine works erected in 1861 were at Finnieston, the site having been bought three years previously. Mr. Barclay, the founder of the firm, continued to exercise influence in its operation, and saw it reach this stage of maturity before he died in 1863. In 1874 the development of the Clyde Harbour compelled the Clyde Trustees to purchase the site of the original yard. The firm had ultimately to concentrate all their shipwork at the Whiteinch establishment, and in consequence of this they had practically to abandon their repair work. In 1880 the firm was further strengthened by the addition of several partners, including Mr. James Gilchrist, after he had been twenty years in the business, as he entered its service as an apprentice in 1861. This year, therefore, is his jubilee in connection with the firm, and it was appropriately signalised by a presentation from the whole of the staff. Under his *régime* many notable developments have taken place, and he has shown remarkable appreciation of character in the number of young men he has appointed to positions of responsibility, many of whom have continued to maintain the traditions of the firm under him, as chairman of the limited liability company formed in 1884. Into the recent work done it is not necessary to enter, as the firm's work is so well known: the story would form more or less an epitome of shipbuilding and marine-engineering developments in recent years. Suffice it to say that from between 1861 and 1911 the firm built 148 sailing-ships, 35 paddle-steamers, and 226 screw-steamers, a total of 409 vessels; the steam pressures increasing from 18 lb. Perhaps the best indication of the activities of the firm is conveyed by the fact that in the past five quinquennial periods the tonnage has increased from 60,000 tons to 168,544 tons, and the horse-power from about 30,000 to 151,702. As to their enterprise, there is the highly creditable fact that they have just completed the first set of oil-engines built in this country for a seagoing ship—the Jutlander, of 5300 gross tons and 3000 brake horse-power.

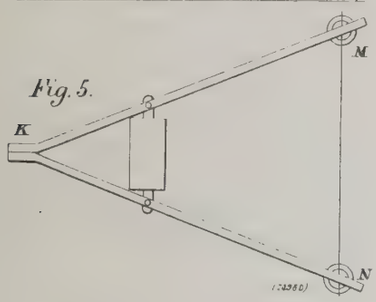
A Tungsten Resistance-Furnace.—Franz Fischer and E. Tiede described, in a recent meeting of the Deutsche Chemische Gesellschaft (*Berichte*, 1911, page 1717) a resistance furnace consisting of a tube of tungsten, made according to H. von Wartenberg's process. The tube has a length of 8 cm., a diameter of 1.6 cm., and a wall thickness of 3 mm., and it can take currents of 3000 watts in a vacuum. It fits at its two ends into the electrodes, two rods of copper, which are fitted with cooling-pipes. The rods and the tube form the horizontal diameter of a glass globe, which is kept wetted with water. A greased rubber tube leads over to the air-pump. The cooling of the electrodes is so effective that a good vacuum can be maintained. A small magnesia crucible can be placed in a hole drilled into the tungsten tube. In this furnace 1.5 grammes of tin (which has a very high boiling point) were distilled in five minutes.

THE WORK OF THE REICHSANSTALT IN 1910.

(*Concluded from page* 743.)

Magnetic Rail-Brake (W. Rogowski).—The determination of the force with which a brake-shoe, suspended above the rail, is attracted by the rail, by means of a pull-off test, requires care; the shoe is likely to tilt, because the resultants of the magnetic and the mechanical forces do not act in the same plane. The arrangement illustrated in Fig. 4 and 5 has been devised. The brake-shoe is fixed between





two spreading-levers K M and K N, which rest on the knife edge M N; the mechanical force is applied at K. By suitably adjusting the supports at M and N, the tilting can be avoided.

Ageing of Fuses (Orlich, Schering).—In continuation of the research on fuses, silver wires, 150 mm. in length and 0.1 mm. in thickness, were stretched in glass tubes, 200 mm. in length and 15 mm. internal diameter, and these tubes filled with dry sand. It was first ascertained that the fuses would bear 6 amperes, and would heat up to 230 deg. Cent. under 4 amperes. Tinfoil was wrapped round the glass tubes, and the wire and foil were joined to the terminals of alternating circuits (50 periods) of 4800 or 600 volts effective. From time to time the wire resistance was redetermined in the cold. With the 4800 volts and 4 amperes the resistance of a wire would soon rise to double its amount, and the fuse would burn through in 10 days; with the 2 amperes the destruction was slower. The 600 volts and 4 amperes were borne for more than 8 months, at the end of which the resistance had only increased by 20 per cent. maximum. In these experiments the fuses were embedded in dry sand in glass tubes, as stated. When the sand was removed, the high voltage and strong currents (4800 volts, 4 amperes) caused the wires to oscillate so violently that they broke in a few minutes; the 600 volts and 1 or 2 amperes were again borne, while similar wires, stretched in the open air (not within glass tubes) were burnt through. The glass tubes thus prevent a rapid oxidation of the fuses.

Resistance of Copper (the late St. Lindeck).—Observations continued since 1905 show that the temperature coefficient of copper a is very nearly proportional to the electric conductivity c, so that ac = constant. When c is the specific resistance of 1 m. of wire, 1 sq. mm. in cross section, the constant has at 15 deg. Cent. the mean value $6.78 . 10^{-5}$. Similar relations seem to hold for iron and aluminium. The relation was simultaneously recognised at the Bureau of Standards by Dellinger, and published by him in September, 1910; but there is no question of priority, for Matthiessen and Vogt found in 1864 that such a law held for pure metals.

Resistance Standards (Lindeck).—With one exception all the standard wire and sheet resistances tested in 1910 consisted of manganin; nearly a hundred of those submitted were for countries abroad. It has already been mentioned that the standards are kept in cupboards in an atmosphere containing 50 per cent. of humidity; some are preserved under paraffin or petroleum in hermetically-sealed boxes. These resistances keep very constant (the petroleum has not answered so well as the paraffin oil); but they cannot readily be handled on testing, and neither of the methods mentioned is suitable for resistance-boxes. Experiments are therefore made whether constancy of the resistance standards could not be secured by providing the wires with some impermeable coating. The atomising process of M. U. Schoop (which we described some time ago) has been tried, and fused tin has been sprayed under high pressure on wire coils coated with shellac. It resulted that 0.04 mm. of tin did not sufficiently protect the wire against moisture; tin deposits of a thickness of 0.1 mm. and 0.15 mm. afforded a better protection. The experiments are being continued.

Electric Testing-Stations (Feussner).—The testing of galvanometers, electricity meters, clocks, &c., is now largely carried out in the Prüfungsämter at Ilmenau, Hamburg, Munich, Nuremberg, Chemnitz, Frankfort (Main), and Bremen. Of these, Munich remains by far the busiest station (about 16,000 tests in 1910), while Chemnitz had little to do (130 tests); a new testing station is being established at Barmen.

Magnetic Laboratory (E. Gumlich, Schmiedel).—The experiments on the direct determination of the field intensity which will produce a certain induction by yoke methods and by the Epstein method are not completed yet. The yoke itself has a disturbing influence which is particularly noticeable in weak fields. Five sets of dynamo sheets had been sent over from the National Physical Laboratory to be tested for total watt losses and hysteresis losses at B = 10,000; the Reichsanstalt found values which were by 3 or 4 per cent. lower than those observed at Teddington. The two institutions did not apply quite the same method, and the Reichsanstalt is now investigating the influence of the strayfields at the corners and joints of its Epstein apparatus, the sheets of which are piled up to form a rectangular frame.

Various irons and steels have been tested after slow cooling or sudden quenching from temperatures of 750, 800, 850 deg. Cent. In the annealing the metal is heated for 24 hours in a vacuum and then slowly cooled; for the quenching the metal is dropped directly from a tilting furnace into ice-water. The researches concern initial permeability, electric conductivity, temperature coefficients, critical temperatures, hardening, &c. In determining the initial permeability by the yoke method, rods from 18 to 35 cm. in length, 0.6 cm. in diameter, are placed in fields ranging from H = 0.008 up to 0.4; sheet metal for transformers and dynamos has, in similar tests, to be applied in stamped rings; but another method is being worked out. Even in fields of less than 0.02 some residual magnetisation is observed, amounting to about 8 per cent. of the temporarily induced magnetisation. Annealing, as a rule, increases the initial permeability, by 160 per cent. in the case of cast iron, for instance; but annealing may actually decrease the permeability, as in the cases of a 0.79 per cent. carbon steel and of low silicon irons.

As regards the influence of the direction of rolling, the Bismarckhütte had observed that the highest permeability was obtained when the metal was cut at an angle of 45 deg. to the direction of rolling, not when cut parallel to the rolling, as usually assumed, and the Reichsanstalt confirms this observation. The influence is, however, of importance only in weak fields, and vanishes with increasing saturation. When the magnetic circuit consists of various materials (as it does in applying the yoke method), and when the materials contain different constituents, like ferrite, pearlite, or martensite, the relations become complex, and the ordinary definition of coercitive force (that field intensity which neutralises the remanent magnetism) is no longer applicable; for the magnetism will not disappear simultaneously in the hard and in the soft portions of the magnetic circuit. A combination of a hard material, having a coercitive force of 41, and of a soft material, with a coercitive force of 1, gave a mean coercitive force of 2.7, instead of the mean 21. Such combinations yield badly-distorted hysteresis curves, and similar curves are sometimes obtained with materials which were badly cooled apparently, and contained martensite in ferrite.

Thermometry (Hebe, H. F. Wiebe, Grützmacher).—The number of clinical mercury thermometers submitted which failed to pass is very high—36 per cent. The reason is that in Bavaria the verification of clinical thermometers had only recently been made obligatory; thus a great number of the thermometers examined by the Reichsanstalt last year were not found to be sufficiently accurate. Most of the thermometer-testing is now done in the special institutions at Ilmenau and Gehlberg, in Thüringia, which Professor Grützmacher superintends on behalf of the Reichsanstalt. These two establishments tested nearly 100,000 thermometers last year.

Stückrath Pressure-Gauge (Wiebe, W. Meissner).—The accuracy of the Stückrath pressure gauge has carefully been inquired into. For the range 20 kg. to 500 kg. per sq. cm. the reliability is within 1 in 2000; the gauge can be used for pressures of 1000 kg, but the pistons show signs of wear then. The temporary extension which the hollow nickel-steel cylinders undergo when the pistons work in them has also been determined for the full pressure range. Meissner and Hebe have also determined the agreement between theory and experiment as to the velocity of discharge of liquids (water and oil) through tubular nozzles of various dimensions.

Thermo-Couples, Resistance Thermometers (Lindeck, Hoffmann, W. Meissner).—There has been a slight increase in the number of thermo-couples presented for standardisation, and especially in constantan silver couples (177, against 94 in 1909). As regards resistance thermometers consisting of platinum wire embedded in quartz glass, the platinum wires supplied by W. C. Heraeus and by G. Siebert, both of Hanau, have been examined. The former firm submitted wires of 0.04 mm., 0.05 mm., 0.1 mm., and 0.15 mm., the latter firm wires of three of these diameters, which were tested at 0 deg., 100 deg., and 445 deg. Cent. The determinations of the constants suggest that the finer wires are very slightly less pure than the thicker wires; somewhat greater discrepancies were, however, observed in nine quartz glass thermometers, and it would appear that the fusing of the platinum with the quartz does affect the metal.

A comparison between the platinum resistance thermometers for low temperatures of the Reichsanstalt with those which Professor Kamerlingh Onnes had sent from Leiden shows an agreement within 0.1 deg. Cent. at — 78 deg., and within 0.2 deg. Cent. at — 190 deg., the range of the comparison was — 40 to — 221.5 deg. Cent., and determinations were made at eight temperatures.

Optical Pyrometers. Seger Cones (Brodhun, Hoffmann, W. Meissner).—The examination of old and new kinds of red glasses, suitable as absorption screens, is being continued, and the optical pyrometers are being standardised against melting gold, palladium, and platinum. A special black body furnace, available up to 1600 deg. Cent., is being constructed for this purpose. Seger cones have been tested in technical ceramic furnaces and in the electric furnaces of the Reichsanstalt, simultaneous readings or records being obtained with the aid of electric and of optical (Holborn-Kurlbaum) pyrometers. The cones were supplied by the Royal Porzellan-Manufaktur, of Berlin, and the Rheinische Chamotte- und Dinaswerke, of Bendorf. It results that the cones always fused or softened at lower temperatures in the ceramic furnaces than in the electric furnaces; in the worst cases the electric furnace indicated that the cone fused at 1335 deg. Cent., while in the ceramic furnace fusion took place at 1235 deg. Cent.; the highest readings were 1480 deg. Cent. (electric) and 1410 deg. Cent. (ceramic furnace). Different ceramic furnaces yielded fairly concordant results. The reasons of the discrepancy between the two types of furnaces are not clear, but the gases and the ash-dust of ceramic furnaces probably lower the softening points of the seger cones.

Optical and Photometrical Work (Brodhun, Liebenthal, Schönrock, Fassbender).—The popularity of metallic-filament lamps showed in the numbers of lamps submitted for testing. The tax on light which has been in force in Germany since October, 1909, has not given the Reichsanstalt much work; cases of dispute are decided by the Prüfungsämter. As the use of the Abbe refractometer in the sugar industry is becoming very general, Schönrock has compiled tables for the relation between the refractive index, sugar percentage, and temperature of sugar solutions.

Chemical Researches. Glass. Oils. Galalith (F. Mylins, E. Groschuff, Hüttner).—The inquiries into the weathering of glass and its technical determination by micro-chemical tests, and also into the rapid destruction of different sorts of glass, have been completed. Cases of brittleness of some good gold coins have been traced down to a rather large lead percentage (0.015 per cent.); but the investigation is being continued. As regards the absorption of moisture by oils, transformer oils in particular, and benzene, it is found that benzene absorbs, at 18 deg. Cent., 0.051 per cent. by weight of moisture, petroleum 0.005 per cent., paraffin oil 0.003 per cent.

Thus petroleum absorbs about as much moisture as the air does, and benzine much more. But the impurities of petroleum modify the solubility of water in the oil considerably. To dry these liquids they are distilled over freshly-fused sodium or potassium-sodium. The drying of the oils is a more difficult matter; most of the moisture can indeed be removed by heating the oil up to 120 or 130 deg. Cent., and the drying can be completed with the aid of sodium or of calcium chloride. But both the heating and the treatment with alkali metal or alloy cause a slight decomposition of the oil, which, though not serious technically, is objectionable when a subsequent determination of the capacity of the oil for water absorption is intended. The oil is discoloured and turns turbid with deposited carbon, so that the test of Alexejew-Rothmund is difficult to conduct; in this test weighed bulks of water and of oil are mixed, and the temperature is observed at which stratification or fogging takes place.

Experiments made by Göpel with galalith, a substitute for hard rubber, which is made of milk after removing the fat, are only partly satisfactory. Galalith is a good insulator, and mechanically very strong, when dry; it swells, however, in a damp atmosphere and becomes inferior to hard rubber.

A New Element in the Platinum Group.—The *Glasgow Herald* announces that Mr. A. G. French, a Glasgow metallurgist, has discovered in the Nelson district, British Columbia, a new metal of the platinum group, which he has named "Canadium." The metal occurs as grains in dyke rocks, its amount varying from a few pennyweights up to 3 oz. per ton. The metal is untarnished by exposure to damp, and cannot be oxidised in a blow-pipe. It has been definitely proved to be distinct from platinum, ruthenium, palladium, and osmium, being much softer, and easily melted in the blow-pipe. Specimens are being sent for examination at the laboratories of Glasgow University. Mr. Thos. French, of the Overlea, Clarkston, near Glasgow, informs us that the mine in which the new element occurs was discovered about six months ago, and promises to prove a very important source of the metals of the platinum group.

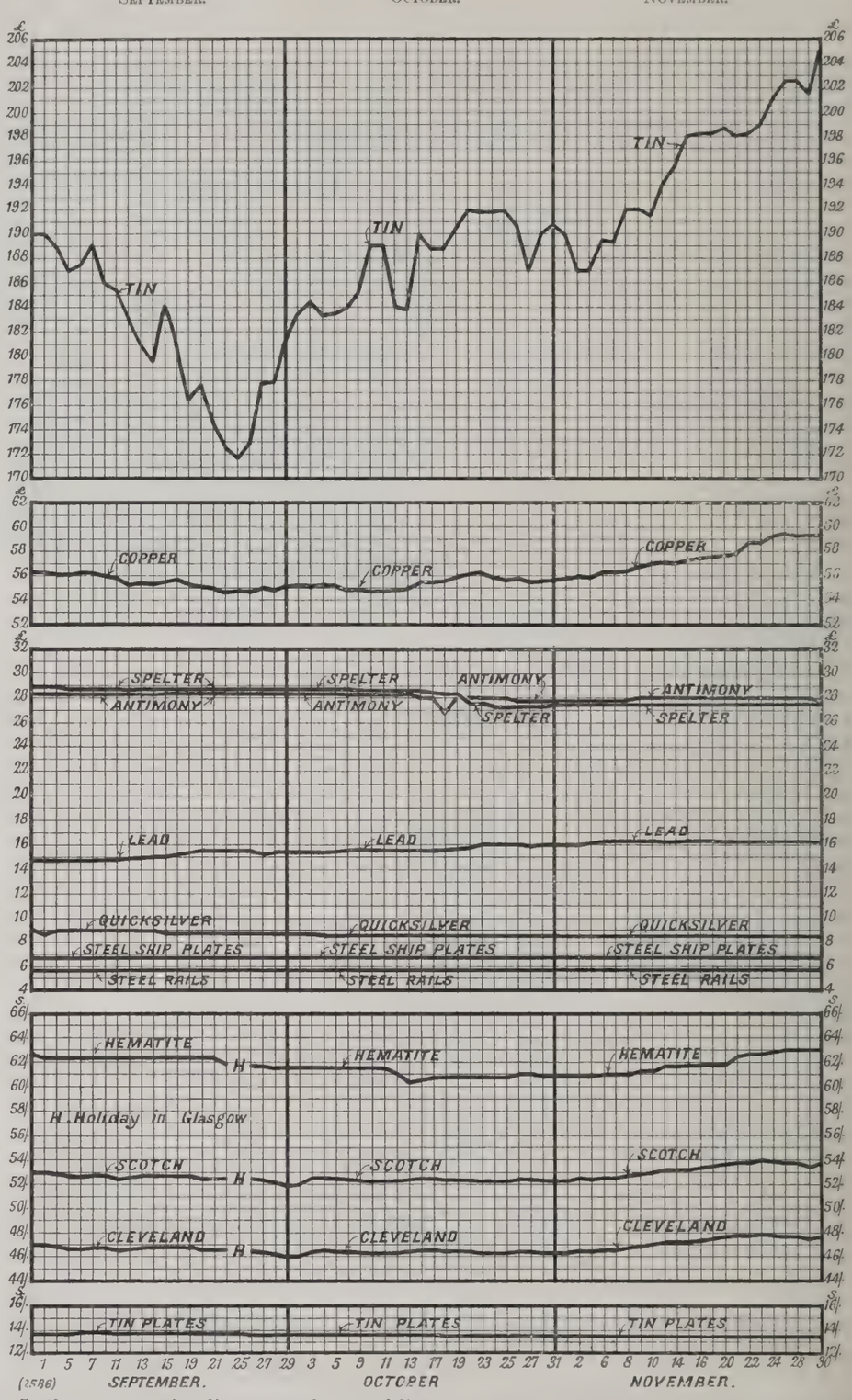
New Reduction Process for Iron Ore.—Much activity prevails within Swedish metallurgical centres, with regard to the reduction of iron ore. The electric smelting process, now in operation at Trollhättan, and adopted at other works, has already been fully dealt with in this journal, and at Höganäs other interesting experimental working is at present proceeding. This is concerned with the reduction direct from the ore to a product called iron "svamp," or sponge, with a percentage of from 96 to 98 per cent. iron and 0.2 to 0.5 per cent. carbon. For this reduction process either cheap coal, with a large percentage of ashes, or peat may be used. This process has been taken up by the Höganäs Company for the purpose of utilising the inferior kinds of coal from the company's mines, and although the process does not yet appear to have passed beyond the experimental stage, and considerable secrecy is observed as regards its details, the result is accepted as quite satisfactory.

The International Union of Boiler-Owners.—This international union now comprises sixty-one unions, located in the following countries:—Germany, France, Italy, Belgium, Austria, Denmark, Switzerland, Russia, Norway, and Finland. The union has recently held a Congress at Constance, and from the report read on that occasion it appears that the first union of boiler-owners, or boiler control union, was formed as far back as 1866, in Baden, but its life was only brief. Now 85 per cent. of all boilers working in Germany are under the control of the unions; in Baden the figure is as high as 95 per cent. The beneficial effect of the union appears from the fact that during the last thirty years, in spite of the tremendous growth of the industries, there have only, on an average, been fourteen boiler explosions in the year. In the course of the year several specimens of torn tubes had been sent in for examination, and the failures investigated. Several papers of interest were read.

Third-Class Sleeping-Cars on the Swedish State Railways.—In accordance with the wishes of the Swedish Parliament the State railways last year built some excellent third-class sleeping-cars, which were put on the Stockholm-Gothenburg line. The new departure received general approval, and it was looked upon as a matter of course that this reform would be adopted on other important State railways. In spite of the admirable equipment of the cars and the very moderate charge (2 kr. 50 öre, or barely 2s. 10d.), the State railways were quite prepared to build an additional number of these cars during 1912, but a year's working has shown that third-class sleeping-cars do not appear to be sufficiently appreciated, only 41 per cent. of the forty-eight berths in each car having, on an average, been taken. As some of the sleeping compartments can be transformed to ordinary compartments, the loss of accommodation has not actually amounted to 60 per cent.; but of the available sleeping-berths, only 70 per cent. have been booked. Under these circumstances the State railways have decided to continue the test-running for another year before increasing the number of third-class sleeping-cars.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



In the accompanying diagrams each vertical line represents a market day, and each horizontal line represents 1s. in the case of tin-plates, hematite, Scotch and Cleveland iron, and 1*l.* in all other cases. The price of quicksilver is per bottle, the contents of which vary in weight from 70 lb. to 80 lb. The metal prices are per ton. Heavy steel rails are to Middlesbrough quotations. Tin-plates are per box of I.C. cokes.

Commercial Preparation of Pure Nitrogen.—A high degree of nitrogen purity is essential for the preparation of calcium cyanamide and nitrolim from calcium carbide and nitrogen, which is sometimes considered a more profitable process for the fixation of atmospheric nitrogen than the electric oxidation of the nitrogen to nitric acid. Any oxygen present in the nitrogen burns the carbon electrodes, by the aid of which the calcium carbide is heated for making it combine with the nitrogen. In the *Comptes Rendus* of October 23, 1911, Georges Claude claims to have perfected his apparatus for the isolation of nitrogen from liquid air to such an extent that he can obtain a nitrogen of 99.9 per cent. and commercially guarantee a nitrogen of 99.8 per cent. His account is not illustrated, and the description of his apparatus is difficult to follow. He re-evaporates about a third of his impure liquid nitrogen, and washes it in a liquid still containing 4 per cent. of oxygen. Both the Società Italiana Carburo di Calcio, at Terni, and the Alby Carbidfabriks have installed his apparatus; the former two apparatus, each supplying 400 cub. m. of nitrogen of 99.7 per cent. per hour, the latter two, each yielding 500 cub. m. of nitrogen of 99.8 per cent. per hour. The Stockholms Superfosfatfabriks, he further states, is installing two sets of apparatus, each for 400 cub. m. of nitrogen per hour.

FORD'S GRAB WITH WIRE-ROPE SUSPENSION.

CONSTRUCTED BY MESSRS. STOTHERT AND PITT, LIMITED, ENGINEERS, BATH.

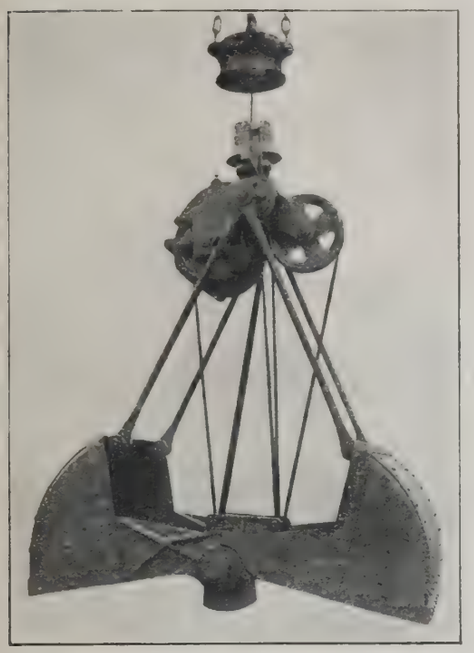
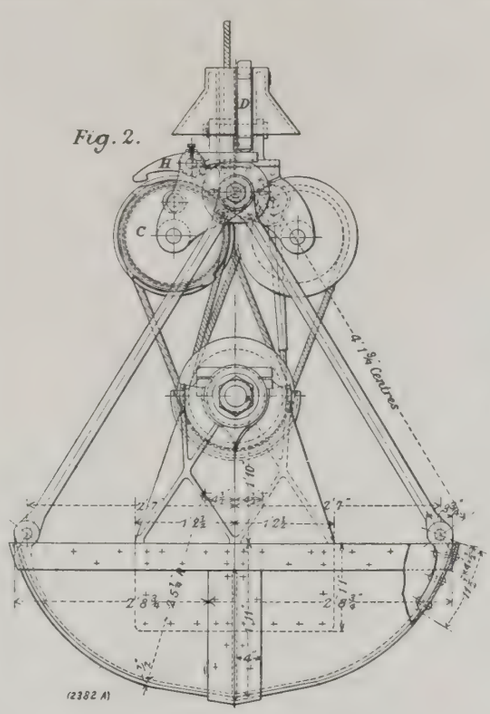
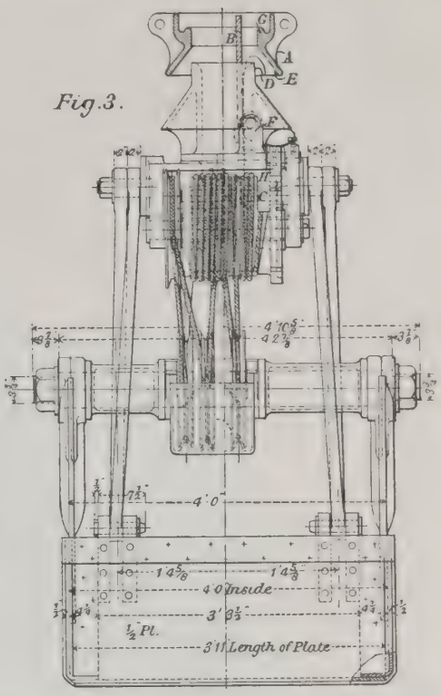


FIG. 1.





IT is now common practice to fit cranes with lifting-ropes instead of chains, and, in order to work a single-chain grab with a crane so fitted, it is, as a rule, necessary first to remove the lifting-rope and substitute the chain, and also to alter the jib-head pulley and lifting-barrel to suit. In the grab we illustrate above, which is manufactured by Messrs. Stothert and Pitt, Limited, of Bath, the rope is so attached that the grab may be hauled in and discharged at the jib-head, or other convenient height, without any alteration having to be made to the standard crane, and without the splice of the crane lifting-rope passing over the pulley. The crane-rope does not pass round the purchase-pulleys on the grab, but is made fast to an attachment in the top barrel, and the crane-rope can be detached from the barrel of the grab, so as to replace the ordinary lifting-hook in a few minutes. It is also possible with the grab shown to give almost any purchase, combined with a great length of stroke. The releasing-gear in the head is very simple.

The grab, with the jaws open, is shown in Fig. 1, which is a perspective view reproduced from a photograph. The details of construction and the action of the grab will, however, be better understood from Figs. 2 and 3, which are respectively an end and a side elevation of the appliance. Referring to these two outline drawings, it will be seen that there is a discharging-ring A, which is suspended from the jib-head by means of chains at any convenient height from the ground, the purpose of this ring being the discharging of the grab when required. We will assume that the grab is closed and hangs down from the crane-rope B, which is attached to the barrel C. When the grab is hoisted up into the ring A the dog D slides up the inclined part E and engages with lip G. As the grab descends the weight of the grab is transferred from the crane rope to the ring A, the dog D sliding up, to the extent of the oval hole F, and dropping the pawl H on to the wheel C (Figs. 2 and 3). The dog D being now held up, by paying out the crane-rope the grab is opened, the ratchet-teeth on the barrel C being so cut that they pass beneath the pawl H in one direction—*i.e.*, when opening the grab. When the grab is open the crane-rope is hauled in and the ratchet teeth on the barrel C engage with the pawl H, keeping the jaws of the grab open. When this takes place the weight of the grab is transferred back to the crane-rope from the ring A. The dog D is then supported on the tail end of the pawl H, and falls back clear of the supporting ring and leaves the grab free to descend. When the grab rests on the ground the pressure between the pawl H and the ratchet teeth on the barrel C is relieved, and the weight of the dog D on the tail end of the pawl H lifts it clear of the ratchet teeth, leaving the barrel C free to rotate in the reverse direction, thereby closing the grab. The crane-rope does not pass round the purchase-pulleys in the grab, but is attached to one end of the barrel C, being coiled on this barrel when the grab is open, and uncoiled when the grab is closed, as shown in our illustrations, the grab-rope and the crane-rope following each other across the barrel each time the grab is closed and opened.

With a grab of this type it is possible to get great length of stroke and a very high purchase, and, owing to the small number of moving parts, the possibilities of the gear getting out of order are very small even when working under adverse circumstances. We understand that this type of grab has been at work in iron ore, &c., for some time with very satisfactory results. It can also be fitted with a chain instead of a rope, the head-gear being so arranged to take the chain instead of the rope.

FOREST RESERVES IN CANADA.—According to the *Journal of the Board of Agriculture* certain lands in Canada are scheduled as forest reserves for the growth of timber, the conservation of minerals, the maintenance of conditions favourable to a continuous water supply, and the protection of fish and other animals. To effect these purposes the Dominion Forest Reserves and Parks Act received the Royal assent in May, this year. The Act provides for the appointment of rangers, and the expropriation of any land within the schedule areas not vested in the Crown. Protection is afforded to those licensed to fell timber, and the making of necessary public roads is provided for. During railway construction fire rangers may be appointed for the protection of the forest, half the cost of which service is to be borne by the railway. The Governor in Council may make regulations for the proper utilisation of the reserves, and may proclaim areas as Dominion parks, parts of which may be made available for building. Twenty forests, of a total area of about 25,200 square miles, are established; of this area 2115 square miles are in British Columbia, 3584 in Manitoba, 937 in Saskatchewan, and 18,564 in Alberta.

SUPPOSED MELTING OF CARBON.—Since 1909 La Rosa has made experiments which appear to him to have proved at any rate an incipient fusion of carbon. He heated rods of graphite by strong electric currents, and found that they bent under their own weight; when the full current was suddenly turned on, the carbons would explode, and some of the scattered particles looked as if they had been fused. Experiments, simultaneously published by O. P. Watts and C. E. Mendenhall in the *Physical Review* and the *Annalen der Physik* of July, 1911, do not confirm this assumption. Rods, 6 mm. in diameter, from 15 cm. to 30 cm. in length, and of three kinds of carbon, made by the National Carbon Company, of Cleveland, by Conradty (German graphite), and by the Acheson Graphite Company, were taken and heated by currents of 600 amperes at 110 volts. The bending and curving observed was ascribed to a softening of the binding material. There was, however, also some bending at an angle of 50 deg. in the pure graphite at 2700 deg. Cent., and this increased afterwards during cooling. Suddenly heated rods showed the tubercular swelling described by Rosa and the formation of a crust of very fine-grained graphite, not upon the hottest parts, however, but upon the colder parts. The appearance suggested that some compound was volatilised and recondensed. Watts and Mendenhall believe that very hot carbon becomes more plastic.

THE ELECTRIC AARHUS-RANDERS RAILWAY, DENMARK.—This Anglo-Danish undertaking seems destined to be constantly hampered in its progress. Some months ago the various municipalities accepted the terms ultimately submitted, the only point remaining in abeyance being the concession, which was looked upon as a mere matter of form. Since then difficulties seem to have arisen. Further, the Aarhus Corporation, which had agreed to supply electric energy at the low price of 7 öre (barely 1d.) per kilowatt-hour, on the advice of their technical expert that this price, though leaving no profit, would not result in loss, seems to have reconsidered the matter, and at a recent meeting they have annulled this offer.

"ENGINEERING ESTIMATES, COSTS, AND ACCOUNTS."—The first edition of this work appeared in December, 1889. The third edition, revised and corrected by the author, "A General Manager," has now been issued by the publishers, Messrs. Crosby Lockwood and Son, 7, Stationers' Hall-court, Ludgate-hill, E.C., at the price of 7s. 6d. net. It deals in detail, and in a most practical way, with estimating and the drawing up of accounts for all classes of shop work, commencing with the calculation of the weights of different engine parts, the cost of materials, the estimation of workmanship in the various trades, and the apportioning of office expenses, down to the calculation of cost of pieces of machinery and boilers, with forms of specification for their supply. A very large number of interesting illustrations are given in the form of tables, which constitute as many examples for arriving at the cost and selling prices of both new work and repair work. The divisions followed in the book facilitate reference for comparison purposes to the examples given, and these, together with the explanatory remarks with which they are accompanied, show that the author is an experienced man of business.

CALCULATOR FOR FERRO-CONCRETE.—Messrs. J. H. Holden and Co., Limited, of 8, Albert-square, Manchester, have just placed upon the market a calculator, due to Mr. W. N. Twelvetrees, for solving mechanically practically every problem in ferro-concrete construction. The instrument is based on the fact that if, as is commonly assumed, plane cross-sections of a beam remain plane after flexure, the stresses in different parts are proportional to the distance from the neutral axis. The instrument is therefore provided with a cursor, on which is pivoted an arm which can be clamped in any position. One end of this arm moves over a scale showing the maximum stress in the concrete, and the opposite end over a scale showing the stress in the reinforcement. If the two stresses are given and the cursor moved, so that opposite ends of the pivoted arm indicate the desired stresses, the cursor will then show, on a scale provided for the purpose, the position of the neutral axis, whilst from another scale can be read off the proportion of reinforcement required and the depth of the effective lever-arm between the compressed and extended elements of the beam. The relative economy of alternative designs of beam can be ascertained almost instantaneously, and rules are given by which the instrument can be applied with equal ease to the case of T beams, such as commonly make up a ferro-concrete floor. A clearly-written descriptive pamphlet, with numerous numerical illustrations of the method of applying the instrument to the most diverse problems, has been drawn up by Mr. Twelvetrees.

THE BELFAST MUNICIPAL TECHNICAL INSTITUTE.

The New Mechanical Engineering Laboratory.

By W. J. Crawford, D.Sc., Mechanical Engineering Department.

Technical education in Belfast is of recent growth, only eleven years having passed since the movement was inaugurated; yet in this short time progress has been very rapid. Year by year there has been an increase in both the quantity and the quality of the work done, until in the present session almost 6000 individual students are attending the Institute, of which a general view is given in Fig. 1, Plate LIX., with this week's issue, and the programme of study comprises instruction in every leading subject required by the trades and industries of the city.

The Engineering Section of the Institute has received very full consideration from the Technical Instruction Committee, and it is with the latest development in this respect—the opening of the new Mechanical Laboratory—that this article has to deal. The whole of this installation has been planned and carried out by Professor Smith, Head of the Department of Mechanical Engineering, who has expended much labour upon it. It comprises a very complete experimental plant of the most modern description.

The opening ceremony was performed by Professor Perry, LL.D., D.Sc., F.R.S., on November 24, who delivered an inspiring address. The eminent lecturer, in the course of his remarks, said that he considered the equipment of the new laboratory was perhaps the finest he had ever seen. In particular he referred to the moderate dimensions within which the individual units had been kept. In many mechanical laboratories large steam-engines and great 100-ton testing-machines were to be found, a type of equipment which the student could only work when a professor and a demonstrator or two were looking after him; the student was afraid of big engines.

The machinery installed in the new laboratory was such that in every case two or three students would be competent to take charge of any unit, and they would run little risk of doing themselves any injury.

The following is a detailed description of the Mechanical Engineering Laboratory, of which a sectional elevation and a plan are given in Figs. 2 and 3, Plate LIX., while in Plate LXII., Figs. 12 and 13, are shown two general views of the inside of this Laboratory. The figures in brackets in the following description refer to the numbers on the plan, Fig. 3:—

Mechanical Engineering Department.—The mechanical engineering laboratory, which is 114 ft. long by 42 ft. wide, is situated on the ground floor of the institute, and, being placed in the centre of the block, has no buildings immediately above it. It is divided into two long bays and is covered with a glass roof. Two hand travelling cranes, placed at such a height as to clear comfortably all pipes and pieces of machinery, run its whole length. The floor is double, there being a clear space of 3 ft. between the levels. This arrangement is very convenient, because it permits the placing of all apparatus not directly needed for experimental purposes, out of sight, and hence the keeping of the floor space proper free for uninterrupted movement of students and teachers. Furthermore, it permits all shafting to be placed below ground. Easy access is given to the space between the floors by numerous trap-doors. The top floor is paved with red tiles, which give a serviceable and at the same time pleasing appearance to it. The laboratory contains a lecturer's and students' desks (1 and 2, Fig. 3). A large office (34), fitted with tables, shelves, &c., is built against the back of the laboratory in the centre of its length, for the use of teachers in storing small tools, small testing implements, drawings, catalogues, &c. This office commands a view of the whole room. An interdepartmental telephone system is installed, so that ready communication may be had with any of the departments of the institute. A small fitter's bench (29) serves for work which it is not necessary to take to the machine-shop.

The laboratory is lighted with sixteen 200-candle-power drawn-tungsten lamps with holophane shades, and small electric hand lamps are also provided which can be moved to any machine at will. The underfloor also is illuminated by incandescent lamps. The laboratory is heated in winter by a system of pipes conveying hot water, and is ventilated as part of the general scheme on the plenum system.

The Testing Plant.—The boiler-house, which is situated across the passage from the laboratory, contains a Lancashire boiler, a marine boiler, pumps, water-meter, economiser, internal feed-water heater, and induced-draught fan with variable-speed motor. The feed water can be heated directly or put through the economiser and the internal feed-heater. Saturated or superheated steam may be drawn off. From the boiler-house pipes radiate to the different steam units in the laboratory. These units discharge to either a surface or an ejector condenser. The piping is so arranged that out of a set of five units it is possible to run complete consumption tests on two units at a time. The circulating water is measured by weirs, and the condensed steam by a calibrated tank.

In the hydraulics section a head of 280 ft., generated by a high-lift turbo-pump, is employed to drive, in sections, the various turbines. The water is taken from a tank below the upper laboratory floor (this tank is divided into two portions), and is discharged to the same tank through a channel and tumbling bay. Arrangements are provided on the pumps and turbines for measuring the electrical horse-power, the brake horse-power, and water quantities. The drawing indicates clearly the general arrangement.

The Boiler-House.—The Lancashire boiler, which is 28 ft. by 8 ft., was manufactured by Messrs. Joseph Adamson and Co., Manchester. In connection with it a Sugden superheater is installed, and steam temperatures are taken at the inlet and the outlet. The marine boiler, which is 11 ft. by 11 ft., is by Messrs. Workman, Clark, and Co., Limited, Belfast. Inside the steam space there is a feed-water heater by Messrs. Hamilton and MacMaster, Belfast. A recording pressure-gauge, connected to both boilers, records on a revolving card the variation of steam pressure during 24 hours. An economiser by Messrs. Green and Son, Wakefield, is employed, and the inlet and outlet temperatures of gases and water are taken by thermometers. The variable-speed motor-driven fan is by Messrs. Musgrave and Co., Belfast.

There are two feed-pumps. One is by Messrs. G. and J. Weir, Glasgow, and is fitted with indicator cocks for both water and steam; the other is by Messrs. Pearn and Co., Manchester, and is similarly equipped. A Kennedy feed-water meter is installed.

Space is left in the boiler-house for a tubular boiler. A complete set of feed-tanks is provided under the laboratory floor, from which the volume of feed-water can be measured. Arrangements are made by which platinum thermometers may be inserted in the furnaces, tubes, combustion-chambers, flues, and chimney, the temperature record being taken by a Callendar recorder fixed in the main laboratory.

Steam Section.—The main steam-engine (22), illustrated in Fig. 4, Plate LX., is of the horizontal cross-compound type, and is by Messrs. Combe, Barbour, and Co., Limited, Belfast. It is of 60 indicated horse-power, at a steam pressure of 120 lb. per square inch, 15 deg. Fahr. superheat, and 100 revolutions per minute. As this engine was specially designed for experimental purposes, it differs considerably from a similar powered engine built to standard patterns for ordinary purposes. It is, for instance, considerably heavier in its various scantlings, &c., as it is used sometimes as a single-cylinder engine, either condensing or non-condensing. As a matter of fact, the piston, piston-rods, &c., are designed for full boiler pressure on the low-pressure cylinder. The high-pressure rods are made the same size as the low-pressure for the sake of symmetry.

The engine is so designed that it can be used under any of the following conditions—viz.:—

1. Compound condensing.
2. Compound non-condensing.
3. Single-cylinder condensing (using low-pressure cylinder).
4. Single-cylinder non-condensing (using low-pressure cylinder).

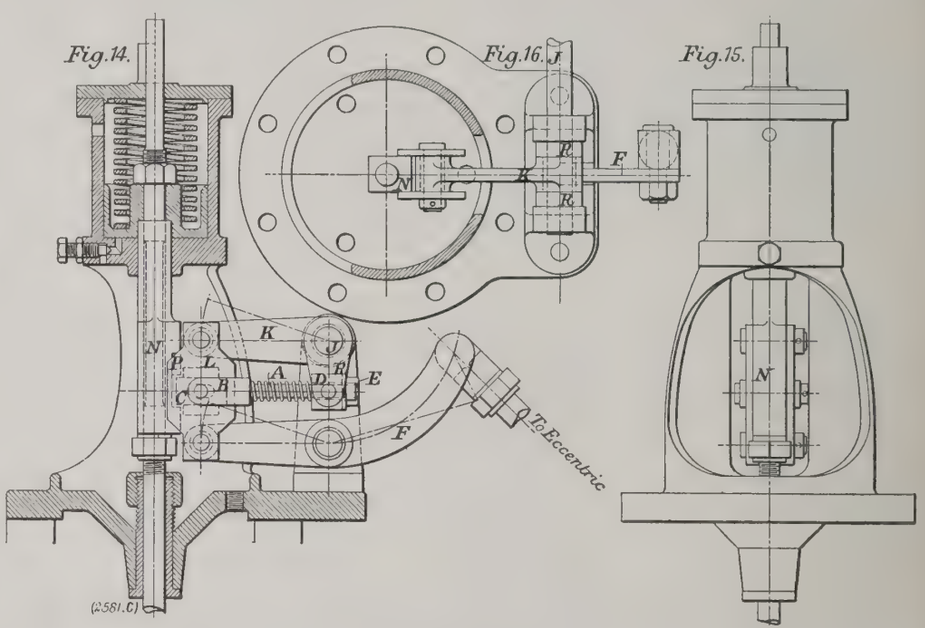
The engine is so arranged that the cranks can be set at any desired angle, the power between the two halves of the crank-shaft being transmitted by a clamping strap tightened up by bolts over the coupling rims. In order to run single cylinder, this strap is slackened off and lies on the idle portion of the shaft, and the high-pressure eccentric straps, which are very small and light, are simply removed from their respective eccentrics. The high-pressure eccentrics are placed outside the others for convenience of adjustment, as these are the ones most affected by a change in the position of the cranks. All the eccentrics are secured each by a single serrated set-screw and die, and adjustments can be made in a few minutes.

A branch is placed on the pipe between the cylinders, to which vessels of various size can be attached for experiments on demonstrating the effects of different receiver volumes.

The valves are all of the drop-piston type, the steam ones being operated by a new form of trip-gear designed by Mr. Crawford, of Messrs. Combe, Barbour, and Co., Limited. As this is now used for the first time, some detailed description of it may be acceptable. It is illustrated in Figs. 14 to 16 herewith. In general it comprises a forked rod attached to a sliding die carried in a link-block, the end of the rod passing through a block swinging about a pin in a lever, the position of the pin being under control of the governor. The cut-off is varied by the change in the position of the die. Such position is controlled by the motion of the block round the centre of a subsidiary lever.

A spring A between the block C and the back of the forked portion of the forked rod B keeps the die C a constant distance from the centre of the block D, and therefore the forked rod operates as a telescopic rod, which is free to shorten, but not to lengthen. The length is primarily determined by the position of a nut E on the screwed tail of the forked rod, which comes in contact with the block D.

The curved lever F, oscillated by an eccentric, is carried on a fulcrum-pin in a bracket fixed to the valve-cover. There is also another pin fixed through, and near, the top of this bracket, and on this pin is mounted a subsidiary lever K, the inner ends of which have pins fastened thereto, on which the uppermost end of the link or guide-block L is swung, whilst the lower end is connected to the inner end of the curved lever. The link or guide-block L is provided with flanges which overlap a squared portion of a trunk N, which is fastened to the vertical spindle. This prevents the spindle or trunk from turning. It also prevents the fixed steel die P which is attached in a recess in the trunk from turning. In the sides of the sliding-link or guide-block L there is a horizontal slot, in which is the sliding-die C furnished with projecting pins for engaging in the recesses in the guide-block L. The pins are attached to the forked rod B. On this rod there is mounted the pin-block D, which is free to slide on the forked rod, and is also secured to the end of two plate-levers R, which are free to swing.



The pin-block D is provided with a leather washer on which the nut of the forked rod butts each time the sliding die C moves into engagement. The pin-block D has also two lugs to prevent the nut on the forked lever from turning and altering the depth of engagement of dies. The spiral spring A keeps the sliding die C in position for lifting the valve. At the bottom end of the spindle the piston-valve is secured. On the upper end of the spindle there is a cushioning piston and cylinder. The cushioning cylinder is provided with an air inlet and regulating-screw. The pin J is connected to the governor of the engine. Thus it will be seen that the cut-off is varied by the changes in the position of the sliding die C coming into engagement with the trunk N, and thus operating the valve.

The exhaust-valves are positively driven in the usual manner. The exact valve-settings can be ascertained by markings on the ends of the spindles which are produced through the bonnets, and marked with the widths of their respective valves, a portion of the covers being set out to represent the valve-ports. Adjustments for lap and lead, &c., can therefore be made and demonstrated without the necessity of having to open up the cylinders. The governor is of the Hartung type, driven off the eccentric shaft, and apparatus has been designed for the determination of complete curves for the analysis of its motion. The brake-band is so arranged that by means of a toggle-lever the load can be thrown off, and governing tests, from various loads to no load, carried out. The cranks are designed for removable balance-weights, so that the effect of different weights with different crank angles can be ascertained by suitable apparatus. Metallic packing by the United States Metallic Packing Company, Limited, is used. The same company supplies four special indicating-cocks which are unable, to jam under any

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(For Description, see Page 778.)

Fig. 1.

Fig. 2.

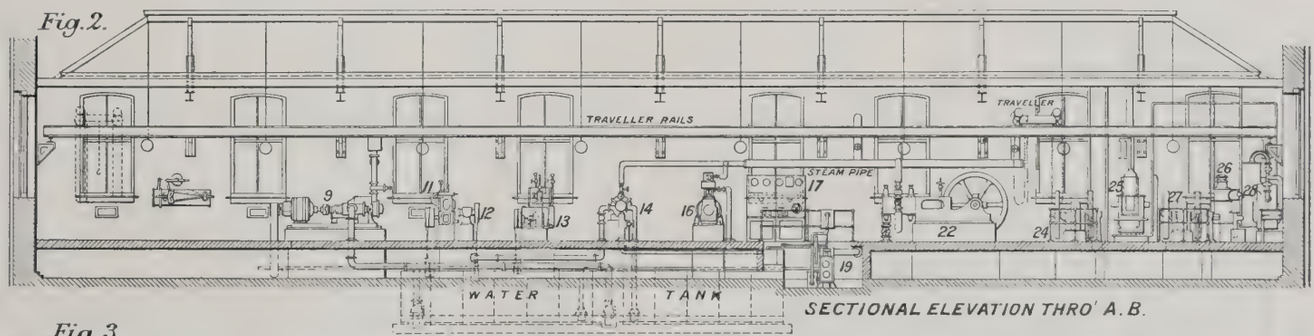
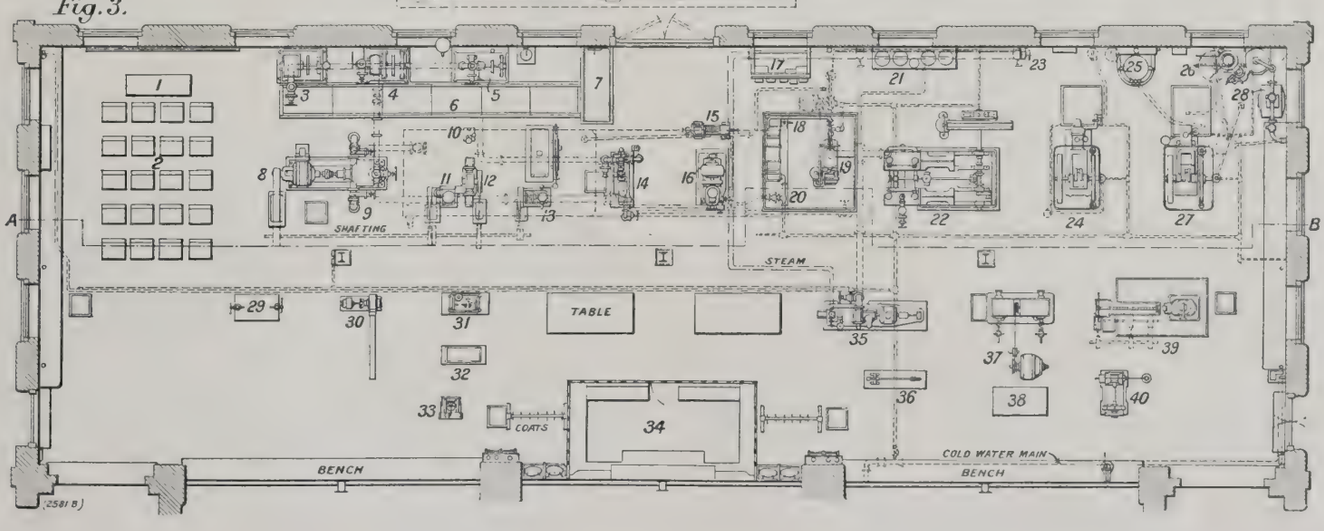


Fig. 3.



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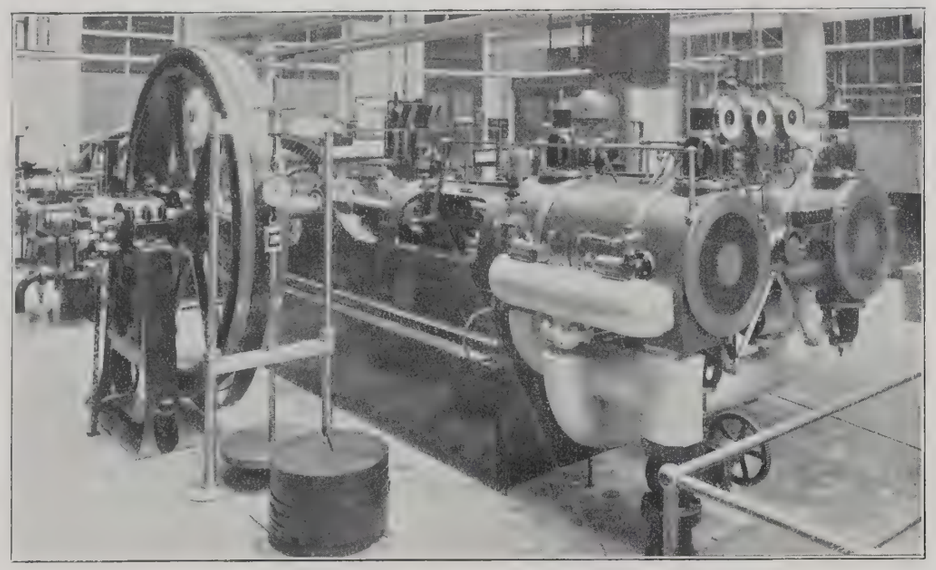

FIG. 4. 60-HORSE-POWER CROSS-COMPOUND STEAM-ENGINE, WITH TESTING-GEAR.

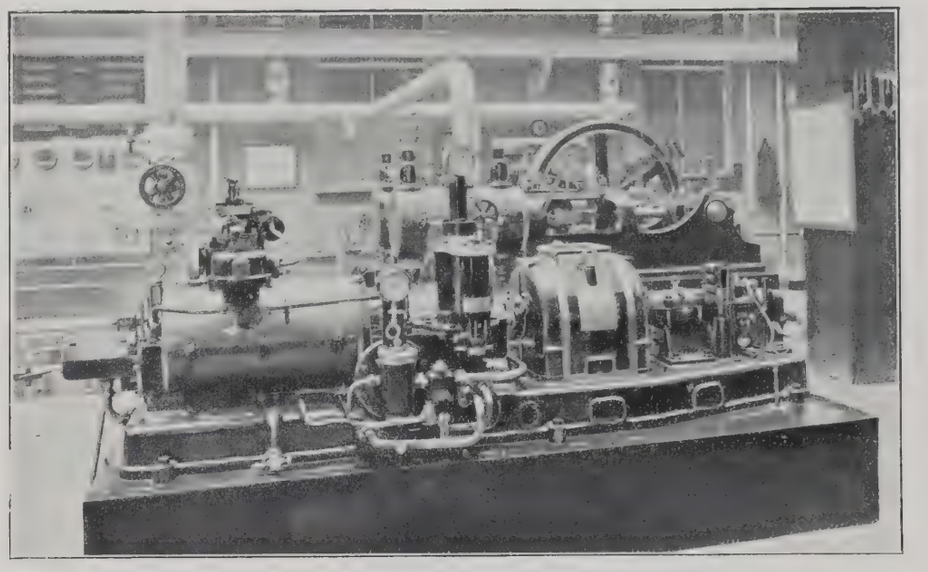

FIG. 5. PARSONS TURBO-ALTERNATOR.

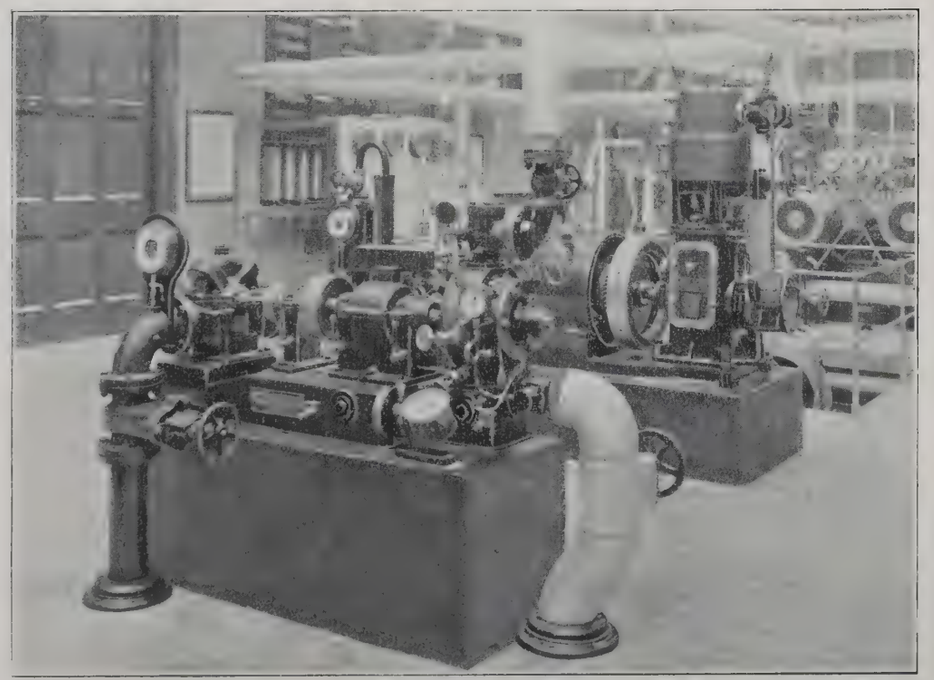

FIG. 6. DE LAVAL STEAM-TURBINE AND PUMP, AND ALLEN HIGH-SPEED ENGINE GENERATOR SET.

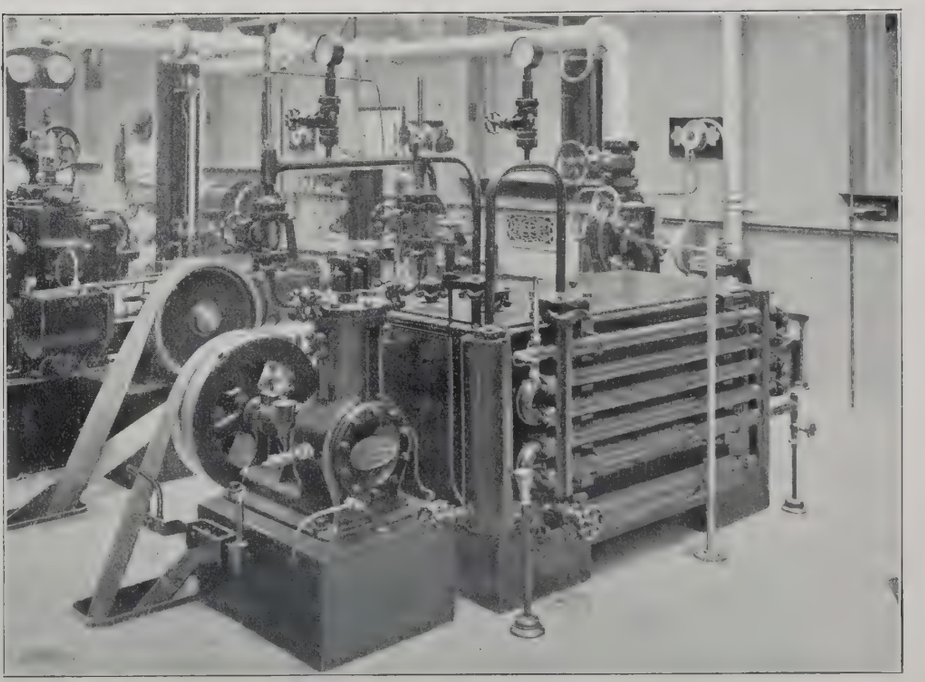

FIG. 7. REFRIGERATING-MACHINE.

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(*For Description, see Page* 778.)

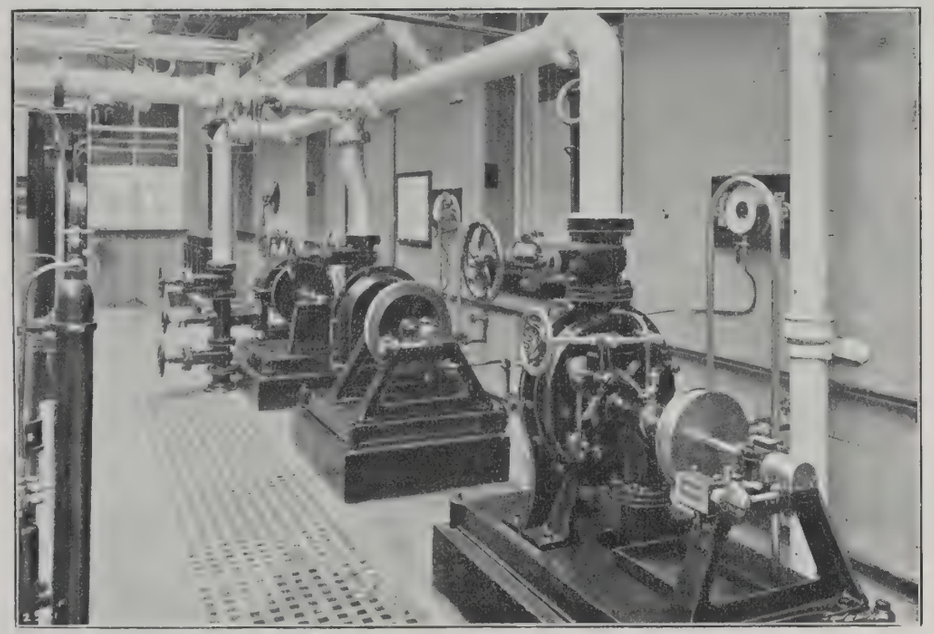

Fig. 8. The Hydraulic Turbines.

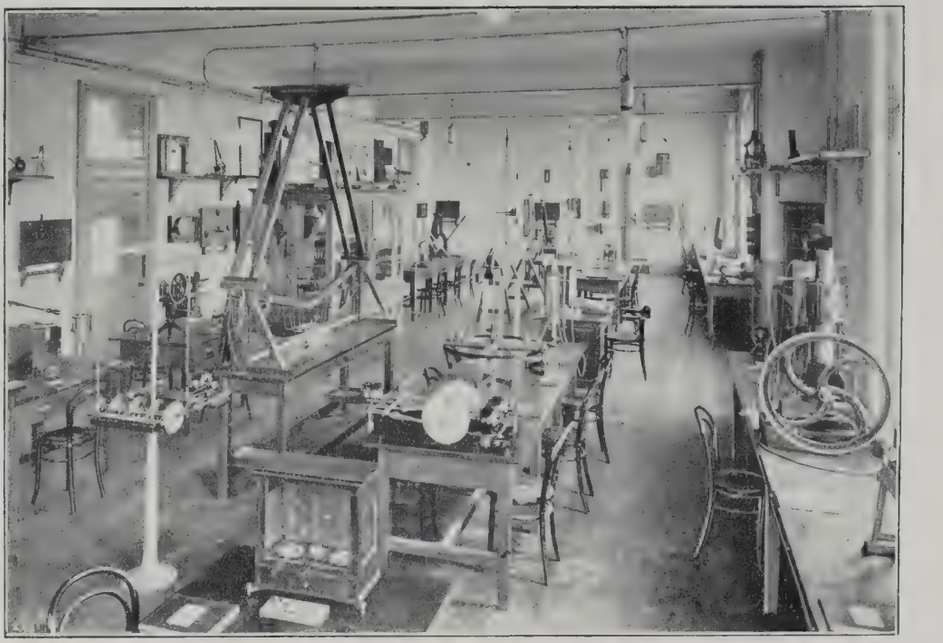

Fig. 9. The Experimental Mechanics Laboratory.

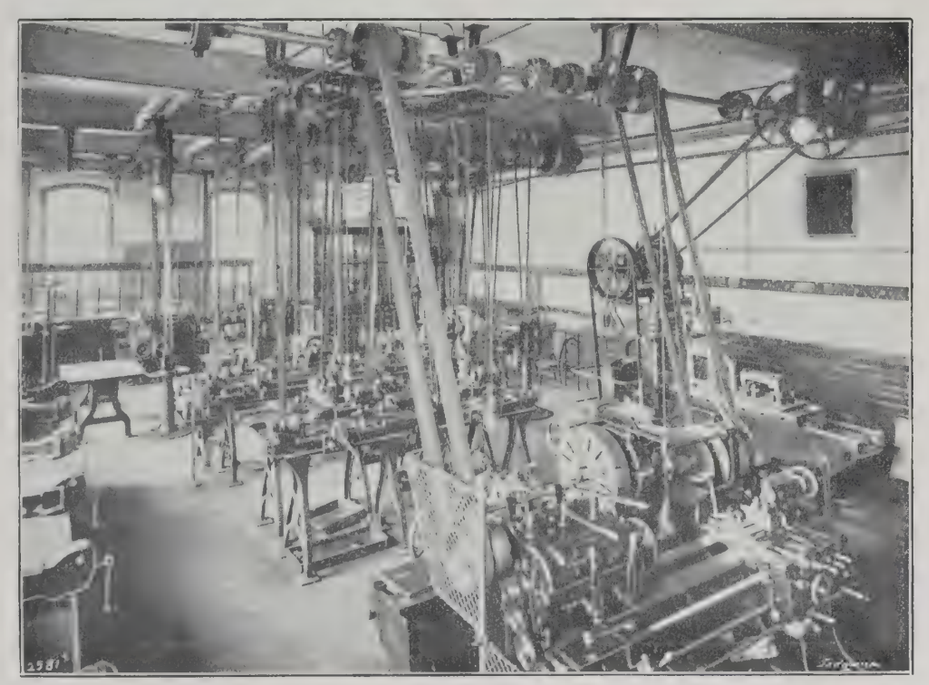

Fig. 10. View in Mechanical Engineering Workshop.

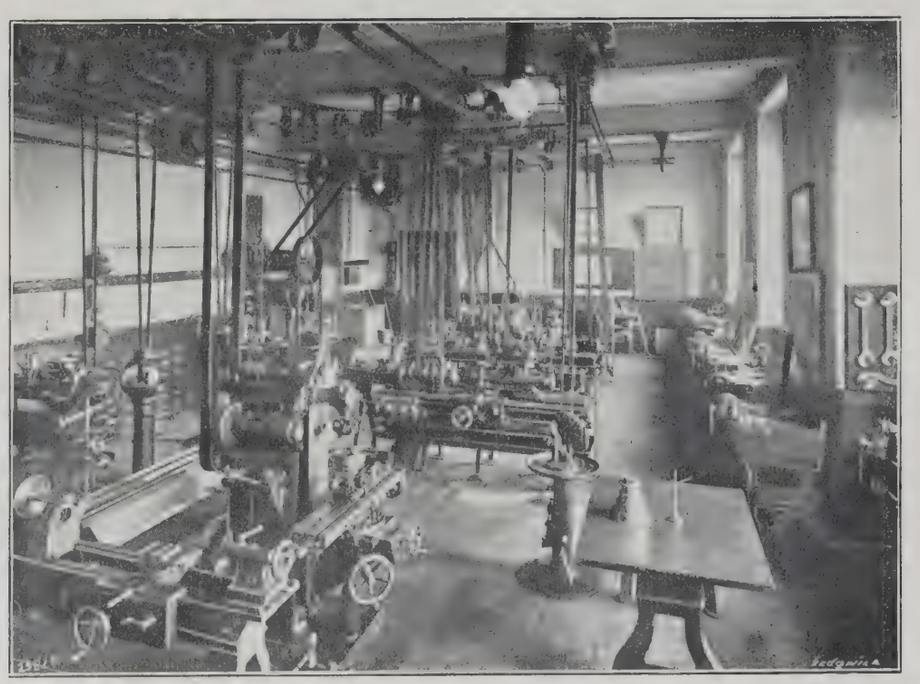

Fig. 11. View in Mechanical Engineering Workshop.

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(*For Description, see Page* 778.)

FIG. 12.

FIG. 13.

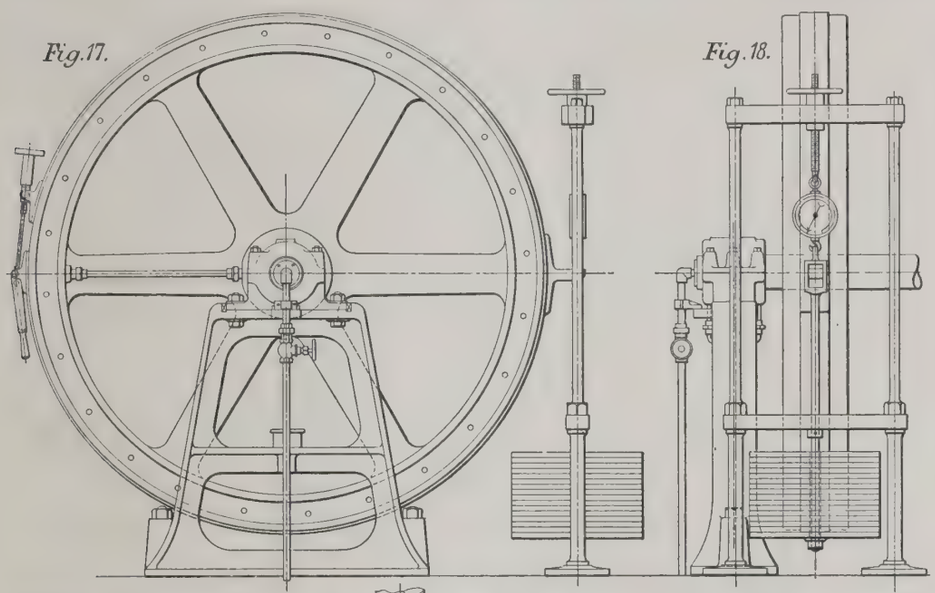
FIGS. 12 AND 13. GENERAL VIEWS IN THE MECHANICAL ENGINEERING LABORATORY.

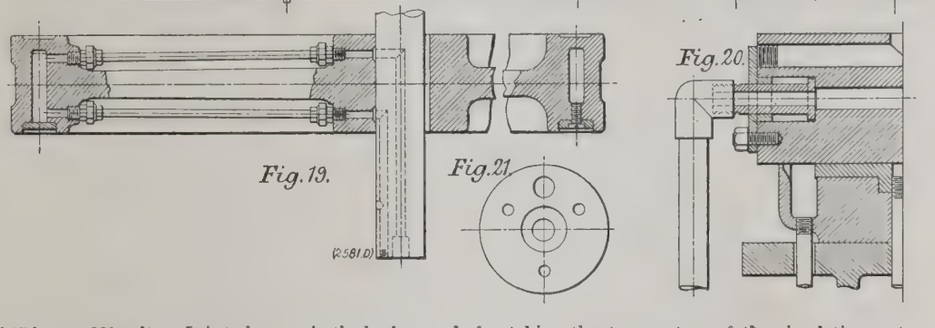
(*To face Page* 779.)

conditions. Three gauges are provided—the first to measure the steam pressure just at the entrance to the high-pressure cylinder, the second to measure the steam pressure just at the entrance to the low-pressure cylinder, and the third to measure the pressure in the exhaust-pipe. The fly-wheel is designed for a Prony brake, and has a hollow water-cooled rim. It may be seen fitted up in this way in Fig. 4, Plate LX., while Figs. 17 to 21 give various details of the brake showing the arrangement for water circulation. In addition to brake tests by weights, the power can be ascertained at a glance by means of a new torsion-meter designed by Professor Smith.

Parsons Steam-Turbine.—A 16-kw. Parsons turbo-alternator and exciter (35), shown in Fig. 5, Plate LX., is installed. The alternator delivers three-phase current, which is taken to the main switchboard. It is intended to experiment later with this current on some of the machines in the textile laboratory.

The High-Speed Engine.—A high-speed engine (16) of 25 brake horse-power, at 750 revolutions per minute, by Messrs. W. H. Allen, Son, and Co., Limited, Bedford, is installed. It drives directly a direct-current generator





of 15 kw. at 220 volts. It is to be seen in the background in Fig. 6, Plate LX. It is of the enclosed type, having forced lubrication. The governor is furnished with a hand regulating-gear, to permit of the speed being adjusted while the engine is running. Two pressure-gauges, one vacuum gauge, and one thermometer cup are suitably mounted near the engine side of the stop-valve. Indicating gear of simple but strong design is provided. The generator is of the compound type, and the electric load consists of similar unit resistance-coils mounted on a framework erected behind the main switch-board, the units being thus easily inspected at any time. The switch-panel, which is part of the main switchboard, will be described later.

Impulse Steam Turbo-Pump.—A De Laval steam-turbine (14), shown in the foreground in Fig. 5, by Messrs. Greenwood and Batley, Limited, Leeds, of 15 horse-power and 40,000 revolutions per minute, drives a centrifugal pump through a 10 to 1 gearing. The pump, which lifts 160 gallons of water per minute against a head of 160 ft., receives water from the tank under the laboratory upper floor and delivers it into the large measuring bay. The pump may be disconnected, when a friction brake mounted on the main shaft enables brake-horse-power tests to be carried out. The various pressure-gauges enable an experimenter to carry out consumption tests, when the particulars of the nozzles have been obtained. The nozzles can be readily withdrawn, and they can be easily tested on a special apparatus of the Stodola type erected on the near wall of the laboratory.

Feed-Pump.—A small Worthington duplex feed-pump (15) of the ordinary commercial type is installed. It draws in water from a small suction tank and discharges through an air vessel and throttling valve to an orifice tank. From this the water flows back to the suction tank. A counter records the number of strokes of the pump. Indicator cocks on both steam and pump cylinders, and simple indicating gear suitable to both cylinders, are supplied.

An experimental plant for the testing of exhaust and live steam injectors has been erected on the laboratory wall. This also includes a small piece of apparatus for testing the condensation occurring in steam-pipes lagged in various ways.

The Condensing Plant.—The whole of the condensing plant, which is designed so as to be suitable for dealing with the largest steam unit in the laboratory, is located in a pit placed centrally with respect to the engines, the pit being enclosed by steel hand-rails,

There are two condensers: (*a*) a surface condenser (19) by Messrs. Isaac Storey and Sons, Limited, Manchester, and (*b*) an ejector condenser (20) by Messrs. Ledward and Beckett, Limited, London. The former is of the contra-flow type. The tubes are of solid brass, $\frac{5}{8}$ in. in diameter, by 18 B.W.G., and are fitted with screwed tops and ferrules of brass. The condenser is fitted with atmospheric pipe and valve, so as to act as an atmospheric condenser when required. For the purpose of the experiment, thermometer cups have been supplied as follows:—One in the water admission, for taking the temperature of the circulating water at entrance; one in the water-discharge pipe, for taking the temperature of the circulating water at exit; one in the hot-well, for taking the temperature of the condensed steam; and one in the upper part of the condenser, where the steam is admitted.

The centrifugal circulating pump of the surface condenser is driven directly by a variable-speed Westinghouse direct-current motor, operating at 440 volts. The speed can be cut down to one-quarter the maximum in numerous steps. The pump draws water from one of the large calibrated tanks below the lower floor of the laboratory, each of which is 5000 gallons capacity, and discharges into a cast-iron weir tank, fitted with baffle-plates and a rectangular brass weir plate, by means of which the quantity passing is estimated. After passing the weir, the water travels back through a specially-designed channel to one of the tanks under the lower floor. Arrangements have also been made to employ circulating water from the city water main. The motor above referred to drives also, by means of a belt, a single-acting Edwards vertical air-pump fixed to the side of the condenser. The hot-well discharge passes by a pipe to a measuring-tank, consisting of two vessels one above the other, each capable of holding about 100 lb. of water, and having brass cocks, gauge-glass, and a measuring device. From the measuring-tank (18) the condensed steam runs to the laboratory drain.

The ejector condenser can also be connected to any of the steam units. All the necessary weir tanks, valves, gauges, &c., for measuring the various quantities under consideration are installed.

The Main Switchboard.—Situated within 6 ft. of the high-speed engine and turbo-sets is a Westinghouse double-panel marble switchboard (17). This controls the current from the two dynamos which form the loads for the high-speed engine and turbine.

For any power above 10 horse-power, loading by means of a brake requires cooling devices, and, moreover, the readings are somewhat unsteady. The electrical method allows the load to be put on in gradual steps, and the readings to be easily taken. In this case it was important that the students should learn various methods of testing, and become familiar with electrical instruments. In consequence, an Allen direct-current generator, running at 750 revolutions per minute, was attached to the high-speed engine, and a Parsons alternator to the turbine. The direct-current generator is capable of a continuous output of 15 kilowatts at 220 volts. The load is thrown on in steps of 10 amperes by means of seven single-pole knife-switches, mounted on the left-hand panel of the board. No damage can be done by throwing in the switches in wrong order, as each controls its load of 10 amperes.

As water resistances for absorbing the power are inconvenient in many ways, metal resistances of the Westinghouse standard pattern were adopted. The frames containing the units are mounted behind the switchboard, and admit of easy inspection and replacement of the units. A double-pole switch, field-break switch, field-regulating resistance, volt-meter, and ammeter complete the panel.

The right-hand panel contains the gear for regulating and controlling the load on the three-phase 16 k.v.a. 200-volt turbo-alternator. The alternator is of the rotating-field type. It has two poles, and runs at 6000 revolutions per minute. The exciter is fitted with the Parsons compounding device, and in consequence at a power factor of unity, the full load may be thrown on with a variation of only 2 per cent. in the voltage. Even if the alternator is accidentally short-circuited, the device prevents the current from reaching a dangerous value. It consists of magnetic leakage paths fitted across the poles of the exciter, carrying a winding, through which the main current of the alternator flows. As the load increases, the leakage coefficient of the exciter is automatically reduced, and the voltage consequently raised. It has the advantage that there are no moving parts, and, if desired, may be cut out of action. Three separate 25-ampere knife-switches with three contacts, one for each phase, control the load. In parallel with these is a rotating switch of the three-phase induction-motor starter type. The combination admits of controlling the current in 2-ampere stops from zero to 50 amperes. The instruments on the board consist of a polyphase integrating wattmeter (connected through two series transformers), so that the total number of units for the test may be registered whether the phases are balanced or unbalanced, a watt-meter and an ammeter in one of the phases and a volt-meter. As in the case of the direct-current set, a field-regulating resistance for the exciter and a field-break switch are also mounted on the panel.

Air-Compression Plant.—The primary object of this plant is to study the efficiency of an ordinary two-stage air-compressor (11) and the losses met with. A "Sentinel" air-compressor, manufactured by Messrs. Alley and Maclellan, Limited, Glasgow, has been installed. It is belt-driven from shafting below the laboratory floor, this shafting itself being driven by the motor which also drives the main centrifugal high-lift pump. Fast and loose pulleys and striking gear are provided. The air pressure generated is from 60 lb. to 80 lb. per square inch. Arrangements are supplied for taking indicator diagrams from the compression cylinder, and for measuring the heat discharge through the walls of the jacket by means of two thermometers, one in the admission pipe and one in the discharge pipe of the jacket. The jacket water is discharged to a sink, and is measured on the way thereto. The machine is supplied with pressure gauges, and a small reservoir for the compressed air discharged. Various pipes and orifices are provided to enable students to study the kinetics of air in motion.

The Refrigerating Plant.—A small refrigerating plant (13) has been provided. This consists of a refrigerating machine and a liquid-air machine. This is shown in Fig. 7, Plate LX. The refrigerating-machine is by Messrs. L. Sterne and Co., Limited, Glasgow, and is employed to produce small quantities of ice, and to illustrate the method of cooling by means of a flow of brine. It is installed also with the object of testing the conversion losses in such plants. It is driven from a pulley on the shaft under the upper floor. Thermometer cups are provided on the pipes leading to and from the compressor and to and from the condenser. The cylinder is supplied with an indicator cock, pressure-gauges, and all the necessary fittings for test-work.

The liquid-air plant is of the type manufactured by the British Oxygen Company. It consists of a Whitehead air-compressor (12) belt driven from the underground shaft, an air-liquefier, and both low and high-pressure purifiers. The whole is supplied with fittings necessary to carry out thermodynamical tests. The gas-compressor is capable of compressing about 550 cub. ft. of gas per hour to a pressure of 150 atmospheres or more when running at 400 revolutions per minute. Under these conditions it requires from 6 to 7 horse-power to drive it, and produces through the liquefier 1½ litres of liquid air per hour. All parts of the compressor are readily accessible, and the lubrication of all parts is controlled from one reservoir.

The liquefying apparatus (10) depends upon a method by which a moderate amount of refrigeration produced by the expansion of a gas may be accumulated and intensified till it reaches the point at which the gas becomes liquid under atmospheric pressure. The method lies in directing all the expanded gas, immediately after its expansion, over the coils which contain the compressed gas that is on its way to the expansion-point. The cold developed by expansion in the first expanded gas is thus communicated to the on-coming compressed gas, which consequently expands from, and therefore to, a lower temperature than the preceding portion. This intensification of cooling gas goes on until the expansion temperature is far lower than it was at starting, and the effect is so powerful that even

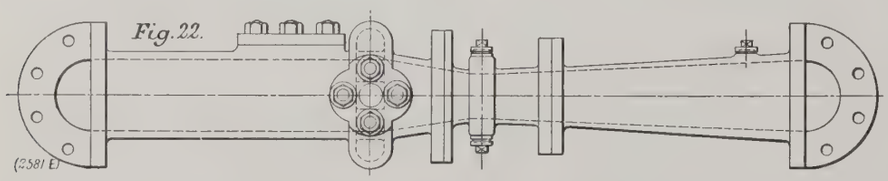
the small amount of cooling due to the free expansion of gas through a throttle-valve may be made to liquefy air without using other refrigerants.

Hydraulic Section.—Various heads of water up to 280 ft. are obtained from a motor-driven high-lift turbo-pump (9), made by Messrs. Mather and Platt, Limited, Manchester. This pump obtains its supply from either side of the measuring-tank sunk in the lower floor. It is used for (*a*) pump-testing purposes, and (*b*) supplying pressure water to any one of three experimental turbines. When employed in pump tests it delivers to the cast-iron water-channel, and works against a head produced by throttling a valve. It is of the three-stage type, and is capable of delivering 400 gallons of water per minute at a head of 200 ft. The pump is direct driven by a direct-current electric-motor (8) of 40 horse-power, 440 volts, and 77 amperes, which is of the interpole variable-speed type, and has a variable resistance of forty steps, corresponding approximately to equal drops of speed. The instruments connected to the motor include a voltmeter and an ammeter of the Weston dead-beat type, mounted on a convenient panel. The motor and pump are rigidly connected on one bed-plate and the motor is connected to the pump by a claw-clutch. The motor is also used for driving the underground shafting mentioned previously as used for the compressors, &c. A pressure-gauge reading in feet of water, and a vacuum-gauge reading in the same units, are mounted on a board near the pump, the former being connected to the pump side of the discharge stop-valve, and the latter on the pump side of the suction-valves. A counter reading to five figures is suitably mounted and geared to the motor-shaft. One experimenter can easily control all the regulating apparatus, both electrical and hydraulic, and all the gauges, instruments, &c., are so placed that he can read them without changing his position.

Cast-Iron Channel and Tumbling Bay.—The cast-iron channel (6), which receives the discharge water of the turbines, is of internal cross-section 2 ft. 6 in. by 2 ft., and has an over-all length of approximately 50 ft. It is built of flanged plates. The channel has four branches, three for receiving the discharge from the turbines, and one for the float from which the head of water above the weir is estimated. The tumbling bay (7) may be fixed in three different positions corresponding to those required for discharging into either end of the large measuring tank or into both ends at the same time. The whole of the apparatus, with the exception of the operating handle, is built so that the upper surface is level with the working floor of the laboratory. The whole channel is covered over with teak trellis-work, built in sections, and this forms a portion of the floor of the laboratory. A pipe and valve are provided for the purpose of draining the channel into the large measuring-tank. The portions of the channel above the tumbling bay and still pool are covered by chequered plates carefully cut to fit the supports provided round the wall of these sections.

The pools to which the turbines discharge are covered by the bed-plates of the machines themselves. The connections between the turbine pools, still pools, and the water channel are partially obstructed by means of perforated plates of cast iron, with rough holes 1 in. in diameter. These plates are removable for convenience in cleaning and painting. The bevel weir-plate, of Muntz metal, 12 in. wide by 16 in. deep, is very accurately machined and finished. The tumbling bay or hopper is constructed of cast-iron mounted on brackets and bearings, and is rigidly attached to the handle which actuates it. The various floats are connected to wooden rods which slide in tubes, or to brass tubes guided by wires, and they are placed in convenient positions for the measurement of different levels in the channels.

Venturi Meter.—A Venturi tube, of which a drawing is given in Fig. 22, is used for measuring the quantity of water flowing from the high-lift turbo-pump. It



consists of two conical pipes, jointed together and inserted in the run of the pipe that connects the pump with the experimental turbines. The flanges are separated by cast-iron packing-rings which do not fill up the space to the bore of the pipes, and in this space brass rings having internal hollow parts are inserted. The inner parts of these rings are open to the pipe by means of numerous small holes, there being eight in each of the two large rings and six in the small one. Connections from the outside are provided in the cast-iron packing-rings and the various small copper branch-pipes, connections, and valves for the attachment of the quantity-measuring apparatus, which consists of a mercurial gauge or U-tube, are inserted.

Pitot tubes are inserted in the pipe between the pump and the Venturi tube. These are fixed in a brass cover fitting in a suitable boss in the pipe. They consist of two ¼-in. bore copper tubes, which pass into the main pipe, and make oppositely-directed right-angled bends in it. They are fitted externally with a cock and fittings for the attachment of strong rubber tubing, to which a sensitive differential pressure-measuring device may be connected. The arrangement of valves for obtaining heads by throttling is such that the readings of the Venturi meter and Pitot tubes are not influenced, for the valves are all on the delivery sides of these instruments.

The Turbines.—The water turbines are shown in Fig. 8, Plate LXI. The Pelton wheel (3) was made by Mr. Percy Pitman, London, and develops 5 horse-power, with a fall of 75 ft., when making 400 revolutions per minute. It has an outer bearing and a brake-wheel, with hollow rim for water-cooling. This machine is fitted with a regulating nozzle and three interchangeable nozzle-tips of different diameters mounted on a swivel, and having locking arrangements for convenience in changing the nozzles. The inside of the case may be inspected, while the machine is running, through two openings, one on each side of the case, covered with plate-glass. A pressure-gauge reading in feet of water is mounted on the wall and connected to the turbine side of the stop-valve, and a counter-reading to five figures is suitably mounted and geared to the turbine-shaft.

The Girard turbine (4) is by Messrs. Gilbert Gilkes and Co., Limited, Kendal, and has a wheel of about 21 in. in diameter, and is designed to develop 6 horse-power on a 75-ft. head when making 550 revolutions per minute. It has a brake-pulley and standard, with water admission-pipes and valves, water-scoop, and drain-pipes in connection with the brake. A pressure-gauge reading in feet of water is mounted on the laboratory wall near the turbine, and is connected to the turbine side of the stop-valve. A counter, reading to five figures, is geared to the shaft.

The Thomson turbine (5) is by Messrs. Gilkes, and gives approximately 4 horse-power, with a fall of 75 ft. The guides are of brass, and have a simple external gear for indicating their position. The turbine is fitted with the necessary brake-gear, and, as in the case of the others, a pressure-gauge and a counter are supplied.

Apparatus for Experiments on Pipe Friction.—Two ¾-in. copper pipes are connected by means of two union joints to points 70 ft. apart on a 2-in. water main installed below the upper laboratory floor. The other ends of these pipes are brought close together through the upper floor of the laboratory and are attached to a differential pressure-gauge, from which the loss of head in feet is obtained. The flow of water is estimated by means of a weighing-machine and water-tank capable of dealing with 2000 lb. of water. This weighing-machine and tank are also employed for calibrating the various measuring-tanks.

Fans.—A small electric direct-driven Sirocco fan (30), a present to the Institute from Messrs. S. Davidson, Belfast, is installed. This apparatus is provided with electrical instruments, air-trunk, throttles, sensitive gauges, &c., for the carrying out of complete tests.

Testing of Materials Section.—The testing of materials is carried out by means of a very modern plant. All tension, compression, and cross-breaking testing is carried out on a Riehlé automatic and autographic machine (39), which is capable of giving a maximum load of 150,000 lb. As this machine, which is shown in the foreground of Fig. 12, Plate LXII., is now fairly well known in this country, no prolonged description need be given of it. It is a compound lever type, and its great feature is, that for its capacity it takes up very little room. It is driven by a Westinghouse direct-current electric motor of 5 horse-power and 440 volts. Eight changes of testing speed are obtained by means of a system of change-speed gears and clutches. The lower part of the machine is placed between the two floors, with the consequence that for a 70-ton machine the portion visible is remarkably small. The Riehlé is used by students for taking tension tests on all kinds of iron and steel, compression tests on iron, steel, wood, stone, slate, cement, &c., bending tests on iron bars, tests on chains, wire-ropes, &c. The facility with which the fittings can be changed from one kind of testing to another is remarkable. Taken altogether, the Riehlé has proved very satisfactory, and much easier to operate than the immense single-lever machines of the same capacity. A complete equipment of measuring devices is installed for the determination of elastic limits both by mechanical and electrical methods. A torsion-machine (40) is also provided.

For experiments on heat treatment of various steels, a gas-furnace (25) by S. W. Brayshaw, Manchester, has been provided. This apparatus is heated by a ring of Bunsen burners, and there is provision for forcing the blast if necessary. In connection with this furnace and for boiler experimental purposes, a Callendar temperature recorder has been installed.

For the purpose of carrying out tension tests on cement, an Adie machine (36) is placed in this section. Students make the cement specimens for themselves from the moulds, and having allowed those to set for the requisite time, they easily learn to manipulate them in the machine. The compression tests on cement are usually carried out on 6-in. cubes on the Riehlé machine.

Tests on the fatigue of metals are carried out from time to time on a fatigue-testing machine (37), which was specially designed by Professor Smith and constructed by Messrs. Combe, Barbour, Belfast. It is shown in Fig. 12, just beyond the Riehlé testing-machine. The complete machine has already been fully described in the pages of ENGINEERING, and the author does not propose to go into it at length here. Briefly, rotating masses give alternate pull and push to a specimen ¼ in. in diameter. A spring, which may be used either in tension or compression, can so alter the amount of load on the specimen that the range of stress may be anything on the tension side to anything on the compression side. Thus not only equal and opposite stresses, but any range of stress may be obtained. The machine consists of two similar units, and both may be simultaneously worked. It is driven by a 5-horse-power variable-speed Westinghouse motor working at a voltage of 440. Several important researches have already been carried out on this fatigue-tester, and others are in progress. A complete electrical equipment (38) for the measurement of heat generated during endurance tests is provided for use with it.

A plant consisting of the necessary grinding and polishing wheels operated by small electric-motors is provided for preparing steel specimens for etching, previous to microscopical examination. This microscopical examination is made in conjunction with experiments on fatigue of metals and statical test phenomena, and in connection with this a micro-photographing apparatus is employed. In order to examine the hardness of metals and to compare such results with ordinary tension test results, a Brinell hardness-testing machine is placed in the laboratory.

Among the smaller pieces of apparatus are a standard pressure and vacuum-gauge tester (31) by Schaffer and Budenberg, Limited, London; two examples for studying machine-balancing problems (32 and 33); and an arrangement by G. Cussons, Manchester, for experimenting on the kinematics of link-motions.

The laboratory also contains an equipment for testing the elastic strength of flat plates of circular, square, rectangular, and elliptical form. The writer has made a large series of experiments with this, and hopes shortly to publish some interesting results.

Internal-Combustion Section.—The plant comprising the internal-combustion section includes a gas engine, a suction-gas plant, an oil-engine, and a petrol-engine, calorimeters for determining the calorific value of town gas, coal, oil, and fuels, and all the necessary indicating and small testing gear. The gas-engine (27) is by the National Gas-Engine Company, and their usual design has been modified to suit the needs of the laboratory. It is of 20 indicated horse-power when working on ordinary town gas, and somewhat less when using the suction plant. By a suitable arrangement of valves town or suction gas may be used at will. This engine is chiefly used for indicated horse-power, brake horse-power, and consumption tests. The fly-wheel, which serves as a brake wheel, has a hollow rim, and a continuous stream of water is kept circulating while the tests are in progress. A brake band with wood sections and weights is used. Explosion indicators are employed for graphing the explosions, but the number of explosions is also registered on a counter. Another counter registers the number of revolutions of the engine. Thermometers placed in cups register the inlet and outlet temperatures of the circulating water, and the quantity of this water is measured by a scale calibrated in pounds per minute.

Thermometer-cups are provided for the study of cylinder-wall temperature, together with an exhaust-heat calorimeter of the type devised by Professor Hopkinson. Sampling-valves are placed at various points for experiments on gas analysis. The gas consumption is read off on a large 200-light meter (28) placed close to the engine. The calorific value of the gas is determined by a Junkers calorimeter. The most modern planimeters, measuring-gauges, and everything for accurate testing are provided.

The suction-gas plant (26) was made by the National Gas-Engine Company. The comparison of consumption and horse-power tests when working on town gas and suction gas respectively has proved very instructive for the students.

The oil-engine (24) is of the Blackstone well-known make. It is of 12 indicated horse-power, and is so far modified from the commercial type as to permit of indicated horse-power, brake horse-power, and consumption tests being carried out with the minimum of adjustment, as in the case of the gas-engine. The equipment of details is similar in all respects to that of the gas-engine. The oil is stored in tanks (21).

The petrol-engine (23) is about 4 horse-power. A special pulley is mounted on the crank-shaft for taking the brake horse-power. The indicated horse-power is taken by means of a beam of acetylene light, and the diagram is clearly reflected on to the glass screen in front of the indicating apparatus. The indicating gear was supplied by Hospitalier-Carpenter, Vanraden, and Co., Limited, Coventry.

A view of the experimental mechanics' laboratory is shown in Fig. 9, Plate LXI. It will be seen to be well supplied with apparatus, much of which has been made at the Institute.

The Machine-Shop.—The machine-shop, which is equipped with modern high-grade tools and machines, is situated on the ground floor close to the main engineering laboratory. Views of this department are shown in Figs. 10 and 11, Plate LXI. The pattern-shop is at the far end of the machine-shop, being divided from it by a glass partition, such that the teacher in charge may keep an eye on both departments. Mr. G. H. Longworth has charge of this section of the work. In the machine-shop, the chief constructive work of the students has consisted in the making of several modern screw-cutting lathes and numerous pieces of scientific apparatus, every portion of which has been designed, machined, and assembled by them under the guidance of the teachers. Manual training metal-work classes are also held in the machine-shop, these being in connection with the Trade Preparatory Section of the Institute, and not strictly with the engineering department. The students attending these classes are young, and the course has been

designed to afford a training in the use of hand-tools and in the different processes of metal work.

Special classes are held in screw-cutting and milling for advanced students, and these have been largely attended by apprentices and workmen desirous of supplementing their customary work by a more extended and advanced use of the lathe and the miller. The machine-shop has been of great service to the other sections of the engineering department, inasmuch as much new and improved apparatus has been made in it for the applied and experimental mechanics laboratory, referred to above, for the materials testing laboratory, &c. The room is lighted at night by enclosed arc-lamps, and, in addition, portable incandescent lamps are conveniently arranged for use on each machine.

The machines installed are as follow:—One universal milling-machine, for cutting spiral gears, spur and bevel gears, &c., with universal attachment, by Brown and Sharpe; one Bateman high-speed planer; one high-speed screw-cutting lathe, with special gear-head, by Pollock and Macnab; one boring and surfacing lathe, with patent variable-speed gear, by John Lang and Sons; six small screw-cutting lathes, by J. Parkinson and Son; one Hendey Norton screw-cutting lathe; one capstan lathe, by Alfred Herbert; one small screw-cutting lathe, by Dempster, Moore, and Co.; one vertical automatic drilling-machine, by the American Tool Works; one sensitive drilling-machine, by Ludw. Loewe and Co.; one shaping machine, with swivel vice attachment, by the Potter and Johnstone Machine Company; one twist-drill grinder; one cutter and reamer grinder, by Ludw. Loewe and Co.; one "Globe" tool-grinder, by D. S. Walker and Co.; one "Paragon" grindstone; two gas forges and anvils; one brazing apparatus; one marking-off table; 16 vices, arranged along the working benches. In addition to the above, all the necessary smiths' tools and engineers' small tools are supplied.

The pattern-shop contains the following:—One hand turning-lathe, by Messrs Selig, Sonnenthal, and Co.; six benches, each fitted with two Emmorts pattern-makers' vices; one circular saw, by Messrs. John Elsworth and Sons; one band-saw, by Messrs. S. Sagar and Co.; one wood-trimmer, by the Oliver Machinery Company. The tool-room is equipped with all modern gauges, measuring instruments, twist-drills, cutters, reamers, &c., and complete set of woodworking tools are also supplied. The engineering department also includes three lecture-rooms, three drawing-rooms, one electric photographing-room, and a mechanical laboratory. These rooms are fitted up with the latest diagrams, models, charts, and small apparatus, together with numerous mechanical experimental pieces, lantern-slides, &c. Such details are too well known to need description.

Courses in the Mechanical Engineering Department.—There are three main courses in this department: (*a*) the Day Technical Course; (*b*) the Day Apprentices' Course; (*c*) the Evening Course. The first two, as the names imply, are held during the day, and the last in the evening.

The Day Technical Course.—This course has been established to provide instruction in the science and technology of mechanical engineering. The conditions of admission are as follow:—(1) Candidates must not be less than fifteen years of age; (2) Candidates must be prepared to pass an entrance examination. Candidates who have passed the matriculation examination of any university, or who hold scholarships awarded by the Department of Agriculture and Technical Instruction, by the City and Guilds of London, or by the Belfast Municipal Technical Institute, are exempted from the entrance examination. A workshop training is not insisted on, but students are informed that practical experience will be found a distinct help in following the programme of instruction. The entrance examination comprises the following compulsory subjects:—English, geography, mathematics, elementary science, elementary drawing, and "general knowledge." The last is a paper set to test the candidate's intelligence in so far as this can be measured from a knowledge of such current public affairs as receive special newspaper or local attention.

The programme of instruction has been designed with due regard to the recommendations contained in the "report of the Committee appointed to consider and report to the Council upon the subject of the best methods of education and training for all classes of engineers," issued in pamphlet form by the Institution of Civil Engineers. The instruction given is of university standard, and is of a thoroughly practical nature. The programme extends over three years. The instruction in the first year is common to all departments. In the second year the programme is more specialised, and in the third year it is almost wholly specialised. The teaching hours are thirty per week and the duration of the session is about forty weeks.

In the first-year course the time is allocated as follows:—

Subject.	Hours.
Mathematics	5
Practical geometry	2
Mechanical drawing	3
Experimental mechanics	3
Machine-shop practice	3
Experimental physics	4
Chemistry	3
English	2
German	2
Freehand drawing and model drawing	2
Physical training	1
	30

In the second-year course the time is divided as follows:—

Subject.	Hours.
Mathematics	5
Geometry	2
Mechanical drawing	3
Mechanics	1
Machine-shop practice	3
Theory of machines Heat engines Hydraulics Strength of materials	7
Electrical engineering	2
Electrical machinery	2
English	2
German	2
Gymnastics	1
	30

The course for the third year is adjusted to meet the requirements of students. Instruction is provided in the following subjects:—Practical geometry, mechanical drawing, mechanics, machine-shop practice, theory of structures, theory of machines, strength and elasticity of materials, theory of heat engines, and hydraulics.

The fee for the session is 10*l*. The Library and Technical Instruction Committee, Belfast, offer the following scholarships annually for students taking the course:—One major scholarship of 15*l*. per annum, together with fees for one year; four minor scholarships, each giving free admission to the school for one year. These scholarships are awarded on the results of the entrance examination. In addition there is annually awarded a scholarship, value 50*l*., with free tuition for one year in the day department. This is given to the student obtaining the best results in the evening section.

Examinations.—A mid-sessional examination is held in February, and a sessional examination at the end of the course of instruction. Marks given for work done during the course of the session count equally with marks gained in the examinations.

Occasional Students.—With a view to meeting the requirements of a number of students who are not in a position to attend the full-day technical course, it has been arranged to admit students to portions of the course, as, *e.g.*, to lectures, mechanical drawing practice, or laboratory or workshop practice. Such students do not require to take the entrance examination.

It should be noted that the engineering subjects of the day technical course form part of the engineering degree course of the Queen's University of Belfast.

The Day-Apprentices' Course.—This course is intended for engineer apprentices and apprentice draughtsmen who are nominated by their employers. Students joining this course attend six hours on Mondays throughout the session. The subjects included in the programme of instruction vary from year to year. This year they are as follows:—Practical mathematics, one hour; heat engines, one hour; machine design, one hour; applied mechanics, one hour; engineering laboratory, two hours. The fee for the complete course is 1*l*. 10s. The Institute authorities furnish periodical reports to employers concerning the progress made by their apprentices, and also notify employers of any absences or of failure on the part of students to comply with the conditions laid down.

Evening Division.—In this division there are three sections—the Preparatory, the Introductory, and the Mechanical Engineering course proper. When new students apply for admission to the Institute, they must sit for a simple examination in English, arithmetic, and freehand drawing. This examination is imposed for the purpose of testing the candidates' capacity for the various classes. If less than 40 per cent. of marks be obtained, the candidate must take the preparatory course; if the candidate obtains between 40 and 70 per cent., he must take the introductory course; and if he obtains 70 per cent. or over, he may begin at once the specialised course. The Preparatory Section meets on two evenings per week, and the subjects taught are English, arithmetic, geometry, mensuration, and freehand drawing. The Introductory Section also meets on two evenings per week, and the subjects are English, workshop arithmetic, and manual instruction. In both the preparatory and introductory courses all the instructors are engineers, and the courses are given a strong engineering bias. The first-year specialised course in mechanical engineering comprises engineering graphics, practical mathematics, and machine construction. The second-year specialised course consists of applied mechanics, machine construction, and practical mathematics. No further course is provided after the second year, but students are encouraged to begin to specialise in the subjects that concern them most in their daily occupation. A very large range of subjects is provided. In almost all these classes the programme comprises an hour's lecture, followed by an hour's practical work in the laboratory. Proper laboratory note-books are kept, and each experiment must be correctly entered up before another is commenced. In the elementary laboratory classes sheets containing outline instructions for carrying out the experiment are supplied to the students. Great stress is laid upon home-work. The volume of evening work is considerable, and this necessitates the employment of a large staff of occasional teachers in addition to the permanent staff.

ILLUMINATION AND PHOTOMETRY.—In the Faculty of Engineering at University College, a special course of eight advanced lectures on "Illumination and Photometry" will be delivered by Mr. W. C. Clinton, B.Sc., A.M.I.E.E., Assistant Professor of Electrical Engineering, beginning on Wednesday, January 10, 1912, at 6.30 p.m. The fee for the course will be two guineas. Full particulars may be obtained on application to the secretary of the College.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a number of colonial and foreign engineering projects, for several of which tenders are asked. Further data concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

India: The *Times of India* states that the Mysore Durbar has sanctioned a large scheme for the extension of the River Cauvery hydro-electric and irrigation works, and the execution of the first stage of the scheme is to be begun immediately. The full project, estimated to cost 253 lacs of rupees (about 1,687,000*l*.), includes the following works:—(1) Dam, 124 ft. high, capable of storing a depth of 118 ft., or 41,500 million cubic feet, of water, 139 lacs (about 927,000*l*.); (2) canal system to irrigate 150,000 acres of land, 106 lacs (about 707,000*l*.); (3) extensions and improvements of the Cauvery power works to provide additional power to the extent of 5000 horse-power, 8 lacs (about 53,000*l*.). The first stage includes the construction of a dam with a full supply of 80 ft. and a storage capacity of 11,030 million cubic feet, but of sufficient section for an ultimate storage of 118 ft., at a cost of 81 lacs (540,000*l*.), and the power works given under (3) above.

British Columbia: With reference to the proposed tunnelling and reclamation works at Lulu Island (Vancouver) for railway terminal facilities, the Imperial Trade Correspondent at Vancouver reports that there seems no likelihood of this scheme being carried out at present.

Turkey: The British Acting Consul-General at Constantinople reports that tenders are invited by the Administration of the Ottoman Public Debt for the construction of a mole at Salif (Yemen). Tenders, accompanied by certificates of competency, and a guarantee for T300*l*. (270*l*.), will be received at the Direction Générale, Dette Publique Ottomane, Constantinople, up to January 20, 1912. Note.—Local representation is practically indispensable in the case of Turkish Government contracts.

Japan: The *Bulletin Commercial*, Brussels, states, on the authority of the Belgian Consul at Kobe, that work is proceeding with the extensions at the harbour of Takao, Formosa. A sum of 4,733,000 yen (about 482,000*l*.) was originally earmarked for this purpose. When the harbour improvements are completed it is expected that there will be berthing accommodation for ten 2000 to 3000-ton steam-vessels, and that it will be possible to handle some 500,000 tons of traffic per annum.

Mexico: The British Vice-Consul at Guadalajara reports that, according to the local press, the Southern Pacific Railway Company (Tucson, Arizona, U.S.A.) has begun surveying operations for a line from Guadalajara to Mexico City, for which it has a concession. The line would compete with that of the National Railways of Mexico. A concession has been granted to Mr. William A. Rogers, of Calle San Francisco, Guadalajara, for the construction of a railway from Guadalajara to the northern shore of Lake Chapala, and the establishment there of a large pleasure resort. This project, adds the Vice-Consul, is still at an early stage of development. The *Diario Oficial* announces that a concession has been granted to Señora Hortensia C. de Siller to use 10,000 litres of water per second from the River Patos for the purpose of carrying out irrigation works in the municipal district of General Cepeda, State of Coahuila. Exemption from Customs duties is allowed in respect of plant and materials which it may be necessary to import.

Brazil: The Bulletin of the Pan-American Union for October states that the Paulista Railway Company proposes to construct a double line from Jundiahy to Campinas, to be afterwards extended as far as Rio Claro. The British Vice-Consul at Santos reports that the São Paulo State Government have granted a concession for the construction of a railway from Pindamonhangaba to Villa de Jaguaribe, with a branch to the boundary of Minas Geraes. Interest is guaranteed on the capital employed up to 267,000*l*. Construction work is to be begun within six months and completed within two years. The Santos municipal authorities have granted a concession for the construction of a railway from Santos to the boundary of the municipality of São Sebastião. Construction work is to be begun within eighteen months and completed within five years. The Secretary of Agriculture has signed a contract for the construction of a metal bridge over the River Tieté at Barra Bonita.

Ecuador: With regard to the proposed water supply, drainage, and sewerage works at Guayaquil, H.M. Consul at Quito reports the publication of a Congressional decree, dated October 5, authorising the President of the Republic to contract with M. Edmond Coignet for the placing of a loan of 50,000,000 francs (2,000,000*l*.), to be issued at 85. Two-fifths of the proceeds are to be used for the sewerage and paving of Guayaquil, and the rest for water supply works, the construction of a new quay, and the repayment of the loan made to the Municipality of that town by the Banco Territorial.

Argentina: The *Boletin Oficial* publishes the following decrees issued by the Ministry of Public Works:—No. 8438, granting to the Compañía Francesa Ferrocarriles de la Provincia de Santa Fé a concession for the construction and working of a railway from a point on the La Sabana-Barranqueras line to the River Pilcomayo, facing Asunción. The line will be divided into three sections. No. 8367, granting to the Buenos Aires Western Railway, Limited, a concession for the construction and working of a railway between a point on the La Lanja-González Moreno line and La Pampa Territory. No. 8436, granting to Señor Andrés R. Fary a concession for the construction and working of a line from the harbour at Santa Fé to the River Bermejo, about 25 miles north-west

of Presidente Roca. No. 8445, authorising the Ministry of Public Works to draw up plans and specifications for the construction of a railway between Patquia and Copacabana, and granting a sum of 200,000 pesos (about 17,500*l.*) for the purpose of carrying on the surveying operations. The *Boletin* also publishes a law, issued by the Ministry of Public Works, granting to the Central Argentine Railway Company a concession for the construction and working of the following lines of railway :—Peyrano to Río Quarto *via* Wheelwright and Sancto Spíritu ; San José de la Esquina to the projected Peyrano - Río Quarto line ; Villa del Rosario to Garza, and thence to Tintina ; Ceres or Selva to the 28th parallel ; Agua Dulce or San Vicente to Santiago del Estero ; Pinto westwards until it joins the Villa del Rosario - Garza line ; San Francisco to the 153rd kilometre of the Villa del Rosario-Las Rosas line ; Pilar to Mecha *via* Media Luna and Cabrera ; Viña to Baradero ; extension of El Chañar line to Rosario de la Frontera. The company also engage to build a line from Cordoba to a convenient point on the Villa del Rosario line at Garza, providing the Government authorities do not within three years construct a line to join up the Dean Funes line at Santa Fé with Cordoba. The following information is taken from the Bulletin of the Pan-American Union for October :—Messrs. D. Selva and Co. have petitioned Congress for a concession to build a branch railway, from kilometre 40, on the San Lorenzo Railway to Villa Casilda, and also a branch line, from kilometre 350, to General Villegas. The company also proposes to build branch lines to San Rafael and Molague, and a line to the north, running parallel to the Mendoza River.

Uruguay: The *Diario Oficial* contains a decree provisionally sanctioning the plans submitted by the Midland Railway of Uruguay, and approved by the National Department of Engineers, for the construction of a railway between Tres Arboles and Piedra Sola.

Norway: H.M. Consul at Christiania states that tenders are invited for the supply to the Norwegian State Railway authorities of about 8765 tons of steel rails and fish-plates, and about 1084 tons of bed-plates. Sealed tenders, marked "Anbud paa Skinner m.v.," will be received at Styrelsens Expeditionskontor, Statsbanerne, Christiania, up to 1 p.m. on December 29. Local representation by a resident agent is required. It should be noted that in all Norwegian Government contracts a preference (apart from Customs duties) is given to Norwegian manufacturers. The foreign article must pay duty, and its duty-paid cost forms the basis of comparison with the Norwegian article.

Swedish Iron Ore.—According to statistics lately published, the production of iron ore in Sweden during last year is the largest on record, owing to the joint causes of the favourable conditions of the European market and the deferment of work from the preceding year, on account of the protracted labour conflicts of that year. The entire output of iron ore during 1910 amounted to 5,184,002 tons of directly serviceable iron ore, and 728,601 tons of ore intended for concentration, making an aggregate of 5,549,987 tons serviceable iron ore, which shows an increase of 1,664,941 tons compared with the previous year. Iron ore has been worked from 283 mines, situated in 13 different läu, or districts, 3,511,954 tons coming from the Noorbotten läu (Lapland), and 1,107,249 tons from Kopparberg läu. An aggregate of 9894 hands has been engaged in the iron ore mines and the concentrating and briquetting works. Extensive contracts for Swedish iron ore have also been placed by America, comprising deliveries for several years. During 1910 pig iron was manufactured at 82 blast-furnaces, the production amounting to 603,939 tons. The production of hammered iron and steel amounted to 151,713 tons blooms, &c., and 472,249 tons of ingots.

The New Orient Liner "Orama."—The new Australian liner Orama, which has been built by Messrs. John Brown and Co., Limited, Clydebank, for the Orient Steam Navigation Company, left London on her first voyage on the 10th ult. The vessel is slightly larger than the five ships completed for the company in 1909, and illustrated and described in Engineering, vols. lxxxvii. and lxxxviii. In her design have been embodied a number of improvements suggested by their service. The most important difference is that the new vessel, instead of being propelled by twin-screw reciprocating engines, is a triple-screw vessel propelled by means of a combination of reciprocating engines and steam-turbines. She is 569 ft. long over all, 64 ft. 3 in in extreme breadth, and 42 ft. in depth from the shelter deck. Her gross tonnage is 13,000. She has accommodation for 293 first-class, 145 second-class, and 867 third-class passengers. The principal public rooms are on the promenade deck. Forward is the first-class lounge and music-room, which is decorated in Louis XVI. style. Aft are the smoke-room and a verandah café. The first-class dining-saloon is on the upper deck. The ventilation has received special attention. The alleyways have grillé doors, and the upper panelling of the cabins has open gratings. The propelling machinery consists of two independent sets of four - crank triple - expansion engines, working on the wing shafts, in conjunction with a low-pressure Parsons turbine on the centre shaft. The reciprocating engines are balanced on the Yarrow-Schlick-Tweedy system, and careful observations taken during the trials revealed an absence of vibration at speeds ranging from 13 knots to 18½ knots. The trials included continuous runs between the Cloch and the Cumbrae Lights, on the Clyde, at 18½ knots, and a 36-hours' coal-consumption trial—half at 17½ knots, and half at 14½ knots.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting on November 10, 1911, held at the Finsbury Technical College, Professor H. L. Callendar, F.R.S., President, in the chair, Professor Silvanus P. Thompson and Professor E. G. Coker exhibited two reflecting polariscopes for the study of optical stress in materials. The polariser in each is a sheet of blackened glass at the polarising angle. One has a field 6 in. square, the other 10 in. square. They were designed for the purpose of studying the stresses in objects cut out in sheets of xylonite (celluloid) subjected to mechanical tension. To eliminate the black-cross effect the objects are placed between two quarter-wave plates of mica, having their axes set at 45 deg. Some larger quarter-wave plates of mica were shown, one of them 24 in. in diameter.

Various experiments on surface tension were exhibited by Mr. C. R. Darling.

In addition to aniline, which has the same density as water at 64 deg., the author has found the following liquids to possess equi-density temperatures :—Anisol at 15, orthotoluidine at 24, butyl benzoate at 48, and aceto-acetic ether at 53. These results have been applied in the production of large drops of liquids by forming them in water, when, owing to the slight difference in density between the drop and its surroundings, the process is much slower than in the case of a drop falling in air, and may be followed clearly by the eye.

Spherical drops of large size may be produced by taking water in a beaker and one of the above liquids at the temperature of equal density. The liquid is admitted through the stem of a funnel, about 1 cm. in diameter, furnished with a tap, the stem terminating below the surface of the water. The liquid sphere forms on the end of the stem, and, if the temperatures be correctly adjusted, may be made to possess a volume of 100 c.c. or more.

Large breaking drops, falling vertically, may be obtained if a liquid slightly denser than water is taken. The liquid is allowed to run into water through a tube terminating in a widened portion about 2 cm. in diameter, the flow being controlled by a tap. A pendent drop forms on the end of the tube, which gradually elongates, and finally breaks away from the tube, drawing out a neck of liquid, which is afterwards resolved into two or more secondary drops. In the case of small drops breaking from the end of a tube, only one small droplet is observed to follow the major portion, and in some cases is not formed. With large drops, however, three droplets of diminishing diameter are generally formed. When the water used is drawn from the tap, orthotoluidine at the temperature of the room may generally be used with satisfactory results ; if observed to be of insufficient density, a little aniline may be added.

Large breaking drops rising vertically are obtained when the liquid is less dense than the water, the delivery tube in this case being bent upwards : the drop rises and finally breaks away, usually giving rise to a single droplet. Orthotoluidine at 30 deg., discharged into water at 30 deg., is suitable for this experiment.

Supported drops, or liquid columns, may be obtained by taking a large test-tube containing a shallow layer of water and pouring into it a quantity of aceto-acetic ether sufficient to form a hanging drop which rests on the bottom of the vessel. The liquid then remains in equilibrium in the form of a column of curved outline surrounded by water, the upper end clinging to the water surface. On adding more water gradually the column becomes thinner and finally breaks, leaving a large drop at the bottom of the vessel, and a smaller drop hanging from the surface of the water. Butyl benzoate is also suitable for this experiment.

A quantity of aniline in water at temperatures above 70 deg. alternately rises to the surface and breaks off in the form of a drop, which sinks to the bottom of the vessel, the two processes being repeated indefinitely. This is due to the liquid cooling on the surface until denser than the water beneath, when a drop is detached ; but in the lower part of the vessel the drop is reheated until less dense than the water, when it rises to the surface. An investigation of the temperatures of the water and aniline made by means of a thermal junction showed that the temperature of the floating aniline was always about 6 deg. below that of the surrounding water, probably on account of the lower specific heat of aniline (0.52).

When a small quantity of impure orthotoluidine is poured upon the surface of water the floating mass is set into violent agitation, finally breaking up into numerous small spheres. On adding a further quantity a number of globules of circular section are formed, which periodically become indented on one side, so as to resemble a kidney in shape ; after which they dart rapidly across the surface. A period of repose follows, after which the globules again become indented and are projected across the surface as before. This procedure is repeated, with decreasing frequency, for two hours or more. When a tranquil state is reached a single large globule is usually observed in the centre of the surface.

A paper on "*The Effects of Holes and Semicircular Notches on the Distribution of Stress in Tension Members*," was read by Professor Coker.

The necessities of practical construction lead to a number of interesting cases of stress problems in which discontinuities like holes and notches occur in great variety, both as regards form and arrangement.

For the experimental determination of stresses in loaded members an optical examination of a model shaped in transparent material has many advantages.

Two cases of primary importance are examined in this way, and the results are compared with those obtained by analysis. The first example relates to the case of a hole in a tension member subjected to a uniformly applied stress p.

The values of $(p_x - p_y)$, the difference between the principal stresses, are readily obtained optically, and they show a fair agreement with the calculated values if the diameter of the hole is not greater than one-quarter of the width of the plate, but beyond this the agreement is not so good. For practical purposes it is important to be able to estimate the maximum stress from the value obtained by assuming that the total load on a tension member is uniformly distributed over the cross-section. A formula based on the relationship found in the experiments takes the form,

$$p_{\max.} = \frac{6c^3}{2c^3 + 2c^2 + c + 1} p_{\text{mean.}}$$

where c is the ratio of the width of the member to the diameter of the hole ; if c is large compared with unity, this reduces to the simple form,

$$p_{\text{mean}} = \frac{3c}{c+1}$$

In the case of two semicircular notches, arranged symmetrically with regard to the centre line and to the cross-section, there appears to be no exact mathematical solution, but an approximate one has been obtained by Leon, resulting in expressions for p_x and p_y at the minimum section of the form

$$p_x = \frac{p}{2}\left(2 + \frac{a^2}{r^2} + \frac{a^4}{r^4}\right), \quad p_y = \frac{p}{2}\left(\frac{a^2}{r^2} - \frac{a^4}{r^4}\right),$$

provided that the radius of the notch is small compared with the breadth of the plate.

Experimental determinations of $p_x - p_y$ show that the maximum values agree very well with those of the formulæ for notches having a maximum radius of about one-quarter of the breadth of the member, but the minimum values do not show a very good agreement if the notch has a radius greater than one-eighth of the breadth. The results appear to indicate that the radial stress for large notches is greater than that given by the formula.

For determining the maximum stress from the applied mean stress a formula is proposed of the form

$$p_{\max.} = \frac{12c^3}{6c^2 + 4c^2 + c + 1} p_{\text{mean.}}$$

and this shows a fair agreement with the experimental values.

Professor Silvanus P. Thompson exhibited a large harmonograph for inscribing on a moving ribbon of paper the harmonic movements produced by compounding together mechanically the oscillations of two heavy pendulums. The recording pencil consists of a glass tube drawn to a fine aperture, in which tube is inserted an ordinary sable-hair paint brush, dipped in ink, so that the mere point of the brush projects through the orifice. He also described his apparatus (shown in operation in the laboratory) for demonstrating the physiological effect of an alternating magnetic field. An alternating electric current with a frequency of 50 periods per second is led into two large copper coils, producing an alternating magnetic field of an intensity of about 10,000 C.G.S. units in the space between the coils. If the head is placed in this space a singular sensation of a flickering bluish illumination is perceived. The effect is greatest if the direction of the lines of force of the field is through the temples.

Professor Thompson also demonstrated several experiments in acoustics. These were—(*a*) a Rubens tube 15 ft. in length, with a row of small gas flames along it, exhibiting the positions of the nodes and ventral segments when the internal gas column was thrown into partial modes of vibration by shrill tones ; (*b*) a Rayleigh flame of peculiar sensitiveness ; (*c*) a dynamical model in glass of the three semi-circular canals of the ear. The canals being filled with coloured liquid, and containing model otoliths (made of glass bubbles filled with air), movement of rotation about any one of the three axes sets the liquid in the corresponding canal into relative motion. (*d*) A set of steel bars for demonstrating the superior limit of audition ; (*e*) a *ton-variator* of Dr. Stern, consisting of a resonant cavity of adjustable volume, excited by a gentle air-blast, and graduated to produce any tone between the frequencies of 200 and 400 per second ; (*f*) an adjustable resonator, in which the size of the front opening is altered by use of an iris diaphragm ; (*g*) a new phenomenon in resonance. If a tuning-fork is introduced into a tubular resonator having a front orifice just wide enough to admit the two prongs, resonance is observed when the prongs are placed just in the opening. On inserting them deeper the sound ceases, but is again heard if they are inserted still further.

The Late Mr. Edouard Widmann.—We regret to have to record the death of Mr. Edouard Widmann, which occurred on October 7 last. Mr. Widmann was a retired Chief Naval Constructor of the French Navy, Officer of the Legion of Honour, Managing Director of the Société des Forges et Chantiers de la Méditerranée. He was also a member of the Managing Committee of the Paris-Lyons-Mediterranean Railway Company and President of the Syndicate of French Shipbuilding Works. Mr. Widmann was a member of the Institution of Naval Architects and frequently attended its meetings ; at the spring meeting of 1887 he read a paper before the Institution "On the Principle of an Hydraulic Apparatus for Transmitting Signals and Power and Controlling all Sorts of Distant Mechanism," which he had prepared in conjunction with the late M. Berrier-Fontaine. He took part in the discussion of a paper on the steam-turbine, read by Sir C. A. Parsons, at the Naval Congress held in Bordeaux in 1907, when he stated that his company, the Forges et Chantiers above named, were the first licensees for the construction in France of the marine steam-turbine of the Parsons type.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

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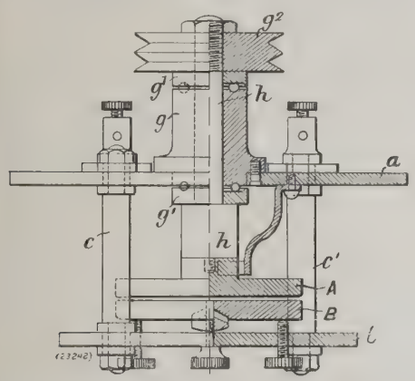
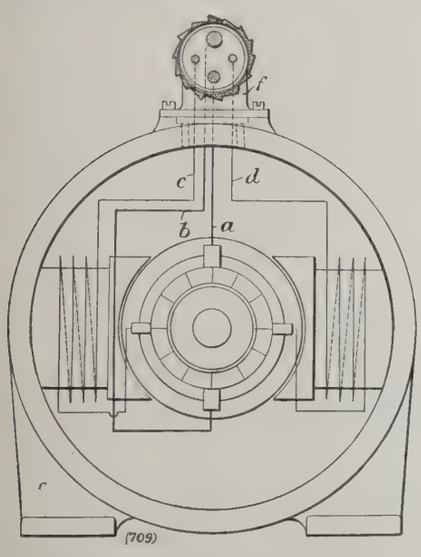
ELECTRICAL APPARATUS.

23,242/10. J. A. Fleming, London. Wireless Telegraphy. [1 *Fig.*] October 7, 1910.—This invention relates to a form of spark-discharger consisting of a series of flat metal plates placed very near together, and in some cases revolving, and having a film of oil between them, so as to take advantage of Wien's discovery of the large damping of short spark-gaps, and hence to quench or destroy suddenly the primary spark, and thus to create free oscillations in the secondary or antenna circuit by impact. In using such a discharger, it is necessary constantly to dismount and repolish the plates, and the efficiency of the discharger as a quenched spark or impact-discharger depends upon the preservation of the surface of the plates in a polished condition. According to this invention, the shaft of the rotating electrode is supported in such a manner as to prevent its endway movement, and the stationary electrode is mounted on adjusting-screws. Further, the electrodes are made of highly polished hardened steel. *a* and *b* are two metal plates separated from each other by four metal



columns, two of which, *c*, *c*¹, are shown. The columns pass through holes in the plates *a*, *b*, and are insulated therefrom. *g* is a bearing fixed to the plate *a*. *h* is a shaft working in the bearing *g* and having fixed to its lower end a highly polished disc A of hardened steel. g^1, g^1 are discs on the shaft *h*, and these discs and the ends of the bearing *g* have ball-races formed in them to receive rings of balls. g^2 is a pulley secured to the shaft *g*. By tightening the nut securing the pulley the balls can be more or less nipped between the discs g^1 and the ends of the bearing *g*; the nut should be so adjusted that while the shaft *h* is allowed to turn freely, any endways movement of it is practically prevented. B is a second highly polished disc of hardened steel; it is secured to the plate *b* by a screw engaging its central boss, and it rests on adjusting-screws. The drawing, for the sake of clearness, shows the discs A and B at a comparatively large distance apart, but in actual use the distance should never exceed $\frac{1}{100}$ in. (*Accepted October* 11, 1911.)

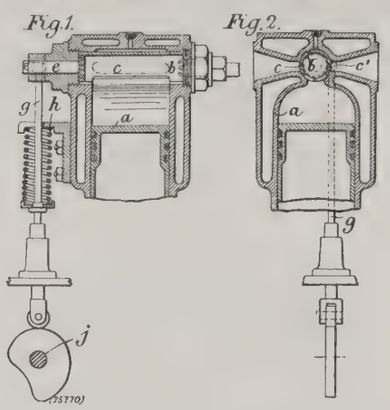
709/11. H. Leitner, Woking. Dynamos. [3 *Figs.*] January 10, 1911.—This invention relates more especially to variable speed machines working in conjunction with accumulators. According to this invention, for the purpose of preventing



the making of incorrect connections of the dynamo terminals with the external circuit, all the connections are brought to a two-part plug of ordinary type, having different sized studs, and so arranged that one-half of the plug connection is attached to, and forms part of, the dynamo, and the other half forms part of the external circuit. When the two halves are separated, the main circuit is broken, and the dynamo is idle and cannot generate. *a*, *b* are the main internal connections, and *c*, *d* the shunt-field connections of the dynamo, which connections are brought to one half *f* of the plug and terminate in sockets, the half plug being secured to the dynamo. The external connections are attached to the other half of the plug, and terminate in studs which engage with the sockets. The halves of the plug are so made that the connections can only be made one way, and this may be brought about, for instance, by having the studs and sockets of different sizes. (*Accepted October* 11, 1911.)

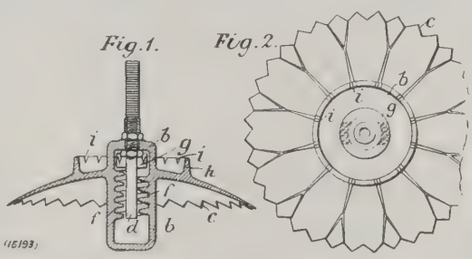
GAS ENGINES, PRODUCERS, HOLDERS, &c.

25,770/10. E. Crowe, Eaglescliffe, and E. Crowe, Berkhamsted. Internal-Combustion Engines. [9 *Figs.*] November 7, 1910.—According to this invention, internal-combustion engines are provided with an oscillating cylindrical valve that is expanded to fit tight in its casing by the compressions and explosions, and is operated in such a manner that whilst performing the usual functions it is stationary during the compression and explosion. The cylinder *a* is provided at its upper end with the combined inlet and exhaust-valve *b* and the



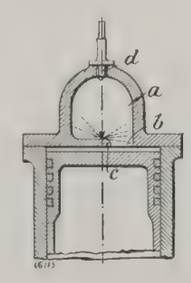
inlet-port and the exhaust-ports *c*, c^1 on opposite sides of the valve-chamber. The valve *b* is a hollow cylinder with a port cut in its side and split throughout its length in order that it may fit the valve chamber and take up its wear. The valve-spindle *e* is provided with a short crank pivotally connected to the tappet-rod *g*, pressed against the cam on the cam-shaft *j* by means of the helical spring *h*. About half the circumference of the cam is of circular form, so that the valve shall dwell during the compression and explosion strokes. (*Accepted October* 4, 1911.)

13,193/11. W. H. Moore and Ambrose Shardlow and Co., Limited, Sheffield. Suction-Gas Producers. [2 *Figs.*] June 1, 1911.—This invention relates to means for distributing water as evenly as possible on the upper surface of a column of coke or other substance which has to be kept cool and moist by means of water trickling through it, and also to prevent the efficiency of the sprinkler from deteriorating after it has been at work for some time. The sprinkler is made in the form of a dome with a hollow boss *b* in the centre, and with indentations *c* arranged all round the edge. Through an orifice in the boss *b* the feed-pipe *d* is passed, and the sprinkler is suspended



from this pipe. The boss *b* is made with a helix *f* on the inside. The end of the feed-pipe *d* is passed down the centre of the boss *b* to within a certain distance from the bottom, the sides of the pipe just clearing the tips of the helix. When the water has left the feed-pipe *d* it is prevented by the helix *f* from gushing upwards, and is led steadily along the annular passage formed between the helix and the pipe. The water is eventually delivered through an opening or openings *g* in the upper part of the boss *b* into a circular tray *h*, around the edges of which are notches *i*. These notches are connected to the indentations *c* by means of grooves formed in the surface of the sprinkler. (*Accepted October* 4, 1911.)

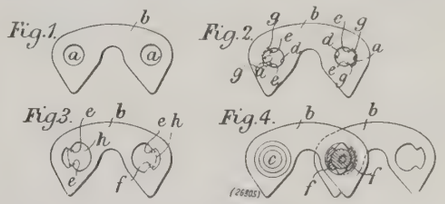
6115/11. E. W. Petter, Yeovil. Oil-Engines. [4 *Figs.*] March 11, 1911.—This invention relates to internal-combustion engines, in which the fuel is low-grade hydrocarbons, and particularly to engines in which the explosions take place in a special



chamber disposed at the end of the cylinder, into which chamber air is compressed by the piston. According to this invention, engines of this type are provided with means for splashing the charge of fuel during the compression stroke of the engine across the mouth or constricted orifice between the cylinder and combustion chamber. On the inner surface or wall of the combustion chamber *a*, as near as can be to the connecting passage *b*, is a projecting surface or lip *c*, the exposed surface of which is arranged to receive the fuel when pumped into the combustion chamber *a* in the form of a jet through the nozzle *d*. The charge of fuel is directed so that it impinges upon the projecting surface *c*, and is thereby broken up and gasified, and the oil vapour produced in this manner splashes or is sprayed across the mouth of the connecting passage or constricted orifice *b* during the compression stroke of the engine. At the same time as oil vapour is being produced in the manner described, air is passing through the connecting passage *b* at high velocity, which air on its passage into the combustion chamber *a* takes up the oil vapour which is being produced at the extreme end of the connecting passage at the entrance to the combustion chamber *a*, the air and oil vapour thereby becoming intimately mixed. (*Accepted October* 11, 1911.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

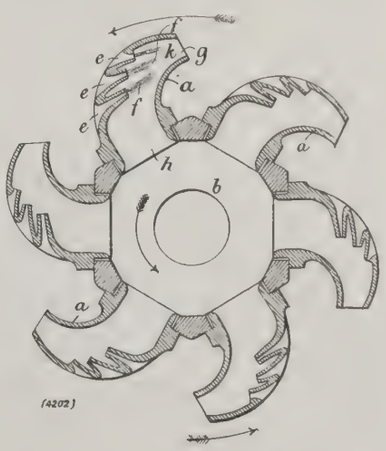
26,805/10. H. Renold, Manchester. Driving-Chains. [8 *Figs.*] November 18, 1910.—This invention relates to chains used for the transmission of power, and known as the silent type of chain. In the manufacture of driving-chains of this type, the method of forming the pivot-holes and segmental bush recesses in the holes consists, in accordance with this invention, in first punching two round holes out of each link-end eccentric in relation to each other and intersecting at points of an arc, the chord of which equals the width of the segmental bush, and then cutting out at each of the intersections a small angular piece to form a segmental bush recess. A round hole *a* is first punched out of each end of the link *b* of a diameter approximately the same as that of the pivot-pin *c*. Then, at the inner side of each of the



holes *a*, is punched a larger hole *d* eccentric thereto, the amount of eccentricity being such as to cause the segmental holes *a*, *d* formed to intersect at the points *e* of an arc, the chord of which equals the width of the segmental bush *f* to be employed in the link. A cutter is then used of such a cross-section that it will remove from the small hole *a*, at the point *e* where it intersects the large hole *d*, small angular pieces *g* (see dotted lines, Fig. 2), which together then form the recess *h*, shown in Fig. 3, for the bush *f*, the cutter being so set in relation to the small hole that the exterior and the edges of the cutter respectively coincide with the side of the small hole *a* and the points at which the small hole *a* intersects with the large hole *d*. (*Accepted October* 11, 1911.)

PUMPS.

4202/11. G. and J. Weir, Limited, and J. Petermoller, Glasgow. Rotary Air-Pumps. [4 *Figs.*] February 20, 1911.—This invention relates to rotary air-pumps. In order to increase the suction produced in the air-discharge nozzles (hereinafter referred to as the main nozzles) by the difference in velocity between these nozzles and the surrounding water, auxiliary nozzles are provided in the main nozzles. These auxiliary nozzles are so arranged as to admit water to the main nozzles with a velocity relative to the main nozzle, substantially the same in direction, and the same in sense, as the velocity of the air through the main nozzles. The water-jets from these auxiliary nozzles therefore assist in discharging the air through the main nozzles. The air is, in fact, subjected to a double action, and a suction effect is produced greater than could be obtained by any single action without the expenditure of relatively great power. *a*, *a*

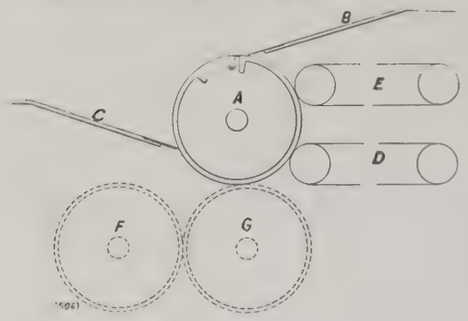


are the main nozzles through which air is drawn from the common chamber *b* in the centre of the wheel. The wheel rotates in the direction indicated by the arrow. Auxiliary nozzles *e*, *e* are provided in each main nozzle, and are so arranged that the movement of each main nozzle through the water in the reservoir causes water to enter the auxiliary nozzles and to be projected in jets *f*, *f* in a direction towards the nozzle exit *g*. It will be understood that the velocity of these jets is considered as relative to that of the main nozzle. These water-jets exercise a sucking and propelling effect on the air in the main nozzle, and produce a difference in pressure between the inlet end *h* and the after portion *k* of the nozzle, thus accomplishing the first stage in the compression of the air. The final stage in the compression of the air is accomplished at the nozzle exit *g* by the relative motion between the nozzle and the water in the reservoir. (*Accepted October* 4, 1911.)

PRINTING AND ALLIED MACHINERY.

23,506/10. J. Shackleton, Leeds. Lithographic Printing-Machines. [1 *Fig.*] October 11, 1910.—In a rotary lithographic off-set printing-machine, the sheet-feeding mechanism is characterised, according to this invention, by a pair of feed-tables B, C, the one at thetop and the other at the lower front part of the impression cylinder. By this arrangement it is possible to print a sheet at each revolution of the impression cylinder. The im-

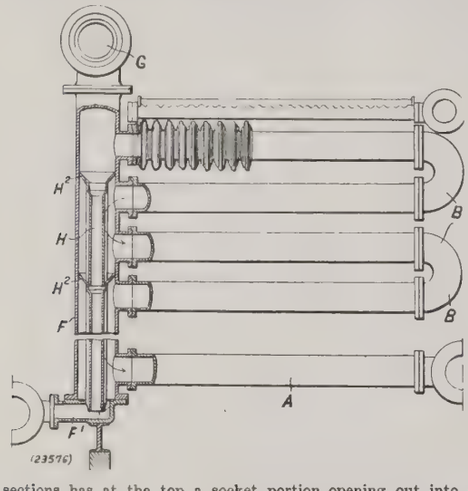
pression cylinder A makes one or more revolutions to one of the transfer cylinder or plate cylinder, and is fitted with two feed-tables B, C, the one at the top and the other at the lower front part thereof. The sheets are laid alternately from the tables B, C, a sheet thus being printed at every revolution of the cylinder. The delivery mechanism is placed under the upper feed-table B, at D, E, and the plate cylinder F and the transfer-cylinder G are provided



with a suitable number of surfaces, and with the usual inking and damping apparatus. The gap in the impression cylinder A is reduced to a minimum, the surface of the cylinder being approximately seven-eights of the full periphery, so that by feeding the sheets endwise a sheet about double the usual size can be printed The feeders having a full revolution for feeding the sheets, a better register is obtainable, and the machine can be run at a higher speed. (*Accepted October* 18, 1911.)

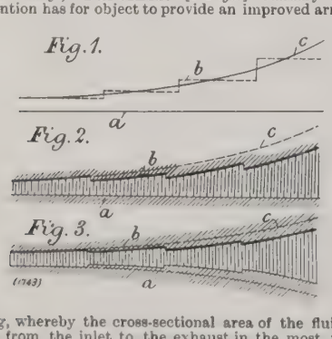
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

23,576/10. E. H. Beckett, London. Evaporative Condensers. [1 *Fig.*] October 11, 1910.—According to this invention, the unions at one end of the series of tubes in an evaporative condenser are replaced by a vertical pipe connected to all the condenser-tubes, and having within it a drainage pipe in sections, each section having a flared mouthpiece at the top to separate the two tube openings above it from the two tube openings below it, and to collect the condensed water from the tubes above it, sufficient space being left between the adjacent drainage-pipe sections to allow the condensed water to drain away into the drainage-pipe. The ends of the tubes A opposite the unions B are all connected to a vertical pipe F which communicates at the top with the exhaust-steam supply-pipe G. Within the pipe F is the central drainage-pipe, consisting of sections H. Each of these



sections has at the top a socket portion opening out into a cone H^2 which fits the pipe F. Each pipe section also has radial ribs, and, at the spigot end, the ribs engage the faucet of the next section, and afford a drainage space between the spigot and the faucet. The cones H^2 are arranged to come between each two tubes, which are connected at the opposite end by a union B, and each cone H^2 constitutes a partition between the two tubes above it and the two tubes below it, so that the exhaust steam is caused to take the usual zigzag course through the condenser. All the water of condensation runs into the vertical pipe F, and each cone H^2 receives the water of condensation from the two tubes above it, and allows this water of condensation to pass through the space between the spigot and faucet, and so down the drainage-pipe to the outlet F^1, which is connected with the pump. (*Accepted October* 11, 1911.)

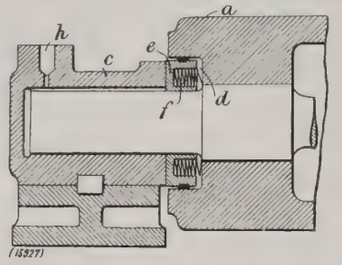
1743/11. The Warwick Machinery Company (1908), Limited, London. (*Allgemeine Elektricitäts Gesellschaft, Berlin, Germany*) **Turbines.** [3 *Figs.*] January 23, 1911.—This invention has for object to provide an improved arrangement



of blading, whereby the cross-sectional area of the fluid passage increases from the inlet to the exhaust in the most favourable manner, and consists in gradually increasing the length of the blades or buckets of each group from the end nearer the inlet to the opposite end, and where the fluid passes from one group to the next, decreasing the length of the initial buckets of the next stage, and altering the cross-sectional form of the buckets. *a* represents the rotor, *b* the casing, and *c* the theoretical bucket length plotted on *a*, assuming that the form of the bucket remains the same throughout the length of the turbine. As shown by the dotted line in Fig. 1, if the buckets are of the same form throughout, the best results are only obtained by dividing the blades or buckets into a large number of stages or groups, and considerable losses occur owing to the blades at the inlet end of the group being too long, and those at the outlet end too short, so the ratio of the peripheral velocity of the wheel to the velocity of the fluid is too great at the beginning of each group or stage, and too small at the end. In the arrangements shown in Figs. 2 and 3 the desired result is obtained by increasing the length of the buckets of each group from the inlet to the outlet end. The buckets of the next succeeding group are so altered in form that they may be shortened, and still allow for the increased volume of the fluid, so that there is no restriction to its passage from the previous group. With this arrangement a very favourable utilisation of the fluid and a relatively short final bucket length will be obtained. (*Accepted October* 4, 1911.)

SHIPS AND NAUTICAL APPLIANCES.

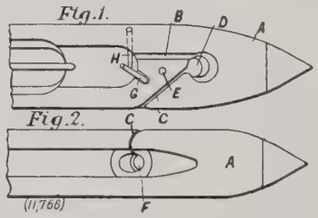
15,927/11. Fleming and Ferguson, Limited, and E. Dunlop, Paisley. Dredgers. [3 *Figs.*] July 10, 1911.—This invention is an improvement on that described in the applicants' Specification No. 10,574, of 1909, and it has for its primary object to prevent the escape of lubricant from the bearings of the rollers used for conveying the buckets of ladder-bucket dredgers, and to exclude water and grit from the bearing



surfaces. Each end of the roller *a* is formed with a recess *d*, into which is fitted a ring *e*, pressed by means of springs *f* against the inner face of the corresponding bush *c*. Packing is fitted between the ring *e* and the roller *a*; the lubricant, which is introduced to the bearing at *h* in any suitable manner, being prevented from escaping, and water and grit being prevented from getting into the bearing surfaces. (*Accepted October* 4, 1911.)

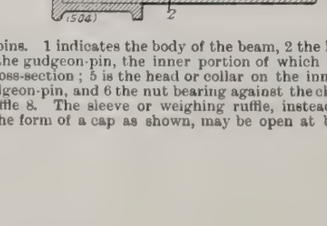
TEXTILE MACHINERY.

11,766/11. J. Tanner and E. Graham, Blackburn. Loom-Shuttles. [3 *Figs.*] May 16, 1911.—This invention relates to loom-shuttles of the kind in which the threading of the weft from the cop through the eye of the shuttle is effected by means of a longitudinal and an inclined slot formed in the head of the shuttle, and meeting in a hole, the weft being passed into the slots and around a pin situated at the apex thereof, and through a slotted eyelet secured in the shuttle-eye. The invention has for object to prevent the shuttle from becoming unthreaded, to obviate ballooning, and to ensure a regular and smooth delivery of the weft. According to this invention, two wires are fixed, one in front of the other, in the head of the shuttle, between the end of the longitudinal slot and the point of the peg or skewer, the free end of one wire crossing an intermediate portion of the other wire at a slight distance therefrom so as to leave a small space or "gate" for the passage of the weft between the wires. A is the shuttle, B the longitudinal slot, C the inclined slot, D the hole in which such slots termi-



nate, E the pin around which the weft passes, F the slotted eyelet, and G and H the wires. The wire G is fixed vertically, or approximately vertically, its lower end being embedded in the bottom of the shuttle, and its upper end turned over to enter a hole formed in the head of the shuttle. The wire H is passed through a part of the head of the shuttle, so that its free end protrudes and extends to the back of the vertical wire, there being a small space or gate between the two wires for the passage of the weft. In threading the shuttle, the weft is passed into the slot B and into and along the slot C, around the pin E, and through the eyelet F. During such transit, the weft passes through the gate between the wires G and H, and takes up a position below the wire H, in which position it cannot escape from the slot B. The wires G and H also provide a smooth delivery of the weft, and impart sufficient drag or tension thereto to prevent ballooning, and also ensure a regular delivery of the weft during the reverse movement or picking of the shuttle. (*Accepted September* 27, 1911.)

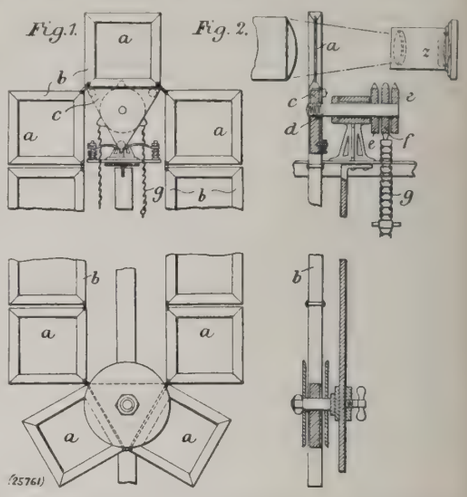
504/11. W. Pemberton, Burnley. Warpers' and Weavers' Beams. [2 *Figs.*] January 9, 1911.—A warper's or weaver's beam is, according to this invention, built up of two or more longitudinal parts or segments of such shape that when secured together a central hole running axially of the beam is formed, in which hole are secured the inner portions of the



gudgeon-pins. 1 indicates the body of the beam, 2 the hard-wood socket, 3 the gudgeon-pin, the inner portion of which may be of square cross-section; 5 is the head or collar on the inner portion of the gudgeon-pin, and 6 the nut bearing against the closed end 7 of the ruffle 8. The sleeve or weighing ruffle, instead of being made in the form of a cap as shown, may be open at both ends, in which case a large washer will be interposed between the end of the beam and the nut 6. (*Accepted October* 4, 1911.)

MISCELLANEOUS.

25,761/10. A. C. T. Rosander, London. Advertising. [4 *Figs.*] November 5, 1910.—This invention relates to a projecting lantern of the kind used for advertising, and, according thereto, the slides *a* are fitted in frames *b* which are linked together so as to form an endless chain. An angular plate *c*, the sides of which coincide with the base of the slide-frames, carries the slide-chain so that one slide at a time is held between the condenser *x* and the objective *z*. The plate *c* is mounted on one end of a shaft *d*,



on which a sprocket wheel *f* is loosely mounted. Over the sprocket wheel passes a continuously driven chain *g*. *e* are discs, also mounted on the shaft *d* on opposite sides of the wheel *f*, and each of the discs *e* is provided with lugs. According to the time the slides are to be exposed, the chain is fitted with pins which, as they pass the wheel *f*, engage the lugs of the discs *e*. The plate *c* is thus turned and exposes a fresh slide before the objective *z*. (*Accepted October* 4, 1911.)

MISREPRESENTATION IN TRADE.—An interesting report by a special committee of the London Chamber of Commerce on the subject of trade misrepresentation has recently been issued, after adoption by the Council of the Chamber. The committee were asked "to consider the general question of misrepresentation in trade, and as to whether any preventive action could be taken by the Chamber," and during their investigations they have collected a large amount of evidence in support of the allegation that there is a growing tendency, both at home and abroad, to misrepresent the nature, origin, quality, quantity, and value of goods offered for sale. The committee, in their recommendations, have not attempted to prescribe remedies for all the different forms of trade misrepresentation and misdescription, but they urge that the Government be asked "to make provision through the Board of Trade for watching for cases of fraudulent misrepresentation, and, where necessary, taking action under the existing law, which is considered adequate in most cases, if effectively set in motion."

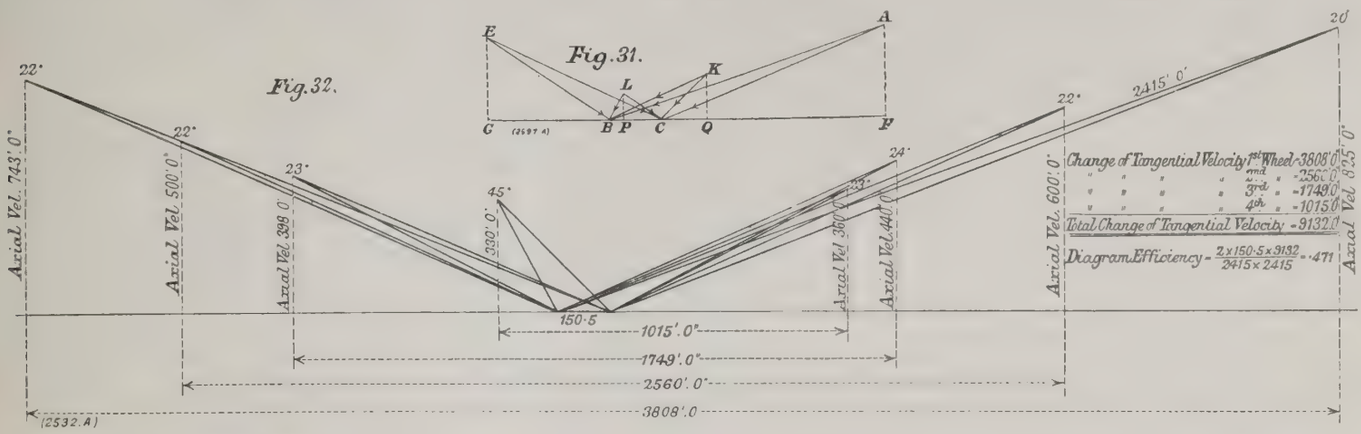
CRITICISM OF AMERICAN WARSHIPS AND ARMOUR.—*Shipping Illustrated*, published in New York, has a strong condemnation of the optimism of lay members of the Navy Department. The article states that:—"Sagacious officers of our navy and of foreign navies state that the battleships and so-called armoured cruisers of our navy are in reality unarmoured. It is true, of course, that these ships, like any other ships of the same class to be found in any navy, have certain parts clad with metal for defensive purposes. However, as regards actual protection they might as well be left without this extra weight of metal, thereby saving displacement, not to speak of the colossal expense. The armour of our capital ships is literally studded with soft spots which small shells from hostile guns would penetrate like cheese, should they ever land upon one of them in battle; an eventuality well within the range of possibility. The existence of these soft surfaces upon the armour-plates of our warships is due to the fact that numerous fittings are attached to the hardened face of the armour, and in order to enable the shipbuilders to drill holes through the plates for the purpose of fastening these fittings, it is necessary that the armour be left unhardened in their vicinity. Furthermore, large holes are cut through the armour for waste-pipes, scuppers, shoots, &c., which offer an inviting entrance to an enemy's projectiles. The common assumption in every country but this is that armour to be protective must present a uniform hardened surface, and consequently manufacturers of armour-plate abroad are supplied with templates of each plate, whereon all fastenings are indicated, and the holes for these are tapped and plugged before hardening the plate. No scupper or other holes are allowed to pierce the armour, but drains of this nature are led down the sides in unsightly shoots, which, at any rate, do not impair the protective efficiency of the armour. Of course, laymen will naïvely ask why our Navy department does not follow the usual practice as regards supplying the builders of warships with armour-plate presenting a uniformly hardened surface. The answer is, that the powerful steel-makers do not look favourably upon a method of manufacturing whereby they would incur the extra expense consequent upon additional handling of the plates, besides drilling and tapping the numerous holes for fastening outside fittings."

THE STEAM-TURBINE.

(*Continued from page* 730.)

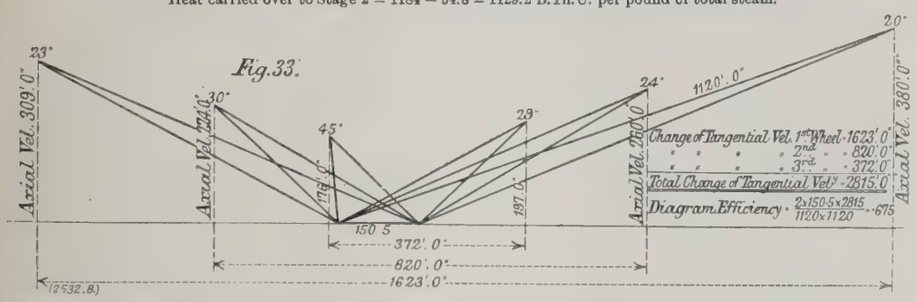
THE theory of the velocity compounded turbine is at present in a thoroughly unsatisfactory condition, and wheels, proportioned in accordance with it, give relatively inferior results.

The method usually set forth is merely an extension of that used in designing the uncompounded impulse wheel. Thus Fig. 31 represents the velocity diagram for a wheel with two rows of moving blades per stage. In this figure A B represents the actual velocity of the steam as discharged from the nozzle—say, 2500 ft. per second—and the blade speed C B is 445 ft. per second. The relative velocity of the steam to the moving wheel is represented by A C, which, by scaling, is found to be 2090. In passing through the wheel the stream of steam is deviated so as to flow along the relative direction E C, the angle E C F being the discharge angle of the first row of blades. Owing to friction the steam loses velocity in the wheel, so that E C is ψ times A C, the value of ψ being taken from Fig. 28, page 729 *ante*. Since A C is 2090 ft. per second, $\psi = 0.795$, whence E C = 1661 ft. The line E B then represents the absolute velocity with which the steam is discharged from the first row of moving blades, and with which it enters the first row of fixed blades. By scaling this is found to be 1265 ft. These fixed blades deviate the steam into the direction K B. As in the previous case, there is a loss of velocity in the passage, and from Fig. 28 *ante* we find that K B = 0.74 E B = 936 ft. per second. Then K C represents the relative velocity with which the steam enters the second row of moving blades, the discharge-angle of which is equal to L C B, and L C then represents the relative velocity of discharge from this row. From Fig. 28 *ante* ψ in this case is 0.695, so that L C = 0.695 × 566 = 393 ft. per second. The absolute velocity of discharge is represented by L B = 260 ft. per second. The blade angles should be chosen to make this as nearly as possible perpendicular to the line B C. The actual coefficients for which the wheel, above taken, was designed were higher than those represented in Fig. 28, which accounts for L B being inclined. There is, however, no direct experimental evidence of values of ψ greater than given by this curve. The change of tangential velocity effected in the first row of blades is equal to G F, which, by scaling, is found to be 3441 ft. In the second wheel the change made in the tangential velocity is equal to P Q, which, by scaling, is found to be 730 ft. Hence the total change of tangential velocity is 4171 ft. The drive on the wheel per pound of steam passed is equal to the change effected in the tangential momentum—*i.e.*, drive

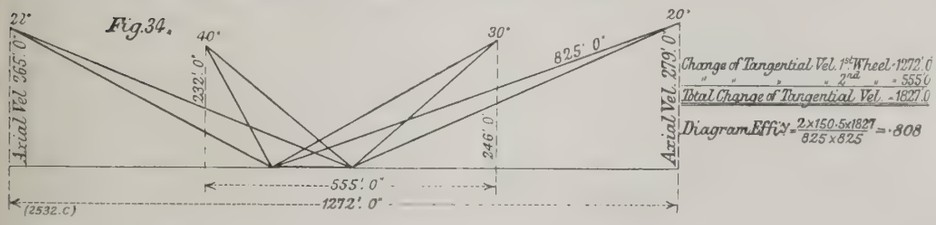


U.S. DESTROYER "PERKINS;" ANALYSIS OF TRIAL AT 25.2 KNOTS, ASSUMING NO THROTTLING IN THE BLADING.

STAGE No. 1.—Steam pressure at inlet = 249 lb. absolute. Quality, 0.975. Total heat content = 1184 B.Th.U. per pound. Steam pressure at discharge = 49.65 lb. absolute. Available heat, 122 B.Th.U. Nozzle loss = 5.65 B.Th.U. Actual velocity of efflux = 2415 ft. per second. Blade speed = 150.5 ft. per second. Minimum diagram efficiency consistent with absence of throttling = 0.471. Corresponding useful work done = 54.8 B.Th.U. per pound of steam passed. Heat carried over to Stage 2 = 1184 − 54.8 = 1129.2 B.Th.U. per pound of total steam.



STAGES 2 TO 6.—Steam pressure at inlet = 49.65 lb. absolute. Heat content = 1129.2 B.Th.U. per pound. Steam pressure at discharge = 7.65 lb. absolute.
Available heat (adiabatic expansion) = 125.0 B.Th.U. Heat available along actual condition line = 127.8 B.Th.U.
Theoretical velocity of efflux = $224\sqrt{\frac{127.8}{5}}$ = 1131 ft. per second. Actual velocity of efflux = 1120 ft. per sec.
Total nozzle losses = 2.5 B.Th.U. Minimum diagram efficiency consistent with absence of throttling in blading = 0.675. Leakage losses, 5.8 B.Th.U. Useful work done = 78.7 B.Th.U. per pound of total steam passed. Heat carried over to Stage 7 = 1050.5 B.Th.U. per pound.



STAGES 7 TO 14.—Steam pressure at inlet 7.65 lb. absolute. Heat content, 1050.5 B.Th.U. per pound. Vacuum 27.96 in. of mercury.
Available heat (adiabatic expansion) = 116.0 B.Th.U. per pound. Heat available along actual condition line = 118.5 B.Th.U. Theoretical velocity of efflux = $224\sqrt{\frac{118.5}{8}}$ = 843 ft. per second. Actual velocity of efflux = 825 ft.
Total nozzle losses, 5.2 B.Th.U. Minimum diagram efficiency consistent with absence of throttling in blading = 0.808. Leakage losses = 1.3 B.Th.U. per pound of total steam. Useful work done per pound of total steam = 90.2 B.Th.U.
Work done per pound of total steam, Stage 1 .. = 54.8 B.Th.U.
" " " Stages 2 to 6 = 78.7 "
" " " Stages 7 to 14 = 90.2 "
Total .. .. 223.7 "
Calculated steam consumption = 11.38 lb. of steam per indicated horse-power per hour.
Actual consumption (turbines only), 14.2 lb. per shaft horse-power hour.

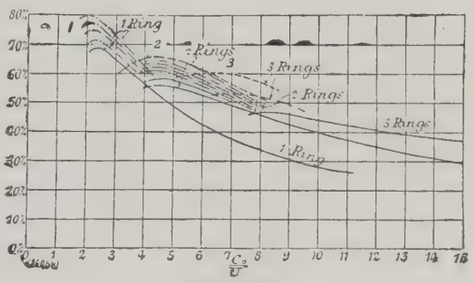


FIG. 35.

$= \frac{4171}{g}$ lb. per pound of steam passed per second. The work done per second is equal to this drive, multiplied by the blade speed—*i.e.*, useful work $= \frac{4171}{g} \times 445$.

On the other hand, the kinetic energy expended per pound passed per second is

$$\frac{A\,B^2}{2\,g} = \frac{2500 \times 2500.}{2\,g}$$

Hence the wheel efficiency

$$= \frac{4171 \times 445}{g} \div \frac{2500^2}{2\,g}$$

$$= \frac{2 \times 445 \times 4171}{2500 \times 2500} = 0.594.$$

To get the stage efficiency this value must be multiplied by the nozzle efficiency.

In an impulse wheel the steam is on the ordinary theory assumed to flow through the wheel without being throttled. Hence, if the nozzle height measured radially is $\frac{5}{8}$ in., the height of the first row of blades at the discharge end must be made equal to $\frac{5}{8} \times \frac{A\,F}{E\,G} = \frac{5}{8} \times \frac{84.5}{65.0} = 0.811$ in. If made less than this the steam will be throttled, whilst if more it will not completely fill the discharge opening. Similarly, the height of the row of moving blades at discharge should be equal to

$$\frac{5}{8} \times \frac{A\,F}{K\,Q} = \frac{5 \times 84.5}{8 \times 390} = 1.36 \text{ in.}$$

and finally the height of the last row at discharge will be the nozzle height $\times \frac{A\,F}{L\,P} = \frac{5 \times 84.5}{8 \times 23.2} = 2.27$ in.

These are the least blade heights which will permit the steam to pass without throttling, and it has generally been assumed that any throttling effect must be pernicious. In actual fact, however, a certain amount appears to be beneficial, and is provided for by all those who have had much experience with velocity-compounded wheels. An analysis of the 25.2-knot trial of the United States destroyer Perkins shows this very clearly. Prac-

tically complete data as to the blading of the turbines fitted on board this boat will be found in our issue of August 18 last. Having the actual blade heights and the angles of discharge, it is easy to find graphically what is the velocity of flow at each row which is just sufficient to avoid throttling the steam. In that case the axial velocity of the steam multiplied by the blade height must be constant.

Referring to Fig. 32, it will be seen that, as discharged from the nozzles of stage 1, the steam had an axial velocity of 825 ft. per second. The height of the first row of blades being 1.33 in., and the nozzle height 1.2 in., the axial velocity of the steam on discharge from the first row of blades will be $\frac{825 \times 1.2}{1.33} = 743$ ft per second. The discharge angle of this row being 22 deg., and the blade speed 150.5 ft. per second, the relative velocity of discharge, which corresponds to an axial velocity of 743 ft. per second, is easily found graphically, and the velocity diagram for the first row completed as shown. For the second row the blade height is 1.65 in., so that the axial velocity on discharge from this row will be $\frac{825 \times 1.2}{1.65} = 600$ ft. per second, and with this value of the axial velocity the diagram for the second row can be drawn. Proceeding in the same way with the other rows, we get the complete velocity diagram shown in Fig. 32. Each moving row effects a change in the tangential velocity of the steam, the total change, as shown in the figure, aggregating 9132 ft. per second, so that the diagram efficiency is 0.471. As will be seen from the data printed below the figure, the available heat at this stage was 122 B.Th.U. per pound of steam passed. Of this, 5.65 B.Th.U. were lost in the nozzles (assuming these to be of the best form), and of the residue the wheel converted into mechanical work 54.8 B.Th.U., so that each pound of the steam carried over to the next stage 1129.2 B.Th.U.

Treating the next stages similarly as in Fig. 33, the average diagram efficiencies for these stages amounts to 0.675. The heat available (after allowance for a reheat factor) is 127.8 B.Th.U. per pound, of which, on the assumption stated, 78.7 B.Th.U. are turned into mechanical work, after making due allowance for leakage losses. Treating stages 7 to 14 in the same way, as shown in Fig. 34, the final result is that the turbine should, on the assumptions stated, require only 11.35 lb. of steam per indicated horse-power per hour, against an actual consumption (turbines only) of 14.2 lb. per shaft horse-power. The losses by windage and disc friction do not appear to amount to more than 30 or 40 horse-power at most, or, say, 1 per cent. of the total output. The nozzle losses and leakage loss may no doubt have been under-estimated, but the discrepancy between the calculated and the actual consumption is much greater than can thus be accounted for. It has, moreover, to be borne in mind that the calculated consumption is the maximum possible without throttling. If the blade friction is so small that the flow fails to fill completely each row on discharge, then the consumption will be less than above calculated. It is obvious, therefore, that the steam flow must have been throttled. It is not merely a case of under-expansion in the nozzles, since in all stages but the first the steam velocity was well below the critical value, which must be exceeded before under-expansion in the nozzles becomes possible. To decide whether or no this throttling has been advantageous or the reverse, the calculation may be repeated on the assumption that the blade-heights are made so long that the stream is "freely deviated."

Using the velocity coefficients given in Fig. 28 *ante*, such a calculation shows that with free deviation the calculated consumption would have been about 18 lb. per indicated horse-power per hour, or more in excess of the actual consumption than the figure previously found was below it. Hence the evidence points strongly towards the view that a certain amount of throttling is advantageous. This conclusion is emphasised by the fact that builders who have commenced to build velocity-compounded turbines on the theory that "free deviation" was the ideal to be aimed at, have uniformly realised very disappointing results.

Too high a degree of throttling might, of course, lead to losses by spilling, but some very interesting experiments made by Mr. W. Chilton and Mr. J. M. Newton, of the Brush Electrical Engineering Company, indicate that the danger of this is perhaps often exaggerated. A nozzle designed for a ratio of expansion about 4 was caused to play on a velocity-compounded wheel, having its first row of blades only a few mils greater than the outlet diameter of the nozzle. No signs of spilling were apparent, even when the inlet pressure was raised, till the ratio of expansion was over 7. In this latter case the jet must have been greatly over-expanded on discharge, yet there was absolutely no trace of "spilling," and an indicating thread held in any position in the vicinity was drawn in towards the jet. This inductive action must, as Mr. Newton has pointed out to the writer, be a source of loss, and indicates the inadvisability of using round nozzles. The latter conclusion is one at which the writer had independently arrived some time previously, from the analysis of the performance of the turbines of the Perkins, which has been given above. If a certain amount of throttling is advantageous, it will be evident that round nozzles are out of place. The nozzles should, in fact, supply a continuous band of steam of constant radial width, so that the same amount of throttling should be experienced by all parts of it.

It is not easy to understand why throttling should be advantageous. Possibly the phenomenon is allied to the fact, found experimentally, that a divergent nozzle a little too short shows a higher reaction than one which is exactly proportioned so as to fully expand the steam. With the too short nozzle the reaction measured is only, in part, due to the momentum of the fluid discharged. A portion is to be attributed to the existence of a residual pressure at the plane of discharge, due to the fact that the escaping fluid is not fully expanded. If the nozzle were longer, this pressure head would be turned into velocity head before the fluid got clear, and in that case there would be a frictional drag on the walls of the extension, which would diminish the observed reaction. Now on passing through an impulse bucket the steam is compelled to follow a curved path, and the resulting centrifugal forces compress the steam against the concave face of the bucket. The rise of pressure is a maximum along this concave face of the bucket, and is zero, or possibly even slightly negative, along the convex wall of the adjoining blade. Considered as a whole, however, the pressure of the steam is raised by the passage, its velocity being correspondingly reduced, and it has to re-expand again as it is discharged. It seems possible that with buckets which slightly throttle the steam, the latter may effect its re-expansion, exactly at the plane of delivery, and that when there is no throttling the re-expansion, with its consequent rise of velocity, takes place inside the bucket, the frictional losses in which are thereby increased. This explanation of the apparent advantages of throttling must for the present be considered as tentative only, and experiments on the subject would be of much interest.

In its present condition, it will be seen, theory is unequal to predicting the efficiency of a velocity-compounded wheel, and the design must therefore be largely empirical. We reproduce, therefore, in Fig. 35 some curves due to Dr. Lasche, representing results obtained experimentally by the A.E.G. of Berlin. These show the efficiencies (corrected for disc friction) of different wheels with different numbers of velocity stages, and with different arrangements of blading. The maximum values given represent, we believe, about the best results obtainable in each respective case, and in the present state of the theory could not, perhaps, be reproduced with certainty in dissimilar conditions.

(To be continued.)

The Congress of Pure and Applied Chemistry and Physics.—The president and organising committee of the second Congress of Pure and Applied Chemistry and Physics in honour of the late D. I. Mendéléeff desire it to be known that the Congress will be held at the University of St. Petersburg, from January 3 to 10 next.

Russian Railway Schemes.—A concession has been granted for the building of a railway, under State guarantee, in the Ural, from the terminus of the Alapajew branch of the Perm Railway to the Bogdanowitsch station on the latter railway, and another railway from a station near Ekaterinenburg, *via* the town of Irbit, to the River Tawda, near Ssaidkow, in the government of Tobolsk, an aggregate length of 484 versts. A railway has further been concessioned, with State guarantee, from the Berdjansch Station, on the Ssamara-Slatonsk Railway, to the Lisswa Station, on the Perm Railway, a distance of 524 versts.

THE STRENGTH OF THICK HOLLOW CYLINDERS UNDER INTERNAL PRESSURE.

By Gilbert Cook, M.Sc., A.M. Inst. C.E. (Vulcan Research Fellow in the University of Manchester), and Andrew Robertson, M.Sc.

The strength of thick cylinders under internal pressure has not been the subject of much experimental research, although some data are available with regard to cast iron* and various alloys.†

The usual mathematical theory, as developed by Lamé, might, without experimental verification, be assumed to give accurately the stress occurring in a perfectly elastic material. The need for experimental work arises because, in employing the usual formula derived from Lamé's theory in the calculation of the pressure at which the elastic limit is reached at the internal surface, it is assumed that the maximum principal stress alone determines this failure; and this has been proved recently, in the case of some materials under certain conditions of stress, to be erroneous.

At the internal surface of a hollow cylinder, closed at the ends, and subjected to an internal pressure p, there exist three principal stresses—namely:—

1. A hoop tension Q.
2. A radial compression P.
3. A longitudinal tension R.

By Lamé's theory,

$$Q = p\,\frac{d_1^2 + d_0^2}{d_1^2 - d_0^2} = p\,\frac{k^2 + 1}{k^2 - 1} \quad . \quad . \quad (1)$$

where d_1 and d_0 are external and internal diameters and

$$k = \frac{d_1}{d_0}$$

Also, it is clear that

$$P = p,$$

and

$$R = p\,\frac{d_0^2}{d_1^2 - d_0^2} = p\,\frac{1}{k^2 - 1}$$

Three hypotheses have been advanced in regard to the manner of failure of a material when subjected to combined stress, which it may here be desirable to enumerate:—

(*a*) The maximum principal stress theory, by which the elastic limit is assumed to be reached when the maximum principal stress attains a certain specified value.

(*b*) The maximum principal strain theory, known as St. Venant's, which states that failure takes place when the maximum strain reaches a certain value.

(*c*) The maximum shear stress theory, in which the maximum shear stress is regarded as the factor which determines the elastic limit. This theory, first enunciated by J. J. Guest,‡ is known as Guest's theory of elastic failure.

A considerable amount of discussion and research has taken place within recent years in regard to the conditions of stress and material in which these hypotheses apply.§ In the case of brittle materials, such as, for example, cast iron, it is generally accepted that the first, or maximum principal stress theory holds. For a hollow cylinder of cast iron, therefore, the theoretical pressure at which failure should take place is given, assuming perfect elasticity, by the equation

$$\frac{p}{f} = \frac{k^2 - 1}{k^2 + 1} \quad . \quad . \quad . \quad (2)$$

where f = stress at failure in simple tension.

Recent research, referred to above, has proved, however, that the maximum principal stress hypothesis does not hold in the case of ductile materials, and, in particular, of mild steel. It appears to have been definitely proved that in certain cases, at all events, the elastic limit is determined by the value of the maximum shearing stress.

In the case of the cylinder under discussion the planes on which the maximum shearing stress exists will be parallel to the axis, and inclined at 45 deg. to the radius at every point. The value of the

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* See Owens College Calendar, 1890-1, Appendix, page cclxix.

† See paper read by Professor H. C. H. Carpenter at the Institution of Mechanical Engineers, December 16, 1910 (Engineering, vol. xc., page 870).

‡ *Philosophical Magazine*, Series V., vol. l., No. 302, July, 1900. (Engineering, vol. lxxviii., page 849.)

§ Smith, "Compound Stress Experiments;" Mason. "Mild Steel under Combined Stress," Proceedings of the Institution of Mechanical Engineers, December, 1909. For further literature on the subject, see references quoted therein.

maximum shearing stress at the internal surface is given by

$$\tfrac{1}{2}(P + Q) = p\,\frac{d_1^2}{d_1^2 - d_0^2} = p\,\frac{k^2}{k^2 - 1}.$$

If now f is the stress at yield in simple tension, the maximum shearing stress, assumed to be the cause of yield, will be $\frac{1}{2}f$, and yield will therefore take place at the internal surface of the cylinder when

$$\frac{f}{2} = p\,\frac{k^2}{k^2 - 1},$$

or

$$\frac{p}{f} = \frac{k^2 - 1}{2\,k^2} \quad . \quad . \quad . \quad . \quad (3)$$

Since k must always be greater than unity, the value of p/f given by equation (3) must always be less than that given by equation (2). When k, the ratio of external to internal diameter, becomes large, the ratio of the two values of p/f, according as the material is assumed to fail by shear or maximum principal stress, approaches the limit $\frac{1}{2}$.*

Finally, it will easily be seen that the maximum principal strain theory gives for the value of p/f at yield,

$$\frac{p}{f} = \frac{4\,(k^2-1)}{5\,k^2 + 2} \quad . \quad . \quad . \quad . \quad (4)$$

The limiting value of p/f given by this equation, when k is large, is four-fifths of the value given in equation (2).

Thus the yield pressure of a thick cylinder forms a criterion between the three theories of failure, and direct experiment is of importance.

The number of tests carried out by the authors was 35. Of these, eight referred to cast-iron cylinders, and the remainder to carefully annealed mild steel. The cylinders were all of the form shown in section in Fig. 1. In the case of cast iron they were turned and bored from a solid casting, whilst those of mild steel were made from solid shafting $2\frac{1}{4}$ in. in diameter. One end was left solid, and at the other end the hole was enlarged and screwed with 1-in. gas threads, a shoulder being formed, against which a mild-steel plug could be screwed. The plug had an annular projection turned in the end, which, when screwed against the shoulder of the cylinder, formed a metal-to-metal joint which proved to be perfectly tight even at the highest pressures used in the experiments—namely, about 15 tons per sq. in. The plug was also drilled with a hole $\frac{1}{8}$ in. in diameter, and connected by means of a union to a high-pressure pump, which was designed some years ago by Professor J. E. Petavel.* By means of this pump, hydraulic pressures up to 20 tons per sq. in. can be produced and maintained for an indefinite time, the pressures being recorded by means of a standard pressure-gauge.

Cast Iron.—In this material the elastic limit and rupture are practically coincident. The results obtained from the tests are given in Table I. The ratios of external to internal diameter varied from 1.30 to 2.96, and the tensile strength of the material, obtained from specimens cut from the walls of the broken cylinder, and tested in the testing-machine, is given in the fifth column. In the sixth and seventh columns are given the observed bursting pressure, and that calculated from equation (2). In the last two columns are tabulated the actual and theoretical values of p/f. These are plotted in Fig. 2, the ordinates giving the values of p/f for particular values of k. It will be noticed that the observed values are in close agreement with those given by formula (2), and in this respect the results are a confirmation of the work of previous experimenters.

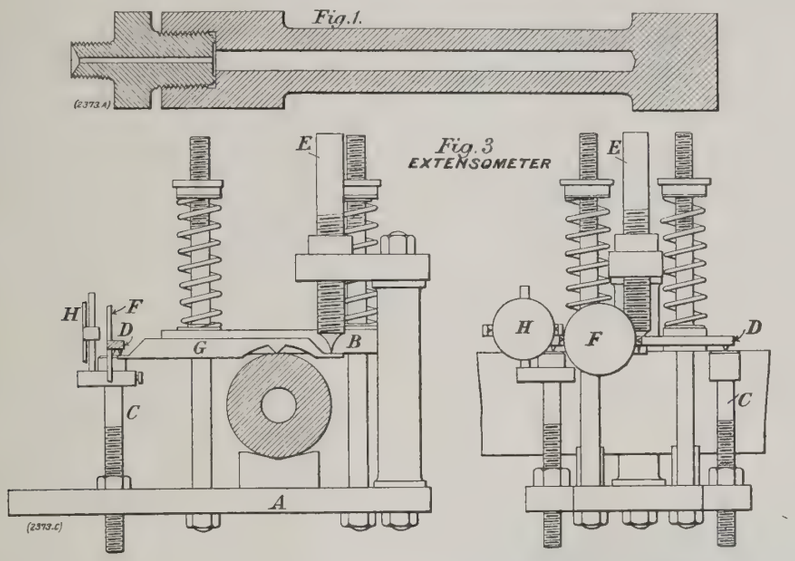
Mild Steel.—In order to determine when yield took place at the internal surface the only method which appeared feasible was by means of the measurement of the elastic extensions on the external surface. While all the stresses are below the elastic limit, the elastic extension of every part of the cylinder is directly proportional to the internal pressure. When, however, yield takes place at the internal surface, this will no longer be true, owing to the redistribution of stress which evidently must take place. If the diametral extensions are plotted against the pressures, a deviation from the straight line should at this point be observed, although the external part of the cylinder, where the extensions are measured, will still be well below the elastic limit. In the earlier stages of the work it was thought sufficiently accurate to observe the diametral extension by means of a diaphragm gauge, the compression of which caused a movement of liquid in a capillary tube, proportional to the amount of the compression—that is, of the increase in diameter of the cylinder. Considerable difficulty was experienced owing to the small scale of the readings obtained, and subsequent work shows that the initial yield occurs earlier than was observed at the time that a preliminary notice was read at the Sheffield meeting of the British Association. The three experiments there described were carried out on unannealed steel.

Fig. 3 is a diagram of the extensometer used in the present work. It consists of a plate A provided with hard-steel V-pieces held up to the cylinder by means of long spiral springs bearing on cross-bars B. The plate is provided with screws C having hardened-steel tops, on which two of the steel points of a tripod D rest. The plate also carries a column, to which the screw E is attached. The tripod carries a mirror F, and the third steel point rests on the end of a lever G, which itself rests by means of a knife-edge on the cylinder, and at the other end bears against the pointed end of the screw E.

The diametral extension of the cylinder causes the mirror to tilt, and the image of a millimetre scale, placed at a distance of 10 ft. from the mirror, was observed by means of a powerful telescope provided with cross-wires. The instrument was supported entirely by the cylinder, which was held at one end by a pipe-vice secured to a rigid table, and was therefore free from any other constraint. A second mirror H rigidly attached to one of the screws C ensured the detection of any angular movement of the instrument as a whole. The difference of the readings multiplied by a constant depending upon the dimensions of the lever and tripod, and the distance of the scale, gave the actual extension of the cylinder.

A difference of 1 millimetre in the scale-reading was found by calculation to correspond to a diametral extension of 4×10^{-6} in. The telescope used was sufficiently powerful to read easily to one-tenth of a millimetre, so that an extension of less than one-millionth of an inch could be observed, and no difficulty was experienced in using the instrument even to this degree of accuracy.

The manner of conducting the tests was as follows:—The cylinders, after being turned and bored, were thoroughly annealed, and again polished up and connected to the pump. The extensometer was attached, and the pressure raised slowly, readings being taken at intervals of 50 atmospheres



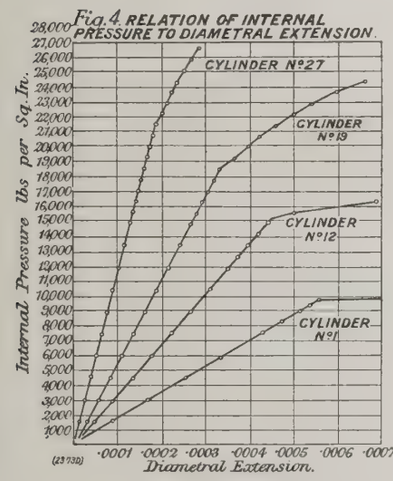
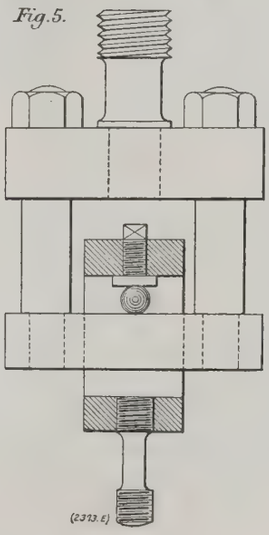
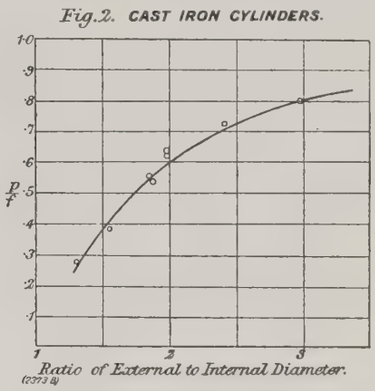


Fig. 4. RELATION OF INTERNAL PRESSURE TO DIAMETRAL EXTENSION.
Internal Pressure lbs per Sq. In.
CYLINDER No. 27
CYLINDER No. 19
CYLINDER No. 12
CYLINDER No. 1
·0001 ·0002 ·0003 ·0004 ·0005 ·0006 ·0007 Ins.
Diametral Extension.
(2373.D)



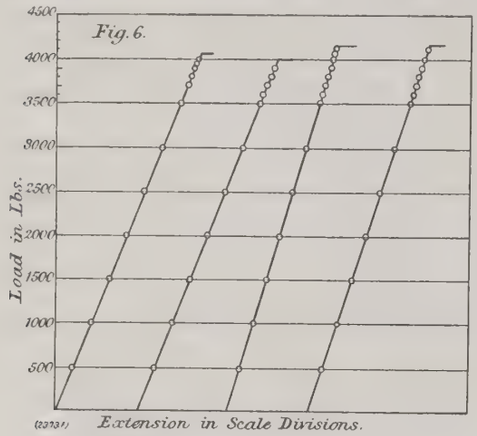


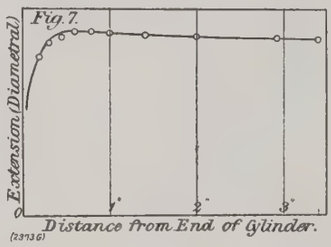
* Smith, "Strength of Cylinders and Guns," ENGINEERING, vol. xc., page 324.

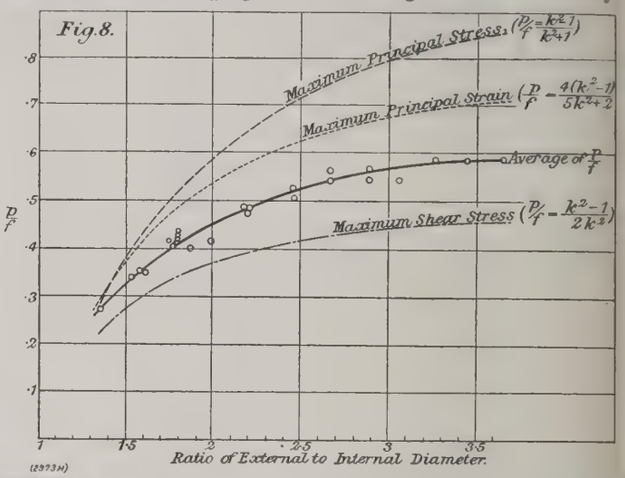
* For a description of this pump, see ENGINEERING, vol. lxxxiv., pages 97 and 98.

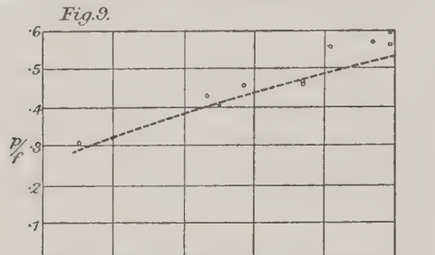
(approximately $\frac{1}{3}$ ton per square inch). In Fig. 4 are given typical diagrams showing the relation of pressure to extension in the case of four of the cylinders. It will be noticed that the yield-point is very distinct, even in the case of the thickest cylinder, the ratio of whose external to internal diameter was 3.66. The sensitiveness of the extensometer may be indicated by the fact that in this cylinder, when yield took place, the stress at the external surface was only $1\frac{1}{2}$ tons per square inch.

Elastic Limit of the Material.—The maximum principal stresses in the cylinder obviously act in a direction at right angles to its length, and therefore to the direction of the rolling. In order to eliminate any possible error due to a difference in the yield-point according as the stress is applied along or across the fibre, it was decided to cut all the test-pieces so that their axes were at right angles to the direction of rolling. These were taken from the solid end of each cylinder, sufficient material being left there to provide for









three or four test-pieces. Each piece was turned up to $\frac{3}{8}$ in. diameter for a length of 1 in., and the ends screwed with $\frac{3}{8}$-in. gas-threads.

In order to determine accurately the elastic limit the observation of elastic strain is essential. The exceedingly short length of the test-pieces, however, prevented any of the extensometers used in the laboratory being attached; but it was found possible to observe the extensions quite easily by means of a simple apparatus, the principle of which was that of a Marten's extensometer. A small steel bar, having at one end two sharp points, was held against the test-piece by means of a light spring. At the other end a small rocking-piece, possessing three points, two of which were in contact with the test-piece, and the third with the steel bar, was supported by friction. To this rocking-piece a small mirror was attached, which, as the test-piece extended, rotated through an angle directly proportional to the extension, the amount being observed, as in the extensometer used for the cylinders, by means of a telescope and scale.

To ensure that the loading of the test-piece should be as nearly axial as possible, a pair of special shackles was designed, a diagram of one of them being given in Fig. 5. It consists of a hollow block of mild steel, into one end of which the test-piece was screwed. In the other end is fixed a hard-steel disc having a spherical depression in the middle, the centre of which coincides accurately with the axis of the hole into which the test-piece was screwed. The load was transmitted through a $\frac{1}{2}$-in. steel ball fitting against the circumference of the spherical cup, and resting on a hard polished steel cross-piece, connected by means of bolts to the main shackle. The deviation of the axis of loading from that of the specimen was found to be very slight, amounting to not more than 0.002 in.

The stress in the material at yield, which in every case coincided with the elastic limit, the breakdown occurring quite suddenly, was found to vary from $15\frac{1}{2}$ to $16\frac{1}{2}$ tons per square inch. The mean value for each set of cylinders cut from the same bar was taken as the true yield-stress used in the calculations. In Fig. 6 are given typical load-strain diagrams for the test-pieces.

Effect of the Cylinder Ends.—It was surmised at the commencement of the work that the ends of the cylinder, one of which was solid, might have a considerable strengthening effect, and that the pressure at which the internal layer would commence to yield would consequently be raised. The point appeared to be of such importance that a determination of the extent of the influence of the ends was necessary, and for this purpose four cylinders were made of the same external and internal diameters—namely, $1\frac{1}{8}$ in. and $\frac{5}{8}$ in., but having lengths of 2 in., $4\frac{1}{4}$ in., $6\frac{3}{4}$ in., and 9 in. Table II. gives the results of the tests of these

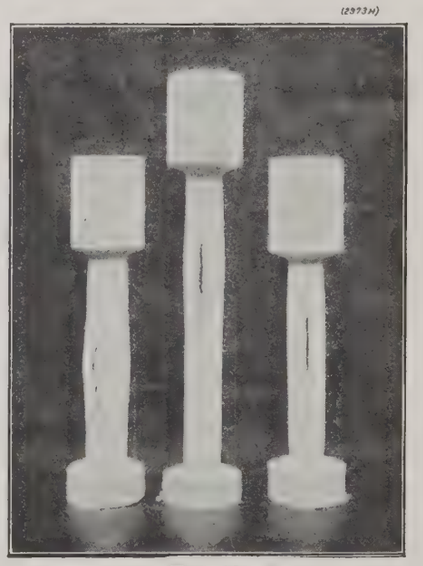


Fig. 10.

cylinders, and the close agreement of the value of the yield-pressure in them is remarkable. It is evident, therefore, that the end effect could not extend more than a very short distance, and it became a matter of considerable interest to determine what that limit actually was. For this purpose the cylinder, whose length was $6\frac{3}{4}$ in., was re-annealed, and the extensometer modified in such a way that it could be fixed so as to measure the diametral extension at any point along the cylinder. The extension caused by a pressure of 600 atmospheres was observed at several points, and the results plotted in the form of a curve (Fig. 7) in which the abscissæ denote distances from one end, the extreme right-hand being the middle point of the cylinder, and the ordinates the extensions in scale divisions. This curve is remarkable for two reasons. In the first place it will be noticed that the extension attains its full value within less than $\frac{1}{2}$ in. from the end; and, secondly, there appears to be a point at which the extension is actually greater than in the middle, and consequently the stress existing there greater also. The amount is about 2 per cent. An effect similar to this has been shown, both mathematically and experimentally, to exist in the case of a boiler, which is, of course, a cylinder whose thickness is small compared to the diameter.*

The amount of the difference is, however, too small to be of any practical importance; but the fact which is brought out clearly by the curve given in Fig. 7 is that the influence of the ends, contrary to what is usually supposed, extends for only a short distance along the cylinder. If such were not the case, the diametral extension would vary gradually from zero at the ends to a maximum at the centre.

Accuracy of Pressure Gauge. — The pressure gauge attached to the pump was a standard Bourdon gauge, graduated in atmospheres, and capable of measuring pressures up to 3000 atmospheres, or 20 tons per square inch. The gauge was compared, for the lower part of its range, with a standard 5-ton gauge, the two being read simultaneously. The difference of the readings amounted nowhere to more than 2 per cent. In view of the fact that the elastic part of the pressure-extension diagram for every cylinder is perfectly straight, it is reasonable to suppose that this percentage error is not exceeded in the higher parts of the range.

Results of Tests on Mild Steel.

In Table III. are given the results of the tests on mild steel. In the third and fourth columns are given the stress in the material at yield as determined by the test in simple tension, and the internal pressure when yield took place at the internal surface of the cylinder. In the fifth column the ratio p/f is tabulated, and the remaining columns give the theoretical values of this ratio for the various theories of elastic failure; that is, as given by equations (2), (4), and (3). These are plotted in the form of curves (Fig. 8), where the abscissæ denote the ratio of external to internal diameter, and the ordinates the value of p/f.

It will be noticed from Table III., and still more clearly from Fig. 8, that the experimental values of p/f lie about midway between the theoretical values as given by Guest's and St. Venant's theories of failure.

It must be pointed out that even the very slight eccentricity of loading in the tension tests might have the effect of making the apparent yield stress less than the true stress, owing to the fact that a uniformly varying stress is set up across the section. It was found by the extensometer that the maximum stress was 4 or 5 per cent. greater than the mean, and therefore the true yield stress might be in excess of that actually measured by this amount. The experimental curve would, on this assumption, be brought closer to the maximum shear-stress curve. The difference would, however, still amount to about 20 per cent.; and the results of the experiments might be conveniently represented by introducing a factor into equation (3). So that

$$\frac{p}{f} = 1.2\,\frac{k^2-1}{2\,k^2},$$

or

$$p = 0.6\,f\,\frac{k^2-1}{k^2} \quad . \quad . \quad . \quad (5)$$

In Table IV. are given the observed yield pressures, and those obtained by calculation from equation (5).

* See Engineering, vol. li., page 468, vol. lxi., page 101.

It must also be borne in mind that in the cylinders used in the experiments there were three principal stresses existing at the internal surface—namely, the hoop tension, the radial compression, and the longitudinal tension. As far as the authors are aware, the whole of the research so far carried out in connection with combined stress has had reference to two-dimensional stress only. The influence of a third principal stress on the elastic limit determined by the other two does not appear yet to have been investigated.* It might seem at first sight possible to attribute the discrepancy between the theoretical and experimental values of p/f to this cause. Yet it must be seen that this is untenable in view of the fact that the proportional difference does not appear to vary appreciably throughout the range of values of k, whilst the third principal stress, acting longitudinally, varies from 1.22 p in the case of the thinnest cylinder down to 0.081 p in the thickest cylinder.

Ultimate Strength of the Mild-Steel Cylinders.—It was found possible, in the case of nine of the cylinders of smaller dimensions, to increase the pressure beyond yield until the cylinder burst. The great increase in internal diameter which accompanied the plastic deformation necessitated the expenditure of considerable time in the test. The bulging, even as seen on the external surface, before the cylinder burst, was considerable. Rupture took place in the form of a longitudinal crack. The maximum pressure the cylinders withstood was greater than that at the moment of rupture, owing to the rapid expansion which just preceded it. The values of the maximum pressure are given in Table V. The ultimate strength of the material was obtained from tests carried out on the small specimens described above.

Although Lamé's theory for the distribution of stress does not hold when the material is stressed beyond the elastic limit, it so happens that the values of the maximum pressure agree fairly closely with the values which would be obtained by calculation from Lamé's formula :—

$$\frac{p}{f} = \frac{k^2 - 1}{k^2 + 1} \quad . \quad . \quad . \quad . \quad (6)$$

where now

f = ultimate strength of the material,
k = initial ratio of external to internal diameter,

and

p = maximum pressure.

This agreement is illustrated in Fig. 9, in which the abscissæ represent the initial ratio of external to internal diameter, and the ordinates the value of p/f. The dotted line is obtained from equation (6).

The application of this equation to the ultimate strength of cylinders of mild steel must be regarded as purely empirical, there being no rational foundation for its use, because—

1. The stress is no longer proportional to the strain.
2. The final dimensions just before rupture are greatly in excess of the initial dimensions, and the value of k is much less.
3. f is also a conventional measure of the ultimate strength of the material—*i.e.*, the maximum load divided by the initial area of section.

TABLE I.—*Results of Tests on Cast-Iron Cylinders.*

No.	External Diameter.	Internal Diameter.	Ratio of External to Internal Dia. k.	Tensile Strength f.	Bursting Pressure p.	Theoretical Bursting Pressure.	Observed Value of p/f.	Theoretical Value of p/f from Eqn. (2.)
	in.	in.		lb. per sq. in.	lb. per sq. in.			
1	1.133	0.873	1.30	18,600	5,060	4,760	0.272	0.256
2	1.420	0.923	1.54	24,500	9,520	9,950	0 388	0.406
3	1 390	0.755	1.83	23,550	13,000	12,710	0.552	0.540
4	1.710	0.922	1.85	26,900	14,550	14,800	0.540	0.550
5	1.561	0.793	1 97	24,200	15,100	14,300	0.623	0.590
6	1.475	0 750	1.97	24,750	16,460	14,600	0.665	0.590
7	1.516	0.635	2.40	26,700	19,250	18,800	0.720	0.704
8	1 870	0 630	2.96	21,700	17,410	17,300	0.802	0.796

TABLE II.

Ratio of External to Internal Diameter k.	Length.	Yield Pressure.
	in.	lb. per sq. in.
1.79	2.00	15,400
1.79	4.25	15,250
1.79	6.75	15,400
1.79	9.00	14,700

* Since the above was written Mr. L. B. Turner has given an account of some experiments on compound stress in three dimensions. See ENGINEERING, July 28, 1911, page 115.

TABLE III.—*Results of the Tests on Mild-Steel Cylinders.*

No. of Cylinder.	Ratio External to Internal Diameter k.	Stress at Yield in Simple Tension f.	Yield Pressure in Cylinder p.	Experimental Value of p/f.	Theoretical Values of p/f according to		
					Max. Principal Stress Theory, Equation (2).	Max. Principal Strain Theory, Equation (4).	Max. Shear Stress Theory, Equation (3).
		lb. per sq. in.	lb. per sq. in.				
1	1.35	35,300	9,700	0.275	0.291	0.295	0.225
2	1.53	35,300	12,000	0.340	0.402	0.393	0.287
3	1.58	35,300	12,500	0.354	0.430	0.415	0.300
4	1.58	35,300	12,500	0.354	0.430	0.415	0.300
5	1.74	35,300	14,700	0 416	0.506	0.475	0.336
6	1.77	35,300	14,400	0.407	0.515	0.483	0.340
7	1.79	35,300	15,400	0.436	0.525	0.490	0.344
8	1.79	35,300	15,250	0.432	0.525	0.490	0.344
9	1.79	35,300	15,200	0.430	0.525	0.490	0.344
10	1.79	35,300	15,400	0.436	0 525	0.490	0.344
11	1.79	35,300	14,600	0.413	0.525	0.490	0.344
12	1.79	35,300	14,700	0.416	0.525	0.490	0.344
13	1.86	34,000	13,600	0.400	0.554	0.511	0.356
14	1.97	34,000	14,100	0.415	0.590	0.539	0.372
15	2.19	36,860	18,090	0.490	0.655	0.583	0.396
16	2.19	36,860	18,090	0.490	0.655	0.583	0.395
17	2.19	36,860	17,650	0.479	0.655	0.583	0.395
18	2.45	36,860	18,740	0 508	0.713	0.625	0.416
19	2.45	36,860	19,400	0.526	0.713	0.625	0.416
20	2.66	36,860	20,150	0.546	0.752	0.649	0.429
21	2.66	36,860	20,850	0.565	0.752	0.649	0.429
22	2.88	36,860	20,300	0.550	0.784	0.672	0.439
23	2.88	36,860	21,000	0.569	0.784	0.672	0.439
24	3.05	36,860	20,200	0.547	0.806	0.684	0.446
25	3.26	36,860	21,700	0.588	0.827	0.697	0.452
26	3.44	36,860	21,700	0.588	0.843	0.708	0.458
27	3.65	36,860	21,800	0.591	0.860	0.718	0.467

TABLE IV.—*Comparison of Observed Yield-Pressures and those Derived from Formula* (5).

No. of Cylinder.	Ratio : External to Internal Diameter.	Observed Yield-Pressure.	Calculated Yield-Pressure.
		lb. per sq. in.	lb. per sq. in.
1	1.35	9,700	9,510
2	1 53	12,000	12,100
3	1.58	12,500	12,700
4	1.58	12,500	12,700
5	1.74	14,700	14,200
6	1.77	14,400	14,400
7	1.79	15,400	14,600
8	1.79	15,250	14,600
9	1.79	15 2 0	14,600
10	1.79	15 400	14,600
11	1.79	14,600	14,600
12	1.79	14,700	14,600
13	1.86	13,600	14,500
14	1.97	14,100	15,120
15	2.19	18,090	17,500
16	2.19	18,090	17,500
17	2.19	17,650	17,500
18	2.45	18,740	18,400
19	2.45	19,400	18,400
20	2.66	20,150	19,000
21	2.66	20,850	19,000
22	2.88	20,300	19,400
23	2.88	21,000	19,400
24	3.05	20,200	19,800
25	3.26	21,700	20,000
26	3.44	21,700	20,200
27	3.65	21,800	20,500

TABLE V.—*Ultimate Strength of Mild-Steel Cylinders.*

Ratio : External to Internal Diameter. k.	Ultimate Strength of Material f.	Maximum Pressure p.	Maximum Pressure Calculated from Formula (6).	p/f Observed.	p/f Calculated from Formula (6).
	lb. per sq. in.	lb. per sq. in.	lb. per sq. in.		
1.35	54,400	16,900	15,800	0.310	0.290
1.53	54,400	23,200	21,900	0.426	0.402
1.58	54,400	24 850	23,400	0.457	0.430
1.67	58,800	27,200	27,700	0.462	0.471
1.67	58,800	27,350	27,700	0.465	0.471
1.71	58,800	30,200	28,700	0.513	0.489
1.77	54,400	30,850	28,000	0.566	0.515
1.79	54,400	30.500	28,600	0 560	0.525
1.79	54,400	32,300	28,600	0.594	0.525

The influence of the ends in dealing with the ultimate strength becomes important. For instance, the strength of the cylinder whose length was 2 in. was 15 per cent. greater than the longer cylinders whose diameters were the same. The effect, however, appeared to be negligible when the length exceeded about four times the external diameter.

General Conclusions.—The conclusions which may be drawn from the experiments may be summarised as follows :—

1. In the case of cast-iron cylinders the failure is determined solely by the maximum principal stress, and Lamé's formula

$$p = f\frac{k^2 - 1}{k^2 + 1}$$

may be applied directly.

2. In the case of mild steel, initial yield takes place when the pressure is about 20 per cent. in excess of that required by the shear-stress theory, the pressure being given very nearly by the equation

$$p = 0.6\, f\frac{k^2 - 1}{k^2}.$$

3. The ultimate strength of the mild-steel cylinders might be denoted empirically by the same formula that applies to cast iron :—

$$p = f\frac{k^2 - 1}{k^2 + 1}$$

where

f = ultimate strength of material, measured on initial section.
k = initial ratio of diameters.

The second of these conclusions is of importance, particularly in its application to the strength of guns. Mild steel is the only ductile material which has been used in this research, but Professor C. A. M. Smith, in his experiments on combined stress,* has found that there is reason to believe that nickel and some other high tensile steels behave in a similar manner to mild steel. Guns are designed with a view to keeping, under ordinary conditions, the stresses in every part below the elastic limit when the gun is fired. An expression equivalent to formula (2) above is used,† which, as will be seen from Fig. 8, gives a value for the working pressure about 30 per cent. too high ; and it is probable that the absence of plastic deformation under service conditions is solely due to the initial overstrain received in the proving-ground.

It is hoped to extend the experimental work to cylinders of steels actually used in gun construction, in order to determine to what extent the data obtained from mild steel may be applied to them.

The authors desire to record their indebtedness to Professor J. E. Petavel, at whose suggestion this work was carried out in the Engineering Department of the University of Manchester, for much valuable help ; and to Professor H. C. H. Carpenter, of the Metallurgical Department, for his care in annealing the cylinders.

* Proceedings of the Institution of Mechanical Engineers, Dec., 1909. ENGINEERING. vol. lxxxviii., page 849.

† Phipps, "Text-Book of Gunnery," Part II., pages 102 to 105.

CYLINDRICAL MILLING-CUTTERS.

IN comparatively recent years many improvements, both as regards the construction of the machines and the designs of the cutters employed, have been made with a view to increasing the output of milling-machines. The application of all-geared driving, both for the spindle and feed motions, and the general stiffening up of machines, has brought the milling-machine into a position to deal with much heavier work than that for which it was formerly considered suitable. A feature, too, that gives the modern machine a wider range of application is the provision of a separate drive for the feed motion, enabling a given feed to be used independently of the speed of the cutters. Although much progress has been made by the modification of machines, it is to improvements in the design of the cutters that the outputs now possible are chiefly due ; and still further progress is rather to be sought by modifying the designs of cutters than by improvements in the design of the machines.

This is the more apparent when it is realised what great advantages accrued by increasing the pitch of the teeth of cylindrical mills. For many years this type of cutter was made with closely-spaced teeth, and its action might be likened to that of a rotary file. Even in recent times it was common to find, say, a cutter of 3 in. diameter having twenty-five teeth, whereas now it is more usual to have eight, or even five, teeth for this size of cutter. Experiments carried out with the increased spacing of teeth demonstrated the saving of power that could be effected, and this apparently without any detrimental effect upon the finish of the work. At the same time the teeth could be made stronger, and more clearance space left for the chips removed.

In comparing the outputs of milling-machines probably the most satisfactory basis upon which to judge the capacity is the amount of metal removed per horse-power absorbed, although in actual workshop practice the efficiency of the machine is not necessarily based on the power used. Even a few years ago results of 0.5 cub. in. of cast iron per horse-power minute were regarded as unusual with notched tooth spiral cutters, whereas at the present time this type of cutter gives results of 1.5 cub. in.

on the evidence of tests published, and outputs of 1 cub. in. are given as the results of regular works practice.

In a paper recently published in the Journal of the American Society of Mechanical Engineers, Mr. De Leeuw gives an account of a new type of cylindrical milling-cutter which is of interest in this connection, although the advantages he claims for the design do not appear to be borne out by the figures he produces regarding the tests. This tool, which is illustrated in Figs. 1, 2, 3, and 4, is described as a "helical" cutter, and, as will be seen from the drawings, it may be considered as a development of the spiral cutter, having the teeth set at a sharp angle with the axis. This new form of cutter, however, has two features which are not possessed by the older form, in that the chips are removed at right angles to the direction of feed—or, in other words, in the direction of its axis—and that it forms "tooth" marks, and not "revolution" marks, upon the work. Owing to the former characteristic there is an absence of spring in the arbor, resulting in there being no necessity for braces when working with a heavy cut; whilst the latter

Fig. 1.

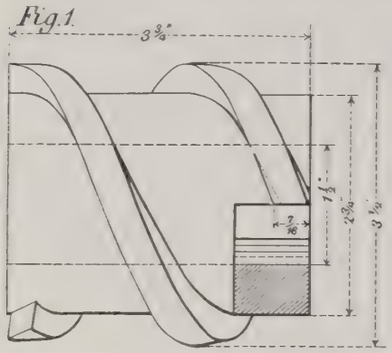


Fig. 2

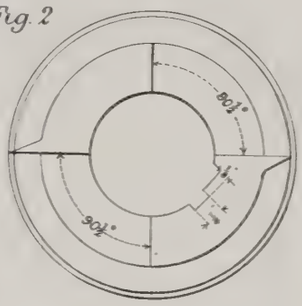


Fig. 3.

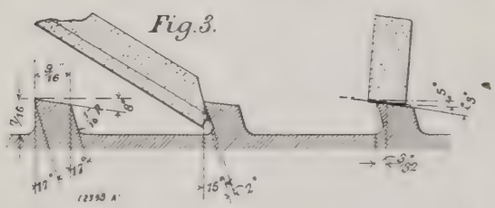
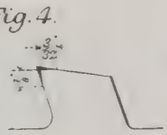


Fig. 4.



enables a coarser feed to be employed, depending upon the number of teeth, it being claimed that a 3-toothed cutter may be fed at three times the rate of an ordinary spiral mill to produce a given finish to the work.

The cutter illustrated is a "single" type, but a "double" type, consisting of a right-hand and a left-hand cutter interlocked, has been designed in order to eliminate the end-thrust produced by its cutting action. From the figures quoted by Mr. De Leeuw, however, this end-thrust would not appear to be of very great importance, since tests made with the two types show that the "single" cutter only required some 6 per cent. more power for driving the machine. The details given in our illustrations will make the construction of the "single" type clear, the cutter shown being designed for dealing with mild steel. For use on cast iron the form of tooth is slightly modified, the angle of rake being made 8 deg. in place of 15 deg., and the clearance angle being 7 deg. instead of 5 deg. as shown.

In Fig. 5 we give a diagram constructed from a series of curves given by Mr. De Leeuw, of the results obtained with this cutter on mild steel and cast iron. In this diagram are given the cubic inches of metal removed per horse-power minute at varying depths of cut and at different speeds of feed.

In referring to the outputs obtained Mr. De Leeuw states:—"The power consumption is extremely low for steel, but does not show up so favourably for cast iron. A roughing cut in steel requires only about one-third the power of the old-type spiral mill." On examining the results as given by the author, however, it is found that these statements are not altogether proved. As regards the results given at the higher rates of feed, it would appear that some error had occurred in recording the power. The curves showing the horse-power taken, given by Mr. De Leeuw, are in all cases straight lines, and if these lines are produced they cut the horse-power ordinate in all cases except for mild steel at the higher rates of feed. In Fig. 7 we reproduce from Mr. De Leeuw's paper the curves showing the horse-power taken per inch width of cut at varying depths of cut.

It will be seen—as might be expected—that in the case of the cast iron the curves produced cut the horse-power ordinate at a point representing 0.5 horse-power, this power evidently being that required to drive the machine with no cut. In the case of mild steel, however, the lines cut the horse-power ordinate near the point zero in the case of the 4-in. feed, whilst at 14-in. feed the curve does not cut the horse-power ordinate at all. It would thus appear that, in the case of the mild-steel results, either the power has been measured at the cutter or some error has occurred in recording the results. As, however, there is nothing in the paper to explain the discrepancy, we give the results as stated by the author.

Fig. 5. DIAGRAM SHOWING METAL REMOVED PER H.P MINUTE BY HELICAL CUTTER

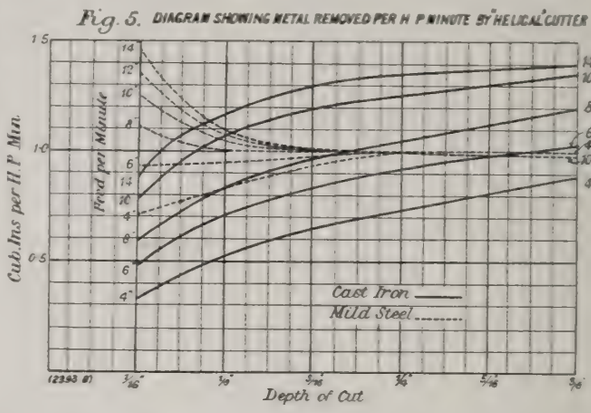


Fig. 6. DIAGRAM SHOWING METAL REMOVED PER H.P MIN. BY NOTCHED SPIRAL CUTTER (¾ PITCH) 8¼ DIAM.

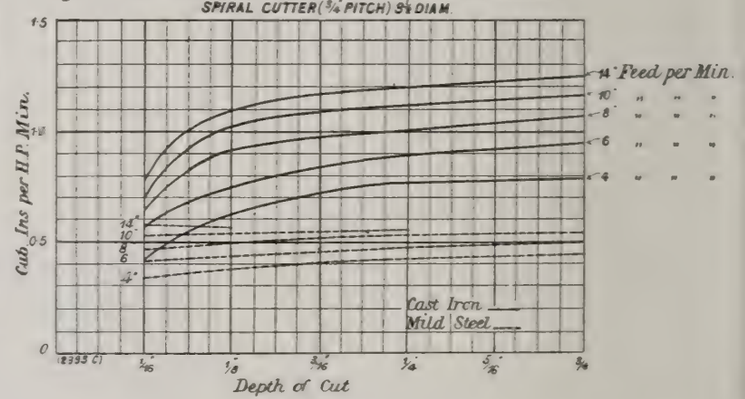
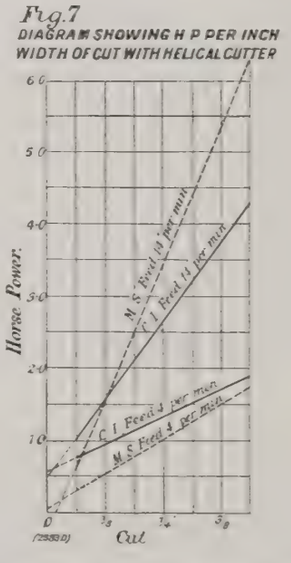


Fig. 7
DIAGRAM SHOWING H.P PER INCH WIDTH OF CUT WITH HELICAL CUTTER



Taking the figures given in the paper, relating to a spiral mill of standard design, with notched teeth of ¾-in. pitch, we have built up the diagram given in Fig. 6, and on comparing this with the results for the helical mill given in Fig. 5 it will be seen that, though there is a distinct showing in favour of the helical cutter in the case of mild steel, the best results are obtained with a light cut and high speed of feed. An increase of cut from $\frac{1}{16}$ in. to $\frac{1}{4}$ in. at speeds of feed of from 14 in. per minute to 8 in. per minute rapidly decreases the efficiency of the cutter, and a curious point is apparent in that with $\frac{1}{4}$ in. cut or over, the output is practically the same at all speeds of feed dealt with in the tests—viz., 4 in. up to 14 in. per minute. Another point is that at feeds of 4 in. and 6 in. per minute the output increases as the cut is increased until it reaches $\frac{1}{4}$ in., when it appears to remain stationary.

A comparison of the results given in Figs. 5 and 6 shows that the new cutter, which we understand was run at the same cutting speed as the older form, will remove about double the amount of steel for a given power as that dealt with by the spiral mill when the heavier cuts are employed. At the lighter cuts and higher speeds already referred to the amount removed is as much as three times that of the older form of mill.

As regards cast iron, the new form of mill shows slightly better results in all cases except at the lower rates of feed and depths of cut. At a feed of 14 in. per minute it is about 12 per cent. more efficient than the spiral mill, whilst at travels of 4 in. and 8 in. per minute it shows no gain until a cut of about $\frac{1}{4}$ in. is employed.

It is probable that further experiments with this new cutter will lead to improvements in the outputs obtained, since it would appear that much must depend upon the proper relation between the speed of rotation of the cutter and the rate of travel with a given form of helical tooth; in fact, the feature mentioned above, as to the metal being removed in the direction of the axis, depends on this relation. The results so far obtained, however, are sufficiently noteworthy, showing as they do a decided advance in the construction of cylindrical milling-cutters.

The Companies' Diary and Agenda-Book. London: Messrs. Jordan and Sons, Limited, 116 and 117, Chancery-lane, W.C. [Price 2s. 6d. net.]—This well-known diary is now issued for the twenty-ninth year, and is therefore well established. It is primarily intended for the use of secretaries of companies, but contains a large amount of information valuable to any man of business and convenient to have at hand. In the front of the book the principal requirements of the Companies (Consolidation) Act, 1908, are set forth, and typical forms of returns, &c., are given. At the end of the diary space, which allows three days to a page, miscellaneous information is given covering such subjects as postal regulations, company law abroad, arbitration, bankruptcy, brokerage, co-partnership, foreign and colonial moneys, returns relating to joint-stock companies, provident and friendly societies, labour exchanges, railways, &c. Furthermore, particulars are given of rates and taxes, the taxation of land values, poor law, workmen's compensation and many other matters, the volume being concluded by a useful set of tables.

MALLET COMPOUND PASSENGER LOCOMOTIV

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Fig. 1.

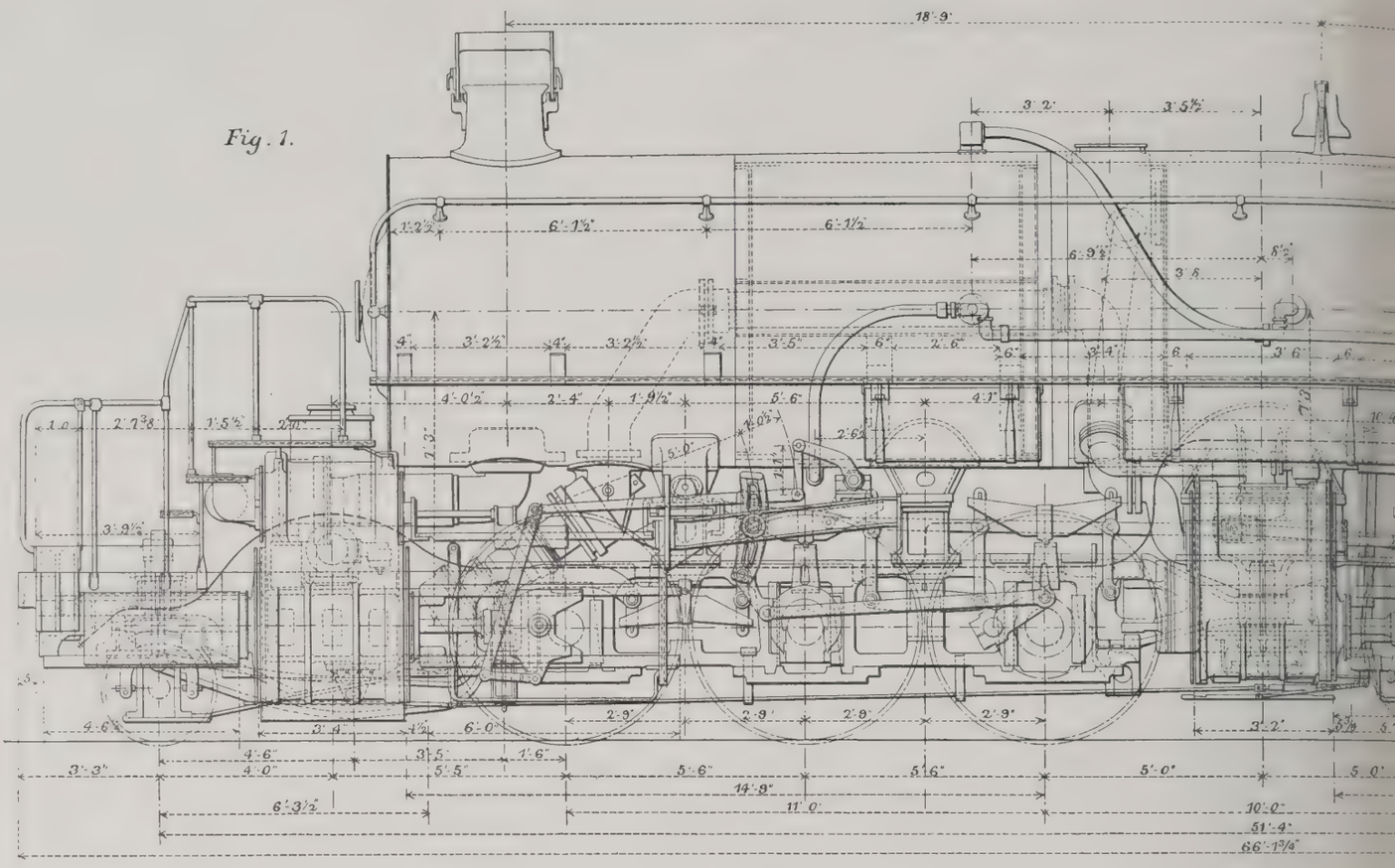


Fig. 2.

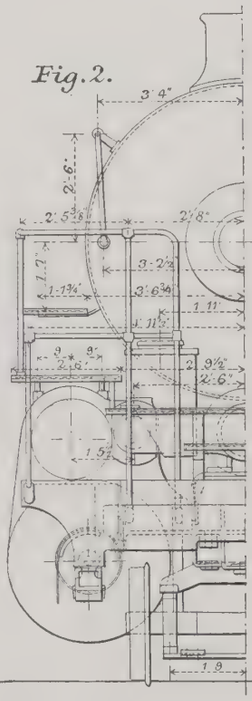


Fig. 3.

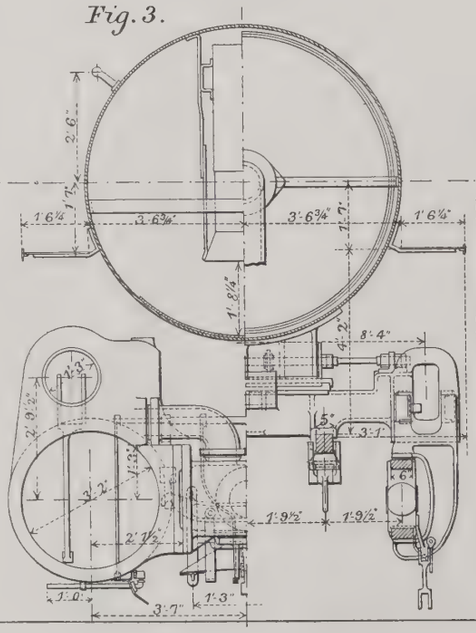


Fig. 4.

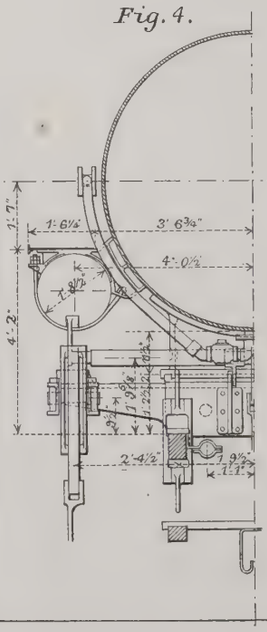
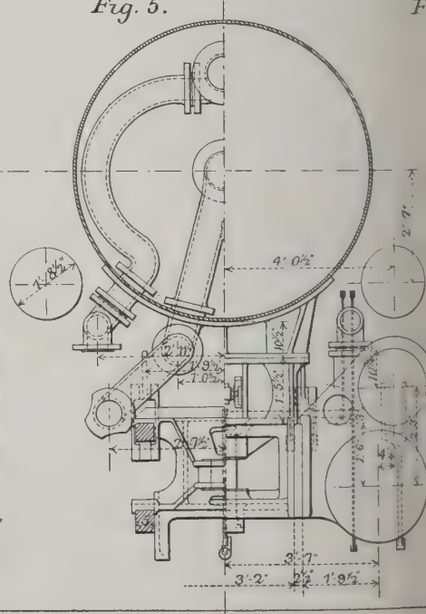
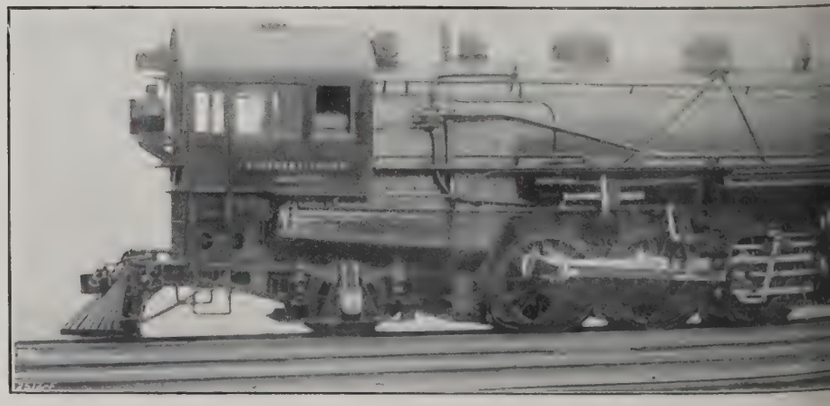


Fig. 5.



Gauge...	4 Ft. 8½ In.
Cylinders, High-Pressure ...	25 In. in Dia.
,, Low-Pressure ...	38 In. in Dia.
Stroke	28 In.
Driving-Wheels, Diameter ...	5 Ft. 3 In.
Working Pressure	200 Lb. per Sq. In.
Weight Available for Adhesion	142.9 Tons



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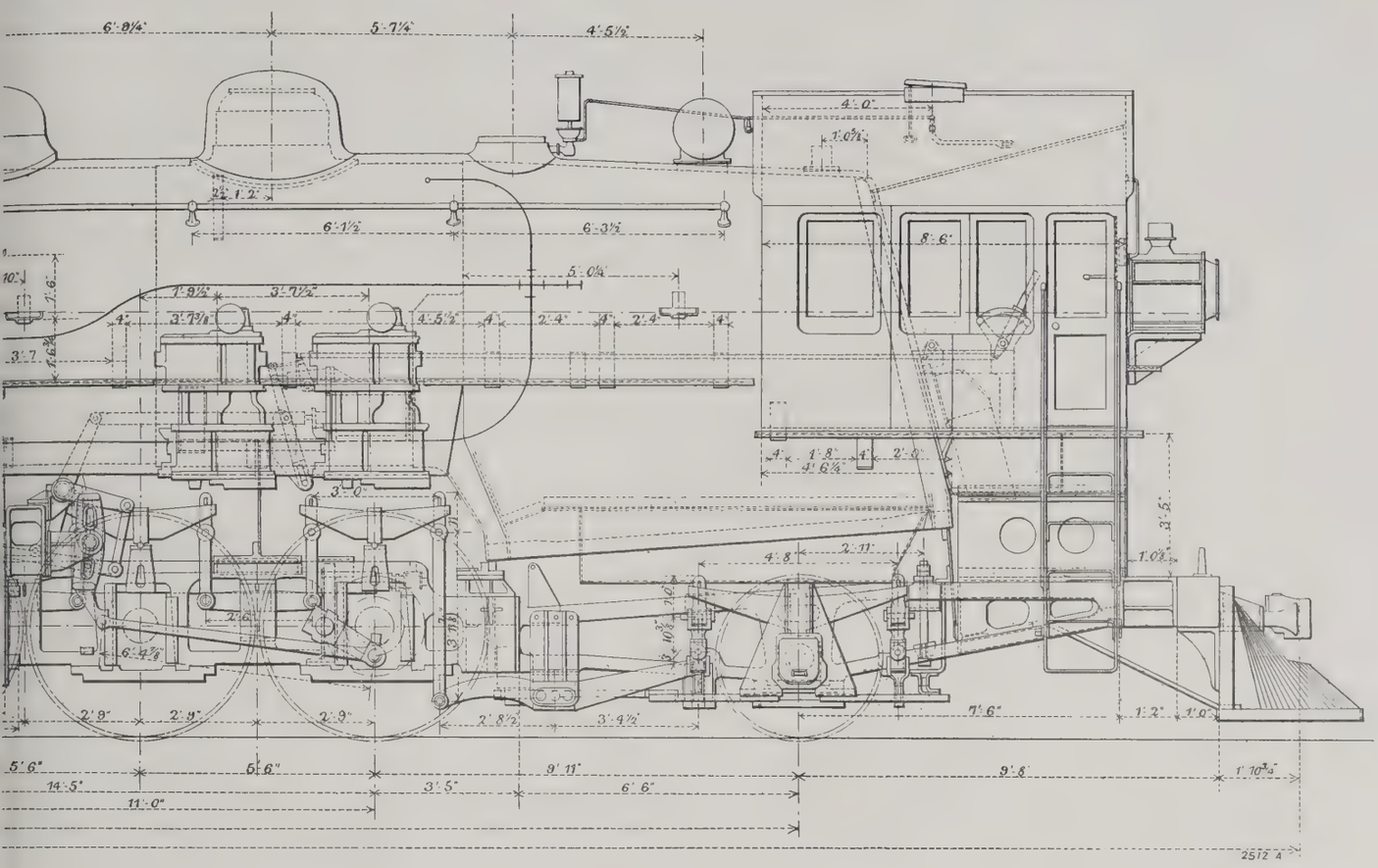


Fig. 7.

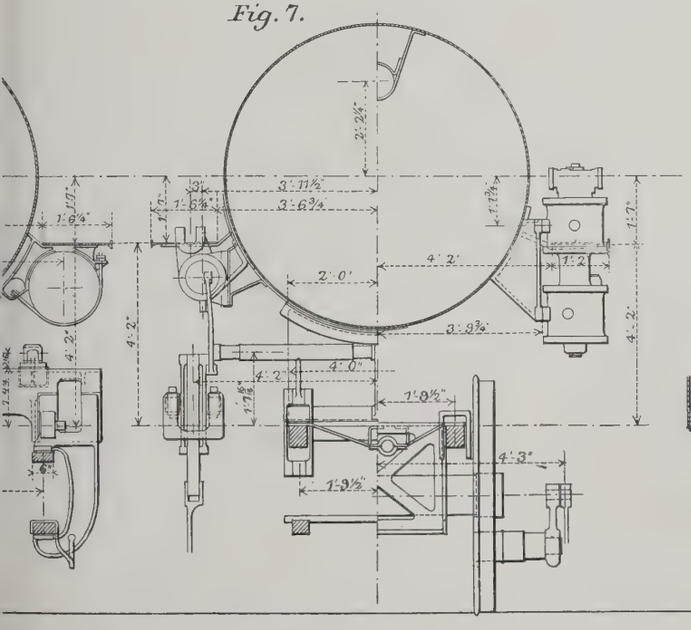


Fig. 8.

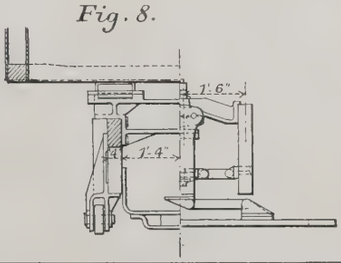
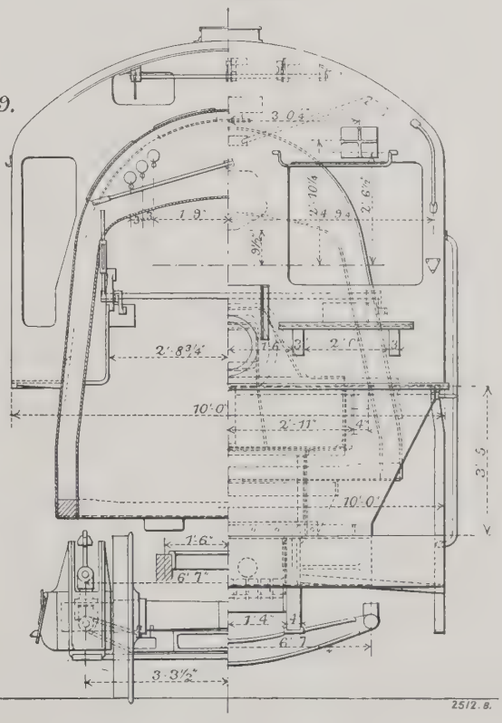


Fig. 9.



Heating Surface, Tubes	...	5292 Sq. Ft.
,, ,, Firebox	...	235 Sq. Ft.
,, ,, Feed-Water Heater Tubes	... ...	1590 Sq. Ft.
Total	...	7117 Sq. Ft.
Grate Area	... ...	70 Sq. Ft.
Total Weight, Engine and Tender		253.57 Tons

MALLET COMPOUND PASSENGER LOCOMOTIVE

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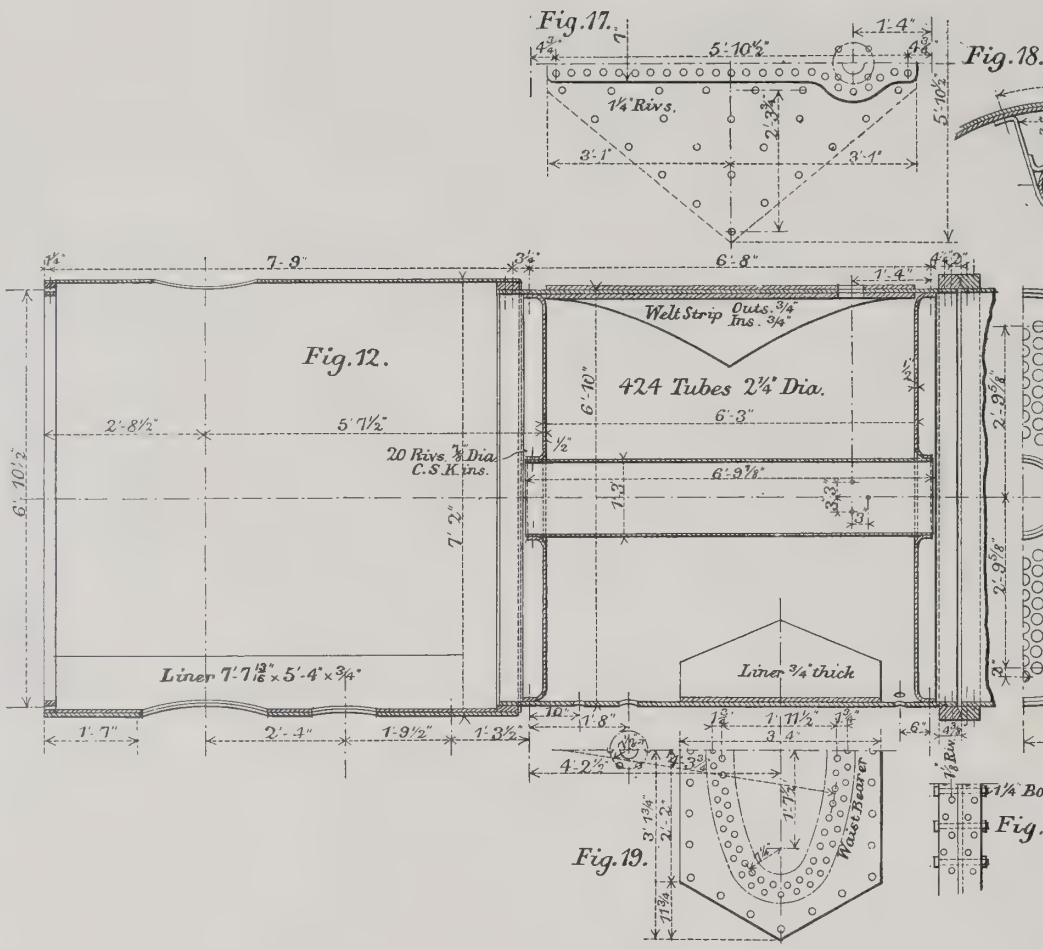
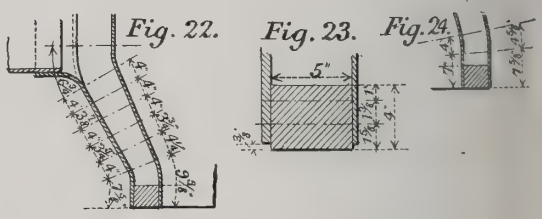
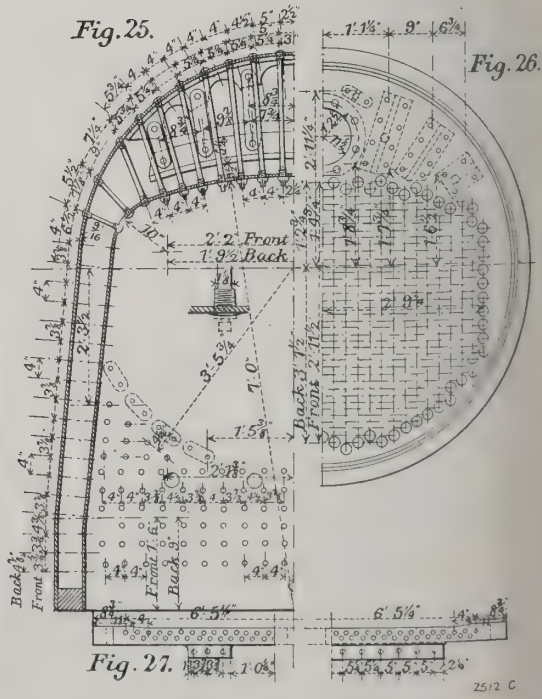


Fig. 40.





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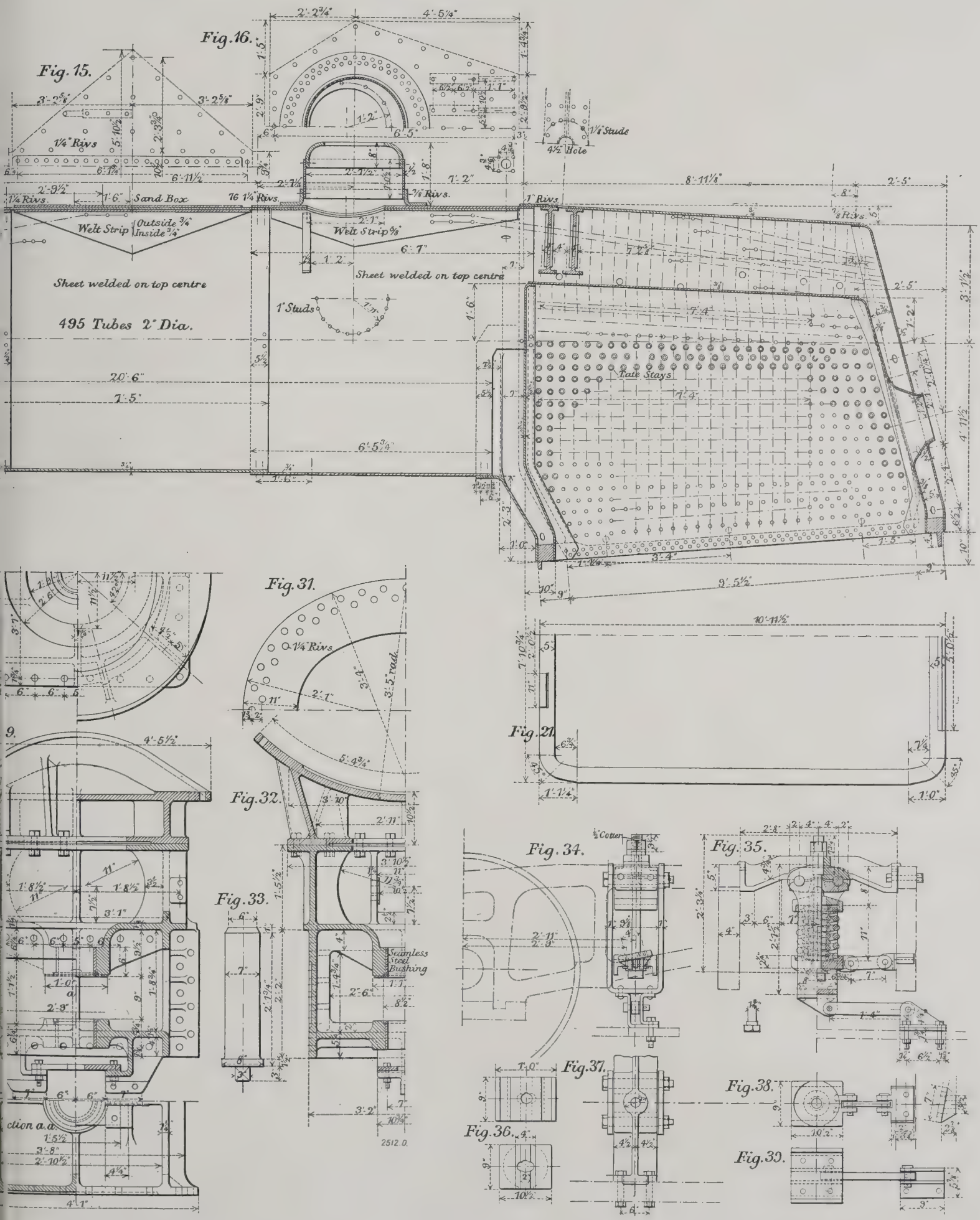


PASSENGER LOCOMOTIVE FOR THE SOUTHERN PACIFIC RAILWAY, U.S.A.

THE Southern Pacific Railway has recently put into service twelve large Mallet articulated compound locomotives, which are at present the heaviest passenger engines in America, and consequently anywhere to be found. The section on which they are used is that on the western slope of the Sierra Nevada, known as the Sacramento Division.

This division is a remarkable one. It carries one on the westward journey in the winter from snow and ice several feet thick down to the orange ranches of California in two or three hours, a change of scene which seldom fails to impress the traveller. On the westward journey the grade on this division is with the train. On the eastward trip it is against it continuously from Sacramento to Summit, a distance of 105 miles, in which a total rise of 7000 ft. is accomplished. For 40 miles the grade is 1 in 45.5. Over this section passenger trains of heavy Pullman and other cars have to be hauled on the service between San Francisco and Chicago. Such trains are of as much as 500 tons weight, and hitherto on the 40 miles of 1 in 45.5 the railway has had to employ double-heading with two ten-wheeled locomotives, weighing each, without tender, 90.6 tons, of which 71.4 tons are on the driving-wheels. The new Mallet compounds, recently constructed by the Baldwin Locomotive Works, Philadelphia, of which we are able to give illustrations herewith, are of such capacity that double heading is dispensed with.

In our two-page Plates LXIII. and LXIV., with this week's issue, we give drawings, &c., of this interesting type of locomotive. The engines are built for oil fuel, which is very largely used in the Western States. With such large engines this has a distinct advantage, in that it allows of running cab first, which enables the driver to have an unobstructed view of the road ahead. In Fig. 1 is given an elevation of the engine, and in the drawings Figs. 2 to 9 are several cross-sections, &c. Of the latter, Fig. 2 is a half end view at the trailing end; Fig. 3 gives half cross-sections just ahead of the low-pressure cylinders and near the yoke, the latter showing the centering device for the articulated frame. Fig. 4 is a cross-section taken at the back of one of the main cross-stays and slides for the articulated frame. Fig. 5 shows two cross-sections, one taken just at the saddle casting and showing the hinge of the articulated frame, and the other at the back of the saddle and high-pressure cylinder castings, showing the socket for the articulated frame hinge and pin. Fig. 6 shows the yoke for the high-pressure cylinder guides. In Fig. 7 one half-section is taken at the back of the expansion link, and shows the lever connecting with the reversing gear, while the other is taken at the leading drivers. In Fig. 8 are shown two part sections, the left-hand one showing the equalising beam fulcrum for the spring gear of the leading group of drivers and the leading two-wheeled truck, and the right-hand one the truck centering device. The half views in Fig. 9 show the interior of the cab and an outside end view. Fig. 10 gives a general view of the locomotive and tender, while in Fig. 40, Plate LXIV., is given a perspective view from the leading or cab end.

The size of the engine may be gathered from a few of the leading particulars. The cylinders are 25 in. and 38 in., with a 28-in. stroke. The total heating surface is 7117 sq. ft., and the weight of the engine alone, without tender, is 171.8 tons, and with the tender 253.57 tons. From the front coupler-head to the trailing end of the engine is just over 66 ft. In general arrangement these locomotives are similar to freight engines of the 2-8-8-2 type, which have been in use on the system since 1909. The low-pressure cylinders are arranged on the articulated frame, and the high-pressure on the main frames, to which is also attached the boiler.

Details of the boiler are shown in Figs. 11 to 27, Plate LXIV. This boiler is of the type which has come to be known as "separable," from the fact that the barrel is built up of two sections, of which the front is detachable from the back. The boiler proper is shown in sectional elevation in Fig. 11. It contains 495 2-in. tubes, 20 ft. 6 in. in length, and giving a heating surface of 5292 sq. ft. The fire-box, of which a cross-section is given in Fig. 25, provides a heating surface of 235 sq. ft. The front portion of the barrel, illustrated in Figs. 12 and 13, is used as a feed-water heater; it contains 424 2¼-in. tubes, and a central flue 1 ft. 3 in. in diameter. The heating surface provided in this section of the boiler is 1590 sq. ft., making a total of 7117 sq. ft. Figs. 14 to 19 show various joint details for the barrel-plates, &c. Fig. 20, together with the large collars shown at the barrel ends, Figs. 11 and 12, illustrate the form of joint employed for securing the front or feed-heater portion to the barrel proper. These two 4-in. rings are turned with a V-joint fit, and are drawn together by bolts at frequent intervals, as shown in Fig. 20. Details of the foundation ring are given in Figs. 21, 23, and 27, and of the front water leg in Fig. 22. The foot of the back water leg is shown in Fig. 24. The barrel tube-plate is shown in Fig. 26.

The dome is placed a short distance ahead of the fire-box, and an internal dry pipe conveys the steam thence to an intermediate combustion-chamber (Figs. 1 and 5) separating the boiler and the feed-heater tube-plates. In this chamber, which will be seen from Fig. 1 to be close to the high-pressure cylinders, there are the usual T-piece and branch pipes, and from these steam is conveyed by outside horizontal pipes on the right and left-hand to the high-pressure steam-chests. The high-pressure exhaust also re-enters this combustion-chamber, and the two pipes converge and, forming an inverted Y, the exhaust is carried in a single pipe through the central flue in the feed-heater. At the smoke-box end the pipe passes downwards, and below the smoke-box is provided with the necessary flexible jointing in order to connect it with the low-pressure cylinders on the articulated frame.

The feed enters the water-heater at the bottom, and leaves it at the top, and it is taken thence on either side to the boiler through clack-valves placed on the horizontal diameter. Clacks are placed at both the boiler and heater ends of this connection.

Steam distribution is controlled by piston valves of the inside admission type, operated with Walschaert gear. The valves are 15 in. in diameter, and are set with a lead of $\frac{5}{16}$ in. The exhaust clearance of the high-pressure valves is ¼ in., and of the low-pressure ⅜ in. By-pass valves are not provided, but relief-valves are fitted on the steam-pipes leading to each cylinder. The low-pressure pistons are fitted with tail-rods supported at their outer ends by cross-heads. The guides for these cross-heads are fixed to the cylinder cover and the cast-steel bumper beam. The cross-heads have cast-steel bodies and bronze gibs, and bear on the tops of the guides only.

The high-pressure cylinders and saddle are made separately. The frames at this point take the form of slabs, 2½ in. thick (Fig. 5) and 26 in. deep. This slab is spliced to the main bar frame by 21 driven bolts 1½ in. in diameter, and by two taper keys driven in a parallel and vertical keyway. This method of keying is also used for the cylinders and saddle connections to the main frames. The saddle is of cast steel and of two sections, the lower extending the full depth of the frames, and forming the support for the hinge of the articulated frame, the pin of which is 7 in. in diameter. Details of this casting, pin, &c., are shown in Figs. 28 to 33. Hitherto a separate cross-tie has been employed to support the lower end of the hinge-pin. The present arrangement forms a much more substantial piece of work. At the low-pressure cylinders the articulated frames also take the form of slabs, to which the cylinders are bolted on the outside, while a steel box casting extends between them on the inside.

As the engine runs cab first, the two-wheeled bogie under the fire-box is the leading truck. This truck is of the Hodges type, with spring links, jointed so as to allow fore and aft as well as lateral motion. It is equalised with the main frame drivers. Details of the centering device provided for this truck are shown in Figs. 34 to 39. A double coil spring is used (Fig. 35), held vertically between two cast-steel washers, and suspended by a vertical bar. This bar is suspended from a cross-tie between the engine frames. The lower washer is attached by links to the main frames (Figs. 35 and 38). Between the top spring washer and the cross-tie is a bearing-plate, and interposed between the two are two 2-in. pins. These pins support a U-shaped strap (Fig. 34), and a link (Figs. 35 and 39) connects this strap with a lug on the truck frame. When the truck is displaced, one or the other of the two bearing-pins is pulled down, and a load is placed upon the coil spring, which therefore tends to return the truck to its central position.

These locomotives are equipped for oil-burning, and the tenders can therefore be conveniently coupled at the smoke-box end. The two tanks are partly cylindrical in shape, and are placed end to end. The water-tank has a capacity of 10,000 gallons, and that for oil 3200 gallons. They are carried on a frame of 12-in. by 40-lb. channels, with strong cross-bracing and bumper beams of cast steel. The tender and engine truck-wheels are of the "Standard" forged and rolled-steel type.

Other particulars are given in tabular form herewith:—

Locomotive:

Cylinders—high-pressure	25 in.
,, low-pressure	38 ,,
,, stroke	28 ,,
Wheels—driving, diameter	5 ft. 3 in.
,, truck, front	3 ,, 9 ,,
,, truck, back	2 ,, 6½ ,,
Boiler barrel, diameter	6 ,, 10 ,,
,, ,, thickness of sheets ...	⅜ in.
Fire-box—length	10 ft. ⅜ in.
,, width	7 ft.
,, thickness, sides, back, and crown-sheets ...	⅜ in.
Fire-box—thickness, tube-sheet ...	½ in.
,, water spaces	5 ,,
Tubes—number	495
,, length	20 ft. 6 in.
,, diameter	2 in.
Feed-water heater tubes—number ...	424
,, ,, diameter	2¼ in.
,, ,, length ...	6 ft. 3 in.
Heating surface—firebox	235 sq. ft.
,, ,, boiler tubes ...	5292 ,,
,, ,, feed-water heater tubes	1590 ,,
Total	7117 sq. ft.
Grate area	70 sq. ft.
Working pressure	200 lb. per sq. in.
Wheel-base—driving	32 ft.
,, rigid	11 ,,
,, total engine	51 ft. 4 in.
Weight on driving-wheels	142.9 tons
,, front truck	19.5 ,,
,, back ,, ...	9.4 ,,
,, total of engine	171.8 ,,

Tender:

Water capacity	10,000 gals.
Oil capacity	3,200 ,,
Wheels—diameter	2 ft. 9 in.

Locomotive and tender:

Wheel-base—total	85 ft. 1 in.
Weight—total	253.57 tons

POKORNY AND WITTEKIND TURBO-COMPRESSORS.

WHEN Professor Rateau read a very instructive paper on turbo-compressors before the Düsseldorf International Congress of Mining and Metallurgy of last summer,* Mr. E. Köster mentioned that his firm, Messrs. Pokorny and Wittekind Maschinenbau A.-G., of Frankfort-Bockenheim, had, in taking up the construction of turbo-compressors five years ago, reduced the number of wheels, and realised an isothermal efficiency of nearly 68 per cent. in the electrically-driven compressor which they had built for the Rand mines in South Africa. We are to-day able to illustrate several of the turbo-compressors of this firm, and to give particulars as to the tests of the electrically-driven compressors and of others coupled to mixed pressure turbines. These test particulars are not less interesting than the construction of the compressors; for there is some disagreement as to the proper manner of conducting the air measurements.

Figs. 1 and 2, on page 792, represent internal parts of mixed-pressure turbines and of turbo-compressors. The first of these was constructed for the Reden mines, near Saarbrücken, and installed in 1909; running at 4200 revolutions per minute, this compressor draws in 7000 cub. m. (247,000 cub. ft.) of air per hour, and discharges it at a pressure of 7 atmospheres absolute (100 lb. per sq. in.). The second turbo-compressor was installed in the summer of 1910 in the Königsborn A.-G. für Bergbau, Salinen- und Sodabetrieb at Unna-Königsborn, in Westphalia; driven likewise by a mixed-pressure steam-turbine at 4200 revolutions per minute, it has a capacity of 10,000 cub. m. (353,000 cub. ft.) of free air per hour, delivered at a pressure of 8 atmospheres absolute (114 lb. per square inch). The turbines are provided with two casings, the one for working with boiler steam, and the other for working with exhaust steam, which are a speciality of Messrs. Pokorny and Wittekind. Steam is taken from the exhaust of the hauling-engines, and normally the two sections of the turbine work together. When the hauling-engines are stopped, boiler steam is sent only to the one casing, the wheels of the exhaust section running *in vacuo*.

The valve gear is so designed as to admit live steam into the first casing as soon as the exhaust-steam feed becomes insufficient. The rotors, shown in Fig. 1, are those of a 1000-horse-power mixed-pressure turbine of this type. The rotors of Fig. 2 belong to the turbo-compressor of the Königsborn installation; there are six wheels in the low-pressure group and seven in the high-pressure group. These numbers are smaller than in some other types, and one of the advantages realised by this reduction is that the total length of the compressor itself with two casings and bed-plate does not exceed 5 m. (16 ft. 5 in.). The intercooler for the two casings is below the flooring, and is fitted with brass tubes. The casings are themselves cooled, deep water-cooled diaphragm partitions being provided between each pair of impellers. The air is discharged at temperatures ranging from 60 to 70 deg. Cent. (140 to 160 deg. Fahr.).

The tests of the Reden installation, conducted by Professor Langer, of the Technical High School of Aachen, yielded the following results:—When 7500 cub. m. (264,900 cub. ft.) of air were compressed from 1 atmosphere up to 7 atmospheres absolute (14.2 to 99.6 lb. per sq. in.), the consumption of saturated exhaust steam of 1.1 atmospheres (15.6 lb. per sq. in.), initial pressure, and exhausted at a vacuum of 0.08

* See ENGINEERING, vol. xc., page 45.

HIGH-SPEED TURBO-AIR-COMPRESSORS.

CONSTRUCTED BY THE POKORNY AND WITTEKIND MASCHINENBAU A.-G., FRANKFORT-BOCKENHEIM, GERMANY.

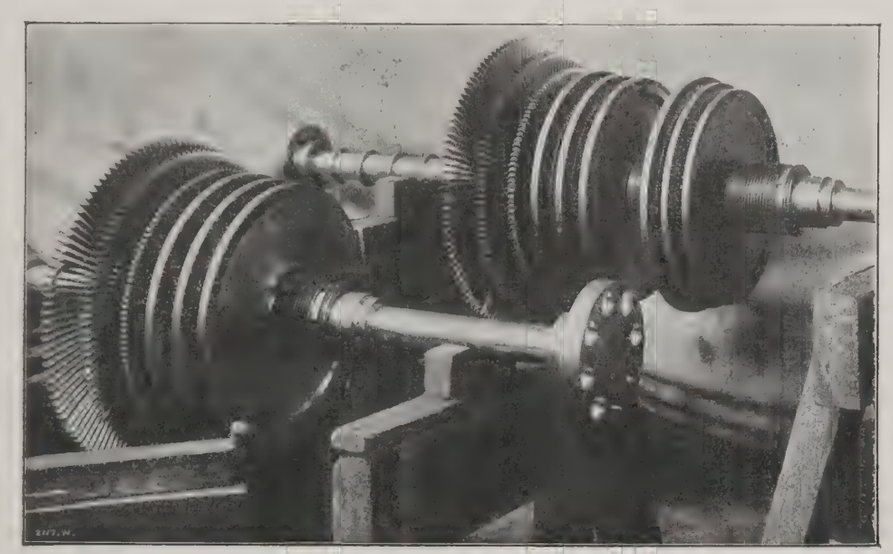


FIG. 1. ROTORS OF MIXED-PRESSURE TURBINE FOR 1000-HORSE-POWER TURBO-COMPRESSOR.

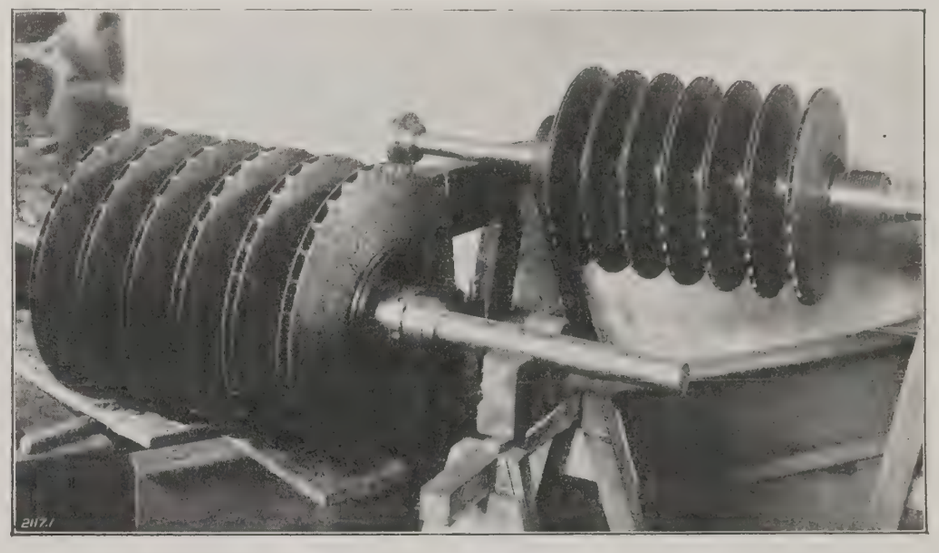
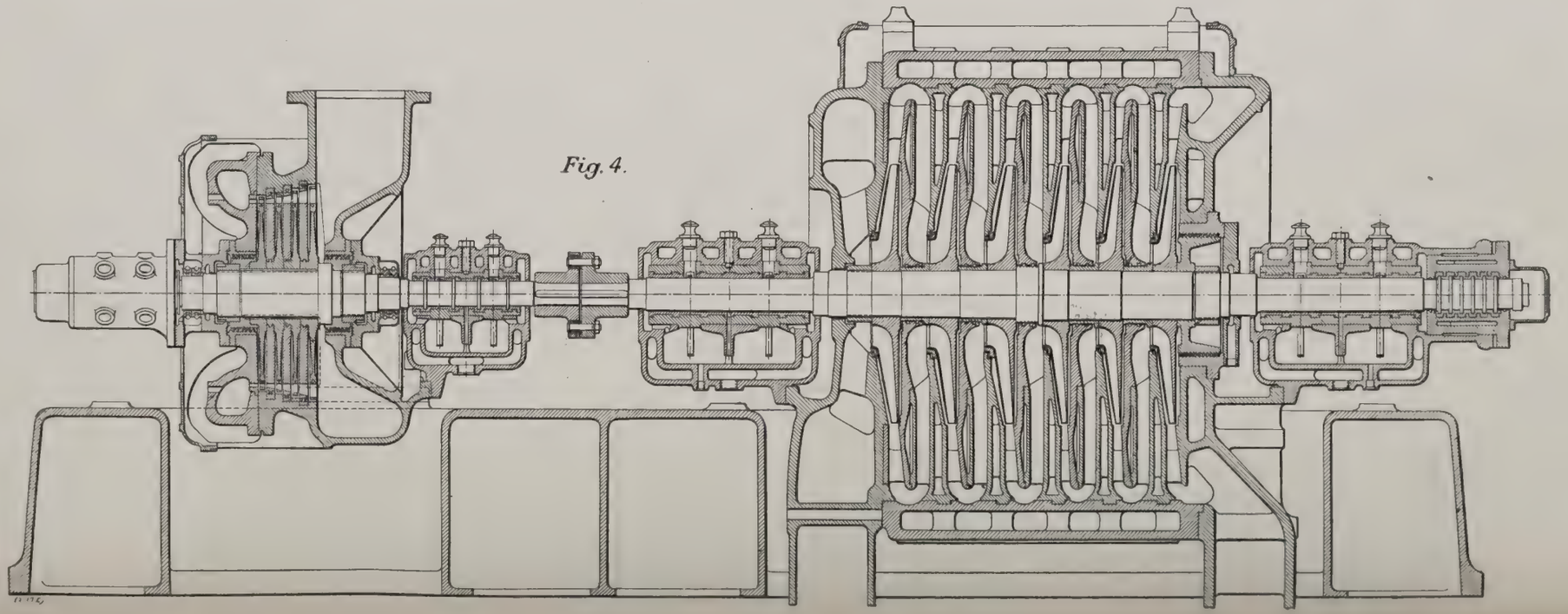


FIG. 2. ROTORS OF TURBO-COMPRESSOR FOR KÖNIGSBORN MINES.

Fig. 4.



4000-H.-P. ELECTRICALLY-DRIVEN TURBO-COMPRESSOR FOR THE RAND MINES.

CONSTRUCTED BY THE POKORNY AND WITTEKIND MASCHINENBAU A.-G., FRANKFORT-BOCKENHEIM, GERMANY.

Fig. 5.

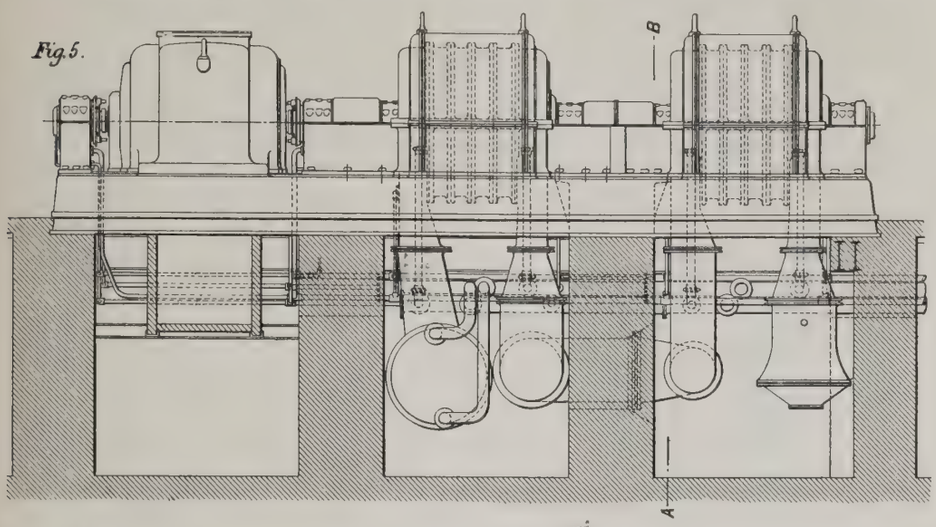


Fig. 6.

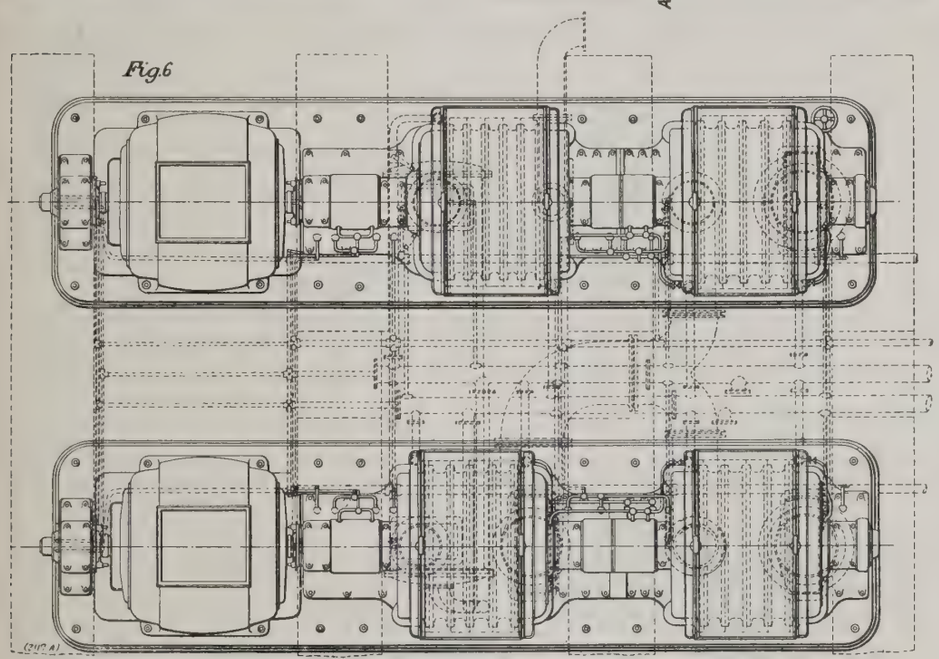


Fig. 7.

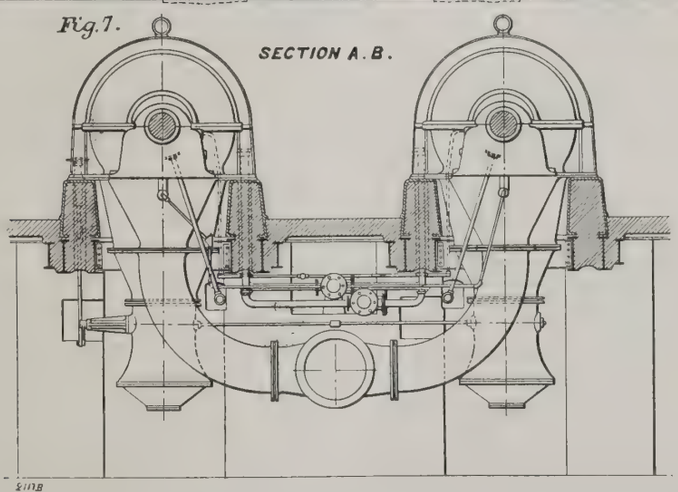


Fig. 8.

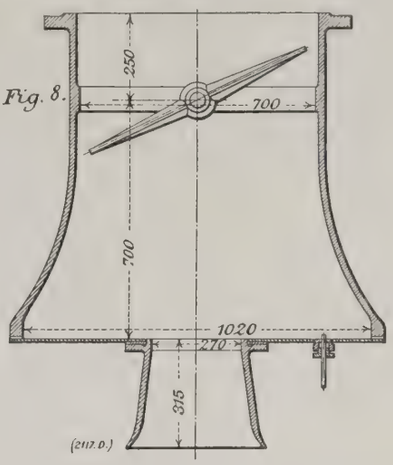
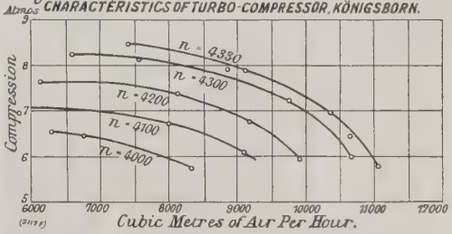


Fig. 4 is a section through a compressor, which, running at 4200 revolutions, draws in 8000 cub. m. (282,000 cub. ft.) of air per hour, and delivers it under a pressure of 3 atmospheres absolute (43 lb. per sq. in.). The compressor is driven by a non-condensing turbine. This type of turbo-compressor has found application in chemical works.

We pass to the 4000-horse-power turbo-compressor constructed for the Victoria Falls and Transvaal Power Company, of Johannesburg, which was formed to install a plant for transmitting 24,000 horse-power of primary electric energy from Victoria Falls to the Rand mines. The order came to Messrs. Pokorny and Wittekind through the Allgemeine Elektricitäts-Gesellschaft and the Siemens-Schuckertwerke, of Berlin. The compressor is one of six, all of 4000 horse-power, installed at the central station for supplying compressed

Fig. 3.



air to the Rand mines, and is to draw 35,000 cub. m. (1¼ million cub. ft.) of air per hour at a pressure of 0.83 atmosphere (11.8 lb. per sq. in.) and a temperature of 20 deg. Cent. (68 deg. Fahr.), and to deliver the air at a final pressure of 9 atmospheres absolute (128 lb. per sq. in.). An isothermal efficiency of 64 per cent. had to be guaranteed, the power consumption not to exceed 4200 horse-power, and the load on the two motors to be balanced within 5 per cent. Johannesburg lies about a mile above sea-level, and the average barometer is 610 mm. (24 in.). Figs. 5, 6, and 7 show the compressor in elevation, plan, and section. It was decided to drive the compressor by electric motor at 3000 revolutions per minute, and as a 4000-horse-power synchronous motor could not conveniently be run at this high speed, the machine was divided into halves, each driven by one synchronous motor of 2000 horse-power. The two shafts lie parallel to one another, and at first glance the two halves would appear identical. The arrangement is, however, such that there are two low-pressure cylinders, one on each shaft, and that there is, in addition, an intermediate-pressure cylinder on the one shaft and a high-pressure cylinder on the other. When we face the low-pressure compressor at the one end (the motor is at the other end), the left-hand low-pressure compressor is on the same shaft as the intermediate compressor. The suction-pipes lead into the low-pressure cylinders; the latter discharge into a common conduit leading to the intermediate-pressure compressor, and thence to the intercooler and the high-pressure cylinder. The subdivision of the low-pressure compressor had the advantage of enlarging the cooling surfaces; an intercooler between the first and second stage was accordingly not required. The air intakes are in the basement, which the air enters after passing through a filter; this filter is common to the whole plant.

The tests of this compressor were conducted by Professor Langer in the new turbine-shops of the Allgemeine Elektricitäts-Gesellschaft at Berlin. Professor

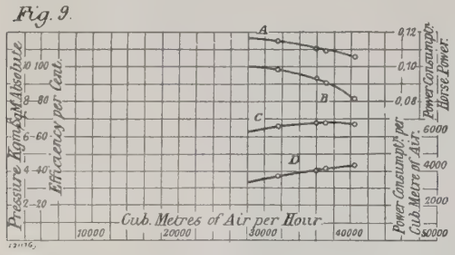
atmosphere (1 14 lb. per sq. in.) absolute, amounted to 1.28 kg. per cub. m. of air; the consumption of boiler steam at 6 atmospheres (85 lb. per sq. in.) absolute, and the same vacuum, amounted to 0 81 kg. The second compressor at Königsborn was also tested. The results of these tests are summarised in Table I., page 794, and Fig. 3 shows the pressure-volume curves for different speeds; these curves demonstrate the efficiency of the governing of the steam-compressor.

It will be seen from the table that in the compression of 8150 cub. m. (287,000 cub. ft.) of air from atmospheric pressure to 8 atmospheres absolute (114 lb. per sq. in.) there were consumed 1.24 kg. of exhaust steam (at a pressure of 1.2 atmospheres and a vacuum of 0.1 atmosphere absolute) per cubic metre of air drawn in. The consumption of boiler steam (at 7 atmospheres absolute and the same vacuum) amounted to 0.73 kg. per cub. m. of air. The isothermal efficiency of the compressor varied between 64 and 65 per cent., and the steam-turbine worked with exhaust at an efficiency of about 68 per cent. and with boiler steam at an efficiency of about 66 per cent.

Langer reported that the compressor ran very smoothly, without any vibrations, though the temporary erection in the testing-rooms could not be effected with the exactitude to be adopted in the final installation. The stuffing-boxes and joints in the casing kept perfectly tight, and the bearings did not run warm. These features, and particularly the high efficiency realised, which surpasses the stipulated efficiency, would tend to prove that the careful design of the compressor upon scientific considerations has successfully solved the practical problems.

In conducting the tests, Professor Langer took temperature and pressure measurements at the two cylinders and in the two intakes. The arrangement

Fig. 9.



of the throttling-valves and measuring nozzles fitted into the intakes is shown in Fig. 8. The pressures were measured by four Pitot tubes, two of which were placed close to the axis of the throttle-valve, one on each side of it, and the others symmetrically between the two former; this was done in order to test the influence of the valve upon the speed of the air current in various parts of the valve-casing at various openings. In the preliminary tests, some bent tubes were tried, the end inside the nozzle being bent over at right angles, so as to meet the air current at right angles; these tubes gave pressure readings about 5 per cent. higher than the straight tubes, parallel to the air current, and they were accordingly abandoned. The height to which the straight

Table I.—*Turbo-Compressor, Königsborn.*

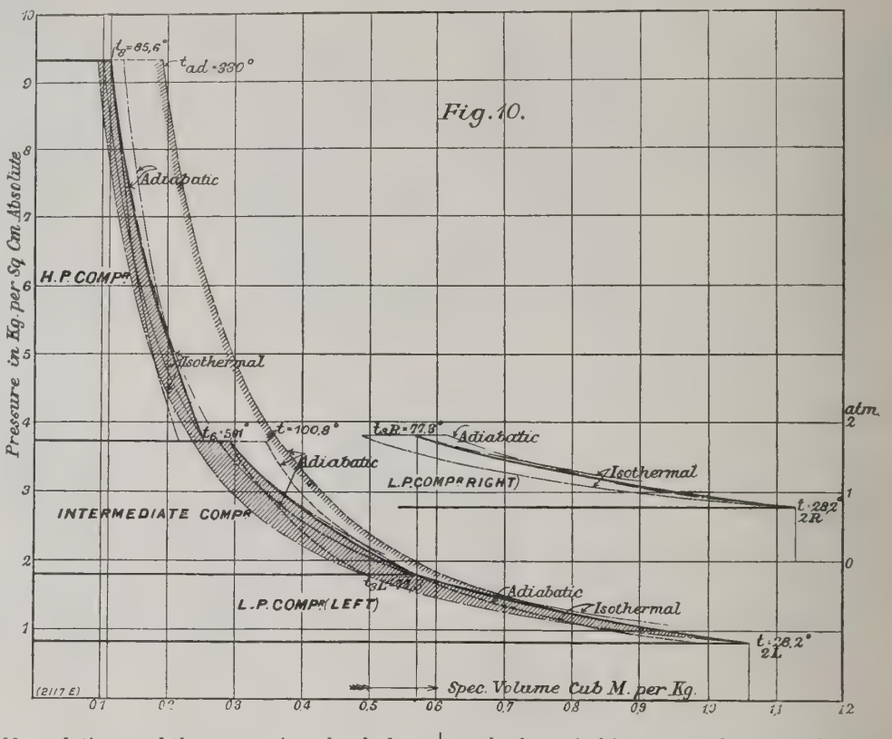
Working with	Exhaust Steam.	Boiler Steam.
Pressure of atmosphere .. .. kg. per sq. m.	1.0282	1.0276
Throttling in nozzle .. .. ,,	0.0132	0.0132
Pressure of air drawn in .. .. ,,	1.0150	1.0144
Temperature of air drawn in .. deg. C.	20.3	21.0
Theoretical weight of air drawn in per sq. m. of nozzle section of nozzle of diameter 250 mm. kg. per sec.	0.00596	0.00596
Weight of air drawn in .. .. kg. per hr.	9660	9650
Volume of air drawn in .. cub. m. per hr.	8150	8170
Steam consumption per hour .. kg. per hr.	11,820	5790
,, ,, cub. m. of air ,,	1.45	0.71
Final air pressure .. kg. per sq. cm. abs.	8.09	8.03
Isothermal work per cub. m. .. m.-kg. per cub. m.	21,040	20,970
,, of compressor .. H.-P. isoth.	635	634
Initial steam pressure kg. per sq. cm. abs.	1.266	7.39
Condenser pressure .. ,,	0.149	0.086
Heat gradient .. .. thermal units per kg.	77	159.5
Energy available .. .. H.-P. theoret.	1440	1460
Total efficiency .. .. .. per cent.	44.1	43.3
Cooling water—nozzle diameter, 65 mm.:—		
,, rate of discharge m. per sec.	3.61	3.54
,, bulk .. .. cub. m. per hour	40.5	39 7
,, temperature increase deg. C.	12.58	12.76
Work of compression of water .. .. h.-p.	807	803
Air temperature .. .. .. deg. C.	62.6	62.4
,, rise in .. .. ,,	42.3	41.9
Work of compression of air .. .. .. h.-p.	154	152
Cooling water for bearings, 3.12 cub. m. per hour; temperature rise, 8 3 deg. C.; work done, h.-p.	41.0	41.0
Cooling water for oil. 0.82 cub. m. per hour; temperature rise, 6 deg. C.; work done, h.-p.	7.8	7.8
Friction (about half of this absorbed by compressor) .. .. h.-p.	48.8	48.8
Power absorbed by compressor .. .. ,,	980	980
Isothermal efficiency of compressor per cent.	64.4	64.7
Thermodynamical efficiency of turbine ,,	68.5	66.9
Calculated for guaranteed power and output :—		
Compressor work, isothermal, 1 to 5 atmospheres absolute .. ..m.-kg. per cub. m.	20,790	20,790
Power consumption for 8000 cub. m. of air drawn in .. .. h.-p.	957	953
Heat gradient .. .. thermal units per kg.	89	54
Steam consumption per hour kg. per hour	9920	5820
,, ,, per cub. m. of air kg. per cub. m.	1.24	0.732

tubes penetrated into the casing was also varied. When this height exceeded 100 mm. or 150 mm. (4 in. or 6 in.), high readings were again obtained, and in the final selected measurements the tubes were almost flush with the bottom of the throat of the measuring nozzle. The four tubes were grouped on the circumference of a circle of about 335 mm. (13 in.) radius, reckoned from the axis of the nozzle. The readings of these four tubes differed by 2 or 3 per cent., and averages were hence taken of four simultaneous readings. It must be borne in mind that a difference of 2 per cent. on the gauge corresponds to a difference of 1 per cent. in the amount of air drawn in, so that the fluctuations are not serious.

The weight of air was calculated from the formula

$$G = 1.532\, F\, p_0\, \mu \sqrt{\frac{1}{T}\left(\frac{p}{p_0}\right)^{0.286}\left[\left(\frac{p}{p_0}\right)^{0.286} - 1\right]}$$

in which G is the weight of air sucked up per second, F the cross-section of the nozzle 0.05^{72225} sq. mm., p the air pressure in front of the nozzle, p_0 the same behind the nozzle, both in kg. per sq. cm. absolute, T the temperature of the air in front of the nozzle in deg. Cent. absolute, and μ the nozzle coefficient. Professor Langer adopted the value $\mu = 0.98$; it is customary to take 0.99, and this latter coefficient has been assumed by Messrs. Pokorny and Wittekind in their efficiency statements. Professor Langer has himself done so in some calculations. As the compressors are to work in the somewhat rarified atmosphere of the Rand mines, the air pressure was for the tests reduced to 0.83 kg. per sq. cm. The motors were kept running



at 3000 revolutions, and the energy they absorbed was determined on the two-wattmeter system; their efficiencies varied between 94.1 and 94.4 per cent. Eight complete series of tests were made, and temperatures and pressures were determined at nine spots marked t, t_1 . . . t_8, Fig. 10.

The highest compressor efficiency, of 67.7 per cent., was realised with cooling water at a temperature of 11 deg. Cent. (52 deg. Fahr.); when the cooling water was preheated to 24 deg. Cent. (75 deg. Fahr.) in order to conform to the conditions to be expected in actual work, the efficiency was 67.3 per cent.—3 per cent. higher than the stipulated value. These efficiencies are referred to the isothermal curve, the air taken in and the cooling water being nearly at the same temperature. The compound diagram, Fig. 9, expresses the results of the series of tests graphically. The abscissæ are the air volumes per hour; the ordinates denote efficiency, pressure, and power consumption. Curve A indicates the horse-power consumed per cubic metre of air. Curve B is the characteristic referred to the initial air pressure of 0.83 kg. per square centimetre, which, as we stated, was maintained so far as possible. Curve C is the isothermal efficiency, deduced from observations made on the left-hand low-pressure compressor. Curve D indicates the total power consumption, which was on an average 4000 horse-power. The amount of air drawn in and delivered at the absolute pressure of 8.1 kg. per square centimetre (115 lb. per square inch), it will be seen, was 40,600 cub. m. per hour.

The isothermal efficiency is the energy ratio of the power required for the isothermal compression to the power delivered to the coupling, the compression taking place at atmospheric temperature between the initial and final pressure. In making the calculations the initial pressure was entered as measured at the left-hand low-pressure compressor. The left-hand low-pressure compressor was chosen for the following reason. Owing to the want of symmetry in the grouping, the intermediate-pressure compressor being on the left-hand shaft, and the high-pressure compressor on the right-hand shaft, the throttling of the air entering the low-pressure compressors was not quite the same for the two compressors, this being necessary in order to balance the power. The initial pressure P L_1 was, in fact, a little greater than the initial pressure P R_1, and the bulk of air drawn in on the left side was greater than that on the right-hand side. The calculations have been based upon the greater initial pressure on the left-hand side, and higher efficiencies would have resulted if the initial pressure on the right-hand side had been selected; the difference would amount to about 0.8 per cent. In Professor Langer's opinion this increased throttling had better be dispensed with, as it would slightly impair the governing and economy of the machine.

The consequences of this unequal throttling become apparent in Fig. 10, in which the temperature and pressure conditions of the air can be studied as the air flows through the different compressors. When an efficiency estimate is deduced from the shaded portions of the diagrams, the resulting efficiency of the actual compression curve is 79.7 per cent. This figure has a merely theoretical interest, and must not be accepted for practical comparisons, since the compressor losses enter into this value; with inefficient cooling arrangements the shaded portion would become greater and a higher efficiency would apparently result.

New York Fire Department.—The "Red Book" No. 156 of the British Fire-Prevention Committee is rather a departure from the usual course, being devoted not to a description of fire tests, but to the subject of the New York Fire Department. It is written by the Hon. R. Waldo, late Fire Commissioner, New York, and is illustrated with ten engravings. In the fifth publication of the British Fire-Prevention Committee, which appeared in 1897, the Fire Department of New York, as it then existed, was described, and the numerical increase since that year has brought the department from 114 officers and men to 4324; from 16 land engine companies to 174; from 3 fire-boat companies to 10; and from 22 hook and ladder companies to 76. The chief officers have been increased from 14 battalion chiefs to 42, and from 3 deputy chiefs to 13. This increase has been, of course, due in part to the natural growth of the city, but also in part due to the inclusion of the former counties of Kings, Queens, and Richmond into the Greater City of New York. The "Red Book" is published at the offices of the British Fire-Prevention Committee, 8, Waterloo-place, Pall Mall, the price being 2s. 6d.

The Institution of Automobile Engineers.—The second meeting of the London section of the graduates of the Institution of Automobile Engineers was held on Thursday, December 7, when an interesting paper, entitled "Carburation," was read by Mr. G. M. Junner, G.I.A.E. The author opened by stating the requirements of the modern carburettor, pointing out the need for fairly weak mixture at high speeds, and slightly rich mixture at low speeds, with capability of ready acceleration accessibility, easy of adjustment, and resistance to wear. After giving the proportions of various mixtures with their formulæ, he went on to point out that the chief cause of excessive petrol consumption is generally an inherent fault in carburettor design, such as low air velocity past the jet. The temperature of carburettors was then dealt with, the author expressing preference for the method of warming only the air supply, and not the mixture. He expressed the opinion that the height of the petrol level in the jet, within limits, had very little effect on the running of the engine, although it made a considerable difference in the matter of petrol consumption. He then described a number of different carburettors, raising objections to the use of spray cones, and stating a preference for multiple jet carburettors.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, December 6.

The revival of demand for iron and steel products is continued, and inquiries arriving almost daily for large quantities of material afford encouragement for a continuance of the favourable conditions. Crude iron is receiving special attention. It has been dragging for months. Southern furnaces are gathering an unusual amount of business. Upwards of 100,000 tons of Southern basic and Bessemer iron have been contracted for at less than 10 dols. per ton at Birmingham. At the present rate of progress Southern furnaces will shortly be out of the market. Large Northern buyers are after basic. Jones and Laughlin want 30,000 tons. Basic is selling at a very low figure, and most of the business now pending will be closed at the low basis pending. Northern furnaces are accumulating orders for all kinds of iron, but not rapidly. Iron for cast-iron pipe has been contracted for in very large quantities. It appears to be the purpose of buyers of crude iron to make arrangements for the first half of the year. A good many furnace companies have closed contracts for all they will require for the coming year, some of them for six months. Nine of the larger consumers have definitely closed contracts which have involved the delivery of 120,000 tons of coke per month. These transactions have hardened the prices 10 to 15 cents per ton. About 1000 ovens are idle, and will resume shortly. An upward tendency in coke is anticipated. In rails more activity prevails, and early in January, at latest, a number of large contracts will be placed in Pennsylvania and Illinois mills. The general tone of the steel market is better, and a hardening of quotations seems the natural thing to expect.

R.N.R. WARRANT ENGINEERS AND ENGINE-ROOM ARTIFICERS.

THERE has recently been issued to Members of Parliament and others interested in the engineering question in the Navy a Memorandum regarding the Admiralty's naval policy as it adversely affects the R.N.R. warrant engineers and the R.N.R. engine-room artificers. This is a subject on which we have time and again expressed our view that the scheme, under which naval stokers are advanced to the position of mechanicians under certain conditions, is inimical to the interests of the Service, as their experience as stokers, and the two or more years' special training proposed, can never make them as efficient as the engine-room artificers, who have been trained from youth as engineers. We append the Memorandum :—

1. Under the Cawdor scheme, promulgated some six years since, a large number of naval stokers have been, and are being, given some two or more years' special training, then made "mechanicians" (which is a term for a skilled mechanic), and afterwards many are promoted to "warrant mechanicians."

2. In the Royal Navy these warrant mechanicians rank, by virtue of their warrant, before chief and engine-room artificers, and are at times placed in charge over these men. The result is that the partially trained mechanic, if such he can be called, is set in authority over the fully trained and specialised mechanic.

3. In the mercantile marine, and in the engineering firms of this country, the engineer and skilled engineering mechanic is always superior in pay and position to the stoker or mechanic's labourer.

4. From the skilled engineering mechanics are drawn the engineers of the mercantile marine and the R.N.R. warrant engineers, as also the R.N.R. engine-room artificers.

5. When undergoing training in the Royal Navy it now often happens that the said R.N.R. reserve men have to serve with, or come under the supervision of, the stoker mechanician and warrant mechanician.

6. This is much resented by the R.N.R. warrant engineers and R.N.R. engine-room artificers. It is highly repulsive to them, and is causing an amount of acute ill-feeling and unrest.

7. Being desirous of continuing to render some useful service in times of danger, and feeling that the Admiralty cannot for one moment wish such a state of things to continue in the engineering department of the King's Navy, it is respectfully asked that amendments be made so that in future R.N.R. warrant engineers and R.N.R. engine-room artificers when serving in the Fleets shall be free from being placed on a par with, or under the orders or supervision of, stoker mechanicians or warrant mechanicians.

8. The stoker warrant mechanicians have only been made about a year, hence the appearance of this memorandum now.

MESSRS. FRIEDRICH KRUPP AND CO.—The firm of Messrs. Friedrich Krupp and Co., of Essen, realised a profit of 2,038,900*l.* in its financial year ending June 30, 1911, as compared with a corresponding profit of 1,636,874*l.* in 1909-10. After all charges had been deducted, the net profit for 1910-11 was 1,443,909*l.*, as compared with 1,071,859*l.* The dividend for 1910-11 is to be at the rate of 10 per cent. per annum upon a capital of 9,000,000*l.* The council of administration also carries 71,780*l.* to the ordinary reserve and 100,000*l.* to a special reserve. After making some further allocations, the council carries a balance of 210,527*l.* to the credit of 1911-12.

WORKMEN'S COMPENSATION CASES.

COURT OF APPEAL CASES.

ONE of several cases recently reversed by the Court of Appeal was that of Jessop *v.* McLeay.

It was an appeal from the County Court Judge of Hull, brought by shipowners against whom an award had been made in favour of a ship's cook, who had been injured by infection from a diseased sheep which he slaughtered on board ship. The diseased blood of the animal was spilled over the man's leg, causing injury, in June, 1910. The vessel returned home in September, but no claim was made till the following January. In the interval the ship had again gone to sea, and the ship's officers were unable to attend to give evidence when the case came before the County Court. The Judge consented to the adjournment on the shipowners agreeing to pay the applicant 10*l.*, and 10s. a week until the hearing of the application. The applicant brought forward his case again in July, but the depositions of the ship's officers had not then arrived, and judgment was given against the shipowner. The shipowner appealed, pleading for the ending or diminishing of the award, and this appeal was allowed by the Court of Appeal. The new hearing was removed from Hull to the York County Court.

Surgical Negligence and Shipowner's Liability.—In another case on appeal from the County Court Judge of Hull, the question had reference to alleged negligence in the treatment of a broken arm. The applicant was steering a tug belonging to the appellant when something went wrong with the steering-gear, and the man had his forearm broken, which happened in the course of his employment. It was alleged that the injury was not skilfully treated, the sailor having had the assistance of a "bone-setter" instead of going to a properly qualified surgeon. The applicant refused to submit to an operation the second time. In an action by the sailor against the bone-setter, 90*l.* damages for negligence was awarded.

The point was, according to the Judge, Was the man's refusal to submit to resetting reasonable? The Judge said he was justified, and decided against the shipowner. This was not the point the County Court Judge had before him. The real point had reference to the claim for disablement, for which the employer was liable to pay compensation. The resetting by a skilled and authorised surgeon would have been an easy matter, and the injured man's disablement would have been quickly ended. He had no legal right, under the circumstances, to refuse proper surgical treatment that would expedite the cure of his disablement. The shipowner, on the other hand, was justified in asking the Court of Appeal to diminish or end the award of the Hull County Court Judge, who went wrong in his view of the law that the disablement from which the man still suffered arose out of the accident, and that therefore the employer was responsible for compensation for the accident.

An employer is liable for the disablement resulting from an accident, but not for the disablement resulting from unskilful or ignorant treatment. This case is of importance to workmen who are inclined to use quack remedies. It should be remembered the risk which employers are bound to cover by insurance does not cover the results of any ignorant or eccentric treatment of a bone-setter. It will be understood that the County Court Judge's mistake was in finding for the workman because he refused to submit to resetting. The question was not whether the man was justified in refusing to undergo an authorised simple and safe operation; the real question was, did his incapacity, for which compensation was claimed from the employer, arise from the accident, for which the employer was liable? As a matter of fact, the disablement before the Court did not arise out of the accident, but arose entirely from the blundering treatment of the bone-setter, with which the employer had nothing to do.

Is a Wasp's Sting an Accident?—A curious case was heard in the Court of Appeal, which decided the point of law that an employer is not liable for compensation in the case of a workman who may die from blood poisoning as the result of the sting of a wasp during the course of his employment, but not arising therefrom. The widow of the deceased workman made the statement that her husband was a blacksmith and engineer, employed by the respondent, and when thrashing wheat was stung by a nest of wasps, and blood poisoning and death ensued.

The ground of the appeal was that the County Court Judge, who granted an award, was wrong, and that there was no evidence that deceased had met his death by the sting of a wasp while working on the appellant's farm. It was argued that it was mere guess-work that a nest of wasps was roused by the noise and heat of the thrashing-machine, and it was upon this supposition that the County Court Judge made his award. The case of the appellant was that the sting of a wasp was such a risk as every person had in common, and was not such as was peculiar to the deceased workman while in this particular employment, and that therefore the risk was not one against which the employer should have insured. It was not an accident within the meaning of the Workmen's Compensation Act.

If an employer had sent the workman to dig up a wasp's nest and he got stung, the man would be exposed not to a common risk, but to a peculiar accident which was incidental to the man's employment, and in such a case the accident would arise out of the employment and involve the employer in responsibility for the fatal result. There was no such peculiar risk arising out of the man's employment in this particular appeal case, and therefore the Court of Appeal reversed the County Court Judge's award. Thrashing wheat in the field involved the workman in no peculiar danger, and the employer had no liability for an uncommon risk in respect of a wasp's sting.

Compensation and the Sliding Scale.—In the appeal from an award of the County Court Judge of Norwich in the case of Newhouse and Co. *v.* Johnson a curious and difficult question was raised in regard to a sliding-scale award, which had been made on an application by the employers to review, diminish, or terminate a weekly payment made to a workman who met with an accident in the employ of the present appellants. The County Court Judge had made an order in a special form, although the Court of Appeal had previously ordered that the County Court had no power to make a prospective award on a sliding scale. As the sum of compensation is always determined by the average rate of the applicant's weekly wage, the question of the rate of the maximum or the minimum wage, where a sliding scale is operative, should in no way affect the County Court Judge's award in compensation cases. The Judge was acting outside his jurisdiction in taking the sliding scale of the workman's wages into account. The Court of Appeal decided that the practice of making a prospective award depend on whether wages were going up or down must cease.

Natural Aneurism and an Accident.—In an appeal from the County Court Judge of Middlesbrough, the Court of Appeal reversed the decision on the ground that it was unfair to the employers, Messrs. Bolckow, Vaughan, and Co. The workman met with an accident by falling on his head and shoulder when he was suffering from natural aneurism. The medical referee agreed with the Judge that the man's accident was not the original cause, but simply aggravated the man's condition. The County Court Judge awarded him compensation at the rate of 15s. a week. Against this the employers appealed. The Court of Appeal reversed the County Court Judge's decision.

There was no evidence that the accident for which the employers were responsible was the sole cause of the man's incapacity. Normal aneurism was the condition of the workman preceding the accident, and the accident could not have produced the aneurism or aggravated it. The man's condition was perhaps the worse for the accident, but the Court of Appeal upheld the employers' appeal, on the ground that the evidence did not justify the County Court Judge in making his award in favour of the injured workman, since it was impossible for the accident not to have some effect on the existing normal aneurism. This releases the employers of liability for the consequences of an accident to a workman who may be suffering at the time of the accident from a deadly disease which can be established to be the originating cause of the man's incapacity.

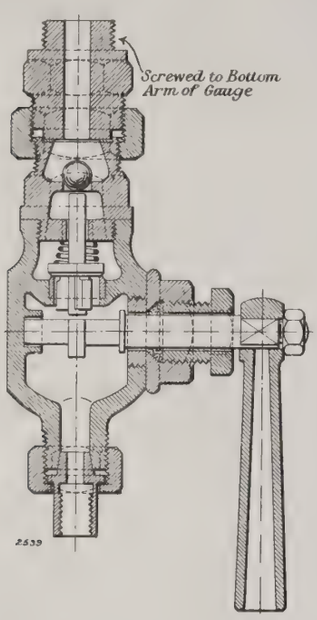
Evidence of Accident.—Inference.—In the case of an appeal from the award of the Glamorgan County Court Judge to the widow of a workman employed by the Glamorgan Colliery Company, the evidence was that he was on the night-shift at 11 o'clock and returned home at 7.30 in the morning, and showed his wife a red patch on his arm. His wife also noticed a scratch on his thumb, and in ten days the man died of blood poisoning. The County Court Judge was of opinion that the evidence of blood poisoning from the scratch to the thumb as a result of the fall at the colliery led him to infer the cause of death. The Court of Appeal held that septic poisoning might have occurred anywhere else than at the colliery. The Judge's inference was not reasonable, and the appeal of the employers was allowed.

PERSONAL.—Messrs. James J. Guest and Co., Limited, mechanical and electrical engineers, state that they have recently erected a new factory, and their new address will in future be: The Charterhouse Works, Northfield-road, Coventry.—The Electro-Chemical Works of Kempen-Rhein have been made a limited company, under the style: Elektrochemische Fabrik Kempen-Rhein, Dr. Brandenburg and Weyland, G.m.b.H.

THE LATE DR.-ING. EMIL BLUM.—We regret to notice the death of Mr. Emil Blum, who was buried on the very day on which he was to take the chair as new President of the Berlin branch of the Verein Deutscher Ingenieure. He was for many years managing director of the Berlin-Anhaltische Maschinenbau A.-G., of Dessau. Born in 1844 at Frankfort-on-the-Main, he passed from the gymnasium (grammar school) of his native city into a locksmith's shop and railway works, and thence to the Technical High School at Karlsruhe. Having worked in several factories and drawing-offices, he started works, while still a very young man, in 1867, for the construction of pumps and transmission gearing in conjunction with Eduard Möller. Coming in contact with the great gas-engine firm at Deutz, he associated himself with Oechelhaeuser and later with Julius Arendt, and the three men established, in 1872, the Berlin-Anhaltische Maschinenbau A.-G., of Dessau, so well known under the initials "B.A.M.A.G." He remained connected with this firm until his end. He took a particular interest in gearing and in the development of machinery for gas-making and for the utilisation of the by-products. He himself designed machines for charging and drawing gas-retorts, and, together with the late Professor Intze, he constructed large gas-holders. He also brought about co-operation between his firm and the Stettiner Chamottefabrik, late Didier, of Stettin. Dr. Blum was on the juries of several International Exhibitions, as, for instance, at Brussels and Turin in the past two years. He was also chairman of the German North-Eastern Trade Association for Iron and Steel. The honorary degree of Dr.-Ing. was conferred upon him by his old Technical High School of Karlsruhe in 1909. His connection with the Verein Deutscher Ingenieure dates from the year 1886. His colleagues and employees revered him as a thoughtful chief who possessed also the gift of being able to train efficient assistants.

SHELTERED TRYCOCK FOR GAUGE-GLASSES.

The illustration below shows a new form of trycock for gauge-glasses, which is being introduced by Messrs. J. Hopkinson and Co., Limited, of Britannia Works, Huddersfield. The idea underlying the arrangement of the cock has had other applications than that here shown, but the particular example of it which the cock embodies is both interesting and neat. Although, in accordance with current terminology, the fitting is described as a cock, it will be at once noted from the figure that it is in essence a valve. The main feature of the design has reference to the fact that the mushroom valve of the fitting, which forms the valve proper, is backed up and sheltered by a ball-valve above it, and that the operating mechanism is constructed to lift the mushroom valve before the ball-valve. The idea of the construction is that as the mushroom valve is always open before steam or water reaches it, when the cock is



being used to blow through, it is protected from the cutting action which takes place on an opening valve with pressure behind it, so that it remains always tight. Any cutting action which occurs will, of course, be transferred to the ball-valve, but this is of little importance, since this valve is in series with the lower one, and in any case it is obviously better that the cutting should take place on a subsidiary rather than on a main valve.

The details of the cock require little description, as they are well shown in the illustration. The mushroom valve, which is made of Platnam metal, is formed with upper and lower projecting studs, the lower of which is acted on by an eccentric carried by a horizontal spindle, and lifted when the spindle is rotated by its handle. The upper stud on rising, owing to the lifting of the valve, comes in contact with the ball-valve, and opens that in turn. There is a clearance between the top stud and the ball to allow the mushroom valve to open before the ball is acted on. The valve has a controlling spiral spring above it, as shown.

The Mining Industry of Upper Silesia.—In the recent report for the year 1910-1911 of the Mining Union of Upper Silesia the president stated the objects which ought to be the principal work of the union. First amongst them was the regaining from the English of the Berlin market for gas-coal and of all the districts in East Germany, at the coast or in the interior, which during the last five decades had gone in for English coal. The union should not any longer permit the German coal consumers to pay tribute to England, or more especially to English colliery owners and miners, of countless millions in hard cash, when Germany herself had the richest coal deposits, which were none too successful. Secondly, the utmost assistance from the State was demanded; and thirdly, railway tariffs must, he said, be adjusted in favour of home production, not only of coal and iron, but also of other articles, as a protection against foreign competition. The fourth point referred to the much-discussed commercial treaties; the fifth to an adequate regulation of the Oder, equal to that of the Rhine, the Elbe, and the Weser; the sixth emphasised the necessity of continuing a strenuous fight against the ever-increasing municipal rating of the industry, and the seventh urged an equally strenuous campaign against the tendency of the Legislature both in the matter of taxes and of erratic provisions for the workmen of all possible and impossible kinds—a fight which would also be to the furtherance of the true interests of the men.

BISSET'S RECIPROCATING FEED FOR SAW-BENCHES.

CONSTRUCTED BY MESSRS. A. RANSOME AND CO., LTD., ENGINEERS, NEWARK.

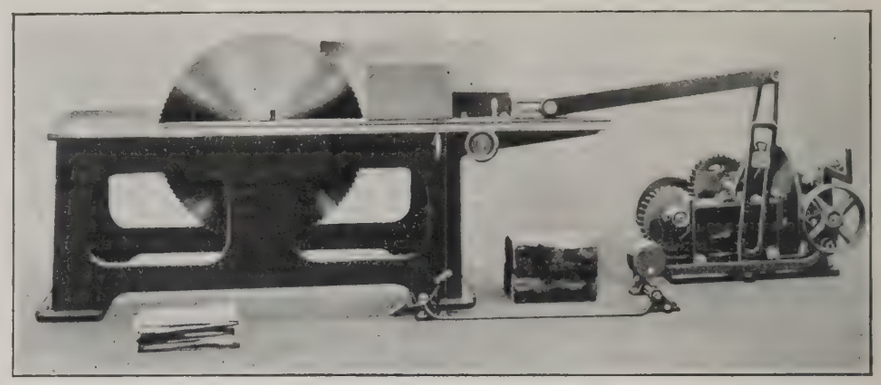


Fig. 1.

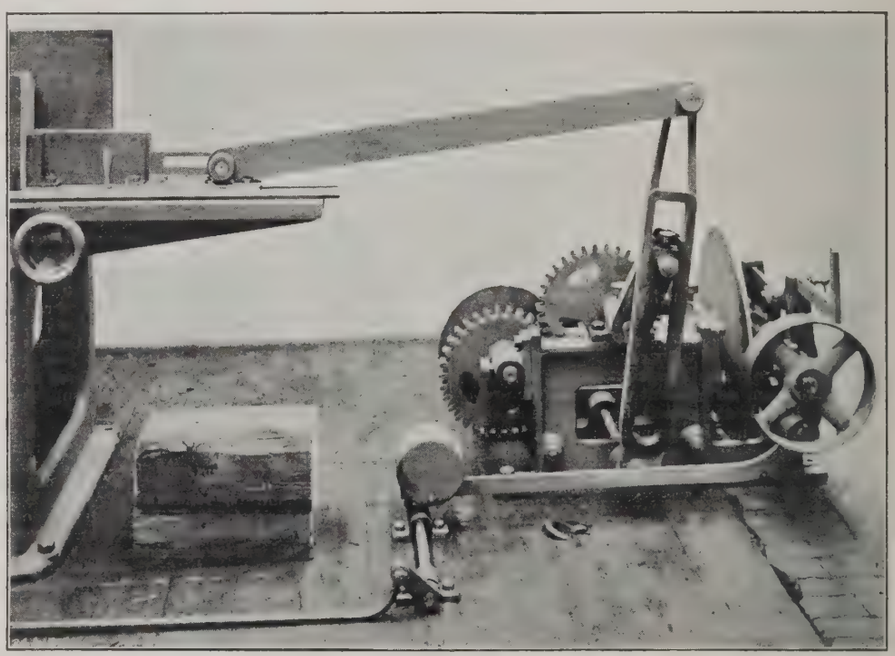


Fig. 2.

We illustrate above a feed appliance for saw-benches which has been expressly designed for rapidly sawing short pieces of wood into thin boards for box-making, &c., and it is claimed for it that it will turn out double the amount of work that any plain saw-bench will do under similar circumstances. It is simple to work, occupies very little space (2 ft. 8 in. by 2 ft. 4 in.), and can be easily fitted to any existing saw-bench. In addition, other points brought forward in its favour are that the rate of feed is under immediate control, and can be varied according to the cutting ability of the saw; adjustments for different sizes of wood are easily made, and there is nothing to hamper the quick changing of the saw. In our illustrations Fig. 1 shows a saw-bench with the apparatus applied, while in Fig. 2 may be seen the feed mechanism alone to a larger scale.

The wood to be sawn is placed on a light steel carriage, which slides on the saw-table as is shown in Fig. 1. To this carriage a reciprocating motion is imparted by means of elliptical gearing (seen clearly in Fig. 2), which gives a quick-return motion through a crank and sliding crosshead. The elliptical wheels are driven by a pair of friction-wheels arranged in such a manner that the rate of feed can be quickly varied up to seventy strokes per minute. By means of the foot-lever shown in Fig. 1 the feed can be instantly stopped or started. The feed is usually driven from the same line shafting as drives the saw-bench. The appliance is made in two sizes: No. 1 for pieces of wood up to 32 in. long, and No. 2 for pieces up to 36 in. long, and it is constructed by Messrs. A. Ransome and Co., Limited, Stanley Works, Newark-on-Trent, who hold the sole right of manufacture for the United Kingdom.

Electrical Coal-Cutting Machines.—In an address to the Mining Electrical Engineers, Mr. E. Kilburn Scott stated that it was estimated that there were over 5000 electrical coal-cutting machines at work in various parts of the world. Twenty-four years ago there was only one, and that one was in Yorkshire. The following table gives the number of machines in use in this country and the amount of coal which was cut by them in 1910 :—

	Number of Machines.	Tons of Coal Cut.
Scotland	425	4,568 980
Newcastle district	35	402,030
Durham district	42	353,360
Yorkshire and North Midland	235	2,461,860
Manchester district	11	96,810
Liverpool and North Wales	18	164,590
Midland and Southern	55	549,310
South Wales	51	318,010

Water Distribution in Cincinnati.—A remarkable illustration of what pure water means to the health of a city is found in a statement just issued by the Cincinnati Water Works Department covering the first three years of the operation of the new 11,000,000-dol. water-works system in that city. It is shown that typhoid fever has been reduced to a minimum, giving Cincinnati a death rate for typhoid fever in 1910 of only 5.7 per 100,000 people. In 1910 there were only 21 deaths in the city from typhoid fever, compared with 239 in 1906, the last year of the operation of the old water works. The total of deaths for 1908, 1909, and 1910 from typhoid fever is 133, compared with 664, the total of the last three years of the operation of the old system. There has also been a falling-off of deaths from other intestinal diseases, of from 563 in the years 1904-5-6, to 246 in the last three years. The report further shows that the present cost of pumping water is only 14.35 dols. per million gallons, compared with 32.05 dols. per million gallons in 1906.

35-TON STEAM BREAKDOWN CRANE.

CONSTRUCTED BY MESSRS. JOHN H. WILSON AND CO., LIMITED, ENGINEERS, BIRKENHEAD.

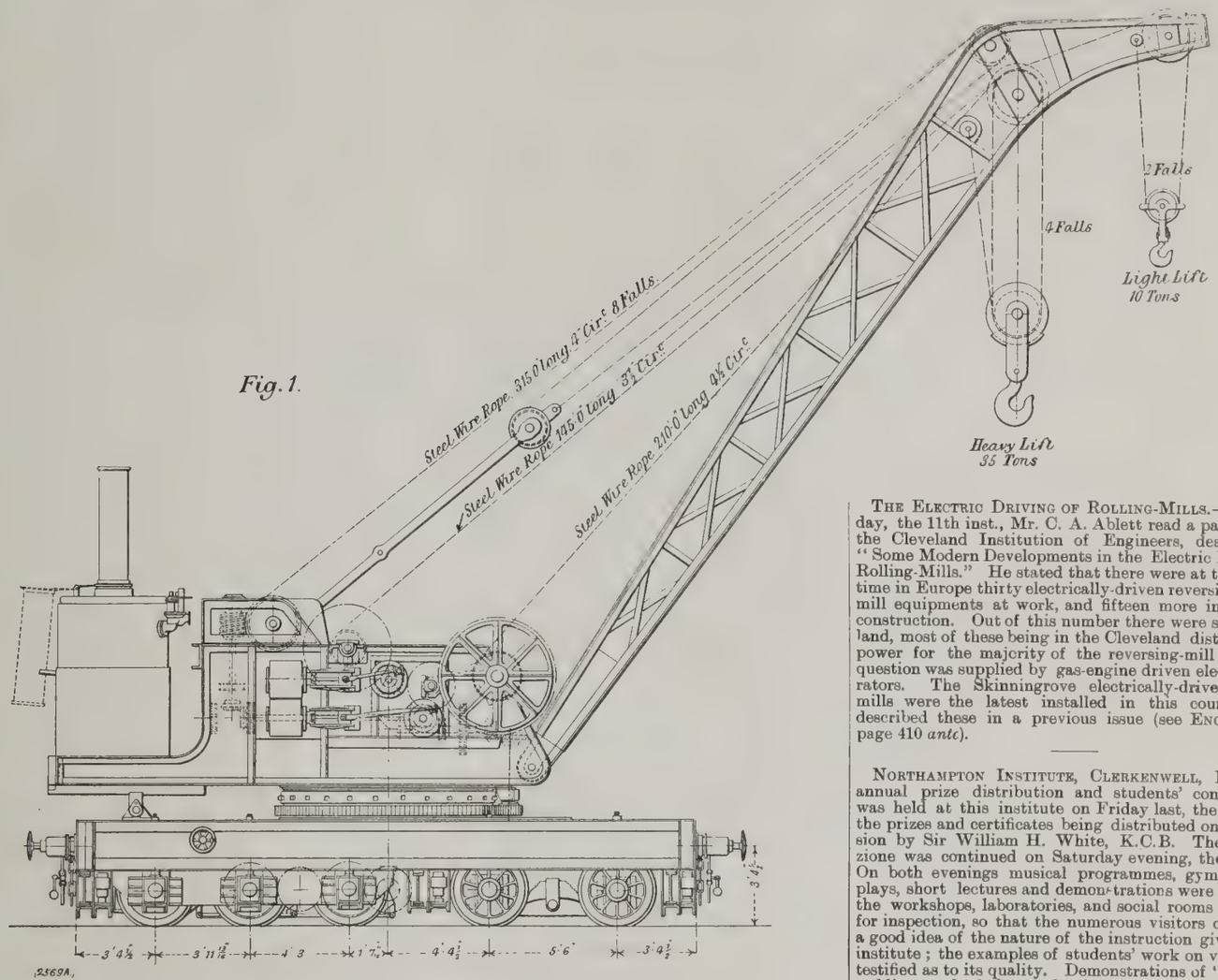


Fig. 1.

ON this page and on page 800 we illustrate a breakdown crane that has been designed and constructed by Messrs. John H. Wilson and Co., Limited, Seacombe, Birkenhead, for the Buenos Aires Western Railway Company, Limited, and has been arranged with all fittings for coupling up to the ordinary rolling-stock. It is shown in side elevation in Fig. 1, and in perspective in Fig. 2, the latter view being a reproduction from a photograph. The crane is capable of dealing with 35 tons at a radius of 19 ft., 25 tons at a radius of 27 ft., and 10 tons at a radius of 30 ft., and, before being sent abroad, it was tested to 20 per cent. excess of the working loads at the above radii. The rail gauge is 5 ft. 6 in. The different motions consist of lifting and lowering, slewing, derricking, and travelling, and these are all worked by steam.

The crane is fitted with two pairs of engines, each pair having two cylinders 8 in. in diameter by 14 in. stroke, the first pair being used for lifting and lowering the heavy loads over 10 tons, and for the luffing or derricking gear, while the second pair are used for the light loads not exceeding 10 tons, and for slewing and travelling. The boiler is of the Spencer Hopwood multitubular type, and is 8 ft. high and 4 ft. 9 in. in diameter, working under a pressure of 100 lb. per sq. in. It has a grate area of 14.2 sq. ft., and a heating surface of 180 sq. ft. The chimney is made to lower, as may be seen in Fig. 1. The lifting-barrels are made with machined grooves to fit the steel-wire lifting-ropes, which are 4½ in. in circumference for the heaviest loads, and 3½ in. in circumference for the light loads.

The superstructure of the crane is made entirely of steel, and revolves on a ring of steel live rollers running between turned-steel roller-paths. The carriage has ten wheels, with a total wheel-base of 19 ft. 9 in., as shown in Fig. 1; six wheels are rigid, with suitable compensating gear, and there is a four-wheel bogie. The axle loads are equalised as much as possible, and do not exceed 17 tons per axle, and specially large axle-boxes are provided to ensure cool running. The travelling gear is proportioned so as to enable the crane to travel at the rate of 250 ft. per minute by its own engines, and the gear is easily disconnected when the crane is put into a train. All the levers for controlling the various motions of lifting, lowering, derricking, and travelling are brought together at the front of the foot-plate, so that the crane-driver has a clear view of his work. The jib is made to lower so that it can rest on a railway wagon when coupled on the train, and there is an arrangement of adjusting-screws for relieving the spring of the load when the crane is at work, and also for the purpose of levelling up the crane when going round a curve. The pillar is made of the best hammered iron, and the carriage and jib of steel plates and angles throughout. The whole of the gearing is of steel and the teeth are machine-cut; the crane is fitted with a patent load-indicator to show the safe loads at the different radii. It was built under the supervision of the company's consulting engineers, Messrs. Livesey, Son, and Henderson. We understand that Messrs. John H. Wilson and Co. have recently supplied three similar cranes of 30 tons capacity to the Buenos Aires and Pacific Railway Company, and that they have now in hand a 35-ton crane for the Buenos Aires Great Southern Railway.

BRITISH MOTOR-BOAT CLUB 21-FT. CLASS ENGINES.—A list of engines suitable for the British Motor-Boat Club 21-ft. class is being prepared, showing the bore, stroke, and cylinder capacity of the various engines that fit the class.

NEW AUSTRALIAN STEAMER.—Messrs. William Beardmore and Co., Dalmuir, launched on the 7th inst. the first of three twin-screw steamers which they are building for the Adelaide Steamship Company of South Australia. The vessel is 410 ft. in length between perpendiculars, 56 ft. 6 in. in breadth, 37 ft. in depth moulded to upper deck, and of about 8000 tons gross and 5000 tons deadweight carrying capacity. Accommodation is provided for about 350 first-class, 120 second-class, and 60 third-class passengers on three principal decks. The propelling machinery, which is designed to give a speed of 15 knots, consists of two sets of quadruple-expansion reciprocating engines, supplied with steam from six water-tube boilers of the Babcock and Wilcox type.

THE ELECTRIC DRIVING OF ROLLING-MILLS.—On Monday, the 11th inst., Mr. C. A. Ablett read a paper before the Cleveland Institution of Engineers, dealing with "Some Modern Developments in the Electric Driving of Rolling-Mills." He stated that there were at the present time in Europe thirty electrically-driven reversing rolling-mill equipments at work, and fifteen more in course of construction. Out of this number there were six in England, most of these being in the Cleveland district. The power for the majority of the reversing-mill plants in question was supplied by gas-engine driven electric generators. The Skinningrove electrically-driven rolling-mills were the latest installed in this country. We described these in a previous issue (see ENGINEERING, page 410 *ante*).

NORTHAMPTON INSTITUTE, CLERKENWELL, E.C.—The annual prize distribution and students' conversazione was held at this institute on Friday last, the 8th inst., the prizes and certificates being distributed on this occasion by Sir William H. White, K.C.B. The conversazione was continued on Saturday evening, the 9th inst. On both evenings musical programmes, gymnastic displays, short lectures and demonstrations were given, and the workshops, laboratories, and social rooms were open for inspection, so that the numerous visitors could form a good idea of the nature of the instruction given at the institute; the examples of students' work on view amply testified as to its quality. Demonstrations of "Thermit" welding, and of the production of ribbon metals, were given at intervals, and these attracted particular attention.

EXPLOSION OF DETONATOR COMPOSITION.—The conclusions come to by His Majesty's Chief Inspector of Explosives as to the probable cause of an explosion of detonator composition, which occurred in June last at Uplees Marshes, Faversham, are of considerable interest. The composition was laid out on "Jaconet" cloths on a bench until sufficiently dry, and the inspector considers that it is more than probable the explosion occurred whilst the man, who lost his life, was spreading it out as thinly as practicable, using his fingers as a comb for the purpose. Any suggestion that the accident was due to carelessness or undue force on the part of the operator is dismissed by the inspector, who attributes it to an incident of altogether unexpected character. The Cotton-Powder Company used a mixture of fulminate of mercury, chlorate of potash, and gun-cotton for filling detonators, differing from the ordinary composition, which consists of 80 per cent. fulminate and 20 per cent. chlorate. In his report the inspector points out that gun-cotton is a di-electric, and was resting on "Jaconet," or rubber cloth, which is also a di-electric and an insulator, and the operator was wearing rubber shoes. The conditions were therefore favourable to the generation of a statical charge of electricity, which might, in due course, result in a spark. The weather was exceptionally hot and dry, and in a few moments the operator's fingers would also be quite dry, and it is well known that sparks under such conditions are easily obtainable. In gun-cotton drying-houses a crackling due to electric discharge is not infrequently heard when manipulating the trays. Certain experiments were made to ascertain whether sparks could be obtained with reasonable facility from gun-cotton, and it was found that the mere rubbing of rubber cloth with the fingers was sufficient to produce audible sparks. The inspector refers to the explosion at Ardeer, in 1901, when a workman re-reeling rifle cordite, and wishing to mend a broken strand with acetone, fired the vapour by a spark from his finger. He was insulated by wearing rubber shoes, and the electric charge was generated by the strands of cordite passing over the palm of his hand. After the accident at Ardeer the operators were "earthed" by means of copper rivets in the soles of the shoes, when it became impossible to obtain sparks from them.

ADIABATIC EXPANSION OF STEAM.

To the Editor of Engineering.

Sir,—On page 759 of your issue of the 8th inst. Professor Smith and Mr. Warren give a table of values for n in the equation for adiabatic expansion $P V^n = C$. According to their statement the value of n depends upon the initial dryness, but not upon the initial pressure. This statement cannot be correct, because the expansion curve for dry steam at, say, 200 lb. pressure is also the expansion curve for wet steam at lower pressures, including, for instance, steam at 50 lb., with a dryness fraction of about 0.9.

More than eight years ago I showed (*The Engineer*, April 10, 1903) that the index n depended upon both the initial dryness and the initial pressure. The results then obtained were as follow :—

Dryness.	Pressure, Pounds per Square Inch, Absolute.					
	250	200	150	100	50	20
1.0	1.129	1.133	1.136	1.139	1.143	1.145
0.9	1.120	1.122	1.125	1.127	1.130	1.132
0.8	1.109	1.111	1.113	1.115	1.117	1.118
0.7	1.099	1.101	1.102	1.103	1.104	1.105

The value of n varies widely, and serious discrepancies may arise in calculations if either initial pressure or dryness are ignored.

Yours truly,
Frank Foster.

7, Victoria road, Whalley Range, Manchester,
December 11, 1911.

[We communicated Mr. Foster's letter to Professor Smith and Mr. Warren, and we have received from Mr. Warren the subjoined reply.—Ed. E.]

To the Editor of Engineering.

Sir,—The point raised by Mr. Frank Foster (to which I am replying owing to the indisposition of Professor Smith) has not been overlooked by us. At the best, the expression of the adiabatic expansion of steam by an equation of the form $P V^n = C$ is only an approximation, though sometimes a convenient one. The only justification of such an approximation is the possibility of simplifying arithmetical calculations—a possibility readily frustrated by excessive refinement. It is the too common practice to use a constant value for the index n under all conditions. A closer approximation is obtained by taking a series of values, corresponding to certain initial dryness fractions, and calculated for a given *range* of pressures. Such a series of values has been in constant use, due, I believe, to Zeuner. Those values, however, required modification in the light of recent research, and we attempted in our article to supply the corrected values. There was no pretence at completeness. The values were only put forward as approximate, and the range of pressures to which they applied was specifically stated. Mr. Frank Foster has republished a series of "point" values. These require correction. What is required is a series of "range" values. These can, of course, be obtained by averaging, but the labour of refining approximations can easily exceed that involved in correct calculation.

Yours truly,
A. G. Warren.

Borough of Aston Manor Technical School,
December 13, 1911.

SPECIFICATIONS FOR STEAM PLANTS.

To the Editor of Engineering.

Sir,—In your issue of December 8 your correspondent, "M.I. Mech. E.," has painted a gloomy picture of consulting engineering as practised by the boiler insurance companies, and the position he takes up is not a logical one.

Anybody can sympathise with the engine-builder or boiler-maker who howls "Down with the consulting engineer," since his attitude, though wrong, is a perfectly understandable one. Here, however, we have the case of a man who runs down specifications and professional advice, and yet advocates calling in a private consulting engineer instead of the maligned boiler insurance company. Surely this is exchanging King Log for King Stork.

Those who have had experience of work carried out by engine and boiler makers on their own initiative, and of similar work carried out by boiler insurance companies, usually acknowledge the superiority of the work installed under the supervision of the latter, even if they do not agree with all the practices and methods of the insurance companies.

"M.I. Mech. E." practically gives his case away by saying that the insurance company is "asked to report," and "knows all the conditions of the case." Precisely. The company is invited to deal with the work because probably the old plant has been insured with it for years, and its officials have become cognisant with all the conditions of working; hence the company's clients lean on it, and not on a stranger, for reliable advice, knowing that the company, with its large staff scattered over the country, has unique facilities for obtaining information on all kinds of technical points, and also for making careful and detailed inspection of the new plant during course of construction and erection.

As regards rigidity of specification, your correspondent has presumably never seen a specification drawn up on behalf of a public body such as a municipality or urban council. Such a specification easily gives the insurance companies' specification "points" as regards clauses for saddling the contractor, both now and hereafter, with unlimited responsibility.

"M.I. Mech. E.'s" statement as to engine-fittings is rather amusing. Why should not certain makes of fitting be specified if these have been proved to give satisfaction? Everyone will grant that a good firm of engine or boiler-makers knows what to put on in the way of fittings, but if they are in unrestrained competition with other firms there is naturally a temptation to allow for cheaper fittings than they otherwise would do. Hence the advisability of putting all the tenderers on a common basis. Surely this is fair to the manufacturer and the purchaser?

As long as tenders are invited on a competitive basis, so long will the need for a detailed specification exist, and this should obviously be drawn up by the consulting engineer who has had the most experience in connection with the work proposed.

I am, Sir, yours faithfully,
December 11, 1911. Mechanicus.

To the Editor of Engineering.

Sir,—I am glad to see one of your correspondents drawing attention to the evils of engine and boiler insurance companies endeavouring to act as consulting engineers. One point, however, "M.I. Mech. E." does not touch upon, and that is, that in almost all such specifications the insurance company insists, or tries to insist, on getting from the contractors a complete set of detail dimensioned drawings of the engine or machine they are supplying. Now in many cases these designs represent years of experience and experiment on the part of the contractor, experience which now represents one of the most valuable assets in his business.

Of course, if the insurance company can secure such valuable information, they are practically free to use it when and where they like. This is surely one of the worst forms of "brain-sucking," and I have seen it attempted, often successfully, again and again. The insurance company practically says to the contractor, "Give up your trade secrets or your tender will not be considered."

As your correspondent points out, the insurance companies in their specifications have raised the gentle art of evading responsibility to quite a high level.

I remember one case where one of our leading insurance companies made a gross blunder when drawing up a specification for a boiler. Six weeks after installation the boiler broke down, and the owners called on the boilermakers to put matters right. The boilermakers pleaded that the faulty portion was specified in great detail, and that everything had been made in strict conformity to the specification.

The insurance company on being approached admitted the error, but pointed to a short clause in their specification to the effect that, notwithstanding any error in design that might appear in the specification or in the approved plans, the contractor was to relieve the insurance company and its chief engineer from all responsibility.

A delicate hint that a court of law would be an eminently suitable place for discussing this interesting point was sufficient. The insurance company paid.

Yours faithfully,
December 9, 1911. Another M.I. Mech. E.

FUEL-ECONOMISERS AT THE BELFAST MUNICIPAL TECHNICAL INSTITUTE.

To the Editor of Engineering.

Sir,—We notice in your last issue, of the 8th inst., that in the description of the boiler-house plant at the Belfast Municipal Technical Institute, as given by Mr. W. J. Crawford, it is mentioned that the fuel-economisers were by Messrs. E. Green and Son, of Wakefield. We beg to point out that this is not correct, as the whole of the economiser and its accessories were manufactured and installed by this company in 1906, and was made to a special design, so as to accommodate their being used for ordinary working or for experimental purposes. We shall be glad if you will kindly give prominence to the above in your next issue.

Yours faithfully,
For the Clay Cross Company,
D. Rushworth.

Clay Cross, Chesterfield, December 11, 1911.

Feed-Water Heating and Superheating on Locomotives : Erratum.—On page 757 of our last issue, above Fig. 42, certain particulars were given purporting to belong to the locomotive there illustrated. These particulars should have been omitted, having no reference to this locomotive as it at present exists and is illustrated in Fig. 42.

Svenska Technologförening.—The general association of all Swedish engineers and architects, which is known as the Svenska Technologförening, celebrated its fiftieth anniversary on November 17 and 18, at Stockholm. The founders were pupils of the Technical High School, of Stockholm, and the association has for a number of years embraced all technical trades of the kingdom; there are about 2000 members. The association has been publishing a journal for 41 years. The president is Mr. Dahlander, but for the jubilee celebration that office was held by Colonel Hansen. The jubilee was also the 250th anniversary of the birth of Christopher Polhem, whom Sweden regards as the founder of her technical science, and to whom Hansen devoted his address. The first Polhem medal was presented to Mr. Eckwall for his researches on ferro-concrete, by the King of Sweden during the festivities.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was quiet, and the turnover was limited to 1500 tons of Cleveland warrants at 47s. 9d. and 47s. 9½d. cash, and 48s. 8d. three months. Closing quotations were firm at 47s. 10d. cash, 48s. 1½d. one month, and 48s. 9d. three months sellers. Cleveland warrants were again stronger in the afternoon, when 4000 tons were done at 47s. 10d. and 47s. 11½d. cash, 48s. 3½d. one month, and 48s. 10½d. three months. At the close sellers' prices were 48s. cash, 48s. 3½d. one month, and 48s. 10½d. three months. On Friday morning the upward tendency of Cleveland warrants made further progress, and 12,500 tons were dealt in at 48s. 1½d. and 48s. 2d. cash, 48s. 5½d. one month, and 49s. 1d. three months. The closing quotations were 48s. 3d. cash, 48s. 6½d. one month, and 49s. 2d. three months sellers. Hematite was quoted at 64s. 3d. cash sellers, with buyers at 63s. 9d. cash, and 64s. 7½d. three months. The afternoon market was steady, and the dealings only amounted to 1000 tons of Cleveland warrants at 48s. 6d. and 48s. 5½d. one month, with sellers over at 48s. 3d. cash, 48s. 6d. one month, and 49s. 1½d. three months. Cash hematite was quoted at 64s. sellers and 63s. 9d. buyers. On Monday morning Cleveland warrants were again strong, and business was done at 48s. 5d. and 48s. 4d. cash, 48s. 5½d. eleven days, 48s. 4½d. four days, 48s. 7½d. twenty-eight days, and 49s. 3d. three months. The turnover was 6500 tons, and closing sellers quoted 48s. 4½d. cash, 48s. 8d. one month, and 49s. 3d. three months. Cash sellers of hematite quoted 64s. In the afternoon the market was quietly steady, and 2500 tons of Cleveland warrants were dealt in at 48s. 7½d. twenty-eight days, 48s. 7½d. and 48s. 8d. one month, and 49s. 3d. three months. At the close sellers quoted 48s. 5d. cash, 48s. 8d. one month, and 49s. 3½d. three months. On Tuesday morning a further advance took place in values of Cleveland warrants, and 6000 tons were put through at 48s. 7d. and 48s. 7½d. cash, and at 48s. 11d. and 48s. 11½d. one month. The closing figures were 48s. 7½d. cash, 48s. 11d. one month, and 49s. 6d. three months sellers. The afternoon session was also strong, and Cleveland warrants amounting to 7500 tons were done at 49s. cash, from 49s. 1d. to 49s. 3½d. and 49s. 3d. one month, and at 49s. 5d. February 2, and 49s. 8d. three months. Closing sellers quoted 49s. cash, 49s. 3d. one month, and 49s. 10d. three months. One lot of hematite changed hands at 64s. 7½d. one month. When the market opened to-day (Wednesday) the tone was firm, and a good business of 8000 tons of Cleveland warrants was done at 49s. 0½d. and 49s. cash, 49s. 5½d. and 49s. 4d. one month, and from 49s. 9d. to 49s. 7d. February 15. Sellers' closing quotations were 49s. cash, 49s. 3½d. one month, and 49s. 10½d. three months. In the afternoon the market was inclined to be a little easier, and 6000 tons of Cleveland warrants were done at 49s. 2½d. and 49s. 1½d. twenty-two days, 49s. 3d. one month, and at 49s. 10½d. and 49s. 10d. three months. At the close the quotations were 48s. 11½d. cash, 49s. 3d. one month, and 49s. 10½d. three months sellers. Hematite (one lot) was dealt in at 64s. 7½d. two months The following are the market quotations for makers' (No. 1) iron :—Clyde and Calder, 63s.; Gartsherrie and Summerlee, 63s. 6d.; Langloan, 64s.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 65s.; Shotts (at Leith), 63s.; and Carron (at Grangemouth), 64s.

Sulphate of Ammonia.—The market for sulphate of ammonia is quietly steady this week, and prices are unchanged. The current quotation for prompt lots is 14*l.* 5s. per ton, Glasgow or Leith. The amount shipped from Leith Harbour last week was 2147 tons.

Scotch Steel Trade: Advance in Prices.—Activity is general in the Scotch steel trade this week, and the works are all well employed. The probability of an early advance in prices caused a rush to cover requirements before any increase was officially intimated, and the bookings since the end of last week have been on a heavy scale. Yesterday (Tuesday) a meeting of the Scotch Steel-Maker's Association took place in Glasgow, when it was decided to make a general advance of 5s. per ton in the minimum selling prices. The following are now the current rates :—Ship-plates, 7*l.* 2s. 6d. per ton; boiler-plates, 7*l.* 17s. 6d. per ton; angles, 6*l.* 15s. per ton; bars, 7*l.* 15s. per ton; tees, 7*l.* 15s. per ton; and channels, 7*l.* per ton, all less 5 per cent., delivered Clyde or equal. A fair amount of business is passing in export orders, and although prices are firmer, no official advance has been made except for ship-plates, which are 5s. dearer at 6*l.* 15s. per ton. Inquiries for structural sections and light material generally are very good, while the position of black-sheet makers is without change, their works being kept running full.

Malleable-Iron Trade.—The conditions in the malleable-iron trade are rather better this week, and with improved prices the outlook is brighter. Crown bars are called 6*l.* 5s. to 6*l.* 7s. 6d. per ton, less 5 per cent. for home consumption, and all round the prices are quoted firmer.

Scotch Pig-Iron Trade.—A fair amount of business has lately been passing in Scotch pig-iron, and makers are all well employed. The forward position is strong, and inquiries for future requirements are numerous. Prices are quoted firmer both for present and forward lots. The demand for hematite is still good, and makers have advanced their quotations, and are not now sellers under about 68s. per ton for prompt lots.

Pilling Boiler Explosion.—We are informed that the formal investigation ordered by the Board of Trade to be held in this matter is fixed for hearing in the Council Chamber, Town Hall, Fleetwood, on Tuesday, the 19th inst., at 11 a.m.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Returns.—A serious falling off is reported in the returns of the amount of coal dealt with at the port of Hull during November, and this makes the year up to date compare still more unfavourably with 1910 than a month ago. As against November last year there is a drop of 98,000 tons, and the figure for the past eleven months—5,871,584 tons—is 471,088 tons less than the tonnage for the same period of last year. The year's total, so far, for exports is 3,102,368 tons, which is a decrease of 421,683 tons. The comparative exports for the two Novembers were 244,856 tons this year, and 257,037 tons November, 1910. France, Egypt, Turkey, and the Baltic ports have all taken increased tonnages, but the decreases have been accounted for by a decline in trade with Germany, Holland, and South America. The output of the Denaby and Cadeby Main Collieries is down to 69,272 tons.

South Yorkshire Coal Trade.—The steam-coal market has remained in a remarkably firm position. There has been some improvement in shipments, and the industrial demand continues phenomenally active, collieries being pretty well cleared of stocks, and in some cases orders being in arrear. The more pacific outlook of the past few days in the labour world is likely to allay the anxiety of manufacturers in regard to the immediate future, though the situation amongst the miners is still one of perplexity and doubt. Increases are being obtained on contract renewals, but there is, as yet, no general move forward on the part of railway companies to cover their requirements for the coming year. For the present they are having to pay good prices for supplies obtained in the open market. Gas coal is sold in large quantities. Slacks are stronger, and collieries are pressed for deliveries. Such large supplies of house coal were stocked early in the present quarter that business showed a marked quietness in the succeeding weeks, and even now the improvement is not on a large scale. Merchants hold substantial reserves, and no rush has been experienced at the pits. Prices remain steady, and the week-end quotations on the Sheffield Exchange were:—Best hand-picked branch, 14s. 6d. to 15s. 6d.; Barnsley best Silkstone, 12s. to 13s.; Silkstone, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. to 11s.; Derbyshire large nuts, 9s. to 10s.; small nuts, 6s. to 7s. 6d.; Yorkshire hards, 9s. 3d. to 10s. 3d.; Derbyshire hards, 7s. 9d. to 8s. 9d.; washed nuts, 8s. to 9s.; rough slacks, 5s. 6d. to 7s. 6d.; seconds, 4s. 6d. to 5s. 6d.; and smalls, 2s. to 3s.

Iron and Steel.—The feature of the raw material market is the advance, practically all round, in iron prices, coinciding with a marked revival of business. Producers are, for the moment, masters of the situation, and are taking an independent line in the majority of transactions. Varying rates, but all of them higher, are being quoted for hematites, and though, in common irons, the Lincolnshire makers have not officially agreed upon increased quotations, they continue to demand premiums upon the basis rates. Following upon the improvement in the bar trade the South Yorkshire Bar-Iron Association have again raised prices 5s., and the quotation now stands at 7*l.* 5s., which is the highest figure since 1907. Most of the manufacturers have covered their requirements for raw material for the first quarter of next year, but they are experiencing difficulty in fixing up contracts for further ahead. With prospects of still better prices, iron-makers hesitate to commit themselves too far forward. The high tide of prosperity in the Sheffield industries is well maintained, and every week brings an influx of fresh work in one department or another. Thus there have recently been received some very satisfactory orders for railway steel and for springs, tyres, and axles for British and South American companies. The railway steel-makers are now very well booked up, and there is talk of raising prices. There are large outputs at the rolling-mills and all branches of the heavy trades are well employed. The good position of the engineering industry is responsible for great activity amongst the tool-makers, and most of the local file manufacturers are working overtime. Makers of agricultural implements and machinery are busy on stock, and right through the lighter trades there is a very satisfactory briskness.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The pig-iron trade continues to steadily improve. Values are moving upward, and the advances are entirely due to the good and growing legitimate demand. Consumers of pig are anxious to get deliveries, and are taking up as much iron as they can get hold of. Supplies are inadequate, and, in fact, several classes of pig cannot now be bought for this year's delivery. It is long since the market was in such a healthy state as it is at present. Reports from other iron centres are such as assist to strengthen the situation here, and prospects generally are regarded as very bright and encouraging. No. 3 g.m.b. Cleveland pig is now realising 49s. 3d. f.o.b., and the other qualities of Cleveland iron have advanced in proportion, No. 1 being up to 53s.; No. 4 foundry, 48s. 6d.; No. 4 forge, 48s. 3d.; and mottled and white iron each 48s.—all for early delivery; 9d. above these rates is named for January business. East Coast hematite is in good request, and Nos. 1, 2, and 3 are now put at 64s., though some buyers endeavour to fix the quotation at rather less. Foreign ore is strong, but there is not a great deal of business doing; that was only to be expected after the heavy transactions of a little while ago. Market rates are based on 21s. 6d. to 22s. ex-ship Tees for best Rubio. Coke is firm, and in very good demand for local consumption. A number of contracts have been made at 16s. 6d. for average blast-furnace coke delivered at Teesside works over the first half of next year.

Stocks and Shipments of Pig Iron.—The statistical situation shows great improvement. Stocks of pig are decreasing rather rapidly. Practically the only iron stocked is the 545,000 tons of Cleveland pig in the public warrant stores, and that stock is this month being drawn upon at the rate of 1100 tons per working day. Shipments of pig iron this month are unprecedented, and this is due very largely to delayed deliveries being made to Continental inland towns, which have been inaccessible for long owing to the inland waterways abroad being dry. To date this month shipments of pig average over 5700 tons per working day, as compared with a daily average of 3600 tons to the same date last month, and a little under 3000 tons per working day during the corresponding part of December last year.

Manufactured Iron and Steel.—Very satisfactory and encouraging accounts continue to be given of the various branches of the manufactured iron and steel industries. All departments are busily employed, and most producers have contracts made which will keep them in full swing for many months. Values show a marked upward tendency, but the only actual changes that have been made as yet are advances of 5s. in both steel ship-plates and angles. The principal market quotations stand:—Common iron bars 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s. to 7*l.* 7s. 6d.; iron girder-plates, 6*l.* 15s.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 7*l.*; steel ship-angles, 6*l.* 12s. 6d.; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 11*l.* 5s.—sheets less the usual 4 per cent. f.o.b., railway material net at works, and all other descriptions less the customary 2½ per cent. discount.

PEAT-GAS PLANT IN IRELAND.—In last week's issue, on page 774, we published an account of a peat-gas plant which has lately been put into operation in Belfast. We were informed, on what we considered to be good authority, "the plant . . . has replaced a Mond-gas plant by which power was formerly provided . . . the anthracite used by the gas plant (8½ tons per week) costing 13*l.* 16s. 3d." We now learn that the previous plant was *not* a Mond plant, and we much regret that we gave currency to a statement which was incorrect. Although it is clear from the context that the new plant was adopted because it could utilise a cheaper fuel—peat—than the anthracite used in the former plant, and not because of any deficiencies in the original plant, yet it is widely known that the Mond plant, as made by the Power Gas Corporation, Limited, of Stockton-on-Tees, has long been successful in the use of peat, with or without ammonia recovery, and that Mond producers which are now using coal can quite easily be worked with peat. We therefore take the first opportunity to dissociate the name of Mond from the apparatus which was superseded.

MECHANICALLY TUNED TELEGRAPHY.—A demonstration of a system of mechanically tuned telegraphy, suitable both for cable and wireless working, was given at 37A, Finsbury-square, E.C., on the 11th inst. by Messrs. A. T. M. Johnson and F. H. Varley. The system depends in essence on a series of vibrating reeds, each of which is mounted at one end of an electro-magnet in the manner of the contact-breaker of an induction coil. The energising of the magnet with direct-current causes the reed to vibrate with a periodicity which is determined by its own dimensions, and a series of current-impulses is accordingly produced in a secondary circuit which, in the case of cable working, forms part of the line wire. The current impulses accordingly travel to the far end of the cable and set in vibration a reed having a similar periodicity to the transmitting one. The vibration of the receiving reed may be used to close a relay-circuit or perform other functions. In practice it is proposed that the letters and signs of the alphabet shall have each a reed of different periodicity from all of the others allotted to it, each reed working in connection with its own electro-magnet, and that a keyboard in the manner of a typewriter shall be used for the transmission of messages. The depression of the keys will close the electro-magnet primary circuits, causing the reeds to be set in motion in any required order, so that a series of impulses of different periodicity will be sent through the cable, and by setting in motion the corresponding reeds at the other end may be caused to print messages in the ordinary type. It is claimed that many messages may be sent through a cable at one time without interference between the impulses of different periodicity. In the application of the mechanically tuned system to wireless telegraphy it is proposed that a continuous series of impulses shall be sent out, which normally will be of slightly different periodicity from the receiving reed, so that they will not affect it, the message being interposed in this continuous series by changing the periodicity into that of the receiving reed for brief periods corresponding to the dots and dashes of the Morse code. The receiving instrument will pick up these periods and record the message, but no instrument without a properly-tuned reed will be able to obtain anything but a continuous and consequently unintelligible series of impulses.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The supply of available tonnage has improved upon the whole, but colliery owners have not been eager sellers, as most of them state that they have not only full order-books for the balance of the year, but also for the first fortnight of 1912. The labour outlook is still threatening, and as this may entail a curtailment of supplies, sellers show a disposition to hold for harder terms. The best Admiralty large steam-coal has made 17s. 3d. to 17s. 6d. per ton; secondary qualities have ranged between 15s. 6d. and 17s.; best ordinary bunker smalls between 8s. 3d. and 8s. 9d.; and cargo smalls between 7s. and 7s. 6d. per ton. House-coal has maintained a good tone; the best ordinary household qualities have made 15s. 6d. to 16s. 6d. per ton; No. 3 Rhondda large, 17s. to 17s. 6d.; and smalls, 9s. 9d. to 10s. per ton. No. 2 Rhondda large has realised 13s. 3d. to 13s. 6d.; and smalls, 6s. 3d. to 6s. 9d. per ton. Foundry coke has brought 17s. 6d. to 20s.; and furnace ditto, 15s. 6d. to 16s. 6d. per ton. As regards iron ore, Rubio has made 20s. to 20s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Coal for the Navy.—South Welsh colliery owners who tendered for next year's Admiralty requirements have received in some cases acceptances and allotments. The price obtained for the best steam coal has been about 16s. 6d. per ton net, free on board, values ranging downwards to 15s. 3d. per ton for secondary qualities. The prices at which tenders have been allotted show an advance of about 1s. per ton as compared with December 1910.

Death of Mr. J. Martin.—The death is announced at Bristol, at the age of sixty-seven, of Mr. J. Martin, Inspector of Mines. He became assistant inspector in 1873, and after spending some time in this position in the Cardiff district, he was promoted to chief inspector in 1886, and transferred to the South-Western district, which includes Monmouthshire, the Forest of Dean, Gloucestershire, Somerset, Cornwall, and Devonshire. In this district he spent the best part of his career; and having reached the age limit, he retired from the service in May last year. He took part in the investigation of several colliery explosions, not only in South Wales, but also in various parts of England. Among the more recent explosions which engaged his attention were those at the Llandash slope and Llanbradach in 1901, the McLaren colliery, in Monmouthshire, in 1902, and Norton Hill, Somerset, in 1908. Mr. Martin was also deputed by the Home Office to proceed to Germany to prepare a special report upon German experiments with coal dust.

Welsh Fuel for Austria.—The Star Patent Fuel Company, Limited, has secured orders from the Austrian naval authorities for 30,000 tons of patent fuel, to be delivered in the course of next year on terms not disclosed. A contract for a balance of 10,000 tons is reported to have been placed in Germany.

CONTRACTS.—An electro-galvanising plant for coating boiler tubes and special fittings is being erected in accordance with Mr. Sherard Cowper-Coles' designs and specifications for the Sociedad Española de Construccion Naval, Ferrol, Spain, which company is entrusted with the building of the new Spanish Navy.—Messrs. Ed. Bennis and Co., Limited, have recently booked, among other orders, contracts for sixteen of their various stoking installations for Great Britain, the Continent, and foreign countries, many of which are repeat orders.—The British Admiralty have been considerably increasing the number of paraffin-engined motor launches in the Service, and have just recently ordered five larger boats than the preceding ones, all of which are to be fitted with Parsons paraffin oil-engine sets. No less than thirty-seven Parsons paraffin engines have either been installed or are now on order for these Admiralty service boats.

THE BENKÖ PRIMARY BATTERY.—Mr. W. R. Cooper, M.A., described in the Faraday Society on December 6 a new form of Benkö cell which he has been testing. The characteristic feature of the cells of Stephan Benkö, of Budapest, is that the carbon is very porous, so that the electrolyte (sodium bichromate, not the potassium salt, which might crystallise) circulates through the carbon walls and keeps the carbon depolarised. In the original type this circulation is ensured by introducing the electrolyte under hydrostatic pressure. The carbon forms a flattened cylinder open above and below; it is provided with a lead ring at the top and a lead bottom, and a lead shell is soldered to the lead, so that there is an outer, narrow chamber between the lead and the outer carbon wall and an inner, wider chamber, in which the zinc is placed. These cells give very strong steady currents; a cell weighing 10 lb. (without electrolyte), 9 in. by 6 in. by 1¾ in., yields 25 amperes at 1.5 volts (first 2 volts) with a circulation of about 0.5 litre of electrolyte per hour. These batteries are very convenient for laboratory work and small house installations; the cost of the electrolyte is the chief item. The new "diffusion" cell does not require an electrolyte cistern, nor a circulation system, and is self-contained. When filling the cell, strong electrolyte (acid and bichromate), density 1.3, is run into the outer chamber, and water, density 1.0, into the inner. The liquids slowly diffuse through the carbon into one another, and as long as a difference of density prevails in the two compartments, the cell will depolarise itself, and give a good current. A 5-lb. cell gave a current of 0.25 ampere (finally 0.20 ampere) for 8 hours on four consecutive days, after which the current fell off rapidly. A 3-lb. cell would keep a small lamp lighted for 8 hours for two days. Several types of portable hand-lamps for motor-cars and for miners were exhibited.

35-TON STEAM BREAKDOWN CRANE.

CONSTRUCTED BY MESSRS. JOHN H. WILSON AND CO., LIMITED, ENGINEERS, BIRKENHEAD.

(*For Description, see Page* 797.)

Fig. 2.

Canadian Coal.—Vancouver Island has five coal-fields—Nanaimo, Comox, Suquash, Cowichan, and Koskeemo—and they are considered the most valuable upon the Pacific Coast of British America. Mr. Dowling, of the Geological Survey of Canada, states that the area of the Nanaimo field is 350 square miles, and that its coal has an average thickness of 6 ft.; he, accordingly, estimates the quantity of coal available on the field at 1,344,000,000 tons. He sets down the area of the Comox field at 300 square miles; its coal thickness is similar to that of Nanaimo, and it is estimated to contain 1,152,000,000 tons. The Suquash field has an area of 10 square miles; its coal is 3 ft. thick, and it contains altogether 19,000,000 tons. The Cowichan field has an area of 9 square miles, its coal is 4 ft. thick, and it contains altogether 23,000,000 tons. The Koskeemo field is 5 square miles in extent; its coal has an average thickness of 3 ft., and it contains altogether 9,000,000 tons. The Cowichan and Koskeemo fields are not at present worked. Another coal-field is expected to be added to the five fields already known—viz., the Alberni.

"The Royal Navy List and Navy Recorder."—The issue for October of the "Royal Navy List and Naval Recorder," published at 10s. by Messrs. Witherby and Co., 326, High Holborn, and 4, Newman's-court, Cornhill, includes the promotions up to the end of September, and a complete record of the current history of the Navy. Since we noticed the previous issue we have been confirmed in the view that the change made in respect to the list of officers is not satisfactory. Formerly this list was arranged in the early part of the book, according to respective rank and seniority, giving the dates upon which successive promotions had been made in the case of each officer. Such a list for flag-officers, both on the active and retired list, is still continued, but the names of the remaining officers are listed in alphabetical order, with a reference to the number of their ship, and with no data as to promotions. This is not so serviceable to many who consult the list, although by reference to the useful record of services, honours, and qualifications of all officers, arranged alphabetically, much information may be gathered regarding these officers. We hope that the editor may yet see his way to revert to the earlier practice, even though it takes up more room. Otherwise the book is as complete as it can be made, and it would be difficult to indicate a direction in which desirable information could be added.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

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NOTICES OF MEETINGS.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, December 15, at 7.30 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-upon-Tyne. Author's reply to discussion on paper:—"The Relationship between Residuary Resistance Horse-Power and Forms of Vessels," by Mr. Ernest Saxton White, B.Sc., Member (read before the Institution on October 27). Paper to be further discussed:—"Certain Aspects of Ship Resistance as Disclosed by the Performance of the Corrugated Sided Vessel 'Monitoria,'" by Mr. Arthur H. Haver, M.I.N.A., Member.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 15, at 8 p.m., in the meeting hall of the Institution, discussion upon "Double-Cutting and High-Speed Planing Machines," by Mr. J. Hartley Wicksteed, Past-President, of Leeds. Paper to be read and discussed (if time permits): "Oil-Burning Locomotives on the Tehuantepec National Railway, Mexico," by Mr. R. Godfrey Aston, Graduate, of Mexico.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, December 16, at 7.15 p.m., at the Institute, Wolverhampton-street, Dudley. Mr. W. H. Lake will read a paper on "The Electrification of the Shelton Mills."

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, December 19, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, a paper will be read by Mr. Haydn T. Harrison, entitled "Some Aspects of Railway Station and Goods Yard Illumination."

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH LOCAL SECTION.—Tuesday, December 19, at 8 p.m., at the Heriot Watt College, Edinburgh. Paper: "The Heriot Watt College Laboratories," by Professor Francis G. Baily, Member.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 19, at 8 p.m. Paper to be further discussed:—"Experiments on the Strength and Fatigue Properties of Welded Joints in Iron and Steel," by Mr. Thomas Ernest Stanton, D.Sc., M.Inst. C.E., and Mr. John Robert Pannell. The papers next to be considered are:—"The Water Supply of the Witwatersrand," by Mr. Donald Calder Leitch, M. Inst. C.E. "Investigations Relating to the Yield of a Catchment Area in Cape Colony," by Mr. Edward Cecil Bartlett, M. Inst. C.E. Students' visit, Wednesday, December 20, to the testing works and museums of Messrs. D. Kirkaldy and Son, Southwark-street, S.E.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, December 20, at 7.30 p.m., at the Institution of Civil Engineers. Papers to be read:—1. "Solar Halos and Brocken Spectres," by Mr. Walter Larden, M.A. 2. "The Statical Changes of Pressure and Temperature in a Column of Air that Accompany Changes of Pressure at the Bottom," by Mr. W. H. Dines, F.R.S.

THE INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.—Wednesday, December 20, at 7.45 p.m. Paper to be read: "Some Experiments with Wireless Telegraphy Transmitters," by Mr. P. R. Condsey and Mr. G. G. Dawson.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, December 21, at the Rooms of the Geological Society, Burlington House, Piccadilly, London, W., at 8 p.m. The following papers will be discussed in the order in which they are given:—"Emeralds; their Mode of Occurrence and Methods of Mining and Extraction in Colombia," by Mr. Charles Olden, Member. "The 'Glen' Bismuth Mines, North Queensland," by Mr. W. C. Walworth Pearce, Associate. "Notes on a Simple Method of Separating Rock from Stiff Clays," by Mr. F. A. Killik, Member. "The Whim Well Copper Mine, West Pilbara, North-West Australia," by Mr. H. R. Sleeman, Member.

READING-CASES.—Reading-cases which will hold twenty-six numbers of "ENGINEERING" may be had of the Publisher or of any newsagent. Price 6s. each.

ENGINEERING.

FRIDAY, DECEMBER 15, 1911.

FOREIGN INVESTMENTS AND MANUFACTURED EXPORTS.

EVIDENCES have lately accumulated to establish the difficulty experienced in raising capital for home industries, a difficulty which greatly influences the prosperity and employment of the working classes. There is another phase of the subject equally worthy of the close attention of all economists. This refers to the direct influence of foreign investments, not only on trade at home, but particularly on the export of manufactures. That these investments in foreign undertakings are increasing is an undoubted fact. This is inevitable in the case of any nation possessing wealth, and we prefer for the present not to consider the causes which may induce those possessing surplus capital to prefer foreign to home outlets for its employment. The effect is most marked, so far as British industries are concerned, because without adequate capital resource there cannot be expansion in manufactures or full play to initiation in design and workshop methods. As a direct consequence there must be retrogression in efficiency and economy relatively to other nations where those stimulating influences are present. The result is that labour suffers. Few recognise, however, the extent to which British capital is being invested abroad. A computation, based upon reliable data, shows that our total investments abroad amounted, at the end of last year, to 3722 million sterling, and that the increase over a period of fourteen years was at the average rate of 91½ million sterling per annum. It is further concluded that these investments bring an annual income of 178 million sterling. Indeed, although only a part of this income can be brought within the wide net of the Income Tax Commissioners, their returns show that the tax is levied on 88,837,000*l.* of income from investments abroad. At a time when contrast is made between the relative earnings of capital and labour, it is well incidentally to point out that such a large amount as 178 million sterling is received in this country without British labour in any way participating in its creation.

The money thus invested is utilised either for the development of natural resources or for the establishment of industries. The former naturally includes agriculture, mineral working and transport, and collateral interests in foreign countries. So far as these are concerned, no direct injury may be experienced by British labour. On the other hand, they tend to augment the supply of food and of raw materials for manufactures and may conduce to lower prices. But the establishment of industries abroad must affect labour in all other countries, because so soon as the manufacturing plant is provided, the products of the works established enter into competition with the manufacture of other countries, at least in the local market. These, however, are conditions that must be met with, and are sooner or later inevitable, even in new countries. The greater portion of the capital invested comes under the first category, and consequently the investments themselves tend to create a market for surplus productions of older countries. To this extent developments in foreign countries conduce also to increase employment for workers in other countries, and certainly profit those nations which have a large mercantile fleet, as is the case with Britain.

It therefore becomes pertinent to inquire whether we, as a nation of lenders, are securing full benefit from our monetary concessions. Benefit is direct and indirect. Those utilising our money have some right to consider that the interest paid, or dividend disbursed, is compensation enough; and from the financier's point of view it probably is. The Socialist orator may orate against the "criminal neglect of our own country" by thus investing abroad; but no one can quarrel with the investor, whether of hundreds or thousands of pounds, in seeking for an adequate return for his investment, combined with safety. Unfortunately, the growing discontent of the working classes in this country, whether engendered on a right or a wrong basis, has conduced to the belief that there are avenues abroad where the conditions are more attractive to the lender of money. Accepting these conditions, and recognising that investments abroad are, to a certain extent, inevitable, it may be asked whether there is no means of securing greater indirect advantage to labour from these foreign investments.

Foreign government loans, as a rule, are for specific works; usually, indeed, for engineering works. In one case a navy may have to be re-organised; in others, money has to be provided for railway construction, or for water-works, or for other enterprises for the development of the country. The London money market is prepared to grant these loans. In many such instances, however, no effort is made to secure the concession that, provided this country raises the loan, the contract for the projected work will be placed with our manufacturers or contractors. In some instances, it is true, notably in naval construction, such conditions have been exacted, not only to the advantage of the Government seeking the money and requiring the ships, but of British labour. As a matter of fact, naval construction contracts very often are made contingent upon the money being provided, and in the past Continental firms have secured very large orders because there is a closer association between the financier or banker and manufacturer. The same applies, more frequently abroad than here, to loans and large investments by some foreign countries for other than naval work, and a development on similar lines in this country would bring great advantage to labour. The Deutsche Bank of Berlin, for instance, has all along recognised the power behind the capital investment, even within Germany, and they have thus assisted greatly towards the development of industry by financing undertakings in the Fatherland. The Deutsche Ueberseesche Bank has indirectly done valuable work for the German export trade, and nowhere has its influence been more operative to a greater extent than in the South American republics. There they have a branch bank, under the style of Banco Aleman Transatlantico, with offices in several centres of activity—in Argentina, Bolivia, Chili, and Uruguay—where facilities are granted to German manufacturers which enable them to carry on trade under the most favourable conditions. It is true that

their intromissions are reckoned only as banking business, but the latter phrase must be interpreted according to the German conception of the ramifications of a bank. As is well known, they take an active hand in the financing of enterprises, and in many cases also in the destination of contracts which borrowers have from time to time to make.

This leads to a question of serious import so far as the constitution of British banks is concerned. Here we have rigidly excluded any speculative element in connection with banking, and, as a consequence, the banks are regarded as being as "safe as the Government." They have been supine to all appeals for assistance in the development of industry either at home or abroad. Notwithstanding the advantages of security, is it not worth considering whether greater influence might not be utilised for ensuring that Britain, in return for her investments, should, as with some Continental countries, secure some support for her industries? Certainly where a loan is contracted it ought to be a definite condition that such works as are to be executed under the loan should be carried out by British firms, if the money is to be provided by British investors.

We admit frankly that the competitive principle enters into the problem to a greater or less extent. The directors of a foreign railway, or of other enterprises, have a right—one might almost say a duty—to bring into play in connection with all work such a measure of competition as will ensure the fullest return for a given expenditure. If, in the case of a South American railway, the preponderating proportion of capital is subscribed by Britain, it seems reasonable to expect that the limits of competition would be confined to British works, and that, in any case, the conditions of British manufacture and wages should be enforced in the case of such Continental firms as might be invited to tender. It is not necessary to enlarge upon the significance of this proviso. We are satisfied that, under equal conditions—economic, manufacturing, and social—British firms could meet the condition we have postulated as regards the duty of directors. Certainly in the interests of British industry those inviting the investment of capital should, as a condition to Britain providing that capital, secure a concession in favour of a greater proportion than is usual of British manufactures being purchased by the aid of such capital. Is this asking too much in the interests of patriotism?

THE RATING OF PETROL-ENGINES.

A most suggestive paper to those who are interested in the rating of petrol-engines was read by Mr. H. L. Pomeroy at the Institute of Automobile Engineers on the 13th inst., entitled "Engines Designed for Taking Advantage of Horse-Power Rating Rules." In some ways the contents of the paper hardly correspond to its title. The only engine rating-rule which is at all thoroughly dealt with is the present R.A.C. rating, and many others, which are, or have been, in use at various times, are left nearly untouched. On the other hand, a considerable portion of the paper deals with the question of an alteration in the present rating rule. Both these subjects are thoroughly gone into, however, and the paper contains some very important suggestions. Horse-power formulæ are used for two purposes, the first being the rating of cars for taxation purposes, the second for competitions. The latter is apparently the only point of view really dealt with in the paper.

The rating rule at present in force in this country for motor-cars is based simply on the assumption that the power of an engine varies directly as the area of the pistons, no other factors being taken into consideration at all, and the early part of the paper consists of a general statement of the essential conditions necessary for success under this rule. Naturally these consist in getting the highest possible mean pressure and piston speed, these being the only two factors determining the indicated horse-power of a cylinder of given area. In order to get the requisite mean pressure, the author states that it is necessary to employ a rich mixture and a high enough compression to cause it to burn in the short time available. He assumes that the engine must increase its horse-power with increasing speed up to at least 2400 revolutions, and, preferably, to 3000. For this a compression ratio of 5 to 1 is considered necessary. Ignition should be by magneto, and the author does not consider there is any advantage in having two sparks.

Granted that these points are correct, the author considers that the only necessary point to secure mean pressures of 100 lb. per sq. in. up to, say, 2500 revolutions per minute, is sufficient valve area to keep the gas velocity down to 120 ft. per second (7200 ft. per minute) through the inlet port. If this rate of flow be not exceeded, he finds that the cylinder is practically filled with gas at the end of the suction stroke—*i.e.*, that the pressure is only ½ lb. below the atmosphere. He does not appear to think that the valve-setting has much influence on the performance of the engine if the valves are large enough, though presumably there must be some limit to this view. The practical limits of size of valves depend upon two points. The first is the pressure necessary to open and close the valves at high speed. The author gives some calculations showing that a 2-in. valve with ½-in. lift will take a force of 72 lb. to close it, presuming that its downward acceleration is constant, and that the time available for its closing is that taken by the crank turning 90 deg. at 2500 revolutions per minute. This would, in practice, mean using a spring with a tension of some 100 lb., when the valve is fully open. This force would increase at least as the square of the diameter of the valve, and also as its lift. Multiple valves get over this difficulty to a large extent, but the author concludes that the friction through them is relatively greater, and that they therefore require larger total area. Whether this conclusion is the result of experiment or only of calculation is not clear.

The second limit to the size of valves arises from the fact that it is impracticable to make them larger than a certain size and yet get a small enough combustion-chamber to give the requisite compression.

Lightness of moving parts is touched upon, but the author does not dwell on it very strongly, probably because its importance is now well recognised. At high speeds he states, however, that even with light pistons, &c., the pressures on the bearings due to inertia are greater than those due to the pressure of the explosions. The effect of heavy moving parts on high-speed engines has, of course, been familiar to engineers for a long time, forged-steel pistons having been used in high-speed engines for over thirty years.

Forced lubrication is considered absolutely necessary for racing, and if long runs are to be made the author considers that the oil should be cooled. The conclusions he draws are :—

(*a*) That high mean effective pressures depend on mixture strength.

(*b*) That high mean pressures at high speeds depend on high volumetric efficiency and high compression.

(*c*) That high volumetric efficiency depends entirely on large ports and valves.

(*d*) That lightness of moving parts is essential if high mechanical efficiency is desired.

Assuming these conclusions to be true, then it follows that, given a sufficient valve and port area, horse-power is directly proportionate to the cylinder capacity and revolutions. If this be so, it will necessarily follow that for a given rating by the present R.A.C. and Treasury rating rule the horse-power will go up directly as the stroke, and we have before said that this seems to be actually the case. The author appears to be absolutely at one with us in this matter, and apparently considers that it is high time that engines should be rated by their cylinder capacity.

The remainder of the paper is devoted to the consideration of various rating rules and to a demonstration of the fact that any rule which takes in the stroke at less than its full value will rate unfairly engines which are of differing proportions of diameter and stroke. The majority of rating rules which have been proposed as alternatives to the rating either by cylinder capacity or area are based on the assumption that the revolutions are limited by the stress on the connecting-rod due to the inertia at the top of the stroke; that is to say, that the stronger the connecting-rod is made, the greater the power given by the engine. Mr. Pomeroy points out that this contention is quite groundless, as the stresses on the connecting-rod, &c., do not in any way limit the speed, and that far higher speeds than are ever run could be provided for.

This paper is a most valuable contribution to the literature of engine rating, for it is the first serious attempt to go into the point which ought to be thoroughly considered before making a rating rule—namely, what it will produce if makers build special engines to "cheat the rule."

In all other competitions, such as yacht-racing, it is assumed that all dimensions untaxed will be exaggerated, and therefore the only thing to consider is what it is desired to produce, and a rule can then be framed fairly accurately. Whether the Royal Automobile Club Committee were totally ignorant of this elementary truth, or whether they thought that they knew so much about the design of engines that they could improve on the cylinder dimensions selected by such makers as Messrs. Rolls Royce, we do not know, but it was quite obvious at the time the rule was made that it would cause the production of a long-stroke engine in all competitions, and that taxation on the same basis would have the same effect, except in those cases where money was of so little consequence that the taxes did not influence the purchaser.

Valuable as Mr. Pomeroy's paper is, however, it might have been more so if it had gone a little more fully into the subject of special design for competition purposes. Nothing is said about the effect of cylinder ratings on weight, which is a most important point. True, a statement is made that "if 40 horse-power can now be obtained from an engine of given size at 2000 revolutions per minute, which formerly only developed a maximum of 20 brake horse-power at 1000 revolutions per minute, the relation of horse-power to weight is obviously doubled." That is to say, that the weight of an engine is inversely as the revolutions per minute. As a matter of fact, this is a complete fallacy, as the author is probably well aware, for he gives the reason in a later part of his paper—namely, that at high speeds the stresses due to inertia are greater than those due to the explosion pressure. An engine weighing 219 lb., including radiator and all accessories, has developed 31½ brake horse-power at 1213 revolutions per minute for over 22 hours' continuous run, the weight of the engine itself being therefore well under 200 lb. It is quite certain that an engine developing the same brake horse-power at double the revolutions does not weigh as little as half this, and most of them weigh more like double. If the author, or any one else, really thought that the excessively high-speed engine was very light for its horse-power, there is little doubt that it would be used for aeroplane work, but here all the engines run at a comparatively slow speed for the simple reason that they have to be as light as possible for their horse-power, and that there is no tax on cylinder dimensions.

The author, moreover, does not deal with engines of very long stroke. If it be worth while doing a thing at all, it is surely worth doing it well, and it would be interesting to know what is the limit of stroke and weight which can be usefully employed for competitions on a given cylinder diameter. It is understood that some racing engines of 80 mm. diameter have been given 280 mm. stroke, or over 3½ diameters.

It seems a pity, especially considering the title of the paper, that no attempt whatever is made to consider what type of design should be adopted to get the best result out of any other rule than the present R.A.C. rating. Two of the principal races of this year—viz., the "Autocycle Tourist Trophy" and the "Coupe Des Voiturettes Legere"—were not run on this rating, but one of cylinder capacity, so it appears that this should have had at least some consideration. Further, there are several other rules which have been tried, and which in many ways are more practical than any rating based solely on cylinder dimension. Thus petrol consumption and weight have both formed bases of classification, and have the advantage that, while it is no advantage (apart from a very small saving in taxes) to the motorist to know that his cylinders are small unless this saves him in some other way, it is an advantage to have a low petrol consumption, and it is an advantage for a car to be light.

The only remarks of the author bearing on the subject are when, comparing the high-speed engine with small torque with the low-speed engine of high torque, he says :—"By virtue of the fact that the small engine is always working with open throttle and relatively high compression as compared with the big one, there is a considerable increase in thermal efficiency with a corresponding decrease in the petrol consumed." We do not quite understand what this means. There is no difficulty whatever in so arranging the gear ratios

that the large engine runs with the throttle open as often as the small. Further, the high-speed engine has been definitely proved not to be so economical in petrol as the larger slow-running one. This was done in the early tourist trophy races, where petrol consumption was the basis, and the high-speed engines were easily beaten by those with larger cylinders running at lower speeds. The very statement the author makes that a rich mixture is necessary to get the power out of these small engines shows that they cannot be really economical.

With regard to the other practical rating rule—viz., weight—it is rather interesting to note that under this, as in the case of the aeroplane engine, the long-stroke high-speed engine found no favour.

As to the latter part of the paper, dealing with engine rating, we are in thorough accord with the author that a cylinder capacity basis would be the fairest all round. We have not space to go into this matter here, but shall possibly refer to it again. Meanwhile we would refer to our issue of May 21, 1909. A point not mentioned by the author is that the motor-cycles have been raced under this rating for three years now, and that it has been proved definitely that it does not produce exaggerations either of diameter or stroke.

GAS-ENGINES FOR COLLIERY POWER-STATIONS.

The day is passed, or is rapidly passing, in which the economy or otherwise of the prime movers of a colliery power-station may be neglected on the score that there is always plenty of coal about, and that it does not cost much. The increasing value of coal of all classes and the increasing cost of labour demand that even the coal-producer must pay adequate attention to the possibilities of economy that may lie in a change of his methods and a modification of his plant. This fact is, of course, becoming ever more generally recognised, and many new plants of various types, which show remarkable commercial efficiency, have been installed in this country in recent years. None the less, the number of examples open to improvement is still very large, and advocates of any and every modern device need be at no lack of data on which to base their arguments. Apart from proposals which turn on the purchase of electric power from an outside source, the possible types of installation for a colliery power-station are pretty well confined to steam-engines and turbines or gas-engines; and although the first of these classes still holds an overwhelming majority, much has now been done with the two latter, and they are every day becoming more serious competitors of the former. Steam-turbines and gas-engines, which together dispute the ground held by their older competitor, are themselves the keenest of opponents in a much larger field than is covered by colliery work, and each is so excellently capable of establishing its own case that it is impossible to forecast that either will ultimately conquer the other. In the smaller field of colliery work, however, it is possible that gas-engines may make relatively greater progress than elsewhere, in virtue of their ability to work in conjunction with coke-oven plants, and their suitability for operation with fuel of such inferiority that it may almost be looked upon as waste, since the cost of its carriage away from the colliery bears such undue proportion to its specific value.

Some useful information bearing on the use of gas-engines in colliery stations was contained in an able paper read by Mr. Alan E. L. Chorlton before the Midland Institute of Mining, Civil, and Mechanical Engineers on the 5th inst. Mr. Chorlton did not, other than in a general way, deal with the relative economy of steam-turbines and gas-engines for this work, and evidently held the superiority of the latter to be established. He, however, instituted an interesting comparison between gas-engines working with coke-ovens as against Mond producers. He pointed out that the two methods of obtaining gas for the engines were not strictly comparable, and that the peculiarities of each might render it suitable for localities in which the other could not profitably be employed. If gas for the engines was to be obtained from coke-oven plant, it was obvious, in the first place, that the available coal must be of a coking type; while, in addition, Mr. Chorlton pointed out that with such a plant the percentage return on capital may be considered to be high, even if the value of the waste gas is not allowed for. Further, and as the converse of this, the capital charge on the gas available for power purposes was low. With the Mond producer the conditions were somewhat different. In the first place, a poor fuel, containing as much as 40 per cent. of ash, might be used, but the percentage return on the capital employed could be high only when the produced gas was sold or profitably used, as the sulphate of ammonia which was manufactured was not in itself of sufficient value to give a high return on the capital cost. With the Mond producer the amount of gas available for power purposes was, in terms of capital expenditure, very large.

Mr. Chorlton's paper contained an estimated comparison between a coke-oven and a Mond plant having each a capacity of 90,000 tons of coal a year. The capital cost of the coke-ovens was put down at 45,000*l*., and taking coal at 7s. a ton the annual cost came out at 49,147*l*. The capital cost of the Mond plant was fixed at 52,000*l*., and taking half the coal used at 7s. a ton and half at 4s., the yearly cost came out at 47,500*l*. The profits shown in the two cases were 12,563*l*. for the coke-ovens and 14,650*l*. for the Mond plant. The profits were, of course, based on the assumption that the whole of the material produced was in each case sold, the value of the sulphate of ammonia being put down at 12*l*. a ton, the coke at 12s. a ton, and the gas at 0.04d. per unit after conversion to electrical power. This comparison, although interesting, does not really put the two plants on the same basis, since, with the coke-ovens there was only 1170 tons of sulphate of ammonia produced, against 3600 tons with the Mond plant, although as an offset the coke-ovens produced 63,000 tons of coke, against, of course, none by the other plant. The gas furnished by the Mond producer was, however, more than six times greater in amount than that produced by the coke-ovens, even after allowing for the difference in quality of the gas in the two cases. It is obvious that these two plants could not profitably be installed each to deal with the same conditions, and that even if the productions which are claimed could be obtained, it would be necessary for success that a market for the material should be available.

The large amount of gas furnished by the Mond producer would seem to render it suitable for large power companies or groups of collieries rather than for comparatively small plants; but Mr. Chorlton's paper contained an estimate for a plant of this class for a colliery requiring 3000 brake horse-power. This estimate was made on the assumption that a very large proportion of shale and belt-pickings, of no value, should be used with the fuel. With a capital cost of 13,200*l*., and an annual cost of 4025*l*., the plant was estimated to bring in an annual sum of 4740*l*., not allowing any credit for the gas produced. The 4740*l*. was made up of 4560*l*. for sulphate of ammonia and 180*l*. for tar. The running charges were put down at 1500*l*. a year, this sum including the cost of the steam for the producer; but it was not clear if this steam was assumed to be taken from gas-engine exhaust boilers.

The latter part of Mr. Chorlton's paper was concerned with a consideration of the various available methods of power distribution for dealing with the winding, ventilating, pumping, hauling, air-compressing, surface-driving, coal-cutting and lighting, which form the main power requirements of a colliery. These methods may be divided into electrical transmission, hydraulic transmission, pneumatic transmission, mechanical transmission, and various combinations of the four. The first of these, electrical transmission, has probably made the most progress of recent years, and for gas-engine driving it is likely that many people would be inclined at first sight to think that no competitive system need be considered. There is no need to dwell on the convenience and efficiency of the electrical transmission of power in a colliery or elsewhere, but considerations and arguments advanced in favour of quite other schemes, if put forward in an able manner, are both interesting and likely to be of service in calling attention to the fact that even in these days electric transmission should not be looked upon as the only system in the field. The trend of legislation suggests that in the future the use of electricity below ground in collieries may have to be restricted below its present extent, and in these circumstances consideration of alternative transmission systems is of great value. It is certainly probable that any legislative restriction on the use of electricity will apply only to limited fields and duties, and that its elimination from any of its present duties will lead only to the installation of combined transmission systems, and not to the adoption of different methods throughout. None the less, Mr. Chorlton's considerations of hydraulic, pneumatic, and mechanical transmission for the whole of the operations in a colliery makes an interesting and somewhat novel study which is well worth attention.

It is unnecessary to deal at any length with the characteristics of electricity as a power-distributing agent in collieries, as they are nowadays so well known, but its singular adaptability for pumping and similar duties may be mentioned, together with the possibility of its satisfactory use for main winding and its pre-eminent suitability as a lighting agent. The position of hydraulic transmission as a medium for the whole power operation of a colliery is more doubtful, and, according to Mr. Chorlton, it has, up to the present, been applied only for pumping. He stated that the method had been brought to its highest efficiency in Germany, and that a plant installed at the Herkules Pit, Essen, gave an efficiency of 78 per cent. The pumps situated in the mine were of the reciprocating type. In the absence of experience as to the general operation of colliery machinery with hydraulic power, it is impossible to argue with any profit as to the likely total efficiency that might be obtained, but Mr. Chorlton suggested that this would probably be high, although installation and upkeep would probably also be high. In this connection Mr. Chorlton pointed to the extensive use of hydraulic power in dock works, and the convenience of the hydraulic accumulator for dealing with peak loads. There is, of course, no doubt that a completely hydraulically-driven colliery would be a mechanical possibility.

The efficiency of a completely pneumatic system would no doubt be less than that of either an electrical or hydraulic one, but its safety would be greater than that of the former, and its flexibility greater than that of the latter. The system is, of course, much used, although not in the complete form suggested. The usually accepted over-all efficiency was given by Mr. Chorlton as about 30 per cent., but he suggested that this might be much increased by improvements in the air-motors. His gas-engine-driven pneumatic scheme involved the use of a two-cycle double-acting engine governed in terms both of the pressure of air in the receiver and in terms of the speed, the second governor only coming into action as full speed was approached. He also proposed the use of a radiator of the motor-car type for dealing with the cooling circulating water.

The idea of the whole of the machinery of a colliery driven by mechanical means direct from a central gas-engine power plant, which formed Mr. Chorlton's fourth proposal, appears somewhat fantastic at this time of day, although one may admit that there is something in his contention that much higher efficiencies might be attained by the adoption of modern appliances than was achieved in the early days in which such systems of transmission were common. With such a purely mechanically-driven colliery the main winding would undoubtedly form one of the most difficult problems, and Mr. Chorlton's suggestion was that the gas-engine forming the power plant should be built with air-cylinders behind the gas-cylinders, the pistons being connected up in the ordinary way with tail-rods. To help the gas-engines over the winding peak the air-cylinders would be driven from an accumulator whose capacity would be regulated by the addition and subtraction of water, and which would be charged up by the cylinders themselves driven by the gas-engine during times of light load. The driving of underground pumps and coal-cutters by mechanical means would, in essence, be a simpler problem than that of winding; but the inconvenience, quite apart from questions of efficiency, would probably be such that there is little probability of the adoption of any such method.

THE CUNARD LINER "LACONIA" AND THE ROLLING OF SHIPS.

In the attainment and maintenance of British maritime supremacy, which is as important to national prosperity as is inviolate naval power, since the latter is a corollary to the former, the Cunard Company has played a prominent part, and

it is eminently satisfactory that the traditions of the line are being continued and strengthened under the chairmanship of Mr. A. A. Booth. With a knowledge of all the requirements of transport, and a courage to advance along the lines of scientific progress, he combines that strong patriotic fervour displayed by his predecessors when they ensured the continuance of the line as purely British, at a time when there was temptation to denationalise Atlantic lines, and deprive the British naval service of possible merchant cruisers. This week we have two convincing proofs of progress. The making of a new record for an all-round Atlantic trip by the Lusitania will add to British shipping prestige, especially as the same ship has in one year made the unique performance of completing thirty-two voyages across the Atlantic, involving 73,600 nautical miles steaming at about 25 knots speed. Of these, four voyages were made within thirty days; and during her short stays in port during that month the vessel had to take in 28,000 tons of coal. The Mauretania has aggregated this year nearly the same mileage, at average speeds varying only between 24.36 knots and 25.67 knots on the outward run, and 24.65 knots and 25.37 knots on the homeward run. Only those conversant with the thousand and one details of steamship management will appreciate what these record mileages and speeds mean in respect of the organisation of the staff under Mr. A. D. Mearns, the general manager of the line. The other evidence of initiatory advance is found in the fact that the new liner Laconia, which was added to the fleet on Tuesday, is the first North-Atlantic mail steamer fitted with the Frahm system of tank, which in this ship proved that a vessel designed with all the properties ensuring maximum stability and buoyancy can be prevented from rolling in a seaway to the discomfort of the passengers.

These evidences of the active policy of the line invest with interest and satisfaction the announcement recently made that the Cunard Company has entered into close association with the Anchor Line—another British progressive concern—since by this combination there is promise of the Cunard traditions being extended to the Indian and Eastern trades. Here, therefore, we have a further strong link welded in the chain which binds us to our Eastern dependency and colonies, and the Cunard becomes an Imperial line in the fullest interpretation of the term.

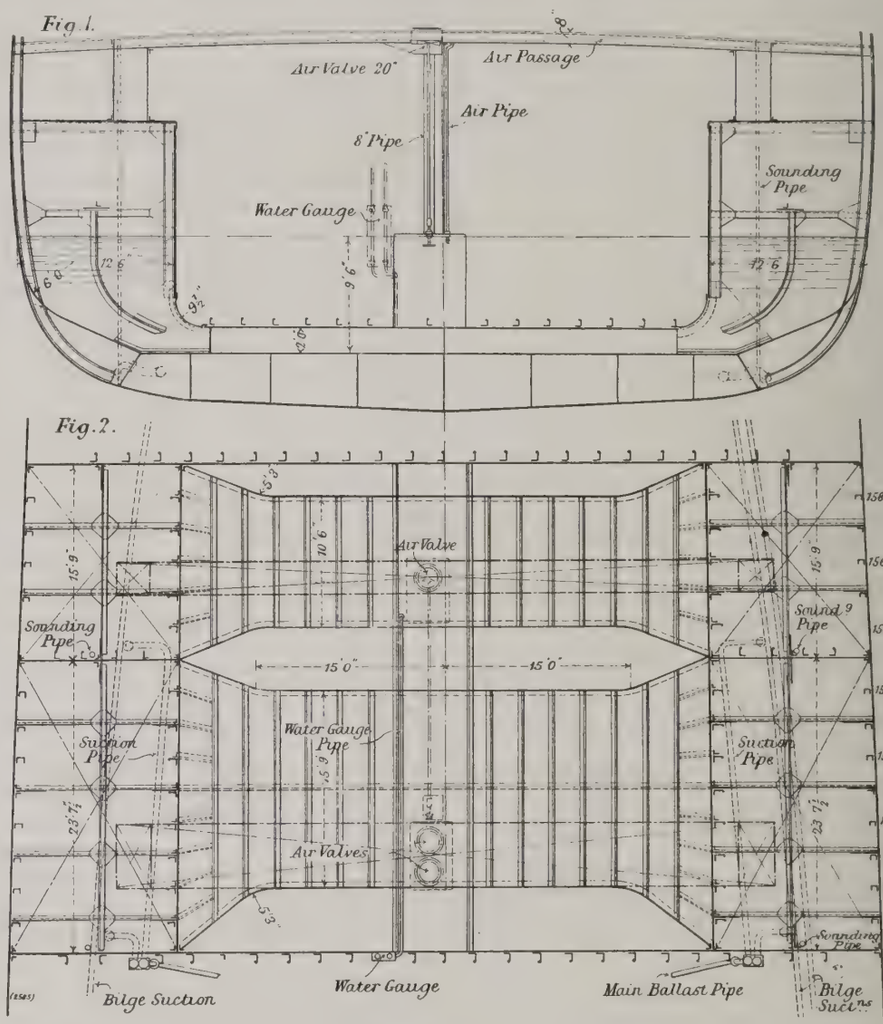
For the present we are concerned principally with the practical significance of the adoption of the anti-rolling tank in the Laconia. It is the most important application of this system yet completed, for although Atlantic liners have been pronounced successes as seaworthy ships, the route affords the most severe test of the shipbuilders' design and work, and of the passengers' physical endurance. Moreover, every effort will be made to deduce from the performance of the ship the fullest data for guidance in the improvement of the system where possible. Encouraged by the chairman and the Board, Mr. L. Peskett, who has been so long the naval architect of the company, prosecutes continuous research and practical observation, in order that all lessons taught by experience may be applied towards improvement in design.

The Laconia is a ship which a few years ago would have been regarded as of exceptional size. She is almost identical with the Franconia, fully illustrated and described in Engineering in February last (see vol. xci., page 246). Here we content ourselves, therefore, with a brief *résumé* of her general features as introduction to a detailed description of the anti-rolling tank. The length over all is 625 ft.; the breadth, 72 ft.; and the registered gross tonnage, 18,150 tons. On a total displacement of about 25,000 tons, she carries 300 first, 400 second, and 2000 third-class passengers, and 7000 tons of cargo. The ship will be used on the Boston service, and in season on Mediterranean cruises, and the accommodation has been arranged specially to meet the requirements of each route. The writing-room, the lounge with its polished level floor suitable for dances, the smoking-room in grey stained sycamore, and the palm court with simulated masonry walls faced with trellis-work for climbing plants, all with their nooks and corners and bays and cottage windows, are as opposed to the old conventional ship saloons as present experience can devise. Several improvements in details have been made. In the case of the dining-saloons, both first and second-class rooms have the full width of the ship, but the kitchen and pantries, between them, are arranged in the centre and starboard side; while on the port side there is a series of separate rooms, where, at five tables, separate companies can have seclusion. Normally the partitions will be without the panels, and the vista thus revealed for some 200 ft. is most effective, being suggestive of Moorish courts.

But the chief scientific feature is the arrangement introduced for preventing the ship from rolling when a beam sea is running. Mr. Frahm described the system at the spring meeting this year of the Institution of Naval Architects (see Engineering, vol. xci., pages 480, 512, and 533), but the principle—as well as the application in the Laconia—may here be described. As the maximum degree of rolling is experienced in all ships when the period of beam waves synchronises with the period of the roll of the ship, there is introduced a U-shaped thwartship tank filled with water in each leg, and connected along the horizontal line, so that the water may oscillate in the tank with a period equal to the individual period of the ship. There is also a top connection in the form of an air-trunk; the relieving of the air through valves allows the water to oscillate as desired. Thus, as soon as the ship is impelled to roll by wave impulses, the water in the columns may be allowed to rise or fall in such a way that the influence of the wave is counteracted, owing to the resonance between the oscillation of the ship and of the water columns in the tank. The oscillations of the water in the tank are at the same rate as those in the ship, but although the periods are exactly identical, the phases are displaced by 90 deg.

In its application the size of the tanks depends upon the displacement and the loading condition of the ship to ensure that the necessary damping effect may be obtained; higher displacement or increased stiffness involves larger capacity tanks. In the Laconia the tank, shown in Figs. 1 and 2, is located in the foremost thwartship bunkers, and extends over fifteen frames—between frames 144 and 160—a position which will easily be identified by reference to Fig. 11, on Plate XVI., in Engineering of February 24 last (vol. xci., page 246). This involves no interference with the arrangement of the ship. By means of a water-tight cross-bulkhead the tank is divided into two unequal and absolutely independent compartments, the after part extending over nine, and the forward part over six, frames. The lower connections between the two side basins or lateral legs of the U are placed on the double bottom. The lateral basins are not water-tight at the bottom, consequently the bilge will also be filled as soon as the anti-rolling device is filled with water by pumps. The water in the bilge, however, remains unaffected, because it does not share the oscillations of the water column in the tank. The separate air-connection pipe in each compartment at the top is placed under the main deck, and is provided on the port side with the necessary cup-valves; two for the larger and one for the smaller compartment. These valves are worked from the pipe tunnel through the forward thwartship bunker. Before and behind the cups of the air-valves, ventilation tubes are introduced, leading in each case to the pipe tunnel, where there are shut-off cocks. For filling or emptying the tank, the bilge of each compartment is connected to the tank-piping.

When filling or discharging the tank, the air-valves have to be shut, whereas the cocks of the ventilation tubes and the water-gauges have to be opened. The water-level in the tank under normal conditions is, amidships, about 9½ ft. above the lower edge of the connection across the double bottom. Care has to be taken that the vessel is in an exactly vertical position when the tank is filled. As soon as the correct water-level is attained, and the cocks of the ventilation tubes and the water-gauges have been shut, the tank is ready for action. The compartments are put in or out of action by simply opening or shutting the air-valves. With the tank in action the tendency with some ships will be that stability may be reduced a trifle, owing



Figs. 1 and 2. Frahm's Anti-Rolling Tank on the Cunard T.-S.S. "Laconia."

to the free water surface in the lateral basins. This, however, can only influence tender vessels, and then only to a slight extent, as is shown in the table appended, applicable to the case of an average cargo ship of 22,000 tons displacement.

As a rule the tank is put into action only if the ship is really rolling—*i.e.*, if she executes to either side rolling movements of more or less importance, which alternately increase and diminish, and are performed approximately in the individual period of the vessel. In general, at the beginning only one compartment—mostly the larger one—will be put into action, and the smaller one will be added only if the larger one by itself proves insufficient for damping the rolling. In most cases real rolling motions will be produced only if the ship, in consequence of low-placed cargo, is rather stiff. This will generally be the case during the first part of the voyage, as long as the bunkers are still filled, in which case the reduction of stability on account of the free water in the anti-rolling tank will be almost without any influence at all. The anti-rolling device, when filled up to the air connection-pipe between the lateral basins, may be used also as a ballast-tank. This, however, will be done only in certain circumstances, and great care will have to be exercised when pumping the ballast into the tanks.

In the Laconia there is fitted a gyroscope-pendulum for recording the rolling motions of the ship, and this is illustrated by Fig. 3, and here it may be noted that the representatives in this country for the Frahm tank and recording apparatus are the Parsons Foreign Patents Company, Limited, London. The essential part of the recording apparatus is a horizontal fly-wheel, directly driven by an electric motor immediately underneath it, the latter being suspended in a Cardan ring, shown in white around the motor, and counterbalanced by a weight, so that the whole gyroscope thus formed remains stable. The gyroscope rotates at about 2600 revolutions per minute. The Cardan ring is suspended in a stand, which has to be so located on board of the ship that the axis of rotation is parallel to the longitudinal axis of the ship. In consequence of the high number of revolutions the gyroscope possesses great inertia, so that the oscillations round the axis of the Cardan are executed in very slow periods of 1 to 1½ minutes' duration. It therefore remains almost uninfluenced by all rolling and pitching oscillations of the ship, because these are executed in much shorter periods. The axis of rotation of the gyroscope tends to conserve its vertical position in spite of the ship's motions, and the relative movements of the stand with reference to the gyroscope represent the rolling of the ship. These relative movements, by means of a special arrangement, are transmitted to the right-hand pencil recording on a strip of paper moved by the electric motor behind the clock.

Under certain circumstances, however, the gyroscope-pendulum can be influenced by lateral accelerations in consequence of turning movements round a vertical axis of the ship (swaying or sheering), which will produce precise movements of the gyroscope, executed in its individual slow period. These movements are noted in the recorded diagrams in the form of long curves, overcut by the rolling curves of the vessel. In this case the rolling amplitudes are indicated by the movements on each side of a centre-line. The relative oscillations are transmitted to the pencil from a segment fitted on the axis of the Cardan frame to a rod, carrying the pencil on one end, by means of two brass bands, which rest lightly on the circumference of the segment and are fastened at one end to the segment and at the other to the transmission rod in such a way that one band coils up while the other is unrolled. With this transmission $\frac{1}{25}$ in. movement of the pencil corresponds to one degree of the ship's rolling amplitude. For recording the speed of the paper, a special time-recording pencil —that to the left on our view—is provided, and is actuated by means of electro-magnets through the clock. This pencil simply draws a straight line, interrupted every five minutes by a little hook, which also serves for ascertaining the exact period of oscillation of the ship. The current for this arrangement is carried through a shunt from the electric motor's main line, in series with two incandescent lamps as resistance. On the trial, to be referred to presently, the electric clock was not in operation throughout to make time-marks on the horizontal line, the intervals of time being indicated on the chart by the observer.

For the gyroscope, as well as for the recording arrangement, simple 110-volt shunt motors are provided; when a higher pressure is employed on board, a corresponding resistance must be fitted. For connection with the board circuit, a junction-box to the right of the large drum for the record slip, and a flexible cable with plug contacts at both ends, is fitted. When starting the device, the motor of the gyroscope has first to be switched on, and when the full number of revolutions is attained, the motor of the recording device is switched on. The motor of the gyroscope is set agoing by the starter under the small receiving-drum of the record-slip. The motor of the recording device is switched on by slowly turning to the right the starter, seen to the bottom and right part of the large drum. It is immaterial which of the two motors is switched off first. The whole apparatus, when in full action, consumes continuously about 1.5 amperes. When starting the gyroscope motor the intensity of current temporarily can rise to 3½ amperes. The shaft of the motor of the gyroscope runs in ball-bearings, and is lubricated automatically by two boxes containing vaseline. The shaft of the motor of the recording device is fitted with ring lubrication.

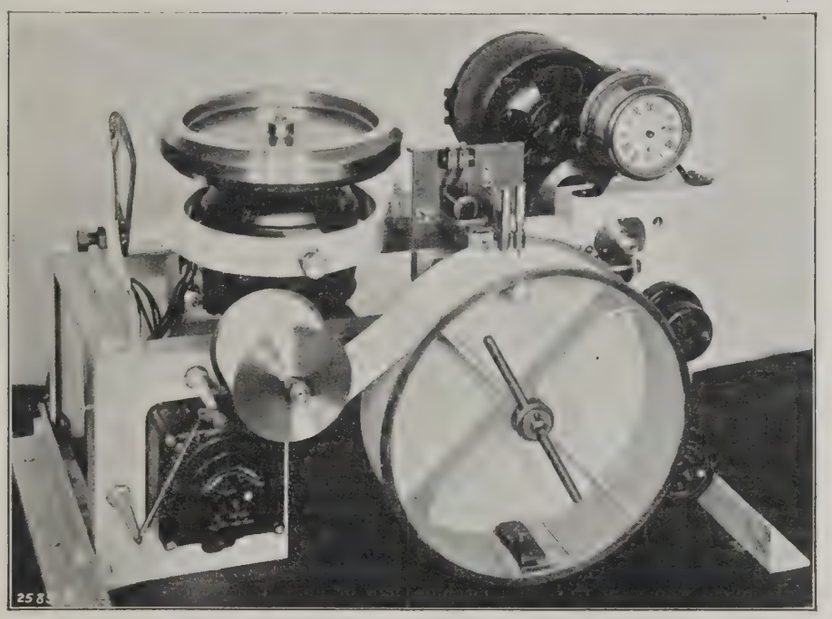


FIG. 3. GYROSCOPE PENDULUM FOR RECORDING THE ROLLING OF SHIPS.

Fig. 4.

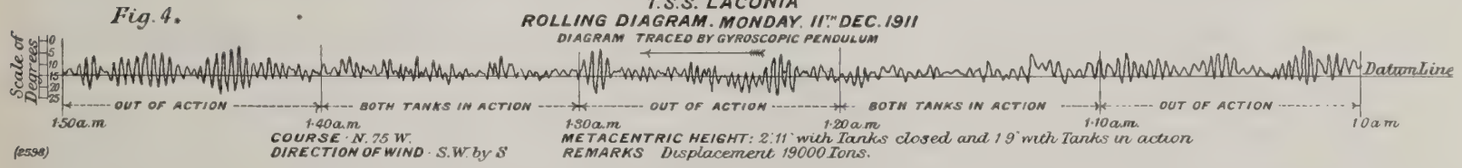


Table Showing Diminution of Stability in Consequence of the Free Water Surface in the Tank, and the Different Contents of Water.

	Fore Compartment.	Aft Compartment.	Total.
Weight of water in tank when partly filled for use as anti-rolling tank ..	tons 128	tons 192	tons 320
Weight of water in tank when entirely filled for use as ballast tank	232	348	580
Increase of MG :—	in.	in.	in.
Tanks partly filled	1.38	2.05	3.43
Tanks entirely filled	1.89	2.84	4.73
Diminution of MG :—			
With tank partly filled in consequence of free surface of water ..	4.92	7.40	12.32
Taking into consideration the increase of MG in consequence of the partly-filled tank	3.54	5.35	8.89

In the above table MG signifies the metacentric height in inches for an average cargo-ship of 22,000 tons displacement.

The rolling period of a ship corresponding to the Laconia can be employed for the approximate calculation of her metacentric height by using the following formula:

$$MG = \left(\frac{107}{t}\right)^2 \text{ in inches,}$$

t signifying the duration of a double period of oscillation in seconds—*i.e.*, the duration of a rolling movement from port to starboard and back to port.

Some trials were made with the apparatus on the voyage of the Laconia from the Tyne to Liverpool, round the North Coast of Scotland, at the beginning of this week. Unfortunately, however, there was not at any time a really heavy swell at sea. Going through the Pentlands in the early hours of Monday morning there was a 10-mile head-current running, with a 30 to 40-mile wind on the port beam, giving the ship a list. The effect of the contrary wind on the "mill-race" offered opportunity for trying the effect of the tanks, although the conditions were not by any means completely suitable. We reproduce in Fig. 4 the graph taken by the gyroscope-pendulum already described, but the datum line should not be mistaken as a basis for measuring from the upright; the instrument can be set to give such a datum when the ship is in an upright condition by means of an adjusting-screw in the apparatus, but this had not been done before departure from the River Tyne, owing to want of time. When the tanks were out of action the rolling motion of the ship seemed to be uniform with regard to a fixed axis—viz., the axis about which the ship would oscillate in still-water forced rolling conditions. When the tanks were put in action the oscillations became less in amplitude, but appeared to centre about an axis which was itself oscillating. This will be at once apparent if a line is drawn through the centres to give the "mean" arc of rolling. It is probable that under more severe weather con-

ditions on the Atlantic, without the disturbing effects of currents, the results of the anti-rolling tank in action would be not only more uniform, but more effective. The general result gives confidence in the belief that the anti-rolling tank will be thoroughly effective when the vessel is subjected to Atlantic waves. Continuous observation will be made by a member of the Naval Architect's staff of the Cunard Company.

As to the speed performance of the ship little need be said; the feature was the remarkable agreement between the Laconia's steaming and that of her sister-ship, the Franconia, on the corresponding trip early this year. We had the times when the latter passed many cross-bearings, and, allowing for the difference in the hour of departure from the Tyne, there was striking agreement throughout the 685 miles run. This regularity in steaming is a desideratum in all mail and passenger liners, ensuring punctuality in arrival. The twin engines of the Laconia, as of the Franconia, are of the quadruple-expansion type, with cylinders 33 in., 47 in., 67 in., and 95 in. in diameter by 60 in. stroke, and are representative of the best practice, embodying all features conducive to economy and reliability. There are six boilers of the double-ended type, 17 ft. 6 in. in diameter and 21 ft. 6 in. long, worked under natural draught. We described the machinery of the sister-ship, so that it only remains to say that the Franconia in service has steamed regularly on a coal consumption of about 200 tons per day for all propulsive purposes, which, in view of the passenger and cargo-earning capacity, is thoroughly satisfactory, and indicates that Mr. John Currie, who succeeded Mr. James Bain—the doyen of superintending engineers—is maintaining the credit of the line from the engineering point of view.

The ship was built, like the Franconia, by Messrs. Swan, Hunter, and Wigham Richardson, Limited, and the machinery by the Wallsend Slipway and Engineering Company, Limited, so that Dr. G. B. Hunter and Mr. Andrew Laing, the heads of the respective firms, have again been associated in another Cunard success. It is a further interesting fact that, with the Laconia's machinery, Mr. Laing's contribution to the Cunard fleet exceeds a quarter of a million horse-power, made up by machinery for fourteen vessels, built by six different shipbuilding firms, having works on three rivers—the Clyde, Tyne, and Wear.

THE STRENGTH OF MONOPLANE WINGS.

The fact that another fatality has occurred with a monoplane owing to the wings collapsing draws attention again to the question of their adequate strength. The whole question of the strength of parts in aeroplanes, as in anything else, can be looked at from two different points of view. We may either provide barely sufficient strength to stand with the most skilful possible handling, blaming the pilot for anything which goes wrong, or we may build the machine capable of standing any stresses it is likely to be put to, giving a sufficient margin for any reasonable unforeseen contingencies; or we may take some course between these two. The second course is that followed in most engineering matters, and with good results.

In the case of a monoplane flying level in still air the stresses on the wings are of two principal parts. The greater of these is the vertical one, due to the weight of the machine resting on the wings. This is usually resisted by suitable ties. The other is the horizontal stress caused by the resistance of the wing to its passage through the air. This is very much less than the former—say between one-twelfth and one-sixth. It usually has little to take it, except the stiffness of the spars and battens, though in some cases a forestay or some sort of diagonal bracing is provided, as is almost invariably the case with biplanes.

While there is little doubt that in most cases the monoplane has strength enough to stand both these stresses while flying exactly level, it is not clear how much margin there is. As the weight of the machine is a fixed quantity, it is obvious that the only way in which the vertical stresses can be augmented is through its inertia. Thus, if a sudden turn to the horizontal is made after a rapid descent, there is a considerable augmentation to the vertical stresses. It is quite easy to calculate what this stress is, granted that we know at what speed the machine is moving and what radius can be turned, but both these appear to be matters for estimation. There is, however, no doubt that in this way a very considerably increased stress can be put on the wings. As they are stayed to the running chassis, as a rule, there should, however, be little difficulty in making the stays strong enough to take any reasonable possible increase.

In the case of a rapid descent there is, however, another increased stress which there appears often to be no provision for at all—that is, the horizontal stress. As the wing moves through the air faster the endways pressure increases. If the machine were tipped right up on end, it would accelerate till the resistance of the parts balanced the weight, and as the resistance would be mainly due to the wings, it would simply mean that the weight was carried on them; that is to say, the horizontal stress on the wing in this condition would be equal to the vertical one when flying level.

It is not, of course, suggested that any aviator would in practice tip his machine up and try a vertical descent, but there is no doubt that a small increase in speed would cause a very great increase in the horizontal stress. Such increase in speed may be intentional, in which case, of course, the aviator, if previously advised of the risk, has the matter in his own hands. There may, however, be occasions in which it is unintentional and possibly unavoidable, and therefore it appears that it should be provided for. We have referred to this matter before, and pointed out the weakness of monoplane wings horizontally, and the possibility of accidents therefrom, in our issues of January 12 and March 25, 1909.

Of course, the matter is largely a commercial one from the constructors' point of view. Aeroplanes have, so far, been sold largely on the results of competitions, and in these it naturally pays to cut cut down the margin of safety to the smallest possible, and to trust to exceptional skill on the part of the aviator to jockey the machine through. If the aeroplane is to be of practical use, however, the opposite course must be pursued, and safety and consistent running must come before speed.

Meanwhile pilots who want to have a machine whose wings will not collapse under any reasonably possible circumstances, must either see that their monoplane wings have the necessary longitudinal strength or else must buy biplanes.

THE MARINO GALVANISING PROCESSES.

Though galvanising is the oldest branch of applied electrochemistry, the time for striking novelties is by no means past. The Harvey Electrochemical Company, of Camden Town, were last week able to display some remarkable novelties in electro-plating at their city offices in Norfolk House, Laurence Pountney-hill, E.C. The most striking feature was, perhaps, the direct electro-plating of porcelain, glass, stoneware, &c., with silver, gold, copper, nickel, &c. There were china teapots, entirely silvered on the outside so as to suggest a silver vessel lined with porcelain; vases gilt all over or in part; glass dishes with thick silver rims, directly coated on the glass; bronzed statuettes, prepared by copper plating the plaster or stoneware and exposing the copper to fumes; ornamental door-plates of glass, with gold patterns in bas-relief. There were also wood mouldings and laths coated with copper, convenient for making metallic joints. To the engineer another kind of novelty will be of greater interest. The difficulty of aluminium plating seems to have successfully been overcome, and aluminium can itself be deposited from ordinary baths. Specimens of aluminium tubes coated with copper, zinc, and brass were to be seen. Such aluminium will resist the action of sea-water, and it can be soldered, and what that means to the automobile industry, to boat-builders, to manufacturers of radiators, and others, need not be emphasised. Finally, horn-plates, screw-bolts, chains, &c., belonging to ordinary scaffolding outfits, were shown, all the iron being coated with zinc by a new process, as simple and direct as the others, and equally inexpensive.

All these processes are the inventions of Mr. Quentin Marino, son of Professor Pascal Marino, late of Naples, now at Brussels. Mr. Q. Marino is associated with his father in these researches, and has been living in this country for about six months. The results of many years of those experiments certainly appear promising. There are several quite distinct processes involved in the novelties we have mentioned, but information can so far only be given about one of them, the electro-plating of china and glass. The surface of the glass has first to be roughened. This is effected with the aid of the emery-wheel, or of the sand-blast, or by chemical means with the aid of hydrofluoric acid. When the surface is glazed, a mechanical treatment has to be applied in the first instance. In the case of biscuit porcelain, stone-ware, &c., the etching with hydrofluoric acid can at once be resorted to. The acid is neither pure nor concentrated. It contains some salt of the metal which is subsequently to be deposited—*e.g.*, copper or silver; sometimes both these metals are used, silver nitrate being precipitated with cuprous oxide, and the precipitate, a complex compound, dissolved in hydrofluoric acid. This solution is smeared over the object, and the metal or two metals (silver and copper in the case mentioned) are then reprecipitated on the object so as to form a molecular coating which will adhere to the surface. This is done in one of two ways. Either the surface is dusted over with a powdered metal (generally zinc or copper) which will reduce the metal contained in the fluoride; this powder is well rubbed into the surface and the excess of powder brushed out afterwards. Or the still wet surface to which the acid had been applied is pressed against a revolving brush consisting of very fine wires of zinc, copper, or brass. These metallic hairs come in contact with every point of the surface, and their tips form local couples with the metal dissolved in the acid or already deposited from it, leading to the deposition of more metal on the stone or glass surface.

This is practically all the novelty in the process. The whole treatment does not take more than a minute or two in the case of a cup, ornamented in haut-relief, which is then at once suspended from the cathode of an ordinary copper bath. A couple of minutes later the cup looks all coated with well-adhering copper deposit. Silver, gold, nickel, &c., are deposited in the same way. When metallic initials or ornaments are to be produced on porcelain or glass, the pattern is etched into the ware mechanically or by means of hydrofluoric acid. The coatings adhere strongly; tests which we made showed that the deposit cannot be peeled off; it will come off when a knife is forced under the metallic surface, but some of the china comes off with the metal. Thick metal rims (on entrée dishes, &c.) have hitherto been fixed to glass and china with the aid of plaster-of-paris or other compounds, and the adhesion left much to be desired; now rims may be deposited in any thickness. It is clear that this direct galvanising of glass, porcelain, stoneware, &c., will find very varied applications; metallisation will be useful in the making of glass apparatus, the dentist will welcome gold-backed artificial teeth, and the plumber will be able to solder his lead or iron pipe to the coppered thread of a stoneware elbow or pan.

As regards the plating of aluminium with other metals, we can only say that the articles are pickled in hydrofluoric acid, and that excellent deposits of brass, copper, and tin are obtained, which improve the appearance of the metal, and allow of its being soldered with the common materials. Lug-clips, carburettors, radiators, &c., of aluminium may now find general application. Aluminium itself is deposited on iron or brass from a neutral bath which does not contain any inorganic acid; currents of 2 volts are used. The process seems as simple as coating with zinc; we saw a gas-bracket coated in a few minutes. The zinc-bath of Mr. Marino is also neutral, and free from inorganic acids; and it is for this reason, he considers, that screw-threads, &c., are galvanised uniformly with the greatest ease. Iron appliances for scaffolding and other purposes, chains, bolts, horn-plates, &c., are first washed in caustic potash, and then in diluted hydrochloric acid and rinsed in water. The articles afterwards pass into the zinc bath, in which they quickly become covered with a uniform coating of zinc, which brightens under the brush or in the sawdust barrel. Mr. Marino also deposits an alloy of zinc and aluminium on other metals; in this case an acid bath is used. The anodes in alloy deposition may, as in other processes, consist of the alloy or of one of the metals only, the other metals being contained in the bath. Considering the great simplicity of the Marino processes, his claims for cheapness may be well substantiated.

NOTES.

LIGHTING BY NEON TUBES.

As has long been known, a vacuum tube charged with neon gives a brilliant light with but little absorption of electric energy, yet, as with other vacuum tubes, there is a progressive absorption of the gas, and the light finally becomes extinguished. In a note presented before the Paris Academie des Sciences, M. G. Claude describes a number of experiments made to overcome this drawback. He found that with the tubes first used, having small electrodes, the latter heated rapidly, nearly to redness, and a metallic deposit formed on the glass in their neighbourhood. After eight hours' working the amount of this deposit was as much as 1.6 grammes. On examining the deposit he found that neon appeared to be occluded in the metal. Since the disappearance of the gas was thus a consequence of the vaporisation of the electrode, M. Claude reasoned that the life of the tube would be increased by using larger electrodes, which would keep cooler. With this object he constructed a neon tube 45 mm. in diameter, having copper electrodes equivalent to a surface of 300 sq. cm. per ampere of current. One of these tubes worked satisfactorily at the Salon de l'Automobile for 210 hours, when it was accidentally broken. Since then, with a tube 6 metres long, and having electrodes presenting a surface of 500 sq. cm. per ampere, M. Claude found that the potential difference necessary to maintain the current only changed by 4 per cent. in 400 hours. The efficiency is stated to be excellent, being 0.8 watt per candle. In this connection it is, perhaps, of interest to note that, were energy wholly convertible into the light to which the eye is most sensitive, the output would be 55 candles per watt, according to recent measurements of MM. H. Buisson and Ch. Fabry.

PERFORATION TESTS OF SHEET METAL.

Some years ago Jules Persoz, of Paris, director of the Condition des Soies et Laines de Paris, introduced an apparatus for textile testing, which found favour. The paper or cloth was clamped between annular jaws, so as to leave a disc unsupported. Against this disc was forced a mandrel ending in a spherical point, and the force required to break or tear the fibre was considered to be a better criterion of the strength of the material than could be obtained by the ordinary folding and stretching tests. In the *Revue de Métallurgie* of August last Persoz now describes an adaptation of this method to tests of sheet metal, and he claims the same advantages for this method, because, among other features, the direction of the rolling and of the texture in fibrous materials would not influence his test, while it is of importance in folding and bending tests. The simple apparatus consists of two frames, which slide in one another. The load is applied to the frame, which carries the tool and also a traction dynamometer. The other frame supports the specimen-holder, against which the tool is pressed when the two frames are drawn apart. The specimen is held between ring-shaped clamps, which leave a circle of 100 mm. (4 in.) diameter exposed; the tool ends in a sphere 25 mm. (1 in.) in diameter. When the tool is pressed against the disc, the disc bulges out in the shape of a nipple until it splits, sometimes diametrically, more frequently in an arc which lies at the circumference of the nipple. Some of the fine photographs illustrating the article show the nipple surrounded by very regular annular corrugations. The rise of the nipple is regarded as an indication of the ductility of the material and of its homogeneity. The experiments were made with sheets of iron and steel of different compositions and degrees of hardness, and also with sheets of brass, lead, &c. The thickness of the sheets ranged from 0.36 mm. up to 0.56 mm., and an iron sheet of 0.5 mm. thickness split under a load of 230 kg., when the metal had bulged out to a height of 13 mm. The test is particularly recommended for sheet metal which is to be embossed.

THE FINANCES OF CHINA.

The struggle which is at present going on in China will have most important results whatever side is ultimately victorious. China is now pretty fully awake, and most important developments may be expected in the near future. The foreign Powers cannot allow the country to fall into a state of chaos, on account of the trade and financial interests which they have in it, and, at the same time, the close relations which now exist between the various Powers in the Far East do not admit of any one of the Powers turning the opportunity to account to achieve its own designs. From a recent issue of the *Tokyo Economist*, we learn that since the late China-Japanese War, China's foreign loans have very greatly increased. Prior to that war the balance of her foreign loans did not exceed 48,000*l.* sterling, but they have now increased to nearly 170,000,000*l.* sterling, as the following table indicates :—

—	Year of Issue.	Interest.	Outstanding Amount.
		p.c.	£
Prior to the China-Japanese War.			
Chartered Bank loan	1886	7	48,000
After the China-Japanese War.			
Hong Kong and Shanghai silver loan	1894	7	817,500
Juichi Bank gold loan	1895	6	4,667,000
Franco-Russian gold loan	1895	4	16,427,476
Hong Kong and Shanghai gold loan	1895	6	1,200,000
Chartered Bank gold loan	1895	6	466,700
Anglo-German gold loan	1896	5	13,342,625
Second Anglo-German gold loan ..	1898	4½	14,584,000
After the Boxer Trouble in North China.			
A loan	1901	4	10,257,254
B loan	1901	4	9,000,000
C loan	1901	4	22,500,000
D loan	1901	4	7,500,000
E loan	1901	4	17,250,000
English currency loan	1905	5	403,333
Anglo-French gold loan	1908	..	5,000,000
Railway Loans.			
Chinese-Eastern Railway loan ..	1896	6	750,000
Intra-Mural Railway loan	1898	5	2,070,000
Chengta Railway loan	1898	5	16,000,000
Pekin-Hankow Railway loan	1898	5	4,500,000
Pienlo Railway loan	1904	5	1,000,000
Shanghai loan	1904	5	2,900,000
Tao-kin	1905	5	700,000
Hsinmintun-Mukden loan	1905	5	32,000
Post and Telegraph Department loan	1905	5	5,000,000
Kilin-Changchun Railway loan ..	1907	5	50,000
Canton-Kowloon Railway loan ..	1907	5	1,500,000
Yeh-Han Railway loan	1907	5	1,000,000
Shanghai-Hanchow Railway loan ..	1907	5	1,500,000
Kyukiang Railway loan	1907	5½	1,500,000
Tsen-Pin Railway loan	1909	5	5,000,000
Grand total	..	..	166,995,888

Besides those included in the above list a few more loans have been contracted, in addition to numerous local loans, so that China's total loans are believed to reach a considerably higher figure. It is difficult to arrive at a correct estimate of the national revenue and expenditure of China, but the Budget, as revised by the Senate, for the present fiscal year puts the total expenditure at 333,000,000 taels, the deficit in revenue amounting to 14,000,000 taels, and the present conditions do not make it possible to increase the revenue to any great extent. Moreover, the civil war will necessarily decrease the revenue from taxes, while increasing expenses. The *Tokyo Economist* says:—"China must therefore have recourse to foreign loans to make both ends meet. The war will impede productive industries, and increase unproductive loans. The financial position of China will thus be rendered increasingly difficult. Should a few countries, having ambitious designs, take advantage of the opportunity, the collapse of China will be inevitable. We must therefore hope that the Japanese nation will watch the development of the situation keenly." It is, however, to be hoped that order will soon be restored in China, and that a strong Government may be able to guide its destinies without the intervention of the foreign Powers, as that would inevitably lead to international complications, which would bring about very serious consequences.

THE ROYAL SOCIETY OF ARTS.—At an ordinary meeting of the Royal Society of Arts on Wednesday last Mr. W. Y. Lewis, A.M.I. Mech. E., read a paper dealing with traffic problems and the advantages of "Continuous Service in Passenger Transportation." Mr. Lewis reviewed the present conditions of traffic in London, and suggested the employment of a continuous transportation system worked with a worm of variable pitch. The proposed system is known as the Adkins-Lewis system, and Mr. Lewis advanced many claims in its favour. The idea is to keep the traffic always moving, the cars having a slow speed at the station and never being brought actually to rest. The author went into several details, such as the negotiation of curves, &c. Change of grade and of curvature are arranged for by having gaps at these points, the screw being at these places of low pitch and following cars helping the preceding one to cross these gaps. These points, it is stated, would be arranged at stations where the screw pitch would be 8 deg. only, compared with the maximum of 53 deg. at points between stations.

INDUSTRIAL NOTES.

As arranged, the conference between the railway companies and the representatives of the railway men commenced on Thursday last at the Board of Trade, but, after a sitting of only about two hours, it was adjourned at 1.45 until 5 o'clock, and after that till the following day. During the interval in the afternoon the men's representatives adjourned to the Houses of Parliament, and had a consultation with some of the Labour Members. The representatives of the companies adjourned to the offices of the London and North-Western Railway Company in Parliament-street, where they met representatives of other companies. The reason for the adjournment in the afternoon was not announced. The conference was continued on Saturday, but was again adjourned, this time until Monday, when an agreement was at last come to, and the findings of the Royal Commission, with certain modifications, were accepted.

The agreement is a compromise regarding recognition. The effect of the compromise on recognition appears to be that, should the men raise any question it is to be discussed by the companies and their own men without interference from outside; and if the parties can agree, the matter is at an end. Failing agreement it must be referred to the Conciliation Board, at which the men may be represented by someone whom they may appoint and in whom they have confidence, though not necessarily anyone in the employ of the company. In case the company should wish to alter the conditions of service adversely, after due notice by circular the matter will go directly before the Conciliation Board, in which case the men will have the benefit of their chosen advocate from the beginning. Less time than heretofore is to elapse in getting the Conciliation Board to work, and a more exact time-limit is laid down. The company shall receive a deputation within fourteen days from the receipt of a petition, and shall give a reply within twenty-eight days of the reception of the deputation. With regard to the signing of the petition by at least 25 per cent. of those concerned, it has been agreed that each company shall settle with its employees the question of percentage. Elections to the Conciliation Boards made in 1911 are to stand good, except when the reorganisation of grades may compel new elections. The Commission scheme provides that settlements under the scheme of 1907 shall remain in force until July 1, 1912, and thereafter until "varied, superseded, or nullified." This provision remains, but it is now agreed to abandon clause 48, under which it was competent to reopen after July 1, 1912, any question which had been dealt with under the 1907 scheme. An important addition to the agreement has been made by the companies with reference to extra and casual men employed in the goods traffic. These men are to be paid at hourly rates not lower than the minimum rates of permanent men. This affects a class of men in the North of England who were particularly dissatisfied. The companies are given power to select as their representatives on the Conciliation Boards railway directors as well as officials. There are also a few other minor changes effected by the agreement, relating chiefly to small companies.

Having now arrived at the above terms of agreement, which appear to be satisfactory to both parties, it is sincerely to be hoped that these terms will be loyally kept and that we shall hear no more for a long time to come of serious friction between the railway companies and their men. Concessions to the men have now been granted on all the important lines, as well as an increase in wages which will represent very substantial reductions in the profits of the companies.

It appears that the railway companies have now arrived at a common decision with regard to the increase of passenger fares, which has been in contemplation for some time, in order to meet the increased cost of working caused by the recent advances in wages to the lower grades. Ordinary fares are to remain as before, for it is thought that the narrow margin of variation possible within the statutory limit of 1d. a mile would hardly compensate for the dislocation and general inconvenience which any far-reaching revision of the fares between stations would involve. The cheaper fares will be affected, for these have for some time been considered by the companies as uneconomical, in view of the continuous upward tendency of working costs. It is therefore expected that a 10 per cent. rise on excursion fares will be added. No date has as yet, however, been accepted for bringing the intended change into operation. On most lines contract ticket-holders have been singled out to bear some share of the added charges. The revised scale of charges for season-tickets on the North-Eastern Railway Company's system, according to the *Times* correspondent in the North of England, comes into force on the first of next month, and is as follows, taking simple distances and third-class rates :—For 10 miles, increase from 7*l.* to 7*l.* 15s. on the yearly rate; for 20 miles, increase from 11*l.* to 12*l.*; and for 30 miles, from 13*l.* 10s. to 14*l.* 10s. In

the case of first-class season tickets, whilst there is an increase for some of the short distances, there is a reduction on those for distances over 14 miles, the company having taken advantage of the revision of the scale to bring its first-class rates into more regular relation to the third-class rates; the variation in future will be a uniform difference of 50 per cent. It is also expected that a general beginning will be immediately made with the increase of cheap bookings over two or more companies' lines. The North-Eastern Railway Company is, it appears, going to carry out a series of experiments during December and January before finally determining the precise form its own advances of fares shall take. Some of the very cheap local excursion trains are to be withdrawn, and in place of the customary cheap Saturday bookings at single fare for the double journey, and the 10-day and 17-day tickets, the company is now issuing day return tickets at single fares between all stations on the North-Eastern system, with a few specified exceptions; and fortnightly return tickets, available to return at any time within the fortnight, at single fare and a half for the double journey, or ⅜d. a mile.

On the Midland Railway the ordinary fares are to remain the same, and traders' tickets will be advanced 10 per cent. In some cases ordinary season tickets will not be affected, while in other cases there will be a slight increase, though in no case will this be more than 5 per cent. For the present, ordinary day fares will remain as before, but in all probability they will be increased in the new year. Half-day fares have already been advanced.

On the Lancashire and Yorkshire Railway and the Cheshire Line Committee the rates for contract tickets will be increased as follows:—2½ per cent. up to 10 miles, 5 per cent. from 11 to 30 miles, and 10 per cent. over 30 miles, and all traders' tickets are to be increased 10 per cent. The North Staffordshire Railway Company will fall into line with the agreement arranged at the Clearing House meeting, but will not make any alteration in the ordinary season-ticket rates. All pleasure parties will be charged single fare and one-third instead of single fare and one-quarter—an increase equal to 1d. in the shilling. Generally, day and half-day excursions will be increased by 5 per cent., and week-end excursion tickets by 10 per cent. Other companies are increasing their fares on similar lines.

According to the monthly report of the United Pattern-Makers' Association for November things are in much the same condition in the trade as they were during the previous month, though there was a slight difference in the number of members signing the vacant-book, the difference being a favourable one, probably brought about by the termination of the strike at Oldham. At the end of November there were 211 members returned as being out of work, as compared with 240 at the end of October, the percentage in both cases being almost identical—namely, 2.7. On the North-East Coast trade is in much the same condition as it has been during the greater part of the year, and may be described as good, especially in centres devoted wholly to marine engineering. In the Clyde district, also, work is plentiful and the number of out-of-work members is very small indeed. The prospects in Barrow appear excellent, but at Belfast things are not so bright, that city showing the largest proportion of members out of work of any branch. There is little change to record from inland centres, trade round Manchester being good, as it also is in the Midland counties. There is some falling off, however, in the Metropolitan district. There seems to be, on the whole, every reason for satisfaction, seeing that the winter months have now been fairly entered.

At the close of this year the Steam-Engine Makers' Society will have entered on the 88th year of its history, a history of which it has no need to be ashamed. Indeed, few trade unions can look back on such a record. It is one of the sound, more conservative societies that has gone on quietly and sensibly, making sure its foundations, and has not been carried away by some of the wild ideas that have possessed many other trade unions where the influence of the wrong kind of Socialism has been strongly felt. The monthly report for December gives cause for congratulations, for in spite of the unrest in the labour world generally the society has had its share of good trade, and shows only 1.2 per cent. of unemployment on the full membership, with an average unemployed list of 167 each month, compared with 370, 534, and 850 for the years 1910-9-8 respectively. These figures, it is claimed, are far and away the best of any kindred trade union catering solely for skilled mechanics. They would, however, have been better but for strikes in other trades. Although trade has been good, there has been a considerable increase in the number of superannuated members during the year, there being now 432 upon the fund compared with 408 a year ago. The expenditure on this account amounted to a cost of 14s. per member per annum for 1911, against 9s. 4d. per member per annum eleven years ago. It is on this account that the executive of the society are very anxious that the present good state of trade shall continue, and that full advantage of the same shall be taken by the members, who are strongly urged to set their faces against all wanton and useless stoppages. The superannuation fund now stands at 66,000*l.*, and the executive hope that with care it may in the course of a few years stand at 100,000*l.*

It is proposed to establish an association for the salaried staff of the London and South-Western Railway Company, and the rules have already been drafted. It is to be called the London and South-Western Salaried Staff Association, and it will come into existence on January 1 next year. It is not a trade-union movement, for the clerks, accountants, district superintendents, stationmasters, and other members of the salaried staff have always held aloof from the trade-union movement; in fact, the late strike showed that trade unionism has got no hold of the men of this company. The main object for which this association is being formed is to enable matters affecting the interests and conditions of work of the salaried staff to be discussed, and representations made, where necessary, to the board of directors. Public questions relating to railways will also be debated at the meetings, and it is proposed to arrange social gatherings in the various districts at intervals. The subscription will be only 1s. a year. Mr. W. C. Wiltshire, of the station superintendent's office, Waterloo Station, was, we believe, the moving spirit in this scheme, with the result that all over the company's system his efforts have been much appreciated, and it is expected that practically the whole of the salaried staff, which numbers about 10,000, will join the organisation. Eight district committees are being formed, and a central committee has been appointed, to which the district committees will report.

On Thursday in last week it was announced that the coalowners and the miners had definitely decided to consider the minimum wage question from the national standpoint, the matter to be discussed at a meeting of delegates representing the parties interested throughout the country. December 19 is the date fixed for the meeting. The Coal Conciliation Board for the federated districts of Great Britain, which cover the whole of England and North Wales, except Durham, Northumberland, and the Cleveland district, decided last week to meet again on December 18, and the Miners' Federation will meet in national conference on December 20, when the results of the negotiations on the two preceding days will be considered.

It will, no doubt, be remembered that the National Shipyard Agreement can be amended or terminated early next March by tendering six months' notice, and last week the Shipyard Standing Committee, under the National Agreement, met in Newcastle to discuss the attitude of the joint trades towards the agreement. The initiative, as far as ascertaining the feeling of their members is concerned, was taken by the Boilermakers' Society, and at the January meeting the trades will be asked to record their votes on the following propositions:—Shall we continue agreement as it is at present? Shall we ask the employers to meet us in conference with the joint trades to have the present agreement amended? Shall we, as a society, have an agreement ourselves with the employers? Shall we notify employers that we desire no agreement? It is not considered probable that the agreement will be abolished, but that after representations of the joint trades have ascertained the feeling of the general body of members, amendment of the agreement will be sought from the masters. The apprentice question, which has been before the Boilermakers' Society during the last two or three months, was again discussed in Newcastle last week by a sub-committee of national representatives. An extension of the age limit has been asked for by the employers, and counter proposals have been submitted.

The danger of a Christmas strike of Post Office servants has been averted. The cause of the trouble was that the men were disappointed and annoyed because an official inquiry into their grievances had been put off until 1913. An exhaustive inquiry by a select committee into the men's grievances was held as recently as 1906-7, and the recommendations then made took effect on January 1, 1908. It is natural, therefore, that the Government should not feel inclined to open up the whole question again at so early a date. In the face, however, of the recent increase in the cost of living, the Prime Minister appears to be inclined to give the matter further and not unsympathetic consideration. The suggestions that the date named for the inquiry should be accelerated appear to have made a favourable impression.

On Thursday in last week the result of the ballot amongst the Durham miners regarding the three-shift system was made known, the figures showing 55,583 votes in favour of abolition, and 21,888 votes against, giving a majority of 33,695 in favour. The Miners' Council decided that should the ballot favour abolition, and the owners withhold their consent, support should be asked for to carry out a national strike.

An interesting event took place in the presence of shareholders and workmen at the South Metropolitan Gas Company's works at Peckham. This was the unveiling by Sir Edward Grey of a statue of the late Sir George Livesey, one of the pioneers of co-partnership, who was formerly chairman of the company. It may be remembered that, when Sir George Livesey introduced his profit-sharing scheme in 1889 a strike ensued which lasted for two months and ended in a victory for the company. The profit-sharing principle was adopted in February, 1890, since which time unbroken peace has reigned between the company and their men, although all around them there has been much discontent. At the present time the majority of the gas companies of the country have adopted co-partnership, the total amount of capital represented being 47,000,000*l.*, the bonus to the employees last year being 88,812*l.*

A note of warning has been sounded by Lord Aberconway, Chairman of the Tredegar Iron and Coal Company, in connection with the unrest in the coal trade. Speaking at the annual staff dinner of the company at Cardiff on Saturday last, he said that the prosperity of the coal trade depended on the amount of coal exported abroad, and if anything cut this off it meant absolute ruin to everybody in the coal trade. If the output fell a few million tons it meant the dismissal of hundreds and thousands of men, the shutting down of a lot of collieries, and general reduction of wages. In 1910 the exports only increased by 650,000 tons, which was a small increase compared with the previous year. In the present year, however, there had been an increase of a million tons, and there was every reason to hope that there would be a prosperous year in 1912. The exports of German coal were increasing at a faster rate than our own, and coal was being carried by American ships to the Mediterranean ports, iron ore being taken back. Two competitors were against them and prices were not inclined to rise. They could no more squeeze a price out of the coal market beyond what the market would give than they could squeeze blood out of a stone. He knew the price of living had gone up, but they must not run away with the idea that any agitation for impossible conditions would succeed. At the next audit wages would, he had little doubt, increase by 2½ per cent., and probably six months later by another 2½ per cent.

Mr. Burt, M.P., speaking at a house dinner of the National Liberal Club on Monday night, said that he did not think that strikes would in future increase in number; but there were signs which led him to think that they might have strikes on a larger scale than they had had in the past, though he thought they would be of short duration. There were signs in connection with the industrial movement that he did not like. He did not like the tendency to break away from awards and agreements. There were other signs, however, that he greatly rejoiced to see—among others, the improvement of the position of the poor, the struggling, and the suffering.

The Lancashire cotton trade is threatened with a stoppage, which will, it is feared, throw out of work about 160,000 hands. The trouble is the outcome of a dispute in a mill at Nelson, where a strike has been brewing because a few non-unionists are employed. It is only another case of the unrest caused by trade-union tyranny. The unions called a strike last Wednesday, and it is said that this action will be followed by similar action at all the mills where members object to working with non-unionists. As a result of this the employers have decided to post up lock-out notices at all the mills of the members of the North and North-East Lancashire Cotton Spinners' and Manufacturers' Association, the notices to take effect next Wednesday.

The monthly report of the Associated Blacksmiths and Ironworkers' Society for the four weeks ending December 2 shows that trade continues good in all the branches, and everything points to a continuance of this desirable state of affairs for a considerable time. The membership continues to increase, being returned as 3285 this month. There was also an increase in the income for the month of 191*l.* 2s. 10½d. over the previous month. The expenditure amounted to 532*l.* 10s. 2½d., made up of the following items:—Unemployment benefit, 77*l.* 6s. 10½d.; superannuation benefit, 157*l.* 19s.; sickness payments, 139*l.* 17s. 7½d.; funeral claims, 45*l.*; and management expenses and grants, 112*l.* 6s. 8½d.

THE MEIJER STEAM THROTTLE-VALVE.

CONSTRUCTED BY MESSRS. FREDERICK A. PULLEN AND CO., LONDON.

Fig. 1.

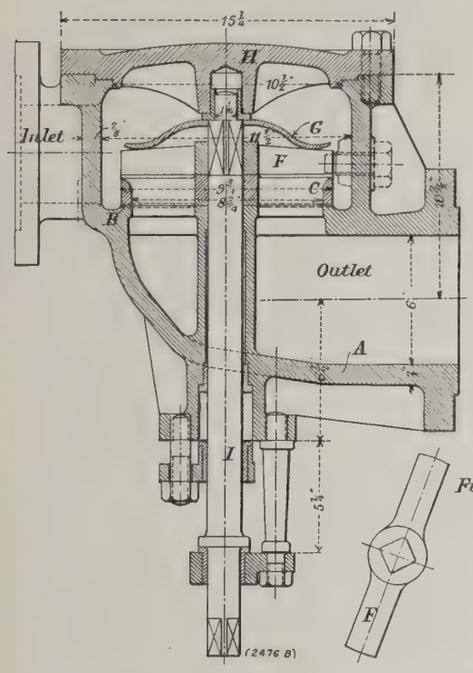


Fig. 2.

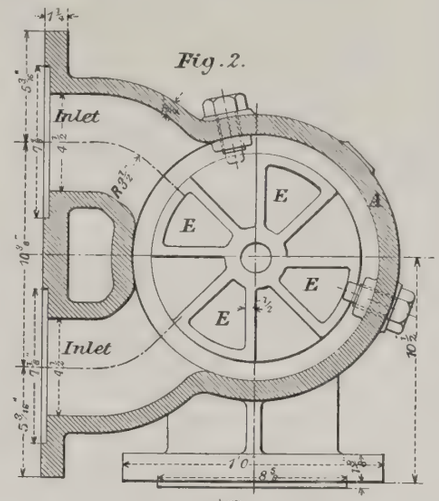


Fig. 3.

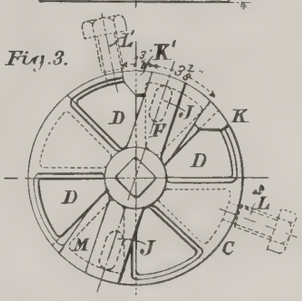


Fig. 4.

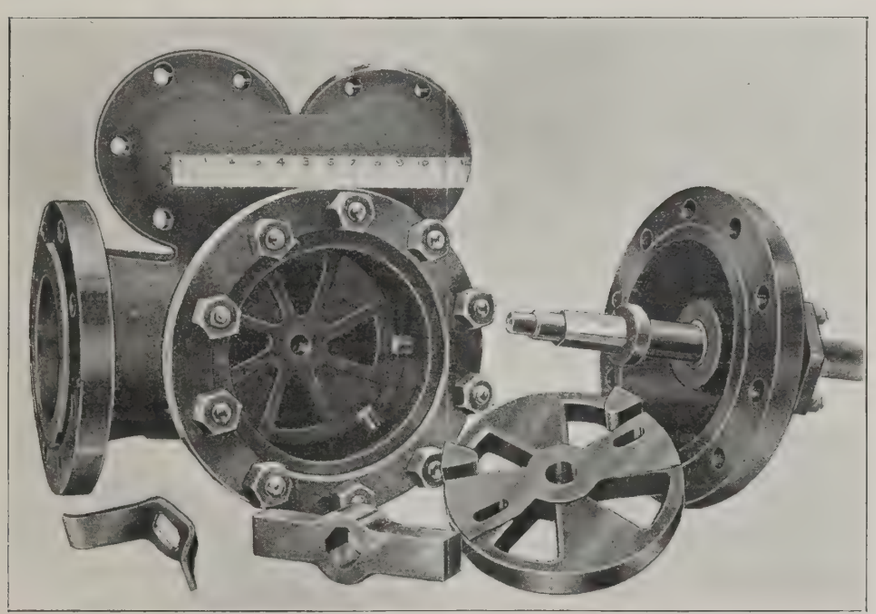


FIG. 5.

IT is quite unnecessary for us in these days of high steam pressures to point out the advantages of balanced valves, or valves that admit or shut off steam in such a way as to reduce as much as possible the labour of the operation. The chief thing is to select a valve that is really efficient in this way. There are, of course, many of these valves on the market, and our attention has recently been called to one which is now being introduced into this country by Messrs. Frederick A. Pullen and Co., 25, Laurence Pountney-lane, Cannon-street, London, E.C., and is illustrated above. The chief advantages claimed for it are: that it is very easy to operate; it occupies less space, and weighs much less, than any other throttle-valve of the same size; it remains absolutely tight after long periods of work; it will not jam or seize in working; the valve-seat and the valve are available for inspection or attention without disturbing the steam-pipe; there is no scoring of the valve-faces, and the valve is specially suited for superheated steam. It is also particularly well adapted for the speed governing or manœuvring of marine engines.

On reference to Figs. 1 and 2, which are respectively a section through the valve parallel with the plane of the spindle, and a sectional plan, it will be seen that the valve consists of an outer casing or chest A, which has either a solid or renewable face B (in the present case it is solid), and on the top of this face is a rotating disc C, in which are radial ports D, Fig. 3. These ports are cast in the disc to correspond with the ports E in the valve-face. On the upper side of the disc C a beam or bar F (Figs. 1, 3, and 4) rests, and is held down by the spring G, which bears at its central part against the under side of the cover H. In the valve shown, the spindle I passes up through a stuffing-box and enters a bushed recess in the cover, the recess acting as a guide for the spindle. The part of the spindle that passes through the bar F is square, so that the latter is actuated by any rotary motion of the spindle. The disc C is, however, free to turn on the spindle as indicated in Fig. 1.

The action of the valve is as follows:—On the spindle being turned the bar F moves towards the projection K on the disc C (see Fig. 3), and in doing so uncovers the two by-pass ports J in the disc and admits a small quantity of steam to the engine, at the same time balancing the disc. If the motion of the spindle is continued, the bar F comes in contact with the projection K, and the disc C is rotated on the valve-seat and the ports E are uncovered to any desired extent until the projection K comes in contact with the stop-screw L, in which position the valve is fully opened. It will be seen that owing to the shape of the ports D and E at the commencement of the opening movement of the valve the steam passage will be very small and will gradually increase with the continued rotation of the disc C. The edges of the ports in the disc and the valve-face act as a shear and will cut any foreign substance that may accidentally come between the valve and its seat. The valve is balanced by recessing the face of the disc C between the ports D, which also effects a considerable reduction in frictional surfaces. For large valves it has been found desirable to have the by-pass ports left open until the main ports have been closed. This is achieved by causing the bar F to wedge in the notch K, which in this case is made of a different shape from that shown in our illustration. In the shutting movement, the bar F carries the disc with it, the wedge action being sufficient to hold the bar in the notch until the stop K^1 reaches the stop L^1, when the continued motion of the bar F closes the by-pass port. When the valve is closed the bar F is, of course, in contact with the stop K^1, having moved the disc C back. Smaller valves than the one shown, up to about 3 in. in diameter, are made without the bar F, as no by-pass ports are required, gradual admission of steam being secured by the disc alone. The valve we illustrate is 6 in. in diameter, and has two inlet pipes, as may be seen in Fig. 2. The largest size made up to the present time is 8 in. in diameter. In Fig. 5 we illustrate in perspective one of these valves dismantled to show the various parts; it is, however, one with the spindle arranged over the valve, and not below it, as in Figs. 1 and 2.

COLOURS FOR PIPE SYSTEMS IN WORKS.—The question of deciding on standard colours for pipe systems has been taken up by the Verein Deutscher Ingenieure, the Association of Miners in the Dortmund District, and the Central Unions of German Heating Engineers, and of German Revision Engineers, and they have come to an understanding on the matter. The *Zeitschrift des Vereines Deutscher Ingenieure* of December 2 publishes the agreement. Green is to indicate water; yellow, gas; blue, air; white, steam; black, tar; pink, lyes; pink with a red ring, acid; brown, oils; and grey, vacuum. A black ring or band indicates impurity, a red ring danger; thus a green pipe with a black ring carries refuse water, a white pipe with a red ring carries superheated steam, a yellow pipe with a brown ring oil-gas, a yellow pipe with a blue ring producer gas, with a green ring water-gas, &c. It is not proposed to paint the whole pipe, which would indeed be impracticable in many cases, because the colours would soon be spoiled. It will be better to fix a kind of label of sheet metal at suitable spots and intervals; these labels may also indicate the direction of flow and further particulars.

THE EXPORT OF LAPLAND IRON ORE.—The exports of iron ore from the large surface iron-ore deposits at Kirunavaara, in Lapland, *via* the Norwegian port of Narvik, in Ofoten, have been fairly steadily increasing, and the market for this ore has materially extended, America now also being a buyer. Contracts with large iron works in the States have been concluded for considerable quantities, and extend over several years. The following table shows the exports from the time the Ofoten Railway was completed, November, 1902:—

	Tons.
1903	786,210
1904	1,182,422
1905	1,493,370
1906	1,649,948
1907	1,401,375
1908	1,517,827
1909	1,570,676
1910	2,000,000 (about)

The iron ore from Kirunavaara and Luossavaara has an unusually high percentage of iron, and the greater part of it contains in addition a considerable amount of apatite. The ore generally sold, as a rule, contains no less than 97 to 98 per cent. iron ore (magnetite, &c.) and apatite. In addition it may contain 1 to 2 per cent. SiO_2, 0.15 to 0.8 per cent. TiO_2, 0.2 to 1 per cent. Al_2O_3, 0.4 to 1.2 per cent. MgO, 0.15 to 0.5 per cent. MnO, and 0.015 to 0.05 per cent. S. In the apatite is a fair amount of lime, about 3 per cent. CaO for each 1 per cent. of phosphorus. The Kirunavaara ore is scheduled in several classes—viz.:—

A ore,	less than 0.5 per cent. P ..	about 68 per cent. Fe
B „	maximum 0.10 per cent. P..	„ 68 „ „
C „	maximum 0.60 per cent. P..	„ 66 „ „
D „	0.75 to about 2.5 per cent. P	66 to 60 „ „
F „	2 to 3 per cent. P ..	60 to 55 „ „
G „	more than 2.5 per cent. P ..	

The bulk is D ore with about 1.5 per cent. phosphorus and 63 per cent. iron.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting of the Physical Society of London, held on November 24 at the Imperial College of Science, a paper on "*The Maximum Value of the Electric Stress between Two Unequal Spherical Electrodes*" was read by Dr A. Russell.

The experiments carried out by F. W. Peek (Journal of the American Institution of Electrical Engineers, 1911) for the General Electric Company of America prove conclusively the value in practical work of a knowledge of how to compute the maximum value of the electric stress between high-pressure conductors. With equal spherical electrodes the electric stress between them can easily be computed from known tables. When, however, they are unequal, the calculation becomes so laborious that it is prohibitive to nearly every experimenter. The author develops formulæ for this case, by means of which, and of the formulæ for the capacity coefficients given in a recent paper to the Society, the calculation is very appreciably shortened. When the distance between the spheres is very small compared with the diameter of either, the following approximate formula for $R_{max.}$ (the maximum value of the electric stress) can be used

$$R_{max.}=(V/x)[1+(2b-a)x/(3ab)+\{4(a-b)^2+ab\}x^2/(45a^2b^2)],$$

where V is the maximum potential difference between the electrodes, x their distance apart, a the radius of the smaller, and b the radius of the larger sphere. In this case a knowledge of the values of the capacity coefficients is not required.

Mr. E. H. Rayner stated that the value of $R_{max.}$ found by the General Electric Company was 10 per cent. lower than that given by some experiments of his own.

Professor C. H. Lees said that experimentalists must try and verify Dr. Russell's formula, and asked whether the presence of ions between the spheres would alter the value of $R_{max.}$ appreciably.

Dr. R. S. Willows asked how the maximum stress found by Dr. Russell agreed with the stress required to produce ions. He further pointed out that the sparking potentials are different according as to whether the small sphere is positive or negative.

Mr. Appleyard pointed out the simplification of the formula when the two spheres are equal.

Mr. W. Duddell observed that now that continuous current at from 50,000 to 100,000 volts, with plenty of power behind it, was available in London, further experiments on sparking potentials should be made.

The author, in reply, stated that he had read Mr. Peek's paper, and that his results agreed with Poynting's ionic experiments to 2 or 3 per cent. With a small Wimshurst machine there was a difference of 3 or 4 per cent. in the sparking potential, according to whether the small sphere was positive or negative. When the small sphere was positive, the electric strength of the air was weaker. This difference, he thought, would disappear if there were more power available.

A paper on "*The Cubical Expansion of Fused Silica*" was read by Mr. F. J. Harlow.

The author described experiments in which measurements of the cubical coefficient of expansion of fused silica from 0 deg. Cent. to 100 deg. Cent., and from 0 deg. Cent. to 184 deg. Cent., were made by the weight thermometer method. The values obtained were ${}_0S_{100} = 99.8 \times 10^{-8}$, and ${}_0S_{184} = 144.7 \times 10^{-8}$. The fundamental coefficient is considerably less than that calculated from previous linear measurements, whereas ${}_0S_{184}$ is only slightly less. A low value of the fundamental coefficient is to be expected, since the coefficient has been shown to change sign at about −80 deg. Cent. Observations of the ice point before and after heating showed that no permanent change in the volume of the bulb occurred through heating, thus confirming the utility of fused silica for thermometric purposes.

Dr. G. W. C. Kaye said that the above results should be useful now that mercury-in-silica thermometers are an accomplished fact, and bid fair to revolutionise mercurial thermometry. He pointed out that Mr. Harlow's results did not agree with the linear expansion found by Chappuis, Holborn and Henning, or Randall and Scheel. Some preliminary results on a silica meter-bar at the National Physical Laboratory confirmed these other workers.

The President remarked that he had found that the expansion of silica was practically linear with no peculiarities up to 1400 deg. Cent., though there might be some below 0 deg. Cent. He pointed out that the cubical expansion may not be three times the linear, since silica cannot be perfectly annealed. If kept at 900 deg. Cent. for a considerable time it devitrifies.

The author, in reply, said it was quite possible the cubical expansion could not be deduced from the linear. He was endeavouring to extend his results to a higher temperature.

A paper on "*The Temperature Coefficient of Diffusion*" was read by Mr. B. W. Clack.

The paper describes further experiments carried out by the author with an improved form of the apparatus previously described (Proceedings of the Physical Society, vol. xxi., page 374), by means of which the value of the coefficient of diffusion of salts through water can be found at various temperatures.

Special flasks, similar to those already employed, were filled with the solution under investigation, and one was suspended from each arm of the balance in a large bath of distilled water maintained at constant temperatures in a thermostat room. The diffusion tubes of both flasks were of equal length, but their cross-sections differed considerably, and a method of differential weighing was used to compensate for any small changes in temperature.

From the rate at which the flasks change in weight the value of the coefficient of diffusion of the salts is deduced. Figures are given for this value in the case of KCl and KNO_3 at various concentrations and at different temperatures, and from these figures the temperature coefficient of diffusion is found.

Dr. Griffiths remarked that the time taken to attain a steady state could be reduced to one-ninth by filling the tube for two-thirds of its length with a solution of two-thirds strength, and filling the remaining third with water, and suggested the use of several narrow tubes instead of one wide one. He also suggested the liquids should be sterilised.

Professor C. H. Lees said that Dr. Griffiths's suggestion of using several narrow tubes was important. We were much in need of further experimental data regarding diffusion.

Dr. H. Borns asked whether the apparatus consisted entirely of glass.

The author, in reply, attached great importance to Dr. Griffiths's suggestion. The apparatus was almost entirely made of glass.

A paper on "*The α Particles Emitted by the Active Deposits of Thorium and Actinium*," by Messrs. E. Marsden and T. Barratt, was read by Mr. T. Barratt.

In a previous paper (Proceedings of the Physical Society, August, 1911) the authors showed that if α particles are counted on a zinc sulphide screen at a mean rate of μ per second, then the probability of occurrence of a time-interval, of length between t and $t + \delta t$, is $\mu e^{-\mu t}$. This formula may be applied to test whether two α particles are given off simultaneously from a disintegrating atom, or whether in any source of α particles there exist two successive α-ray products, the latter being of short life.

In the previous paper uranium and polonium were shown not to give such irregularities, and in the present paper the same result has been found for actinium and thorium active deposits, although experiments of various investigators pointed to the probability of positive results.

The experiments further suggest a lateral disintegration in thorium active deposit, and this is proved to be the case by results which show that the two α-ray products in Thor. Act. Dep. (Th. C_1 and C_2) do not give an equal number of α particles when the active deposit is in equilibrium, which is required by the ordinary disintegration theory. Thus it is concluded that of the atoms Th. C, 35 per cent. give rise to α particles of 4.8 cm. range, and 65 per cent. to α particles of 8.5 cm. range, with probably the intermediate emission of β particles. Various cognate questions are also discussed in the paper.

A paper on "*The Magnetic Transition Temperature of Cementite*," by Messrs. S. W. J. Smith, W. White, and S. G. Barker, was taken as read.

The temperature at which cementite (carbide of iron) loses its ferro-magnetism is determined sufficiently accurately for purposes of thermo-magnetic analysis, and examples are given to show the possibility of using the thermo-magnetic properties of cementite to determine whether that substance is present in any iron-carbon alloy.

Professor S. P. Thompson wrote expressing his interest in the problem discussed by the authors, and suggesting that it would be interesting to know whether structurally free cementite differs thermo-magnetically from the cementite extracted from pearlite.

The secretary replied that this, amongst other questions, had been considered. The paper contained an account (intentionally very brief) of a few only of the experiments they had made. It was worth remembering that under ordinary circumstances two forms of cementite probably could not exist in equibrium with iron except at one particular temperature.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a series of colonial and foreign engineering projects. Further particulars concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Australia: According to the bulletin of October 23 of the South Australian Intelligence Bureau, the Broken Hill Proprietary Company, Limited, have been making inquiries as to the advisability of establishing iron works in connection with the iron-ore deposits, in which the company are interested, at Iron Knob, about 40 miles from the head of Spencer's Gulf. At this place there is stated to be a quantity of iron ore estimated at 21,000,000 tons. The *Argus*, Melbourne, publishes the text of the Australian Premier's budget speech, from which it appears that provision is made for the expenditure in 1911-12 of 4,306,365*l.* for new works, buildings, &c., the following being among the chief items:—Construction of fleet, 1,515,000*l.*; Federal capital at Canberra, 100,000*l.*; wireless telegraph stations, Pennant Hills, and Fremantle, 16,800*l.*; telegraphs and telephones, 1,300,000*l.*; warlike stores, 300,000*l.*; four batteries of field artillery, 45,000*l.*; rifles for senior cadets, 65,000*l.*; reserve of gun ammunition, 31,700*l.*; armament and stores for fixed defences, 55,600*l.*; buildings, &c., in Northern Territory, 26,900*l.* Orders are shortly to be placed for the supply of material for three torpedo-boat destroyers of the "River" class, to be constructed in Australia. Provision is made for placing two 9.2-in. guns on North Head, Sydney, and also for fortifying Goode Island, which is adjacent to Thursday Island. As noted above, an expenditure of 100,000*l.* is set apart towards the establishment of the Federal capital city. It is proposed to acquire the privately-owned lands within a radius of 7 miles of the city site and other properties, upon which works for various purposes will be constructed, such as pipe-lines, reservoirs, bridges, weirs, &c. Provided these lands are acquired immediately, a sum of 50,000*l.* could be profitably expended on necessary works during the year. These works embrace the construction of a weir on the Cotton River, a bridge over the Murrumbidgee River, laying of water-pipes, construction of a reservoir, a temporary railway from Queanbeyan to the centre of distribution of material, power plant, brickmaking plant, supply of timber, road-making, &c. Provision for the connection of Papua with Australia by wireless telegraphy has again been included in the Estimates. The Budget also provides for new postal works and buildings, 1,531,214*l.*; new defence works, 2,510,980*l.*; and special defence material, 468,700*l.*

Italy.—The *Gazzetta Ufficiale* (Rome) contains a decree granting to the Società Anonima della Tramvia Milano-Magenta-Castano a concession for the construction and working of another section of steam tramway in the neighbourhood of Castano Primo.

Mexico.—H.M. Minister at Mexico City reports the publication of a contract between the Mexican Government and Señor Luis B. Arias for the construction of a line of railway, 7½ miles long, in the Federal District (*i.e.*, Mexico City and neighbourhood). The gauge is to be somewhat less than 1 metre, and steam or other means of traction may be employed. The line is to be completed within a year from the early part of November. Construction material, &c., may be imported free of duty.

Argentine Republic: The *Boletin Oficial* publishes decrees as follows:—No. 8455, authorising the executive authorities to draw up plans for extending the Argentine Central Northern Railway from San Javier to Reconquista, and earmarking 50,000 pesos (about 4400*l.*) for carrying out the surveying operations. No. 8440, authorising the same authorities to extend the Salta - Tala-Pampa line, belonging to the Argentine Central Northern Railway system, from Tala-Pampa to a point called Rodeo de las Lastas, and earmarking a sum of 810,000 pesos (about 71,000*l.*) for this purpose. No. 8439, granting to Señor Mariano J. Paunero a concession to construct and work a railway from Mar del Plata, Province of Buenos Aires, to the Chilian frontier in the direction of Antuco, passing by way of Carhué, General Acha, and Chos-Malal, with a branch to Bahia Blanca; nine years are allowed for the completion of the whole undertaking. No. 8368, granting to the Compañía Francesa de Ferrocarriles de la Provincía de Santa Fé a concession for the construction and working of a railway from Reconquista to the 28th parallel, passing by way of the colonies of Avellaneda, Las Garzas, Ocampo, San Antonio, Las Toscas, and Florencia. Nos. 8443, 8437, and 8444, empowering the executive authorities to draw up plans for the erection of bridges (1) across the River Perucho Verna, on the road which goes through Colón (Entre Rios) in the direction of Concordia; (2) across the River Paraná, with the object of opening up direct communication between the provinces of Entre Rios, Corrientes, and Territorio de Misiones and Buenos Aires; (3) across the River Yaucha, and also further bridges across the Rivers Papagayos, La Paja, Hondo, Carrizalito, Diamante, Atuel, and Salado, on the road which runs from San Carlos (Province of Mendoza) in the direction of the Neuquen Territory. No. 8454, authorising the executive authorities to arrange for the building of (1) a bridge across the River Guachipas, on the road from Veña to Guachipas, at a cost of 340,000 pesos (about 31,000*l.*), and (2) a bridge across the River Vaqueros, on the road from Salta to Jujuy, at a cost of 265,000 pesos (about 23,000*l.*).

Brazil: The *Diario Official* publishes a decree, No. 9077, approving the plans submitted by the Ministry of Ways and Communications for the construction of a section of line from Aporá (on the Timbó-Propriá Railway) to the 40th kilometre, forming part of the extension from Timbó to Sipó. The cost of these 40 kilometres (about 25 miles) of line is estimated at 1,483,300 milreis (about 99,000*l.*).

Chili: With reference to the paving works at Santiago de Chili, the Commercial Intelligence Branch of the Board of Trade is now in receipt, from the Chilian Legation in London, of a copy of the specification, statement of conditions, &c., in connection with the laying at Santiago of 70,000 square metres of asphalt paving, for which tenders will be received at the Intendencia, Santiago de Chili, up to 10 a.m. on March 10, 1912. A deposit of 2 pesos (1s. 9d.) for each square metre of paving is required to qualify any tender. The contractor is to keep the paving in good repair for a period of five years.

Peru: El Peruano states that permission has been granted to the Peruvian Corporation to extend the Paita-Piura Railway along the right bank of the River Piura up to a point opposite Catacaos.

THE MARINE TERMINAL OF THE GRAND TRUNK PACIFIC RAILWAY, PRINCE RUPERT, BRITISH COLUMBIA.*

By Frank E. Kirby and William T. Donnelly, Members.

When, in 1910, the authors of this paper were retained to visit the Pacific Coast for the purpose of studying the shipping and marine repair facilities and to visit Prince Rupert, the western terminus of the Grand Trunk Pacific Railway, they were at a loss how to proceed, for not only was Prince Rupert beyond their geographical knowledge, but it also failed to appear upon any available map or chart. However, with an abiding faith in the Grand Trunk Pacific, they undertook the commission.

Proceeding to the Pacific Coast over the Northern

* Abstract of paper read at the eighteenth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 16 and 17, 1911.

20,000-TON FLOATING DOCK WITH TIMBER PONTOONS AT PRINCE RUPERT, BRITISH COLUMBIA.

Fig. 1.

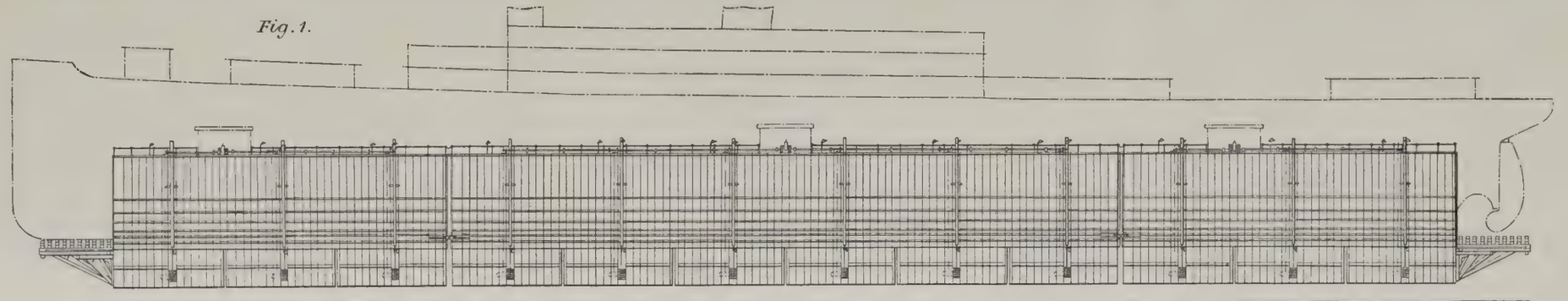
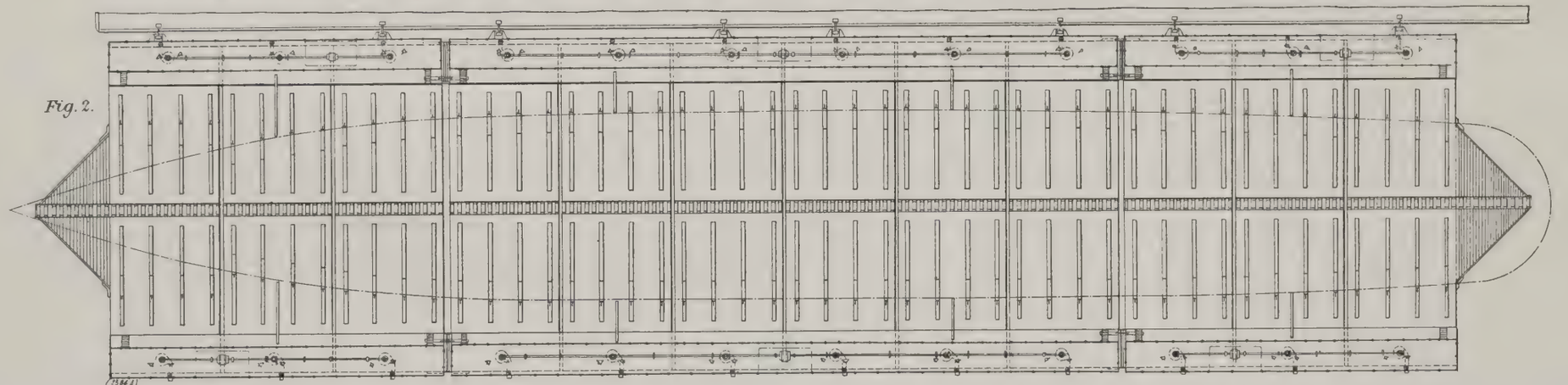


Fig. 2.

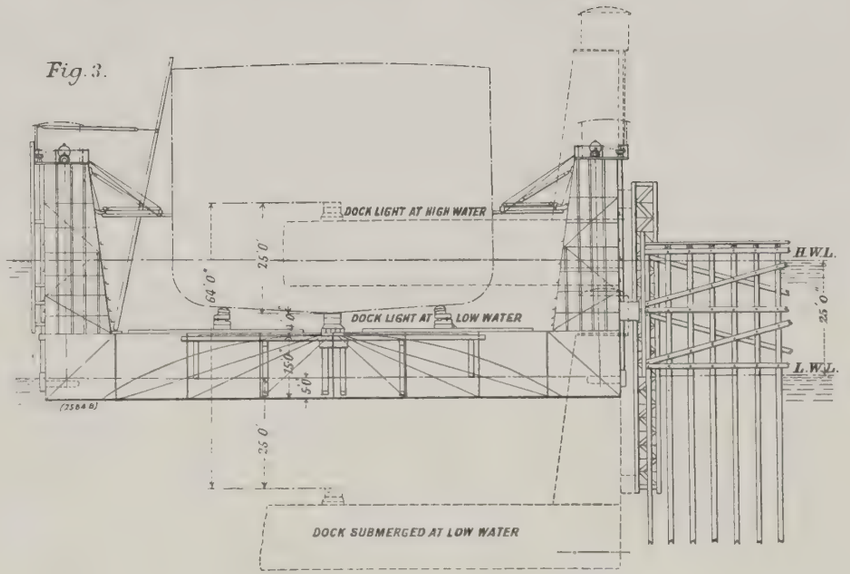


Pacific, they visited Portland, Seattle, Tacoma, and Bremerton, in the United States, and Victoria, Vancouver and New Westminster, British Columbia, finally proceeding from Vancouver on the Canadian Pacific steamer northward through the inland passage, and after three days' steaming through the narrow waterways which were literally the submerged valleys of the Coast Range, they arrived on the evening of the third day in the harbour of Prince Rupert, and were, for the first time, fully convinced that such a location actually existed.

Those who are especially interested, and desire to extend their geographical knowledge, are referred to the most recently published charts of the Northern Pacific and Alaskan Coasts, on which Dixon's Entrance, north of Graham Island, between 54 deg. and 55 deg. north latitude, can be readily located. To the east of Dixon's Entrance, Brown Pass leads to Chatham Sound, and across this to the east, between Digby and Kaien Islands, is found Prince Rupert Harbour. So hidden away and unprepossessing is the entrance that, until 1906, it was supposed to be unnavigable. Actual surveys show it to be one of the most easily entered and satisfactory harbours on the Pacific Coast. The entrance, which is from the south, is about three-eighths of a mile wide. It is entirely unobstructed, with a depth of water nowhere less than 20 fathoms. The entrance may be said to extend northward for 3 miles, when the harbour is reached, extending north-east for 4 miles, with an unobstructed width of from $1\frac{1}{2}$ to $\frac{3}{4}$ miles.

The city of Prince Rupert is located on Kaien Island, which forms the right of the entrance and the south-east shore of Prince Rupert Harbour. The city proper is laid out over an area $3\frac{1}{2}$ miles in length by 1 mile in breadth,

Fig. 3.



on the shore of the island, with a background rising to an elevation of from 1600 ft. to 2000 ft., the general characteristics reminding one very forcibly of the city of Montreal with Mount Royal behind it.

The Grank Trunk Pacific Railway will reach the Coast by the Skeena River Valley about 15 miles to the south, and crossing to Kaien Island at its southern end, will closely follow the shore to and along the water front of Prince Rupert.

The general character of the shore of Prince Rupert is bold and rocky, falling off very rapidly to a depth of approximately 20 fathoms. A careful examination of the entire length of the harbour front of Kaien Island determined Hays Cove as the only practical place for such a development as was contemplated—that is, a floating dry dock of 20,000 tons lifting capacity, so designed as to be capable of operating in sections as a number of smaller docks; an adequate shore plant, comprising electric power generating plant with air-compressors, machine-shop, boiler and blacksmith's shop, and covered construction shed, under which the pontoons of the floating dry dock could be built.

The dock is to be of such a design and construction as to be almost entirely built upon the site. To accomplish this, the general plan provides for the practical completion and equipment of the shore plant before the dry dock is commenced.

One of the controlling features in the general plan of this development was the fact that the city of Prince Rupert will be 600 miles from the nearest base of supply, or point where any considerable assistance, mechanical or otherwise, can be obtained. It was therefore determined at the outset that the mechanical equipment, large tools, &c., must be of the very best, and most complete. Also,

that on account of the high price of labour on the Pacific Coast, ample provision for the use of power in every way possible should be made. This has resulted in the design of an electric power generating-station, with ample capacity for all present needs, and with a large possibility of extension.

As the plans were laid out in such a manner as to make the development progressive, constructing those parts first which could, when completed, be used in the construction of the remainder, this outline will be followed in the description.

The first work to be undertaken will be the "Pier No. 1." This will be 420 ft. in length and 60 ft. in width, the piling being on 10-ft. by 5-ft. centres. The pier will require about 600 piles. At the same time there will be built the platform at the shore end of this pier 80 ft. wide by 930 ft. long, having an area of 74,400 sq. ft., and requiring about 1600 piles on 5-ft. by 10-ft. centres.

At the western end of this platform there will be an extension off shore 350 ft. long by about 100 ft. wide, and at right angles to this an extension 560 ft. long by 80 ft. wide for the attachment of the floating dry dock. A double line of diagonal bracing is used in the pile work. This is on account of the excessive rise and fall of tide at Prince Rupert, which for spring tides is 25 ft. The tops of the piles are thoroughly secured by double 6 by 12 clamps, and connected by 12 by 12 caps. The decking is to be of 4 by 12 planking. Piles are to be creosoted. The total area of the platform and pier-work will be 181,400 sq. ft. The completion of this work, it is expected, will provide ample space for the landing and handling of materials for the rest of the plant.

In front of the main platform, east of the pier, there will be built a launching platform for side launching. This will be 80 ft. wide by 440 ft. long, and will be carried on 16-in. piles on 5-ft. by 10-ft. centres, braced and reinforced by heavy piling along the edge over which the launching will take place. The outer half of the building platform has a slope of $1\frac{3}{4}$ in. to the foot, which is approximately the launching grade for side launching.

Electric power is to be furnished for operating the pumping machinery of the floating dry-dock, for compressing air, and to operate machinery in the various shops, also for furnishing electric lighting for the plant. The building is to contain both boilers and power plant under one roof, with fireproof dividing walls, and is to be 104 ft. wide by 148 ft. long, having a covered area of 15,392 sq. ft. The building will be of modern steel-frame construction, the walls and roof to be of reinforced concrete.

There will be installed six 400-horse-power water-tube boilers, supplied with automatic stokers, chain-grate type, such as are known to give good satisfaction with Pacific Coast coals. Provision is made for adding two extra boilers. There is also a provision for the installation of an economiser, in case it is found that the load-factor warrants the expense. Draught will be obtained by a steel or concrete chimney 175 ft. high and 11 ft. in diameter. An overhead trolley is provided for handling coal from storage to hoppers above the stokers, and also for handling ashes.

Provision is made for receiving coal both by water and rail. Coal by water will be received at the outer end of the pier, for the unloading of which there is provided a standard grab-bucket installation, so arranged as to load cars beneath the hoppers, the cars to be handled by small yard locomotives to the coal pocket of 1000 tons capacity, located adjacent to the boiler-house. Coal received by rail will be delivered direct from the cars of the Grand Trunk Pacific Railway, which pass at the rear of the property, to the coal pocket approached by an incline.

There will be two main engines of 900 horse-power each, and while vertical reciprocating compound engines are specified, using steam at 175 lb. pressure and 258 revolutions per minute, turbine engines will be considered as an alternate.

Jet condensers are specified, but alternate figures will be taken for surface condensers. The type to be used will depend upon local conditions as to the cost of water at the time of installation. Condensing water will be obtained through the rock cutting and shaft sunk within the power-house, the circulating water being handled by a vertical centrifugal pump operated by an electric motor.

Electric generators are to have a capacity of 600 kw., 3-phase, 25-cycle, 550-volt alternating current. For these generators there will be provided two steam-driven exciters, one of 50 kw. and one of 25 kw. capacity. These machines are to be direct current, 220 volts. There is also to be a motor-driven exciter of 25 kw. capacity, the motor for this machine to be a 35-horse-power 3-phase 25-cycle 550-volt alternating-current squirrel-cage type motor.

There will be provided for the erection of this machinery in the power plant a 15-ton overhead travelling crane. This will be operated by electricity, and the current supplied will be from one of the steam-driven exciter sets.

For furnishing compressed air to the shops of the plant, there will be provided a compound Corliss air-compressor, having a displacement of 1580 cub. ft. of free air per minute when operating at 150 revolutions. This compressor is to be designed for a steam pressure of 175 lb. per sq. in. and for an air pressure of 100 lb. The distribution of the air will be by means of underground piping through the yard.

The entire system of light and power throughout the plant is to be controlled from the switchboard located on the main floor of the power-house.

The ground is very difficult, all the property either having to be cut down or raised to grade by "fill." The location of the power-house was determined by the condition of the ground, which, at this location, is of rock, which will have to be reduced to the grade required. The cut and fill work is intended to go forward at the same time as the pier work, and the power plant will be commenced as soon as the site can be levelled. The rock cut for the power-house and yard grading will amount to 18,000 cub. yards; the rock-fill for retaining-walls, 57,000 cub. yards; and the earth-fill for grading, 73,000 cub. yards. The dredging between the pier and the dry-dock bulkhead will amount to 100,000 cub. yards to obtain a depth of water of 20 ft. at low tide.

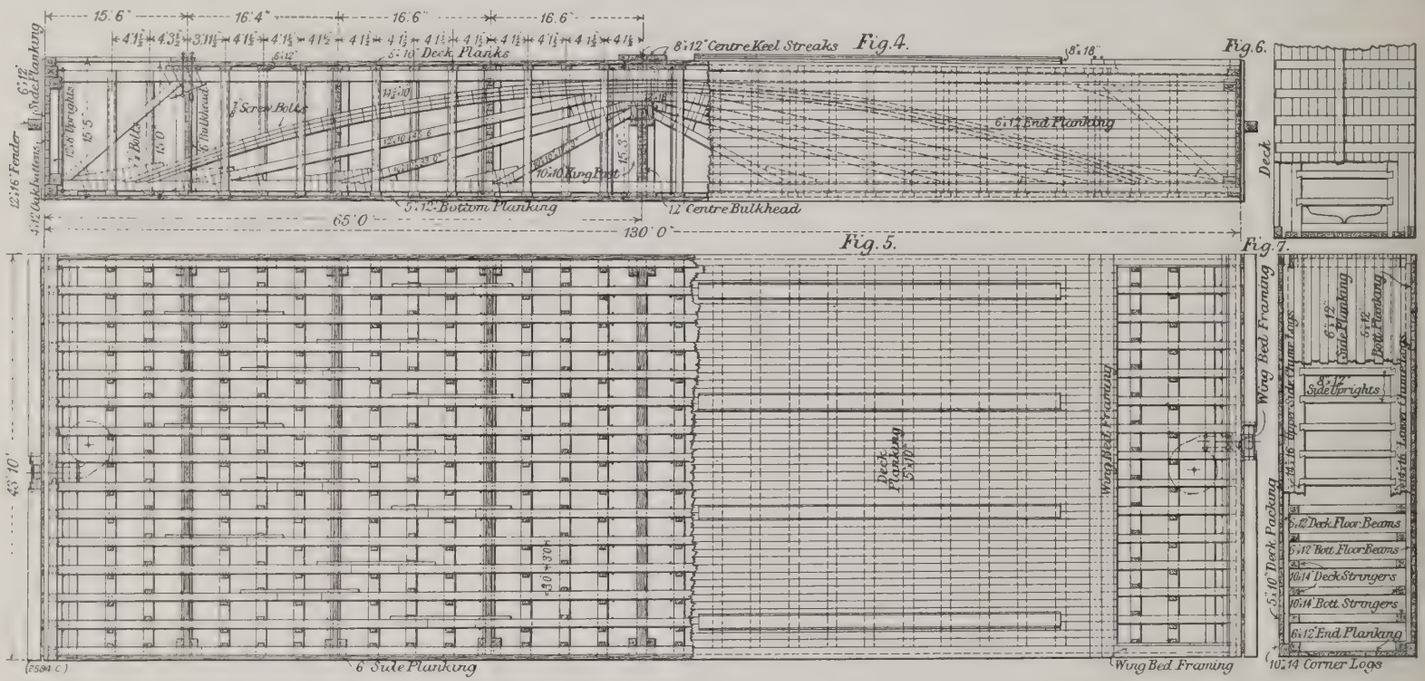
The combined boiler and blacksmith shop is to be 76 ft. wide by 150 ft. long, the central part to be 33 ft. wide, provided with a 15-ton travelling crane. The design is of the usual steel-frame shop construction, and will, in this instance, be covered with wood. The flooring will be of concrete with heavy foundations for the large tools. The tool equipment will be very complete, comprising heavy punch and shears, rolls, plate-planer, flanging clamps, &c., heavy steam-hammer, and a full equipment of blacksmiths' tools.

The building for the machine-shop will be constructed from the same set of plans as the boiler and blacksmith's shop. The flooring will be of concrete with special foundations for large tools. Ample provision is made for thorough lighting and the building will be steam-heated throughout. A very complete equipment of machine-tools will be provided, comprising all machinery necessary to handle the heaviest crank and other shafting of large steamers; also boring, drilling and turning machinery for repairing all the secondary machine equipment of steamships. Large tools will be driven by individual motors, the smaller tools being arranged for group driving.

A 15-ton overhead travelling crane will be provided for both boiler and machine-shops. The building will be supplied with compressed air and a special room will be fitted up for the repair and care of air tools. The location of the machine-shop is such that ready access may be obtained from the dry dock and water front, and provision is made for entering the boiler and machine-shops with railroad cars. Provision is also made for the extension of these shops as the business develops.

On account of the excessive rainfall in Prince Rupert, it will be necessary to do the work of building the pontoons for the floating dry-dock under cover. In laying out the general plan for the property and in view of its future development, the possibility of shipbuilding was carefully considered, and while there is no immediate prospect for the building of steel vessels so far from the base of material, it was thought advisable, in preparing for the building of the pontoons under cover, to make the construction of a permanent nature, suitable for shipbuilding, to be used in the immediate future for wooden shipbuilding, and later on for steel shipbuilding. The building is located over the launching platform and over part of the general platform extending eastward from Pier No. 1, with foundations carried down to the rock. The property is laid out for side-launching, this being the only practical development that was possible under existing natural conditions. The building about to be described is the result of these conditions.

While side-launching is unusual in Europe and generally in America, it is practically universal on the Great Lakes, and the general design of this structure is the



The shipbuilding portion of the structure is designed to have a covered width of 86 ft. by 300 ft. long, with a clear height under cranes of 50 ft. and under girders of 56 ft. The shop section of this building is to have a width of 80 ft. and a length of 300 ft. The ground floor will be used for machinery, and the upper floor will be used as a laying-out floor.

The equipment of wood-working machinery will be most complete, comprising large re-saw band saw, timber-sizer, rip and cross-cut saws, and other wood-working and finishing machinery.

There will be an office and administration building 40 ft. wide by 100 ft. long, constructed of wood, two and one-half stories high. This will be fitted up with draughting-room, accounting and book-keeping department, and private offices. The exact location of this building has not been determined, as this will depend largely upon the opening and grading of streets approaching the property.

Referring to Figs. 1, 2, and 3, there will be seen the general design drawing of a 20,000-ton pontoon floating dry dock, description of which has been reserved until the last from the fact that, as previously stated, it was to be almost entirely constructed at and by the plant of which it is to be the principal feature.

This dock is to have an over-all length on keel-blocks of 604 ft. 4 in., a clear width of 100 ft., and a width over all of 130 ft. The lifting power is the aggregate of twelve pontoons of timber construction, each 130 ft. long, corresponding to the width of the dock, 44 ft. wide in a direction corresponding to the length of the dock, and 15 ft. deep. These pontoons are to be united by steel side walls or wings 38 ft. high, 15 ft. wide at the bottom and 10 ft. wide at the top, the walls being divided so that the whole structure may be used under ordinary conditions as three separate docks, one of six pontoons, with an over-all length of 269 ft., and two of three pontoons each, with an over-all length of 164 ft. each. The largest commercial ship upon the Pacific Coast at the present time is the Minnesota, the outline of which is shown on the dock. This vessel would have a dead weight in ordinary unloaded condition of approximately 18,000 tons.

The machinery for pumping the dock will consist of

centrifugal pumps operated by electric motors, the capacity of the equipment being sufficient to pump the entire lifting power of the dock in less than two hours. A detailed description of the pumping machinery will be given later.

The structure as a whole is secured to the shore by the engagement of clamps on the dock with a vertical truss secured to the pile platform or pier in such a way that it is free to rise and fall with the tide, and when being raised or lowered with a ship. The location of these attachments is such that when it is desired to use the dock in three separate sections, the bow section may be detached and moved around the corner of the pier work located as shown on the general plan alongside the platform, and secured in the same manner as provided for in its original position. To make the other two sections available as separate docks, it is only necessary to detach the middle section, comprising six pontoons, from the pier work and advance it the length of the detached section, when the sliding clamps upon the wings will coincide with those used for the previous section when the dock was operated as a whole. This will allow ample space between the centre and stern sections for the overhang without interference of vessels which may be docked on them.

As the feature of a sectional dock, to be used as a whole or separately, is somewhat new, it is desired to call attention to the fact that the three largest commercial docks in the United States—namely, the 10,000-ton floating dry dock of the Tietjen and Lang Dry-Dock Company, built in 1900; the 12,000-ton dock of the Morse Dry-Dock Company, built in 1902 (both in New York Harbour); and the 10,000-ton dock of the port of Portland, Portland, Oregon—are sectional docks in five sections each. All of these docks are of timber construction, and are giving excellent service.

As previously stated, the pontoons for this dock are to be twelve in number, constructed entirely of timber. By referring to Figs. 4 to 7, there will be seen the design and construction plan of these pontoons. They are to be 130 ft. by 44 ft. by 15 ft. deep, with a crown of 3 in. at the centre, and will have 15 trusses spaced on 3-ft. centres. There will be a centre water-tight bulkhead 12 in. thick, and above this bulkhead the centre will be reinforced for carrying keel-blocks. There will be three partial bulkheads on each side to stiffen the pontoons. All diagonal braces are heavily reinforced with anchor-stocks. The arch brace is made up of planking through-bolted with screw-bolts, and is intended to take the reverse stresses when the dock is floating light. This is a considerable amount when it is considered that the wings are superimposed weights carried at the extreme ends of the trusses, supported by an evenly distributed pressure over the entire bottom. Deck beams, 6-in. by 12-in., are worked across the upper and lower truss members, carrying the 5-in. deck and bottom planking parallel to, and reinforcing the truss members for the maximum stress. This construction also makes it possible to get in double vertical tie-rods alongside of bulkheads in such a manner that they may be replaced at any time. The whole structure is made water-tight by caulking with white pine wedges.

To protect the exterior from teredo and other marine worms, it is first thoroughly graved with tar poisoned with arsenic, then sheathed with two layers of hair-felt, each thoroughly saturated with tar and arsenic, and then with creosoted lumber, also treated with arsenic and thoroughly secured with galvanised nails. This treatment, together with the facility for inspection afforded by the possibility of detaching and docking any pontoon, has been found to give satisfactory protection.

Each pontoon will require approximately 330,000 board feet of lumber, or a total, including outrigger or prow on the end pontoons, of 4,000,000 board feet. The whole of the lumber will be of selected grade of Oregon pine or Douglas fir.

As previously stated, it is the intention to have these pontoons built upon the launching-platform under the building-shed, using the tools and equipment provided for the plant. Sufficient room has been allowed to build three pontoons at the same time. As soon as they are launched, they will be moved into the basin between the pier and dry-dock platform, and temporarily united together in correct relative position by timber clamps, when they will be ready for the erection of the steel wings.

For further information relative to the use of wood for the construction of floating dry docks, parties interested are referred to a paper on "Floating Dry Docks in the United States—Relative Value of Wood and Steel for their Construction," appearing in the Proceedings for 1910 of the Society of Naval Architects and Marine Engineers.

From Figs. 1 to 3, showing the completed structure, and from the details of the wing trusses and plating in Figs. 8 and 9, a general idea will be gained of the construction of the wings. They consist of channel and angle frames on 3-ft. centres, corresponding to the trusses of the pontoons, and a covering of plating varying in thickness from $\frac{1}{2}$ in. to $\frac{6}{16}$ in. The construction is greatly facilitated by reinforcing the plating against water pressure on the outside by horizontal angles. This does away entirely with troublesome intercostal connections and gives the material used very much greater value in the construction as a whole.

For the construction of the wings for the completed pontoon there are required about 2200 tons of steel. Where the wing meets the deck of the pontoon there is a steel shoe secured to the frame of each pontoon, and a corresponding shoe riveted to each frame of the wing. These are connected together by a steel link about 15 in. long, and pins, the upper one of which is tapered $\frac{1}{2}$ in. to the foot. The driving of this pin wedges the pontoon and wing together. At the point of contact, the bottom of the wing is reinforced by a 12-in. by $\frac{1}{2}$-in. plate, and made water-tight by canvas packing saturated with red-lead. On the outer side of the wing the method of securing is similar, except that the shoe on the pontoon is replaced by a cast-steel strap through-bolted to the pontoon.

Provision is made for multiple punching on uniform centres of 3 in. and 6 in. throughout, and the intention is to have the material fabricated in Europe or the eastern

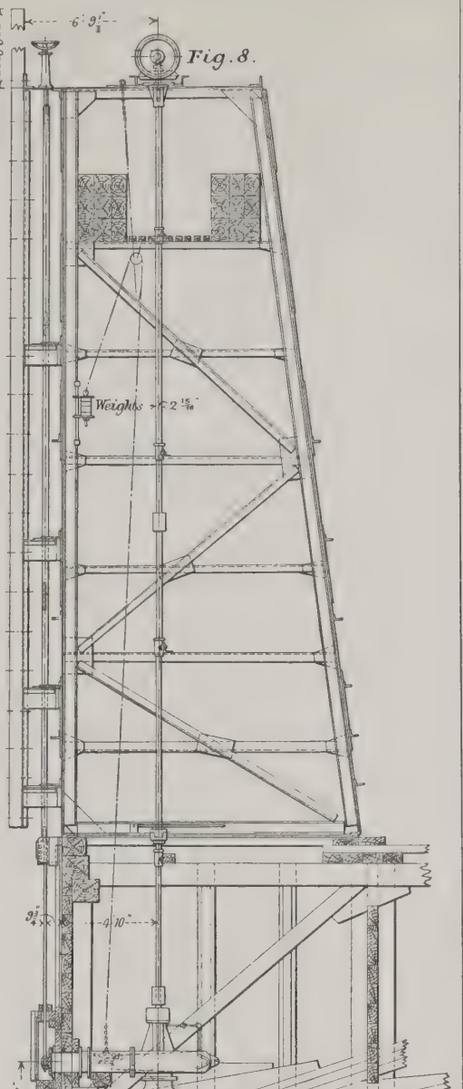


Fig. 8.

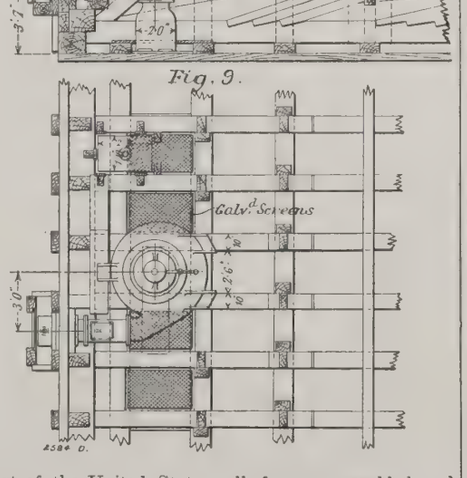


Fig. 9.

part of the United States, all frames assembled and shipped by water to Prince Rupert. The erection of the first section is to be commenced as soon as the first three pontoons are launched, the compressed-air machinery of the plant being used for pneumatic riveting.

The dock will be pumped by twenty-four 12-in. centrifugal pumps, one in each end of each pontoon. By referring to the illustrations given, the general arrangement and detailed construction of these pumps will be seen. The pump suction will take water from the bottom of the pontoon, the suction being protected by a liberal area of screen. Delivery will be directly through the flood-gate used in lowering the dock.

The pumps will operate at approximately 275 revolutions per minute, being driven by a vertical shaft. All the pumps on each side of each section will be driven through gearing and horizontal shafting by one electric-motor, as shown in Figs. 2 and 8. A jaw-coupling is provided in the wing at about the level of the top of the pontoon for disconnecting the vertical shaft when the pontoon is removed for self-docking.

For determining the level of water in the wings, a water-level indicator is provided. This consists of a counterweighted float in vertical guides and a vertical rod extending through the deck of the wing. As the water enters the wing the float rises, and the height of the rod above the deck will indicate the depth of the water in the wings.

A similar device, not shown, is provided to show the depth of the water in the pontoon. The flood-gates are operated to control the lowering of the dock, and also to control the pumping collectively and individually of the different pumps, it being understood that with the pumps running, no water will be delivered if the flood-gates are entirely closed, and that, by a regulation of the gates without altering the speed of the pumps, any degree of control or any distribution of control can be accomplished. In case one side is rising too rapidly, the partial closing of the gate on that side, without disturbing the operation of the machinery, will effect the control, or the gates may be left at the same opening and the machinery stopped.

By this method a much quicker and more powerful control may be obtained, as not only will the discharge of water from the dock stop, but will immediately commence to enter, thus doubling the power of control which would be obtained by closing the gates.

As previously explained, the group of pumps on each side of each section of the dock will be operated through horizontal and vertical shafting by one electric-motor. Thus for the two smaller sections of three pontoons each there will be required four 100-horse-power motors, and for the larger section of six pontoons there will be required two 200-horse-power motors. The motors are to be alternating-current, three-phase, 25-cycle, 550-volt, and will operate at approximately 500 revolutions per minute. They are to have wound rotors and slip-rings for variable-speed control. The armature-shaft is to be extended on both ends, and will operate the distribution-shafts through reduction-gearing at a speed of approximately 275 revolutions per minute.

While steam-driven air-compressors are provided in the power plant to furnish compressed air for the shops, it was deemed inadvisable, on account of difficulty due to the extreme rise and fall of tide, to make flexible air-connections to the floating dry dock, and to provide an electrically-driven air-compressor upon each section.

Electric current for operating the air-compressors will be taken from the circuits supplying the motors for pumping the dock; and as air will be used only after the dock is pumped up, the capacity of these circuits will be more than ample.

Referring to Fig. 3, there will be seen the arrangement of keel-blocks and bilge-blocks. The keel-blocks are to be of oak 12 in. by 16 in. by 4 ft. long, and are to have a height of 4 ft. The bilge-blocks are to be on about 12-ft. centres, and operated, according to the usual American practice, by means of a galvanised chain on the floor of the dock, and a leading rope through 6-in. sheaves secured to the wing near the deck, leading up and returning over the pipe railing around the tops of the wings. The return rope leads to the tail-dog, and is used in tripping the dog and pulling the block out when the ship is leaving the dock. The bilge-blocks are provided with an elevating-screw, which has been found to be of great service for removing blocks one at a time for painting.

In the American practice of handling floating dry docks side shoring is not used. There is a general practice, however, of using centering trams for locating and steadying the vessel in position until firmly at rest upon the keel and bilge-blocks. The arrangement of these trams can be seen in Figs. 2 and 3, showing the general design of the dock.

MESSRS. ANSALDO - ARMSTRONG. — We read in the *Giornale dei Lavori Pubblici e delle Strade Ferrate* that a new type of armour-plate has recently been tested at the Castagna proving-ground. The plate was manufactured on the Marrel patents, and gave excellent results. The Ansaldo Company have paid, so it is said, 40,000*l.* for the patent. The results of the proving-ground experiments, it is added, fully justify this expenditure. The thickness of the plate, the number of rounds fired, and the striking energy are not stated; the weapon used was a 203-mm. (8-in.) gun; the projectiles broke up on impact without perforating the plate.

THE FIRE-BRIGADE HAND-BOOK.—Mr. James Compton Merryweather, M.I.M.E., has prepared a second edition of this hand-book, which was first published in 1888. This, as is stated on the title page, is a manual of the organisation and equipment of fire brigades, for the use of volunteer firemen and others. Owing to the great changes which have occurred in the service since the first edition appeared, and due to legislation affecting fire brigades, the introduction of motor fire apparatus, horsed escapes, chemical engines, the growth of the National Fire Brigades' Union, and so forth, the author decided to re-write a considerable portion of the book. This is very interesting reading, and the book will not only be found useful by persons interested in fire brigades, whom we may style, in this connection, the "active" part of the public, but also by the "passive" part of the public —*i.e.*, householders, owners of works, factories, and other property, and tenants in general. It is published by Messrs. Merritt and Hatcher, Limited, 2, Grocers' Hall-court, Poultry, E.C.

EXPERIMENTS ON THE STRENGTH AND FATIGUE PROPERTIES OF WELDED JOINTS IN IRON AND STEEL.*

By T. E. Stanton, D.Sc., M. Inst. C.E., and J. R. Pannell.

These experiments were undertaken at the suggestion of Sir John Wolfe Barry, in 1908, the object being to obtain a comparison of certain properties of welded joints—made by different processes and by different makers—with the corresponding properties of the unwelded material from which the joints were made. It was hoped that by this means some estimate of the general reliability and efficiency of modern welding processes might be arrived at. In order to obtain material for the work a circular letter was sent from the National Physical Laboratory to various engineers, inviting them to submit specimens of welded joints for testing. Sixteen firms responded to this invitation, and the total number of welded joints received was 167. The method of welding and treatment of the joints was left entirely to the makers, the only condition being that all specimens should be made from bars 1¼ in. in diameter. The tests to which the joints were subjected were: first, a tensile test; and secondly, a fatigue test by the Wöhler method. The former included determinations of the elastic limit, the yield point, the maximum stress, the total elongation, and the general and local elongations.

For the rapid carrying out of the fatigue tests a machine was constructed in which the specimen was rotated at a speed of 2200 revolutions per minute. Owing to the results of a previous investigator with another type of machine having shown a decided reduction of fatigue strength with increased rapidity of stress alternation, preliminary experiments were carried out to determine the amount of this effect for the particular type of machine used. The results showed that for speeds of 200 and 2200 reversals per minute there was practically no difference in the fatigue strength. The assumption was therefore made that the apparent reduction of fatigue strength with rapidity of alternation in the case referred to was a characteristic of the machine used.

The mean results of the tensile tests on the welded joints, expressed as a percentage of the strength of the original material from which the joints were made, were:

	Per Cent.
Hand-welded iron	89.3
,, steel	81.6
Electrically-welded iron	89.2
,, ,, steel	93.4

Joints made by the oxy-acetylene process were also submitted by two makers, but the results were not comparable with those obtained by the hand or electric processes.

The various determinations made in the tensile tests showed a distinct want of uniformity in the material in the region of a weld, but the results of the fatigue tests proved that this does not materially affect its resistance to reversals of stress. When failure under alternating stresses of low value takes place, it is invariably due to a defect in the actual weld itself. The number of defective joints which were discovered in the whole investigation, however, leads to the broad conclusion that in important work, where the failure of any particular welded joint may involve serious damage to the structure, the subjection of each joint to a proof-load is still desirable.

The Dust Problem in Foundry Practice.—At the monthly meeting held in Berlin on November 25 of the Verein Deutscher Giessereifachleute, Berlin Section, Mr. Ernst Danneberg referred in detail to the danger to health of the smoke, dust, and acid vapours which were very frequently produced in large quantities in the iron and brass foundries, the fettling-shops, and sand-blast cleaning installations. He stated that the best means of fighting the evil was to put down dust-collecting and ventilating apparatus, and he illustrated his lecture by a number of lantern-slides. In this connection we may refer our readers to our illustrated description (on page 84 *ante*) of Messrs. Sulzer's plant for this same purpose.

The Thomas Transmission-Gear for Motor-Cars.—In our issue of May 5 of this year we gave a description of the combined electrical and mechanical gearing for motor-cars, which is known as the "Thomas Transmission." At that time a 2000-mile R.A.C. reliability trial was being carried out on a Leyland lorry fitted with the gear, and since that time a heavy rail-car with the transmission has been shipped to South Africa. Particulars are now to hand of an R.A.C. trial run from London to Edinburgh and back of a 13.96 horse-power Delahaye touring-car fitted with the gear. The car was two years old, and had before the trial already run a distance of 24,000 miles. The whole run was completed in four days, necessitating a considerable amount of night driving, and on the first and last days the weather was wet and the roads heavy. On the night of the third day two hours were spent travelling through a dense fog. The average speed throughout (running time only) was 19.15 miles an hour, and the petrol consumption was 35.73 miles per gallon, and 67.92 ton-miles per gallon, the total running weight being 4258 lb. The lubricating oil consumed was 4.495 pints, equivalent to 1417.35 miles per gallon. Throughout the trial, which, it will be seen, was very satisfactory, the engine was started electrically through the medium of the transmission gear, and the electric lamps were supplied with current from the same source.

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* Abstract of paper read at the ordinary meeting of the Institution of Civil Engineers on Tuesday, December 12.

CATALOGUES.

Pulley-Blocks, Overhead Cranes, and Runways.—We have received from the Derome Standard Pulley-Block and Crane Manufacturing Company, 78, Southwark-street, S.E., a small catalogue giving particulars of worm-gear pulley-blocks, hand-power and electric overhead travelling cranes and runways. Prices are stated for the pulley-blocks and cranes.

Pumps.—From Messrs. W. H. Bailey and Co., Limited, Albion Works, Salford, Manchester, we have received a copy of their list of power-driven pumps. The list includes vertical and horizontal three-throw ram-pumps, arranged to be driven by belt or by an electric-motor. These pumps are especially suitable for mine-pumping, boiler-feeding, fire service, water supply, &c.; the horizontal type is made for heads up to 1000 ft. Particulars are also given of centre-packed ram-pumps, double-acting piston-pumps, and other types for all purposes.

Locomotives, Steam-Engines, Pumps, &c.—From the Hannoversche Maschinenbau A.-G., formerly Georg Egestorff, of Hannover-Linden, Germany, we have received a book containing some effective illustrations of their works and productions. The latter include passenger and goods locomotives, tramway and fireless locomotives, steam-engines and boilers, pumps, and apparatus for drying sewage sludge. The titles to the illustrations are printed in the English, French, German, Spanish, and Portuguese languages. At the end of the book a number of clearly-printed tables for converting British weights and measures to the metric system, and *vice versâ*, are given.

Electro-Magnets for Lifting.—Messrs. E. G. Appleby and Co., 10, Victoria-street, Westminster, S.W., who have taken up the sale of the "Phœnix" electro-magnets for handling rails, girders, plates, pig iron, scrap, &c., have sent us a pamphlet illustrating and describing the magnets and some of their applications. These magnets can be used with any type of crane, and can deal with hot or cold material. They can be fitted with a safety device by means of which the load is sustained in the event of the current supply being accidentally cut off. The pamphlet gives particulars, with prices, of six sizes, for lifting from 12 cwt. to 5 tons of girders, rails, and similar sections.

Railway Switches, Crossings, &c.—Messrs. Thomas Summerson and Sons, Limited, Albert-hill Foundry, Darlington, have sent us a copy of an attractive catalogue they have issued to illustrate the class of work they undertake. The illustrations in the catalogue show a few of the standard types of switches and crossings, switch-levers, turntables, &c., and also give some examples of "lay-out" work, of which the firm make a speciality. They also undertake the complete construction of railway sidings of all descriptions, and supply rails, fish-plates, bolts, chairs, and other permanent-way material. Iron castings up to 6 tons in weight are also made for all purposes.

Chains.—We have received from Messrs. Alfred Phillips and Co., Atlas Works, Tipton, a copy of the 1911 edition of their catalogue, giving full particulars, with prices, of chains, &c. The catalogue deals with short-link chains of different qualities, in sizes ranging from $\frac{5}{16}$ in. to 2 in., as well as with single and double slings or lashing chains, slip or collar sling chains, and endless slings. Prices and particulars are also given of short-link and stud-link chain cables, and of various hooks, stretching screws, and other accessories. The firm also undertakes the annealing, testing, examining, and repairing of chains, and the catalogue states the prices charged for this work.

Pure Metals and Alloys.—From Thermit, Limited, 27, Martin's Lane, Cannon-street, E.C., we have received a leaflet giving some particulars of metals and alloys produced by the alumino-thermic process. The metals include chromium, manganese, molybdenum, vanadium, and titanium; various alloys of these and other metals are also listed They are stated to be very uniform in quality, and absolutely free from carbon. Another leaflet from this firm deals with "Titanium Thermit" for use in iron and steel foundries. It is claimed that this substance, when added to the contents of the ladle, cleanses the metal, renders it more fluid, and produces close-grained castings free from blowholes.

Signalling Apparatus for Mine Winding.—Messrs. Siemens Brothers and Co., Limited, Caxton House, Westminster, S.W., have sent us a copy of a pamphlet which illustrates and describes their bell-signal indicator for use in connection with mine winding and haulage. This indicator, which can be used with any bell-signalling system, is arranged to show at a glance the number of strokes given by the bell. The indicator comprises a pointer moved over a circular dial by means of an electro-magnet, the pointer moving over one numbered division of the dial for each stroke of the bell. Mechanism is provided so that the pointer can be set back to zero, after the signal is completed, either by hand or automatically by the engine. The pamphlet illustrates and describes the application of the indicators to shafts with one or more levels.

Locomotives.—The American Locomotive Company, of New York, U.S.A., have issued a four-page pamphlet giving some particulars, with illustrations, of a Mallet compound locomotive, ten of which have recently been purchased by the Baltimore and Ohio Railroad. The engines, which are of the 0-8-8-0 type, weigh about 206 British tons, without the tender, and are capable of exerting a maximum tractive force of nearly 47 tons when working compound, or about 56 tons when high-pressure steam is admitted to the low-pressure cylinder. The high-pressure and low-pressure cylinders are 26 in. and 41 in. in diameter respectively, the stroke in both cases being 32 in. Steam is generated at a pressure of 210 lb. per square inch, and is highly superheated in a superheater of the fire-tube type. The engines are used for pushing service on heavy grades.

Foundation Felt.—Messrs. Mitchells, Ashworth, Stansfield, and Co., Limited, 23 and 24, Old Bailey, E.C., have sent us a catalogue of their "Mascolite" foundation felts for reducing the noise and vibration from machinery of all kinds. The felt, which is damp-proof and vermin proof, is also largely used by underground railways for deadening noise, felt pads, generally about ½ in. in thickness, being placed between the chairs and sleepers for this purpose. Several other useful applications of the material are also illustrated in the catalogue. The felt is supplied in sheets, the maximum dimensions of which are 48 in. by 32 in., the thickness ranging from ⅛ in. to 1 in. in steps of ⅛ in. It is also supplied built up to almost any thickness with alternate layers of felt and cork, or felt and rubber. Prices are stated for these sheets, and also for discs and washers.

Air-Compressors and Vacuum Pumps.—We have received from Messrs. W. H. Bailey and Co., Limited, Albion Works, Salford, Manchester, a small catalogue of Köster air-compressors and dry vacuum pumps. The former are two-stage single-acting compressors having a single-trunk piston of the differential type, so that the two compressions are effected in a single cylinder. During the suction stroke the air is admitted to the whole volume of the cylinder, and, after having been compressed by the return of the piston, it is delivered, through an intercooler, to the annular space between the smaller part of the piston and the cylinder walls, in which space the second stage of the compression takes place. The inlet-valves are both of the piston type, and are positively operated by an eccentric, while the delivery valves are spring-controlled and air-cushioned. Particulars are given in the list of belt-driven horizontal compressors for pressures up to 150 lb. per square inch, having capacities ranging from 39 to 880 cubic feet of free air per minute. They are, however, made in capacities up to 2000 cubic feet per minute, and can be arranged for direct driving by steam engines or electric motors. The list also deals with Köster's patent slide-valve vacuum pumps, particulars of both belt-driven and steam-driven pumps being given. One of the special features of these pumps is that the slide-valve is not enclosed in a valve-chest, but works on the outside, where it can easily be examined and adjusted; no stuffing-box is required for the valve spindle with this arrangement. When exhausting a closed vessel these pumps are capable of maintaining a vacuum of 29.8 in. of mercury. For higher vacua, up to within $\frac{1}{10}$ in. of a perfect vacuum, a "double" pump is supplied.

Artificial Diamonds.—In 1910 Werner von Bolton, experimenting in the Berlin-Nonnendamm works of Messrs. Siemens and Halske, noticed the formation of black carbon mirrors and apparently of minute diamond crystals, during electric discharge experiments. The carbon seemed to be deposited merely owing to the interaction between mercury vapours (rising from sodium amalgam) and hydrocarbons (coal-gas). He has recently tried (*Zeitschrift für Elektrochemie*, November 15, 1911) to make real diamond fragments grow by this reaction. He poured sodium amalgam into a test-tube, smeared the free inner glass surface of the tube with sodium silicate, and strewed diamond-powder on this coating; the powder was amorphous, and showed under the microscope only a few minute crystals. The tube was kept in boiling water for four weeks, during which moist coal-gas was passed over the amalgam. Only a little black carbon was deposited. After the silicate had been dissolved by means of hydrofluoric acid and sulphuric acid, the sediment seemed to consist almost entirely of minute crystals, which disappeared when heated in oxygen or when fused with sodium carbonate. The grains of the diamond-powder thus seemed to have formed nuclei for the growth of crystals, which were, however, far too small for proper analysis.

Russian Imperial Barge.—The firm of Messrs. J. Samuel White and Co., Limited, of East Cowes, have just shipped to Russia, for the service of the Imperial yacht Polar Star, two very handsome launches. One of them is fitted with surface-condensing steam machinery, and the other with a Wolseley motor installation. The principal dimensions of the craft are:—Length between perpendiculars, 44 ft. 9 in.; breadth, moulded, 8 ft.; and depth, 4 ft. 3 in. For the motor launch the six-cylinder petrol marine engine is of a special light type, weighing, exclusive of clutch and fly-wheel, some 15¾ cwt.; the total weight, including reverse gear, fly-wheel, and control, is 19 cwt. At a speed of 975 revolutions per minute 130 horse-power is developed. The cylinders have a bore of 6½ in. and a stroke of 7 in. The starting is effected by means of compressed air. The air-compressor is fitted at the forward end of the engine, and is driven by means of a crank off an extension of the cam-shaft. A reservoir capable of withstanding a pressure of 95 lb. per sq. in. is used for storage purposes. The engine is required to develop not less than 130 horse-power at a speed of 950 revolutions per minute for four hours continuously. The machinery of the steam launch is of Messrs. White's standard type, comprising a compound surface-condensing engine, with out-board condenser, and boiler of the direct-tube type. Forced-draught arrangements are provided, with brass-cased funnel. It may be remarked that Messrs. White are the builders of the steam-boat equipments of the British Royal yachts and also for the Imperial yacht Hohenzollern, and have a long record in this class of construction for British and other European Royal yachts.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

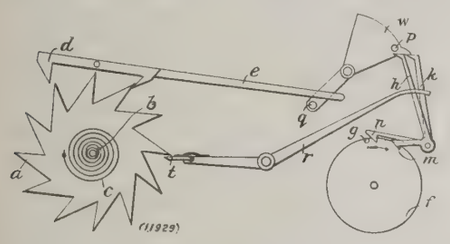
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

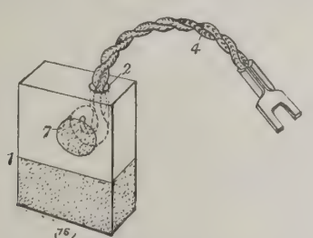
ELECTRICAL APPARATUS.

11,929/11. W. S. Sprague and Chamberlain and Hookham, Limited, Birmingham. Electricity Meters. [1 *Fig.*] May 17, 1911.—In prepayment mechanism for electricity meters, the escapement lever, which is operated by the meter to control the movement of and cut-off of supply by the prepayment mechanism, is operated by a weight released by the meter and returned by a spring or weight wound up by hand. A toothed wheel *a* is mounted upon a shaft *b* to which is attached one end of a spring *c*. Engaging with the wheel *a* is an escapement *d* carrying a lever *e*. *f* is a disc driven from the meter-train and carrying a pin *g*. *h*, *k* are two trip-levers pivoted so that the ends of their arms *m*, *n* are engaged by the pin *g* as it revolves. *w* is a weight pivoted in a position to rest normally upon the upper end of either the lever *h* or *k*, engagement with the former, in the construction shown, being made through a pin *p*. The weight *w* also carries an arm on which is a pin *q* which engages the end of the lever *e*. In addition, there is a lever *r* having at one end, which engages the wheel *a*, a pawl *t* hinged so as to allow the wheel *a* to be rotated anti-clockwise, but to be itself depressed by the wheel *a* revolving clockwise.



The other end of the lever *r* engages the weight *w* when the latter is allowed by the levers *h*, *k* to fall. The operation is as follows:—The wheel *a* is rotated on the insertion of coins by the engagement of the coins with its teeth. The spring *c* is thus tensioned. The return movement of the wheel *a* can only take place as allowed by the escapement *d*. Assuming that the wheel *a* has been rotated some distance by the insertion of coins and that the meter is in operation, the disc *f* will be driven by the meter train, and the pin *g* will eventually engage the arm *n*, the lever *k* will be lifted, and the weight *w* allowed to fall so that the pin *p* rests upon the lever *h*. Further revolution of the disc *f* will, in turn, trip the lever *h*, and the weight *w* will be allowed to fall clear of both the levers *h*, *k*. This movement of the weight *w* causes the pin *q* to move the escapement *d*, and allows the wheel *a* to rotate one tooth in a clockwise direction under the action of the spring *c*. The movement of the wheel *a* depresses the one end of the lever *r*, the other end, as it rises, meeting the falling weight *w*, and returning it to its original position resting on the top of the lever *k*. (*Accepted October* 18, 1911.)

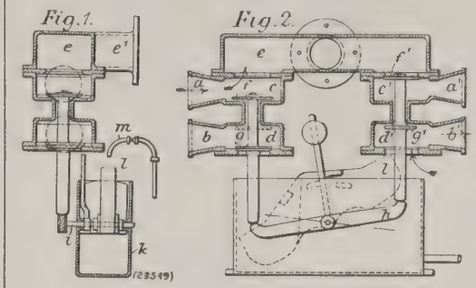
76/11. The British Thomson-Houston Company, Limited, London (*General Electric Company, Schenectady, U.S.A.*). **Brushes.** [3 *Figs.*] January 2, 1911.—A flexible conductor is fastened to a brush of a dynamo electric machine by forming a recess or hole in the brush, inserting the conductor in this recess or hole, and then filling the remainder of the recess with an expanding cement. When the cement hardens, the conductor is pressed into intimate contact with the brush. 1 represents a carbon block or brush. A recess is formed in one side of



the block, and is arranged near one of the upper corners thereof. A passage 2 leads from the recess to the upper end of the block 1. The flexible conductor 4 has a portion, preferably in the form of a loop, placed in the recess, and another portion passing through the passage 2. The loop is spread out as much as possible in the recess, and is held in place by cement 7, which expands upon hardening, so that the flexible conductor is pressed into intimate contact with the block 1. The cement fills the part of the recess not occupied by the loop, and is placed therein under pressure. (*Accepted October* 18, 1911.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

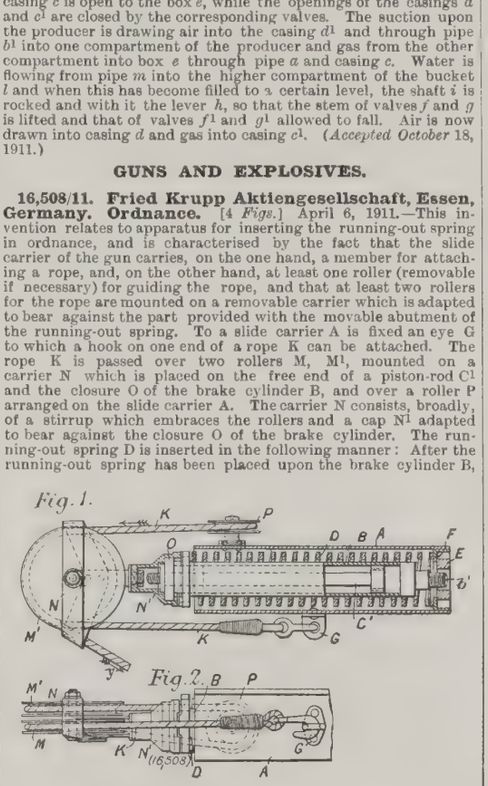
23,549/10. T. W. S. Hutchins, Stockton-on-Tees. Gas-Producers. [3 *Figs.*] October 11, 1910.—In a gas-producer having its generating chamber divided into compartments, the blast is admitted during one working period into one of the compartments and during the next working period into the other compartment, this alternation being continued so long as the producer is in operation, and the take-off of the gas-producer being similarly alternated. A valve gear having rotary valves for effecting the alternation of both the air and the gas automatically by a water motor in a producer of the kind mentioned is already known. The use of rotary valves presents certain difficulties, and the present invention relates to the construction of valve gear for producers of the kind mentioned, in which the valves have a rectilinear reciprocating movement or a rocking movement. The pipes *a*, a^1 are connected with the gas take-off pipes leading respectively from the two compartments of the producer, and pipes *b*, b^1 are connected with the air-supply pipes leading respectively to the two compartments. Pipes *a* and *b* terminate respectively in superimposed valve casings *c* and *d*, while pipes a^1 and b^1 terminate respectively in like casings c^1, d^1. Casings *c*, c^1 communicate with a box *e* from which the gas produced is taken off by a pipe e^1, and casings *d*, d^1 communicate with the atmosphere. The superimposed casings of each pair communicate with each other by a passage in which slides a stem common to two disc-valves *f*, *g* and f^1, g^1. These valve stems are supported respectively on the



ends of a rocking-bar *h* fixed to a shaft *i* journalled in a tank *k*. To the shaft *i* is also fixed a bucket *l* divided into two compartments to form a rocking water-motor of well-known type. In the position shown, casing d^1 is open to the atmosphere, and casing *c* is open to the box *e*, while the openings of the casings *d* and c^1 are closed by the corresponding valves. The suction upon the producer is drawing air into the casing d^1 and through pipe b^1 into one compartment of the producer and gas from the other compartment into box *e* through pipe *a* and casing *c*. Water is flowing from pipe *m* into the higher compartment of the bucket *l* and when this has become filled to a certain level, the shaft *i* is rocked and with it the lever *h*, so that the stem of valves *f* and *g* is lifted and that of valves f^1 and g^1 allowed to fall. Air is now drawn into casing *d* and gas into casing c^1. (*Accepted October* 18, 1911.)

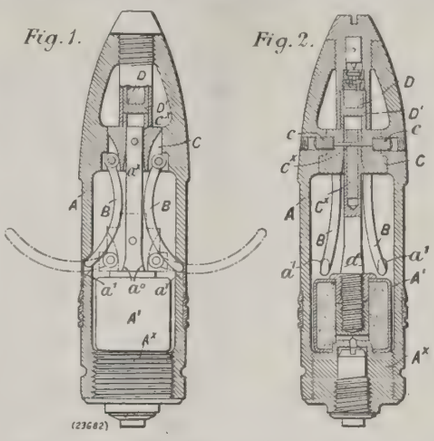
GUNS AND EXPLOSIVES.

16,508/11. Fried Krupp Aktiengesellschaft, Essen, Germany. Ordnance. [4 *Figs.*] April 6, 1911.—This invention relates to apparatus for inserting the running-out spring in ordnance, and is characterised by the fact that the slide carrier of the gun carries, on the one hand, a member for attaching a rope, and, on the other hand, at least one roller (removable if necessary) for guiding the rope, and that at least two rollers for the rope are mounted on a removable carrier which is adapted to bear against the part provided with the movable abutment of the running-out spring. To a slide carrier A is fixed an eye G to which a hook on one end of a rope K can be attached. The rope K is passed over two rollers M, M^1, mounted on a carrier N which is placed on the free end of a piston-rod C^1 and the closure O of the brake cylinder B, and over a roller P arranged on the slide carrier A. The carrier N consists, broadly, of a stirrup which embraces the rollers and a cap N^1 adapted to bear against the closure O of the brake cylinder. The running-out spring D is inserted in the following manner: After the running-out spring has been placed upon the brake cylinder B,



the latter is introduced into the slide carrier A until the running out spring strikes against the abutment F. The roller P is then placed on the slide carrier and the carrier N, with the rollers M, M^1, is placed on the closure O of the brake cylinder. The hook on the rope K is then hooked into the eye G of the slide carrier, and the rope first passed over the roller M, then over the roller P, and finally over the roller M^1. If now the free end of the rope be pulled upon in the direction of the arrow *y*, the brake cylinder B will be thrust into the slide carrier by the carrier N, and the running-out spring D stressed. The force which acts here on the running-out spring amounts, if the friction losses be ignored, to four times the tractive force exerted on the rope K. The pull on the rope K is continued until the screw-threaded pin b^1 on the brake cylinder B has passed through the spur E on the gun barrel, and the brake cylinder bears against the spur E. By screwing a nut on to the screw-threaded pin b^1, the brake cylinder B is connected to the spur E. After disconnecting the rope K, and taking off the carrier N and the roller P from the gun, the slide carrier is closed in front and the piston-rod C^1 connected to this closure. (*Accepted October* 18, 1911.)

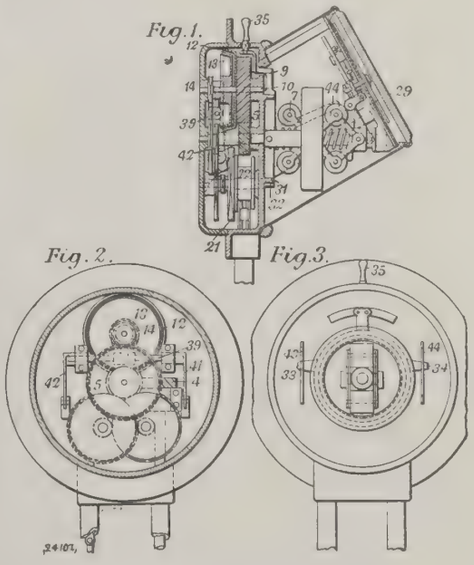
23,682/10. Sir A. T. Dawson and L. Silverman, London. Projectiles. [5 *Figs.*] October 12, 1910.—This invention relates to projectiles adapted for use against balloons, airships, or the like, and provided with members which, when the projectile is fired, assume a lateral position with respect to the projectile to engage with the fabric of the balloon. According to the present invention, the engaging members are so arranged in relation to the projectile that they are retained in their normal or inoperative position by means of a locking or retaining device carried by the projectile, and adapted to be released when the projectile is fired. A is the body of the projectile, and B, B are the engaging members pivoted to the movable block C. The movable block C and the members B, B are retained in their normal or inoperative position by two plungers *c*, *c* disposed in holes in the sides of the projectile and engaging recesses in the block C. The plungers are connected by a rod c^*. This rod passes through a prolongation a^* of the base plug A^x of the projectile, and through a weight C^* disposed in the prolongation, and constituting an inertia device. The weight C^* is so arranged that the breaking of the rod c^* and the liberation of the plungers *c*, *c* is effected by relative movement of the weight on shock of discharge, the plungers then moving outwardly under the influence of centrifugal force, so that they no longer engage the recesses in the block C, and the latter is therefore free to be moved to cause the members B to assume their engaging position. The prolongation a^* is made slightly conical towards the rear at a^0, and the movable block C is formed with a corresponding conical recess, so that when the block is caused to slide along the prolongation, and reaches its position with the engaging members protruding from the projectile, the conical surface of the prolongation and the block bind together, thus firmly retaining the block in this position. The engaging members are normally



disposed entirely within the projectile, with their end portions directed towards the base and engaging in holes a^1, a^1 formed in the sides thereof. The means for effecting the movement of the block C comprise an explosive charge D of a slow-burning composition contained in a casing D^1. The charge is ignited by a percussion-cap fired on shock of discharge, a delayed action taking place between the firing of the percussion-cap and the ignition of the charge D of sufficient duration to give time for the projectile to leave the gun before the charge explodes. When the explosion of the charge occurs, the block C is forced towards the rear of the projectile, and causes the engaging members B, B to protrude laterally from the projectile, as shown in broken lines in Fig. 1. The bursting charge is arranged in the casing A^1 near the base of the projectile and surrounds the prolongation a^*. (*Accepted October* 18, 1910.)

MOTOR ROAD VEHICLES.

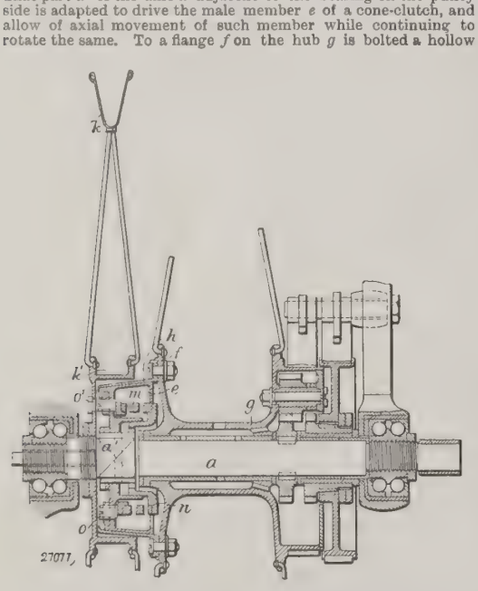
24,107/10. J. B. Hamilton, London. Speedometers. [3 *Figs.*] October 18, 1910.—This invention relates to instruments for indicating the speed of a vehicle, and consists in the combination with means for indicating the speed, of speed-limiting means disposed within such instrument, and comprising a relay or reducing gear consisting of intermeshing pinions and wheels driven from the same driving means as the firstly-mentioned means, but normally disconnected therefrom, and means for causing the connection of said gear with the driving means and comprising a clutch, the movable member of which is under the control of an actuating device that in one position holds a part in the path of a part actuated by the firstly-mentioned means in an attitude to be acted on thereby, as and when the speed of the vehicle rises above a predetermined rate, and to cause the actuation of the clutch and speed-limiting means, and in another



position has no action on said part with the result that the firstly-mentioned means do not actuate the clutch when the speed rises above a predetermined rate. The casing of the speedometer is of tripartite construction. The speed-indicating means is driven from one of the road wheels through flexible shafting. The speed-limiting means is also driven through this shafting, the one end of which extends within the casing, and has attached to it a skew-wheel 4 that gears with a toothed wheel 5 mounted on the spindle of the governor 7 forming part of the speed-indicating means. The toothed wheel 5 also gears with a toothed wheel 9, which has attached to it one member 12 of a clutch, the other member 13 of which is loosely mounted on a spindle 10. The two clutch members are normally out of contact. The clutch member 13 is in connection with the first member 14 of a reducing gear, consisting of intermeshing pinions and wheels, the last wheel 21

being connected with a drum 22, on which a flexible connector is wound when the gear is put in operation. The flexible connector is led to and connected with the motive machinery. The speed-limiting means is not operative unless and until the two clutch members are in driving connection, and to bring about the driving connection when the speed of the vehicle has attained a predetermined limit, the arrangement now to be described is adopted. 31 is a circular flange that forms a bearing for an actuating device which has three positions, in two of which it is operative. The actuating device is a ring 32, having two laterally extending and oppositely arranged arms 33, 34, and a handle 35. The device is capable of a partial rotary movement on the flange 31. The clutch member 13 is moved into driving connection with the member 12 by a lever mounted on a shaft, having at each end, and in rigid connection therewith, an arm 41 or 42. Pivotally mounted on the lower end of the arm 41 is an arm 43, that extends forwards, and terminates in proximity to the speed-indicating mechanism 29. 44 is an arm similar to the arm 43 but pivotally mounted on the lower end of the arm 42. The arms 43, 44 are of different lengths, and are so positioned in relation to the mechanism 29 that when one or other is moved about its connection with the arm (41 or 42), and in a downward direction, its end will come into the path of the one or other of two arms operated by the mechanism 29 and be acted upon thereby. Normally the arms 43, 44 are maintained in such positions that they will be clear of the mechanism. When the handle 35 is moved to one or other limit of its motion, the arm 33 or 34 comes into contact with and presses upon the arm 43 or 44 and forces the end of this arm downward and into a position in which it will be in the path of one of the arms of the mechanism 29. As the speed of the vehicle approaches the predetermined limit, an arm approaches the depressed end of the arm 43 or 44, and when the predetermined limit is attained comes into contact therewith and acts thereon, forcing the arm 43 or 44 to move rearwardly. The rearward movement of the arm 43 or 44 causes the shaft 39 to partly rotate and the clutch member 13 to be moved into driving connection with the member 12. The rotation of the flexible shafting will thus be transmitted to the drum 22 and the flexible connector wound thereon and the parts of the machinery to which it is connected actuated in a manner to cause the speed to be retarded. When the speed limiting means have been put in operation on the vehicle attaining the predetermined speed limit, the means are maintained in operation until the speed falls below such limit, and when this happens the clutch members 12, 13 come out of driving connection, the necessary energy for this purpose being provided by springs forming parts of the machinery actuated and which were stressed. The mechanism 29 also comes out of contact with the end of the arm 43 or 44 and allows this action. (*Accepted October* 18, 1911.)

27,077/10. The Rex Motor Manufacturing Company, Limited, and H. Sarginson, Coventry. Clutch Mechanism. [2 *Figs.*] November 21, 1910.—This invention relates to clutch mechanism for motor-cycles, and, according thereto, the means for adjusting the pressure exerted by the springs which operate the clutch may be operated from the outer face of the clutch relative to the machine. The cone effecting the connection between the hub of the belt-pulley and the road-wheel are laterally movable independently of the belt-pulley, and it is unnecessary to displace the pulley when operating the clutch. That part a^1 of the axle a adjacent to the bearing on the pulley side is adapted to drive the male member e of a cone-clutch, and allow of axial movement of such member while continuing to rotate the same. To a flange f on the hub g is bolted a hollow



conical shell h, with the internal face of which the male member e engages. Also connected to, and locked on, the axle a is the hub k^1 of the belt-pulley k. To retain the clutch members in engagement a spring m is incorporated, one extremity abutting against the male member e, the other extremity pressing against a disc n secured to the axle. The whole of the parts are so arranged that the working faces of the clutch and the spring are entirely enclosed and protected. To this end the hub of the belt-pulley encircles and extends transversely across the outer member h of the clutch. The compression of the spring m is adjusted by screws o, which are inserted in the outer face of the male member and receive the thrust of the spring, apertures o^1 being formed in the belt-pulley hub co-axial with the screws. (*Accepted October* 18, 1911.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

11,447/11. Croft and Perkins, Limited, and H. Lindsay, Bradford. Multiple Disc-Clutches. [11 *Figs.*] May 11, 1911.—The invention relates to multiple disc-clutches, and, according thereto, the discs of one or both sets of discs are positively interconnected by lazy-tong devices so arranged that when the clutch is disengaged the discs are always separated by an equal amount from each other. Preferably positively operating means are provided for actuating the lazy-tong device when the clutch is disengaged, although springs may be used for the purpose. a is the driven shaft, and b is a portion of the flywheel on the driving-shaft. The clutch is actuated by means of a pressure-plate c operated in known manner. The driving and driven discs e, f are connected to their respective parts by projections entering slots g. The discs of each set are also provided with a series of projections h, while the driving and driven portions respectively are provided with corresponding grooves j, k. A series of small jaws are arranged to engage the projections h of the discs. The jaws of each set are connected to the pivotal points of a lazy-tong device m, while these pivotal points are, on the opposite side of the lazy-tong m, provided with projections n which slide in the grooves j and k respectively. In the arrangement shown, it will be noted that the outermost disc of the discs f on the right-hand side is rigidly

Fig. 1.

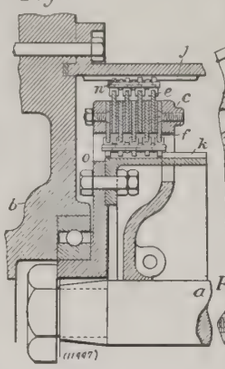


Fig. 2.

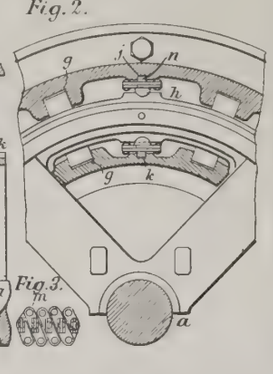


Fig. 3.

secured to the pressure-plate c, while the outermost disc on the left-hand side is rigidly secured to a plate o immovably connected to the driven shaft. When, therefore, the pressure-plate is pulled back to disengage the clutch, the distance between the discs of the driven set will be increased uniformly, and the discs will be positively moved owing to their connection with the lazy-tong device. The discs e of the driving set will also, owing to the action of the driven set of dics and the respective lazy-tong device, be forced apart uniformly. (*Accepted October* 18, 1911.)

25,476/10. A. C. King and J. King, Southgate, and F. Hamer, Hayes. Gearing. [4 *Figs.*] November 2, 1910.—This invention relates to power-transmission systems in which a prime mover is connected with a load through a combined clutch and variable-speed-gear device comprising an electrically energised member and epicyclic gearing. In particular, the invention relates to power-transmission systems in which the prime mover rotates one member of the combined clutch and variable-speed-gear device and the load is connected to one member of the epicyclic gearing, said member being geared to a second member of the combined clutch and variable-speed-gear device, and said second member being mounted so as to be rotatable about its own axis and about the axis of the first member, the arrangement being such that when the first member of the combined clutch and variable-speed-gear device is rotated, compound rotation is imparted to the second member, the rotation of the latter about its own axis being retarded more or less according to the energisation of the first member. According to the present improvements, the electromagnetic retardation of rotation of the second member is assisted by friction, and, for this purpose, the second member, in addition to having a rotation about its own axis, is also capable of movement along its axis, and carries means which engage frictionally with means mounted on, or carried

Fig. 1.

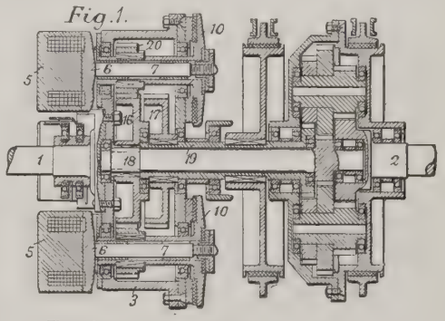
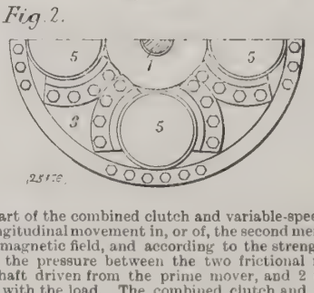


Fig. 2.



by, a part of the combined clutch and variable-speed-gear device. The longitudinal movement in, or of, the second member is effected by the magnetic field, and according to the strength of the field, so will the pressure between the two frictional members vary. 1 is a shaft driven from the prime mover, and 2 is a shaft connected with the load. The combined clutch and variable-speed-gear device is connected with the shaft 1, and one member thereof comprises a casing 3, which contains the epicyclic gearing and is closed by a cover-plate. 5, 5 are electromagnets; there are four of these electromagnets, and they are secured on the exterior of the casing 3 and spaced equidistantly apart. The poles of the electromagnets are positioned a little distance from the casing 3 to permit of the interposition of parts of the second members in the spaces thus formed. 6, 6 are the armatures of the electromagnets. Each armature 6 is carried by a spindle 7 which extends through the casing 3 and beyond the outer face of the cover-plate, and is enclosed and supported at one or more points within a hollow shaft mounted in bearings in the casing 3 and cover-plate. Each hollow shaft carries a circular flange 10. The outer end of each spindle 7 is screw-threaded and on each spindle is screwed a nut. The flanges 10 are provided on one face and around the orifices of the hollow shafts with rings of frictional material, and the faces of the nuts on the ends of the spindles 7 that come in contact with the material are also faced with frictional material. The nuts are screwed up so that the two rings of frictional material are in close contact: a spindle 7 and hollow shaft are thus connected together, and will rotate as one as long as the forces applied thereto are not so great as to overcome the frictional resistance between the materials. A ring of frictional material is also mounted and secured on the face of each flange 10 and around or near the outer edge thereof, and rings of frictional material are also mounted on the outer face of the cover plate, and positioned so as to be opposite and to coincide with the rings on the flanges 10. 16, 17 are the central wheels of the epicyclic gearing. The wheel 16 is mounted on a shaft 18, and the wheel 17 on a sleeve 19 mounted on the shaft 18. 20 are the planet wheels that gear with the wheel 16. The planet wheels that gear with the wheel 17 cannot be seen. The planet wheels 20 are mounted on the hollow shafts. From what has been said it will be understood that there are four hollow shafts and four planet wheels. Of these planet wheels, two gear with the wheel 16 and two with the wheel 17. The lastly-mentioned planet wheels are not in the same plane as the planet wheels that gear with the wheel 16, and are positioned on their hollow shafts near the inner side of the cover plate. Current for energising the electromagnets is derived from a suitable source of energy. The variation of the current strength or the connection of the windings will cause variations in the strengths of the electromagnets, and these variations will result in alterations in the drive or transmission of power. (*Accepted October* 18, 1911.)

An Electric Train-Lighting Plant.—A new form of electric train-lighting plant is being brought out by the India-Rubber, Gutta-Percha, and Telegraph Works Company, Limited, of Silvertown, London, E. It is made under patents taken out by Messrs. Anderson, Russel, and Gray, and is at present under trial by one of the large English railways. The arrangement consists of a dynamo driven from one of the coach-axles, and fitted with a centrifugal governor which is arranged to operate switches which cut in, or cut out, one or other of two accumulator batteries. One battery is normally connected to the lamp circuits, and the other across the armature, so that it may be charged. The dynamo is of ordinary type, except that it has differentially wound field-magnets, one winding being of the shunt type, and connected across the battery which is connected to the lamps, and the other of the series type, and arranged so that the charging current to the second battery passes through it. The two windings oppose each other. In addition there is a diverter resistance connected across the series winding, and adjustable by hand, so that the amount of current passing through the series winding may be adjusted to suit the particular conditions of working. This allows the series field current to be limited to such a maximum that it never overpowers the shunt-field current, so that the dynamo voltage never becomes zero. The centrifugal governor cuts in the batteries when the dynamo speed is such that the voltage would be equal to that of the lamps were the field energised by the shunt coil only. The object of the differential field is to maintain a constant dynamo voltage with any speed of the train above that at which the batteries are cut in, so that excessive rates of charging are impossible. If the charge rate tends to become too great, the voltage is automatically reduced by the weakening action of the charging current itself. In addition to the gear already mentioned, there is a switch on the centrifugal governor which changes over the functions of the two batteries when the train reverses its direction of running. When no lights are being used the two batteries are placed in parallel by the act of switching off, and the armature current is led part through the series winding and part to a special lamp resistance.

Titanium Rails.—A set of sections illustrating the wear of rails laid down on the Kessler's Curve in West Virginia, on the Baltimore and Ohio Railroad, has reached us from Messrs. T. Rowlands and Co., Stirling-chambers, Sheffield. The diagrams have been drawn out by Messrs. Robert W. Hunt and Co., New York, for the Titanium Alloy Manufacturing Company, Pittsburg, and deal with open-hearth and titanium-treated Bessemer rails. The curve on which these tests were made is one of 9 degrees, the superelevation of the outer rail being 6 in. 90-lb. rails were used. A previous test of ordinary Bessemer and titanium-Bessemer rails on this curve showed an improvement in favour of the latter of 294 per cent. In the present test, the difference in favour of the titanium rails is not so great. The test extended for 338 days, the loss being measured in square inches of sectional area. Of the rails on the inside of the track, the open-hearth rails averaged a loss of 0.250 sq. in., and the titanium rails as follows:—0.03 per cent. titanium, 0.273 sq. in.; 0.05 per cent. titanium, 0.169 sq. in.; 0.1 per cent. titanium, 0.155 sq. in.; 0.15 per cent. titanium, 0.147 sq. in. The wear was even all across the head, and the open-hearth rails thus showed 1.70 times the amount of loss of the 0.15 per cent. titanium rails. On the outer rails the wear was principally, of course, on the inside of the head, the wear being as follows:—Open-hearth, 0.36 sq. in.; 0.03 per cent. titanium, 0.428 sq. in.; 0.05 per cent. titanium, 0.39 sq. in.; 0.1 per cent. titanium, 0.389 sq. in.; 0.15 per cent. titanium, 0.273 sq. in. The ratio of wear of the open hearth to that of the 0.15 per cent. titanium rails is thus 1.32:1. The average ratio for the loss of all open-hearth rails to the 0.15 per cent. titanium rails, on both sides of the track, is 1.45 : 1. It may be added that the open-hearth rails were of 0.64 carbon steel, while the titanium Bessemer rails averaged 0.47 carbon. A test carried out some time ago on the Chicago, Burlington, and Quincy Railway, lasting for nine months and including nickel, manganese, plain open hearth, Bessemer, and two makes of titanium rails, showed that the titanium rails, of which the extra cost per ton is only about 2 dols., were equal to the nickel-steel rails, the extra cost of which per ton was no less than 40 dols., being, moreover, superior to the other makes covered by the test.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of this Institution was held on Friday last, the 15th inst., at the Institution House, Storey's Gate, Westminster, the chair being occupied by the President, Mr. E. B. Ellington.

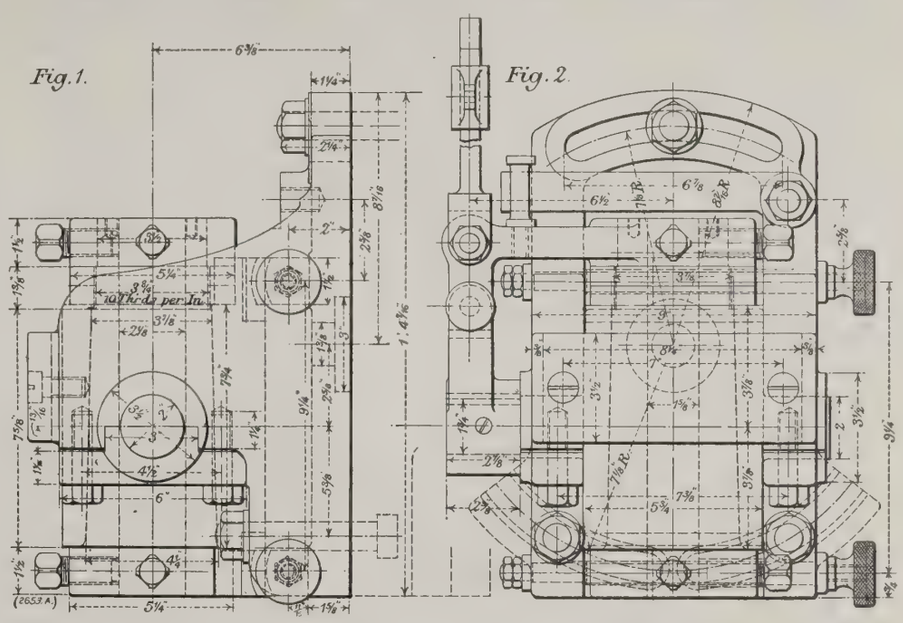
DOUBLE-CUTTING AND HIGH-SPEED PLANING MACHINES.

At the last general meeting of the Institution, held on the 17th ult., a paper bearing the above title was read by the author, Mr. J. Hartley Wicksteed, past president, the discussion of this paper being adjourned until Friday last. We reprinted the paper in full in our issue of the 24th ult., page 700. We now report the discussion, which took place on the 15th inst., after the conclusion of the formal business.

Mr. Wicksteed first remarked that he had given in his paper what he thought was a useful specification for any planing machine—namely, expressing the power in terms of the pull that the drive was capable of imparting to the table. He had stated that at the slowest speed the drive of the machine described would exert a pull on the table of 15 tons, of 10 tons at the middle speed, and of 7 tons at the quickest speed. He had thought it of interest to exhibit some shavings, in order that members might realise the meaning of the pull upon the table. The shavings were all similar, being fairly heavy cuts from 40-ton steel ; there was nothing exceptional about them. To cut one of these shavings had required a pull upon the table of about 12 tons, this being exerted at the rate of about 20 ft. a minute by a continuous running motor without any overload. A horse-power was represented by 15 ft.-tons per minute ; therefore 20 horse-power would give 300 ft.-tons per minute. He concluded, therefore, that the shavings had required about 250 ft.-tons per minute to remove them, affording an ample margin, without overloading the motor for friction and other things like inertia resistances. In reply to a question by Mr. Patchell as to the weight of steel removed per minute, Mr. Wicksteed added that the amount removed was one-tenth part of a square inch multiplied by 20 ft., giving a weight of 6.6 lb. per minute.

Mr. L Pendred opened the discussion. He said that all who were in the habit of visiting workshops would be of opinion that double-cutting was very rarely used. He could only assume that this was because managers were opposed to the slightly extra complexity involved in double cutting. It was due to Mr. Wicksteed's own improvements in the planing-machine that double cutting was not more employed. In conjunction with the electrician, who had done much to perfect the reversing motor, Mr. Wicksteed had so improved the planing-machine and increased the rate of return that it was now not so essential to cut on the return stroke. Formerly a great deal of time was saved by cutting on the return stroke. One of the great objections to the planing-machine was the enormous load at the moment of reversal. In 1900 Captain Tressider had made some experiments at Messrs. John Brown and Co.'s works, some very valuable diagrams being obtained and published. He found from Captain Tressider's figures that in one case, where the machine was cutting at 9½ ft. and returning at 19 ft. per minute—it was cutting armour-plate with the very small feed of only $\frac{1}{24}$th of an inch—the cutting power and the power for return were about equal (between 7 and 8 horse-power). The meters at the beginning of the cut went up to 14½ horse-power, and at the beginning of the return rose to no less than 29 horse-power. These tests were made with an electrical drive. The improvements that had been introduced in the way of regenerative control had done a great deal to reduce the enormous power required at the beginning and at the end of the stroke ; they had also done much to check the introduction of double cutting.

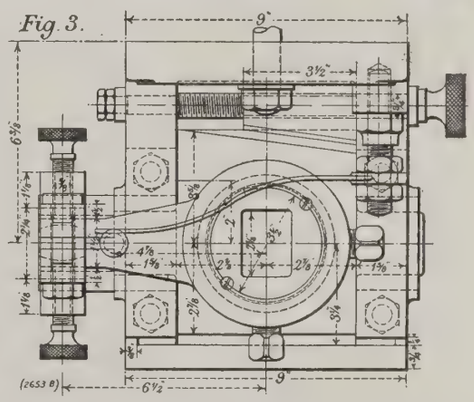
If an ordinary planing-machine were put before any engineer to whom it was a new tool, he would, he thought, have no difficulty in saying in which direction the cut should go. If two tools were used back to back, and the cut taken on the reverse, the whole tendency would be to lift the saddle off the shears, and the pressure of the cut was taken on the inclined face at the back of the slide. The shape of the machine generally was designed to take the thrust, and not a pull. Perhaps Mr. Wicksteed would say whether that point had had any influence on the little favour shown to double cutting. One of the most important points was the modification of Mitchell's drive which Mr. Wicksteed had adopted, and the speaker would be much obliged if Mr. Wicksteed could give a comparison between a machine fitted with a belt drive, such as was described, and a purely electrical machine—*i.e.*, a machine with electrical reversing and unequal speed motor. It appeared to the speaker that nearly all that was wanted could be obtained from the belt-driven machine. The modification of the Mitchell drive was an extremely pretty device ; it embraced a small diameter of pulley and a low-speed belt, and anybody who had calculated the waste of power caused by the sudden stoppage of a high-speed pulley of large diameter—generally used in planing-machines—would appreciate the fact that what was wanted was a low-velocity belt and a small-diameter pulley. These things had been secured with the device which Messrs. Buckton had taken up.



Mr. J. E. Darbishire desired to emphasise his approval of the Sellers drive. He had been connected with the old firm of Sharp, Stewart, and Co , Atlas Works, Manchester. They had at those works rack machines with a plain rack, and also machines with step racks. There were also screw-driven machines made by Whitworth, with revolving tool-box. This tool-box had been abandoned for, he thought, the very reason that Mr. Pendred had called attention to—that it gave a pull on the cross-slide which was very difficult to take up, and produced an irregular torque. The rack machine and the Whitworth screw-machines were all driven by single belts. About the year 1864 or 1865 Sellers produced his planing-machine. The Atlas Works had acquired the license for this country, and imported a small Sellers machine. The motion was very quiet and free from backlash, and nothing could have been better. From that time they never made any planing-machine excepting the Sellers. Some of the first machines they had made were made for the Barrow Shipbuilding Company. After some ten to twelve years or more, there was a fire, and those planing-machines were seriously damaged. They were returned to the Atlas Works for rebuilding, were rebuilt, and in some respects improved, but they had put back into them the very same pinions and racks without re-cutting or doing anything to them, and the machines were practically free from backlash. He had never seen any gearing wear so well as the Sellers pinions and racks. One advantage derived from the Sellers machines was that they could be at once speeded up 20 per cent. They could be run, even with the tool steel of that period, at a cutting speed of something like 22 ft per minute, which was then very high. After the Sellers patents had run out one of the first to adopt that drive was Mr. Wicksteed.

Mr. Richard Allen said that it had been remarked that some managers of works were opposed to double cutting. He did not believe that was really so. It seemed, however, to have been fashionable for years past to cut in one direction, but he ventured to think that if an efficient double-cutting planing-machine could be placed on the market, there would be a very large sale for it. It would be obvious, of course, that if the articles to be planed were small and intricate, there was no great advantage in double cutting. If, however, the work were straightforward, advantage would be derived from double cutting. Recently, at Newcastle, he had seen a machine specialy constructed for planing the shells of Yarrow boilers, the drums of which were made sometimes in halves and sometimes in three pieces, the steel being planed to a sharp edge in order to get the true diameter. This machine did double cutting, and it was working exceedingly well, the saving in time being considerable.

He (Mr. Allen) had watched the Vickers drive for several years. He had applied it to a fairly



large planing-machine of 8 ft. square, with a 16-ft. table. This drive had been a great improvement on the original belt drive, although there were slight defects in the apparatus, principally due to the fact that the electrical switches were operated by a bicycle chain. This chain stretched in time, with the result that the switches got out of action, and the table had occasionally run off, doing considerable damage. In applying electrical devices to a high-speed planing-machine, simplicity should be a main consideration, with a view to minimising risk of breakdown. When he had been, early this year, at the Sellers works in Philadelphia, he had found that there they preferred, to the so-called electrical drive, a system of driving planing-machines through clutches operated by compressed air. Machines so operated certainly worked exceedingly well. But such a machine was at once put out of action if the works air-compressor failed. It was his opinion that the planing-machine under discussion would be the machine of the future.

Mr. W. Deakin thought the great prejudice against double-cutting machines was due to want of fair consideration of the subject. In his view, 75 per cent. of the jobs in many engine works were eminently suited for double cutting, and in works

of any size there should be ample work to keep a double-cutting planer in constant operation. It might interest the members if he described a device which overcame many of the obstacles hitherto existing to double cutting. This is illustrated in Figs. 1 to 3, on page 817. The device consisted of a pivoted tool-box, to which was given a semi-rotary motion, both vertically and horizontally. The device went half as far as Whitworth, who turned the tool all the way round. It had been found unnecessary to go all the way round, a practice which had the serious objection that considerable space was required. Moreover, with the box illustrated, the work could be effectively done by one tool instead of two. Mr. Deakin proceeded to draw on the blackboard a tool with a double-cutting edge, the ordinary relief face being ground at right angles to the shank, and thus, when tilted slightly, providing the necessary angle of relief. This tool could be tilted either way to give a similar angle of relief, and might be used for cutting either way. This alteration of angle was effected by an additional shaft on the cross-slide of the machine, which moved at each end of the stroke like the ordinary feed motion. One advantage was that not only could ordinary surface-cuts be taken, but also side-cuts and under-cuts.

In the speaker's own works it had been possible in practice to beat the milling-machine in the under-cutting of slots of machine-tables. The tables machined were fairly small, and were just milled with the milling-cutter and the under-cutter. With the form of tool-box illustrated, it was possible to under-cut a slot without lifting the tool out of the slot at all. The central piece (Fig. 3) provided for the vertical radial motion. That was necessary for a side cut, when the edge of the tool needed to be twisted alternately either way at an angle to the work. That applied to side-cutting and under-cutting. One trouble encountered had been the difficulty in adjusting the relative angles of the tools usually used in double cutting. He was ignorant of Mr. Wicksteed's system, but he assumed that the tools had to be put down on the level surface—[To this Mr. Wicksteed assented]—and were not capable of further adjustment. In the arrangement he was describing there were wedge blocks (Fig. 3) between the two shears. By just screwing the knobs at the right hand (Fig. 2) the amount of oscillation that would take place in the tool-box could be determined. The same device was shown in Fig. 3 for the semi-rotary motion vertically. When the box was being used for vertical cutting both the wedges were fixed up against the back of the block to prevent any movement in the horizontal direction. A lever connected with the shaft that was placed over the cross-slide of the planing-machine was connected with the end of the lever shown in Fig. 2, and at each stroke of the planing-machine that vibrated, and so gave an angle of inclination to the tool. A speaker had alluded to the pull of the cross-slide on the return stroke. He (Mr. Deakin) did not, however, consider the objection on this score to be very formidable. There was a torsional strain on the cross-slide, and this constituted the chief weakness of the planing-machine. If some alteration were made in the direction of stiffening-up the cross-slide generally, one serious objection to double cutting would be eliminated. It was, he thought, chiefly prejudice that stood in the way of double cutting, and too much was generally made of the unsuitability of some jobs to this process. This prejudice should be put aside and the double-cutting machine made to do all the jobs possible. The planing-machine, like the milling-machine, had its function in the shop.

Mr. Charles Wicksteed said that it was a mistake to search for reasons for the non-adoption of the double-cutting machine in the form of mechanical defects. The real reason was the intense conservatism of the engineering profession. The inventor of new machines or methods had seldom been able, notwithstanding years of effort, to get recognition of their intrinsic merit from any works of importance. The works manager was not usually the man who had so recognised them, but, as a rule, was rather one who preferred to follow the few adventurous people who had launched the inventions and brought them to practical success. Anything likely to bother the management and involve valuable time in looking after men and so on would be shunted. Nothing in double cutting appealed to the imagination, and it was put off year by year. When we should be producing as much as possible in the shortest time, the advantages of double cutting, more particularly in large work, seemed so obvious that, were it not for British conservatism, he would be surprised at the disfavour shown towards it. If a single-cutting machine took three minutes to make a cut, and returned in a third of the time, or occupied four minutes per cycle, and a double-cutting machine required three minutes forward and three back, the time occupied per cycle was in the proportion 4 : 6. The output would be increased half as much again. Shop room occupied was decreased and speed of production increased.

Mr. W. H. Patchell asked the author to give a few additional particulars as to size and depth of cut, weight of material removed, and the gain in speeding-up. Speeding-up without the removal of more material was no gain. The author appeared to be very keen on jockey-pulleys. Many engineers had had, however, very unhappy experiences with such pulleys. Dr. John Hopkinson, one of the greatest advocates of the jockey-pulley, had put them in the stations of the Manchester Corporation and for the City and South London, but their employment entitled the engineers who had to work them to a great deal of sympathy. To get any life at all with such pulleys, the belts had to be link-belts, and link-belts were an abomination. There were so many "improvements" in them that they did not give a proper grip. Makers said they gripped properly because the leather was edge on. He would rather have less width of leather and a more satisfactory pull. He had been rather surprised when on the Continent to see some 400-horse-power motors running with air-compressors and jockey-pulleys, and, according to accounts, giving no trouble. He had not had an opportunity of seeing the machine stopped, and of overhauling the belt, but, so far as he could see, the belt was not a laminated stitched belt, but a plain belt with stitched joints. It was evident that the French engineer who introduced these belts into Germany had succeeded in making a jockey-pulley run much more satisfactorily than they usually ran in England.

Mr. A. W. Marshall, who followed, said it appeared to him that the use of a single double-edged tool prevented it being shaped to the form which, at any rate for planing-machines, used to be recognised as correct; that was to say, one in which the cutting edge was not in line with the front of the shank, but with the back. When the stress came on such a tool it tended to give, and it relieved itself. Modern practice seemed to be going away from that idea, and the tendency was to shape tools on the North country idea of "knocking the lumps off." He thought that the double-cutting arrangement must impair the accuracy of work, as with it it was difficult to get two cuts alike. The belt-drive just referred to was, he thought, that known as the Lenix drive, in which the jockey-pulley was generally pivoted concentrically with the driving-pulley, so that as the belt went round the tendency was to wrap the belt further round the pulley. A weight was applied to the jockey-pulley. The action was automatic and adjusted itself to the drive. In cases where it was impossible to pivot the jockey concentrically it was pivoted in a line which gave a nearly correct movement.

Dr. H. S. Hele Shaw wished to refer to the forces acting on the box and cross-slide. From Mr. Wicksteed's drawing it appeared that the distance from the tool-point to the line of reaction at the bottom vee might be taken as 1, to the centre line of the cross-slide as 2, and to the line of reaction of the top slide as 3. If R_1 was the reaction at the top vee, R_2 that at the bottom vee, and F the force on the tool-point, then, taking moments round F, it would be seen that $R_2 \times 1 = R_1 \times 3$, and therefore $R_1 = \frac{1}{3} R_2$, the reaction at the bottom vee. Also, taking moments on the line of R_2, it would be found that $R_1 \times 2 = F \times 1$, $F = \frac{2}{3} R_2$. It was clear, therefore, that a reversal of direction did make a considerable difference.

Professor R. H. Smith remarked that everybody knew that nowadays springy tools, such as were referred to by the last speaker but one, had been given up except for quite special work; except under special conditions they were not useful for accurate cutting. He wished, further, to indicate why the use of two separate tools was better than the use of a single tool tilted backwards and forwards. When a single tilted tool was used, the cutting action in the two directions could not always be exactly equal. If one edge were blunted first, it followed that it would not cut so deep as the other. As it was essential that the cutting should be equally deep, it would be necessary to grind both edges.

Mr. Deakin here pointed out that provision had been made for securing equal depths of cut in the adjustment of swing allowed to the tool-box shown in Figs. 1 to 3. Grinding was just as simple as for an ordinary tool.

Mr. Wicksteed then replied to the discussion. He was convinced that it was no good pressing the matter of double cutting. He had at one time sold a large single-cutting quick-return planing-machine to a maker of turbines. Gradually the work overtook the machine. He had taken the precaution of constructing the machine to hold double-cutting boxes, and to hold them properly. A proper machine would cut just as well backwards as forwards — perhaps better. In double-cutting lathes with four rests, usually only two were used, and the attendant would use the two rests at the back that had the tool inverted. Large lathes for turning down ingots and crank-shafts, &c., had tools on both sides. The back rest could be made as strong as the front, and it made the sweeter cut of the two. Instead of jumping up and down, the pressure of the tool and the weight of the work were both in the same direction. The back cutting-tool did not require to be cranked to cut sweetly; it relieved itself of its own accord. The spring was spent in the direction of easing the tool, and not in making it dig in. There was absolutely no objection to cutting on both strokes if the work were suitable to the purpose. With heavy planing of engine-beds, for instance, there would be less change of tools, not more, because they would not require changing until they had finished the job.

Returning to the planing-machine supplied to the turbine-makers, Mr. Wicksteed stated that on being consulted he had told the firm to put on double-cutting tool-boxes. He was then asked why he had not made this suggestion before, and he explained that he had done so, but found that they did not believe in it, and so he had let the matter drop. A new set of double-cutting holders was then ordered, with the result that the night shifts were saved. The firm had further put in a reversing motor, which enabled them to have a quick return, or, at pleasure, to cut both ways.

Conservatism and prejudice did not fairly explain the case. It was useless fitting double-cutting tool-holders to existing machines unless they were to do more work. This they would not do without double feed. If the feed were taken at both ends, when the machine had made one cycle it had done twice as much work. The feed-motion was the worst of the whole matter. A good feed was ever so much better than speed. The question, therefore, was not merely one of the speed at which the table moved, but of the amount of work which could be done owing to improved feeds. The taper vees were not right for the planing-machine, whether the machine was for single or double cutting. There was very little in the point. The vees should be made square. If the machine were made strong enough to cut one way, it would be strong enough to cut both ways. It was not a question of testing the breaking strength of the machine.

The chief difference between electric and belt-driving appeared with short strokes. The armature of the electric drive was a heavy item with a good deal of kinetic energy when revolving at a good speed, and it had to be reversed. The pulley made of aluminium or wood was a very light item, perhaps weighing not more than a tenth part as much, and therefore only one-tenth part of the kinetic energy had to be first arrested and then re-accelerated. That difference was most emphasised on short-stroke work. He thought he would be right in saying that with a given length of short stroke—a foot, for example—thirty cycles could be taken with the belt drive against twenty with anything heavier, such as the armature. There was, however, not complete agreement on that, and often people did not care whether they took a little longer or not, so long as they were clear of belts. Such people had probably not had experience of broad belts with inside jockey-pulleys.

If it were necessary to resort to the link belt, that would be an end of the matter. The link belt could not do heavy work. Double the width was needed where link belts were used, because of the alternation of links and spaces, or only half the strength was obtained. To that must be added the wear and tear on the soft eyes of the belt. Every link was perforated for

the skewer to go through, and the space round the hole was extremely weak. The pull it was desirable to have on a jockey-pulley, say 1 cwt. to the inch of face, would result in the eyelets being pulled out, and no end of taking up would be required. A jockey-pulley drive applied to such a belt from the outside had the apparent advantage that contrary flexure could be ignored. That might be so, but it was a hopeless belt to begin with. Possibly the work might be done in that way with the Hendry belt, which was made of strips sewn together in the neutral axis of the piece. Such a belt would bend pretty well both ways; but, even so, subjected to contrary flexure, the leather would stretch faster and wear faster. On a machine taking cuts like those exhibited at the meeting, the jockey-pulley had not been adjusted since August—that was. for four months. If on some occasions the belt "shirked," became stalled, and slipped a little, it was simply necessary to take a key and tighten the jockey-pulley half an inch. There was no need to send for the belt-sewer, who would usually proceed to cut the laces and tighten the belt up at least 1 in. to the next punching-holes, making a bad joint, which possessed all the elements of self-destruction. It was too much strained, and began to tear and stretch itself from the very first. In his machine the belt had no joints at all, and all that was needful was to make the jockey-pulley close up another half-inch or so. The effect was such as to eliminate any consciousness of the machines being driven by belts; nothing was heard about them, and there was never any need to order new ones. He could confirm the observations as to the small wear of the Sellers spiral pinion; it was quite extraordinary. He thought there was something quite new in the horizontal movement of the double-cutting tool-box described by Mr. Deakin enabling undercutting to be done; that was very clever.

Oil-Burning Locomotives.

The next paper—read by the Secretary in the absence of the author—was one entitled "Oil-Burning Locomotives on the Tehuantepec National Railroad, Mexico," by Mr. G. R. Aston, Graduate, of Rincón Antonio, Oax., Mexico. This paper we print in full in another part of this issue.

The first speaker in the discussion was Mr. T. Mein, of the Great Eastern Railway. He represented Mr. Holden, who was unable to attend. He wished to congratulate the author upon the efficiency of the railway upon which he was employed, on which, according to his statement, tubes remained tight for about two and a half to three years. The burner adopted by that railway was an inverted type of "Best" burner, in which the oil fell down and came in contact with a slice of steam. The oil was practically shovelled into the fire-box. It was essential in liquid-fuel burning that complete atomising of the fuel should occur. Towards the close of the paper it was stated that when using the Mexican native oil a large piece of carbon, or coke-like substance, was formed in the fire-box, and grew up from the bottom of the pan or grate directly under the burner mouth. It appeared to the speaker that that meant that complete combustion did not take place. Otherwise the cone-like formation would not appear.

The cost of liquid fuel was a bar to its adoption or greater use in this country. Freight from the oil-fields amounted to 20s. or 21s. per ton, and the evaporative efficiency of the oil was 14 lb. of water per pound, as against approximately 8 lb. of water to a pound of coal. There were thus conditions which made it almost impossible to burn it economically in this country. The advantages of liquid-fuel burning were many. There was less wear and tear on the fire-box plates, because there was not the same scarifying action of the moving fuel, due to the sharpness of the blast necessary for the consumption of a certain amount of coal. A larger blast-pipe orifice could be used, with resultant reduction in back pressure in the cylinders. There was also an absence of smoke when the admission of air and steam and fuel were properly regulated, while the very objectionable emission of sparks—now such a serious matter for railway companies—was also avoided. Another advantage was the reduction of labour for the fireman, who had not to shift about 40 lb. to 45 lb. of coal every mile that was run. Next, there was more rapid steam generation and saving in storage room.

Mr. Mein then exhibited a section of the burner used on the Great Eastern Railway, the working of which he explained. As the form of this burner is probably familiar to most of our readers, and will be found in several text-books on the locomotive, we need not give any lengthy description of it here. The fitting takes the form of an injector with steam cones and a combining-piece and discharge-nozzle, through which the stream of steam and oil is forced into the box. At the same time, owing to the formation of the cone, air is introduced, so that at the end of the cone air, steam and fuel are mingled. Together they pass out of the nozzle. A ring in front is used for atomising; there are three small holes at the bottom and three at the top of the ring through which steam is discharged. The bottom holes are so drilled that the steam jet issuing from them strikes the main stream about 6 in. forward of the nozzle. The holes at the top are not sloped to such an extent, and it is claimed that by this means, in addition to breaking up the mixture, a spiral action is also given to it. There was, Mr. Mein explained, in addition, an auxiliary supply delivered over the main jet. This allowed of an auxiliary supply of fuel if it were not possible to get sufficient through the body of the injector. At the back end of the central air-passage was a ball in a pocket, and a cage upon which that ball could take its seat. This fitting might be coupled to the vacuum-brake gear, and used to maintain or assist in maintaining the vacuum, air being drawn out of the pipe through the mixer. Directly the burner stopped working, the ball fell back and sealed the vacuum in the pipe. The quantity of fuel got through an injector of that kind was about 80 gallons per hour, and the Great Eastern Railway Company had been able to run an engine over 562 miles without the fire being cleaned. The company had fitted boilers provided with ordinary fire-grates, so that the change from oil-fuel to coal could be made immediately.

Mr. Pagnand, of the Baldwin Locomotive Works, stated that in America a large number of locomotives had been fitted with oil-burning apparatus, although only in the western and south-western parts of the States. Oil was only used where the distance from the coal-fields was great, and liquid fuel was very cheap. With regard to the Tehuantepec Railway, the coal consumption with a Baldwin 20-in. by 26-in. cylinder engine, having a grate area of 24.9 sq. ft., was 89.6 lb. per mile, at a cost of 13.8d. When they started burning oil, the consumption, in like circumstances, was 9 gallons, the equivalent of 67.5 lb. per mile, and costing 10.7d. There was not much saving there. It was found in America that unless the cost of coal per ton, speaking of short tons of 2000 lb., were three times that of a barrel of oil, the use of oil was not worth considering. In America the insurance companies would not allow an oil-tank to be placed within 30 yards of any building of any description. If oil-tanks caught fire, there was an end of them. Even with coal-sheds there was a great chance of fire. There was but one way of preventing an oil-tank being totally destroyed. If the tank were covered entirely, so that it could be made air-tight at short notice, and then steam were injected into the top, it would be possible to put out a fire; but great celerity was needed in this work. The cost of changing from coal-engines to oil-burning engines, according to the Tehuantepec line, was about 118*l*. If this capital charge were added to the cost of the oil-burning apparatus, the capital cost of locomotives would be considerably increased. This permanent charge ought to be included. The design of the fire-box for the Tehuantepec locomotives was more or less a deviation from the usual type. There were no dampers. In the drawing given of the fire-box there was an air space shown between the fire-brick wall and the fire-box. Cold air usually went up through that space and across the top of the fire-box to the top row of tubes, resulting in a cold current of air going right on to the top of the oil-flame. In cases where there was a large amount of fire-brick and in which the brick-pan was moved up into the fire-box, there was a considerable reduction of the heating surface of the fire-box; if the pan had been dropped and fastened to the mud-ring, there would have been a larger heating surface. The speaker's experience was that oil-fuel considerably affected the stay-bolts, and in America the practice had been to taper the stay-bolts, so that if the head were burnt off by the heat, the bolt would not drop.

The burner described was the Baldwin standard type, which had been fitted to several hundreds of locomotives. The Southern Pacific Railroad had published some interesting figures relating to oil-burning. This railroad had more oil-burning locomotives than any other in the States, and the figures were based on about 745 locomotives working on the Mountain Division. The calculations were on the basis that 152 gallons, or 3.62 barrels of oil, were equal to 2000 lb. of coal, the oil being taken at 18,500 B.Th.U., and the coal at 13,350 B.Th.U., the coal being probably soft. The horse-power of the Mallet locomotive was 2057, and the pounds of water evaporated per square foot of heating surface per hour were 6.39. The oil per square foot of heating surface per hour was 0.51 lb.; per indicated horse-power it was 1.61 lb., and the equivalent evaporation per pound of oil was 15.04 lb. It was interesting to note that the weight of the train was 1056 tons. Undoubtedly the combustion in the oil-burning fire-box was, in the case of the Tehuantepec locomotives, not complete; otherwise it would be unnecessary to use so much sand. He considered the chief trouble to be the absence of sufficient fire-box volume. The average temperature of oil-burning fire-boxes was found to be about 2500 deg. Fahr., as determined by Professor Gray, of the California University.

The President then announced that the next meeting would take place on Friday, January 19, 1912. Two papers of a very interesting character were under consideration. One was by Dr. Diesel on the "Diesel Oil-Engine," and the other was by Dr. Edward Hopkinson upon the "Evolution and Present Development of the Turbine Pump." One of these papers would be read at the next meeting.

The proceedings then terminated.

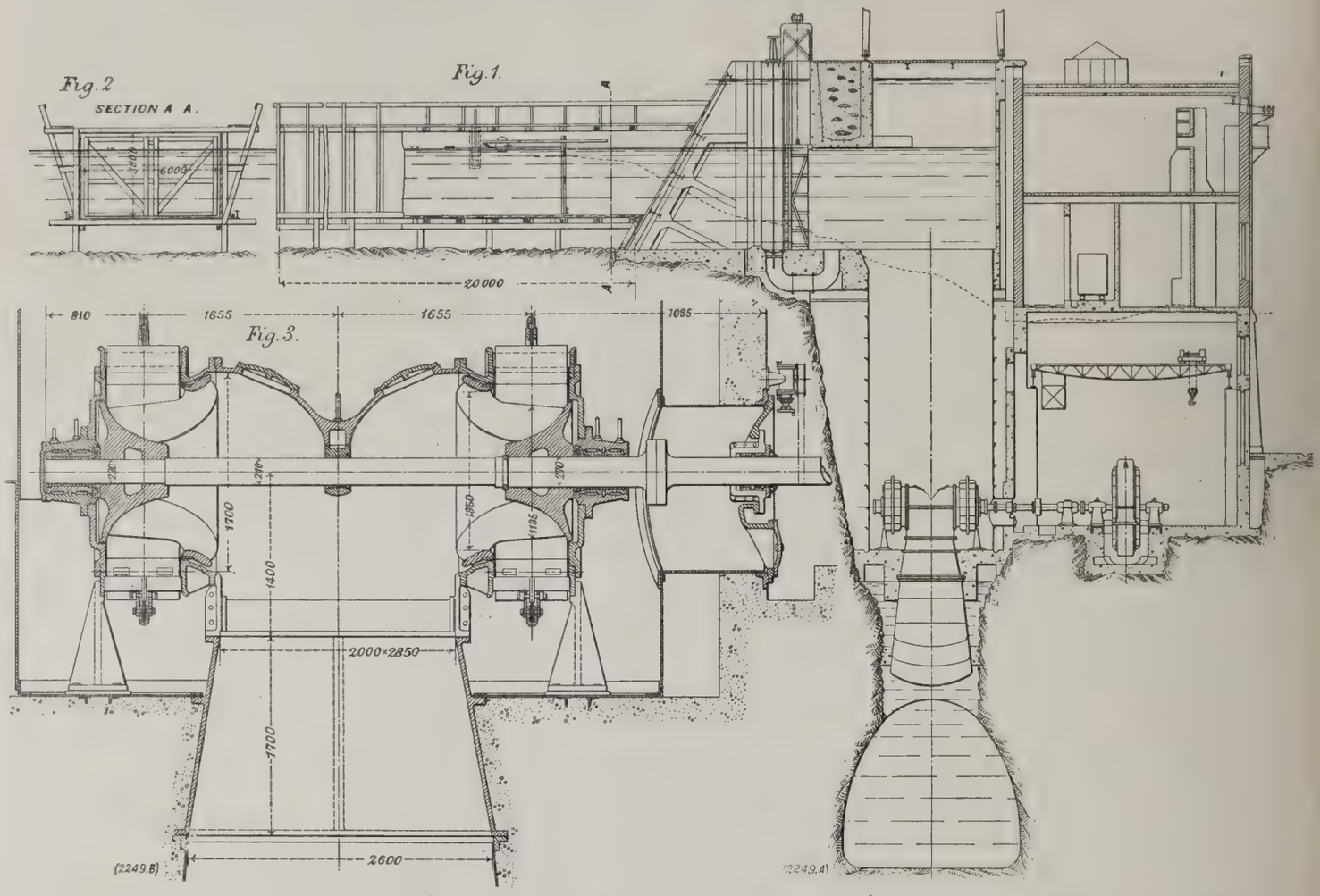
THE GULLSPANG HYDRO-ELECTRIC POWER-STATION, SWEDEN.

The Gullspang Hydro-Electric Power-Station is one of the most important in Sweden, and was at its completion, rather more than a year ago, the largest working concern of the kind. The Gullspang River is the lower portion of a stream, which at its different stages has different names, and which, next to the Klara River, is the largest of the streams having their outlets into Lake Vänern. Prior to reaching this lake, it passes Lake Skagern, the river distance between the two lakes being about 8 miles, and the level of the latter lake being about 24 m. (79 ft.) higher than that of Lake Vänern. There are two falls—the Gullspang Fall, or rather rapid, which, over a distance of $\frac{5}{8}$ mile, has an aggregate height of about 21 m. (69 ft.), and the Aras Fall, of about 3.5 m. ($11\frac{1}{2}$ ft.) height. The Gullspang Fall had for a considerable time been used for working various mills, &c., but these grew less and less important, and in 1906 a company—the Gullspang-Munkfors Power Company—was formed for the rational exploitation of the two falls, and for supplying electric current to the towns of Lidköping, Mariestad, Kristinehamn, Hällekis, Björneborg, Bäckhammar, &c.

The combination of the two falls in one power-plant was advantageous, inasmuch as the Munkfors Fall has no reservoir, whilst the Gullspang Fall has the already-mentioned Lake Skagern, with its (through regulation) unlimited possibilities for storage. By the aid of certain regulating works the Gullspang power-station could be planned for more than 3600 cub. ft. of water per second, although the average volume of water may not exceed 2520 cub. ft. per second, and the low-water volume has been as little as 972 cub. ft. per second. The smallest quantity of water that will be available after the regulation of Lake Skagern, and its damming up to its present high-water level, has been calculated at 1520 cub. ft. per second, 108 cub. ft. being reserved for the passing of fish. There is at present no timber-floating in this river. By the further regulation of some lakes higher up these figures may be raised.

It was first proposed to construct a solid dam, which, slightly arched against the water, should span the river between the two rocky banks; but when the place had been laid dry it was found that the rock bottom in the centre was $26\frac{1}{2}$ ft. below the river bed, and the proposed dam, if carried down to the firm rock, would consequently prove very costly. The construction was therefore altered, and a straight solid dam was built on the western shore, and across the western half

GULLSPANG HYDRO-ELECTRIC POWER-STATION, SWEDEN.



of the river-bed, where the rock was right up to the surface, whilst an arch dam was built across the portion where the rock lay deeper, its one end being supported by the solid dam, and the other by the rock on the eastern shore. By building a short, solid dam, also on the eastern shore, the width of span of the arch dam could be reduced to 131 ft. and its radius to 110 ft., an arrangement which entailed a considerable saving of masonry. The upper portion of the dam, to a height of 6½ ft., is constructed of strong reinforced concrete, the mixture used being 1 : 2 : 3. The reason for this strengthening lies in the fact that the arch dam, in order to provide sufficient outlet for the water, like the solid dam, had to be constructed with apertures separated by intermediate pillars, which support the necessary beams for the regulating-sluices. The intermediate pillars of the solid dam obtain sufficient stability by having their bases extended in the direction of the water pressure; in the arch dam, on the other hand, the intermediate pillars must be calculated as being inserted in the arch, which has to receive the water pressure both on the sluices and the intermediate pillars. The pressure on the concrete of the reinforced arch, with a water-level of 76½ ft., amounts to 228 lb. per square inch. This part of the arch is, besides, subject to changes of temperature and to one-sided strains from the sluices, which circumstances, under unfavourable conditions, made it necessary to reckon upon a pressure of 40 kilogs. per square centimetre (572 lb. per square inch).

The concrete dam is covered with masonry on all surfaces exposed to the water, except the back portion of the intermediate pillars of the arch dam, which would only have been weakened by being faced with stone. The mixture used for these pillars is 1 : 3 : 5. The front side of the dam is faced with cement, and in the solid dam there are drainage canals. In order to by-pass floods, the dam contains fifty wooden sluices, arranged in ten outlets; in the middle of the dam provision is made for the passage of the ice. All these outlet arrangements are so constructed that the level of the water at the dam can be raised to the highest level of Lake Skagern. There are efficient provisions for the passage of fish.

For the laying dry of the river-bed during the construction of the dam, a temporary tunnel of 50 sq. m. area (537 sq. ft.) and 50 m. (164 ft.) length was blasted in the rock on the left shore. This tunnel took all the water of the river for more than a year; it was rather an expensive affair, but the arrangement entailed very material advantages in connection with the building of the dam. It was considered that tests with concrete laid under water, undertaken elsewhere, had demonstrated that concrete so laid, even when fairly strong mixtures are used, was a very unreliable material. Entirely different results are obtained by pure cement amongst stones. The cement fills all the voids, and, left to itself, gradually hardens. After exhaustive tests, it was decided to use this method for the final closing of the tunnel, which had in the meantime been closed by a very strong arrangement of iron and wooden beams.

The inlet canal at Gullspang is principally blasted in the solid rock, and is in its upper portion protected by low earthen walls, and in its lower by high concrete walls, ordinary solid walls, mixture 1 : 5 : 7, with inserted stones, except at the front side, which is made of a somewhat stronger mixture.

The power-station and the distribution basin are situated together, as shown in Figs. 1 and 2, above. The turbines are placed, in open installation, in vertical metal cylinders, an arrangement which, both as regards the fixing and the inspection of the turbines and their efficiency, entails distinct advantages, but which, on the other hand, when it is a question of such considerable height of fall as exists here, materially increases the cost of installation. When, however, the volume of water per system is fairly large (720 cub. ft. per second), as in this case, and the conditions are otherwise favourable, the advantages may be said to outweigh the additional cost, which becomes smaller in proportion to the increase of the volume of water. The vertical metal cylinder is of 5.5 m. (18 ft.) diameter and 13 m. (43 ft.) height, with an upper chamber of reinforced concrete. Each turbine-chamber is independent, without any connection with the next, and rests on intermediate pillars of concrete erected between the plate-cylinders, but not directly on the rock. The necessary provisions for expansion have been made at all places.

The power-station, with its three stories, is located in a cavity blasted in the rock to a depth of 10 m. (32 ft.) below the surface. The outer walls of the buildings are entirely free of the surrounding rock, so as to avoid, as far as possible, dampness in the machinery hall. On the bottom floor, which rests on the rock, the electric generators are installed, direct coupled to the turbines, under which, in the longitudinal direction of the power-station, is formed the outlet tunnel, into which are taken the pipes from the turbines, as shown in Fig. 1. These suction-pipes are cast into strongly reinforced-concrete beams, which have to sustain the pressure from the plate cylinders and from the volume of water in and above these. The lower ends of the suction-pipes are also encased with concrete so as to protect them from rust (see Fig. 1).

The outer walls of the bottom story of the power-station are made entirely of concrete, partly because this material better resists the damp and partly because the load, especially on the longitudinal walls, is considerable. The wall towards the turbine chambers is built with a number of arches, supported by the intermediate pillars, and having the rock for outer support. The outer walls are made of reinforced concrete, and there is efficient provision for ventilation through openings to the respective turbine chambers, and ample exit through windows, &c. The transformers and high-voltage instruments are installed in the second story, and further instruments in the third story. The beams and floors are of reinforced concrete; the former were constructed when the girders had been brought in position, whilst the floor, so as to advance the work, was formed in advance in conveniently sized slabs,

GULLSPANG HYDRO-ELECTRIC POWER-STATION, SWEDEN.

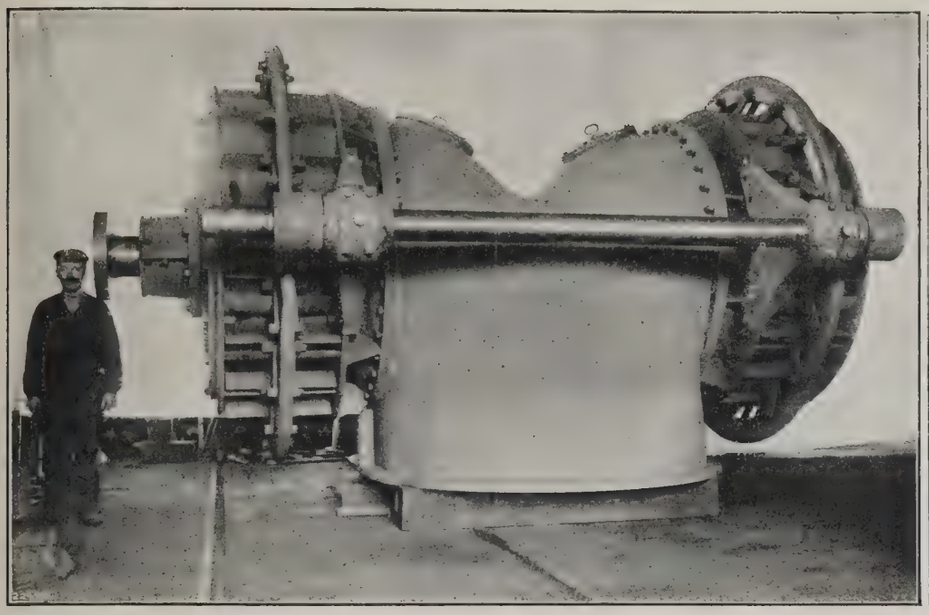


Fig. 4. Francis Type Double Turbine; The Kristinehamn Engineering Co., Kristinehamn.

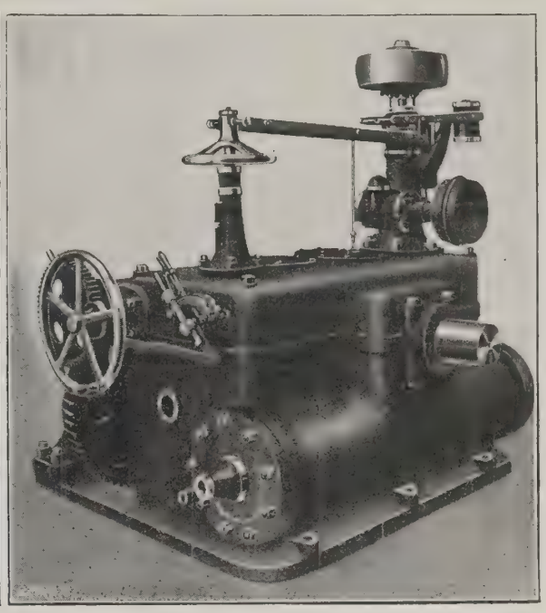
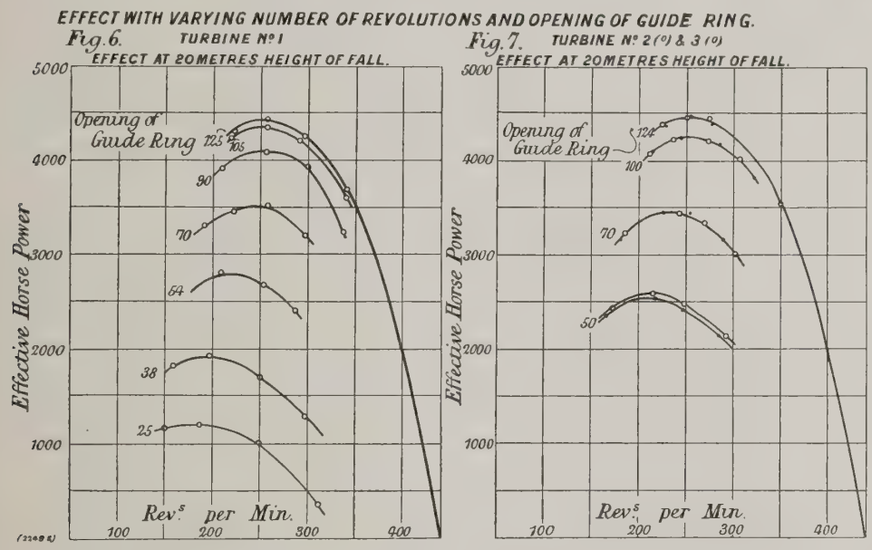


Fig. 5. Hydraulic Power Governor.



The exciting turbines are placed in insulated vertical plate-cylinders, of 2 m. (6 ft. 6¾ in.) diameter, to which the water is led from the distribution basin through horizontal pipes of 1 m. (3 ft. 3⅜ in.) diameter. Opposite the exciting plant there is a lower two-storied structure, along the longitudinal wall of the power-station, which contains the necessary low-voltage appliances, the switchboard forming the partition wall between the upper story and the machinery hall.

The power-station is at present built for four units, but the east-end wall is only a temporary one, made of wood. The distribution basin has, however, been designed and the blasting work carried out with the final capacity in view, so that extensions can be undertaken at any time. The power-station and the distribution basin are also placed sufficiently low to allow of a future junction with the Aras Fall, which will then be removed by blasting; this, with some regulation of the intermediate stream, will increase the present height of fall 20 m. (65½ ft.) by additional 2 m. (6 ft. 6¾ in.) at least. The first three units each have a turbine-shaft capacity of 4000 horse-power, the fourth of 4500 horse-power. The capacity of the exciting units is 200 horse-power for each. The outlet canal is partly constructed as tunnel, partly as open canal, and mostly blasted in the rock; owing to the possible future junction with the Aras Fall, it has been made 2.25 m. (7½ ft.) lower than would otherwise have been necessary.

The cost of the Gullspang Power-Station has considerably exceeded the calculated figure, which was admittedly too low, in addition to which various circumstances have added to the expense—amongst others, the rapidity with which the work had to be pushed ahead. Still the actual cost comes out reasonably, as will appear from the following table:—

First Stage.	Effective Turbine Horse-Power.	Cost. Total.	Cost. Per Horse-Power.
		kr.	kr.
Installed	16,500	3,175,000 (176,000*l.*)	192 (10*l.* 13*s.* 4*d.*)
Exclusive of reserve ..	12,000	3,175,000 (176,000*l.*)	265 (14*l.* 14*s.* 5*d.*)
Fully completed	25,000	3,500,000 (194,444*l.*)	138 (7*l.* 13*s.* 4*d.*)
Exclusive of reserve ..	21,000	3,500,000 (194,444*l.*)	167 (9*l.* 5*s.* 7*d.*)

The above full capacity figures are a fraction below those for the large State power-station at Trollhättan, and include the preparatory work for the junction with the Aras Fall already referred to.

The design and the execution of the engineering and constructive work has been carried out by the well-known Stockholm firm of Vattenbygnadsbyran, several of whose works have already been exhaustively dealt with in this journal. The turbines have been supplied by the Kristinehamn Engineering Company, Kristinehamn, and the electric plant by the General Swedish Electric Company, Westeras. The hydro-mechanical installation, according to the plans of Mr. H. Th. Holm, with the turbines placed in open plate cisterns, is of special interest, and has worked very satisfactorily.

According to contract, three of the large turbines, with 20 m. (66 ft.) effective height of fall, and 250 revolutions per minute, should develop at least 4000 horse-power each, and possess a mechanical efficiency of 79 per cent. with full load, 78 per cent. with three-quarter load, and 72 per cent. with half load; there is also one turbine yielding 4500 horse-power, with an efficiency of respectively 78, 79, and 72 per cent. at the loads previously mentioned. The contract contained the clause that for each per cent. the average efficiency was short of that guaranteed the manufacturers should pay a penalty of 2000 kr. (111*l.*) per turbine, and for each per cent. by which the efficiency exceeded the figures of the guarantee the manufacturers were to have a premium of 1500 kr. (83*l.*) per turbine.

It was specified that the hydraulic governors should maintain the speed variations within

± 15 per cent. with 100 per cent. power variation,
± 6 ,, 50 ,, ,,
± 3 ,, 25 ,, ,,

provided that the rotating portion of the generators, coupled to the turbines, was of a specified weight. The test was not to be considered as passed until these regulating conditions had been complied with.

The turbines, shown in Figs. 3 and 4, have been constructed as double Francis turbines, placed in open plate cylinders of 5.5 m. (18 ft.) diameter, and run at 265 revolutions per minute when developing 4000 horse-power, which is comparatively quick running. The guide-rings are fitted with eighteen movable blades of cast steel, and regulating-rings, likewise of steel, are attached to the middle of the guiding-rings. The motion from the governors is transmitted through two strong shafts, connected with each other by a system of arms in the power-station. The turbine shafts are of nickel steel and rest in three Babbitt-lined bearings, lubricated with grease, each from its own mechanically-worked lubricator. This lubricating arrangement, which had not previously been applied to such large turbines, acts most satisfactorily. The wheels are made of cast iron, with twenty blades of 12-mm. (½ in.) steel plates cast on. The inlet diameter of the wheels is 1135 mm. (3 ft. 9 in.), and their internal diameter at the ring 1350 mm. (4 ft. 6 in.). The general construction of the turbines otherwise is shown in Fig. 3, which is a section.

The governors (Fig. 5) are of the hydraulic type, with cylinders 330 mm. (13¼ in.) in diameter; the stroke is 450 mm. (18 in.), and the angle of the regulating shafts 60 deg. A servomotor, with oil-cistern and pendulum, besides hand-regulation, is attached; whilst the pump of the governor, with its air-bell,

is mounted on a separate foundation plate. The pumps are of the rotary type and deliver 3.5 litres (6 pints) of oil per second.

The height of fall was measured direct by means of a float in the outlet tunnel, and a gauge inserted in the turbine pool.

The results of the tests are shown graphically in Figs. 6 and 7, page 821, which show the output of the turbines at various openings of the guide-rings and revolutions per minute and with 20 m. (65½ ft.) height of fall. From these it will appear that turbine No. 1, with 250 revolutions per minute and 20 metres (65½ ft.) height of fall, develops 4410 horse-power, and the turbines Nos. 2 and 3, under the same conditions, 4460 horse-power each.

The diagram also shows that the power and the openings of the guide-rings correspond for all the turbines, so that the measurement of the water was confined to No. 1 turbine. The result of this measurement will appear from the appended table :

Opening of Guide-ring, in Millimetres.	Revolutions per Minute.	Depth of Water in Conduit, in Metres.	Volume of Water, Cubic Metres per Second.	Height of Fall, in Metres.	Theoretical Horse-Power.	Actual Horse-Power.	Efficiency.
25.5	256	3.190	6.26	21.32	1780	1025	0.576
38	253	3.150	9.09	21.32	2584	1979	0.766
54	253	3.150	12.53	21.30	3560	2991	0.840
70	253	3.140	16.00	21.25	4535	3870	0.853
125	252	2.997	22.20	20.96	6207	4743	0.764

From this it will appear that the efficiency of the turbines is :—

At full load	82 per cent.
,, three-quarter load	85 ,,
,, half load	79 ,,

As the guaranteed figures for the efficiency were respectively 79, 78, and 72 per cent., the efficiency actually obtained exceeds the one guaranteed by 5.67 per cent. The turbine No. 4, of 4500 horse-power capacity, was originally installed with slightly different wheels, but this was altered in accordance with those of the other three turbines, and the makers obtained the premium stipulated for all four turbines.

All the governors were subjected to tests, at which the speed variations were recorded by means of a self-registering tachograph. The results will appear from the subjoined table :—

Turbine No.	Pressure in Air-Bell.	Sudden Loading. Altered Horse-Power.	Greatest Speed Variation.	Corresponding Guarantee
	kg. per sq. cm.		per cent	per cent.
Large—1	13 (186 lb. per sq. in.)	− 1000	2	3
		+ 1000	3	
		− 2000	4	6
		+ 2000	5	
		− 3000	6	
		+ 3000	8	
		− 4000	10	15
		+ 4000	11	
Large—2	10 (143 lb. per sq. in.)	− 1000	2	3
		+ 1000	3	
		− 2000	4	6
		+ 2000	6	
		− 4000	12	15
		+ 4000	13	
Large—3	10 (143 lb. per sq. in.)	− 1000	2	3
		+ 1000	3	
		− 2000	4	6
		+ 2000	6	
		− 4000	12	15
		+ 4000	13	

The governors will consequently be seen to answer fully the conditions of the contract and work, free of hunting, at all loads. The figures representing the efficiency are particularly good, and possess special interest on account of the tests having been carried out with the greatest care. The results correspond most satisfactorily with those obtained at the Kristinehamn Works, and are the outcome of several years' systematic testing of different types and constructions; they fully bear out the accuracy of the methods of calculation adopted.

New Tunnel near Christiania.—At the end of the present year (1911) work will commence on the new tunnel for the railway from the Puselök road to Majorstnen, which will materially shorten the distance from the Aker district to Christiania. The work is to be completed by May 17, 1914. The tunnel partly passes through rock and partly through loose soil, of which latter the borings have evidenced more than had been anticipated.

LITERATURE.

Jahrbuch der Schiffbautechnischen Gesellschaft. Vol. XII. Berlin: Julius Springer. [Price 40 marks.]

The twelfth volume of the Jahrbuch der Schiffbautechnischen Gesellschaft, an elegant small quarto volume of 503 pages, profusely illustrated, as its predecessors, contains the proceedings of the twelfth annual meeting of the German Naval Architects, held at Berlin on November 17 to 19, 1910. The usual summer meeting of the Society was postponed till 1912 in view of the fiftieth anniversary meeting of our Institution of Naval Architects. A further increase in the membership had hardly been expected, since the leading shipbuilders had all joined. Yet the year 1910 closed with a roll of 1571 members of all classes, 17 more than in 1909; 20 members had died and 41 resigned, while 78 new members had been enlisted. Among the deceased were Hans Richter, manager of the engine department of the Germaniawerft, Kiel, formerly connected with the construction of large gas-engines at Nuremberg and rebuilder of the Thyssen Steel-Works at Mülheim, who died in his forty-second year; Consul-General Axel Johnson, of Stockholm; General Enrique Garcia de Angulo, of Madrid; Isidor Loewe, brother and partner of Ludwig Loewe, of Berlin, a man of eminent capacity and energy; Franz Clouth, founder of the well-known rubber works at Cöln-Nippes; and Heinrich Mehlis, of Berlin, whose name we shall mention lower down as one of the contributors of papers to the meeting; he died in his thirty-eighth year.

At the Berlin meeting of the Society the chair was taken either by the Honorary President, the Grand Duke Friedrich August of Oldenburg, or by the President, Professor C. Busley. As regards the tenor of the discussions, it might, perhaps, be said that the German engineer proceeds at once to a critique, without wasting words on compliments and on congratulating the meeting; there is not much difference otherwise between British and German discussions.

Several of the communications brought before the meeting have already been noticed in our columns. We commented upon Professor Frahm's important paper on "New Tanks for Preventing the Rolling of Ships" in our issue of December 16, 1910, and upon the communication of Dr.-Ing. Gebers on "The Development of a New Type of Tug for Canals by Means of Model Experiments" in our issue of June 23, 1911.* With respect to the anti-rolling tanks we have to add that Dr.-Ing. Horn, of the Germania-werft, has contributed a special memoir on "The Theory of Frahm's Tanks" to the volume, in which he explains his views more fully than he did at the meeting. Dr. Horn starts in his deductions from Föppl's ship's top, and he regards the resonance phenomena between the oscillations of the ship and of the waves, which Frahm, in Horn's opinion, considers the chief factors to be studied, as secondary. This statement was not accepted by Professor Frahm, and the purely theoretical considerations of Horn will less appeal to the engineer than Frahm's exposition, which is based on experiments and confirmed by observations on board.

The first paper brought before the meeting was one by Professor J. Stumpf, of Charlottenburg, on "The Further Development in the Construction of the Uni-Directional-Flow Steam-Engine," mentioning the construction of railway locomotives and of marine engines by the Stettiner Maschinenbau-Gesellschaft Vulcan, Messrs. Frerichs and Co., Gebrüder Sachsenberg, of Cöln-Deutz, and others. Professor Stumpf was criticised by several speakers during the discussion. Dr. W. Schmidt, of Kassel, thought that the ring for the exhaust-ports cooled the cylinder in radiator fashion, and he could not understand why superheated steam at 325 deg. Cent. should require jacketed cylinders; Mr. Gerdau, of Düsseldorf, asked why the cooling effect of the large piston of the Stumpf engine was altogether neglected in the calculations; Mr. Lichtensteiner, of Mannheim, thought that Professor Stumpf's comparative locomotive trials had not been conducted with comparable engines, and Mr. Henkel, of Kassel, objected that Professor Stumpf had made a change of front, inasmuch as he had, a year previously, demanded superheated steam for his engines and now recommended them for saturated steam. Professor Stumpf in his reply claimed the right of making progress in the course of a year. Engineers were immerged in dogmatism. He had in vain approached thirty German firms five years ago and had had to go abroad to get his first engines constructed; now he had engines aggregating half a million horse-power running or under construction.

The paper by Captain K. Thorbecke, of the German Navy, on "The Construction of Heavy Gun-Turrets on Board Ship" is noteworthy, because naval gunnery experts rarely express more than a very guarded general opinion in public meetings, and because firms like Messrs. Krupp do not often consent to the publication of drawings, such as they had placed at Captain Thorbecke's disposal. Captain Thorbecke would prefer three-gun turrets even for 35.5 cm. (14 in.) guns to two-gun turrets, and electric power to hydraulic power, on the biggest warships, at any rate; an efficient electrical training of the men would, of course, be required, but that was generally desirable on warships, and, it was acknowledged during the discussion, seemed to have been secured in the German Navy.

The paper by Mr. Th. Saiuberlich on "Marine Diesel Engines" describes and illustrates very fully the engines of two boats built by Messrs. J. Frerichs and Co., of Osterholz-Scharmbeck, the tug Frerichs, driven by a four-cylinder Diesel engine of 200 horse-power at 360 revolutions, and the herring-tug Ewersand, driven by a two-cylinder 90 horse-power Diesel motor at 330 revolutions. There was no technical discussion of this communication; the only speaker, Professor Flamm, regretted that his inquiries about Diesel engines addressed to other firms had elicited replies demanding high prices, while declining sufficient guarantees.

A paper on "Superheated-Steam Plants and Valve Engines for Marine Propulsion," compiled by Mr. Heinrich Mehlis, of Berlin, was, owing to the serious illness of the author, who died shortly afterwards, supplemented and read by Mr. L. Lichtensteiner, of Mannheim. Mr. Mehlis had dealt with the same subject in a previous communication of 1906, and he described now recent constructions, comprising those of 6000 horse-power tandem-engines for torpedo-boats, and the installation on board the yacht Lensahn of the Grand Duke of Oldenburg. All these engines are fitted with Schmidt superheaters and with Lentz valve-gear, and Mr. Lichtensteiner claimed for them that they required less oil with superheated steam than they would want with saturated steam. These and other claims found support in the meeting, though Professor Mentz, of Danzig, considered superheaters as objectionable on board ship, since the superheater could not be safely cut off at once when the engines had to be stopped, and because there was no time for repairs with marine engines; there had been trouble, moreover, he thought, on the Navy tender Drache with the lubrication. According to Mr. Henkel, of Kassel, the Geneva Steamship Company had actually realised a saving in oil whenever they passed from running with saturated steam to running with superheated steam in their stationary engines, and the oil consumption on the boats of the Oldenburg-Portuguese Steamship Company and of the Argo Line, which were provided with superheater installations, only wanted $\frac{1}{29}$ gramme (half a grain) of oil per horse-power hour, something like $\frac{3}{4}$ kg. every 24 hours. The valves of the marine engines as built by the firm of Heinrich Lanz, of Mannheim, were the same as those of their railway engines, except that the valves were horizontal on the locomotives. The Drache, it was pointed out, was not perfect in its auxiliary machinery, but it answered its purpose. The Grand Duke of Oldenburg admitted that he had so far needed a good deal of oil on his yacht (two 580 horse-power engines at 180 revolutions, driven by steam at 400 deg. Cent.); but that defect was being cured, and he would not part from his new engines, which would reverse almost more rapidly than he could himself manipulate the hand telegraph; there was no trouble whatever about cutting out the superheater when the engine was stopped.

The strong recommendations of electric thermometers of various kinds which Mr. Otto Weiss, of Berlin, gave in his lecture on "Temperature Measurements on Board Ship," indicated that the lecturer was better acquainted with his apparatus than with marine practice, and induced Dr. Max Wittenberg, of Hamburg, to stand up for the old mercury thermometer. For certain observations automatic temperature recorders are, of course,

* Compare Engineering, vol. xc., page 832, and vol. xci., page 828.

indispensable ; but if the sailor on the whole prefers to rely upon personal supervision at regulated frequent intervals, instead of trusting a number of dials, public safety will not be endangered.

The most instructive discourse on "Movements Accompanying Shooting," *i.e.*, movements of the projectile, the gun, the powder and gases, the air, and the object struck, delivered by Mr. C. Cranz, of Charlottenburg, stands apart from the other papers. In spite of the wonderful ingenuity displayed in the improvement of firearms by mathematicians as well as by practical experts, the artillerist has still to rely upon empirical rules in many simple problems, as regards the trajectories, *e.g.*, because he cannot supply the mathematician with sufficient data for the determination of his constants. Mr. Cranz makes in his studies extensive use of the photographic method introduced by E. Mach in 1885, and of the modern kinematograph. By means of spark photographs the velocity of the projectile and indirectly, hence, the air resistance and its dependance upon the shape of the projectile, can be investigated. Apart from the recoil, the rifle or gun oscillates longitudinally, transversely, and torsionally while being discharged. Mr. Cranz has only been able to observe the transversal vibrations, which may be said to correspond to a fundamental oscillation and to its harmonics. The fundamental oscillation and the first harmonic, he finds, have a common node, the position of which can be fixed photographically and also with the aid of Chladni figures. The upper harmonics in particular tend to deflect the gun upward or downward, so that the target is hit at too high or too low a spot ; fortunately these effects become weaker with increasing initial velocity. Mr. Cranz also showed, by the photographic method, how some unburnt powder grains were scattered about, so that the gases rushing in front of the projectile might make or break a chronograph circuit before the projectile itself acted, and that the cartridge of a magazine rifle might enter the explosion chamber obliquely instead of horizontally. The exact positions of parts of the locking mechanism during the discharge may also be ascertained by photographic means.

The air resistance and the air waves in front and in the rear of the projectile are studied with the aid of Mach's interference refractor, and Mr. Cranz has been able to prove that the attempts made to reduce the air resistance by perforating the projectile longitudinally are futile. Very little is definitely known about the deflections which the projectile undergoes in its trajectory. The rifling, which steadies the motion by rotating the projectile about its longitudinal axis, introduces a kind of precession effect, for instance, which has not, so far, been measured. A projectile, to mention an interesting case of another kind, sent vertically upward with a velocity of 890 m. per second, struck the ground again, still in the same vertical position, with a velocity of only 30 or 40 m. By his concluding demonstrations Mr. Cranz illustrated the explosive effect which high-speed projectiles produce in the object struck, lumps of clay, bones, bladders filled with water, &c. ; it is as if the projectile ignited some blasting agent contained in the object. The Emperor William II., who was present during the discourse, referred to this point in his contribution to the discussion ; for years he has had observations and measurements taken on the deer which he shoots. Mr. Cranz ascribed the terrible destruction wrought by the bullets partly to the nutation of the projectile, which reacts against impediments in the manner of a spinning-top.

BOOKS RECEIVED.

Business Prospects Year-Book, 1912. Edited by JOSEPH DAVIES and C. P. HAILEY. London, Sheffield, Cardiff : The Business Statistics Company, Limited. [Price 5s. net.]

The "Mechanical World" Pocket Diary and Year-Book for 1912. Twenty-fifth year of publication. Manchester : Emmott and Co., Limited., *Mechanical World* offices. [Price 6d. net ; post free, 8d.]

The *"Mechanical World" Electrical Pocket-Book for* 1912. Containing a collection of electrical engineering notes, rules, tables, and data. Manchester and London: Emmott and Co. Japan : The Maruzen-Kabushiki-Kaisha. [Price 6d. net.]

Ontario: Twentieth Annual Report of the Bureau of Mines, 1911 ; *being Vol. XX., Part I.* Toronto : L. K. Cameron, Printer to the King.

Junta de Obras del Puerto de Bilbao: Memoria que Manifiesta el Estado y Progreso de las Obras de Mejora de la Ria y Puerto de Bilbao y Cuenta de Ingresos y Gastos durante el Año de 1910. Bilbao : Imprenta y Litografia de Emeterio Verdes y Achirica, Antigua Casa de Juan e Delmas, Calle del Correo, No. 9.

Pocket Dictionary of the English and Russian Languages. English-Russian and Russian-English. Hossfeld's Educational Series. By S. W. LINDEN and Dr. TH. KAWRAISKY. London : Hirschfeld Brothers, Limited ; Glasgow : Alexander Stenhouse, [Price 7s. 6d. net.]

The Navy League Annual, 1911. Edited by ALAN H. BURGOYNE, M.P. Fifth year of issue. London : John Murray. [Price 2s. 6d. net.]

Canada : Department of Mines. Report on the Molybdenum Ores of Canada. By T. L. WALKER, M.A., Ph.D. Ottawa : Government Printing Bureau.

Canada : Department of Mines. Report on the Gypsum Deposits of the Maritime Provinces. By WILLIAM F. JENNISON. Ottawa : Government Printing Bureau.

The Journal of the Municipal School of Technology, Manchester. Vol. IV., 1910.

Reinforced-Concrete Construction in Theory and Practice. By HENRY ADAMS, M. Inst. C.E., M.I. Mech. E., and EERNEST R. MATTHEWS, Assoc. M. Inst. C.E. F.R.S. (Ed.). London: Longmans, Green, and Co. [Price 10s. 6d. net.]

Petrol-Air Gas. By Professor C. A. M. SMITH, M.Sc. London : P. A. Gilbert Wood. [Price 2s.]

Twenty-Fourth Annual Report of the Commissioner of Labour, 1909. *Workmen's Insurance and Compensation Systems in Europe.* In two volumes. Vol. II.—*Great Britain, Italy, Norway, Russia, Spain, Sweden.* Washington : Government Printing Office.

Electric Mains and Distributing Systems. By J. R. DICK, B.Sc., M.I.E.E., and F. FERNIE, A.M. Inst. C.E., A.M.I.E.E. London : The *Electrician* Printing and Publishing Company, Limited. [Price 10s. 6d. net.]

The Railway Conquest of the World. By FREDERICK A. TALBOT. London : William Heinemann. [Price 6s. net.]

New South Wales : Annual Report of the Department of Mines, 1910. Sydney : William Applegate Gullick, Government Printer.

British Columbia : Annual Report of the Minister of Mines for the Year ending December 31, 1910 ; *being an Account of Mining Operations for Gold, Coal, &c.* Victoria, B.C. : Richard Wolfenden, Printer to the King.

Metropolis Water Act, 1902. *Eighth Annual Report of the Metropolitan Water Board for the Year ended March* 31, 1911. London : Metropolitan Water Board, Savoy-court, Strand, W.C. ; Charles Straker and Sons, Limited, Bishopsgate-avenue, E.C.

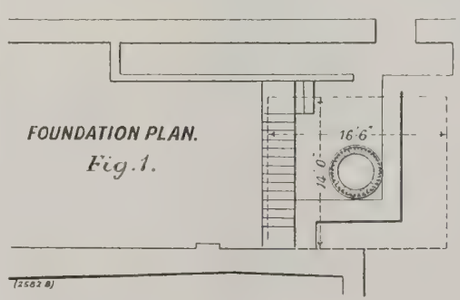
Gleichgang und Massenkräfte bei Fahr- und Flugzeugmaschinen. Eine Untersuchung über Zylinderzahl und Zylinderanordnung. By Dr.-Ing. OTTO KÖLSCH. Berlin : Julius Springer. [Price 5 marks.]

A CHIMNEY-STACK OF REINFORCED CONCRETE.

By OSCAR FABER, B.Sc. A.M.I.C.E.

A CHIMNEY recently erected by the firm of G. Trollope and Sons and Colls and Sons, Limited, of 5, Coleman-street, E.C., to whom the writer is chief engineer, has several features which it is thought are of sufficient general interest to justify the publication of a brief account.

The chimney was erected to the order of a company in London on a site near Drury-lane, W.C., the object



FOUNDATION PLAN.
Fig. 1.

of the stack being to carry the exhaust gases from internal-combustion engines to such a height from the ground that they cannot constitute a nuisance in the surrounding neighbourhood. The stack is erected to replace four steel pipes having a total height of 85 ft. from the ground, which were found to be insufficient to effect the above-mentioned purpose. The decision of the company to erect a new stack was also largely due to the installation of several additional units in their generating station.

The new shaft is 144 ft. 9 in. in height, measuring from the top of foundations, which coincides with basement-floor level. As the volume of gases to be carried up is comparatively small, an inside diameter of 2 ft. 6 in. was considered sufficient.

It will be of interest here to explain the considerations which led to the erection of the chimney in reinforced concrete, since, though the advantages of this material are frequently lauded in a general way, the particular chimney under consideration could hardly have been built in any other material. The chimney, if built of brick, would have to comply with the London Building Act of 1894, Section 65, which enacts, *inter alia*—

(1) Every shaft shall . . . taper gradually from the base to the top of the shaft at the rate of at least 2½ in. in 10 ft. of height.

(2) The thickness of brickwork at the top of the shaft . . . shall be at least 8½ in., and shall be increased at least one half-brick for every 20 ft. measured downwards.

(6) The width of the base of the shaft . . . shall be at least . . . if the same is round . . . one-twelfth of the height.

(7) Any fire-bricks built inside the lower portion of the shaft shall be provided as additional to, and independent of, the thickness of brickwork prescribed by those rules, and shall not be bonded therewith.

It will be seen from these that the minimum dimensions permissible for the brick-shaft would be :—

Outside diameter at top	4 ft.
,, ,, base	12 ft.
Wall thickness at top	9 in.
,, ,, base	3 ft.

Allowing a wind pressure of 25 lb. per sq. ft. on the projected area of the chimney (this pressure being assumed to include the reduction factor for circular cross-section), it will be found that the overturning moment

$$M = 1{,}748{,}000 \text{ ft.-lbs.},$$

and the weight

$$W = 638{,}000 \text{ lb.}$$

Whence

the eccentricity $e = 2.74$ ft.

If the brickwork were capable of resisting tension, the maximum compressive stress would be

$$C = \frac{638{,}000}{84.75} + \frac{1{,}748{,}000}{158.8}$$

$$= 7530 + 11{,}000 = 18{,}530 \text{ lb./ft.}^2,$$

or 128 lb./in.^{2}.

This figure would only be justified if the brickwork were capable of resisting a tensile stress of 3470 lb./ft.^{2}

or 24.1 lb./in.^{2}

The exact calculation of the maximum pressure when the tensile strength is ignored is not a simple matter, although it may be determined in the same manner as that advocated for reinforced-concrete chimneys in the article by Messrs. Taylor, Glenday, and the writer, which appeared in ENGINEERING, March 13, 1908. It is obvious, however, that it would exceed 128 lb. per sq. in., whereas 125 lb. per sq. in. is the limiting stress allowed by the London County Council for hard brick in cement mortar. It will be seen, therefore, that an outside diameter of 12 ft. is not only the least permissible by the London Building Act, but is also the least which a prudent engineer would care to erect.

This size of chimney, though small in comparison to its height, is, however, considerably greater than could be erected at Short's Gardens, owing to great scarcity of room. The alternatives were therefore reduced to a self-supporting chimney of steel or reinforced concrete. The first of these could not be passed as a permanent structure by the London County Council, owing to the corrosion of the steelwork, and only a reinforced-concrete chimney would meet the case. When it is seen that the diameter at the base was kept down to 5 ft., it will be seen how effective was the substitution of reinforced concrete for brick.

The site occupied by the chimney is shown by Fig. 1, annexed, while the details of the design are illustrated by the engravings on page 824. From these it will be seen that the lower portion of the chimney, up to flue entrance, is 1 ft. 3 in. thick, and above that 6 in. thick. Above the flue entrance a lining of firebrick 5 in. thick is provided, with an air-space 4 in. thick between it and the outside shell. Vent-holes are left near the flue entrance, through which a current of air is induced in the air-space between the liner and the outer shell.

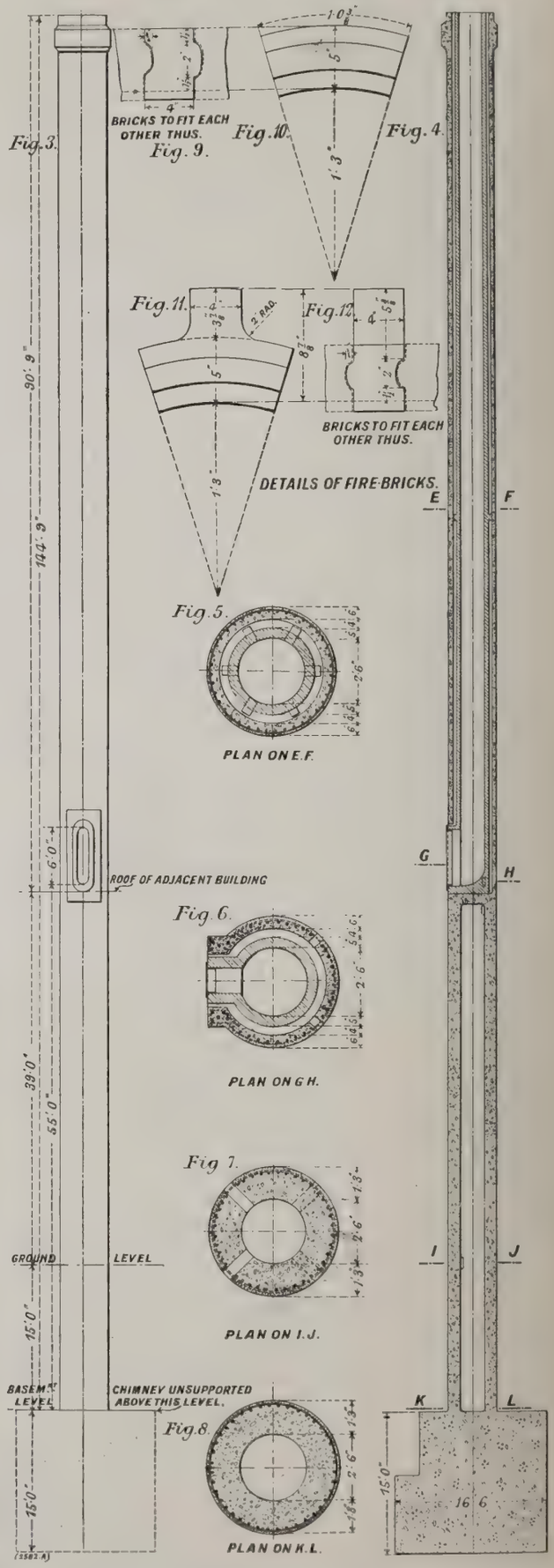
Experience with several chimneys of this type has shown that the concrete shell is liable to crack badly under the heat of the chimney, and this fact has no doubt hindered to no small degree the employment of reinforced concrete for this purpose. Some theoretical calculations of temperature stresses led the writer to a system of construction in which timber rings are embedded at intervals on the inside face of the concrete shell, which practically reduces to zero the stresses due to expansion. This system of construction, which is patented by the writer, was adopted by the Associated Portland Cement Manufacturers in a chimney built by them at their works at Burham, on the Medway. This chimney has now been in use several months, and is quite free from any cracks due to temperature stresses. The chimney forming the subject of this article was also built on this system, though, of course, its success here cannot be gauged at the time of writing.

The lightning conductors are four in number, and are screwed on to the tops of four of the longitudinal bars, thus saving the copper strip down the length of the chimney. Electrical connection was made between the lower ends of the bars and earth, and a test of the resistance between the spikes of the conductor and earth showed that the connections were all they should be. This is of interest, as no special precau-

CHIMNEY-STACK OF REINFORCED CONCRETE.

CONSTRUCTED BY MESSRS. G. TROLLOPE AND SONS AND COLLS AND SONS, LIMITED, CONTRACTORS, LONDON.

Fig. 2



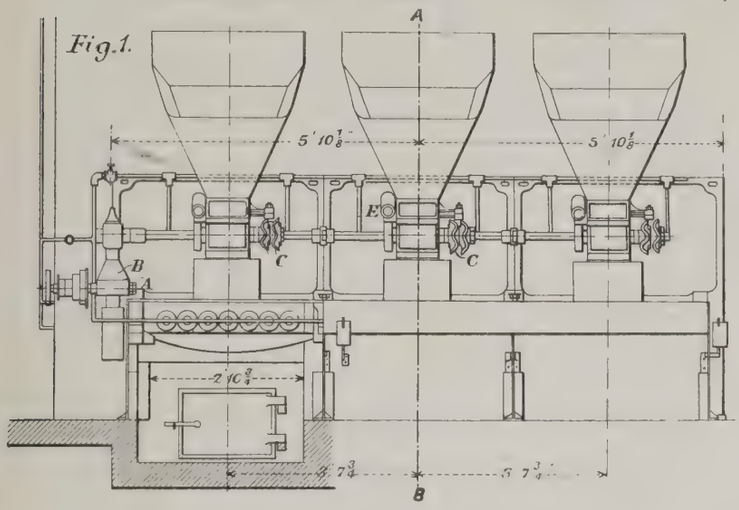
tions were taken to ensure good contact where the longitudinal bars lapped with those of the higher tier, the bars being simply lapped and held together by ¾-in. U-bolts. The reinforcement used in the chimney was indented bars.

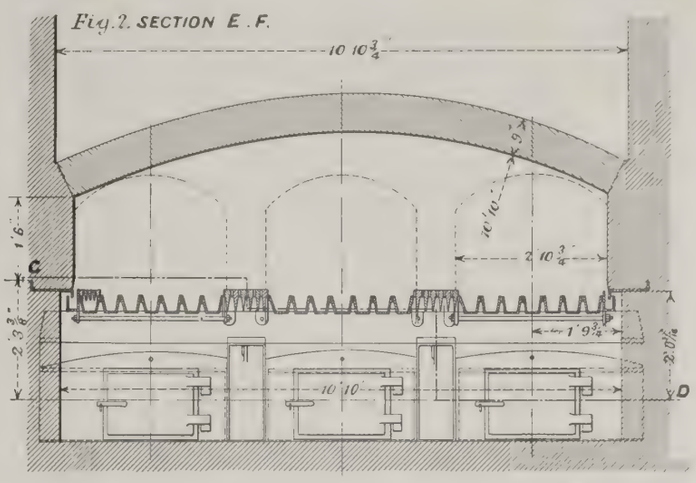
The foundation had to be taken down 15 ft. below basement level, which is itself 14 ft. 9 in. below ground level, and as it was necessary to underpin the existing walls under which it was built, it was made a solid block of concrete 16 ft. 6 in. by 14 ft., thus serving for the underpinning also. A staircase is formed out of the foundation block for giving access to the engine-room, which is below the yard.

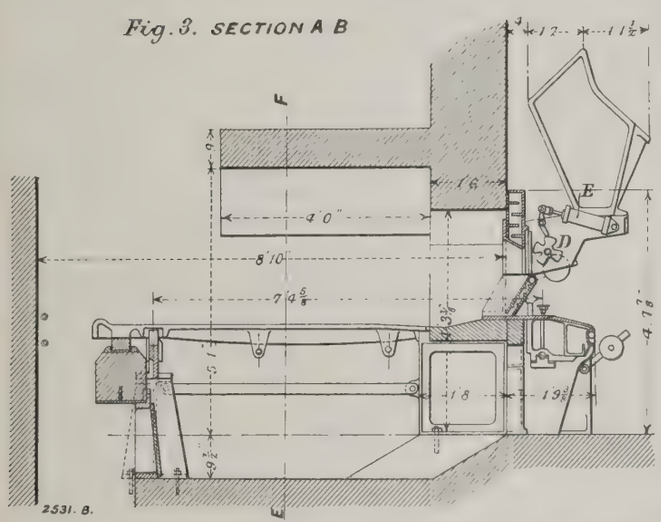
The firebrick lining consists of special firebricks made with a raised rib, 2 in. by ¾ in., fitting into a corresponding recess in the next course. To ensure the lining remaining concentric with the outer shell, special bricks are used at intervals 10 ft. apart, with side projections. About ⅜-in. clearance is left between these projections and the outer shell to allow for expansion of the firebricks.

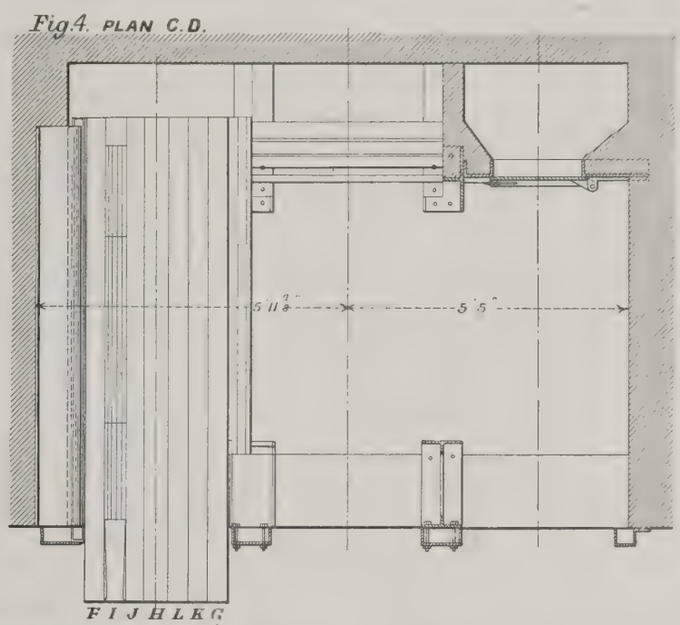
MECHANICAL STOKERS AT THE MINES DE DOURGES CO.'S WORKS, FRANCE.

CONSTRUCTED BY MESSRS. ED. BENNIS AND CO., LIMITED, ENGINEERS, LITTLE HULTON, BOLTON.









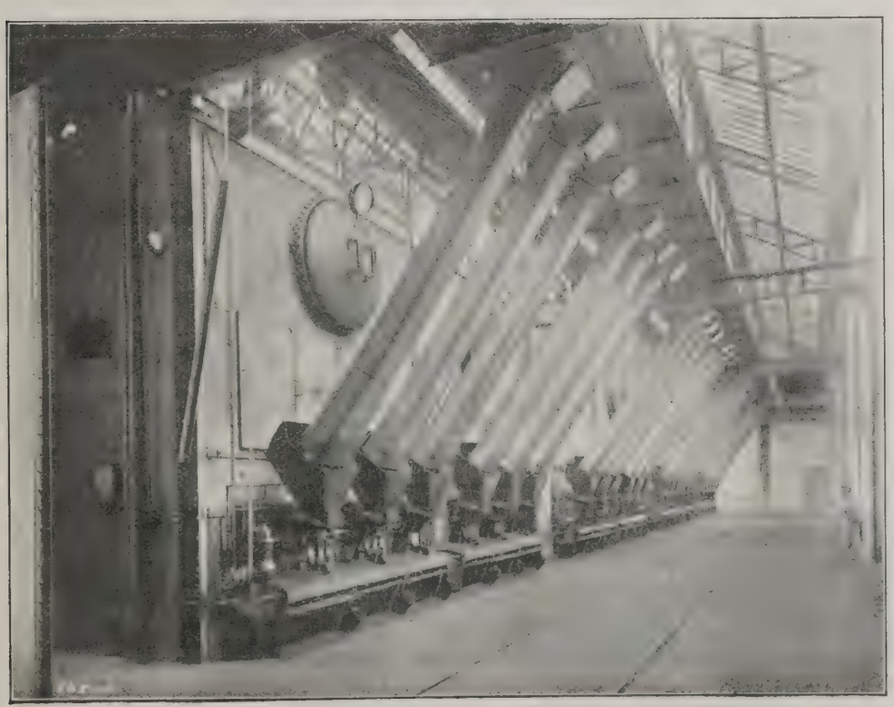


FIG. 5.

WE have from time to time described in our pages installations of furnace plant fitted up by Messrs. Ed. Bennis and Co., Limited, Little Hulton, Bolton, in connection with steam boilers, and we now illustrate another plant by the firm which has recently been installed at the works of the Mines de Dourges Company, France, which contains some special features. A general view of the installation is shown in the half-tone engraving, Fig. 5, while detail views of one of the furnaces may be seen in Figs. 1 to 4, above, these being respectively a front elevation, a transverse section, a longitudinal section, and a sectional plan.

In the course of 1902 and 1903 the Mines de Dourges Company tested one double mechanical stoker under a semi-tubular boiler of 250 sq. m. (2687 sq. ft.) heating surface, and they carried out a number of comparative tests between hand-firing and the Bennis stokers with various grades of fuel, ranging from the best qualities produced at their collieries down to the lowest grade washings. As a result of these tests, the company began to erect, in the year 1909, a central electric power-house, which includes the following plant:—Eight Buttner water-tube boilers working at a pressure of 200 lb. per sq. in., each boiler having a heating surface of 270 sq. m. (2900 sq. ft.). Attached to each boiler there is a superheater of 85 sq. m. (914 sq. ft.) area, formed of solid-drawn weldless tubes of 38 mm. (1½ in.) outside diameter, and 4 mm. (0.16 in.) thick. By means of this superheater the temperature of the steam can be raised to 325 deg. Cent. In addition, the boiler plant is supplied with four Green's economisers, one to each pair of boilers, each economiser consisting of 192 cast-iron tubes, 10 mm. (0.4 in.) thick, 2.72 m. (9 ft.) long, and having an internal diameter of 99 mm. (4 in.). These tubes are jointed into twenty-four "elements," or groups, by special cast-iron boxes. The heating surface of each economiser is 178 sq. m. (1910 sq. ft.), and the boilers are fed usually by an electric centrifugal pump of the Rateau type. There is also

a double-acting steam pump driven by two compound steam cylinders, and automatic valves are fitted, which regulate the admittance of the water to the boilers in such a way as to ensure a constant water-level.

Coming now to the mechanical stoker, which is a special part of the installation, and was fitted by Messrs. Ed. Bennis and Co., Limited, it will be seen by Fig. 1 that there is a shaft A carrying a cone pulley in the gearing bracket B, the shaft receiving its motion from another shaft driven by an electric motor, not shown in the drawing. The motion of the shaft A is communicated to the feed-shaft and to the bar-shaft of the machine by means of worm gearing, and the feed-shaft in turn turns the scroll cams C which work the pushing-shovel for the fuel, and give to it a backward and forward motion which forces the required quantity of fuel over the grate according to the regulation of the scroll cams. Meanwhile the four-arm cam D, which is also fixed on the same shaft, draws back the throwing-shovel, and by moving a piston in the pneumatic cylinder E compresses the air within that cylinder while the coal, to be thrown on the grate, is falling in front of the throwing-shovel. This throwing-shovel was fully illustrated and described by us on page 95 of our last volume, and we need not, therefore, devote much space to it here. We may, however, say that as soon as the lever of the throwing-shovel escapes from the cam D the shovel is rapidly drawn forward by the compressed air in the pneumatic cylinder E and strikes the fuel, which it throws forward to a certain distance all over the grate. Since the arms of the cam are unequal, four different throws are given to the shovel, and four different sections of the grate are successively covered with fuel. The distance to which the fuel is thrown at each turn is regulated, according to the quality of the fuel, by adjusting the pneumatic cylinder.

While the fuel is being fed, as described above, the grate is itself operating as follows :—The shaft driving the bars is actuated by gearing which takes its movement from the cone pulley seen in Fig. 1. The end cams of each set of seven fire-bars press on the heels of the side bars F and G, Fig. 4. These bars move about 7 cm. (2¾ in.) out of the furnaces, and then remain stationary. The cam which actuates the middle bar H then comes in contact with the wearing-piece on that bar, and withdraws it the same distance. After this the cams belonging to the bars I, J, K, and L cause these bars to move forward in a similar way in succession. Thus each bar is moving between two stationary bars. When the side bars F and G move forward, an iron bar, which is placed between two projections on the upper surface on these bars, comes forward with them, and the intermediate bars then move forward until the projections on their upper surface touch this iron bar. The cam-shaft continuing to turn, the other cams belonging to the movable bars F and G come into action, and force these bars into the furnace again, and by means of the iron bar mentioned above and the projections the intermediate bars go in simultaneously.

The same series of movements is repeated at every turn of the cam-shaft, the object being to break up clinkers on the grate, to separate the clinker from the coal, and to cause the whole to move gradually towards the end of the grate, where the ashes finally fall into a chamber provided between the end of the grate and the bridge of the boiler. The ashes are withdrawn at intervals during the day by means of conveyors or by hand. The back is separated from the space beneath the bars by a partition, in order to avoid the admission of cold air, the partition having hermetically-closed doors. The fuel being thrown intermittently in small quantities and on different parts of the grate, each feed varying according to circumstances from 300 to 500 grammes (0.66 lb. to 1.1 lb.), the coal lights up rapidly, and the fire is always bright, being constantly cleaned from ashes and clinker. The maximum efficiency appears to be obtained by means of rapid and complete combustion, which, it is said, results in the complete abolition of black smoke.

The fuel is brought in trucks into the mixing-room, where it is placed in towers provided with an arrangement similar to ploughshares, which ensure the intimate mixture in proper proportions of the various qualities of fuel to be consumed. The mixed fuel is then fed into the hoppers of the mechanical stokers by means of an elevator and conveyor. The fuel at present used at these works is made up of the following mixture : —75 per cent. of mixed washings, including very small nuts of coal and a lot of fine dust, which is not easily separated from it ; 25 per cent. of small matter, carbonaceous earth, and of material from the walls of the mine. The analyses of these fuels were as follow : —Small coal—moisture, 15 per cent. ; ash, 35 to 37 per cent. ; volatile matter, 16 to 17 per cent. Refuse—moisture, 2½ per cent. ; ash, 25 to 28 per cent. ; volatile matter, 23 to 24 per cent. The engine-room includes two turbo-alternators, of an output of 3000 kw. each.

THE CHINESE TRAINING CRUISER "YING SWEI."

Special interest attaches to the drawings reproduced on our two-page plate this week, as they illustrate the views of one of our leading naval construction firms as to the type of ship best suited for the training of officers and men in connection with modern munitions of naval warfare. The successful completion of the trials of the ship this month also foreshadows the beginning of a revival of the naval prestige of the Empire of China. This vessel is the Ying Swei, built by Messrs. Vickers, Limited, at their naval construction works at Barrow-in-Furness. While having all the fighting capacity possible in a ship of the draught (13 ft.) and of the limited displacement (2400 tons) prescribed by the Chinese authorities to meet certain harbour conditions, she excels in the comprehensive character of the provisions introduced by the designers for the effective training of Chinese officers and men. Messrs. Vickers, Limited, are responsible for the design, which, like the plans for many of the later warships, has been prepared by Mr. T. G. Owens, the naval constructor and a special director of the company. The special features of the design are :—(1) The great variety in the size of the guns fitted—6-in., 4-in., 14-pounders, 3-pounders, and 1½-pounders—all introduced primarily for instructional purposes ; but incidentally making the cruiser a formidable fighting ship. (2) The different types of boilers on board—cylindrical and water-tube—so that the Chinese stokers may acquire experience. (3) The adoption of alternative systems of auxiliary machinery, as far as is consistent with efficiency, for the education of Chinese officers and crew. (4) The unusually large quantity of ammunition carried : 160 rounds for each of the two 6-in. guns, 200 rounds for each of the four 4-in. guns, and 1000 rounds for each of the smaller guns, which permits of extensive battle practice, and confers the advantage in the maintenance of a long engagement in war. (5) The embodying of an unusually thick protective deck—1½ in.—in such a light cruiser. (6) The ensurance of a speed of 20 knots under easy steaming conditions and without exacting that care and organisation in the stokehold which come only with prolonged experience.

The principal dimensions of the ship are as follow :—

Length between perpendiculars ...	330 ft.
Breadth, moulded	39 ft. 6 in.
Depth, moulded	23 ft. 9 in.
Mean draught	13 ft.
Displacement (about)	2500 tons.
Speed (about)	20 knots.

The hull, as shown by the longitudinal section (Fig. 2), is divided into numerous compartments by strong water-tight bulkheads and flats, the forecastle, or collision bulkhead, being made specially strong. A double bottom extends throughout almost the entire length of the vessel, in which stowage is provided for feed-water and oil-fuel for the boilers.

The armament consists of two 6-in. quick-firing guns, one carried on the forecastle deck (Fig. 3), and the other on the poop-deck (Fig. 3); four 4-in. quick-firing guns placed on the upper deck (Fig. 4)—two at the aft end of the forecastle and two at the fore end of the poop, at the sides of the ship ; two 14-pounder quick-firing guns, one on each end of the upper deck amidships ; six 3-pounder quick-firing guns, three carried on each side of the upper deck in the waist (Fig. 4), and two 1½-pounder quick-firing guns placed on the bridge (Fig. 3).

Two 18-in. revolving deck torpedo-tubes are carried, one on each side of the upper deck aft (Fig. 4). The guns and torpedo-tubes are controlled in accordance with the latest practice.

The vital parts of the vessel are protected by an armoured deck of the usual shape, fitted in the vicinity of the water-line and extending throughout the entire length of the vessel (Fig. 2). The steering-gear and the engine in connection with the capstan-gear are placed under the protection of this deck. The coal-bunkers are so arranged along the sides of the vessel, as shown in Figs. 5 and 7, both above and below the protective deck, as to give a maximum of protection from gun-fire.

The ammunition for the large guns is taken through armoured tubes on its way to the guns, and an armoured conning-tower is built on the forecastle deck (Fig. 2), while an armoured tube protects the gear-rods, &c., passing from the conning-tower to under the protective deck. The range-finder platform, searchlight platform, and navigating bridge are placed over the aft end of the forecastle deck, above the conning-tower (Fig. 3). A searchlight platform is also fitted over the fore end of the poop. The larger guns are served by electric bollard-hoists.

Accommodation is provided for 230 officers and men and 40 cadets. A long forecastle and poop are built above the upper deck at the ends of the vessel, which provide accommodation for the crew, &c., forward, and for the captain and chief officers aft (Fig. 4).

The two masts are made suitable for taking a wireless telegraph installation of wide range.

Under the upper deck forward accommodation is provided for the crew, their wash-places being built in the casing amidships. The quarters for the officers and the school-room and quarters for the cadets are placed aft (Fig. 5).

The galleys are placed in the casings on the upper deck amidships, and the steam and other boats are carried on skid-beams and in davits along the sides of the upper deck.

Under the protective deck forward and aft (Fig. 7) are placed the magazines, shell-rooms, store-rooms, fresh water, &c. A cold store for the preserving of meat, vegetables, and fish is placed under the protective deck forward. The ship is lighted throughout by electricity on the latest system.

The propelling machinery is of the Parsons turbine type, with three lines of shafting, and one propeller on each shaft. The turbines are arranged in one engine-room (Fig. 7). The high-pressure ahead turbine is on the centre shaft, and a low-pressure ahead on each wing shaft. The wing shafts are arranged for working astern, a reversing turbine being incorporated in each of the two low-pressure turbine casings. In addition to the main steam connections to the high-pressure ahead turbine, separate steam connections with regulating-valves are fitted to each of the low-pressure ahead and astern turbines. For economical working at low speeds a cruising element is fitted in the high-pressure end of the high-pressure turbine. All the turbine bearings and shaft bearings are arranged for forced lubrication, pumps being supplied for this purpose, together with an oil-cooler and tanks, &c. The shafting throughout is of forged steel, and the various lengths filleted into one another. The propellers are three-bladed, the bosses and blades being cast solid of manganese bronze ; the wing propellers are arranged to work outwards when going ahead.

There are two condensers—one in each wing of the ship (Fig. 7). They are cylindrical in form, with the casings built up of steel plates and angles, and with conical ends made of gun-metal. The circulating water is supplied by two pumps of the centrifugal type, driven by independent single-cylinder engines ; these pumps are also arranged to draw from the bilges. The main air-pumps are independent, direct-acting, two in number, one for each condenser.

The distilling and evaporating machinery supplied is of ample capacity, two evaporators being fitted capable of supplying 35 tons of water per 24 hours, and one distilling condenser capable of condensing all the steam from the evaporators. The evaporators are arranged to work under the closed exhaust system, the steam pressure in the generating coils being 25 lb. per square inch, taken from the auxiliary exhaust system or the auxiliary steam service.

There are six boilers arranged as shown in Fig. 7. These include water-tube, cylindrical boilers and generators of the White-Forster type. The latter are arranged to burn oil fuel as well as coal. There are four water-tube boilers, and these together are capable of producing steam for about two-thirds of the total horse-power. The cylindrical boilers are of the single-ended return-tube type, designed to work under the forced-draught closed-stokehold system. The total heating surface is 12,900 sq. ft., and a total grate surface of 287 sq. ft. Air is supplied to the stokehold by six steam-driven fans of the double-inlet type, the engines being of the enclosed type, fitted with forced lubrication. The feed-water is supplied to the boilers by four feed-pumps of Weir's direct-acting type.

The vessel, as shown, has two funnels and two masts, and the steam and other boats are carried on skid beams and in davits along the sides of the upper decks.

The Ying Swei carried out a complete series of trials, which terminated on the 2nd inst. These trials, which were undertaken in the presence of technical members of the Chinese Embassy, included twenty-four hours' coal consumption trial at about 12 knots speed, during which time six runs were made on the measured mile ; a full-speed trial of six runs, also on the measured mile ; and progressive speed runs on the measured mile. In addition, there were steering-gear trials, ahead and astern, the latter at two-thirds of the full-speed ; hand-steering tests, circling trials, anchor-gear tests, and gun and torpedo-firing trials. At the full-power trial the vessel attained a speed of 21.214 knots as the mean of the six runs on the measured mile, three with and three against the tide ; the mean boiler pressure was 190 lb., and the turbines, running at an average of 556.4 revolutions, developed 6300 horse-power. On the twenty-four hours' trial the average speed was 12.35 knots, with a steam pressure of 147 lb., and with the turbines running at 311.1 revolutions. In all respects the conditions of the contract were met.

Austrian Mine-Owners.—In order to stimulate the federation of Austrian mine-owners a committee has met, and has resolved to arrange for a general miners' festival to take place in Vienna during the latter half of September, 1912.

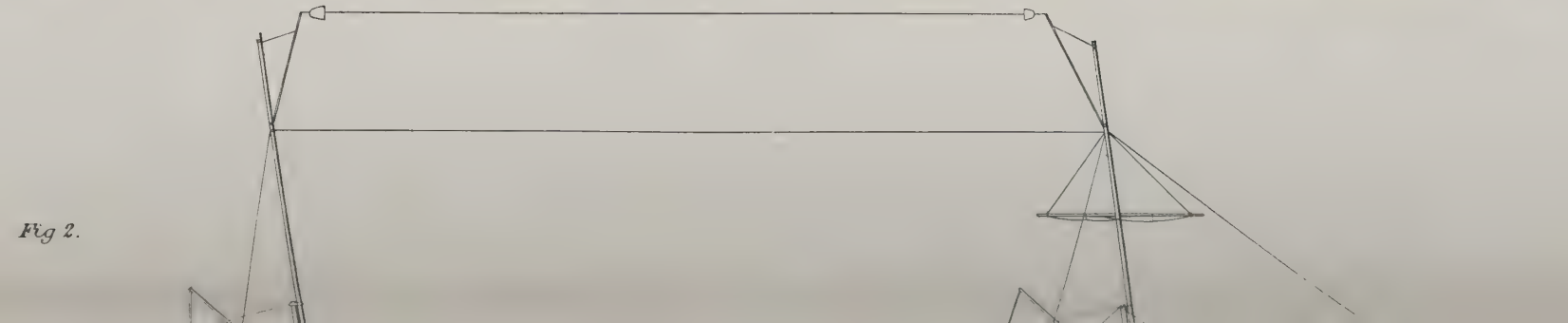
THE CHINESE TRAINING-CRUISER "YING SWEI."

CONSTRUCTED BY MESSRS. VICKERS, LIMITED, AT THEIR NAVAL CONSTRUCTION WORKS, BARROW-IN-FURNESS.

(*For Description, see Page* 826.)

Fig. 1.

Fig 2.



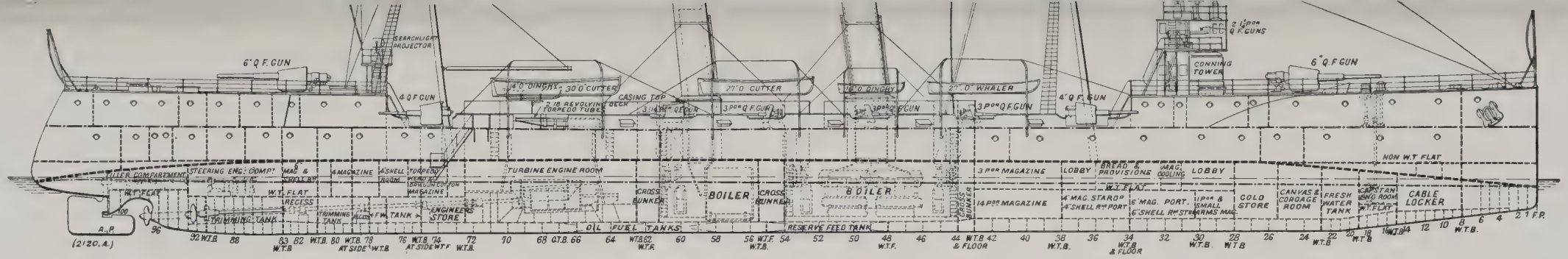


Fig. 3.

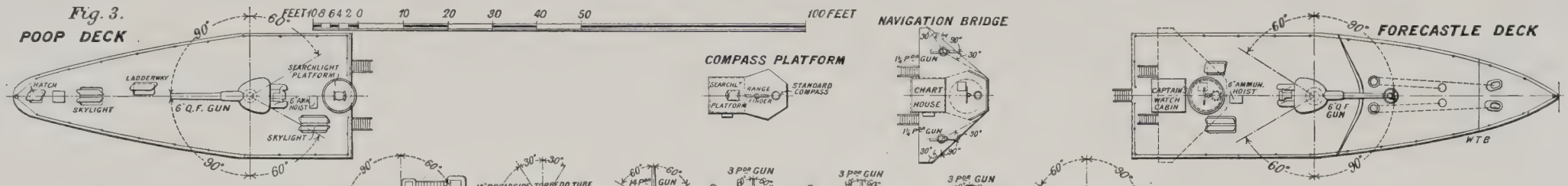


Fig.4.

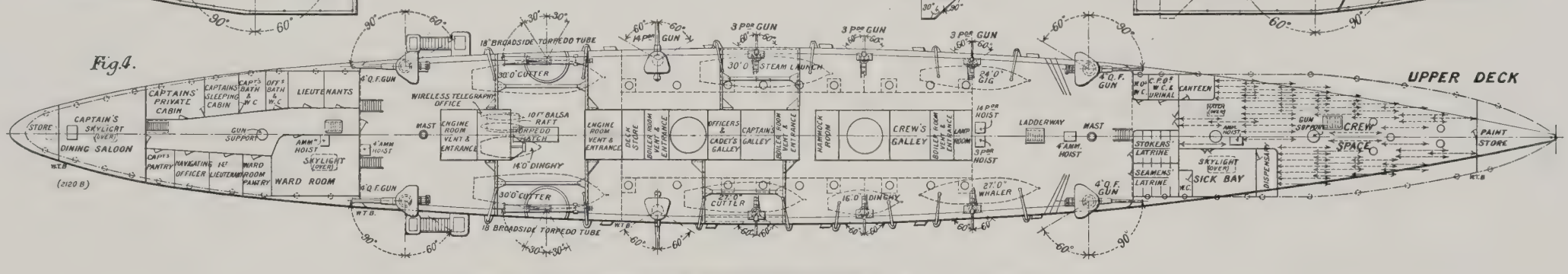


Fig.5.

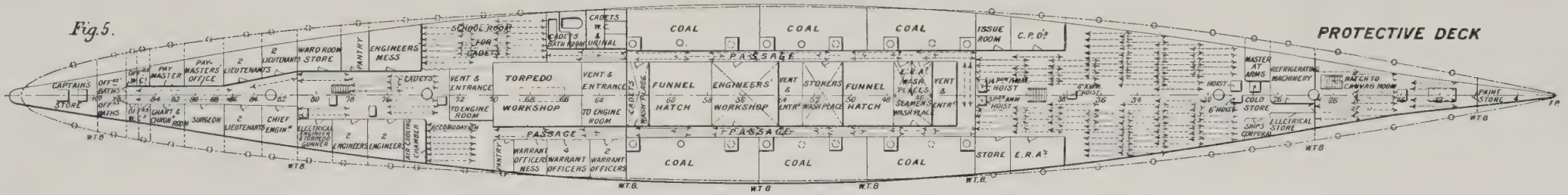
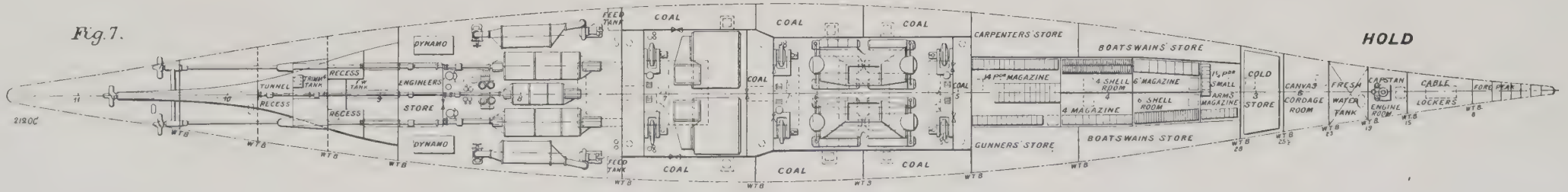


Fig6

Fig.7.



INDUSTRIAL NOTES.

ACCORDING to the *Board of Trade Labour Gazette*, issued on the 16th inst., the state of the labour market in November was as follows:—

Employment was, on the whole, much about the same as in October. There was some increase in employment in the metal, engineering, shipbuilding, and boot and shoe trades, and the printing and bookbinding trades showed a seasonal improvement. On the other hand, there was a seasonal decline in the brick-making, building, and furnishing trades. As compared with a year ago, there was a general improvement in most of the principal industries, but there was a decline in employment at blast-furnaces and in the printing, linen, and jute trades.

In the 394 trade unions, with a net membership of 800,532, making returns, 20,540 (or 2.6 per cent.) members were unemployed at the end of November, 1911, compared with 2.8 per cent. at the end of October, 1911, and 4.6 per cent. at the end of November, 1910.

Returns from firms employing 450,979 workpeople in the week ended November 25, 1911, showed an increase of 0.3 per cent. in the amount of wages paid compared with a month ago, and of 4.5 per cent. compared with a year ago.

The changes in rates of wages taking effect in November affected 23,300 workpeople, and resulted in a net increase of 1500*l.* per week. Amongst those whose wages were increased were 2500 coal-miners at Bristol, and 10,200 workpeople in the engineering and shipbuilding trades at Belfast.

The most important disputes in progress during the month were those involving 9900 motor-cab drivers, washers, cleaners, &c., in London, 2500 coal-miners at Bristol, 2300 machinists, filers, tool-setters, &c., at Birmingham, 2000 oil-millers at Hull, 1100 coal-miners near Wakefield, and 300 cotton operatives near Manchester. The number of disputes beginning in November was 60. The total number of workpeople involved in all disputes in progress during the month was 37,076, or 21,452 less than last month, and 55,885 less than in November, 1910. The total number of working days lost by these workpeople was 409,500, or 35,100 less than the previous month, and 1,403,900 less than the corresponding month of last year.

Cases dealt with under the Conciliation Act include those affecting railway workers of the United Kingdom, seamen and firemen, and also share fishermen at Hull, locomotive workers at Horwich, tramway workers at Ashton-under-Lyne, &c., carters at Greenock, confectionery workers in London, shoe and slipper-makers at Rossendale, boot and shoe operatives at Anstey and at Hinckley, copper-smiths, sheet-metal workers and braziers at Southampton, shipwrights and joiners at Belfast, crane slingers and drivers at Scunthorpe, pottery turners at Glasgow, and workers in the steel trade in the West of Scotland.

The monthly report of the United Society of Boilermakers and Iron and Steel Shipbuilders for November shows an increase in membership during the month of 297. So far, the year has proved a satisfactory one for the society, which, collectively, is laying up the wherewithal with which to provide against the proverbial rainy day. The members signing the "idle" book at the end of November numbered 2206, against 2404 at the end of October. The number of members on the sick fund was the same at the end of each of these months—namely, 1179; members on superannuation at the end of November totalled 2463; and at the end of the previous month, 2466. There was a decrease of 334*l.* 0s. 6d. in the expenses for November as compared with October, the amounts being 5614*l.* 15s. 9d. and 5948*l.* 16s. 3d. respectively.

The employees in the Nelson and Colne district of the Lancashire cotton industry have only themselves to thank if they are locked out before Christmas, owing to the practice, which is becoming intolerable, of striking at the shortest notice and refusing to work with non-union men who have quite as much right to work as have the men who belong to the unions. Of course, the union will blame the masters for the lock-out, shutting their eyes to the fact that the employers are only doing their duty as a means of protecting men in their employ over whom the unions tyrannise. On Wednesday last week the operatives' officials advised the men to remain at work, but the weavers in the district appeared determined to take the risks of a lock-out, and continue their campaign against the non-unionists. Notices were posted in all the mills owned by the North-East Lancashire Spinners and Manufacturers' Association, and all existing wages contracts came to an end on Wednesday last. Official notices were sent out by the secretary of the Accrington and District Weavers' Association involving eight cotton mills. The trouble has spread to Blackburn and Preston. At the time of going to press the lock-out was looked upon as inevitable.

A conference in connection with the taxi-cab dispute was held on Friday in last week at the offices of the Board of Trade, under the chairmanship of Sir George Askwith. It was agreed between the London Motor-Cab Proprietors' Association, Limited, and the London Cabdrivers' Trade Union, to have consideration given to the question as to the fair and proper conditions of service and payment under which the taxi-cab drivers should work on the assumption that the existing fares remain unaltered This is without prejudice to either party being entitled to show what improvements might be expected if a change in fares either by increase or decrease were made. The Board of Trade is to appoint a court of arbitration of three members to decide the question, and the Board of Trade may accept the adhesion of other associations other than those mentioned in this agreement.

The result of the railwaymen's ballot as to the acceptance or otherwise of the conditions laid down in the report of the Railway Commission will not be made public, as it was decided at the end of last week that, in the face of the recent agreement between the representatives of the companies and the unions, it would be unwise to issue further figures.

If we are to judge by reports from various centres, the recent Board of Trade settlement with regard to the railwaymen's dispute does not appear to have given complete satisfaction, and the situation has not been improved by the decision of the union railwaymen's joint executive committee not to publish the result of the recent ballot of the men on the question of the acceptance of the report of the Inquiry Commission. In some cases the immediate resignation of the leaders is called for. Mr. J. H. Thomas, M.P., however, speaking at Nottingham on Sunday last, repudiated the insinuation that the workers had been "sold" by their leaders. The broadest view had, he said, been taken of the situation, and a settlement had been secured which embodied many advantageous points. Although he knew the result of the ballot, he would not publish it after the joint conference that had taken place. It is still the lack of what they claim—full recognition—that troubles the men. It is to be hoped that all this lingering dissatisfaction will soon pass away when the new arrangements have been given a fair trial.

A definite decision has been come to by the principal railway companies regarding the increase to be made on the excursion and season fares now in force, and the increase will come into force on January 8, and not on January 1, as was formerly mentioned. Excursions over New Year's Day will therefore escape, and any inconvenience will be avoided.

The Scottish Coal Conciliation Board held a meeting in Glasgow on Thursday in last week to consider the miners' demands regarding wages. The claims of the men which were made by the miners' representatives at the previous meeting were again pressed forward. These were (1) an individual district minimum wage to be paid in all circumstances to all men working at the coal face; and (2) the standardisation of wages to all on-cost men and boys and youths on a definite scale. The reply from the coal-owner members to these demands was that (1) they could not agree to them, and that the arrangement made at the Board of Trade on July 30, 1909, must be adhered to; (2) that they (the masters) could not agree to the standardisation of the wages of on-cost men and boys and youths on the lines proposed, and that they adhered to the agreement already referred to; and (3) that they are willing to recommend the establishment of permanent machinery to deal with the disputes in the collieries regarding the rates to be paid in abnormal places where any dispute affects twelve or more miners, and to recommend the classification, according to age and experience, of boys and youths working at the coal-face. No definite conclusion was come to.

There was a largely-attended conference of the Scottish Miners' Federation in Glasgow on Saturday last, at which it was decided to send nine delegates to attend the conference of the Miners' Federation of Great Britain to be held in London on the following Wednesday. They had instructions to support the proposal for a national strike.

On Monday a meeting was held at the Westminster Palace Hotel, London, between the representatives of the coal-owners and the workmen on the Conciliation Board for the Federated Districts of Great Britain, after which the following statement was handed by the coal-owners to the men's representatives:—"That after the further explanations given by the miners' representatives to-day as to the conditions they would assent to be associated with the minimum wage, which have put a different aspect on the proposal, the matter should be again submitted to the districts for further consideration, the date of a further meeting to be arranged by Sir Thomas Ratcliffe-Ellis and Mr. Thomas Ashton." The meeting on Monday was the third of a series, and both sides went to it in a conciliatory spirit, and the men's representatives are said to have shown a willingness, in the event of the adoption of a minimum wage, to discuss means by which the owners should be protected against the possibility of their suffering from either the inability or the indisposition of the men to perform a fair day's work. The difficulty, however, of deciding on some scheme whereby this could be done is by no means small. The meeting was adjourned till Wednesday, but was again adjourned without settlement until yesterday, and there seems every likelihood of a ballot being ordered to ascertain whether the men favour a national strike. The two old propositions were before the Federation on Wednesday—namely: (*a*) Whether Rule 21 of the Federation, which enables this conference to order a general stoppage, shall be put into operation; or (*b*) whether negotiations shall be continued for a further period. There appeared to be three sections in the conference—the moderates, who are opposed to drastic action, and who include most of the miners' members of Parliament; the extremists, who demand the immediate enforcement of Rule 21, and who are composed chiefly of the South Wales leaders and certain northern delegates; and a third section of men who are not very decided about any definite course.

With regard to the cost of labour in coal-mines, Mr. D. A. Thomas, speaking at a debate at Cardiff University Settlement on the minimum wage, said that the cost of living had not increased since the last agreement was signed, as had been claimed by some people, that the value of the coal mined was 1,250,000*l.*, and that there were 23,000 more colliers at work than last year. If the cost of living had increased 20 per cent. since 1897, the cost of labour had increased 75 per cent. The average wage of the collier above and below ground, in 1909, was from 32s. to 33s., and at the coal face from 42s. to 45s. a week, and many colliers earned a guinea a day. The minimum wage meant considerably over 1s. a ton, which would more than extinguish the profits on the ordinary shares of the collieries with which he was concerned.

Dundee has been the scene of serious rioting this week in connection with a strike of carters and dock labourers, the condition of things becoming so bad in the town that the authorities had to appeal to the War Office for soldiers to quell the disturbances. Consequently 300 infantry were sent from Edinburgh without delay, and arrived in Dundee late on Tuesday night, where they were quartered in the Drill Hall. It is said that many factories were compelled to cease work owing to lack of fuel and material, and the men who were thus rendered idle joined the rioters.

THE GERMAN NAVY ESTIMATES.—These have now been published in the German Press, and show that provision has been made for the second instalment of the cost of three battleships and one cruiser which belong to the financial year 1911, for the third instalment of the cost of three battleships and one cruiser which belong to the 1910 financial year, and for the fourth instalment of the cost of three battleships and one cruiser which belong to the financial year 1909. The programme for which a first instalment is to be provided in 1912 includes one battleship, the Ersatz Brandenburg, and one cruiser, the Ersatz Kaiserin Augusta. Provision is also made for two small cruisers, and for the first instalment of the cost of a torpedo-boat flotilla. The sum for submarines remains the same as last year—*i.e.*, 750,000*l.* A sum of 150,000*l.* will be provided towards the cost of the new Admiralty building, Berlin. For keeping the ships in commission a sum of 175,850*l.* in excess of last year's amount is provided, an excess which is said to be due to a more extensive commissioning of large units; this leads also to an excess of 118,150*l.* in the provision for ammunition as compared with last year.

SWEDISH STATE RAILWAYS.—The report for the Swedish State Railways during 1910, which has now been made available, contains some interesting particulars about their working, &c. The railways for which the gross receipts exceed the working expenses amount to an aggregate of 3305 km.—that is, 75.5 per cent. of the total of the Swedish State railways, which have cost 417,210,000 kr.; whilst the sections of the State railways on which the gross receipts do not cover the working expenses amount to an aggregate of 1071 km., of which the cost of building amounts to 88,590,000 kr. The aggregate net revenue of the former portion amounts to 18,500,000 kr., or 4.4 per cent. of their cost, whilst the aggregate loss on the latter was 2,160,000 kr., or 2.4 per cent. of their cost. The most favourable results are shown by the iron ore railways in Lapland and by the east, south, and west trunk lines. The Gellivara-Riksgränsen line heads the list with 10.65 per cent., and then come the Katrineholm-Nassjö line with 7.61 per cent., the Lulea-Gellivare line with branch lines to Malmberget and Koskullskulle, with 7.32 per cent., the west trunk line with 6.11 per cent., and the south trunk line with 5.42 per cent. The lines which have given a negative result are mostly branch lines to the different trunk railways, the Sköfde-Karlsborg Railway being at the bottom of the list with 4.03 per cent. on the wrong side. The State railway ferries average 1.12 per cent., the Trelleborg-Sassnitz railway ferry having yielded 2.4 per cent., whilst the Malmö-Copenhagen railway ferry shows a loss of 2.84 per cent.

THE REFRIGERATED-MEAT INDUSTRY OF SOUTH AMERICA.

THE first freezing plant on modern lines for dealing with meat for oversea transport put down in South America was built as early as 1885, by Messrs. Sulzer Brothers, Winterthur, for the Compania Argentina de Carnes Congeladas, San Nicolas. It was situated on the right bank and quite close to the Parana River, means being provided for the rapid carriage of the frozen-meat quarters on board ship. It contained eventually three Sulzer compressors of about 200,000 calories (capable of abstracting 794,000 B.Th.U.) per hour, and it dealt with about 800 sheep per day. The plant has remained idle since 1898. It is shown in Figs. 1 and 2.

The largest and most interesting plant of this kind existing at the present day is that of the Compania Sansinena de Carnes Congeladas; the machinery for this has also been built by Messrs. Sulzer Brothers. The company was formed in 1884 by Mr. Gaston S. Sansinena. It owned at first a slaughter-house, La Negra, in the vicinity of Buenos Aires, which dealt exclusively with the preparation of potted meat. The first freezing plant was put down in 1891. In 1902 the La Negra installation was enlarged and a new plant was put down at Bahia Blanca, the southernmost point on the Argentinian Railway system, at a distance of 600 km. (370 miles) from Buenos Aires. On July 1 of the present year the Compania Sansinena was further extended by the purchase for a sum of 7,500,000 francs (300,000*l.*) of the slaughter-house plant of the Frigorifica Uruguaya, Montevideo. The Compania Sansinena has a capital of 34,000,000 francs (1,360,000*l.*) in 5 per cent. bonds and 15,000,000 francs (600,000*l.*) in shares. The daily production of the three installations is the following:—

	La Negra, Buenos Aires. Carcases.	Cuatreros, Bahia Blanca. Carcases.	Frigor. Uruguaya, Montevideo. Carcases.
Oxen—300 kg. (661 lb.)	800	200	600
Sheep—25 kg. (55 lb.)	3000	2500	2000

The La Negra Installation, Buenos Aires.—This is located on the Riachuelo. It covers an area of about 37,000 sq. m. (398,000 sq. ft.) and occupies 1200 men. The sanitary conditions are supervised by two veterinary surgeons. At a distance of 5 km. (3.1 miles) the company owns pasture land sufficient for 5000 oxen and 20,000 sheep. The installation contains seven freezing plants of 1,700,000 calories (capable of abstracting 6,749,000 B.Th.U.) per hour, and 11 boilers capable of supplying steam for a total of 2800 horse-power. There are further 16 refrigerating-rooms, having together a floor area of 3325 sq. m. (35,800 sq. ft.), and a capacity of 11,208 cub. m. (395,000 cub. ft.), and 37 cold-storage rooms, of 5950 sq. m. (64,000 sq. ft.) floor area and 16,513 cub. m. (582,000 cub. ft.) capacity. This installation is illustrated in the diagram, Fig. 3, and in the views, Figs. 9 to 12, on page 832.

The "Cuatreros" Plant, Bahia Blanca.—The second installation was put down at Bahia Blanca owing to the satisfactory local conditions. In the first place vessels can steam up the harbour quite close to the plant, and there are also in close proximity extensive pasture lands on which the cattle can be raised. The slaughterhouses are at a distance of 3 km. (2 miles) from the town of Bahia Blanca. The company owns a harbour, in which the steamers for exporting the frozen meat are berthed. Loading is facilitated by a system of narrow-gauge railways. The company also owns a steamer fitted with cold-storage holds for deliveries along the coast. The installation gives occupation to 450 men, and is conducted on the same lines as that of La Negra; the sanitary conditions are supervised by a veterinary surgeon. The cattle are first led into a covered corral, whence they are driven into the slaughter-house. This consists of the slaughter-room, and of a second room, in which the carcases, after dressing, are allowed to hang for five or six hours, exposed to an air-current for drying and cooling. By this means the refrigerating-rooms remain much dryer than otherwise would be the case. From the drying-room the meat is conveyed over the bridge F (Fig. 7) by means of an overhead line, to the freezing chambers of the buildings D and E. The sheep carcases are generally conveyed six at a time, three at top on short hooks and three at

Fig. 1.

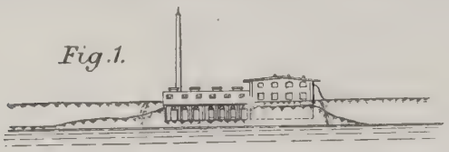


Fig. 2.

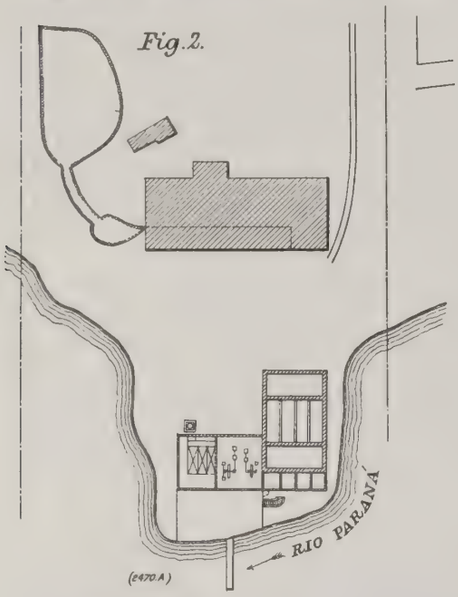


Fig. 3.

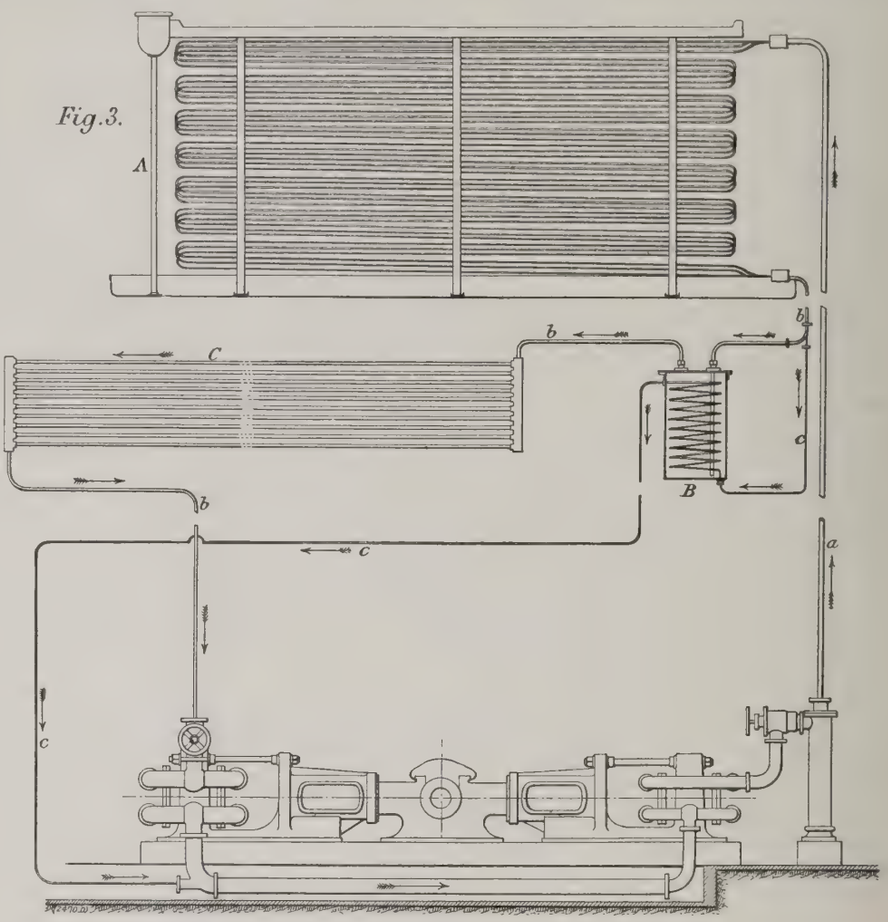
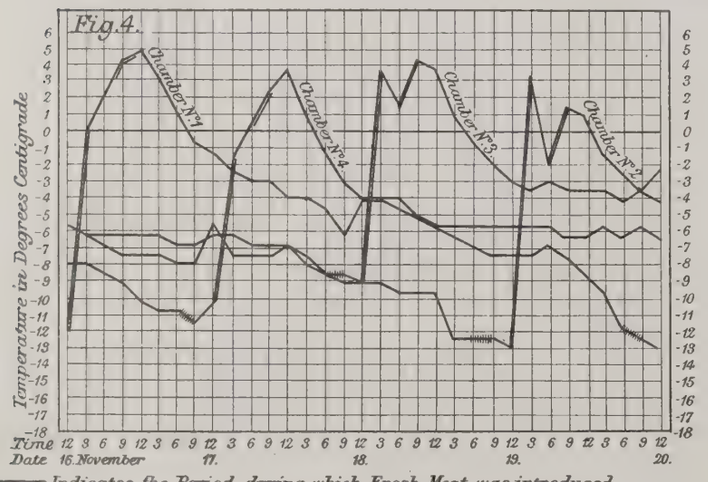


Fig. 4.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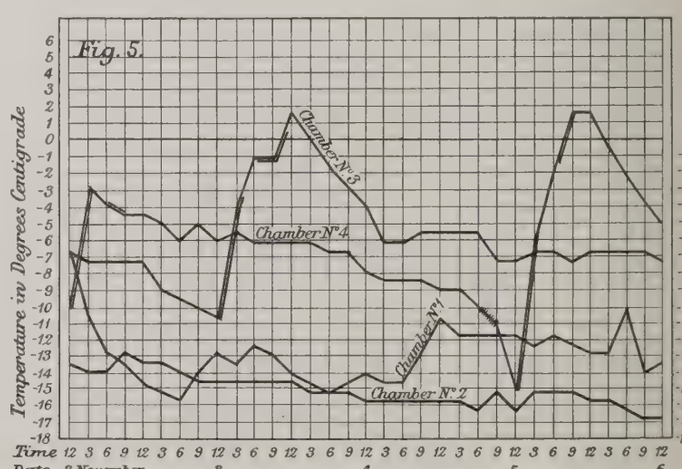
Chamber N°4
Chamber N°3
Chamber N°2
Temperature in Degrees Centigrade
Time 12 3 6 9 12 3 6 9 12 3 6 9 12 3 6 9 12 3 6 9 12 3 6 9 12 3 6 9 12
Date 16 November 17. 18. 19. 20.

Indicates the Period during which Fresh Meat was introduced.
(2470 E) Indicates the Period during which the Frozen Meat was lowered to the Cold Storage.

Fig. 5.


Chamber N°3
Chamber N°4
Chamber N°1
Chamber N°2
Temperature in Degrees Centigrade
Time 12 3 6 9 12 3 6 9 12 3 6 9 12 3 6 9 12 3 6 9 12 3 6 9 12 3 6 9 12
Date 2 November 3. 4. 5 6.

(2470 F) The Chambers 1 & 2 were used for Cold Storage 2nd to 6th November.

THE "CUATREROS" REFRIGERATED-MEAT PLANT AT BAHIA BLANCA.

CONSTRUCTED BY MESSRS. SULZER BROTHERS, ENGINEERS, WINTERTHUR, SWITZERLAND.

Fig. 6.

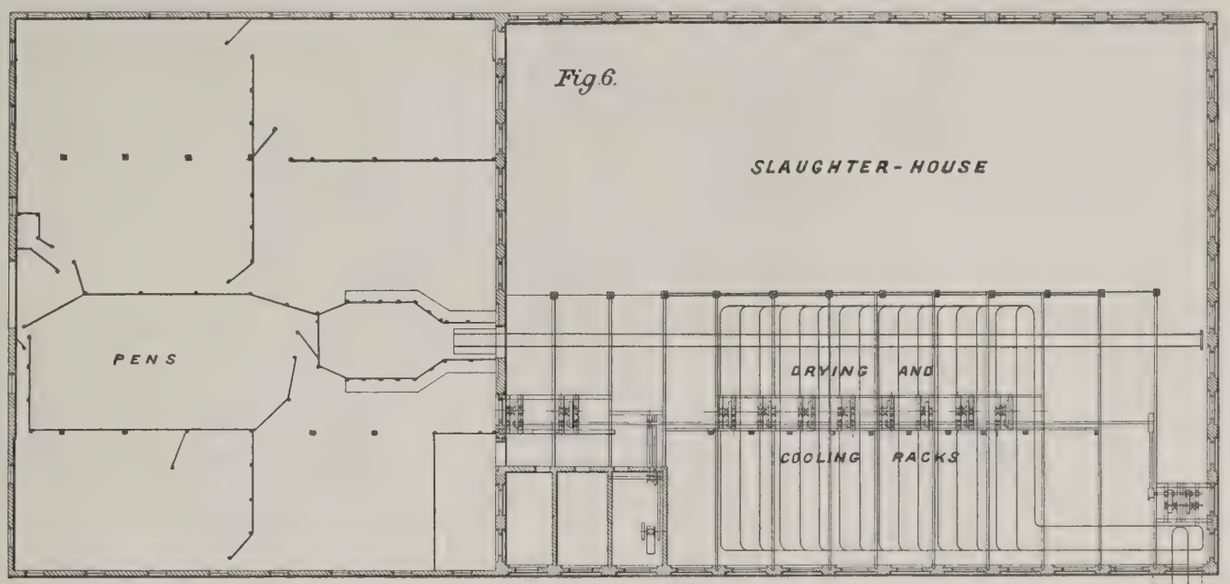


Fig. 7.

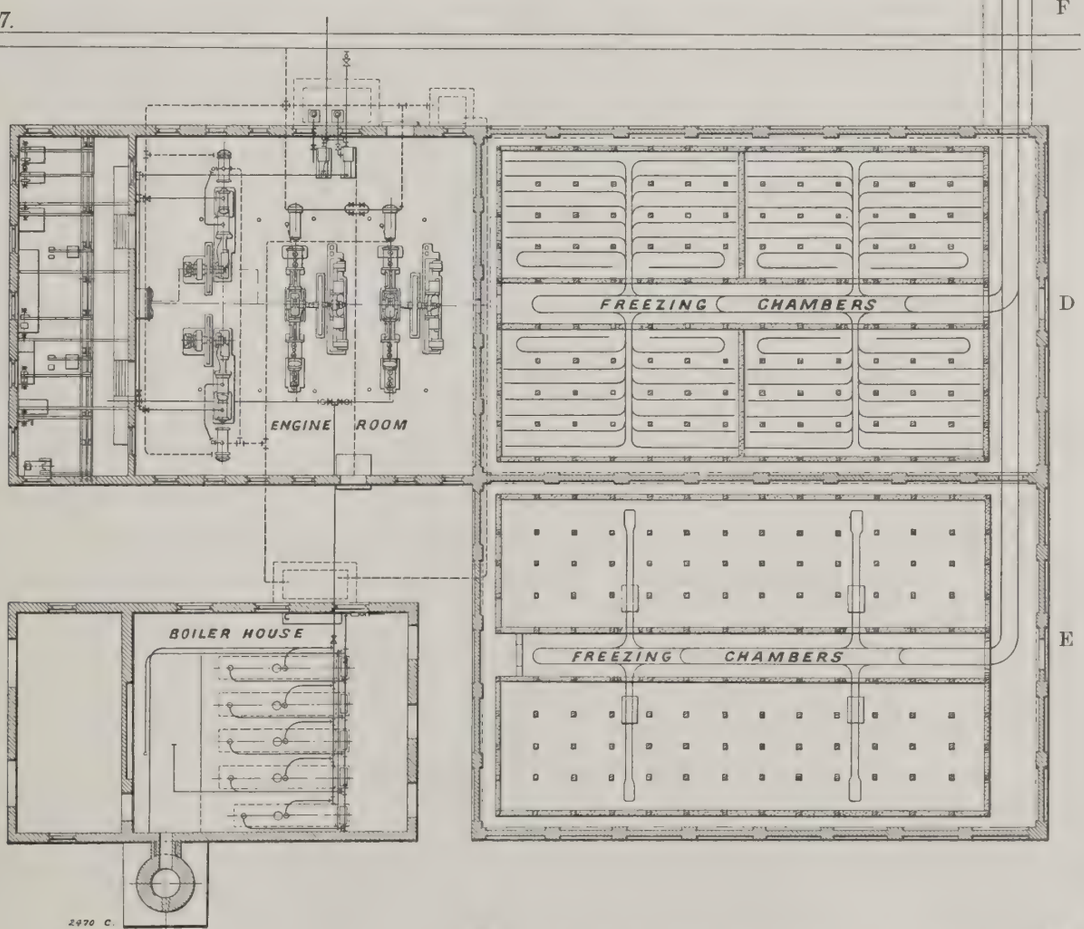
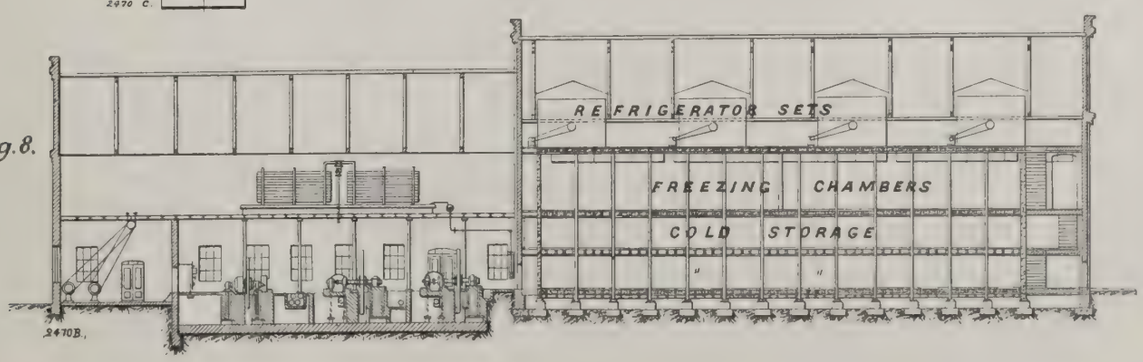


Fig. 8.



bottom on long hooks suspended from a horizontal bar. The refrigerating-plant connected to the refrigerating-rooms is located under the roof of each of the two buildings (Fig. 8, page 829). The rooms containing the plant in question communicate with the refrigerating-rooms underneath by air-passages. The height of the storey of the building D beneath the refrigerating-plant is 4.4 m. (14 ft. 5 in.), the storey being divided into four refrigerating-rooms; the refrigerating-rooms of the building E are also situated underneath the corresponding refrigerating-plant, but are 2.2 m. (7 ft. 3 in.) only in height. When the meat is refrigerated—*i.e.*, about three days after the commencement of the process—it is lowered through openings to the cold-storage rooms. The meat is delivered from the latter direct to the ships, loading taking place mostly at night-time in order to take advantage of the lower night temperature. The cold-storage holds on board the ship have simply to maintain the meat in its refrigerated state as it comes from the cold-storage rooms on land. We illustrate this installation in Figs. 6 to 8, page 829.

The refrigerating-plant is of Messrs. Sulzer's ammonia-compression type. Compound compressors, combined with after-coolers, are used, the latter raising the efficiency of the plant. The arrangement is shown in Fig. 3, page 828. The condenser A is located over the power-driven compressors in the engine-room; the after-cooler B is placed in any suitable position, and the various expansion sets C are distributed under the roof of the building in which refrigeration takes place. The fluid liquified in the condenser A (see diagram, Fig. 3) flows, with a view to lowering its temperature still further, to the after-cooler B, through the pipe *b*, and thence to the expansion sets C. A small pipe, marked *c*, opens into the connecting-pipe *b* and forms a serpentine inside the after-cooler B. A small proportion of the fluid from the condenser A flows through this pipe *c*; it vaporises inside the serpentine of the after-cooler B, thereby expanding to the pressure of the low-pressure cylinder.

The plant works as follows:—The vaporised refrigerating agent is drawn by the pipe *b* into the low-pressure left-hand cylinder (Fig. 3), where it is partly compressed. It is then compressed to its final pressure of 8 to 14 atmospheres (117 lb. to 205 lb. per sq. in.) in the right-hand cylinder, whence it flows through the pipe *a* to the condenser A. Water is made to drip constantly over the tubes forming this condenser, and this, by cooling the gaseous refrigerating agent, causes it to liquefy. The liquid ammonia then passes through the pipe *b* to the evaporisers or freezing sets C, flowing on its way, as aforesaid, through the after cooler B, in which it is cooled down to about 0 deg. Cent. (32 deg. Fahr.). A small portion of the refrigerating agent—10 per cent. at the most—is branched off through the pipe *c*. The refrigerating agent enters the pipe *c* at a pressure up to 14 atmospheres (205 lb per sq. in.); as this pipe *c* ends at the low-pressure cylinder, in which the pressure is considerably below that figure, this 10 per cent. of the refrigerating agent vaporises almost instantaneously in the serpentine of the after cooler B, and leads to an effective cooling down of the main portion, 90 per cent. of the refrigerating agent circulating round the serpentine in question. Regulating valves are fitted in the pipes *b* and *c*. The compressors are each coupled to a Sulzer trip-valve engine, having cylinders 360 mm., 600 mm., and 900 mm. (14.17 in., 23.62 in., and 35.43 in.) in diameter, with a 700 mm. (27.56 in.) stroke. The engines run at a speed of 62 to 75 revolutions. The high-pressure and intermediate cylinders are at one end of the engine, and the low-pressure cylinder, with a surface-condenser of 35 sq. m. (377 sq. ft.) cooling surface, at the other end. For steam condensing, the overflow water from the ammonia condensers is used.

Two Sulzer-valve compound engines are used for generating current for light and power; these have cylinders 230 mm. and 400 mm. (9.05 in. and 15.75 in.) in diameter, with a 700 mm. (27.56 in.) stroke. They run at a speed of 130 revolutions. The surface-condenser is located below the high-pressure cylinder. Each engine is direct coupled to a Siemens and Halske 110-volt 550-ampere dynamo.

A neighbouring shop for maintenance and repairs contains a number of machine-tools, driven by a 10-horse-power steam-engine.

The boiler-house contains four horizontal Sulzer boilers, each having about 58 sq. m. (625 sq. ft.) heating surface, and working at 11½ atmospheres (169 lb. per sq. in.) pressure. A fifth (smaller) boiler is also available. The plant contains, further, two condensing-pumps, having a capacity of 11,000 litres (2420 gals.) per hour; a Green economiser is also provided. The necessary draught for the boilers is insured by a chimney 40 m. (130 ft.) high.

Refrigeration takes place by indirect air cooling. As above stated, the freezing sets for cooling the air are located directly underneath the roof of the buildings D and E. The air cooled in the plant sinks through a conduit into the refrigerating-rooms, surrounds the quarters of meat which are suspended in the latter, "yields up gradually its low temperature," becomes lighter, and rises back to the cooling sets above, where its temperature is again lowered, the same process being repeated. The air circulation in the building D is increased by a fan for each separate room containing a freezing set C, which draws the less cold air from the refrigerating-rooms containing the meat. This means of obtaining an artificial circulation of the air has not been adopted in the building marked E, mainly because, owing to the lesser height of the refrigerating-rooms containing the meat, 2.2 m. (7 ft. 3 in.), a natural air circulation is sufficient. Each building, D and E, contains eight refrigerating batteries arranged in sets of four. The total cooling surface of each battery-room of the building D is 265 sq. m. (2850 sq. ft.); that of each battery of the building E is 247 sq. m. (2660 sq. ft.). As dampness is removed from the meat during the freezing process, there occurs a continuous precipitation, and the pipes of the freezing sets C have to be periodically freed of the rime which covers them. For this purpose the refrigerating sets are isolated from the refrigerating-rooms, and the temperature in the latter is not increased in any way during the interval for removing the rime.

The cold air circulation is regulated by valves inserted in the air-conduits. Each of the refrigerating-rooms in the building D measures 17.5 m. by 9 5 m. (57 ft. 5 in. by 31 ft. 2 in.), giving an area of 166 sq. m. (1787 sq. ft.). The height being 4.4 m. (14 ft. 5 in.), the cubic contents equal 731 cub. m. (25,800 cub. ft.). The two refrigerating-rooms in the building E measure each 35 m. (114 ft. 10 in.) in length, 9.5 m. (31 ft. 2 in.) in width, equal to a floor space of 332.5 sq. m. (3575 sq. ft.); and the height being 2.2 m. (7 ft. 3 in.), their cubic contents is the same as the former ones, or 731 cub. m. (25,800 cub. ft.). Each one of the four rooms of the building D can contain 2500 sheep or 200 ox carcases; each room in the building E can take double those numbers. The temperature in the rooms varies from + 35 down to − 15 deg. Cent. (95 to 5 deg. Fahr.). The working of the refrigerating-rooms depends in a great measure upon the temperature and dampness of the atmosphere for the time being. The diagrams, Figs. 4 and 5, page 828, give a comparison of the readings taken at different periods, during which carcases were put into and taken from the refrigerating-chambers.

Both the ground floor and the first floor of the building D are divided into cold-storage rooms. The storey underneath the refrigerating-rooms of the building E is 2.2 m. (7 ft. 3 in.) in height—the same height as the refrigerating-rooms on the storey above—and is divided into two cold-storage rooms. The temperature in the cold-storage rooms varies between + 5 and − 8 deg. Cent. (41 deg. to 17 deg. Fahr.). The cooling pipes of the cold-storage rooms are located in the rooms themselves; they serve to maintain the meat in its refrigerated state. As there is no dampness to deal with in these rooms, there occurs no rime precipitation on the cooling-pipe coils.

All the buildings are carefully insulated. The walls are provided over their whole height with air spaces 80 cm. (30 in.) in width. The outside walls are provided with windows, so as to enable an energetic ventilation of the air insulation spaces; this means has been taken owing to the fact that the ground-water level is comparatively high, and the risk of flooding had to be reckoned with. The partitions, floorings, and ceilings are also carefully insulated by means of layers of impermeable cardboard and layers of cork covered by wood panels on both sides.

The "Frigorifica Uruguaya" Plant, Montevideo.—This plant was installed on a large scale in 1903. The two large double-acting compressors of the original plant have a capacity of 300,000 calories (capable of abstracting 1,190,000 B.Th.U.) per hour each. A third double-acting compressor of 550,000 calories (2,180,000 B.Th.U.) was put down in 1908, the total capacity being, therefore, of 1,150,000 calories (4,560,000 B.Th.U.) per hour. A fourth, similar one is being completed which will raise the capacity of the plant to 1,700,000 calories.

The Institution of Automobile Engineers.—The third meeting of the session of the Institution of Automobile Engineers was held on the 13th inst, when a very able paper was read by Mr. L. H. Pomeroy, Wh.Ex., on "Engine Design for taking advantage of Horse-Power Rating Rules," the author basing his claims on actual experience with engines constructed and run by the Vauxhall Motor Company. Interesting particulars were given of an engine with a bore of 3.12 in. but with a stroke of no less than 8 in.

Yarrow Boilers for Italian Battleships.—We are pleased to learn that the Italian Government have decided to adopt Yarrow boilers in their two latest battleships. These ships are each to be fitted with 20 boilers, and the work of erecting and fitting them on board will be carried out by Messrs. Ansaldo, Armstrong, and Co., at Genoa. The complete designs for the boilers are being prepared by Messrs. Yarrow and Co., who are also to manufacture the most important parts of the boilers, including steam-drums and water-collectors complete. These are the first large Yarrow installations adopted by the Italian authorities, and the preference for them is due to the success of the boiler in other vessels.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Saw-Manufacturers' Combine.—An important step is contemplated by the leading saw manufacturers of Sheffield and district. At a meeting a week or two ago, proposals that the price of circular-saws, hand-saws, and long-saws be increased by 5 per cent. all round received the support of about 80 per cent. of the firms represented, and as the Saw Manufacturers' Association are backing up the movement, it is practically certain that the advance will be made, and customers will probably be advised about Christmas. A few firms have shown a tendency to stand out, but their position is not sufficiently important to influence the others. It is stated that the increase in price has become necessary owing to the growing costs incidental to manufacture, principally charges under the Workmen's Compensation Act, the claims of the new Insurance Act, and heavier taxation generally. It is about five years since a similar rise in price took place, and it was then due largely to the higher cost of raw materials.

South Yorkshire Coal Trade.—The position in the steam-coal market is rather interesting. In spite of the advancement of the winter season, shipments have been going away very well, and the demand for hard coal for industrial purposes has been stronger than ever. Consequently, collieries are well placed and prices are firm. Usually pits are working on short time close to Christmas, but this year they are working well, and there are practically no stocks held. The exceptional call from manufacturers, of course, explains the satisfactory position of hard coal. The gas companies are taking very large deliveries on contract, and the shipments of this class of fuel are good. Slacks are active, and there is pressure for deliveries. Contracts are being renewed at small advances. The coke trade is good. A freer movement has been noticeable in house coal. Orders have come to hand better at pits and dépôts, and some of the merchants are well occupied. The pits are working good time, and prices are kept up. For forward business colliery owners, who are not very anxious to book, are asking considerable advances. The prices on the Sheffield Exchange on Friday were:—Best branch hand-picked, 14s. 6d. to 15s. 6d.; Barnsley best Silkstone, 12s. to 13s.; Silkstone, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. to 11s.; large nuts, 9s. to 10s.; small nuts, 6s. to 7s. 6d.; Yorkshire hards, 9s. 6d. to 10s. 6d.; Derbyshire hards, 9s. 3d. to 10s. 3d.; washed nuts, 8s. to 9s.; rough slacks, 5s. 6d. to 7s. 6d.; seconds, 4s. 6d. to 5s. 6d.; smalls, 2s. to 3s.

Iron and Steel.—A certain amount of quietness was not unexpected in the iron market. The near approach of Christmas has had the usual effect of restricting buying and deliveries, and slackness is further due to large orders being given out just recently, when prices were moving steadily upwards, covering the requirements of consumers for the immediate future, and accounting for a good deal of the output of the iron-makers for the next month or two. Prices all round continue firm, and it is not at all unlikely that further advances will take place in the New Year. The work at present in the hands of steel manufacturers is sufficient to keep them busily occupied for a considerable time to come, and consequently the maintenance of a big demand for hematites is assured. After insisting on premiums for several weeks, the Lincolnshire iron-producers have added these to their association rates, and are now quoting correspondingly higher figures, No. 3 being offered at 51s. 6d. to 52s., and forge at 50s. 6d. to 51s. This is still somewhat below the Derbyshire figures. There is a big consumption of basic iron, and the billet trade is very good. Heavy buying has taken place recently in anticipation of price advances which are likely to come about owing to the growing cost of raw materials. Continental competition in billets is almost negligible. Amongst the important branches of the Sheffield steel trades, which are in a particularly favourable position just now, must be mentioned railway steel. Further orders have come in to the local manufacturers, and they have now sufficient work to keep them busy for a few months. With all the trades on big production, the Christmas stoppage this year will only be a short one. The brief respite will be welcome for more than the usual reasons. Machinery has been kept so fully employed for several months that overhauling and repairing will be very necessary. All the tool-makers are exceedingly busy, a state of things largely due to the revival in engineering. What is practically a new industry in Sheffield has been started by a firm who are manufacturing gas-engines and plant. The future of the venture will be watched with interest.

The Institution of Mining and Metallurgy.—The Council have accepted, on behalf of the Institution, an invitation from the Canadian Mining Institute to hold a joint meeting in Canada early in 1912. The meeting, for the reading and discussion of papers, &c., will occupy three days—Wednesday, Thursday, and Friday, March 6, 7, and 8, 1912. The annual dinner of the Canadian Institute will be held on Friday, March 8, and on Saturday, the 9th, an excursion to the mining districts of Cobalt and Porcupine will be arranged, provided a sufficient number of the members of the Institution from England express a wish to visit those localities. Should any of the members of the Institution individually desire to visit mines in other localities, the secretary of the Canadian Institute will be glad to make the necessary arrangements to enable them to do so, provided he is in possession of their wishes well in advance. Further details can be obtained from Mr. C. McDermid, secretary, Salisbury House, E.C.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was fairly active, and 11,500 tons of Cleveland warrants were put through at 48s. 11½d. cash, 48s. 11d. thirteen days, 49s. 1d. twenty-two days and nineteen days, 49s. 3d. one month, 49s. 6½d. February 20, and 49s. 9d. and 49s. 10d. three months. Closing sellers quoted 49s. cash, 49s. 3½d. one month, and 49s. 10½d. three months. One lot of hematite changed hands at 65s. three months, with cash sellers over at 64s. The market became very strong in the afternoon, when 10,000 tons of Cleveland warrants were done at 49s. 2½d. and 49s. 3d. cash, 49s. 4½d. and 49s. 6½d one month, 50s. and 51s. 1½d. three months, 50s. March 6, and 50s. 0½d. and 50s. March 8. At the close sellers quoted 49s. 3½d. cash, 49s. 7d. one month, and 50s. 1½d. three months. Hematite was firmer at 64s. 3d. cash sellers. On Friday morning the upward movement continued, and Cleveland warrants were dealt in at 49s. 6d. cash, 49s. 9d. twenty-four days, at 49s. 9½d., 49s. 9d., and 49s. 9½d. one month, and from 50s. 6d. to 50s. 4d. to 50s. 5d. three months. The turnover amounted to 15,000 tons, and closing prices were 49s. 6d. cash, 49s. 9½d. one month, and 50s. 5d. three months sellers. Hematite was firmer at 64s. 6d. cash, and 65s. 6d. three months sellers. The afternoon market was also active, and about 13,000 tons of Cleveland warrants were done at 49s. 7½d., 49s. 8d., and 49s. 7½d. cash, 49s. 10½d. and 49s. 11d. one month, and at 50s. 7d. three months. Closing sellers quoted 49s. 8d. cash, 49s. 11½d. one month, and 50s. 6¾d. three months. A feature of the session was the dealing in hematite, which totalled 5000 tons, at 64s. 6d. cash, 65s. and 64s. 11½d. one month, with closing sellers at 64s. 7½d. cash and 65s. one month. On Monday morning the market was again very active, and some 35,000 tons of Cleveland warrants were put through at from 49s. 6½d. to 49s. 8d. to 49s. 7d. cash, from 50s. to 49s. 10d. to 49s. 11½d. one month, at 50s. 2½d. two months, and from 50s. 7d. to 50s. 6d. to 50s. 7d. to 50s. 5½d. three months. At the close sellers quoted 49s. 8½d. cash, 50s. one month, and 50s. 7d. three months. Hematite was the turn easier at 64s. 4½d. cash, at which figure 500 tons changed hands, with buyers over and sellers at ½d. more. The tone of Cleveland warrants was easier in the afternoon, and 6000 tons were dealt in at 49s. 8½d. and 49s. 7d. cash, 49s. 6½d. four days, 49s. 9½d. eight days, 49s. 10d. one month, and at 50s. 6d. and 50s. 5½d. three months. The closing quotations were 49s. 7d. cash, 49s. 10½d. one month, and 50s. 5½d. three months sellers. On Tuesday morning the market opened a little weak, but became firmer. Cleveland warrants advanced from 49s. 4½d. to 49s. 6½d. cash, and the turnover of 17,500 tons included dealing at 49s 5d. seven days, 49s. 10d. one month, and from 50s. 3d. to 50s. 5½d. three months, and closing sellers quoted 49s. 7d. cash, 49s. 10½d. one month, and 50s. 6d. three months. One lot of hematite was done at 64s. cash. In the afternoon the tone was very like that of the previous session, and 2000 tons of Cleveland warrants were put through at from 49s. 5d. to 49s. 7d. cash, and from 49s. 8½d. to 49s. 10d. one month. At the close sellers quoted 49s. 7½d. cash, 49s. 11d. one month, and 50s. 6d. three months. When the market opened to-day (Wednesday) Cleveland warrants continued on the upward movement, and 17,500 tons were done at from 49s. 6½d. to 49s. 8d. cash, 49s. 10d. to 49s. 11½d. one month, and at 50s. 6d., 50s. 5½d., and 50s. 6d. three months. Closing sellers quoted 49s. 8½d. cash, 50s. one month, and 50s. 7½d. three months. Hematite—1000 tons—changed hands at 64s. 4d. one month, with cash sellers at 64s. 0½d. In the afternoon the market was strong and active, and dealings amounted to 17,500 tons of Cleveland warrants at 49s. 9d. and 49s. 10d. seven days, 49s. 8½d. six days, 50s. one month, 50s. 1½d. January 18, 50s. 2d. two months, and from 50s. 6d. to 50s. 9d. three months. Closing prices were 49s. 11d. cash, 50s. 2d. one month, and 50s. 9½d. three months sellers. Hematite, 1000 tons, was done at 64s. 5d. six weeks, with closing buyers at 64s. 4d. one month. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 64s.; Gartsherrie, Summerlee, and Langloan, 64s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 65s.; Shotts (at Leith), 64s.; and Carron (at Grangemouth), 65s.

Sulphate of Ammonia.—There has been practically no change in the sulphate of ammonia market of late, and a fairly steady demand still exists. The price for prompt delivery is quoted at 14*l.* 5s. per ton, Glasgow or Leith, and the total amount exported from Leith Harbour last week was 4234 tons.

Scotch Steel Trade.—The Scotch steel trade is at present very active, and, with specifications in plentiful supply, makers are turning out a large tonnage of material. One notable feature just now is the falling off in Continental competition, the German producers being so busy on home requirements that lots for this country are many weeks overdue. Quite a satisfactory business is passing in export orders, and some decent lots of ship and boiler-plates and angles have been put through for shipment to North European ports, while general material is in request for India, Australia, South America, and the Far East. Light plates and structural sections are in good demand for shipment, while the all-round demand for black sheets is as brisk as ever. Makers are being kept fully employed, and with order-books so well filled they cannot promise delivery for a month or two ahead. Their prices are very firm.

Malleable-Iron Trade.—The prevailing conditions in the malleable-iron trade of the West of Scotland are certainly much better of late, and works are very well employed at present. Quotations are again stronger, and for forward lots of crown bars sellers are now asking 6*l.* 10s. per ton, less 5 per cent. The negotiations which have recently been going on for the formation of a combine or amalgamation in the trade have been so far successful, and at a meeting of the makers in the West of Scotland, held in Glasgow last Saturday, terms were fixed. The preliminary agreement was signed by a number of the firms, while several others, unable from various reasons to join, are in full sympathy with the movement, and have promised honourable co-operation with the amalgamated firms. The capital is to be 900,000*l.*, of which 300,000*l.* will be guaranteed debentures, 250,000*l.* preference shares, and 350,000*l.* ordinary shares, the latter being taken by the vendors or makers. The valuation of the works in the Coatbridge and Motherwell districts will be made by independent auditors during the time these establishments are closed for the New Year holidays. In well-informed circles it is considered that there is now practically nothing in the way to prevent the new scheme being fully adopted.

Scotch Pig-Iron Trade.—The Scotch pig-iron trade is a trifle easier this week, as local consumers have been curtailing their demands. The export business, however, is very good, and buyers in the South have been sending quite a number of orders. Hematite is active, and the demand is better than it has been for some time back. The current quotation is now 68s. per ton, delivered at the local steel works, and a fair amount of buying is reported at that figure.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Notwithstanding that the Christmas holidays are right at hand, there is a fair amount of business passing. Usually there is little or nothing doing at this time of year, but on the present occasion buyers are a good deal in evidence, and show anxiety to place forward business at higher rates than rule on early account, but sellers are not disposed to commit themselves ahead, as they have confidence in the future, and believe that higher prices and great activity will be experienced in the spring. Values of Cleveland pig-iron are higher than they have been since the early part of January last. No. 3 g.m.b. is fully 50s. f.o.b., whilst No. 1 is 53s. 6d. to 53s. 9d.; No. 4 foundry, 49s. 6d. to 49s. 9d.; No. 4 forge, 49s. 3d. to 49s. 6d.; and mottled and white iron, each 49s.—all for early delivery. For next quarter buyers offer 9d. above the foregoing quotations. East Coast hematite pig shows further upward tendency, and producers have committed themselves as far ahead as they care to go in a rising market. Nos. 1, 2, and 3 stand at 65s. for immediate delivery, 66s. is the price for January, and 67s. 6d. for delivery over the first quarter of next year. Foreign ore is strong, but after heavy transactions of a little while ago there is very little selling. Market rates are based on 21s. 6d. to 22s. ex-ship Tees for Rubio of 50 per cent. quality. Furnace coke is practically unobtainable for prompt delivery. Up to 17s. has been paid for average kinds delivered over periods next year.

Stocks and Shipments of Pig Iron.—Stocks of pig iron continue steadily to decrease. Cleveland pig iron is this month being taken from the public warrant stores at the rate of over 800 tons per working day, and the stock now held there—which is practically the only stock in existence—is down to 543,000 tons. Shipments of pig-iron are unprecedented. To date this month they average no less than 5426 tons per working day, as compared with a daily average of 3151 tons to the same date last month, and an average of 3093 tons per working day for the corresponding part of December last year.

Manufactured Iron and Steel.—Excellent accounts are given of nearly all branches of the manufactured iron and steel industries. Many firms have contracts made which will keep them in full swing over the whole of next year, and good orders are still in the market. Under these favourable conditions values naturally show a marked upward tendency, but the only actual upward movement this week is in galvanised sheets, which have followed steel plates in advancing 5s. per ton. Market rates now stand:—Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 7s. 6d.; iron girder-plates, 6*l.* 15s.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 7*l.*; steel ship-angles, 6*l.* 12s. 6d.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 12s. 6d.; steel joists, 6*l.* 10s.; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; steel railway sleepers, 6*l.* 10s.; and iron and steel galvanised corrugated sheets, 11*l.* 10s.—sheets less 4 per cent. f.o.b., railway material net, and all other descriptions less 2½ per cent. discount.

Cleveland Ironstone Miners' Wages.—A joint meeting between the Cleveland Ironstone Mineowners' Association and the Cleveland Miners' Association was held at Middlesbrough this week. The men's executive recently submitted to the owners a list of basis rates which they wished to be applied to the various classes of men employed in the Cleveland mines, and to this the owners replied as follows:—"The Cleveland Mineowners' Association are not prepared to accept the basis rates submitted, but have no intention of seeking to reduce the rates now prevailing in the various mines in Cleveland for the various classes of labour plus the amount awarded by Sir David Harrel."

NOTES FROM THE SOUTH-WEST.

Cardiff.—Steamers have again been delayed by rough weather, and this has considerably affected business in both large and small steam-coal. Colliery owners have been badly off for empty trucks, as the result of chartered vessels not arriving in time. As regards later deliveries, they have been quoting prices as firmly as ever. The best Admiralty large has brought 17s. to 17s. 6d. per ton, while secondary qualities have ranged between 15s. 6d. and 16s. 9d. per ton; best bunker smalls have made 8s. 9d. to 9s., and cargo smalls 6s. 6d. to 7s. 3d. per ton. The house-coal trade has shown no great change; the best ordinary qualities have made 15s. 6d. to 16s. 6d.; No. 3 Rhondda large, 17s. to 17s. 6d.; and smalls, 9s. 9d. to 10s. per ton. No. 2 Rhondda large has been quoted at 13s. to 13s. 3d., and smalls at 6s. 3d. to 6s. 9d. per ton. Foundry coke has realised 17s. 6d. to 20s., and furnace ditto, 15s. 6d. to 16s. 6d. per ton. As regards iron ore, Rubio has made 20s. to 21s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Bluenavon Company, Limited.—The annual meeting of this company was held on Monday at the Cannon-street Hotel, London. The directors, in their report for the year ending September 30, recommended that of the credit balance of 17,209*l.*, 1500*l.* should be devoted to the payment of a half-year's preference dividend, and that 15,709*l.* should be carried to the credit of the current half-year. The directors stated that during almost the whole of the past year the iron trade had been in a depressed condition, while prices in the coal trade remained at a low point. The directors added that the result of an experimental working of the steel works and mills did not justify them continuing to operate those departments.

Dowlais.—The Dowlais works have shown a fair activity, especially considering that we have arrived at the close of the year, when trade is often a little slack. Steel sleepers, tin bar, &c., have been turned out upon a large scale in the Goat Mill; the Big Mill has been engaged upon light rails and other colliery requisites. The collieries have not been fully occupied.

Bristol Docks.—Before his recent appointment as general traffic manager of the Bristol Docks, Mr. D. Ross-Johnson was for five years secretary of the Indian Railway Conference Association, which is equivalent to the Railway Clearing House of this country. He first went to India in 1880, and entered the service of the Madras Railway Company, now absorbed in the Madras and Southern Mahratta Railway Company, which serves Madras harbour. He eventually became general traffic manager of the Madras and Southern Mahratta system.

Abertillery.—At the last sitting of the Abertillery and District Water Board, tenders were received for the construction of a dam and pipe-lines at Grwyne Fawr, and pipe-lines to and in the Western Valley. They were referred to the engineer.

HEAVIEST CONCENTRATED RAINFALL ON RECORD.—According to the *Engineering News* the Catholic meteorological station at Manila, P.I., reports an exceedingly heavy rainfall as having occurred in Western Luzon last July and August, which is said to have been the greatest ever recorded. There were in that district three typhoons between July 11 and August 2, 1911, the heaviest of which raged from July 11 to 17, during the first three days of which the total rainfall recorded at Bagnio was 88 in., 32 in. of which is said to have fallen during the first twenty four hours. Bagnio is the mountain resort in the province of Banquet, at an elevation of several thousand feet above sea-level. The road leading to it was built a few years ago at a great expense, and is reported to have suffered considerably from the floods that followed the storm. Previously a remarkably heavy rainfall had occurred in Jamaica, which was at the time regarded as the heaviest on record. It took place in 1909, and amounted to 48 in. in four days.

FACTORY AND COMMERCIAL PROPERTY SALES, 1911.—Messrs. Leopold Farmer and Sons, London, report that the year now closing has shown better results than was the case in 1910 in the disposal of factory property, wharves, land, &c. Values have been maintained and sales transacted at good-times prices. The prices realised might not convey to the reader that the standard of values has been kept up, as hardly two factory properties are alike. The tendency, however, is for the price to rise, consequent on the improvement by development in certain manufacturing districts, which have special advantages in rail, water, and other facilities. There is a migratory movement amongst manufacturers to districts outside large towns, where the lowest possible cost of manufacture can be obtained. It is difficult to say which branch of any particular manufacture has progressed more than any other in the year 1911; one which is, however, very noticeable is the manufacture of electric filament lamps, and several companies interested in the business have acquired factories and are carrying on large businesses. Development has taken place in the motor and rubber trades, factories having been opened in consequence for manufacturing purposes. Acquisition of factories, &c., and the building of works, consequent on reorganisation and extension in trades, are always in progress; those in the engineering, milling, chemical, and spinning trades have been well to the front in development in the year under review. The effects of the Patents and Designs Act are still pronounced; foreign holders of English patents are still on the look out for factory property to comply with the requirements. There is every likelihood of a great amount of prosperous activity in the industrial world.

THE LA NEGRA REFRIGERATED-MEAT PLANT, BUENOS AIRES

CONSTRUCTED BY MESSRS. SULZER BROTHERS, ENGINEERS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 828.)

FIG. 9. GENERAL VIEW.

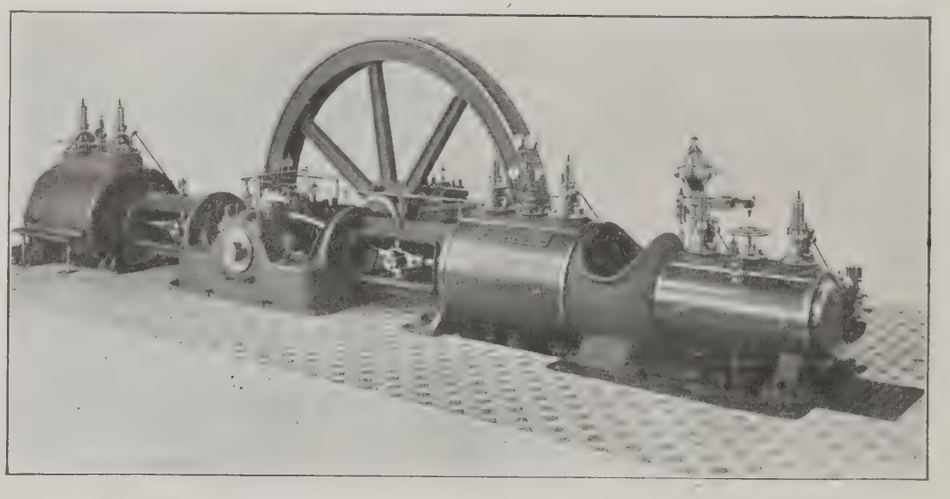


FIG. 11. TRIPLE-EXPANSION STEAM-ENGINE DRIVING COMPRESSOR.

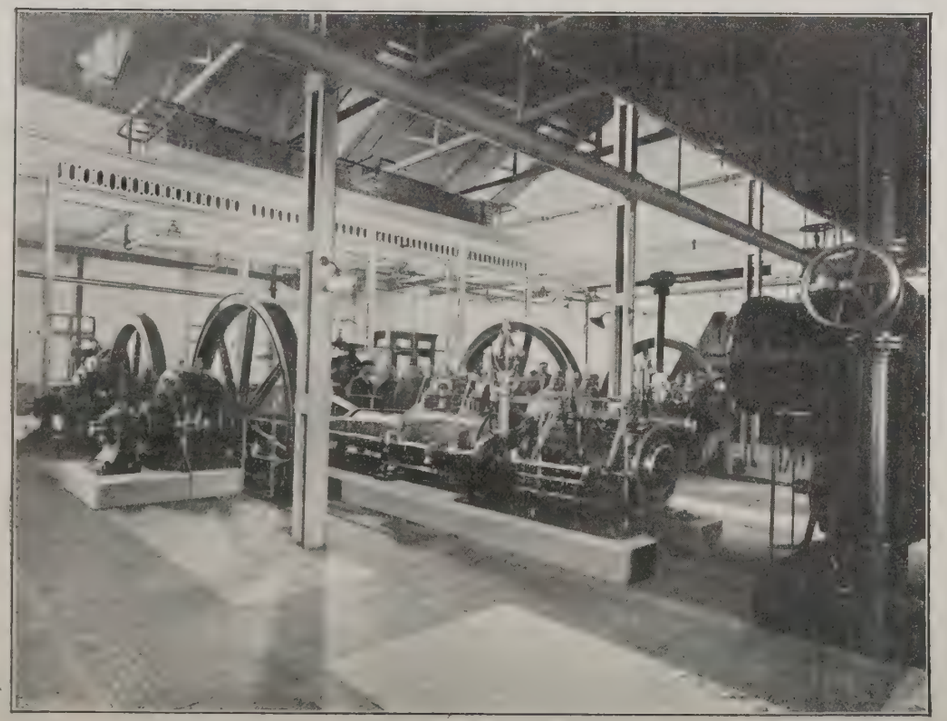


FIG. 10. POWER-HOUSE.

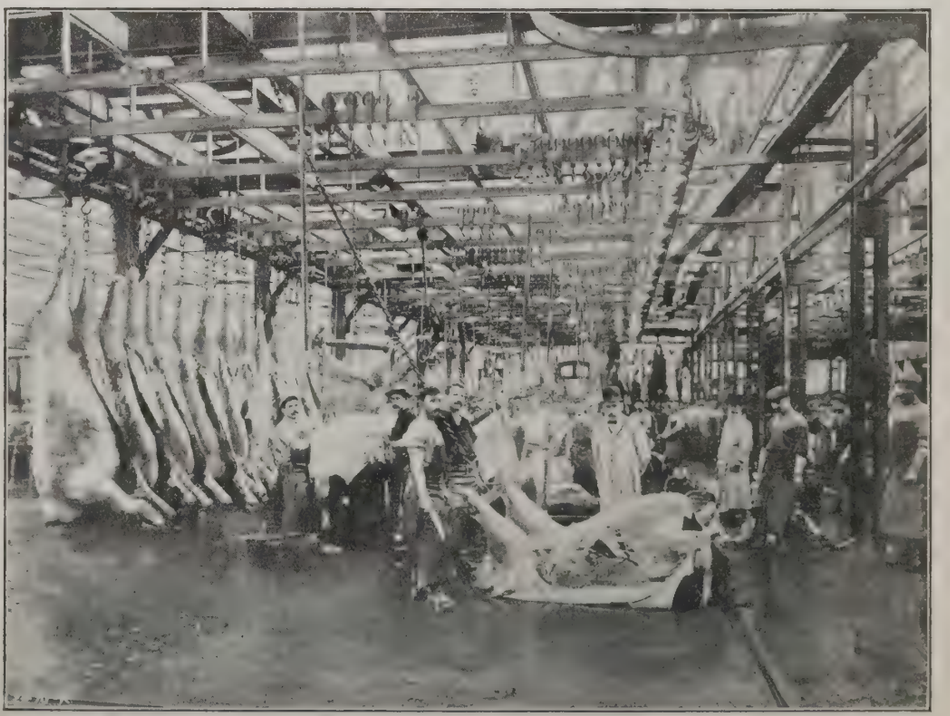


FIG. 12. DRESSING AND DRYING-ROOM.

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NOTICES OF MEETINGS.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Thursday, December 28, and Saturday, December 30, at 3 p.m. A Christmas Course of Illustrated Lectures, adapted to a Juvenile Auditory, on "The Childhood of Animals," by Mr. P. Chalmers Mitchell, LL.D., D.Sc., F.R.S., Secretary, Zoological Society of London. No. I. Introductory. No. II. The Duration of Youth.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday afternoon, December 29, at 3 p.m. Visit to the factory of Messrs. Otto Monsted, Limited, margarine manufacturers, at Southall.

READING-CASES.—Reading-cases which will hold twenty-six numbers of "ENGINEERING" may be had of the Publisher or of any newsagent. Price 6s. each.

ENGINEERING.

FRIDAY, DECEMBER 22, 1911.

THE AEROPLANE IN WAR.

ONE of the most interesting features of last summer's military manœuvres in France, and also of the conflict in Tripoli, is the lesson they have given of the influence of the aeroplane in war. Briefly, it has been found that it is impossible to conceal any movements from an enemy possessing a force of aeroplanes. The effect of this will be most far-reaching, and it is interesting to speculate on the results.

If we assume that two armies are of fairly equal numbers and equally well supplied with information by their aeroplanes, it seems that it is possible for a sort of stalemate to ensue. Normally, one army would attack the other, massing a sufficient number of troops at the decisive point to give it a large numerical superiority there. It is now generally admitted that it is useless to attack, at a given point, an army supplied with modern long-range weapons unless there is a very great numerical superiority at that point. Such massing of troops, however, absolutely depends on keeping the enemy in ignorance of the intended movements, for if they are aware of the number and position of the troops moved, they can equally well mass troops for the defence. It seems quite possible, therefore, that neither side could dare to take decisive action. It is, however, not the least likely that any two armies would be equally well supplied with information by their aeroplane corps. Just as one army is usually able to penetrate or force back the cavalry screen of the other, and to obtain valuable information, so one army, by dint of superior forces of airmen, or by greater daring, will generally be better supplied with information than the other, and will have a proportionate advantage.

It is, however, quite possible, in fact probable, that the matter may go much further than this. It appears to be assumed by many writers that each side will allow the other to use aeroplanes for reconnoitring purposes without any opposition, save that which can be offered by shooting at them from the earth. This, however, is to ignore all the teaching of history. The art of war lies greatly in anticipating the enemy's movements, either by intuition or by obtaining information, and also in leading him to form incorrect opinions as to the *locus* of the attack to be made on him. Wellington said that he had spent his military life in guessing what was happening on the other side of the hill. The principles of strategy are constant, and it is certain that no commander can ever hope for success who tamely views his opponent inspecting his lines and makes no effort to frustrate him. Just as every battle has hitherto been preceded with skirmishes of outposts, followed by an artillery duel, so in the future there will be fights in the air before the men on the ground come into contact. The side with the greatest force of aeroplanes will never let an enemy's machine fly over their own position without sending a superior force of aeroplanes to capture or destroy it. As defeat in the air means certain death, it may be presumed that in many cases surrender would be preferred, and in this case a very short time would see one side in possession of complete command of the air, and therefore able to get all the information it required without allowing the enemy to get any.

This might in itself render even a very large army perfectly helpless, as every endeavour to advance would only lead it into carefully prepared positions. On the other hand, the smaller army could always find out the weak points to attack. If the numerical superiority of the enemy were too great for attack to be made at all, stalemate might result; but it must be remembered that huge armies cannot be kept in the field indefinitely, owing to the enormous expense, and to the fact that calling out all the reserves means the withdrawal of the workmen from the various productive industries of the country. Unless such an army can attack, it must be eventually disbanded, and peace made on the best terms obtainable.

While this is all we may, perhaps, expect at the present time, the rapid progress of the aeroplane makes it interesting to speculate on the results of an equally rapid increase in its efficiency in the future. The money hitherto expended in constructing aeroplanes has been measured in thousands, but if this were increased to a very few millions, it is quite possible that in the near future aerial fleets capable of carrying several thousand men with light guns and a supply of explosives could be produced. In the face of such a force any army without aeroplanes would be useless, for it would be unable to keep up its communications. In fact, it would be unable even to protect its base. The aerial fleet could roam about the country at will destroying the railways, telegraphs, and other means of communication. The recent railway strike has shown us what the interruption of railway communication means even for a few days, and it is quite certain that a very short spell of it would reduce any country to making peace.

It is of the utmost importance that we should thoroughly appreciate the importance of these points. Owing to the smallness of our population, and the fact that we do not have conscription, it is quite impossible for us to keep up a huge army as do the Continental Powers. We have hitherto kept command of the sea, and it is now becoming equally important to have complete command of the air. It is therefore high time that we determined that we will do so, and that, however many aeroplanes any other Power builds, we will build more, just as we do with the ships. Further, that however many men any other Power trains to flying, we will train more. We have plenty of men who would make as good, or better, flying-men than any if it were made worth their while; but we must have a really good Government school and flying-ground, and reasonably good pay must be given. It is also necessary that constructors should be encouraged to put up factories in England at which aeroplanes can be turned out in numbers, to provide for the wastage of war.

We therefore welcome, as a preliminary to more important developments, the fact that the War Office have published the conditions of a competition for aeroplanes, to be held about the middle of next year. As we have already said, it is undoubtedly high time that something was done to encourage military aviation in this country, and we are therefore very glad that this competition has been decided upon.

A list of the prizes offered, and a statement of the conditions of the competition, are printed on page 840 of the present issue, and it is unnecessary, therefore, to repeat them here. Taking them all round, these conditions appear very fair. It is, however, to be regretted that more money is not being spent on prizes for British-made machines, and that there appears to be no encouragement to the use of British engines. It is just as important that we should build our military aeroplanes in this country as our fighting ships, and therefore the sooner a substantial amount of money is spent on fostering the industry the better.

With regard to the technical conditions there appears to be little fault to find. There are, however, several points which may entail a good deal of modification in existing machines. Thus it is not at all certain that the landing chassis of the ordinary aeroplane will comply with the conditions laid down as to alighting and starting on rough ground. There is no doubt that in this matter many machines are capable of a great deal of improvement. We have before commented on this and on the very small wheels generally fitted. If the standard wheels will not comply with the conditions, however, it seems likely that the principal alteration required will be an increase in the size of the wheels, or some modification of the skids.

The requirement that the aeroplane shall carry two persons, and that it shall be capable of being controlled by either, may necessitate some modification of existing machines, but this will not be great. The condition that the view of the country should be as open as possible both to the pilot and to the observer may not be easy to fulfil in some

types, especially when taken in conjunction with the stipulation that the men are to be shielded from the wind. The usual position occupied by the pilot in a monoplane complies with the latter condition very well, but not altogether with the former. On the other hand, the position of the pilot at the front edge of the front plane in a biplane affords an excellent view, but exposes him to the wind. It appears possible that the best view of any would be obtained from a monoplane with the wings set out about a foot from the body. The increased stress due to this would be very small, and the view in every direction very good. There may, of course, be some practical objection to this plan, but it seems worth a trial.

If the condition that the engine must be capable of being started by the pilot alone means that he must be able to set it in rotation without assistance in holding the aeroplane, it implies either some form of anchorage or else brakes sufficient to prevent the machine from moving. Possibly the latter will be necessary to ensure stopping in the space specified. There does not seem to be any theoretical difficulty in fitting brakes to hold the machine with the engine running. If it be preferred not to have these, it would be quite easy to arrange for an anchorage with a trip-gear to release the aeroplane when required.

While there appears to be little to criticise in the conditions, it is perhaps a pity that a definite date for the competition was not announced, so that competitors should know exactly when their machines are to be ready. There is also no indication of what relative importance will be attached to the various points. Probably this is wise, as it leaves the committee a freer hand in their awards, and it is only by experience that the relative importance of different features can be ascertained.

DIRECTED RADIOTELEGRAPHY WITHOUT VERTICAL ANTENNÆ.

An important contribution to the problem of the propagation of Hertzian waves in radiotelegraphy was presented to the Deutsche Physikalische Gesellschaft at Berlin on October 20 by Dr. Franz Kiebitz, of the research staff of the German Telegraph Department. High vertical antennæ are at present used because the waves are supposed to travel essentially through the atmosphere. At the same time it is generally admitted that the earth plays some not well-understood part in the phenomena. Kiebitz now proves experimentally that efficient radiotelegraphic communication can be maintained without any aerials, merely with the help of earth antennæ — *i.e.*, wires stretched horizontally near the earth's surface, above it or embedded in it, and that the waves can be directed with such arrangements. Horizontal antennæ are, of course, not novel. They have been tried by several investigators. On board ship wires are stretched high up between the mast-heads, and at Clifden parallel horizontal wires are supported by double rows of high poles or masts. But a suspension high above ground has been considered necessary,* and these antennæ are charged with strong currents at very high potentials, which render the insulation very difficult. The earth antennæ can be carried close to the ground or be buried in it, and they are charged with weak current whose insulation does not cause any difficulties. The experiments so far made are not conclusive, of course; and it may be that the great simplicity of the installation will vanish as the system develops, finally to be, possibly, again reacquired. But it looks as if high vertical aerial antennæ could certainly be dispensed with in certain cases, because the earth takes its share in propagating the electric waves.

That this is so was already believed years ago. Since two stations separated by the curved earth can communicate with one another, it was assumed that the electric vector of the propagating waves was essentially vertical to the earth's surface. E. Lecher argued, in 1902, that radiotelegraphy was based upon the spreading of electric charges on the earth's surface, and that it would be possible to telegraph, in particular directions, with two earth antennæ. Professor L. Zehnder, of Halensee, near Berlin, patented, in 1905, a simple arrangement for this purpose. The principle of this arrangement, which is the same as that adopted by Kiebitz, is the following:—

Two earth plates, C_1 and C_2, are connected by wires with a source of alternating currents of moderate frequency A; the lengths of the two wires C_1 A and A C_2 are l_1 and l_2, and the relation between them and the wave-length λ, given out by A, is such that $(l_1 - l_2)/\lambda + x/\lambda_1 = \frac{1}{2}$, where x is the distance between the two earth-plates, and λ_1 the length of the wave corresponding to λ when passing through the earth. The whole wire system is tuned to wave-length λ; the corresponding λ_1 will be considerably smaller than λ [the waves are shorter in metals, water, &c., than in air], and it will therefore be possible to make the distance $C_1\ C_2 = \lambda/2$, without letting this distance become inconveniently large. As a rule, l_1 and l_2 will each be about equal $\lambda/4$. The C_1 and C_2 are in reality earthed condensers. Zehnder was quite aware that the want of homogeneity in the earth strata would complicate the phenomena and would disturb the tuning, because the waves would be diffracted and refracted, and that mountains, rivers, valleys, and heavy local rains would affect the propagation of the waves; he also pointed out that when earth-plates were inserted in a lake, islands situated between them would make a difference. Zehnder has recently* ascribed the fact that the radiotelegraphic range is shorter in daytime than at night to the circumstances that the sunlight heats and dries the earth and the air, and causes winds and convection currents in both these media, and that electric waves would irregularly be refracted and reflected just as light waves.

We pass to the experiments of Kiebitz. They were undertaken with the assumption that Hertzian waves in the air and electric-charge waves in the earth's surface must mutually influence one another, and that the electric field is essentially vertical to the earth's surface, already close to the transmitter, as he demonstrated in 1908. He considers that the earth antennæ—*i.e.*, straight lengths of wires—behave like metallic cores embedded in a semi-conductor, that these cores have a selective conductivity for certain wave-lengths, and that it is hence possible to generate stationary waves in them, which will be radiated out. The phenomena are therefore those of selective emission and absorption.

Kiebitz made his experiments last summer on a sandy heath near Belzig, situated 65 km. south-east of Berlin; the lakes or broads of the winding Havel River are to the north of the straight line Belzig-Berlin and partly near it. The station consisted of a shed S, and earth antennæ or wire lines were laid in different directions, but always in straight lines $E_1\ E_2$, $E_3\ E_4$, &c., and such that the shed S was in the middle of the $E_1\ E_2$. The lines ended in earth-plates which were not always in circuit, however; these earth-plates consisted of seven or four zinc sheets, embedded in the moist sand in pits, 4 metres in depth. Earth-plates were also arranged symmetrically around the shed S. The lines themselves were of different kinds and lengths: bronze wires, 1.5 mm. in thickness, stretched on china insulators fixed on wooden poles, 1 metre above ground, or insulated with gutta percha and placed in a shallow conduit; or 0.8-mm. copper wire, stretched on poles, 8 metres in height; or copper ribbon, 2 cm. in width, 0.2 mm. in thickness, mounted like the bronze wire. In and near the shed where the lines crossed, insulated copper wires, 1.5 mm. in thickness, were used. The nature of the line did not make much difference on the whole; but the copper ribbon on 1-metre poles frequently came out best. Near each terminal was mostly a battery of Leyden jars. The two lines, the l_1 and l_2 of Zehnder, were joined in the shed to a split coil, connected in the middle to a variable condenser; the circuit comprised a contact-detector (a crystal of galena pressed against graphite) and a telephone. The intensity of the signals received was estimated, as usually, by the parallel-ohm method; a resistance free from self-induction is coupled parallel to the telephone, and this resistance is diminished until the signals cease to be audible. When this minimum resistance is 20 ohms, *e.g.*, it would be said that the operator was receiving with 20 ohms.

Signals from the station at Schöneberg (Berlin), situated in the exact continuation of the earth antenna (or line) $E_1\ E_2$, 65 km. away, were best heard (with 6 ohms) when the insulated wire in the conduit or the copper ribbon were used. Swinemünde, 230 km. to the north, at an angle of 23 deg., was easily heard. The great station at Norddeich, 405 km. to the west, was also heard, even when—without making use of the just-mentioned earth antenna—an insulated wire, 700 metres in length, was simply placed on the ground in the direction of Norddeich—*i.e.*, east-west. The Eiffel Tower signals (810 km.) were distinctly overheard; there a wave-length of 1000 metres appeared to be used. The Admiralty station in Whitehall was overheard day and night, with the earth antenna of 240 metres length, while the radiotelegraph station at Schöneberg, Berlin, which is equipped with an aerial 40 metres in height, can only understand these signals at night time. Poldhu was also overheard. The experiments seemed to show that Poldhu used a wave-length of 2800 metres, and Whitehall a wave-length of 3400 metres. In order to facilitate receiving from Clifden (1550 km.) and Glace Bay (in Canada, 5100 km.), a wire-line of a length of 1270 m. ($\frac{3}{4}$ mile, roughly) was laid in the direction of Glace Bay; the insulated wire rested partly on the ground and partly on the lower branches of the trees of a bush adjoining the heath; the earth terminals were formed of wire netting. The receiving apparatus was the same as before, but it could be tuned to wave-lengths ranging from 3000 up to 8000 metres. Clifden was easily listened to in the third September week; Glace Bay was occasionally heard between 6 A.M. and 7 A.M.; but thunderstorms greatly disturbed these signals. The determinations of the wave-lengths gave 5600 to 5800 metres for Clifden, and 5800 to 6000 metres for Glace Bay. Atmospheric and earth currents very frequently caused trouble, especially in July, when, with a perfectly clear sky, distant thunderstorms were often heard.

Further experiments were made with the object of fixing the influence of the direction of the transmitting station by the aid of the radiogoniometer of Bellini and Tosi. For this purpose an antenna-cross was used, consisting of two lines, one north-south, the other east-west, crossing at the station-shed S. In many instances the direction of the transmitting station (*e.g.*, Poldhu and Paris) was correctly estimated within 3 deg. But there were curious anomalies. Schöneberg (only 65 km. distant) sometimes appeared to be in a direction wrong by 8 deg. when waves of 1400 metres were used, and wrong by even 10 deg. when waves of 2900 metres were used. The direction of Norddeich was correctly estimated on some days, and appeared deflected by up to 7 deg. on others.

For the transmission experiments current was generated by a 2-kw. alternating dynamo giving currents of from 400 to 700 periods. These currents were transformed up, and the primary was closely coupled with the secondary coils of the previous arrangement. Schöneberg was easily reached; waves of 1350 were received at Shöneberg with an intensity of 40 ohms. Swinemünde was likewise reached. Norddeich could hear faint signals when the 1270-metre wire and waves of 3500 metres were used, and currents of 1 kw. supplied to the antenna, although the insulation of the long wire was very poor. But Schöneberg, although much nearer, could not hear these signals, the reason being that this antenna made an angle of 8 deg. with Norddeich, but an angle of 122 deg. with Schöneberg.

From these and other experiments Kiebitz concludes that horizontal earth antennæ, close to the ground or in the ground, could be used for radiotelegraphy. Earth-plates would not be necessary, but may be advisable; the antenna must be of great length, however, and such that the pressure has its maximum at the ends, and the current its maximum in the middle. In some respects a line with insulated ends, half a wave in length, close to the ground, would be best; but such a line would be unsuitable for close coupling. It would therefore be better to let the system oscillate with two half waves, such that loops form at the outer ends of the two wires and at the variable condenser, and nodes at the inner ends of the wires. In any case the horizontal antenna arrangement would offer many advantages. It would be much cheaper than the vertical antenna and less exposed to atmospheric disturbances, though more sensitive when tuned to long waves, a rather unfortunate circumstance. The possibility of working with close coupling and yet feeble currents (4 amperes were used in the transmission Belzig-Swinemünde, and the antenna gave only very small sparks) of alternating generators was, on the other hand, a great advantage. Small stations and ship stations for

* See *Verhandlungen Deutsche Physikalische Gesellschaft*, 1911, page 876.

* *Elektrotechnische Zeitschrift*, November 2, 1911, page 1101

small wave-lengths would probably retain their vertical aerials, Dr. Kiebitz thinks; for large stations using waves of lengths exceeding 1000 metres the horizontal earth antenna would be preferable.

In conclusion we would like to refer to a suggestion made by Zehnder. He accentuates that his arrangement sends out directed signals, and further that the much-desired secrecy of radiotelegraphic messages can be secured in a very simple way. Any code can be deciphered, he points out, if used for some time, because certain letters occur far more frequently than others. If, however, the code were changed at intervals, deciphering would become impossible. The message should simply be typed out on a special machine. When the typist begins, the characters a, b, c, d, e, f would correspond to x, m, o, s, a, g, for instance. When a line has been typed, the type-wheel is turned through one tooth; then the characters a, b, c, d, e, f mean m, o, s, a, g, v, and so on. The same machine would decipher the received message, and similar devices could be added to other typewriters without necessitating the adoption of separate keyboards, which would likewise solve the problem, but in a less simple way. Zehnder would also use horizontal antennæ, with terminals dipping into the sea, on board ship; considering the length of modern ships, waves of sufficient lengths would be applicable.

THE IRON AND STEEL INDUSTRY.

A RETURN has just been issued by the Board of Trade showing the output in the iron and steel industries of the world up till and including 1910. It is computed in this return that the combined output of iron ore for the world in 1909 amounted to about 130 million tons. So far as available figures allow of an estimation, this figure was exceeded in 1910. The increase in output in the case of several countries was very marked. For instance, the United States, producing 56,890,000 tons in 1910, had an output 11 per cent. greater than the year before. France increased her output by 21.5 per cent. over 1909. In the case of Germany and the United Kingdom the increase, though appreciable, was not so marked. Of the more important countries, the United States, of course, easily heads the list with an output of ore more than twice as great as that of Germany, including Luxemburg. The United Kingdom had an output of 15,226,000 tons, or slightly more than half that of Germany, and about one million tons more than France. The figures for Spain and Russia are not yet available for 1910, but those for Spain are 42 per cent. over the previous year, in which, however, a large drop from the figures for several previous years was recorded. Of the minor ore-producing countries, Newfoundland and Cuba and Algeria continue to be the more important, the latter having exports amounting to 1,048,000 tons. The two former countries have outputs of 1,125,000 and 1,418,000 tons respectively. The output in British India fell off from 83,000 tons in 1909 to 55,000 tons in 1910. China has increased her output at a phenomenal rate. In 1906 and 1907 she produced about 104,000 tons. A slight increase was recorded in 1908, but in 1909 the amount of the previous year was more than doubled, and last year (1910) it more than doubled again, amounting then to 713,000 tons.

In 1910 the United Kingdom imported for home consumption 6,970,000 tons of ore, exporting 9000 tons of native ore, having thus a balance of imports over exports of 6,961,000 tons. In Germany the balance of imports over exports was 5,002,000 tons, and in Belgium 3,465,000 tons, while the United States imported 1,079,000 tons more than she exported of native ore. The supplies came principally from Spain, which had a balance of exports over imports of approximately 8,183,000 tons; from Sweden, with a balance of exports of 3,635,000 tons; and from France, with imports of 1,572,000 tons, and exports of native ore of 2,970,000 tons. In addition to these there are, of course, supplies from Russia and the minor producing countries.

The aggregate output of pig-iron for the world in 1910 is put at 65 million tons, which is above any previous year by about five million tons. Again the United States heads the list with an output of 27,304,000 tons, next to which comes Germany with an output of 14,556,000 tons, with the United Kingdom third with an output of just over 10,000,000 tons. The important countries have more than recovered from the year of small output of 1908. The pig available for consumption differs but slightly in amount from the pig produced in the various countries.

The world's output of steel in 1910 is estimated at between 59 and 60 million tons, the combined output of the United States, Germany, and the United Kingdom having exceeded 46 million tons, divided between these three countries in the proportion of 26 : 13 5 : 6.5. The United Kingdom showed the smallest increase of the three. Outside the usual countries it may be stated that China, producing only 23,000 tons of steel in 1908, turned out in 1910 no less than 60,000 tons. Of the 26,095,000 tons produced in the United States in 1910, 15,641,000 tons were open-hearth, of which 14,858,000 tons were basic. Bessemer acid ingots were produced in that country to the amount of 9,354,000 tons. In Germany, which has only a small acid output, 7,903,000 tons were produced by the Bessemer basic process, and 4,894,000 tons by the open-hearth basic, out of a total of 13,479,000 tons. In Great Britain, however, the acid production preponderates, and out of a total of 6,515,000 tons, 4,155,000 tons were acid, against 2,219,000 tons of basic steel. Of the acid steel, nearly three times as much was produced by open-hearth furnaces as by the Bessemer process, the proportion being very nearly the same also for the basic steel.

In view of the drastic proceedings being taken at the present time in the United States to dissolve the big corporations, it is interesting to note that in 1910 the United States Steel Corporation produced 54 7 per cent. of the total steel output of that country, whereas for the period 1901-5 it turned out 63.1 per cent. of the total. The charge that this corporation has eliminated competition can scarcely be maintained, in view of the increased activity of the so-called independent companies. In nearly all items except pig iron and rails has the proportion of the independent companies increased since 1901. The largest change is noticeable in black and coated sheets. Of these, the Steel Corporation produced 67.3 per cent. of the total in 1901; now the independents produce 61.1 per cent. In seamless tubes the Steel Corporation, in 1901, controlled 82.8 per cent. of the total; the proportion is now 55.3 per cent. from Steel Corporation works, and 44.7 per cent. from the independent companies. Black plate produced in tin mills was divided, in 1901, so that 79.8 per cent. came from the Steel Corporation; now only 52.9 per cent. is so produced, the proportion of the independent works having, of course, risen from 20.2 per cent. to 47.1 per cent. In all cases of steel ingots and castings, structural shapes, plates, wire-rods, &c., the independent concerns have largely increased their output, and do not therefore appear to be suffering from the ill-effects which are supposed to follow on the activity of large corporations.

Compared with exports the imports of steel into the United Kingdom are not large, but in actual amounts they are considerable. The largest class of net imports is that embracing steel ingots, blooms, billets, slabs, &c., coming chiefly from Germany and Belgium, and amounting to 558,973 tons in 1910. Pig iron to the amount of 171,491 tons was imported in that year, chiefly from Sweden and Germany. No other class of imports attained to 100,000 tons, though the four classes of wrought-iron bars, steel girders, plates, and wire rods each reached amounts approaching that figure. It is noticeable that the imports of rails were smaller in 1910 than in any year since 1906.

THE LATE SIR JAMES C. INGLIS.

ENGINEERS will learn with profound regret of the death of Sir James Charles Inglis, General Manager and Consulting Engineer of the Great Western Railway, and past-president of the Institution of Civil Engineers. Sir James was not only an admirable exponent of engineering, but a strong advocate, on the one hand, of maintaining the dignity and efficiency of the profession, and, on the other hand, of developing fuller recognition on the part of legislative and administrative bodies of their responsibilities in ensuring the satisfactory design and effective supervision of public works under fully accredited engineering advisers. Indeed, if he had done no more than to plant the germ of the idea that such recognition was most highly desirable in the interest of the public he would have deserved high credit, and there can be no doubt that the seed thus planted will fructify and give vigour to a new era in connection with the expenditure of public money.

Sir James Inglis, who died late on Tuesday night at Rottingdean—the direct cause being pneumonia and exhaustion—had only reached his sixty-first year, having been born in Aberdeen in 1851. He received his early education at the grammar school there, and, with a view of following an academic career, was sent to Aberdeen University, where he studied for three years—from 1867 to 1870—taking prizes in natural science and mathematics. The call of engineering, however, came to him early, at a time when steam engineering and railway construction appealed to the public mind and offered a great field for enthusiastic and capable youths, and Inglis entered the workshops of Messrs. Norman, Copeland, and Co., well-known millwrights and engineers in the St. Rollox district of Glasgow. Here the youth—equipped with high mental qualities, as the result of his liberal education, and eager energy—came into contact with a great variety of mechanical problems, and gained good experience in general mechanics, the late Mr. John Norman recognising the need for soundness in all work. Observing his great ability, some of his friends, notably the late Dr. Alex. C. Kirk, advised him to adopt railway engineering as his speciality, and young Inglis became a pupil of the late Mr. James Abernethy, Past-President of the Institution of Civil Engineers. From 1871-74 he was mostly engaged under Mr. Abernethy on dock and harbour works—notably in the construction of the Alexandra Docks at Newport, Mon.

From this time onwards Mr. Inglis (as he then was) was closely associated with the West country, and on its railways and harbours he left a strong impress, doing much for the prosperity of Devon and Cornwall. When he left Mr. Abernethy, he became assistant, in January, 1885, to the late Mr. P. J. Margary, who was chief engineer of the South Devon and Cornwall Railways, which, later, became part of the Great Western system. Under Mr. Margary, Mr. Inglis was engaged in the construction of Plymouth Station, the harbour railway there, and the widening of the Newton to Torquay line. It was in 1887 that he first joined the staff of the Great Western Railway, and became resident engineer of the dock works at Millbay, being responsible there, under officers of the company, for works totalling in value 120,000*l*. At this period he did not continue long on the staff of the Great Western Railway, but took up practice on his own account. The connection with the railway, however, was not completely severed, as during the next few years he continued to carry out important work for the company upon commission. He occupied several important positions in the district, and carried out many interesting undertakings.

Thus in 1878 he was appointed engineer to the Cattewater Harbour Commissioners, and built the Mount Batten breakwater at Plymouth, 950 ft. long, and terminating in a depth of 20 ft. at low water of ordinary spring tides; this work cost 27,000*l*. Similarly, as engineer to the Sutton Harbour Company of Plymouth, he designed and carried out a large fish-market there. In 1882 he became engineer to the Compton-Gifford Local Board, with the special object of carrying out extensive sewerage and outfall works. About this time also he was engaged in the construction of a fishing harbour at Newlyn, which involved the building of a pier for protecting the harbour, the length being 720 ft., and on it was erected a wrought-iron lighthouse tower. This was a most beneficial undertaking, as several attempts had been made to provide safe harbourage for the fishing fleet, and the Public Works Loan Board, becoming interested in the scheme, assisted in the provision of the harbour, embracing many acres, and costing 60,000*l*. This harbour now yields a revenue of 3000*l*. per annum. He also carried out the Torquay harbour works under Mr. Abernethy as consulting engineer. Among the work done on behalf of the Great Western Railway during this period was the construction of the Princetown Railway from Devonport, 10½ miles long, through very heavy country. He was resident engineer on this undertaking, and it occupied a large part of his time between 1881 and 1883. His next work for the Great Western Company was the construction, also as resident engineer, of the Bodmin branch, 4½ miles in length, which was completed in 1887. He continued in

practice until 1892, and further suggestion of his wide interest is found in the help he rendered in the construction, in 1888, of the laboratory of the Plymouth Marine Biological Association.

It was in June, 1892, that he became assistant engineer to the Great Western Railway, the late Mr. French being his immediate superior. Four months afterwards (October, 1892), Inglis was appointed chief engineer of the line. From this time onwards an active engineering policy was pursued, the average sum spent per annum on the system, in maintenance and new works, amounting to about two million sterling. What this meant in the way of design and supervision to a man so conscientious in his work as was Sir James Inglis will be appreciated by the technical reader. It is not, however, our intention to make an elaborate review of the work, but a reference may be made to the two outstanding events—namely, the conversion of the line from the broad to the standard gauge* in 1892, and the reconstruction of all the old timber viaducts in Cornwall. The first of these two undertakings afforded evidence of his great organising ability, the second of his undoubted mechanical ingenuity and foresight in providing against contingencies. Many of these viaducts, which were monuments of Brunel's great skill and boldness as well as of his originality of design, were of very considerable length, and it was important that the traffic should be maintained during the progress of the work. The original viaducts were found to be perfect as staging for putting in the steel girders on the stone piers where such existed, but in many cases the piers were also of timber, and many expedients had to be devised to enable the work to be done. Certain problems arose in connection with the design of the new bridges, so that the transverse girders could be got through at exactly the proper level below the beams carrying the railway; but these and all other difficulties were overcome as a consequence of the versatile and extensive experience possessed by the subject of our memoir. Another direction in which considerable knowledge and ingenuity were required was in connection with railway subsidences due to coal-workings. The extent of these on the Great Western line is indicated by the fact that some 60,000 or 70,000 yards of filling per annum were required throughout the system.

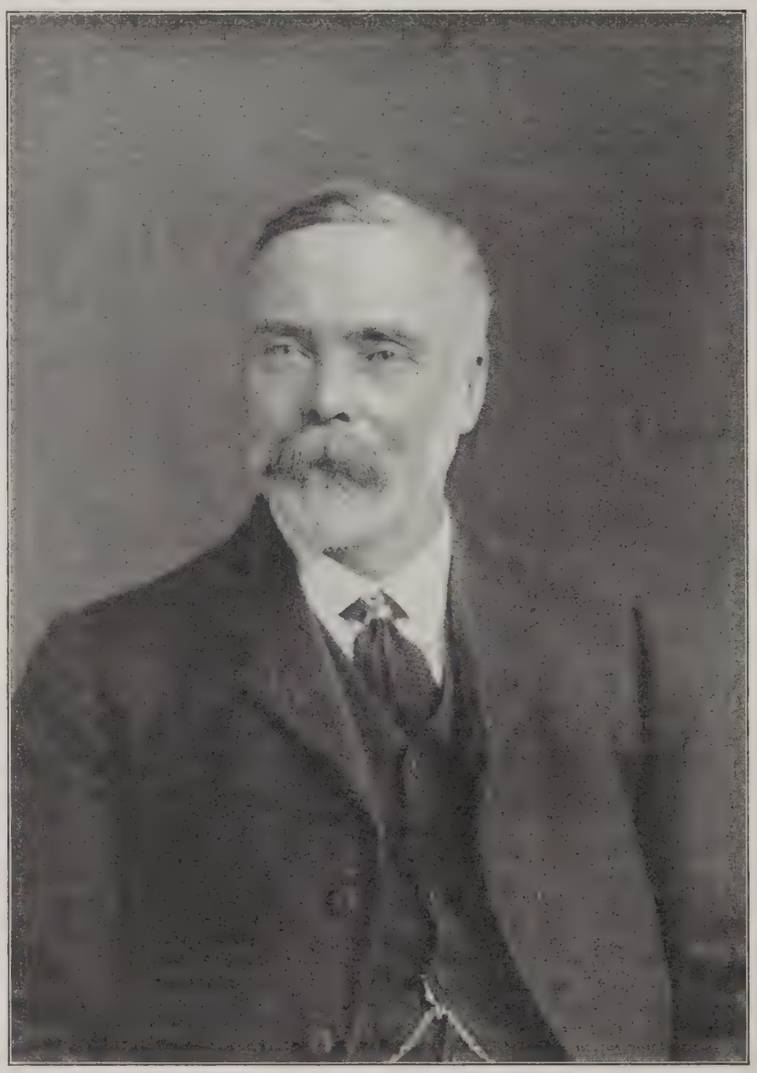
In 1903 Sir James Inglis was appointed the general manager of the Great Western Railway, a position which he well merited, not merely for the services which he had rendered, but because of his administrative ability. At the time general satisfaction was expressed by the appointment of a leader of the profession to the full control of an undertaking in which engineering problems bulked so largely. In this the Great Western Railway Company followed the precedent set by the Lancashire and Yorkshire Railway in promoting Mr. J. A. F. Aspinall, formerly their chief mechanical engineer, to be the general manager. Other railways have since taken the same course, a circumstance which was, in some measure, due to the success of Mr. Aspinall and Sir James Inglis in their control of the lines under their charge.

An outstanding event in the management of the Great Western by Sir James Inglis was the construction, involving seven years' work, of the Fishguard Harbour, in North Pembrokeshire,* and the establishment of a fast service, by means of high-speed turbine steamers, with Rosslare, in Ireland, the connection there being with the Great Western and Great Southern and Western Railways of Ireland. The harbour, for which Sir James was engineer, involved the construction of a quay-space half a mile in length and 250 ft. in average width, a wall 1100 ft. long, and a breakwater 2000 ft. in length, as well as the provision of an extensive station and sidings. This new connection with the South of Ireland has been a great boon, not only in developing Irish agriculture, but in bringing the most-favoured resorts of Ireland within easy reach of the Metropolis. There was also great advantage from the construction of the South Wales direct line *via* Badminton, and of the joint line of the Great Western and Great Central Companies, the latter shortening materially the route of the former company's railway to Birmingham.

Sir James served the profession in many capacities. He was lieutenant-colonel in the Railway Staff Corps, and a member of the Engineering Standards Committee. Along with Sir William Matthews he was arbitrator for the purchase of the Tanjong Pagar Docks, Singapore. He was a member of the Royal Commission on Canals and Inland Navigations. In recognition of his services to the profession and the country, he was made a Knight in January of this year by King George. He also possessed the insignia of the Order of the Crown of Italy, and the insignia of the Third Class of the Prussian Order of the Red Eagle.

Sir James Inglis had the distinction—rare in recent years — of being for two sessions President of the Institution of Civil Engineers, from 1908 to 1910. From the beginning of his professional career he was closely identified with the Institution. As a student he won a Miller prize in the early 'seventies for a paper on "Theory and Practice in the Construction of Tanks;" he became an associate in 1876, a member in 1884, and was elected to the Council in 1897, and to the vice-presidency in 1906. Excepting his presidential addresses,* which were concerned with the responsibilities of the engineer, and of public authorities spending money on engineering works without the assistance of accredited engineers, his only contribution to the proceedings was a paper on "The Design of Permanent Way and Locomotives for High Speeds,"† as an introduction to a discussion at one of the conferences. He frequently spoke in debate, and his remarks were confined, as a rule, to the review of the lessons of practical experience, so that they were ever welcome.

He was eminently practical, with a mechanic's instinct to recognise that which rang true. We can recall his strong advocacy of Baker's view that when they followed engineering principles to their fullest limits engineers had no need to fear the strictures of the æsthetic critic. Every scheme which was presented to him had to comply with the one standard—utility and practicability; but no detail was too trivial to be considered if it had a direct bearing on the ultimate issue. He was thorough; broad in his views, alike in engineering and in his more private opinions; and thus, although a Liberal in politics, he was an Imperialist in the highest sense of the word. He was large-



From a Photograph by Thomas Fall.

The late Sir James Charles Inglis.

* See Engineering, vol. liii., pages 657 and 690.

* See Engineering, vol. lxxx., page 178, and vol. lxxxii., page 106.

* See Engineering, vol. lxxxvi., pages 622 and 630 vol. lxxxviii., pages 619 and 623.

† See Engineering, vol. lxxv., pages 821 and 830.

hearted, and in business and in private did much to encourage others, but he had a short way with the dilettante and "humbug." He was not an orator, if that term be applied, as it too often is, to the maker of fine phrases ; but the members of the Institution welcomed him as the official exponent of their views, because of the directness and practical soundness of his language, simple as it was in diction. Of this proof was afforded notably at the ceremony of laying the foundation stone of the new building of the Institution in October last year. In council and committee work his administrative services were of great value, while in the semi-public social functions he was genial and ever kindly in his comments. His death will undoubtedly be deeply regretted by a wide circle of professional and private friends.

The funeral of Sir James Inglis will take place to-morrow (Saturday), the memorial service being held at St. James's Church, Paddington, at 11 o'clock, while the interment will be at Kensington Cemetery, Hanwell, at noon, or shortly thereafter.

THE PHYSICAL SOCIETY'S EXHIBITION OF SCIENTIFIC APPARATUS.

THE seventh annual exhibition of electrical, optical, and other physical apparatus, arranged by the Physical Society of London, was held in the Imperial College of Science and Technology, South Kensington, last Tuesday afternoon and evening. The very convenient alphabetical order was retained in the catalogue this year, and, with the aid of the plan of the location of the exhibitors, every exhibit could easily be found. A few of the exhibits had been shown last year ; these were dealt with in our issues of December 23 and 30, 1910, on pages 866 and 888.

We will first mention the two discourses prepared for the occasion. Professor the Hon. R. J. Strutt, F.R.S., gave a discourse on "Electric Discharge and the Luminosity that Survives it," twice, in the afternoon and evening. The luminous phenomena which accompany electric discharges in general cease as soon as the discharge is stopped. Sometimes a certain luminosity, an after-glow, persists, and Professor Strutt has within the last two years presented several papers on these after-glows to the Physical Society. What he demonstrated on Tuesday was new, however. He made use of two apparatus. In the first nitrogen gas was drawn through a horizontal discharge-tube and passed then through a wider horizontal glass tube or bulb, about 3 in. or 4 in. in diameter ; other gases were introduced into this second tube, in which they therefore arrived without having been exposed to the discharge, but mixed with the nitrogen, which had been submitted to powerful discharges ; there were several large Leyden jars in the circuit. When nitrogen alone was circulating, the wide bulb glowed with a pale orange colour, and the whirls of the gas could distinctly be seen. The spectrum of this luminosity resembled the band spectrum of nitrogen, as to the position and structure of the bands, under discharges at high current density, such as Professor Strutt applied ; but they were only a few of the nitrogen bands in this luminosity spectrum, which the lecturer likened to a defective set of teeth. Professor Strutt said that he regarded this luminous nitrogen as an active modification of nitrogen, which was very unstable, and that the luminosity was evidence of the change of active nitrogen back into common nitrogen. He was not able to enter into a full explanation of his reasons. But his second experiment supplied one of the arguments. Through a side tube he introduced into the wider bulb some nitric oxide (NO) in the way pointed out above. The luminosity, so far orange in colour, at once turned green and changed in character ; the gas mixture of nitrogen, nitric oxide, and the resulting products was passed through a U-tube standing in liquid air. It was shown that a blue liquid condensed in this tube, which became filled with brown-red fumes when the tube was slowly heated afterwards. Now the blue liquid and the brown vapours suggested the presence of the higher oxide, NO_2, and it would thus appear that nitrogen and nitric oxide together produce a higher nitrogen oxide under the discharge conditions, instead of yielding a lower oxide, as one would expect. Thus nitrogen behaved, in this case, like oxygen, and this was one of the reasons why Professor Strutt thought that his nitrogen, having passed through the discharge-tube, was in an active condition and capable of transferring some of its energy to the other gas. The reaction might be expressed by the formula, $N + 2\ NO = NO_2 + N_2$, which was hypothetical, however.

In another experiment Professor Strutt introduced some tin chloride vapours into the wide bulb, through which the active nitrogen was being drawn. The colour of the luminosity (pale orange) changed into a beautiful blue. The spectrum of this blue luminosity consisted of a broad band between the yellow and blue, which could be resolved into several bands resembling those of uranium salts ; two blue tin lines were also noticeable, and some tin might, therefore, be reduced during the reaction ; but an explanation of these phenomena could not yet be offered.

Professor Strutt finally made an experiment with the second apparatus. A wide, horizontal glass tube, several feet in length, was filled with nitrogen under reduced pressure. Near its one end the tube was encircled with a few turns of insulated wire, joined, as in the other experiments, to an induction apparatus with Leyden jars in circuit. The tube had no electrodes. When the discharge passed through the coil, a pink ring - discharge (known to our readers from our accounts of Sir J. J. Thomson's discourses) was seen in the tube. When the room was darkened, and the discharge stopped, an orange-yellow luminosity was seen to travel towards the far end of the tube. This after-glow remained quite distinct for more than a minute, and much longer probably, though it became fainter. Professor Strutt then remarked that, if a piston were introduced into the tube, the after-glow, already faint, would revive as the piston advanced, in the compressed portion of the nitrogen, to die out completely immediately afterwards. Instead of using a piston, he admitted some nitrogen into the tube, from a flask joined to it at the short (coil) end. It was very striking to watch how a dark space advanced from this end when the tap of the flask was opened, and that a cushion of intensified luminosity seemed to travel in front of the dark space, until the whole tube turned completely dark —all within the space of a second or two.

In describing the exhibition we follow the alphabetical order of the catalogue. Messrs. R. and J. Beck, of Cornhill, exhibited the holophane lumeter of Dow and McKinney, which we have noticed on previous occasions. The new instrument is a flat ebonite box, a few inches in dimension ; by means of an electric light and a graduated shutter, the brightness of a surface may be determined ; the pointer on the one outside face marks brightness from 0.01 up to 200 foot-candles. In a new "handle-model" microscope shown by the firm, the limb is in the shape of a handle, by which the microscope can be lifted without disturbing the adjustments, and an iris diaphragm is set in the thickness of the stage, so that a diaphragm remains for use when the sub-stage is swung aside.

The Cambridge Scientific Instrument Company was strong in novelties. The Duddell oscillograph outfit, for 50,000-volt circuits, had just arrived back from the Turin Exhibition. It is intended for power-stations, and was demonstrated at work on the 100-volt circuit of the College. Fig. 1, page 838, shows the whole apparatus except the resistance, which would find room under the table. The oscillograph proper is mounted in a porcelain insulator, the cylindrical porcelain cover of which has been removed in the photograph. The resistance of half a million ohms consists of asbestos and constantan ribbon. Between the oscillograph and the photographic box is a glass plate, of finger thickness ; the chimney-like tube on the box is the fall-tube for the photographic plate ; when the simultaneous current and potential waves are only to be watched, the observer stands on the far side of the box, next to the arc-lamp lantern, whose light is reflected on to the plate. There is no transformer, therefore, which might distort the wave-form, and non-inductive high resistances can be employed without having to dissipate a large amount of electric energy. The oscillograph contains two vibrators. The essential parts of a vibrator are two very fine flat strips of copper stretched on a bronze frame-piece over ivory guides and pulleys in such a way that the portion of the strips which lies in the gap of the permanent steel magnet has a length of 1 cm. and a free period of 0.0001 second. The gap is vertical, and in order to reduce the clearance as much as possible, a very small width of steel is left between the two copper strips. The current to be measured passes through the strips. The two vibrator frames of an oscillograph are vertically mounted by the side of one another in the oscillograph, the upper portion of which is filled with oil ; the frames can turn about adjustable pivots. The photographic plate drops out of a black silk bag which is pulled over the chimney, and falls into a similar bag below. Beautiful curves were shown.

The Paschen galvanometer, of the Cambridge firm, is an instrument of exceedingly high sensitivity, designed for bolometer and radiometer work. It is of the moving-magnet type, in which the magnets are arranged in two groups after the manner of a Thomson galvanometer. The instrument is the result of the investigations of Paschen, Mendenhall, Waidner, and Abbott. The two groups, an upper and a lower group, each of thirteen quite short and small magnets, of the magnet system are arranged alternately on two sides of a fine glass stem, suspended by quartz fibre. The astaticising of the system is so perfect that periods approaching ten seconds can be obtained. Each group is between the two galvanometer coils of a pair, and the chief task of Paschen and the other scientists has been to secure the maximum effect for a given resistance of copper by winding with different sizes of wire, beginning with the smallest sizes, and winding each layer in such a manner that it lies within a surface, of which the polar equation is $r^2 = d^2 \sin \theta$, where r is the length of radius making an angle θ with the axis of the coil, and d the value of r when $\theta = 90$ deg. The theory of this winding was given by Maxwell, and Paschen winds the coils with six sizes of wire on an elliptically-shaped former, which shape yields an efficient field and permits of using the greatest number of magnets.

The Paschen thermopile, also exhibited, is a tubular instrument, a modification of the type with which H. Rubens has been conducting his remarkable researches on Reststrahlen and on waves from the two extremes of the spectrum. The fifteen couples consist of copper and constantan, and the hot junctions are all in the middle. To reduce the heat capacity the wires have been rolled down flat ; the temperature increase due to radiation is 98 per cent. within 2 seconds, and is practically completed within 4 seconds.

The cathetometer, Fig. 2, page 838, has a height of about $2\frac{1}{2}$ ft., and the total vertical range of the telescope is 20 in. The whole pillar turns about its vertical axis, and the telescope slides up and down the pillar, and can be clamped in any position with the aid of a five-point bearing. Micrometrically the instrument can be raised through a vertical range of 2.5 cm., and the micrometer head allows of reading this range within 0.005 mm.

The new laboratory chronograph of the Cambridge Company, illustrated in Fig. 3, traces curves on a band of Morse paper 1 in. in width, which is drawn under three styles by the aid of a small electric motor, whose pulley can be seen on the left side of the figure. The styles are attached to the rocking armatures of three electromagnets ; the one pen is connected with a contact clock, the other two record the curves. It will be seen that the whole upper part of the frame is pivoted, so that the styles may be lifted off the paper without stopping the motor ; the paper movement may also be interrupted while the motor runs on.

Fig. 4, page 839, is a photograph of a recording electro-meter for meteorological investigations, designed by Mr. J. Patterson, of the Meteorological Office, Toronto, and the Cambridge Scientific Instrument Company. It is essentially a quadrant electrometer, provided with two sets of quadrants and a double needle. The needle is made of aluminium, and is fitted with an extra vane for magnetic damping. A boom, which is free to swing over the moving chart, is attached to the needle, but insulated from it. At intervals a horizontal bar is allowed to drop and to force this boom on to the chart ; a dot is then produced, and the dots are close enough to one another to form a curve.

The new modification of the Féry radiation pyrometer, which is illustrated in the photograph, Fig. 5, and the diagram, Fig. 6, is due to Mr. R. S. Whipple, of the Scientific Instrument Company. The modification is intended for measuring the very high temperatures of technical practice. The blind-end tube A is made of fireclay, plumbago, steel, or quartz, and is inserted into the molten metal, salt, &c. ; C is a steel tube, F a screen to shut off the heat ; at D the steel tube is bolted to the pyrometer head E, which contains the mirror M, on which the radiations

of the black body A fall to be focussed on the thermo-couple E; H is the handle, and the leads L join the couple to the direct reading temperature-scale; the instrument does not require any focussing, and may be used in any position. For the demonstration the tube A was pushed into an open muffle furnace heated by a Méker burner, when a temperature of 790 deg. was indicated. If the tube A, which may be several feet in length, should break, this part could easily be replaced; there is no risk of injury to the other parts. We reserve a description of the Rosenhain portable potentiometer for use with thermo-couples; it has a range of 40 millivolts.

Messrs. C. F. Cassella and Co. showed some new meteorological exhibits, rainfall recorders, &c.; also their theodolites and surveying instruments. Messrs. A. C. Cossor, Limited, of 54, Farringdon-road, E.C., showed their new patent electro-mechanical high-vacuum pump for engineers, which, they claim, will produce as good a vacuum as a Gaede pump in a shorter time. It is intended for exhausting lamp-globes, X-ray tubes, &c. The machine—a kind of beam engine with fly-wheel—is driven by an electric-motor, and comprises two oil-pumps coupled in series, an auxiliary pump and a vacuum pump. In the vertical cylinder of the latter an iron-rod piston moves up and down under the influence of the attraction of the solenoid-box surrounding it, which is raised and lowered by the machinery. The upper valve is kept open during a fourth of the down stroke to allow the oil to return; the auxiliary pump keeps the oil deaerated. The rod is introduced into the cylinder through a ground-metal joint, which is oil-sealed.

Messrs. Harry W. Cox and Co., Limited, of 47, Gray's Inn-road, exhibited the portable apparatus for the analysis of the air of mines, which Dr. J. S. Haldane, F.R.S., designed, ten years ago, in the form which the new regulations of the Home Office render obligatory. The glass apparatus determines the carbon dioxide, carbon monoxide, methane, and oxygen by absorption and combustion tests, and fits into a wooden case, 19 in. by 12 in. by 2½ in. A smaller apparatus, for determining small percentages of CO_2 in the air of factories, was also shown.

The flux-meter of Messrs. B. H. Morphy, A.M.I.E.E., and U. A. Oschwald, B.A., also exhibited by Messrs. Cox, is intended for studying the flux distribution in the air-gap of a generator, &c., and has been used for some time at the South-Western Polytechnic, S.W.

The flux-meter may be described as a flat exploring needle, which, in experimenting on the pole-gap flux, would be held parallel to the armature, being attached to a radial arm which is carried by the armature shaft. The needle forms itself a mirror galvanometer. It consists of a slender shaft which is provided with needle-points at each end; a coil of twenty turns of a very fine copper wire is wound longitudinally between two notches. Through silver filaments the ends of this coil are connected to terminals, so that a weak current of about 0.03 ampere can be passed through it. The small shaft also carries a fine hair-spring, which controls its deflection, and a small square brass block, on the four sides of which mirrors are mounted. The whole movement is held between brass bearings inside a brass tube, which has a width of ⅛ in., increasing to ⅜ in. in the portion which surrounds the mirrors and springs. Windows are cut in this wider portion of the tube, through which the light of a small osram lamp falls on to the mirrors, and is reflected on to a scale. The

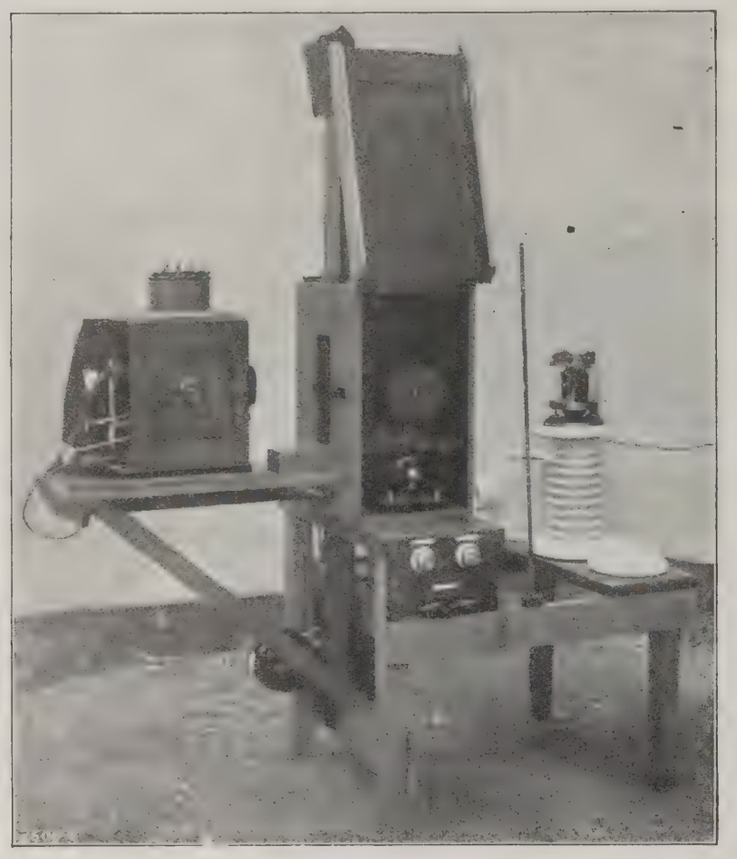


Fig. 1. Duddell Oscillograph.

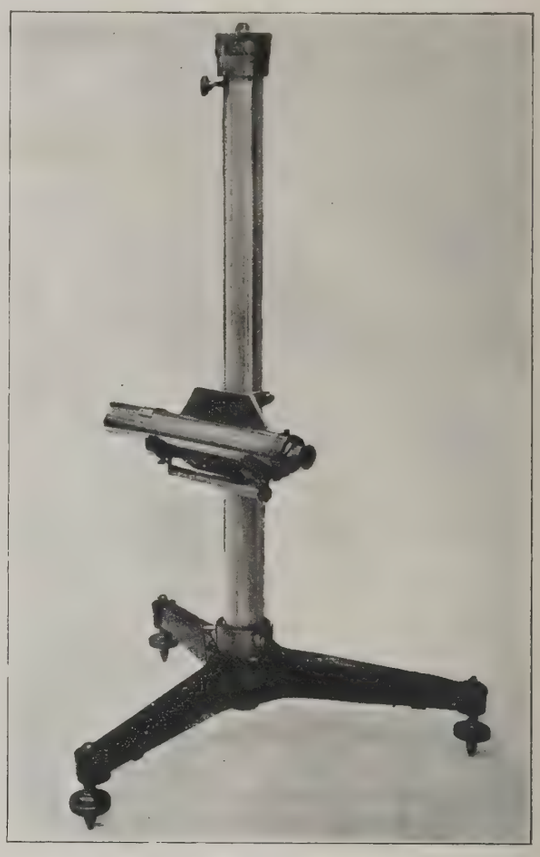


Fig. 2. Cathetometer.

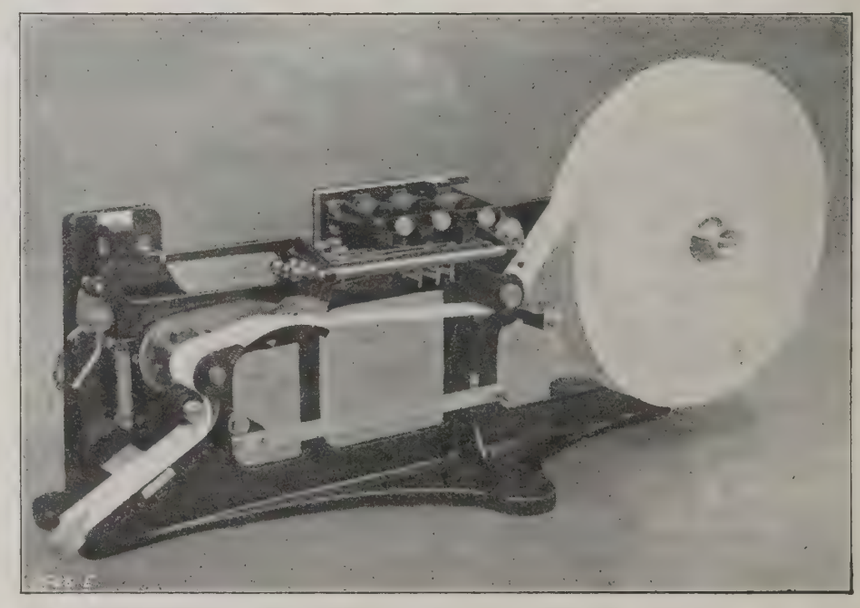


Fig. 3. Laboratory Chronograph.

lamp and the scale are supported by the radial arm already mentioned. In making a test the arm is moved through the gap, and a current passed through the small coil, first in the one and then in the other direction. The apparatus brings out the flux variations near the armature teeth very well.

Messrs. Crompton and Co., Limited, of Chelmsford, exhibited in addition to the Crompton potentiometer, switchboard instruments, and series trans-

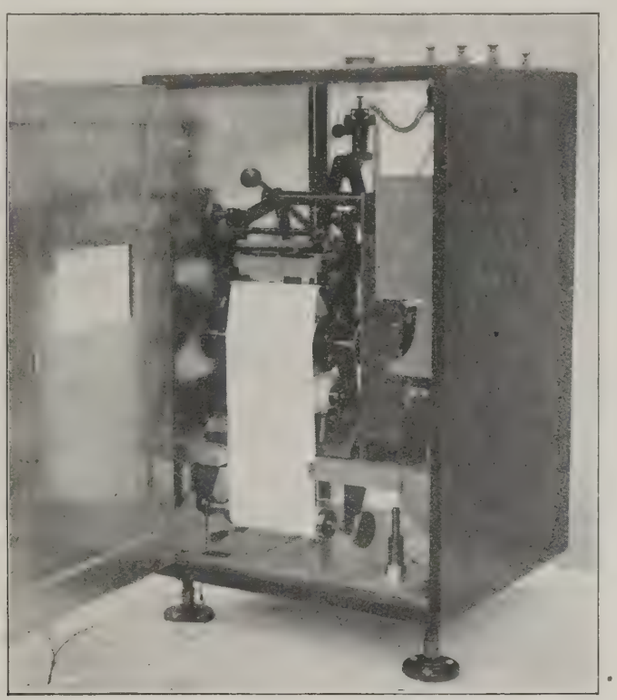


FIG. 4. RECORDING ELECTROMETER.

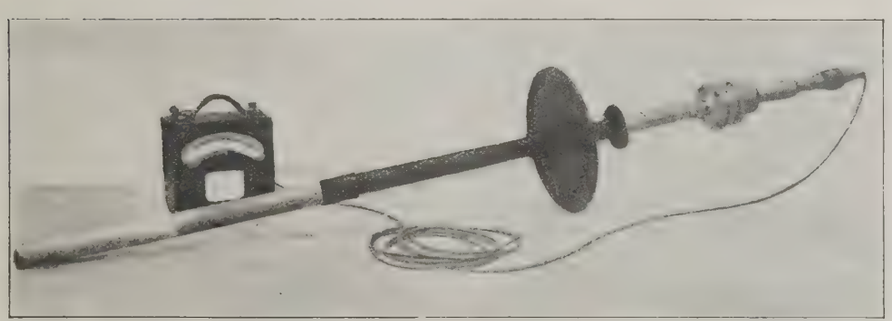
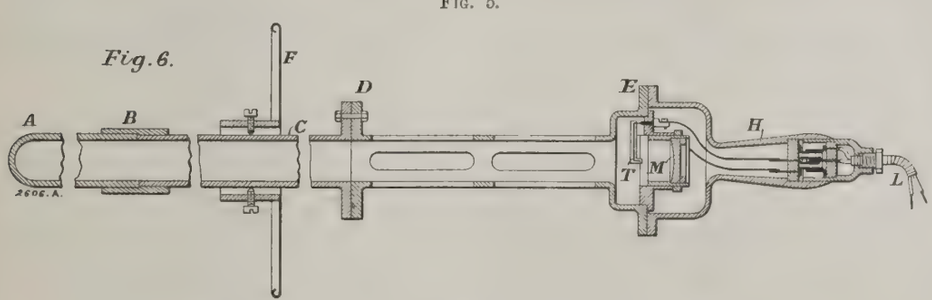


FIG. 5.



FIGS. 5 AND 6. WHIPPLE-FÉRY RADIATION PYROMETER.

formers for operating automatic switch-gear, the road-wear measuring-machine used by the Road Board. The idea is that a wire is stretched across the road, and that the distance of this wire from the road is measured. Pairs of cast-iron sockets, about 2 in. square, are let into the sides of the road, where their foot-plates rest on small concrete bases; the sockets of a pair are placed immediately opposite one another. Ordinarily the sockets are closed by screw plugs to keep out the dirt. The parts which support the wire are mounted on mild-steel spindles which are provided with shoulder-pieces. One of these supports has mounted on it a small drum carrying wire. The wire passes from the drum under a guide-pulley through the jaws of a friction device across the road and over guide-pulleys mounted on the other support, where it terminates in a hook from which a weight is suspended. The same wire and weight being always employed between supports at fixed positions, the wire will form a datum line, apart from small temperature variations, for which, we suppose, allowance might be made if the roads were smooth enough to study accuracy to this extent. Measurements are made with the aid of a measuring-stick whose foot-plate is placed on the road. A small arc-shaped piece of sheet-metal projects from the stick, and a mirror is fixed on the inside of the arc, opposite which are two cross lines, which are attached to the central sliding-piece of the measuring-stick. The arc forms a kind of a hook-recess for the wire when the stick is placed near it, and the slide is raised or lowered by means of a handle carrying a rack and pinion, until the cross lines are immediately opposite the wire; the adjustment is made by the observer from above, with the aid of a telescope and the mirror, and the actual height of the cross lines from the road is then read off on a scale fitted with a vernier. A set of readings is taken in different positions, the stick being shifted across the road, the wire remaining in position. The reading device is due to Messrs. Stanley and Co., of Great Turnstile, Holborn, W.C.

Messrs. J. H. Dallmeyer, Limited, had several instruments on view displaying their noted accurate workmanship. Their snapshot telephoto lenses work at the apertures $f/10$, $f/6$, and $f/4.5$, and give pictures on a scale $2\frac{1}{2}$ and 5 times those obtainable by ordinary lenses. Their iris diaphragm comes very near the theoretically possible maximum opening, which, according to C. F. Lan-Davis, is 82 per cent., whilst they claim to realise 76.5 per cent. with their 24-leaved shutter. The firm has also introduced auto-catches to prevent, or to make unlikely, double exposures of a plate. They also demonstrated the use of proof-planes and a large right-angle prism for determining true plane surfaces.

Messrs. Elliott Brothers showed the latest form of the Wimperis recording accelerometer, which we described some time ago; the C. W. triple testing set (measuring amperes, volts, and watts) for direct and alternating currents, and a new pattern of their well-known "Century" testing set, distinguished by lightness and compactness.

(*To be continued.*)

NOTES FROM THE UNITED STATES.

PHILADELPHIA, December 13.

Heavy purchases of pig iron continue to be made in all markets east and west. The prevailing low prices, coupled with an exhaustion of stocks, and the practical certainty of a continued demand and an upward tendency, accounts for the present activity. Besides, production has not increased. The output of coke and anthracite iron for November was 1,999,433 tons, as compared to 2,102,147 tons in October. The Baldwin Locomotive Works have purchased 11,000 tons of foundry grades this week, the Pennsylvania 5000 tons, and eastern cast-iron pipe-makers 25,000 tons. Basic iron is also moving more freely than for months. Furnace-makers are avoiding where they can deliveries for the second quarter of next year, as they anticipate an improvement in prices. Steel billets have gained considerably in activity. The general pig-iron outlook is much better. Messrs. Jones and Laughlin have purchased 40,000 tons of basic. No. 3 Homestead plant of the Carnegie Steel Company has had a record run, producing in the twenty-four hours 8961 tons of open-hearth steel. All of the mills in Western Pennsylvania are working to fuller capacity than for a year. The Pittsburg Steel Company is inquiring for 60,000 tons of Bessemer, and the American Rolling-Mill Company for 15,000 tons of basic. Wire products have dropped another dollar per ton, and this has led to very heavy buying. Open-hearth plants are increasing their output, and a large amount of new business is being submitted for acceptance. The general feeling is that the present activity will continue for an indefinite period. The car-builders report a large addition in the volume of business pending, and in the bookings for the past two months. Tin-plate exports for October were 15,941,983 lb., worth 533,997 dols. The imports for the same month were 1,286,870 lb., worth 48,284 dols.

SUPERHEATER PATENTS.—The Fuel-Economiser Company, of Wakefield, have withdrawn the patent action brought by them against McPhail and Simpson, Limited, the well-known steam-superheater manufacturers, also of Wakefield, which was down for trial before Mr. Justice Eve, in the Chancery Division, and have been ordered to pay the costs, including the costs of an action which McPhail and Simpson, Limited, brought to restrain the Fuel-Economiser Company from threatening their customers with proceedings for alleged infringement. The patent in question was for improvements in feed-water heaters for use in connection with steam-generators.

PERSONAL.—Messrs. Blichfeldt and Co., 16, Waterlane, Great Tower-street, E.C., state that they have decided, for family reasons, to convert their business into a private limited company, under the title of Messrs. Wettern Brothers, Limited. There will be no change in the management.—Growth of business has compelled the Armorduct Manufacturing Company, Limited, to make considerable extensions to their Witton Works. These extensions, when complete, will practically double the present capacity of the works, thus enabling the company greatly to increase their present output.—For the convenience of their electrical customers in London, the Adams Manufacturing Company's London business has been transferred to Balfour House, Finsbury Pavement, London, E.C., to which address all communications regarding Adams Igranic motor-controlling apparatus should be directed.

MILITARY AEROPLANES.

WE give below a list of the prizes offered by the War Office for military aeroplanes, together with a specification of the requirements which the competing aeroplanes will have to fulfil. An article dealing with this competition appears on page 833 of the present issue.

Conditions laid down and Prizes offered by the War Office for a Competition to fulfil the Requirements of the Accompanying Specification for a Military Aeroplane.

The prizes to be awarded by the War Office on the recommendation of a Committee, which will judge the tests, and will decide whether any machine submitted is to be subjected to any test.

A. *Prizes open to the World for Aeroplanes made in any Country :—*

	£
First prize	4000
Second prize	2000

B. *Prizes open to British Subjects for Aeroplanes Manufactured wholly in Great Britain, except the Engines :—*

	£
First prize	1500
Two second prizes ... ... (each)	1000
Three third prizes ... ... (,,)	500

No competitor to take more than 5000*l.* The War Office to reserve the right to vary the proportions of totals under "A" and "B" between the various prizes if the merits of the machines warrant it, or to withhold any prize if there is no machine recommended for it by the Testing Committee.

The War Office to have the option of purchasing for 1000*l.* any machine awarded a prize.

The owners of ten machines which are submitted to all the flying tests and are not awarded a prize to receive 100*l.* for each machine so tested.

Oil and petrol to be supplied free for the tests.

The place of delivery of aeroplanes entered for the competition will be announced later.

E. W. D. WARD.

War Office, December 14, 1911.

Specification for a Military Aeroplane.

The following conditions are those required to be fulfilled by a military aeroplane :—

1. Be delivered in a packing-case suitable for transport by rail, and not exceeding 32 ft. by 9 ft. by 9 ft. The case must be fitted with eye-bolts to facilitate handling.

2. Carry a live load of 350 lb. in addition to its equipment of instruments, &c., with fuel and oil for 4½ hours.

3. Fly for 3 hours loaded as in Clause 2, and maintain an altitude of 4500 ft. for 1 hour, the first 1000 ft. being attained at the rate of 200 ft. a minute, although a rate of rise of 300 ft. per minute is desirable.

4. Attain a speed of not less than 55 miles per hour in a calm (loaded as in Clause 2).

5. Plane down to the ground in a calm from not more than 1000 ft. with engine stopped, during which time a horizontal distance of not less than 6000 ft. must be traversed before touching.

6. Rise without damage from long grass, clover, or harrowed land in 100 yards in a calm, loaded as in Clause 2.

7. Land without damage on any cultivated ground, including rough plough, in a calm, loaded as in Clause 2, and pull up within 75 yards of the point at which it first touches the ground when landing on smooth turf in a calm. It must be capable of being steered when running slowly on the ground.

8. Be capable of change from flying trim to road transport trim, and travel either on its own wheels or on a trolley on the road ; width not to exceed 10 ft.

9. Provide accommodation for a pilot and observer, and the controls must be capable of use either by pilot or observer.

10. The pilot and observer's view of the country below them to front and flanks must be as open as possible, and they should be shielded from the wind, and able to communicate with one another.

11. All parts of aeroplane must be strictly interchangeable, like parts with one another and with spares from stock.

12. The maker shall accurately supply the following particulars, which will be verified by official test :—

(*a*) The horse-power and the speed given on the bench by the engine in a six hours' run.
(*b*) The engine weight, complete (general arrangement drawing), and whether air or water-cooled.
(*c*) The intended flying speed.
(*d*) The gliding angle.
(*e*) Weight of entire machine.
(*f*) Fuel consumption per hour at declared horse-power.
(*g*) Oil consumption per hour at declared horse-power.
(*h*) Capacity of tanks.

13. The engine must be capable of being started up by the pilot alone.

14. Other desirable attributes are :—

(*a*) Stand still with engine running without being held. Engine preferably capable of being started from on board.
(*b*) Effective silencer fitted to engine.
(*c*) Strain on pilot as small as possible.
(*d*) Flexibility of speed ; to allow of landings and observations being made at slow speeds if required, while reserving a high acceleration for work in strong winds.
(*e*) Good glider, with a wide range of safe angles of descent, to allow of choice of landing places in case of engine failure.
(*f*) It is desirable that the time and number of men required for the change from flying trim to road trim, or packed for transport by rail, and *vice versâ*, should be small, and these will be considered in judging the machine. The time for changing from road trim and packed condition to flying trim to include up to the moment of leaving the ground in flight, allowance being made for difficulty in starting engine.
(*g*) Stability and suitability for use in bad weather and in a wind averaging 25 miles per hour 30 ft. from the ground without undue risk to the pilot. Stability in flight is of great importance.
(*h*) The packing-case for rail transport to be easily dismantled and assembled for use, and when dismantled should occupy a small space for storage.

"SHORT-STROKE WORK ON PLANING-MACHINES."

TO THE EDITOR OF ENGINEERING.

SIR,—*Re* the article, title as above, in your issue of December 1, describing the "Vulcan" clutch, as supplied by Messrs. Cecil E. Lugard and Co., Limited, of Chester, the writer, who has spent the last seven years on the application of reversing motors to planers, &c., would like, if your space allows, to make the following remarks :—

Considering the question of the reversing motor used to give the comparative time efficiency tests with the "Vulcan" clutch, the armature of this appears to be of exceptionally massive design. Taking an armature as supplied nowadays by most makers, and one giving 50 horse-power at 588 to 900 revolutions per minute on 220, 440, or 500 volts direct current, and calculating the stored energy at these two speeds, they are found to be 8150 ft.-lb. and 19,000 ft.-lb. respectively. These stored energies when compared with the figures put forward—*i.e.*, 17,605 and 41,445 ft.-lb.—show a remarkable difference. Therefore, according to Messrs. Lugard's theory, if the motor was of a reasonable size the time efficiency would be vastly improved. It is, of course, also probable that the acceleration of the motor when starting up is very slow, because the starting resistance takes too long to cut out. This remark, of course, only applies if the motor is of the type where the main current is reversed each reversal.

Regarding the "Lancashire" equipment for planer-driving, &c., as made by the Lancashire Dynamo and Motor Company, Limited, Manchester, this consists primarily of the following :—

Planer motor, motor-generator set, reversing switch, and, when required, a speeding-up switch for use between faces, or else for accelerating and decelerating the cutting speed when the tool has entered and is leaving the metal respectively. The action of this switch enables high cutting speeds to be used by lessening the shock on the tool, and also enables better-class work to be produced in cast iron, owing to preventing the trouble of breaking off casting edges.

On testing various sizes of this type of equipment, varying between, say, a 4-ft. planer at cutting speeds of 30 ft. to 120 ft. per minute and returning at 180 ft. per minute, and a 10-ft. by 10-ft. by 30-ft, planer, cutting 25 ft. to 75 ft. per minute and returning 100 ft. to 140 ft. per minute, the following points have been verified :—

1. The planers will reverse to a line on both strokes, and in many cases are now being used for planing up to a dead end, which, as all practical men know, is one of the worst possible tests for a planing-machine. In fact, an instance occurred lately where a face on a bedplate had been omitted, and this was machined $\frac{3}{16}$ in. deep out of the solid, the tool both starting and stopping in the metal. The speed of cutting in this instance was 45 ft. per minute, and the speed of the return was 175 ft. per minute, the size of the planer being 6 ft. by 6 ft. by 18 ft., and the total weight of table and job approximately 14 tons.

2. Regarding the "overrun," this word by itself is ambiguous, if it applies to the overrun of the job past the tool at the ends of the strokes; this can be reduced to a minimum by closing in the main dogs. With most up-to-date planers for general work, the feed is put on by either a part or a whole revolution of one of the shafts, and therefore necessitates an overrun of approximately 3 in. at the end of the return stroke, the feed being generally applied at the beginning of the cutting stroke, so as to save the tool rubbing on the work. If the term "overrun" means the distances the table travels after the full travel of the knocking-off lever has been acquired, these can be regulated according to the requirements of the machine, and depend upon the design of the moving members and the load on the table, &c.

3. The reversal of a planer at anything like high speeds without shock is well known to be one of the most important features, and when adjusted properly should give the best combination of absence of shock and minimum reasonable loss of time at reversal,

With a reversing motor, if found necessary, the table could be stopped practically dead ; and as regards the starting up, this could be practically instantaneous ; but from a practical standpoint this is extremely undesirable.

4. Regarding short-stroke work, the limit of this is only found by the necessary travel required by the knocking-off lever, which is often used for working the reversing switch. If the lever is so designed as to be quick enough in its action, a planer motor on the "Lancashire" system can be made to give the shortest stroke required for any practical purpose, and, in fact, can be reversed by hand on a 1-in. stroke.

5. With reference to the question of stored energy in the planer motor armature, this does not to any appreciable extent affect the actual time of reversal, for the simple reason that as soon as the reverse action commences the motor regenerates, thus giving a perfect brake and cushioning effect. With this point in view it may be easily understood that the greater the speed of the motor the greater the braking effect.

6. Reverting to the question of time lost at reversal from a theoretical standpoint, this should be reduced to the absolute minimum ; but when considered from the practical side, as pointed out above, it is not advisable to reverse the machine too quickly.

A test was made on a 10-ft. by 10-ft. by 25-ft. planer, having a table weight of 22 tons and with a job of 35 tons being planed, the total weight on the bedslides being 57 tons. The machine in question was a fairly old machine, and when tested was cutting 50 ft. per minute and returning 100 ft. per minute. The backlash in the gears was considerable, and therefore reduced the efficiency somewhat. On a 2-ft. 6-in. stroke the time efficiency of the machine was 65 per cent., and on a 5-ft. 6-in. stroke the efficiency was 80 per cent.

7. Considering the current consumption of the three machines which are necessary for the "Lancashire" system, it has been stated that the efficiency of same must be very low. This, however, is a statement which has been proved several times to be erroneous.

For a comparative test two machines were taken, one being a motor-belt-driven planer, and the other a reversing motor-driven planer. Similar jobs were done on both machines, and the total current consumption by a watt-hour meter taken on both. The cutting and return speeds were the same in both cases, and the same amount of metal was removed in an equal time. There was practically no difference in the current consumption, and, if anything, this was in favour of the reversing motor drive.

The explanation of this lies in the fact that with a reversing motor an efficient regenerating action takes place. Moreover, the motor can be direct coupled to the machine without belts, and also with a minimum of gearing and shafts, &c.

Yours truly,
W. HARGREAVES.

ENDURANCE OF METALS AND ANNEALING.

TO THE EDITOR OF ENGINEERING.

SIR,—I believe I am right in saying that in the recent paper read before the Institution of Mechanical Engineers, on "The Endurance of Metals," and in the discussion which followed, reference was made to annealing only in regard to its effect on material so treated by the manufacturers, and no reference was made to the question of the periodical annealing of material subject to shock and vibration, such as in chains and connecting-rod bolts.

The writer would be very glad to hear some further opinion expressed on the question. Is annealing liable to disintegrate and seriously weaken wrought iron, and can it be said to cancel the effect of vibration or "fatigue" in material, and give it a "fresh lease of life"? The determination of this question is of more practical value than the question as to whether the ultimate strength or the elastic limit is lowered.

IT. 50.

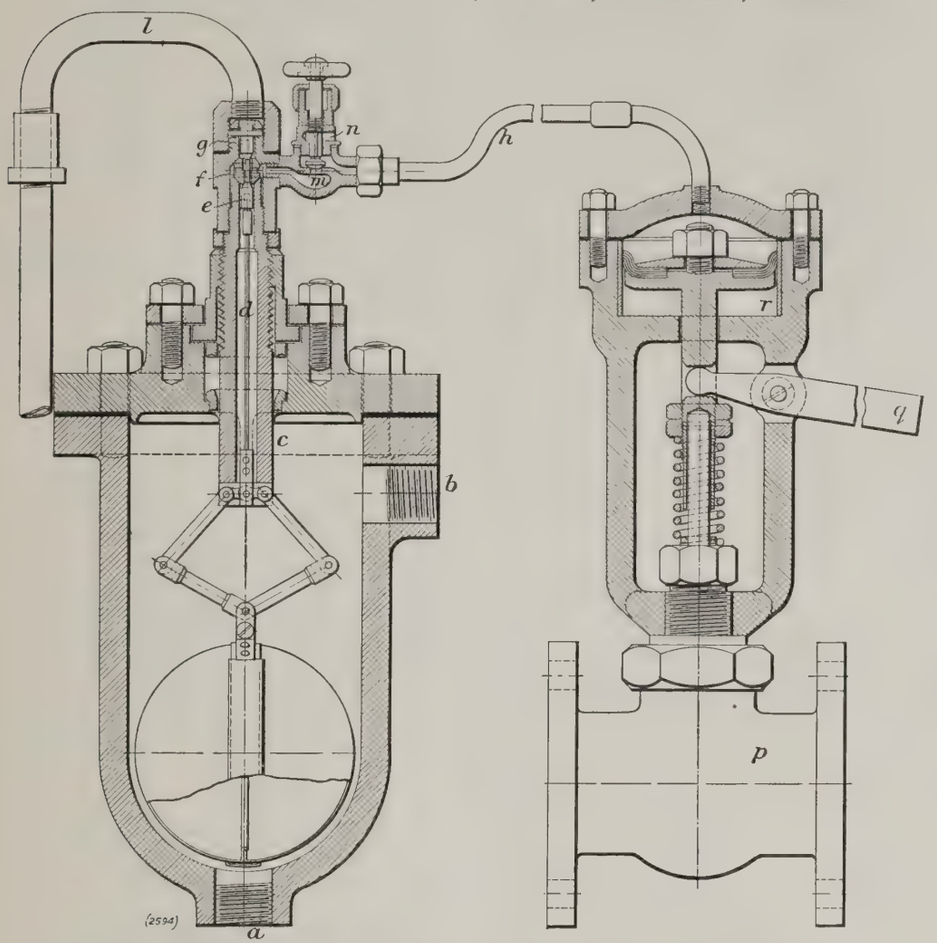
LOSSES IN STEAM PLANT DUE TO CONDENSATION.—This subject was dealt with by Messrs. Geo. Wilkinson, M.I.E.E., M.I. Mech. E., and J. Rendell Wilkinson, B.Sc. (Lond.), on December 13, in a paper read before the Association of Engineers-in-Charge. Different methods of returning condensed water from steam-pipes, jackets, traps, &c., back to the boilers automatically, and with as little loss of heat as possible, were described, including the author's own system.

THE BALTIC EXHIBITION, MALMÖ, 1914.—The work in connection with this Exhibition, which will comprise the countries bordering upon the Baltic—that is, Sweden, Denmark, Germany, and Russia—is being pushed ahead with much energy, and the well-known Swedish architect, M. Ferdinand Boberg, has prepared some interesting designs for the building. M. Boberg was also the architect of the Stockholm Exhibitions in 1897 and 1909. The Exhibition, which will be the largest held in Scandinavia, will have ample ground at its disposal, south-west of the town of Malmö, but within a convenient distance. The site is somewhat undulating, and comprises two small lakes. The three foreign countries will each have their own building, that of Denmark being placed in the centre.

THE INSTITUTION OF CIVIL ENGINEERS: STUDENTS MEETING.—At the Students' meeting held at the Institution on Friday, the 15th inst., at 8 p.m., Mr. John J. Webster, M. Inst. C.E., in the chair, Mr. E. F. Hunt, B.E., Stud. Inst. C.E., read a paper on "Tests of Reinforced Concrete." The paper gave the results of the author's experiments on reinforced-concrete beams and columns carried out at Liverpool University, together with a careful comparison of the ultimate calculated compression stress in the beams, and the ultimate strength of plain concrete cubes. Mr. R. W. Brims opened the discussion, which was continued by Messrs. A. J. Hart, G. A. Clark, H. J. F. Gourley, J. E. Burkhardt, C. Mitchell, T. J. Taplin, H. V. Hutt, and G. R. Shaddick.

THERMOFEED REGULATOR FOR BOILERS.

MESSRS. RONALD TRIST AND CO., LIMITED, ENGINEERS, LONDON.



WE illustrate herewith a boiler-feed regulator which is being placed on the market by Messrs. Ronald Trist and Co., Limited, 4, Lloyd's-avenue, E.C. This regulator is a development of one for which this firm has fulfilled a large number of orders in recent years. It embodies some interesting features. It consists of a float-chamber attached outside the boiler, and in communication with the water and steam spaces of the boiler by means of the connections *a* and *b* respectively. Above the float-chamber is a relay-valve operating a control-valve on the feed-pipe to the boiler. It is one of the special features of this new pattern of regulator that this relay-valve is in a vertical position, and is far removed from the water surface.

The valve is attached to a stem or rod operated by the float through toggle-levers. At the lower end these levers are attached to the float. Near the upper end of the upper limbs they are attached by fulcrum-pins to the adjustable sleeve *c*. From these pins the levers have short arms extending towards each other, and overlapping and working on a pin within a stirrup attached to the valve-rod *d*. Any movement of the float in the chamber below consequently tends to move this valve-rod up or down, the direction being the reverse of that in which the float moves. If the water-level sinks, and the float falls, the valve *e* is pressed on to a seat formed for it in the block *f*. At the same time the valve *g*, which is fixed to the lower valve, and is also, therefore, operated by the rod *d*, moves off its seat on the block *f*. This opens a connection between the pipe *h* and an exhaust-pipe *l*. The valve *m* is a double valve. It may either be screwed down on to its lower seat, thereby cutting off communication between the pipe *h* and the float relay valve, and simultaneously opening a passage *n* to the atmosphere, or it may be screwed up, its normal position, so as to shut off the latter, and put the float relay valve into communication with the feed-control valve *p*. The latter is a double-seated valve, normally held open by a spring shown surrounding the spindle above it. To a continuation of this valve spindle is fitted a piston working in a cylinder, as shown at *r*. The piston is provided with a S.E.A. Ring cup. An indicator arm *q* gives a visible indication of the working of the regulator valve.

The operation is as follows:—If the water-level in the boiler falls, the float falls, and the toggles, being extended, force the valve-rod *d* up and the valve *e* on to its seat. With the valve *m* on its upper seat this puts the top part of the cylinder *r* into communication with the exhaust-pipe *l* by way of the valve *g*, which is likewise raised by the movement of the rod *d*. The upper side of the piston in the cylinder *r* being relieved of pressure, the spring forces the valve up into the full-open position, and the full feed is supplied.

As the water rises in the boiler the float rises, and the valve-rod *d* is then pulled down, the valve *g* being brought on to its seat, and *e* being pulled off its seat. Communication with the exhaust-pipe *l* is now cut off, and in its stead connection is made between the steam space in the float-chamber and the upper side of the piston in the cylinder *r*, by way of the pipe *h*. This overcomes the pressure of the spring and forces the feed-control valve operating in *p* to descend, thus curtailing the supply until the float falls again slightly. The relay is constantly in motion, but it is claimed that the level of the water is kept within $\frac{1}{8}$th of an inch. The valve *m* is provided so that if it should be desired for some purpose to raise the water-level of the boiler temporarily, the relay control may be cut out and the main feed-control valve *p* be kept open by the spring. To adjust the float and relay to changes in water-level, intended to be of a permanent character, the sleeve *c* is made so that it can be raised or lowered for a range of several inches. For this purpose it is screwed on the outside and works in the gland nut of a stuffing-box in the float-chamber cover. The upper threads of this nut are cut away so as to take the form of a die, for the purpose of cleaning up the sleeve thread before it enters the nut proper. This is to prevent damage to either thread if the sleeve thread has become foul through disuse of this adjustment. The details of the valves *e* and *g* and the seat-block *f* are particularly neat. This little double valve and seat is made up as one piece, the block *f* being solid and the two valves being made so as to join together, carrying *f* between their faces. A pin prevents the upper valve from turning round, except when the upper part is unscrewed purposely for removal.

It will be seen that the relay-valve is far removed from the water-level, and no dirt or sediment should therefore reach it. In addition its vertical position tends to ensure the seat being kept clean. The working parts are all of non-rustable metals and keep quite clean of deposit. The float is made of spun copper with a bismuth soldered joint surrounded by a ring of electrolytically-deposited copper, thus ensuring hermetical sealing and non-porosity of the metal.

OIL-BURNING LOCOMOTIVES.

*Oil-Burning Locomotives on the Tehuantepec National Railroad, Mexico.**

By R. GODFREY ASTON, of Rincón Antonio, Oax., Mexico.

THE object of this paper is to give an account of liquid-fuel burning in the locomotives of the Tehuantepec National Railway, showing some of its advantages over coal, and giving a general description of facilities for handling and storing this fuel-oil, the methods of burning it, and a few results gained, which are taken from the monthly performance of locomotives. The author does not intend to deal fully with costs, &c., as it is too large a subject for so short a paper, but will confine himself to a more practical point of view.

The Tehuantepec Railway is a trans-continental line of standard gauge (4 ft. 8½ in.), 304 km. (189 miles) long, running across the Mexican Isthmus of Tehuantepec from the port of Puerto Mexico (Coatzacoalcos) on the Atlantic, to the port of Salina Cruz on the Pacific, with grades varying from level to 2.15 per cent., and abounding in curves up to 11 deg. 28 sec., or 100.10 metres radius, and where the speed of trains is limited to 24 km. (15 miles) per hour.

Storage Facilities.—All fuel-oil for the company is received at the terminal of Puerto Mexico, where the main storage tanks are situated; these comprise three cylindrical steel tanks, each composed of six tiers of steel plates riveted together and a light steel roof, with three manholes, and a ventilator in the middle, through which gases arising from the oil can escape. Two of these tanks are 95 ft. in diameter and 37 ft. 6 in. deep, each with a capacity of 46,996 barrels of 42 U.S. gallons (35 British gallons).† The third tank is 92 ft. in diameter and 29 ft. 9 in. deep, and has a capacity of 35,138 U.S. barrels.

These tanks are all enclosed in separate earthen embankments and are connected together by an 8-in. pipe-line, which enters the tanks 1 ft. 6 in. from the bottom, this space being required for water, &c., settling out of the oil, and which can be drawn off through a 3-in. valve at the bottom of the tank. The pipe-line runs down to the wharf, where it is fitted with an 8-in. check-valve, and it is from there that vessels delivering cargoes of oil can pump straight into any tank, the two largest tanks being about 2 km. (1¼ miles) from the wharf. At convenient places in the pipe-line near to the round-house are stand-columns for filling engine-tanks, tank-cars, &c., and near the round-house is also a supply-tank of 28,000 U.S. gallons capacity, erected upon a structural steel frame, also used for giving oil to engines, &c.

The terminal of Salina Cruz is laid out in the same manner, except that there are only two storage-tanks, 95 ft. diameter and 37 ft. 6 in. deep, of 46,996 barrels capacity. The capacity of all these storage-tanks has been calculated out in U.S. barrels of 42 gallons for every 6 in. of depth, allowance being made for all internal stays, supports, &c. The fuel-oil is shipped from Puerto Mexico to the other fuel-stations in specially constructed double-truck steel-frame tank-cars of 6600 U.S. gallons capacity, the gallons per inch of depth of these cars being known, so that the exact amount contained in each car can be credited to the station to which it is shipped.

Fuel-Oil.—The fuel-oil used by this company is purchased from the Texas Company of Port Arthur, Texas, at about 97½ cents gold per barrel of 42 U.S. gallons, delivered at Puerto Mexico, and pumped into the railway company's tanks by the delivering vessel. This fuel-oil is generally delivered in tank steamers, sometimes towing barges, which come right up alongside the railway company's wharf; the coupling between the vessel and the company's land-pipe line is made with a flexible rubber or steel hose, which is supplied by the vessel.

This fuel-oil is quite thin and flows readily through pipes of any diameter; it is sometimes nearly black in colour, and sometimes a dark brown with a green fluorescence. The railway company stipulates in its contracts with the Texas Company that the flash-point (closed) shall not be under 110 deg. Fahr., as a lower flash-point than this is liable to be dangerous, on account of the volatile gases and fumes which arise from the oil at comparatively low temperatures, and the author has seen the oil catch fire from a torch which was some 10 ft. or 12 ft. away from it. Some oils may be used in the crude state as fuel, while others have to be passed through the refinery; after the lighter oils, &c., have been taken off, the by-product or residuum is used in a satisfactory manner as fuel, and as such has been, and is, used in Mexico. Fuel-oil contains no power of spontaneous combustion, and, unlike coal, does not deteriorate if stored in tanks or reservoirs.

The specific gravity of this oil varies from 0.790 to about 0.942, and its weight per U.S. gallon from 6.4 lb. to 7.75 lb. The British thermal units vary from 17,000 to 20,000, the average being from 19,500 to 19,800, and between this and the best steam coal there is a very great

* Paper read before the Institution of Mechanical Engineers, December 15, 1911. See also paper by Louis Greaven, read before the Institution of Mechanical Engineers in April, 1906, reprinted in ENGINEERING, vol. lxxxi., page 597.

† 1 U.S. gallon = 231 cub. in. 1 British gallon = 277.27 cub. in. U.S. gallon = ⅚ British Imperial gallon. The value of the Mexican dollar is assumed throughout this paper to be 2s.

difference. The analysis of two samples of the oil as used by this company for fuel is as follows:—

Specific gravity at 60 deg. Fahr.	0.931	0.881
Baume gravity at 60 deg. Fahr.	20.5 deg.	29 deg.
Flash-point (closed) ...	130 deg. F.	135 deg. F.
Flash-point (open) ...	160 ,,	160 ,,
Fire test	220 deg. Fahr.	224 deg. Fahr.
Setting point	3 ,,	20 ,,
Viscosity at 100 deg. F.	200 seconds (Redwood)	78 seconds (Redwood)
Sulphur	0.77 per cent.	0.26 per cent.
Calorific value	10,688 calories	11,000 calories
Colour	Dark brown	Dark brown
Water and dirt	1 per cent.	0.25 per cent.

The standard temperature for the measurement of fuel-oil is 60 deg. Fahr., and expansion is allowed for at the rate of 1 per cent. for every 20 deg. Fahr. increase in temperature above 60 deg. Fahr., and contraction at the same rate for decrease in temperature below 60 deg. Fahr.

over with fire-brick. No brick arch or baffle-plate is used.

As mentioned in the preceding paragraph, the burner is placed 4 ft. 2 in. from the flue-sheet, and midway between the sides of the fire-box, so that both in front and behind the burner or atomiser there is a flat bricked-over area of fire grate; and as the burner is placed parallel to the lower grate, there is a 4-in. space between the front and back grates, this 4-in. space being left open to admit air, extending from one side of the fire-box to the other.

Brickwork.—This should be of the very best material and workmanship, as it is subject to a much greater heat than from a coal fire; if this is not done, the walls will not stand, and engine failures will occur; moreover, the failure of only one brick will perhaps necessitate new brickwork throughout, thus needlessly running up expenses. There is no reason why the brickwork should not stand from four to six months, and perhaps longer, if due care be taken from the start.

A good brick should contain about 80 to 85 per cent. of silica and from 20 to 15 per cent. of alumina, and should

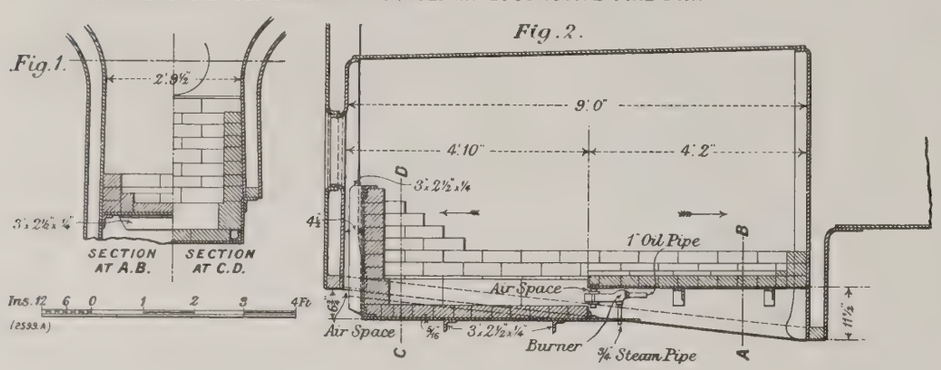
2. Its facility for keeping clean and free from clogging.
3. Its adjustability in giving the right direction to the flame or spray, and regulating the proper proportion of oil and the agent, either steam or air, used for atomising.

A burner which will vaporise or atomise the oil at the point of expansion of the agent used for that purpose, and which is easily handled, and which will atomise the greatest amount of fuel with the least possible energy, is the highest and most efficient that can be designed. On this railway steam is used as the atomising agent, because, after various experiments, it was found to be superior to air. The steam to a very great extent heats the oil as it flows into the burner before delivery in the form of a vapour spray. The flame from the burner should not be too long, or it will pass into the flues and become extinguished. Gases which are only partly consumed will re-light in the smoke-box.

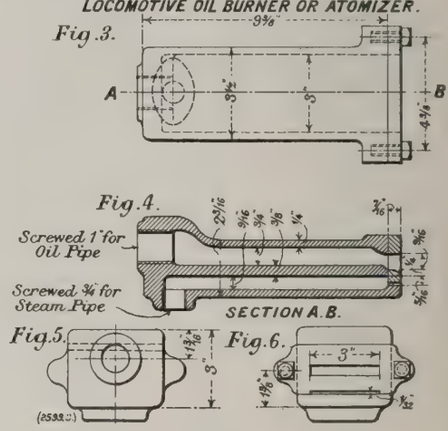
Lighting up an Oil-Burning Engine.—In each round-house of this company is a stationary boiler, always in steam, used for the washout and other pumps, as well as for lighting up dead engines. From this boiler is laid a 2-in. steam-line to points between each engine road or

TEHUANTEPEC NATIONAL RAILWAY

FRONT-END OIL-FUEL BURNER ARRANGED IN LOCOMOTIVE FIRE-BOX.

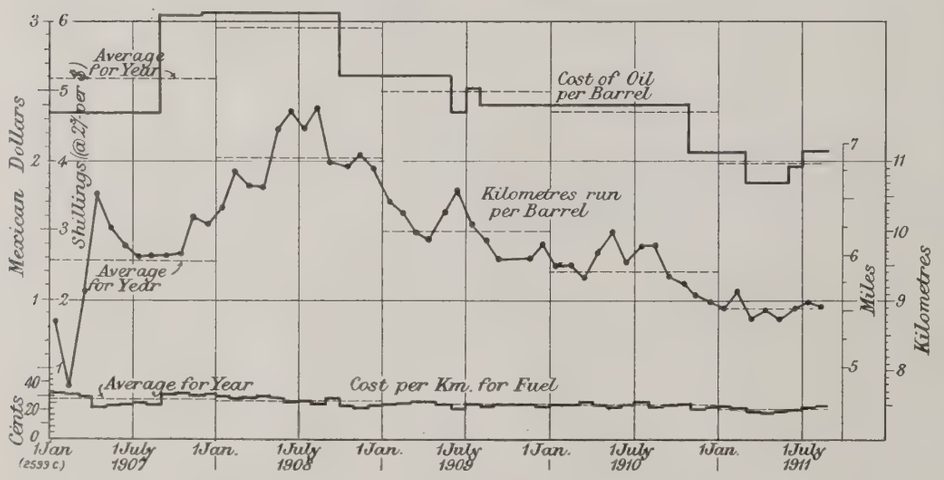


LOCOMOTIVE OIL BURNER OR ATOMIZER.



TEHUANTEPEC NATIONAL RAILWAY.

Fig. 7. **DIAGRAM SHOWING COST OF FUEL-OIL AND DISTANCE RUN PER BARREL FROM JANUARY 1907 TO AUGUST 1911.**



Locomotives.—The locomotives in use on this road are of the Baldwin consolidation type, the main dimensions of which are:—

Cylinders	20 in. by 26 in.
Wheels (drivers) ...	53 in. diameter on tread
Fire-box	Length inside, 108 in.; width inside, 33½ in.
Flues	239 of 2 in. outside diameter
Grate area	24.94 sq. ft.
Heating surface ...	Fire-box, 147 sq. ft.; flues, 1700 sq. ft. Total, 1847 sq. ft.
Boiler pressure ...	170 lb. per sq. in.

The oil-tank is fitted into the coal-space of the tender, and its contents calculated for every ½ in. of depth. Most oil-tanks have a capacity of 2000 gallons, and the oil is fed from the tank to the burner or atomiser through suitable connections and flexible brass ball-joints.

Fire-Box Arrangement.—The company's practice, after trying various types of burners and atomisers, is to use what is called a "front-end burner" (Fig. 1 and 2); that is, the burner-mouth points towards the back of the fire-box or fire-box door-plate; the burner is placed, in a 9-ft. fire-box, 4 ft. 2 in. from the flue-sheet, the flame playing against a brick wall built up to the level of the fire-box door opening. Between this brick wall and the fire-box back-plate is a 4-in. air-space extending the whole width of the fire-box and right up to the top of the brick wall. Brick walls are built up on each side of the fire-box from the height of the brick wall at the back, gradually sloping downwards; the floor of the grate or ash-pan is laid all

be as free as possible from alkalies, which cause fluxing. A good brick becomes surface-glazed though remaining rough and porous; it should be perfectly dry when built up in a fire-box, otherwise the heat will cause it to crack; if possible, the fire-bricks should be fired at a temperature as high as that to which they will be exposed when in use.

Burner or Atomiser.—There are many and various kinds of hydro-carbon burners, and after a trial of various types, including the Baldwin and "Best" burners, this company is using with considerable success a burner which is made in their own shops, and which is really an inverted "Best" burner (Figs. 3 to 6, above). It is a simple device, which allows the oil to fall from an orifice 3 in. wide by $\frac{9}{16}$ in. deep over the top of a flat steam-jet 3 in. wide and $\frac{1}{32}$ in. deep, the steam picking up the oil and sending it into the fire-box in the form of a spray; the underneath jet of steam delivers the spray of oil at an angle so that it strikes the brick wall in the middle, instead of shooting out from the burner parallel with the bottom of the ash-pan. This burner may be called an outside atomiser, and although it is in general use, it has its drawbacks; but it has been found to be more efficient than any other they have used.

The most essential points about a burner or atomiser are:—

1. Its atomising capacity. All fuel-oil is heavy, and will burn in the form of a vapour or spray only when mixed with air. The object should be to fill the fire-box with a soft and voluminous flame, and not to impinge it in any one place.

stall. From there a connection can be made to a locomotive through a three-way cock or T-piece in the steam-pipe leading from the steam-stand on top of the fire-box to the burner; by use of this steam the burner can be started and kept going until the boiler has generated enough steam to keep the burner going itself. A piece of oily waste is lighted and thrown into the fire-box just in front of the burner from which the spray ignites. Connections can be made to any other engine all ready in steam should the stationary boiler not be available for any reason.

Firing and Cleaning Flues on Road.—With an oil-burning engine there is always a fire of equal intensity and one which never gets dirty, so that good steaming is practically ensured. It is a popular idea that it is a very easy matter to fire an oil-burning engine, but this is not the case, as both skill and care are required, so that the author thinks it best to lay down a few of the most important rules:—

1. See that the oil-tank is full, and if heaters are used, that they are in operation, and that the temperature of the oil is as it should be.
2. See that the sand-box on the foot-plate is full, and that the scoop is in its place.
3. Before starting the fire see if the temperature of the fire-box is below igniting point, which is a dull read, and if so, open dampers (if used), start the blower, and open the atomiser-valve fairly hard; then put a piece of saturated oily waste on the bottom of the grate after setting it alight, close the dampers (if used) and fire-box door, and turn on the oil very light. When the oil has ignited, reduce the blower and atomiser to a light feed, also the oil until the chimney is quite clear of smoke.
4. See that the fire is burning brightly, and that there is no oil on the bottom of the pan, also that the brickwork is in good condition, and that no bricks or any other obstructions are on the bottom of the grate or pan so as to obstruct the flame or jet on its way from the burner to the brick wall.
5. As regards cleaning flues on road, it is best to sand frequently if the engine is being worked hard—say every 15 km. or 20 km. (9 or 12½ miles); but if the engine is being worked light, every 50 km. or 60 km. (31 or 37 miles) will be sufficient.
6. Having attained a fair rate of speed, fill the scoop with about a quart of sand, close dampers (if used), and put reverse-lever near full stroke, then open regulator wide, insert the end of the scoop in the round hole in the fire-box door, and allow the sand to be drawn out of the scoop through the fire-box and flues and out of the chimney; sanding is best done when the engine is working hard up a grade.
7. Black smoke shows incomplete combustion, and should never be allowed to be emitted from the chimney, as it only fills up the flues with carbon, besides being a non-conductor of heat, and it is also a great waste of fuel. If a bluish-coloured smoke or fumes are seen coming from the chimney, it is a sign that the burner is cut down too fine.
8. When putting out the fire the oil-valve should always be closed first, then the atomiser-valve (in their case steam), then the blower. The oil-valve is always the last to be turned on and the first to be turned off.
9. Never go near an open tank with a lighted lamp

or torch, as at any time an explosion may occur, especially if the oil used has a low flash-point.

Round-House or Shed Work.—An oil-burning engine has a great many advantages over a coal-burner, but this is specially noticed in the round-house or shed when squaring up an engine after a day's run; there are no fires to be raked out, no flues or smoke-box to be cleaned (the smoke-box door of an oil-burning engine need be opened only once every three or four months for cleaning purposes); there is no coal to be sacked, weighed, or otherwise handled, and oil-burning engines do not carry fire-rakes, prickers, flue-brushes, shovels, or picks, so that all these things, besides other minor details, represent a great saving in engine equipment.

Among other advantages are the rapidity with which steam can be raised, and the facility with which the boiler can be forced when greater calls are made; the author has in a special case of necessity raised steam in a dead engine to a pressure of 130 lb. per sq. in. in 50 minutes from cold water, without any serious effects on the boiler, whereas in a coal-burner from 2 to 3½ hours is needed to raise steam if no jet from a live engine is used.

Another very great advantage is in switching, or shunting, or standing pilot, when engines frequently have to stand in steam for hours at a time. The burner can then be cut down or extinguished, thus effecting a great saving in fuel, as an engine will always retain a sufficient amount of steam to start the burner or atomiser again; and any danger of the fire-box or crown-sheet being injured through the water getting too low is entirely obviated. The heat lost while standing is the same whether coal-fired or oil-fired.

Effects of Oil-Burning on Fire-Box, Flues, &c.—Oil-burning is no more injurious to a fire-box or flues, &c., if ordinary care be used, than coal-burning; in fact, from the author's experience, it is not so hard on a fire-box as coal-burning, for it is quite noticeable in the fire-boxes of coal-burning engines that stay-heads, plate-edges, flue-ends, and crown bolt-heads show signs of wear, corrosion, or burning, but in their oldest oil-burning engine not any of these signs are noticeable, everything being clean and in good condition.

This company uses steel boxes with wrought-iron tubes and copper ferrules. A set of tubes will last, and remain perfectly tight, from 2½ to 3½ years, when they may have to be taken out to be re-ended; some of the engines are working to-day with tubes over four years old, many of which are as tight as they were on the day they were put in. Some of the wrought-iron tubes are being replaced by mild steel, because, after the holes in the tube-sheet get worn, tubes of steel stand the expanding better; but at present those that are in service have not been in use long enough for one to form an opinion of them as compared with wrought iron.

Some people are of the opinion that more than 2 per cent. of sulphur in fuel-oil is injurious to the fire-box, but as the amount of sulphur in the Texas oil the company has been using is below 0.75 per cent., no ill-effects have been noticed; but as there are coals which show as high as 3.5 per cent. of sulphur, the author does not see why sulphur should be more injurious in oil than in coal.

Engine Performance.—Although the engine tonnage has practically doubled since 1908, the author gives the following statistics, Fig. 7, for each month from January, 1907, to August, 1911:—

(1) Cost of fuel-oil per barrel of 42 gallons (Mexican currency);

(2) Cost per kilometre for fuel (Mexican currency); and

(3) Kilometres run per barrel of oil;

but it must be understood that since about the middle of 1909 all engines are loaded down to their capacity, single trains averaging 750 to 800 tons behind the draw-bar. As the road-bed is by no means level, helper engines are used over certain sections where the grades are long and heavy, so that this will explain the decrease in kilometres run per barrel of oil between 1908, 1909, 1910, 1911, as the tonnage per engine has been increased to the maximum.

Oil-Fuel. Monthly Averages.

During	Cost of Oil per Barrel.		Cost for Fuel.		Distance Run per Barrel.	
	Dollars (Mexican).	Shillings.	Cents per Km.	Pence per Mile.	Km.	Miles.
1907	2.585	5.17	28.476	10.99	9.546	5.928
1908	2.957	5.91	27.151	10.48	11.04	6.855
1909	2.502	5.01	25.19	9.73	9.999	6.209
1910	2.356	4.71	25.02	9.66	9.41	5.843
1911 (8 months)	1.990	3.98	22.23	8.58	8.89	5.520

The cost of fuel-oil per barrel of 42 U.S. gallons (231 cub. in.) as charged out every month is made up of the following items, and also depends upon whether there is any shortage or overage when the inventory is taken at midnight on the last day of each month; this accounts for the variation in prices:—

1. Price of oil per barrel f.o.b. in ships' tanks at delivering port (Puerto Mexico).
2. Commission to purchasing agents in United States.
3. Consular invoices.
4. Inspection fees for inspecting cargo in ships' tanks at shipping port.
5. Stamps.

Items 2, 3, and 4 only refer to oil purchased out of Mexico.

Based on tests which have been made, the company reckons 3½ barrels, or 147 U.S. gallons, of oil as being equal to 1 ton of coal or 1000 kg., or 2204 lb. or 3½ barrels of oil equal one unit of fuel.

The author is unable at this time to give any reliable data of fuel consumption on a tonnage basis, as no records are kept of the company's freight hauled over the road, although it is considerable; but the average loaded passenger and freight cars hauled 1 kilometre per unit of fuel from January 1 to December 31, 1910, was 330.89, and from January 1 to June 30, 1911, 333.60. The average loading weight of freight-cars is approximately 30 tons.

In August this year (1911) the company received the first cargo of a native or Mexican fuel-oil, under a contract with the Campañia Mexicana de Petroleo, El Aguila, S.A., at a price of 1.75 dols. (Mexican) (3s. 6d.) per barrel of 42 U.S. gallons delivered into railway company's tanks at Puerto Mexico. This oil, which is used in its crude state as fuel, is jet black in colour, thick, and has a heavy asphalt base, and although the company has not used it sufficiently long to be able to compare it with the Texas oil, it may be of interest to state a few of the difficulties met with when first they began to use it.

As this oil is thicker than Texas oil, heaters have to be used in the engine-tanks, but it has been found that if this oil is heated up to about 150 deg. Fahr. (which can be done with Texas oil), great difficulty is experienced in getting the burner spray to light, and the oil settled very thickly at the bottom of the tank; it would not run through the pipes to the burner, and could only be burnt effectively by mixing a fresh supply of oil with it. In order to burn this Mexican native oil successfully, it requires to be only just warmed. When using this, a large piece of carbon or coke-like substance is formed in the fire-box, and grows up from the bottom of the pan or grate directly under the burner-mouth. This may vary from 6 in. by 4 in. by 4 in. to 12 in. by 10 in. by 8 in. in size, growing up in such a manner as almost to smother the burner-mouth. The analysis of this substance is as follows:—

	Per Cent.
Ash	1.25
Sulphur	7.89
Carbon	90.86
Asphalt	nil

It shows, to a certain extent, that there is incomplete combustion, which can be remedied by admitting more air; but this cannot very well be done without affecting the steaming qualities of the engines. However, by raising the burner slightly, these lumps of carbon have decreased in size, and it is hoped eventually to adjust things in such a manner as to prevent their forming at all.

The analysis of two cargoes of this Mexican crude fuel-oil is as follows:—

	No. 1.	No. 2.
Specific gravity at 60 deg. Fahr.	0.944	0.942
Baume gravity at 60 deg. Fahr.	18.4 deg.	18.8 deg.
Flash-point (closed)	78 deg. Fahr.	102 deg. Fahr.
,, (open)	104 ,,	120 ,,
Fire test	165 ,,	180 ,,
Viscosity at 100 deg. Fahr. (Redwood)	1080 seconds	920 seconds
Sulphur	3.44 per cent.	3.35 per cent.
Calorific value	10,971 calories	10,610 calories
Colour	Black	Black
Water	Nil	0.5 per cent.
Asphalt	—	37 ,,
Carbon (coke)	—	12 ,,

It may be explained that the 37 per cent. asphalt is obtained by distilling off the distillates from the crude until only 37 per cent. residue is left, which consists of asphalt. The 12 per cent. coke is obtained by distilling this 37 per cent. down to 12 per cent. residue (on the crude); so that if they get 37 per cent. asphalt, they do not get the 12 per cent. coke; and if they get the 12 per cent. coke, they do not get the 37 per cent. asphalt.

The author regrets that at this time he is unable to go deeper into this subject, but he hopes that what little information he has been able to give with regard to oil-fuel burning in the Tehuantepec locomotives will be of interest to others working in the same direction.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

TENDERS FOR CONTRACTS ABROAD.

WITH reference to the colonial and foreign engineering projects, the summary of which we give every week, we are requested by the Board of Trade to call the attention of British manufacturers and contractors to the fact that tenders based on any variation from the specification on which the contract is offered are usually disallowed. If it be desired by a tenderer to introduce any variation whatever, it would be well for him to put in two tenders—one adhering strictly to the specification, and the other based on such variations as he desires. The variations should be such as will enable him (*a*) either to tender at a lower cost than in his first tender, while showing that the variations do not materially affect the efficiency of the work to be done, or (*b*) to tender at the same cost as in his first tender, while showing that the variations make for increased efficiency.

We give below a series of colonial and foreign engineering projects, for several of which tenders are asked. Further data concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Canada: His Majesty's Trade Commissioner has forwarded an extract from the *Monetary Times*, Toronto, the following particulars from which may be of interest as a suggestion of some of the openings that exist for contractors in British Columbia, and as showing the way in which United States firms are taking advantage of these openings:—The contract for paving Granville-street from the Vancouver city limits to Eburne, a distance of 4 miles or more, was given last year to the Columbia Bitulithic Company, which for purposes of convenience has offices in Vancouver, though it is virtually and thoroughly American. A contract valued at 5,000,000 dols. (about 1,028,000*l.*) has recently been awarded to a firm at Portland (Oregon) for the construction of a section of the Canadian Northern Railway beyond Kamloops. With considerable development going on in British Columbia, United States firms, ever on the alert, see the opportunities for business, and are on the spot when there is an important undertaking. They either incorporate a local company, naming as directors prominent men, or they register as "extra-provincial" companies; but the real seat of operations is either in Seattle or Portland, where the head offices are situated. Material and everything else is brought from the United States. American engineering firms are getting nearly all the work that is going. One of the most recent cases is the award to a Seattle firm, with an office in Vancouver, of the reclamation of 30,000 acres at Sumas Lake, Chilliwack district, at a cost of about 1,000,000 dols. (about 205,000*l.*). The Imperial Trade Correspondent for Ontario reports the contemplated extensions of the water-works system and of the hydro-electric system of a town in that province, at an estimated cost of 650,000 dols. (about 133,600*l.*) and 1,108,378 dols. (about 227,800*l.*) respectively. The water-works extension will include the construction of a new reservoir, for which a sum of 120,000 dols. (about 24,600*l.*) will be allotted.

South Africa: The *Union Gazette* publishes the text of regulations for obtaining supplies and services required by the South African Government, and for disposing of public stores. The regulations do not, however, apply to the Department of Railways and Harbours. It is provided that a tender board shall be established. Contracts for public works of a value of over 1000*l.*, and for other non-recurrent services of over 100*l.*, and recurrent services of over 50*l.*, are, with certain exceptions, to be put up by the Tender Board to public tender. Wherever possible, the Tender Board, other factors being equal, is to call for tenders for, or give preference to, articles produced or manufactured within the Union.

Hong Kong: According to the *Hong Kong Weekly Press*, the Governor of Hong Kong, in his statement on the estimates for 1912, announced that it is intended to construct a new water supply reservoir at Tytam Tuk, at a cost of 2,000,000 dols. (about 183,300*l.*), of which 100,000 dols. (about 9200*l.*) is to be expended in 1912.

Egypt: With reference to a call for tenders for the construction of the Kaid Bey branch of the East Port breakwater at Alexandria, H.M. Consul-General at that place now reports that the time for the receipt of tenders has been extended to April 2, 1912. Tenders should be addressed to the President of the Municipal Commission, Alexandria. Particulars and plans may be obtained from the Technical Office of the Municipality, Alexandria, on deposit of E£5 (about 5*l.* 2s. 7d.).

Denmark: The *Licitationen*, Copenhagen, notifies that the harbour authorities of Fredericia invite tenders for the carrying out of harbour works, the plans of which, as well as the terms for the issue of a loan to meet the expense involved, are to be approved by the State. Tenders will be received, up to mid-day on December 20, at the Borgmesterkontoret, Fredericia. Although this contract will doubtless be awarded to a Danish firm, the execution of the works may involve the purchase of some materials and plant out of Denmark.

Italy: The *Gazzetta* announces that tenders will be opened on December 29 at the offices of the Ferrovie dello Stato, Rome: (1) For the construction of a section of railway from Favara to Bivio Margonia, a distance of 9 miles, forming part of the Sicilian Complementary Railway System: the upset price is put at 2,208,000 lire (88,320*l.*); (2) for the construction of two sections of line, one from Bosseglia to Briga, a distance of nearly 1¼ miles, and the other from Rioro to San Dalmazzo di Tenda, about 1½ miles, both forming part of the Cuneo-Ventimiglia Railway; the upset price is put at 6,084,000 lire (243,360*l.*). Although the contracts will doubtless be awarded to Italian firms, nevertheless the carrying out of the contracts may necessitate the purchase of some materials out of Italy.

Spain: The *Gaceta de Madrid* announces that Don Ignacio Coll y Portabella and Don Julio Bielsa y Perim have applied to the Ministry of Fomento, Madrid, for a concession for the construction and working of a railway from Puerto de la Luz to Agaete (Grand Canary). H.M. Consul-General at Barcelona reports that a new company has been formed in Northern Spain to supply electric light and power in that province, including the city of Barcelona, developed particularly by water power, but partly by a steam-generating plant.

Portugal: The *Diario do Governo* notifies that tenders will be opened on January 28, at the offices of the Conselho de Administracão do Porto de Lisboa, Lisbon, for the carrying out of harbour works, consisting of improvements to the Alcantara dock and the construction of a breakwater west of the Santos dock. A deposit of 50,000 milreis (about 10,000*l.*) will be required to qualify any tender.

Argentina: The *Boletin Oficial* publishes a decree (No. 8445) notifying that the Argentine executive authorities have arranged for surveying operations to be carried on relative to the construction of a railway from Patguia (North Argentine Railway) to Copacabana, passing by way of Pagancillo, Villa Unión, Villa Castelli, Vinchina, and the Hermoso Valley; and allocating a sum of 200,000 pesos (about 17,500*l.*) for carrying out the survey. The *Boletin* also publishes decrees as follows:—No. 8461, granting to the Compañia Carbonifera de Chcs

Malal a concession to construct and work a railway from either Puerto Belgrano or Bahia Blanca up to the Chilian frontier, passing by way of Chos Malal. Seven years are allowed for the completion of the work. No 8450, granting to Señor Luis Stremitz a concession for the construction and working of a railway from Embarcación to Yacuiba. Two years are allowed for the completion of the work.

AUTOGENOUS CUTTING AND WELDING OF METALS.*

By F. Carnevali.

It is well known to every one who takes an interest in autogenous melting and welding processes that the existing opinions as to the value of the processes and the practical results obtained differ widely. The chief ground for the uncertainty that exists in regard to them lies in the fact that these new processes have only recently been introduced in industrial practice, and rest entirely upon empirical bases. Although the autogenous melting of iron is now extensively practised, and is of great theoretical and practical interest, it has never been made the object of systematic and exhaustive research. With the object of remedying this state of affairs, and of supplementing the existing knowledge of the subject, the author has undertaken investigations on the autogenous melting of various metals in general use. In doing so he endeavoured carefully to adhere as closely as possible to the conditions which accompany the ordinary works practice, and he therefore limited his researches to the oxy-acetylene process, which, after a preliminary study of other processes, he was compelled to regard as the best and most practical. The advantages and disadvantages of the various processes of autogenous melting may be summed up as follows:—

1. The electrical process requires costly installations which are cumbersome and inconvenient, whilst, on the other hand, owing to the difficulties involved in controlling the high temperatures attained, the results are uncertain. In addition to this, the high temperatures are restricted to very narrow zones of the metal.

2. The oxygen process is subject to many serious drawbacks owing to the variation in the volumes of the mixed gases, the presence of water vapour, and of other gases likely to prove injurious to the metals, while the low temperature attained, which rarely exceeds 1600 deg. Cent., prevents rapid working.

3. The oxy-hydrogen process does not permit of easy control of the melting flame, while the variable amounts of free oxygen present occasion injurious oxidation of the metal. On the other hand, such free hydrogen as may from time to time be present is occluded by the molten metal, leading to the formation of blow-holes. The dissociation of the water vapour formed in the flame also lowers the temperature considerably.

4. The thermit process is only suitable in a limited number of cases. Its action is not thorough, and it is difficult to control.

5. The oxy-acetylene process, on the contrary, when properly worked, possesses numerous marked advantages over the other processes mentioned. In the first place, the operating flame can be easily controlled, and the temperature attained at various zones can therefore be readily regulated. In the second place, the work can be readily accomplished, owing to the high temperatures (nearly 3500 deg. Cent.) which can be reached by the combustible gases, and by the dissociation of an endothermic gas like acetylene. Other advantages arise from the employment of pure gases, which have no injurious effect on the metal, by the fact that the products of combustion (hydrogen and carbon monoxide) do not dissociate, and from the great economy of the method as compared with others, as this permits of high temperatures being attained with a minimum cost, while the appliances are easy to handle and reliable in operation.

The researches which have hitherto been published on this subject are more or less exclusively connected with the melting of mild steel, and bear for the most part on the manufacture of large boilers. This limitation is singular when it is considered that autogenous melting can readily be applied to all the most commonly occurring metals, and might be employed in many important directions. It is useless to give a lengthy bibliography of the subject, as it would almost inevitably relate to mere advertisements of some particular method. All that need be done in this direction is to refer briefly to some of the most important recent publications on the subject. Professor Bach and Mr. Baumann,† of the Stuttgart Polytechnic, have published a series of researches on plates and boiler parts of mild steel. It is, however, to be remembered that these researches dealt only with samples of previously prepared meltings, while the study of the melting process itself, which should have proved in practice the most interesting feature, has been neglected. The researches of Mr. H. Rinne‡ are more complete in this respect, although they are once again limited principally to mechanical trials made on boiler plates soldered by the oxy-acetylene process. The excellent results obtained by Mr. Rinne§ show that satisfactory welds can be obtained in practice with mild steel; although, as a matter of fact, he operated under highly favourable conditions, which cannot be expected in ordinary practice. Further researches of the same nature were made in connection with boiler plates by C. Diegel,‖ the results being similar to those of Professor Bach, and supporting the latter's conclusions.

The literature relating to the oxy-acetylene melting of carburised steel, pig iron, and other metals commonly employed in works practice, such as copper or aluminium, or their more important alloys, such as brasses and bronzes, is very scanty. Mr. L. B. Springer* reports good results obtained in connection with bronze, pig iron, and aluminium castings, but he brings forward no experiments in support of his conclusions.

The most important conditions for securing good results in oxy-acetylene melting are:—

1. The use of the purest acetylene obtainable.

2. The use of a blow-pipe so designed as to ensure careful adjustment in the proportions of the mixed gases, and to secure their exit at a velocity capable of maintaining the metal sufficiently fluid without the melting flame being too rigid.

3. The provision of an absolutely neutral zone in the melting flame.

4. The use of a pure cementing material of well-defined composition, similar to that of the metal to be melted, in the form of small rods, of such a size as to be rapidly melted without hindering the simultaneous heating of the adjacent parts.

5. Care should be taken that the edges should be free from impurities, and that, whenever possible, they should be arranged at an angle to each other so as to allow the neutral zone of the flame to penetrate well into the inside, and so completely melt the two surfaces before the extraneous metal is introduced.

6. The use of deoxidising and fluxing powders for the purpose of eliminating the oxides present, together with the incidental impurities. In view of the unavoidable oxidation of the metal subjected to the melting process, it is necessary to bear in mind the relation between the temperature of the melting-points of the oxides and that of the metal itself.

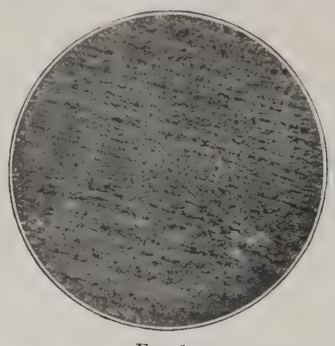


Fig. 1.

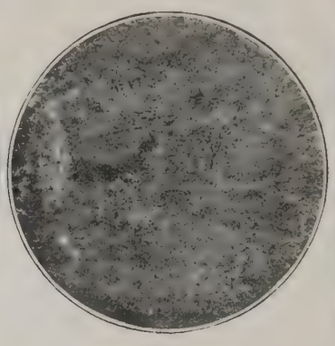


Fig. 2.

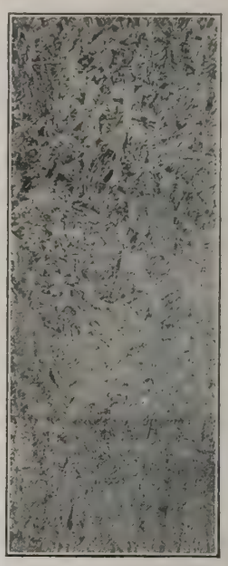


Fig. 3.

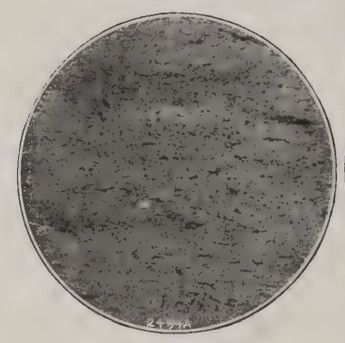


Fig. 4.

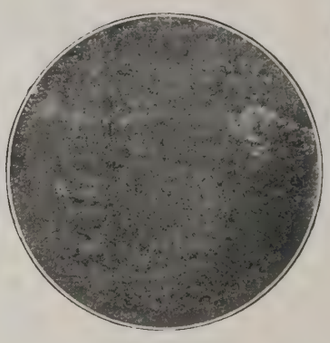


Fig. 5.

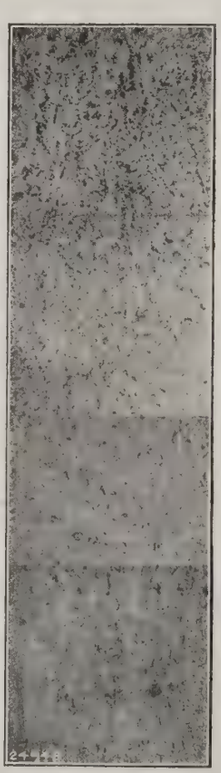


Fig. 6.

Fig. 9.

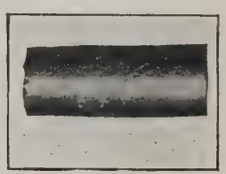


Fig. 7.

Fig. 8.

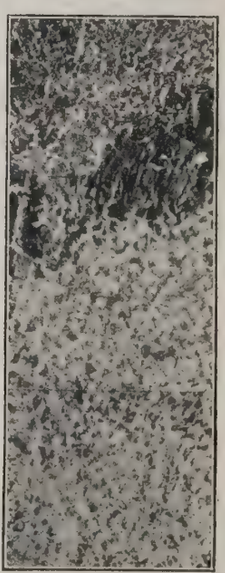


Fig. 10.

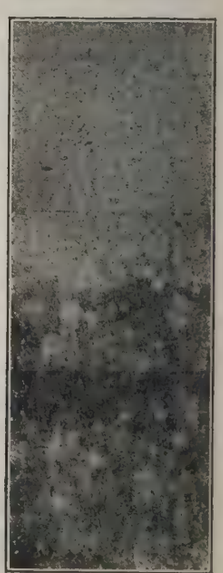


Fig. 11.

* Paper read before the Iron and Steel Institute.

† *Mitteilungen über Forschungsarbeiten*, 83-84 Hefte, 1910.

‡ *Verhandlungen des Vereins zur Beförderung des Gewerbefleisses*, Hefte 1-45, 1911.

§ *Stahl und Eisen*, vol. xix., 1909.

‖ *Verhandlungen des Vereins zur Beförderung des Gewerbefleisses*, Hefte 1-45, 1911.

* The *Foundry*, vol. xxv., 1909.

7. Rapidity in melting, in order to avoid excessive heating, which will not only alter and deteriorate the original structure of the metal, but would even favour the occlusion of gas—particularly hydrogen—and so occasion the formation of blow-holes in the melted zone.

In addition to these conditions, care should be taken to see that no sudden cooling should take place owing to any sudden projection of the flame, whilst, on the other hand, the conditions must, of course, be modified with regard to the conductivity and specific dilatation of material, as well as with regard to the thickness, size, and shape of the pieces operated upon. These precautions were observed as far as possible by the author while conducting his experiments, whilst, on the other hand, his researches on the weldings effected were directed to the changes in the chemical composition and the mechanical properties caused by the welding process, and to ascertain the best ways of avoiding such alterations chemically, thermally, or mechanically, and endeavouring to ascertain from a careful examination of the melted zone what the original structure of the material might have been. These experiments were supplemented by chemical and mechanical tests, and by microscopic and macroscopic examination both of the melted zone and of the neighbouring parts.

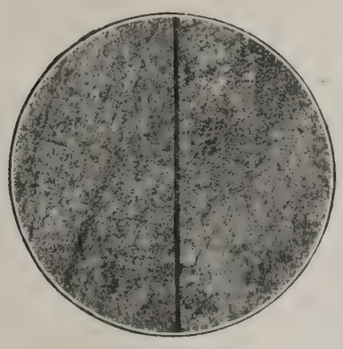


FIG. 12.

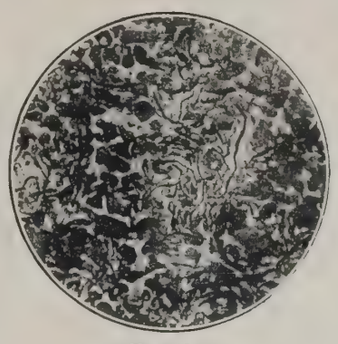


FIG. 13.

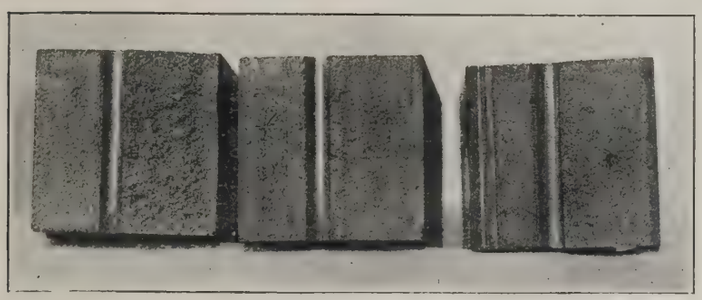


FIG. 14.

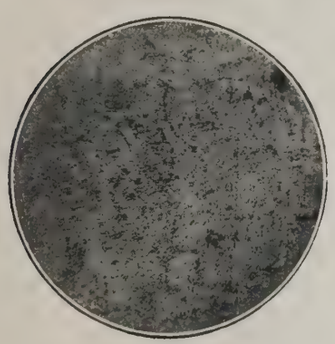


FIG. 18.

Experiments were, moreover, carried out on molten metals both before and after subjection to mechanical stresses and deformation, in order to ascertain to what extent, if any, the various constituents of the metals are influenced by the process. Researches were simultaneously carried out on the mechanical properties of various metals when subjected to the strong heat of the melting flame without being melted, and for the same period of time as might be required for the autogenous melting of pieces of the same size. These experiments were also extended to various qualities of material used for the purpose of filling the cavities during the autogenous melting of various metals. The researches were grouped in four classes, special regard being paid to the iron-carbon alloys as being the most interesting, and most frequently employed in practice. These classes were as follow:—

1. The oxy-acetylene melting of steels containing a low percentage of carbon.
2. The oxy-acetylene melting of steels containing medium and high percentages of carbon.
3. The oxy-acetylene melting of pig iron.
4. The oxy-acetylene melting of other metals selected from amongst those most commonly used, such as copper and its more important alloys, bronzes, brasses, and aluminium.

The experiments made on the first, second, and third of the above groups are given in detail. Those relating to the fourth group will be published separately.

GROUP I.

OXY-ACETYLENE WELDING OF MILD STEELS.

The first series of experiments was conducted on boiler plates of 7 mm., 10 mm., and 20 mm. in thickness (indicated below by the letters A, B, and C). The chemical composition of these plates was as follows:—

FIG. 19.

Plate.	A.	B.	C.
	per cent.	per cent.	per cent.
Carbon	0.23	0.105	0.11
Manganese	0.64	0.51	0.54
Silicon	0.07	0.024	0.022
Phosphorus	0.060	0.025	0.050
Sulphur	0.079	0.053	0 064

The metal used for the weld was homogeneous iron of a very pure description, the composition of which was as follows:—

	Per Cent.
Carbon	0.125
Manganese	0.4
Silicon	0.047
Phosphorus	0.037
Sulphur	0.021

Swedish iron wire is not employed, as the quantity of slag it contains remains partly in the molten pieces.

In practice, care was taken to maintain ordinary practical conditions as far as possible, although bearing in mind the theoretical considerations needed for obtaining the best results.

Samples were taken from each plate in the direction of the rolling, and each sample was cut into two pieces, the edges arranged V-wise at an angle of about 45 deg., and after the melting had been effected some of the samples were cooled in air, while others underwent a special heat treatment and mechanical operations. Finally, mechanical tests were made on rough, unmachined samples of the welds and upon finished pieces, care being taken to see that the weld was well in the middle of the sample. Before and after the mechanical tests, a piece of metal was taken from the molten zone, and from the neighbourhood of the weld in each sample, for the purpose of a microscopic examination. In Table I., page 846, the experiments and observations made in connection with the first series are given.

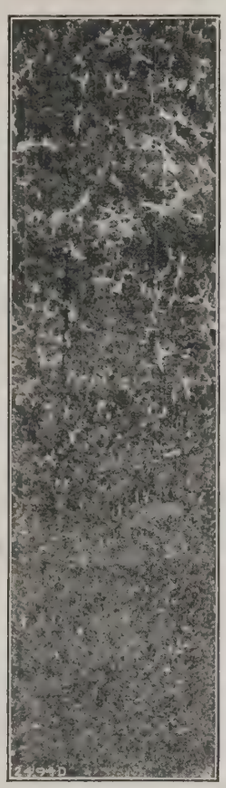


FIG. 15.

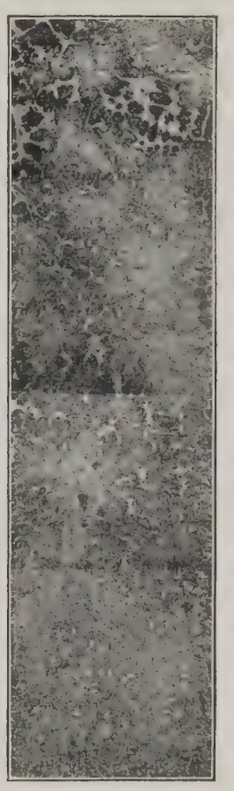


FIG. 16.

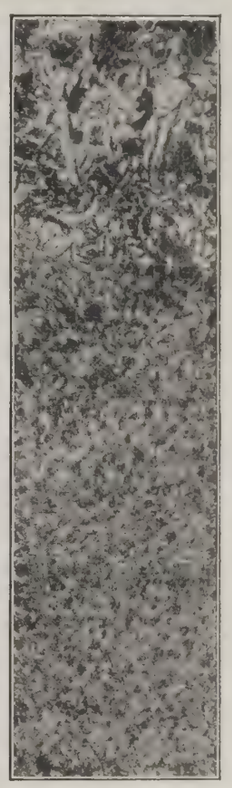


FIG. 17.

The microscopic examination of the samples carried out on material from the three zones—the melting zone, the intermediate zone, and the unaltered metal in this first series—confirms the fact of the change undergone in the mechanical properties of the metal by welding, and the profound alteration in the structure. This is shown on comparing Figs. 1 and 2, which show sections of the material (etched with an alcoholic solution of 4 per cent. picric acid, and as seen under a magnification of 80 diameters). Fig. 1 shows the original structure of Plate A, and reveals the deformation resulting from the stress which the metal underwent in the immediate neighbourhood of the fracture. (Sample 2, see Table I.)

Fig. 2 shows the structure in the molten zone of sample 4A, which resembles that of samples B and C, which underwent the same treatment. The structure of this metal, which is absolutely slag-free, so far as simple macroscopic observation of the surfaces of fracture go, is characteristic of the cast metals, and also shows the reduction in carbon which the cementing metal underwent during its brief melting period. This reduction, as will be seen later, varies considerably with the conditions of welding. The loss corresponds to very nearly 44 per cent. of the original carbon (repeated analyses of the melted portions gave as an average 0.07 per cent.), although for this type of metal the loss cannot be said to have much effect. These alterations are even more evident in Fig. 3 (etched with 4 per cent. alcoholic pieric acid, and seen under a magnification of 80 diameters) relating to sample 7A (Table I.). They occur exactly in the zone between the original and the cementing metals. The figure shows a similar structure to that of samples 6B and 4C (Table I.), and was taken longitudinally from the sample employed for mechanical tests from a section in the immediate vicinity of the surface of fracture, which happened to be in the molten zone. On examining this figure, as well as on comparing it with Fig. 2, which relates to a structure which did not undergo mechanical treatment, no deformation of any single constituent is found as the result of the mechanical stress undergone, although such deformation is plainly evident in Fig. 1, which refers to the structure of the original metal after having undergone mechanical stress.

The mechanical treatment leads to a resemblance of the structure of the molten zone to that of the original metal, as shown in Figs. 4 and 5, Fig. 4 being the original structure of the plate, and Fig. 5 that of the sample

TABLE I.—The Oxy-Acetylene Welding of Mild-Steel Boiler-Plates.

Plate.	No. of Sample.*	Thickness of Sample and Fusion Zone.	Thermal and Mechanical Treatment.	Mechanical Tests.† Ultimate Stress, Kg./mm².	Average Elongation per Cent.	Average Brinell Hardness, 1000 Kg.; Ball 10 Mm. in Dia.‡	Tests of Cold Bending on the Molten Zone.§	Chemical Analysis.‖ Metal, per Cent.	Fused Zone, per Cent.	Notes.
		mm.								
A	1	6	.. ..	56.8	18.5	140	180 deg.	..	..	Unwelded.
	2	6	Tempered to 850 deg. to 950 deg. during 20 minutes	50.5	23.8	110	..	..	..	Unwelded.
	3	6	Heated with the melting-pipe till incipient smelting of the surface, only central parts	54.8	21.2	142, heated part 125, unheated part	..	..	..	Unwelded.
	4	7	Air-cooling	44.2	4.1	..	180 deg. without traces of flaws in the weld	C 0.125, Mn 0.40, Si 0.047	C 0.08, Mn Si	Welded; broke at weld; rough grains structure.
	5	6	Air-cooling	43.0	3.7	140, 25 mm. from the weld 155, into the weld	..	..	..	Same as above.
	6	6	Weld hammered in heated state, cooled in the air	41.0	2.4	.. ..	..	..	..	Welded; broke at weld; fine, fibrous structure.
	7	6	Tempered to 850 deg. during 70 minutes	45.3	16.5	140, 25 mm. from the weld 146, into the weld	180 deg. without traces of flaws in the molten zone	..	..	Same as above.
	8	6	Two consecutive times the hot metal was hammered on the weld, and two consecutive tempers, slow cooling	47.2	5.9		130 deg. flaws in the molten zone	..	..	Same as above.
B	1	6	..	36.5	16.6	90	..	..	..	Unwelded.
	2	6	Same as A 2.. ..	36.5	19.7	90, non-heated part 83, heated part	..	..	..	Unwelded.
	3	10	Same as A 4.. ..	31.2	5.8	..	180 deg. without traces of flaws in the molten zone	C 0.125 Mn 0.40 Si 0.047	C 0.07 Mn 0.32 Si	Same as A 4.
	4	6	Same as A 4.. ..	29.0	4.8	91, 25 mm. from the weld 104, into the weld	160 deg. flaws into the molten zone	..	..	Same as A 4.
	5	6	Hot hammered on the weld, slowly cooled	36.5	13.1	90, 25 mm. from the weld 107, into the weld	180 deg. without traces of flaws in the molten zone	..	..	Welded; broke at weld; fine, slightly fibrous structure.
	6	..	Tempered during 20 minutes to 850 deg. to 900 deg. Cent., slowly cooled	37.0	10.5	..		..	..	Same as above.
C	1	20	..	40.6	26.5	..	..	..	..	Unwelded.
	2	20	Air-cooled	33.2	10.4	..	..	C 0.125 Mn 0.40 Si 0.047	C 0.06 Mn Si 0.020	Same as A 4.
	3	20	Same as A 6.. ..	31.4	8.0	..	..	..	..	Same as A 6.
	4	20	Same as A 7.. ..	35.1	12.3	..	..	..	..	Same as A 5.
	5	10	Same as A 7.. ..	34.6	13.1	..	..	..	..	Same as B 5.

* Two samples, especially prepared and treated, correspond to each number.

† Dimensions of specimens. Samples { 6 mm.; section, 6 mm. × 18 mm.; useful length, 120 mm. / 7 mm.; section, 7 mm. × 21 mm.; useful length, 140 mm. / 10 mm.; section, 10 mm. × 30 mm.; useful length, 200 mm. / 20 mm.; section, 20 mm. × 15 mm.; useful length, 200 mm.

‡ The Brinell tests were conducted on samples entirely different from those of stress tests, and on which the bending trials were first carried out.

§ The bending trials were on plates of original thickness, 300 mm. wide, 500 mm. long.

‖ The analysis of the metal in the molten part is executed on the drillings taken with a small drill from the molten zone of specially prepared pieces.

TABLE II.—The Oxy-Acetylene Welding of Mild-Steel Bars.

No. of Sample.*	Original Diameter of Sample in Millimetres.	Thermal and Mechanical Treatment.	Mechanical Trials on Round Samples, 12 Mm.; Length, 120 Mm. Average Tensile Strength, Kg/mm.²	Average Elongation per Cent.	Average Contraction, per Cent.	Average Brinell Hardness‡ 1000 Kg.; Ball 10 mm. Diameter.	Chemical Analysis. Metal, per Cent.	Fused Zone, per Cent.	Notes.
1	20	.. ..	43.0	30.0	7.0	125	..	..	Unwelded.
2	20	Same as Table I., A 3 ..	42.5	28.5	7.0	..	..	..	Unwelded.
3	20	Slowly cooled after melting	41.0	12.3	10.0	..	C 0.125 Mn 0.40 Si 0.037	C 0.08 Mn 0.29 Si	Same as Table I., A 4.
4	20	Same as Table I., A 6 ..	38.5	10.6	10.9	..	..	..	Welded; heterogeneous structure, coarse in the interior, fine on the outside.
5	20	After melting tempered to 850 deg. to 900 deg. during 40 minutes, slowly cooled	42.0	29.0	6.8	119	..	..	Welded; broke in the available portion of the sample
6	20	Hammered when hot on the weld, tempered to 850 deg. to 900 deg. during 40 minutes, cooled very slowly	42.4	26.3	6.9	133	..	..	Same as above.
7	20	Same as Table I., A 8, only tempered during 40 minutes	42.5	29.2	6.9	129	..	..	Same as above.

* See note, Table I. ‡ Brinell tests were conducted on the samples for the tensile tests before being machined to final size, but after a preliminary polishing. ‖ See note, Table I.

TABLE III.—Oxy-Acetylene Welding of Medium and High-Carbon Steels.

Plate.*	No. of Sample.	Original Diameter of Sample in Millimetres.	Thermal and Mechanical Treatment.	Mechanical Trials on Cylindrical Samples, 12 Mm.; Length, 120 Mm. Average Tensile Strength, Kg./mm.²	Average Elongation, per Cent.	Average Brinell Hardness‡ 1000 Kg. Ball, 10 Mm. in Diameter.	Chemical Analysis. Metal, per Cent.	Fused Zone, per Cent.	Notes.
M	1	25	.. ..	67.2	19.3	193	..	..	Unwelded
	2	25	Same as Table II., 3	42.1	3.2	193, 20 mm. from the weld 178, on the weld	..	..	Same as Table I., A4
	3	25	Same as Table I., A6	39.0	0.9	.. ..	..	..	Same as above
	4	20	Same as Table I., A7	35.0	1.2	.. ..	C 0.60 Mn 0.91 Si 0.20	C 0.35 Mn 0.53 Si 0.08	Same as above
N	1	26	..	84.1	16.1	218	..	..	Unwelded.
	2	26	Same as Table I., A 3 ..	82.1	13.2	218, unheated part 208, heated part	..	..	Same as above.
	3	26	Same as Table II., 3 ..	53.4	2.1	218, 25 mm. from the weld 135, into the weld	..	..	Same as Table I., A 4
	4	26	Same as Table I., A 6 ..	51.4	0	.. ..	C 0.60 Mn 0.91 Si 0.20	C 0.32 Mn Si 0.10	Same as above.
P	1	15§	Same as Table I., A3.	78.0	13.3	238	..	..	Unwelded.
	2	15	Same as Table II., 3.	74.0	1.9	.. ..	..	..	Same as Table I., A4
	3	15	Same as Table II., 6.	53.0	2.1	.. ..	..	..	Same as Table I., A6.
	4	15	Same as Table I., A6.	46.0	0.6	.. ..	C 1.09 Mn 0.79 Si 0.04	C 0.9 Mn 0.31 Si 0.04	Welded; broke in the fusion zone, heterogeneous structure.
	5	15	Hammered hot on the weld, quenched at 600 deg. in water at 15 deg. Cent., tempered nearly 30 minutes 850 deg. to 900 deg., slow cooling.	69.0	10.5	238, 25 mm. from the weld. 209, into the weld.			

* See note, Table I. Only M was not prepared in double samples owing to the lack of material. ‖ See note, Table I.
‡ See note, Table I. § The samples of P steel were reduced to 10 mm. diameter; length, 100 mm.

numbered 5 B (see Table I.). Even in these circumstances, however, the individual constituents do not appear to have opposed much resistance to the stress, as is clearly shown on comparing Figs. 5 and 6, The latter refers to the structure of sample 8A, which was taken in a similar manner to sample 7A, and reveals a structure which is common to samples 6A, 5B, and 3C (see Table I.).

A second series of researches of the same nature was made on round bars of mild homogeneous and very pure steel, the chemical composition of which was:—

	Per Cent.
Carbon	0.119
Manganese	0.62
Silicon	0.023
Phosphorus	0.066
Sulphur...	0.062

As cementing metal an iron wire was employed similar to that used for the first series; the experiments took place in the same manner, and the precautions previously noted and the conditions necessary for obtaining a satisfactory melting were carefully observed. The preparation and cutting of the samples for the various tests were carried out in the same manner as for those of the first group, the only differences being that the microscopical examinations were carried out on the samples before machining them, and that the samples for the mechanical tests were all reduced to the same diameter (12 mm.) from their uniform original diameter of 20 mm. This was done in order to check the quality of the several welds. Table II. shows the experiments and the results of this second series of experiments.

The microscopic observations made on the samples confirm Table II., and agree so closely with the first series that the author cannot do better than to refer the reader to the conclusion stated above.

As regards the deformation occasioned by the mechanical treatment of samples 5, 6, and 7 (Table II.), it is evident that a long subsequent heating is apt to remove the effects of the sudden high temperature produced in the metal during the melting; and though the breaking-point is far removed from the melting zone, the latter shows a deformation in its external part (in one sample just in the middle of the melting), which confirms the view, in the case in question, that the connecting material is really embodied with the molten metal. Fig. 7 (as

TABLE IV.—THE OXY-ACETYLENE WELDING OF CAST IRON.

No. of Sample.*	Original Diameter of Sample in Millimetres.	Thermal Treatment.	Mechanical Tests on Samples, Diameter, 20 Mm.; Length, 120 Mm.		Notes.
			Average Tensile Strength, Kg/mm.²	Average Brinell Hardness 1000 Kg.; Ball 10 mm. in Diameter.†	
1	35	.. .. ..	15.2	166	Unwelded.
2	35	Same as Table I., A 3	..	166, non-heated part	Unwelded.
				171, heated part	
3	35	After melting, air-cooling ..	16.2	171, 30 mm. from the weld ..	Same as Table III., P 5
				218, into the weld	
				227, into the intermediate zone..	
4	35	Same as Table II., 3	16.7	..	Same as above.
5	35	After melting during 30 minutes at 850 deg. to 900 deg., then slow cooling	14.8	168, 30 mm. from the weld ..	Same as above.
				200, into the weld	
				209, into the intermediate zone..	
6	25	Slowly cooled	16.5	..	Same as above.

* See note, Table I. † The Brinell tests were carried out on the longitudinal flat sections of the samples after the stress trials.

TABLE V.—BRITTLENESS TESTS WITH CHARPY APPARATUS ON PIG IRON SAMPLES OF THE CHARPY TYPE (30 × 30 × 160 MM.); DISTANCE OF FIXED POINTS, 120 MM.

No. of Sample.	Initial Size of Sample.	Thermal Treatment.	Angle of the Indicator.	Work of Breaking Kgm.	Resiliance per 100 mm.² Calculated for a Section of 450 mm.², Kgm.	Average Chemical Analysis.*		Notes.
						Metal per Cent.	Fused Zone per Cent.	
			deg.					
1	Square sticks of 35 mm.	.. ..	80	7.90	1.75	..	..	Unwelded.
2	Ditto	.. ..	79	13.31	2.73	..	..	Unwelded.
3	Ditto	Same as Table I., A 3 ..	79	13.31	2.73	..	..	Unwelded.
4	Ditto	Same as Table II., 3 ..	79	13 31	2.73	Ct 2.94 Cc 0.33 Si 4.50 Mn 0.87	Ct 2.21 Cc 0.67 Si 3.70 Mn	Welded; fine structure.
5	Ditto	After melting, cooled rapidly to the air	79	13.31	2.73	Ct 2.94 Cc 0.33 Si 4.50 Mn 0.87	Ct 2.68 Cc 0.43 Si 3.61 Mn 0.56	Same as above.
6	Ditto	Tempered after melting during 15 minutes to 800 deg. and slowly cooled	79	13.31	2.73	Ct 2.94 Cc 0 33 Si 4.50 Mn 0.87	Ct 2.62 Cc 0.35 Si 3.41 Mn 0.48	Unwelded; intermedial structure between unwelded and preceding samples.
7	Ditto	Same as above	79	13.31	2.73	..	..	Same as above.

* The chemical analysis of the metal in weld was done on the drillings taken with a little drill in the melting zone of the samples used for brittleness tests after breaking.

seen under a magnification of 1.5 diameters) shows the external part, and Fig. 8 the longitudinal section (as seen under a magnification of 2 diameters, and etched with a 5 per cent. solution of nitric acid in amylic acid)—the first-named showing the deformation in the melting zone, and the second the nearly complete homogeneity (which is perfectly uniform in all samples of the same treatment) between the original and the cementing metal.

GROUP II.

OXY-ACETYLENE AUTOGENOUS WELDING OF MEDIUM AND HIGH-CARBON STEELS.

The experiments were made on round samples of three different types—M, N, and P—whose chemical composition was:—

—	M.	N.	P.
	per cent.	per cent.	per cent.
Carbon	0.48	0.70	1.09
Manganese	0.31	0.93	0.79
Silicon	0.141	0.19	0.09
Phosphorus	0.054	0.049	0.041
Sulphur	0.079	0.057	0.060

As a cementing metal for M and N steels, little steel rods of the following composition were used:—

	Per Cent.
Carbon...	0.60
Manganese	0.91
Silicon	0.20
Phosphorus	0.067
Sulphur	0.051

This material had a composition similar to, yet intermediate between, that of the steels with a high percentage of manganese and silicon to compensate partially for the loss of these elements which takes place during the melting (see Table III.). In the present experiments the same precautions were employed as for Group I., the same conditions required, and the same type of samples and tests were made. During the melting a large amount of deoxidising and descorifying powder was used, in the form of sodium carbonate and bicarbonate mixed together (owing to the fact that the mixture of oxides formed has a melting point very near to that of the metal itself), so as to avoid inclusion of oxide in the weld.

Table III. shows the results of this second group.

The remarks made respecting the microscopic examination of the fusion zone of the first group again apply here. The stronger carburisation of the metal and the effect of the profound modification by the sudden heating and the rapid melting of the metal are, of course, more in evidence, and the phenomena of oxidising during the melting is strongly pronounced in the fusion zone. Fig. 9 represents the type of the three steels which had undergone the same preparation and treatment (samples 2 M and 2 P, see Table III.) It is seen under a magnification of 80 diameters, etched with picric acid, and refers to the intermediate zone between the molten metal (lower part of figure) and the original metal in 4 N sample (upper part of figure) (See Table III.). The alteration of the structure and chemical composition are shown clearly, and the chemical analysis is given. The mechanical treatment and short tempering bears out what was found with mild steels; the fused zone was reduced like that of the original metal. Fig. 10 confirms this; it refers to sample 4 M (as seen under a magnification of 80 diameters, etched with picric acid), and shows the zone referred to between the cementing material and the metal (the structure of which is represented by the upper portion); sample 4 M being fairly typical for all three steels subjected to the same treatment. Nevertheless, the internal strain undergone by the metal is such that it does not retain any malleability, and consequently no deformation under mechanical stresses results in the portion which has been subjected to the sudden shock of the melting process.

This is clearly shown by the examination of Fig. 10, representing the structure in the immediate neighbourhood of the fracture in the stress test. In the fused zone (lower part of the figure) the constituents do not show the least deformation (which is, however, very pronounced in the upper part, and the zone of metal immediately next to the molten zone), and are unaffected by the melting. The figure shows further the decarburisation which has taken place in the metal during the melting, which is confirmed by chemical analysis (see Table III.).

Fig. 11 (as seen enlarged 80 diameters, and etched with picric acid) refers to sample 4 P, and shows the three zones—the fusion zone, the intermediate zone, and the original metal zone—which may serve as typical of the two other steels. The sudden passage from one to the other of the two zones of various structure and composition accounts for the bad results of the stress tests.

Finally, Fig. 12 (as seen enlarged 80 diameters, and etched with picric acid) refers to sample 5 P. The left-hand portion reproduces the initial structure of the metal, while the right-hand portion shows the structure in the middle of the zone of fusion. From a comparison of the two zones it is evident that the treatment undergone by the sample has made the structure of the zone of fusion very like that of the initial metal, thus confirming the good results obtained by the mechanical tests.

The results and observations summarised in these two groups of experiments show that:—

1. The violent heating and the sudden melting undergone by the metal alter profoundly its quality. This alteration becomes specially manifested by an internal strain of the metal (meaning by this word an injurious modification of the metal's mechanical properties, caused by thermal and mechanical phenomena, owing to the high temperature of the process) as the stress and hardness tests show, although uninfluenced by modifications in the chemical composition (steels). The absence of deformation in the individual structural constituents in stress tests is a further confirmation.

2. The alteration in the mechanical qualities (tenacity and elasticity) cannot be remedied by simple hammering on the molten zone—which often proves to be most injurious to high-carbon steels—but must be coupled by proper thermal treatment, such as annealing, which is much more efficient when prolonged over a sufficient time (30 to 40 minutes), so that the interior stress can be nearly wholly eliminated. Further, the other thermal processes (quenching, &c.) have the greatest influence on high-carbon steels.

3. A remarkable influence on the mechanical properties (more especially of the latter steels) is to be attributed to cooling processes, the slowest cooling being the best and most effective.

4. Apart from the alteration in mechanical properties (the principal of which is the change in the elongation), very important modifications take place in the chemical constitution, especially in high-carbon steels. These changes consist chiefly in the diminution (in the percentage) of carbon, silicon, and manganese. Such variations, which are proportional to the percentages originally present in the steel, are, it is very easy to understand, caused by the strong oxidising influence to which the metal is subject during the melting, and becomes modified by the different methods employed in this process. It is easy to remedy this defect by using as a cementing material a steel of analogous composition to the pieces intended for welding, but containing higher percentages of the more easily oxidised elements.

5. The mechanical properties are, owing to the short duration of the process, only slightly altered when, instead of the fusion process, a simple heating with the flame is substituted, as is easy to foresee. As the metal during the melting is subjected to a strong internal stress, with every increase in the depth of the fused portion, the efficiency of the remedial heat treatment, undergone after the melting, rapidly decreases.

GROUP III.

PIG IRON.

The experiments on pig iron were limited to grey varieties, their extension to the very rarely used white varieties being deemed useless. Phosphoric pig iron cast into well-dried sand moulds in the form of round and square bars, in order to secure a uniformly homogeneous structure, was selected as material for the experiments. The pig iron had the following composition:—

Total carbon, 2.94 per cent.; silicon, 2.42 per cent.
Total carbon in combination, 0.33 per cent.; manganese, 0.87 per cent.
Total graphitic carbon, 2.61 per cent.; phosphorus, 1.47 per cent.; silicon, 0.09 per cent.

The high percentage of phosphorus is evident in Fig. 13 (as seen under a magnification of 80 diameters, and etched with picric acid), representing the structure of this pig iron.

As a cementing metal, little rods of the same composition as the pig iron were used, only modified in their silicon percentage, bringing it up to about 4.5 per cent., because of the above-mentioned oxidising influences and the losses caused by them in the melting process. The tests were made on cast samples just as they came from the foundry, every precaution being employed as before. Care was taken during the melting to use plenty of deoxidising and de-scorifying powder as used in the experiments on carbon steels, because the melting-point of the mixed oxides is higher than that of the metal, which might have caused considerable blow-hole formation.

Some of the samples were submitted to several coolings, and some to careful annealing; after which they were reduced to the required size for the mechanical tests. These were divided into tensile and hardness tests. These tests having been carried out, the samples were cut longitudinally in the middle, and on sections thus obtained hardness tests were made, after polishing and a microscopic examination. The hardness tests were made on the fused and on other zones. The hardness test-pieces (after the microscopical examination) were also analysed in order to study the alterations in composition at the fused zones, and the microscopic examination of each sample completed the researches. In Tables IV. and V. are described the conditions under which the experiments took place, and the results of each.

The very appearance of the fractured surfaces in the brittleness tests demonstrates at once that the melting process produces a finer and more compact structure than the original in the molten zone of the metal. This is evident in Fig. 14 (as seen under a magnification of 1½ diameters), relating to three samples, in which the welding was, as usual, carried out in the centre of the pieces. The first shows the original metal (sample 2, Table V.), the second the broken surface of the welded piece rapidly air-cooled after melting (sample 4, Table V.), and the third the welded pig iron, annealed at 800 deg. after melting, and slowly cooled (sample 7, Table V.). It is, moreover, evident that the effect of the annealing on the structure of the metal is very marked, even if the process be a short one. The grain becomes coarser and more compact, as shown from the examination of sample 3 (broken). The microscopic examination of the welded samples affords fresh confirmation of this statement. The structure of the pig iron investigated can be referred to three fundamental types shown in Figs. 15, 16, and 17 (as seen under a magnification of 80 diameters), representing the passage from the molten zone to that of the pig iron unsubjected to the melting. The first type, which, as the other two, does not present any sudden passage in the structure, refers to the welded samples rapidly cooled in the air (sample 3, Table IV., and sample 4, Table V.). In the structure of the metal one observes that, on account of the sudden variations of temperature (the upper part of the figure refers to the structure of the original metal not having undergone melting), the patches of ferrite pre-existing in the pig iron employed (see Fig. 13) are no longer visible, while the graphite crystals (not well shown in the figure) persist, although a large portion of the carbon has passed into solution as combined carbon.

The same features are to be observed in the zone of fusion, where, on the other hand, the modifications in

the structure are influenced by the effects of the rapid cooling and of the variation in the chemical composition. Indeed, the percentage of total carbon is notably diminished, as shown in Table V., simultaneously with the percentage of silicon, notwithstanding the large amount of the latter element contained in the cementing metal.

The second type of structure relates to welded pig iron subsequently subjected to slow cooling after fusion (No. 4, Table IV., and No. 5, Table V.). This confirms the observed fact of the strong influence of melting, notwithstanding that the diminished loss in silicon (sample 5, Table V.) has had an influence in reducing the amount of combined carbon and of segregating in a free state the previously existing graphite crystals, with the consequent formation of appreciable quantities of ferrite as shown in the figure.

Finally, the third type of structure represents that of the fusion zone in a sample which, after welding, has been annealed at 800 deg. and slowly cooled (sample 5, Table IV., and samples 6 and 7, Table V.). In this instance the thermal treatment restores the original structure of the pig iron (see Fig. 13) in the immediate vicinity of the zone of fusion into which the cementing metal has been poured. Notwithstanding that, in this zone the fine structure, observed in the previous types and resulting from the rapid solidification of the metal, is maintained. There is a marked diminution in the amount of combined carbon, and numerous patches of ferrite appear round the patches of tempered carbon. This cannot be seen in Fig. 17, but is well shown in Fig. 18, which refers to the same fused zone, but represents the surface simply etched. Further, from a collective examination of Figs. 15, 16, and 17, the gradual transition in the structure without sudden variations indicate that the welding has taken place with the complete fusion of the two parts to be united, whilst the modification of the composition of the cementing material permits of the special type of structure of the pig iron employed in the experiments being maintained throughout the whole zone of fusion.

Fig. 19 shows longitudinal sections which were taken from Nos. 3 and 5, Table IV., after the tensile tests. On comparing the surfaces, which were polished and subsequently etched with an alcoholic solution of picric acid, confirmation is obtained of the influence of annealing on the internal structure (sample 5, Fig. 19). This is also shown by the coarser structure of the portions in the immediate vicinity of the zone in which the union has occurred by fusion, showing that the original structure of the metal has undergone further modification, owing to the high temperature to which it has been subjected.

Conclusions.

The results obtained and the observations made in this third group of experiments show clearly :—

1. That the rapid melting and cooling of the pig iron subjected to the oxy-acetylene process causes, as might have been foreseen, a fine compact structure in the zone of fusion.

2. That owing to the high temperature and to the energetic conditions of heating which take place during the process of welding, the composition of pig iron (and therefore of its internal structure as well) undergoes considerable modification, chiefly owing to the loss in carbon and silicon (as shown in the analyses in Table V.), elements both of which strongly influence the structure of the metal. This loss, of course, varies with the different melting processes employed. An easy method for partly remedying this loss is to employ an appropriate cementing material, which will supply the elements eliminated by oxidation.

3. The mechanical properties of the metal are not greatly influenced by oxy-acetylene welding, when properly carried out. The internal stress suffered by the metal confers greater hardness on the zone of fusion, as shown by the Brinell tests. The brittleness tests, although they reveal the good quality and homogeneity of the metal, do not appear to be affected by the slight variations due to the melting of the metal.

4. The heat treatment and the cooling conditions, though they exert considerable influence on pig iron subjected to the process, do not appreciably modify the mechanical properties, and are of interest only when it becomes necessary to take into consideration the dilatation of the metal in relation to its low thermo-conductivity in the melting of special engine parts in which the physical properties are of great importance.

Ocean Cruising Yacht "Arcadian."—A more than usually interesting vessel left the works of her builders, Messrs. Harland and Wolff, Belfast, on the 16th instant, for Southampton, there to take up her station as an ocean-going cruising yacht. This vessel, the Arcadian, has been built specially for such cruises, and the passenger accommodation has been arranged in a very luxurious style, the absence of cargo hatches and cargo appliances greatly improving the appearance of the vessel, and conducing to the comfort of the passengers. The vessel is of considerable size, being over 500 ft. in length, of 14,120 tons displacement, and 8780 tons gross register. The upper promenade deck has a length of 260 ft., while the main promenade deck extends right fore and aft for the complete 500 ft., and arranged centrally upon it is an open space 35 ft. by 55 ft. for an open ball-room. The dining-saloon occupies the whole height of two decks, with a gallery round the intermediate height, so that the ceiling is 15 ft. above the deck. There are also in the ship a tiled swimming-bath, 35 ft. long, with dressing-rooms adjoining it, and a large gymnasium, with all the latest appliances for exercise. The vessel will make her first cruises in the West Indies, and in the summer will be engaged in Norwegian tours.

CATALOGUES.

Heating Boilers.—From Messrs. Robert Jenkins and Co., of Rotherham, we have received a copy of a catalogue giving prices and particulars of all kinds of welded and riveted boilers, and various accessories for heating greenhouses, public buildings, &c., by means of hot water. Prices are also stated for iron and copper range-boilers, cisterns, circulating cylinders, steam-jacketed pans, &c.

Electric Generators and Motors.—We have received from the Phœnix Dynamo Manufacturing Company, Limited, Thornbury Works, Bradford, copies of two of their recent bulletins. One of these illustrates and fully describes the construction of Phœnix direct-current multi-polar generators and large motors. The other bulletin relates to alternators, and, besides dealing with their construction, gives outputs, efficiencies, and other particulars of machines, with capacities ranging from 12.5 to 200 k.v.a.

Fans, Ventilating and Dust-Collecting Plant.—A small catalogue recently received from Messrs. John Gibbs and Son, 72, &c., Duke-street, Liverpool, contains prices and particulars of air-propelling and ventilating fans driven by belt or by electric motors; similar fans, driven directly by small steam-engines, can be supplied. Some particulars of "Peerless" blowing and exhausting fans are also given, and prices are stated for small dust-proof electric motors and interlocking starting switches. The latter are arranged so that it is impossible to switch on the current unless all the resistance is in circuit. The catalogue also contains numerous illustrations of installations for collecting dust and removing fumes from factories and workshops. This firm also manufactures weather-proof ventilators for ships, and some illustrations of these are included.

Heating and Ventilating Workshops. — Messrs. Matthews and Yates, Limited, Cyclone Works, Swinton, near Manchester, have published a little booklet relating to the application of their "Cyclone" system of heating and ventilating to industrial buildings. Both exhaust and plenum systems are dealt with, but the latter system is generally recommended. On the plenum system, air supplied by a "Cyclone" centrifugal fan is passed over an air heater, consisting of a battery of gilled steam-pipes, and then distributed through ducts to the various rooms. If necessary the air, before it reaches the fan, may be passed through an air-filter, consisting of a rectangular framework filled with small coke, over which water is allowed to trickle. The pamphlet also deals with humidifiers, particularly suitable for use in textile factories, and with apparatus for extracting steam and noxious vapours from dye-houses, &c. The application of the system to drying-rooms is also touched upon.

Lathes and Screwing Machines.—From Messrs. J. Archdale and Co., Limited, Ledsam-street, Birmingham, we have received a copy of their latest sectional catalogue dealing with high-speed capstan lathes, engine lathes, and screwing machines. The catalogue gives full particulars of a 9-in. centre capstan lathe with "all-gear" headstock, and another with 7-in. centres, having a friction-geared headstock. Smaller sizes, with cone-pulley drive, are also dealt with. A standard outfit of tools for bar or chuck work on these lathes can be supplied, and particulars of these tools are included. The catalogue also deals fully with sliding, surfacing, and screw-cutting lathes, ranging from 6-in. to 16-in. centres, for high-speed work. These lathes are supplied with either "all-gear" or cone-pulley headstocks. Particulars are also given of pipe-screwing and cutting-off machines, and bolt-screwing and nut-tapping machines. Excellent illustrations are given of all the tools dealt with.

Power-Transmission Accessories.—We have received from Messrs. Frank Wigglesworth and Co., Limited, Clutch Works, Bradford, a copy of a useful catalogue of various appliances for the transmission of power by mechanical means. The catalogue is divided into nine sections, of which the first four deal with shafting, loose collars, shaft-couplings, rigid and swivelling plummer blocks, sole-plates, hangers, wall-boxes, stools, and other accessories for line-shafting. The following sections give particulars of belt and rope-pulleys, right-angle drives, guide-pulleys, toothed gearing, friction clutches, and haulage gears. The friction-clutch section, which is especially noteworthy, deals with clutches of the rim, band, shell, disc, and Seymour types, giving particulars of each, and illustrating numerous applications. The catalogue is fully illustrated throughout, and also contains some useful notes and data which should help to render it of service to those engaged in designing and estimating for all kinds of millwrights' work. Prices are quoted for most of the appliances dealt with.

Heavy Lathes.—From the Niles-Bement-Pond Company, 111, Broadway, New York, U.S.A., we have received a catalogue of heavy engine and gun lathes designed for use with tools of high-speed steel. The catalogue illustrates double back-geared engine lathes in four sizes, ranging from 24-in. to 36-in. swing, and also a 36-in. triple-geared lathe, giving the leading dimensions of each size, together with a general specification. Similar particulars are also given of lathes from 42-in. to 72-in. swing with all-geared headstocks. The foregoing tools are arranged for driving either by belt or by an electric-motor. When the latter form of driving is employed the motor is completely controlled from the saddle, so that the operator need not leave the work. In the larger sizes the leading screw is supported on hanging bearings, which are automatically picked up by the saddle as it advances, and replaced at equi-distant points along the bed on the return journey. This catalogue also gives general particulars, without illustrations, of larger engine lathes, with swings ranging from 84 in. to 120 in., and of gun lathes from 53-in. to 108-in. swing. The London address of the Company is 25, Victoria-street, Westminster, S.W.

Insulation Cutter for Commutators.—A leaflet illustrating and describing a handy tool for recessing the mica insulation between the commutator segments of electric generators and motors, has come to hand from the Maschinenfabrik Oerlikon, whose London address is Oswaldestre House, Norfolk-street, Strand, W.C. The apparatus consists of a bronze casting, provided with two handles, and carrying a small milling-cutter operated through a telescopic shaft by means of an electric motor. The tool, when placed on the commutator, rests on two supports, which can be exchanged or separated, more or less, to suit the radius of the commutator. For use, the supports are so arranged that the cutter penetrates to the required extent into the insulation, and the tool is then drawn slowly along by hand from the windings to the end of the commutator, so that a slight groove is cut between each pair of segments. One of the handles is made hollow, so that, if desired, a flexible tube from any available exhausting apparatus can be connected to it for the purpose of drawing off the dust produced by the cutter. For operating the tool the company recommend one of their portable drill motors, which can, of course, be used for drilling when required. The pamphlet states prices for the tools, motors, and various spare parts.

Air-Heaters for Boiler Furnaces—From the Underfeed Stoker Company, Limited, of Coventry House, South Place, E.C., we have received a pamphlet relating principally to the "Usco" air heaters, which are primarily intended for heating the air supplied by mechanical means to boiler furnaces; they may, however, also be used in connection with installations for heating buildings and drying materials. The heaters consist of a number of narrow, semi-circular chambers, constructed of sheet steel, and placed side by side, a small distance apart, in any convenient position in the path of the waste furnace-gases which pass between the separate chambers. By means of a fan the air is drawn or forced through these chambers on its way to the furnace, travelling in the opposite direction to that of the hot gases. In this way the air extracts much of the heat from the waste gases, and returns it to the furnace, thereby economising fuel and improving combustion. The soot which is deposited on the heater is removed by means of steam-jets from perforated pipes, one of which is situated between each pair of chambers. These pipes radiate from a central trunnion-pipe, and are arranged so that they can be turned round at intervals to sweep over the entire heating surface. The pamphlet gives a general illustrated description of these heaters (which were dealt with in our issue of August 5, 1910, on page 200), and points out the advantages they possess over economisers; their application to different types of land and marine boilers is also illustrated. The pamphlet also contains some general notes on the subject of mechanical draught, pointing out its advantages over natural draught, and dealing briefly with its production and use.

The Mechanical Design of, and Stresses in, Turbo-Alternators.—A lecture was delivered on November 23 before the Keighley Association of Engineers on "The Mechanical Design of Turbo-Alternators," by Mr. H. Rolfe, M.I. Mech. E. After describing various types of machine now in use, the lecturer gave an account of the stresses set up in the various parts, and of the assumptions that had to be made in computing them. In some cases the stresses were largely indeterminate, either inherently so or else due to exigencies of design and manufacture. Hence, rigorous mathematical treatment was not always feasible, and formulæ and curve diagrams suitable for actual designing were given. One of the difficulties that confronted the mechanical designer and constructor was the fact that a metallic connection between the field-coils and the rotor-core was impossible, insulation always intervening. In a set of steam turbo-alternators, large and small, the centrifugal pull of a pound at the periphery might range from 1000 lb. to 4500 lb., the lecturer pointing out that the amount depended on the diameter and revolutions per minute, and not on the peripheral speed merely, as was sometimes thought. The outward throw of the coils was thus seen to be very great, and as all such pulls were transferred to the rotor, the interposition of mica, cloth, shellac, &c., between the several turns of a coil, and between the coil and the rotor, was a source of trouble. Granted that an initial running balance was obtained, the machine might, sooner or later, speed up 25 per cent. or more, due to a temporary failure of the governor; this would increase the pressure on the insulation by more than 50 per cent., and cause the coils to "creep" outwards slightly. If the insulation were homogeneous, the balance would be maintained; but as there was certain to be weak spots—more shellac in some places than in others—the coils would not move out uniformly, and an unbalance would result. This referred less to former-wound coils than to certain others in which there might be 100 or more turns wound on the flat. End bells for restraining the end windings should be centered on the shaft, and not merely be carried by the coils; any unbalance in the bell would then be taken up by the shaft instead of surging to and fro on the coils and thereby disintegrating the insulation. Another difficulty of the mechanical engineer was that his and the electrical engineer's requirements as to material usually differed. The former could not always use the strongest or stiffest material at his disposal, but must have regard to the necessary qualities of permeability in some cases, and of non-magnetism in others.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

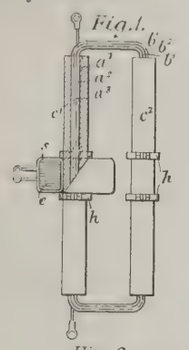
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

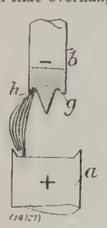
ELECTRICAL APPARATUS.

17,208/11. Siemens Brothers and Co., Limited, London. (*Siemens and Halske Aktiengesellschaft, Berlin, Germany.*) **Current-Transformer.** [2 *Figs.*] July 27, 1911.—The invention relates to current-transformers for high voltages in which the primary circuit is surrounded by two insulating cylinders which may be stepped down in known manner, arranged side by side, and, according thereto, one of the cylinders is surrounded by a ring-shaped iron core carrying the secondary winding. The primary consists either of a continuous conductor



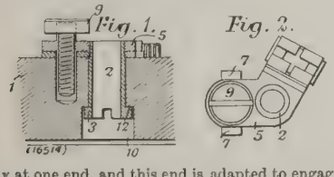
surrounded by the two parallel insulating cylinders c^1, c^2, arranged side by side, or of two groups of conductors a^1, a^2, a^3 and b^1, b^2, b^3, which are inserted in the cylinders and joined at the ends, or ∪-shaped conductors may be collected into a bundle, inserted into the insulating cylinders and connected in series at their free ends. The central part of the cylinder c^1 is surrounded by a ring-shaped iron core e which carries the secondary winding s. The cylinders c^1 and c^2 are surrounded by the straps h which serve to connect them to the wall brackets k which support the transformer in a vertical position. (*Accepted October* 25, 1911.)

14,127/11. Siemens Brothers Dynamo Works, Limited, London. (*Siemens-Schuckertwerke, G.m.b.H., Berlin, Germany.*) **Arc-Lamps.** [2 *Figs.*] June 14, 1911.—The invention relates to electric arc-lamps employing practically non-combustible electrodes, and, according thereto, the electrodes are formed in a manner such that overhanging the projecting tip of



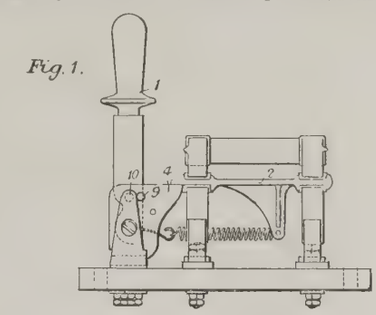
the electrode is a rim giving rise to eddies in the ascending stream of gases. a denotes the lower electrode, and b the upper electrode. Near the tip of the electrode b is formed an overhanging rim h, with depression g. When the lamp is in operation, the ascending gases impinging on the lower end of b are deflected sideways by the rim h, eddies being formed which prevent the climbing of the arc. (*Accepted October* 25, 1911.)

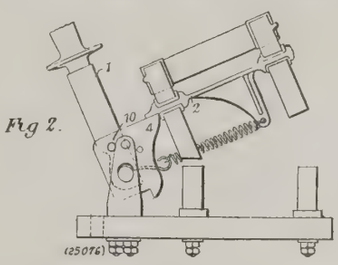
16,514/11. A. P. Lundberg, G. C. Lundberg, and P. A. Lundberg, London. Electrical Terminals. [2 *Figs.*] July 18, 1911.—This invention has relation to terminals for connecting the ends of electrical conductors with the parts of electrical apparatus, and in accordance therewith a terminal comprises a terminal-plate provided with a known construction of terminal, consisting of a screw positioned between two upstanding lugs, and a tube-like member. This member is screw-threaded



externally at one end, and this end is adapted to engage a tapped hole in the terminal-plate. The arrangement is such that the terminal-plate forms the nut which holds the tube-like member in position on the electrical apparatus, and also, it may be, holds in position a connector or other part of the electrical apparatus. The electrical conductor passes through the tube-like member, and its end is secured to the terminal on the terminal-plate. 1 is a base of insulating material, 2 is the tube-like member, screw threaded at one end, and at its other end provided with a flange 3. 5 is the terminal-plate having a hole tapped to receive the screw-threaded end of the member 2, and upstanding lugs 7, between which is another tapped hole to receive a terminal screw 9. The hole 10 in the base 1 is formed with a shoulder 12 against which the flange 3 may abut. In assembling the parts, the terminal-plate 5 is placed on the base 1, the member 2 is then passed upward of the hole 10 and screwed into the hole in the terminal plate 5, its flange 3 coming into contact with the shoulder 12. The terminal-plate thus acts as a nut to the member 2, and the member 2 acts to fix all the parts mentioned together. The electrical conductor passes from the underside of the base 1 through the member 2, and is then bent over and its end passed under the head of, and around the shank of, the screw 9, which, when screwed down, tightly holds the conductor in place. (*Accepted November* 1, 1911.)

25,076/10. Spagnoletti, Limited, and V. E. Joyce, London. Switches. [5 *Figs.*] October 28, 1910.—In electric switches of the quick make-and-break type and in which the switch-blades are frictionally held in their "on" or "off" position, the switch-blades are, according to this invention, held in their "on" or "off" position by forming in the arm carrying the switch-blades concavities, each adapted to be engaged by a spring-operated retaining device located on the bracket carrying the spindle upon which the switch-arm turns. The handle 1 and switch-arm 2 are supported on a spindle about which they can independently turn. The switch-arm 2 is provided, at its forward

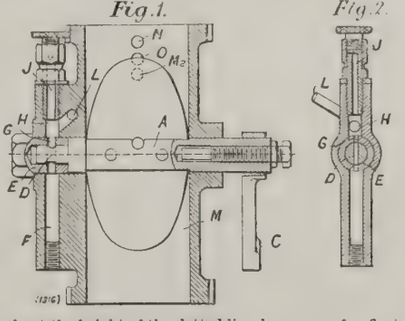




end, with a forked extension, the arms of which are supported on the spindle, and between these arms the lower end of the handle 1 is located. Each arm 4 of the forked extension of the switch-arm has two spherical recesses 9, 10, adapted to be engaged by a spring-pressed ball; the recess 9 is engaged when the switch is "off," while the recess 10 is engaged when the switch is "on." On operating the handle 1, the balls are pressed outward from their recesses against the action of the spring and lie against the outer faces of the arms 4 until the movement of the switch has been effected, when the balls enter the other recesses in the arms. (*Accepted November* 1, 1911.)

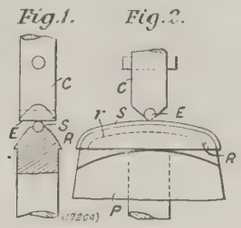
GAS ENGINES, PRODUCERS, HOLDERS, &c.

1316/11. P. A. Poppe, Coventry. Carburettors. [3 *Figs.*] January 18, 1911.—This invention relates to carburettors of the single-lever type, having a variable jet interconnected with the throttle. According to this invention, a butterfly throttle-valve is used, and the spindle controls the jet outlet. For this purpose, the throttle-spindle is drilled to form a fuel passage, and it lies within a bush or casing provided with holes, so that as the throttle is moved to decrease the passage through the carburettor the jet outlet is decreased, and *vice versâ*. For instance, the throttle-spindle may project outside the throttle-chamber, and the fuel outlet, constructed as described, may communicate with a small air-chamber, which may be in communication with the throttle-chamber at any suitable point, either so as to be closed partially by the throttle-disc or not. Preferably the intake to this small air-chamber is adjustable. The petrol is maintained



at or about the height of the dotted line by means of a float-feed mechanism. The throttle-spindle A carries a disc, which is actuated by a control-lever C. The throttle-spindle A is extended, and this projecting part is provided with a fuel passage D. The projecting portion lies in a short bush E provided with a hole on its underside communicating with the supply passage F. The bush E is formed on its upper side with the fuel outlet G, and from it the petrol issues into a small air-chamber H. The air enters the air-chamber by means of a tube J, the inlet to which may be varied by adjusting a needle-valve. The outlet from the chamber H is by way of a passage L, and it may communicate with the main spraying-chamber M. For instance, it may enter the spraying-chamber at M^2 at a point where it is acted on by the throttle-disc, or at N, where it is not so acted on, or it may lie at an intermediate position O, where it is partially closed when the throttle-disc is shut right down. The position of the inlet to the throttle-chamber may thus be varied according to the results required. When it is arranged at N or O preferably the holes D, G are so set that they are not completely closed when the throttle is shut. Thus, with the passage through the spraying-chamber closed, a small quantity of carburetted air can be drawn through the passages J, L, sufficient to keep the engine running slowly. In this manner a kind of by-pass is formed around the throttle-valve. (*Accepted October* 25, 1911.)

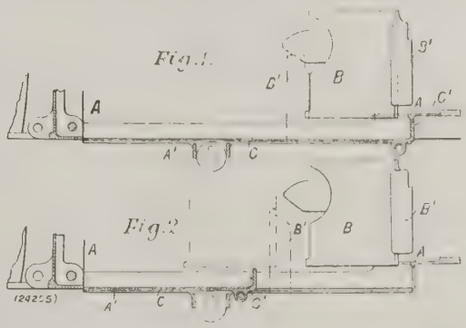
17,204/11. F. H. Royce and Rolls-Royce, Limited, Derby. Internal-Combustion Engines. [3 *Figs.*] July 27, 1911.—In high-tension distributors for electric-ignition systems for internal-combustion engines, the ends of the contact-pieces between which the current passes are formed, in accordance with this invention, of pieces of platinum wire, one piece being arranged so that it lies parallel to, or approximately parallel to, the axis of the distributor, and the other so that it lies at right angles, or approximately at right angles, to the first piece. The ring forming the body of the distributor is constructed of non-conducting material, and carries terminals, to which the



leads of the sparking-plugs are connected, and contact-pieces C, the terminals and contact-pieces being equally spaced around the circumference of the ring. The contact-pieces C each consist of a rod of conducting material, the sparking end of which carries a piece of platinum wire E. The revolving contact consists of a central part P of non-conducting material driven by gearing from the crank-shaft of the engine and of a T-headed contact-piece R, the head r of which is the arc of a circle whose centre is the axis about which the part P revolves. The contact wire S is embedded in the head of the T-piece R in a similar manner to the wire E in the contact-piece C. (*Accepted November* 1, 1911.)

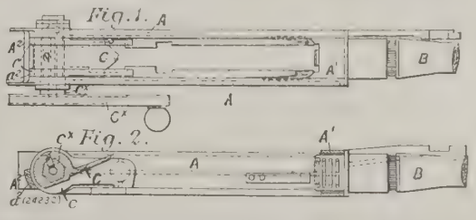
GUNS AND EXPLOSIVES.

24,255/10. Sir A. T. Dawson and G. T. Buckham, London. Automatic Guns. [4 *Figs.*] October 19, 1910.—This invention relates to automatic guns and has particular reference to the shutter for closing the aperture in the bottom of the mechanism casing through which the empty cartridge-cases pass. According to this invention, the shutter is so constructed that when in its closed position the gun cannot be loaded, thereby preventing the gun from being fired with the aperture closed. For this purpose, the shutter is manually operated, and when in its closed position will arrest the downward movement of the cartridge-carrier and thereby prevent the gun from being loaded. A is the mechanism casing, B the lock-casing, and B^1 the cartridge carrier. C is the shutter. The base of the mechanism casing is provided with a bottom plate A^1, formed with an aperture of substantial length



and width beneath the lock-casing when in its advanced position. The forward part of the mechanism casing is formed with the usual ejection opening. The shutter C is in the form of a plate slidable in longitudinal grooves in the plate A^1, and the forward end thereof is furnished with a vertical projection C^1 which, when the plate covers the aperture in the bottom plate A^1, will close the ejection opening. The shutter C is provided with a catch for retaining it in its closed and open positions. If, when the shutter C is in its closed position, an attempt is made to load the gun, the lower part of the cartridge-carrier B^1 will come into contact therewith and its downward movement will be arrested. When, however, the shutter is moved rearwardly to its fully open position, the cartridge-carrier B^1 can complete its descent and the gun can be loaded by reason of the lock-casing B being free to move in the ordinary manner. (*Accepted October* 25, 1911.)

24,232/10. Sir A. T. Dawson and G. T. Buckham, London. Automatic Guns. [6 *Figs.*] October 19, 1910.—This invention has particular reference to those Maxim guns of rifle calibre in which the recoiling plates are connected together at their forward and rear ends by cross-connecting members to form a solid recoiling guide, the forward of the members being

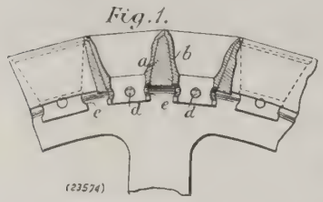


connected to the barrel. According to this invention, the rear connecting member is in the form of a segmental bridge-piece, whose inner surface is an arc struck at such a radius from the crank axis as to conform to the diameter of the boss of the crank. A, A are the recoiling plates, B is the barrel, C the crank. A^1, A^2 are cross-connecting members. The rear connecting member A^2 is in the form of a segmental bridge-piece, whose inner surface a^2

is an arc struck at such a radius from the crank axis as to conform to the diameter of the boss c of the crank C, so that the thrust due to recoil is taken up by the bridge-piece. The crank is shown as provided with a hexagonal hole for the reception of the journal c^*, which may be solid with the crank-handle C*. (*Accepted October* 25, 1911.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

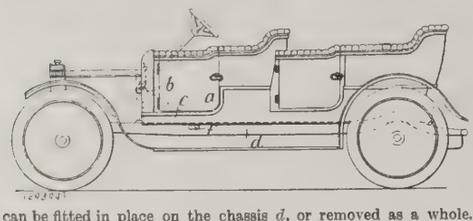
23,574/10. F. Humphris, Eastleigh. Toothed Gearing. [10 *Figs.*] October 11, 1910.—This invention relates to toothed gearing of the kind wherein cup-shaped recesses on one member are engaged by correspondingly shaped teeth on the other member, and wherein each of the recesses is provided with a removable cup or sleeve. According to this invention, each recess is provided with a liner presenting the requisite wearing surface, and projecting through the rim of the wheel and adapted to be secured at the inner periphery thereof. The rim a of the



wheel is bored with sockets for the reception of the liners b, each socket being flared towards the outer periphery of the rim, and being circular in cross-section throughout its radial depth. Each liner b consists of a cup of hard and wear-resisting material, and fits into its socket, its inner surface being shaped to present the configuration necessary for engagement with a tooth on the other member of the gearing. Each liner b is secured within its socket by a cotter-pin d, which passes through holes e in the inner end of the liner. (*Accepted October* 25, 1911.)

MOTOR ROAD VEHICLES.

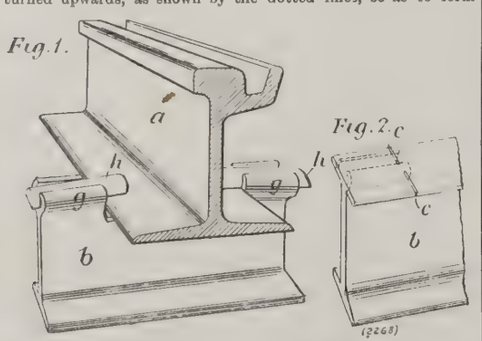
24,344/10. The Daimler Motor Company (1904), Limited, and F. M. Charles, Coventry, Automobile Vehicles. [2 *Figs.*] October 20, 1910.—The present invention consists broadly in a vehicle body formed in one with the dashboard, the whole being flexibly supported on the chassis frame. In the type of car having a door a on each side of the driver's seat, the car-body is connected to the dashboard b by side-pieces c, thus forming a self-contained body with doors complete, which



can be fitted in place on the chassis d, or removed as a whole. The body is pivotally connected to the rear part of the frame; the body and dashboard may thus together be tilted about the pivot for inspection purposes by means of the usual body-lifter. The front part of the body, instead of being rigidly bolted to the chassis frame, merely rests on the latter, with the interposition of resilient devices, such as rubber buffers f. (*Accepted October* 25, 1911.)

RAILWAYS AND TRAMWAYS.

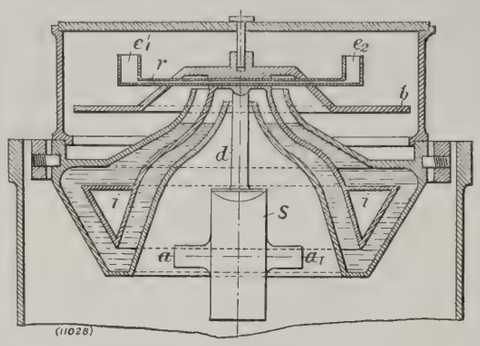
2268/11. Thomas Green and Son, Limited, and E. Rhodes, Leeds. Anchoring Tramway Rails. [2 *Figs.*] January 30, 1911.—An anchoring device for tramway rails, according to this invention, comprises sockets formed on the anchor girder at right angles to the line of the tramway rail, and wedges adapted to be driven into such sockets so as to bear down on the upper side of the bottom flange of the tramway rail. a is the tramway rail, and b the short length of anchor girder. Saw-cuts c (Fig. 2) are made on both sides in the top flange of the anchor girder, at equal distances from the ends. The portions of the top flange between the saw-cuts and the ends of the girder are turned upwards, as shown by the dotted lines, so as to form



sockets g (Fig. 1). The inner section of these sockets is dovetail or semicircular, to correspond approximately with the section of the wedges h, which are made of half-round bars. The width between the inner ends of the socket—that is, between the saw-cuts c—is slightly greater than the width of the bottom flange of the tramway rail, so that this flange can be readily dropped into place between the sockets, or lifted out, without having to move the tramway rail sideways, whilst this bottom flange has the full width of the top flange of the anchor girder between the saw-cuts c to rest upon. The flat underside of the wedges rest and press tightly on the upper side of the bottom flange of the tramway rail. (*Accepted October* 25, 1911.)

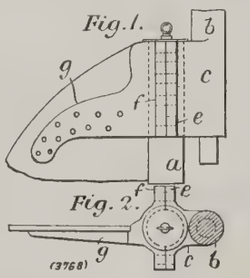
SHIPS AND NAUTICAL APPLIANCES.

11,028/11. Firm Anschutz and Co., Neumuhlen, Germany. Gyroscopic Compasses. [1 *Fig.*] June 11, 1910.—This invention relates to a gyroscopic compass in which the axis of the gyroscope is fixed by gravity in the horizontal plane, and therefore makes oscillations about the N.S. direction. Simultaneously with these oscillations in the horizontal plane, the axis makes small oscillations in the vertical plane. The invention comprises a device for damping these oscillations by work performed by the gyroscope during the vertical oscillations. To that end, on the movable system of the gyroscopic compass, in the N.S. direction, are arranged two vessels containing a liquid and connected by a capillary tube of a given time of passage. During the oscillation of the gyroscopic axis, differences of level are produced in the two vessels. Consequently liquid is forced from one vessel into the other, and the energy required for the purpose, which, during the passage through the narrow cross-section of the tube, is converted into heat, must be supplied by the oscillating spindle of the gyroscope. For that reason, the amplitudes of oscillation decrease to a corresponding extent. The narrow cross-section of tube produces a considerable lag between the oscillations of the axis of the gyroscope, and the equalisation of the liquid, and that is of paramount importance. The required



retarded movement of the masses, instead of being produced by a liquid, could also be brought about by a ball or a pendulum, which has to overcome a resistance in the path of its movements. The most favourable case is a time movement corresponding to about one-quarter of the time of oscillation of the compass. The drawing represents a cross-section through a gyroscopic compass. s is the gyroscopic casing, in which the gyroscope must be imagined to be mounted about the spindle a, a^1. The float i carries the whole compass system. To the card b are secured two communicating vessels e^1 and e^2. The connecting tube r is of narrow cross-section. The vessels are filled with liquid—for instance, mercury—and are rigidly connected by means of a part d to the bearings of the gyroscope, and therefore when the compass oscillates, energy is given off by the gyroscope to the liquid, and then converted into heat in the tube r. (*Accepted October* 25, 1911.)

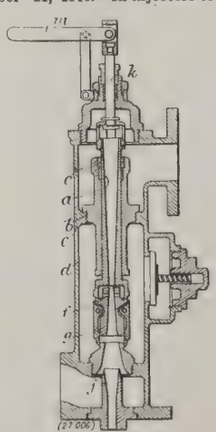
3768/11. R. S. Bagnall and Sons, Limited, and C. L. Bagnall, Sunderland. Ships' Rudders. [6 *Figs.*] February 14, 1911.—This invention relates to ships' rudders of that class in which the rudder-post and stock are made in separate parts detachably connected together, and refers particularly to means for connecting the rudder-post to the rudder-stock, the means comprising, according to this invention, the formation of the cross-stay on the rudder and the top gudgeon on the stock, each to half encircle the rudder-post, and the provision of vertical flanges on both the stay and gudgeon connected by bolts. The



upper end of the post a projects above the lower end of the rudder-stock b, and part of the coupling for connecting the post and stock together forms the top gudgeon c of the rudder. The gudgeon may be in one piece with the stock as shown, or shrunk thereon, or otherwise fixed on it. The top gudgeon extends laterally to the rudder-post, and is flanged as at e and shaped to half encircle it. The gudgeon is bolted to the inner end of the upper cross-stay g of the rudder, which is correspondingly flanged at f and shaped to half encircle the stock. In the top of the post an eye-bolt is screwed for lifting purposes. (*Accepted October* 25, 1911.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

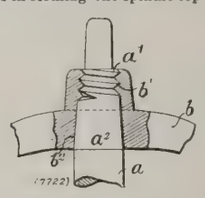
27,006/10. H. E. Gresham, Salford. Injectors. [5 *Figs.*] November 21, 1910.—In injectors of the type adapted



for lifting and forcing purposes, and having a sliding nozzle extending into the overflow and delivery chambers, and automatic opening and closing overflow means in the combining nozzle adjacent to the lifting and forcing steam nozzle or nozzles, means, according to this invention, extend through the delivery chamber for positively operating the sliding nozzle and causing the same to be clear of, or abut upon, the combining nozzle for lifting and forcing purposes respectively. The nozzle a slides through a sleeve b secured in the wall c separating the overflow chamber d from the injector delivery chamber e, the inlet end of the nozzle a being adapted to abut against the end of the combining and delivery nozzles. Further overflow gaps may be provided in the end of the combining nozzle which passes within the cylinder-like extension on the end of the delivery nozzle. The combining nozzle also has overflow apertures, closed by hanging valves g, at a point adjacent to the steam-inlet nozzle j, which serves both for lifting and forcing purposes. To positively move the delivery nozzle a, a spindle k is provided; this spindle extends through a stuffing-box in the end wall of the delivery chamber e, and is detachably secured to the delivery nozzle. The outer end of the spindle is pivotally attached to one end of a lever m, by actuation of which the delivery nozzle a can be moved away from the combining nozzle f so as to allow a very large area for the escape of the steam from the steam-nozzle j for water-lifting purposes. When the injector is working normally, the pressure in the delivery chamber e acts upon the sliding delivery nozzle a and forces the cylinder-like extension of the latter into engagement with the combining nozzle, so closing the outlet from the overflow gap or gaps at that point. (*Accepted October* 25, 1911.)

TEXTILE MACHINERY.

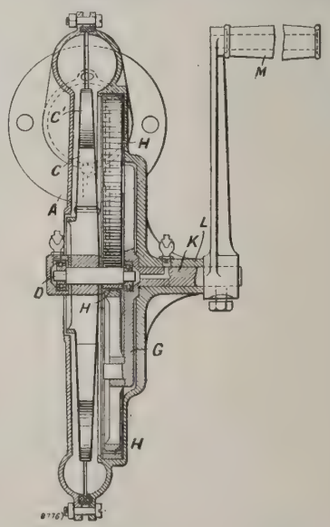
7722/11. Jonathan Hattersley and Son, Limited, H. Petersen, and J. Lee, Leeds. Spinning-Frames. [5 *Figs.*] March 28, 1911.—The invention relates to spinning-frames, and has for object to further facilitate the securing and detaching of the flyer to and from the spindle. To this end, the invention consists in forming the spindle top and flyer-head each



with a screw-thread of V or triangular section, or of "wire" or rounded section, of only two convolutions or thereabouts, commencing below the spindle-nose and top of the flyer-head respectively, and extending a short way down these parts, which at their lower sections are formed with long conical seatings. a is the spindle, b the flyer, a^1, b^1 the screw-threads, and a^2, b^2 the conical seatings. (*Accepted October* 25, 1911.)

MISCELLANEOUS.

8776/11. J. Keith and C. Tuson, London. Centrifugal Fans. [2 *Figs.*] April 8, 1911.—Centrifugal fans for use where a small volume of air at a moderate pressure is required, and only hand-power is available, consist of the arrangement or combination of parts now to be described. The volute fan casing A is made in two parts, joined together by bolts and nuts, with packing interposed. C is the fan runner having curved blades C^1; the runner is of comparatively large diameter and narrow width, and is secured to a spindle D mounted in ball-bearings arranged in the casing A and in a rotatable crank member G. The casing A is grooved to receive resilient friction-rings H which are interposed between the casing and the fan spindle D, and are made of a diameter slightly greater than the distance



between the bottom of the groove and the periphery of the spindle, so that when the rings are in place they engage and transmit motion to the spindle D. The rings H are driven by means of wheels mounted on pins on the crank member G, which member may be formed integral with a spindle K coaxial with the spindle D, and rotatably mounted in a bearing L on the casing A, the spindle K having secured to it an operating handle M. The arrangement described permits a very high gear ratio to be obtained, and when such gear is used in conjunction with a narrow fan of comparatively large diameter, it is possible to obtain a suitable blast for the purposes mentioned. The resilient friction-rings are self-adjusting and take up any wear, thus dispensing with the necessity for employing adjusting gear. (*Accepted November* 1, 1911.)

Still Larger Cars.—The Pennsylvania Railroad Company has designed a new freight-car, 52 ft. long and of 80 tons capacity, for the handling of certain kinds of steel products, such as pipes and tubes, which are made in lengths longer than an ordinary freight-car, so that in shipment they have to be loaded across two cars. The company proposes to order 200 cars of the new type.

THE STEAM-TURBINE.

(*Concluded from page* 786.)

IN concluding this series of articles reference may be made to a certain semi-empirical formula, by which the principle proportions of a compound steam-turbine of any type may be determined with great ease and rapidity. The formula was first made public by Mr. E. M. Speakman in a paper read before the Institution of Engineers and Shipbuilders in Scotland in 1905 (see ENGINEERING, December 8, 1905, page 761). The use of the formula was explained in somewhat greater detail in our issue of December 13, 1907.

It is based on the hypothesis, which is nearly true, that two similar turbines will have same efficiencies if the value of $N s^2$ is the same for each. Here N denotes the number of moving rows of blades, whilst s stands for the blade speed measured in feet per second. In marine work the constant, to which this product is made equal, is often about 1,500,000, but it is generally much higher in the case of turbo-electric generators. For many purposes the formula is more conveniently written in the form

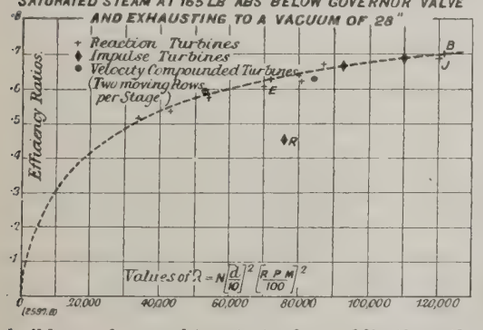
$$N \cdot \left(\frac{d}{10}\right)^2 \cdot \left(\frac{\text{R.P.M.}}{100}\right)^2 = \lambda,$$

where N, as before, denotes the number of moving rows of blades, d the diameter of the blade path in inches, and R.P.M. the revolutions per minute. For reaction turbines d is often taken as the diameter of the high-pressure drum. With the formula expressed as above, the value of λ ranges from 60,000 up to 180,000 or over, though so far as our information goes it has never yet reached a value of 200,000. Within certain limits the efficiency of a turbine is higher the higher the value of λ, but for a stated number of revolutions the cost also increases with λ and at a much more rapid rate than the efficiency.

In Fig. 36 the relation between the efficiency ratio of a turbine and the value of λ has been plotted as a curve. Most of the experimental points for the reaction turbine have been deduced from the progressive trials of a very large and very efficient set of marine turbines. The point marked J refers, however, to a large 6000-kw. electric-lighting unit, and that marked E to the famous Elberfeld turbine. The point B represents the results obtained with a 1500-kilowatt unit. This was remarkably efficient, considering the size of the machine, and the plotted point indicates that if worked with the high superheats used by Continental turbine-

Fig. 36.

EFFICIENCY RATIOS FOR DIFFERENT TURBINES TAKING DRY SATURATED STEAM AT 165 LB ABS BELOW GOVERNOR VALVE AND EXHAUSTING TO A VACUUM OF 28"



builders when making tests for publication, the machine would have attained nearly record results. In all the cases plotted, the "over-all" figure has been corrected for the generator losses. The two impulse turbines, for which the corresponding points fall on the curve, are both 6000-kw. units of the same type, but sold under different names. The point marked R represents the results attained with a 150-kw. impulse machine of rather an old pattern. It could, no doubt, be bettered now. The points given for the velocity-compounded turbines are based on guarantees, and are not the results of actual tests. The one with the higher efficiency is a 4000-kw. unit, whilst the other is a small 400-kw. set. The most notable feature about the curve is, perhaps, the remarkable way in which with turbines of all types the same value of λ gives about the same efficiency.

It has, however, to be observed that in the case of the velocity-compounded wheel it is probable that any further considerable increase in the value of λ would probably result in a diminution of efficiency, and to a lesser degree the same may, perhaps, be the case with the impulse type, whilst the efficiency of the reaction machine would continue to increase for values of λ much beyond the limits of the diagram.

In applying the curve to practice there is a "size" factor to be taken into account. With small machines a reasonable efficiency seems to be more easily attained with velocity-compounded turbines than with rival types. The importance of this size factor is well shown by the fact that with a small reaction turbine a value of λ equal to 180,000 gave only 0.63 efficiency ratio when reduced to the standard of Fig. 36. This machine had, however, very large tip clearances. Similarly, the point for the 150-kw. impulse unit is very much below the normal for larger machines.

All the results plotted in Fig. 36 have been reduced to the same standard conditions, the steam below the governor-valve being taken as dry saturated, and its pressure as 165 lb. absolute, whilst the condenser pressure is equivalent to a 28-in. vacuum. If the steam were superheated, the efficiency ratio would be increased, a point which should always be borne in mind in making comparisons between turbine tests. It is sometimes stated that the difficulty of securing a high efficiency ratio is greater, the greater the available heat, but the very reverse is the case, if the increase in the available heat is obtained by superheating. Turbines of all types seem to have practically the same superheat corrections, so that all can easily be reduced to the standard of dry saturated steam.

High vacua, on the other hand, generally lower the efficiency ratios, though they diminish the consumption per kilowatt-hour. The vacuum correction is, however, not the same for all turbines, since, if a firm cares to try for a record, regardless of commercial considerations, the low-pressure end of the turbine can be built with a view to utilising very high vacua with good efficiency. For ordinary commercial practice, however, the correction curves given in Fig. 22, page 661 *ante*, may be taken as pretty generally applicable, but in tests of importance the true vacuum correction should be determined by direct tests of the turbine.

The method used in reducing to standard conditions the various tests plotted in Fig. 36 was to reduce the actual test figures to the case of dry saturated steam at the same pressure by means of the curves in Fig. 22 *ante*. A correction to the pressure of 165 lb. absolute was then made, by assuming (what is substantially true) that with a given turbine the efficiency ratio is constant for a given pressure ratio. Thus, if in a trial the observed pressure was 185 lb. absolute and the back pressure 1 lb. absolute, the back pressure which would give the same efficiency ratio with an initial pressure of 165 lb. absolute is $\frac{165}{185} \times 1 = 0.892$ lb. absolute. The consumption under these conditions can then be calculated, and finally corrected to a 28-in. vacuum, for which the curve, Fig. 37 (taken from

EFFECT OF VACUUM UPON STEAM CONSUMPTION OF STEAM-TURBINE OF 1000 K.W. TURBO-GENERATOR.

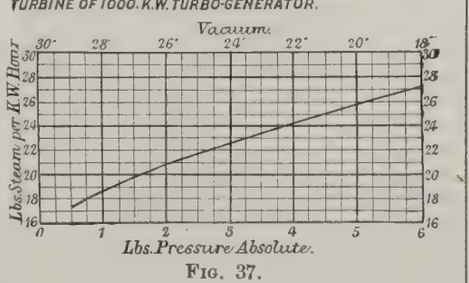


FIG. 37.

Sir C. A. Parsons' paper before the Institution of Naval Architects, April 9, 1908), was used for points outside the limits of Fig. 22, page 661 *ante*.

The use of the coefficient λ can be illustrated as follows:—Suppose it is required to design a reaction turbine to have an efficiency ratio under the standard conditions of about 68 per cent. This will require, the curve shows, a value of λ of about 100,000. In practice the value of $\frac{d}{10} \cdot \frac{\text{R.P.M.}}{100}$ for the high-pressure end ranges from 18 to 29, the latter corresponding to a drum speed of about 127 ft. per second, and the lower figure to one of 78.6 ft. per second.

The highest blade speed is commonly associated with the highest value of λ. For electric-light turbines $\frac{d}{10} \cdot \frac{\text{R.P.M.}}{100}$ is often about 27, and if we take this value we get

$$N \times 27^2 = 100{,}000.$$

Whence

$$N = 138.$$

If we decide to construct the turbine of twelve groups with a common rate of $\sqrt{2}$, this value of N must be increased to 144, or lowered to 132, so as to get a number divisable by 12, making λ equal to 104,300 in the first case, and to 95,800 in the second.

If we accept the first alternative, we will have twelve moving rows per group, or twenty-four stages, reckoning each row of blades, whether fixed or moving, as a stage.

In order to keep down the length of the turbine and the length of the low-pressure blades, it is usual to build an electric-lighting turbine in three sections—viz., a high-pressure, an intermediate, and a low-pressure section, the former doing each one-fourth of the total work, whilst the low-pressure section is accountable for the remainder. Since the whole turbine is to consist of twelve groups, the high-pressure and intermediate sections will each consist of three groups, and the low-pressure section of six. Further, the respective drum diameters are commonly made in the ratios of $1 : \sqrt{2} : 2$. The number of rows in each group is made inversely proportional to the squares of these ratios, so that the high-pressure end will consist of three groups having each twelve rows of moving blades, the intermediate of three groups having each six rows of moving blades, and the low-pressure of six groups having each three rows of moving blades. The steam speed at entrance to the first row of the intermediate section is taken to be $\sqrt{2}$ times of what it was at the entrance to the high-pressure end, whilst the corresponding figure for the low-pressure end is 2. Hence the blade height at entrance to the intermediate section is made equal to the blade height at the second group of the high-pressure section, and the blade height at entrance to the low-pressure section is equal to the blade height of the third group of the high-pressure section.

It only remains to find the height of the first row of blades at the entrance to the high-pressure section. This will, of course, depend upon the output of the turbine and the revolutions specified. Assuming this is to be 2000 kw. at 1500 revolutions per minute, we have since

$$\frac{d}{10} \cdot \frac{\text{R.P.M.}}{100} = 27. \quad d = 18 \text{ in.}$$

The efficiency ratio being about 0.68, and the available heat about 320, the consumption under the standard conditions will be about 15.6 lb. per kilowatt measured at the turbine shaft, or about $16\frac{3}{4}$ lb. at the switchboard.

Of this amount about 8.5 per cent. may be taken as flowing through the high-pressure dummy, so that about 15.5 lb. per kilowatt-hour will pass through the high-pressure blading. From Table I., on page 245 *ante*, the velocity of flow will be about 217 ft. per second. The volume of steam passed per second is $\frac{2000 \times 15.5 \times 2.757}{3600} = 23.7$ cub. ft.; so that the area needed will be $\frac{23.7 \times 144}{217} = 15.74$ sq. in.

If, allowing for tip clearance, we take the effective area as one-third the annulus, the annular area required is 47.22 sq. in. The standard blade height most nearly corresponding to this is $\frac{7}{8}$ in., giving an area about 10 per cent. greater than is needed. This may be adjusted in several ways if desired. The number of rows of blades, for instance, may be increased by 20 per cent., making $\lambda = 125{,}000$, with a corresponding increase in efficiency, but involving a considerable increase in the length of the turbine. We may alternatively make the diameter 17 in.; then a blade height of $\frac{7}{8}$ in. will be about right. This would reduce the value of λ to 96,500. Actually we shall rely on the by-pass valve, and use $\frac{3}{4}$ in. blades on $18\frac{1}{4}$ in. diameter, shouldering up the drum by this amount, so as to maintain the end balance when the by-pass opens. The make-up of the turbine thus becomes as shown in the first three lines of Table X., page 852.

Some writers, in applying rules similar to the foregoing, calculate the speed of the steam into the first row of blades at the high-pressure end

TABLE X.—PROPOSED 2000-KW. TURBINE FOR DRIVING ELECTRIC GENERATOR; DESIGNED INITIAL PRESSURE AT FIRST ROW, 165 LB. ABSOLUTE; REVOLUTIONS, 1500 PER MINUTE.

	High-Pressure Section. Weight through Blades = 8.39 Lb. per Second.			Intermediate Section. Weight through Blades, 8.82 Lb. per Second.			Low-Pressure Section. Weight through Blades, 9 Lb. per Second.					
Group No.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Drum diameter ... in.	18½	18	18	25½	25½	25½	36	36	36	36	36	36
2. Number of moving rows per group	12	12	12	6	6	6	3	3	3	3	3	3
3. Blade height h ... in.	¾	1	1½	1	1½	2½	1½	2½	3	4½	6	6*
4. Clearance c ... "	0.020	0.020	0.020	0.025	0.025	0.030	0.050	0.060	0.060	0.070	0.080	0.080
5. $h - c$ ...	0.730	0.980	1.480	0.975	1.475	2.095	1.450	2.065	2.940	4.180	5.920	5.920
6. $h + \sigma c$ ...	0.793	1.043	1.543	1.054	1.554	2.190	1.607	2.254	3.129	4.406	6.171	6.128
7. Net area through blades Ω † ... sq. ft.	0.1033	0.1360	0.2062	0.1917	0.2375	0.4150	0.4135	0.5860	0.8375	1.201	1.775	2.865
8. Pressure on discharge from group p_N ... lb. per sq. in.	172.2	124.0	86.10	42.22	29.10	20.40	14.21	9.65	6.35	3.908	2.381	1.470
9. Volume " " " V_N ... cub. ft. per lb.	*3.628*‡	5.012	6.612	9.600	13.29	18.32	25.33	35.94	52.60	82.6	127.0	200.0
10. Velocity " " " v_N ... ft. per sec.	294.0	309.0	279.0	442.0	407 5	389.2	551.0	552.0	564.5	616.0	643.0	620.0
11. $p_N V_N$ ...	449.5	431.8	416.0	405.5	386.8	373.5	360.0	346.8	334.0	321.3	302.8	294.0
12. Mean blade speed s ... ft. per sec.	124.2	124.2	127.6	173.6	176.6	180.9	245.2	249.4	251.2	263.6	275.0	275.0
13. $\delta = \frac{s}{v_N}$ ...	0.42	0.39	0.45	0.39	0.43	0.46	0.44	0.45	0.45	0.43	0.43	0.44
14. $x = \frac{\text{pressure at entrance to group}}{p_N}$ ...	1.390	1.440	1.370	1.490	1.450	1.425	1.435	1.475	1.520	1.625	1.640	1.620
15. B (from Fig. 21, page 661 *ante*) ...	0.851	0.830	0.860	0.812	0 835	0.840	0.830	0.825	0.815	0.788	0.778	0.788
16. $N + 1.05 \log x$ ...	24.14	24.15	24.14	12.18	12.17	12.16	6.17	6.18	6.19	6.22	6.225	6.22
17. v_N B cos α $(N + 1.05 \log x)$ ...	5735.0	5880.0	5500.0	4150.0	3960.0	3776.0	2681.0	2673.0	2700.0	2865.0	2960.0	2635.0
18. $\frac{N s}{2}$ ...	1490.4	1490.4	1531.2	1041.6	1059.6	1085.4	735.6	748.2	753.6	790.8	825.0	825.0
19. Q = line 17 − line 18 ...	4244.6	4389.6	3968.8	3108.4	2900.4	2690.6	1945.4	1924.8	1946.4	2074.2	2035.0	1810.0
20. Work done per lb. $= \frac{h - c}{h + \sigma c} \cdot \frac{s}{32.2}$ Q ft. lb. ...	15,070	16,410	15,090	15,500	15,100	13,850	14,800	14,070	14,270	16,180	15,960	14,930
21. " " " ... B.Th.U.	19.36	21.09	19.40	19.95	19.40	17.80	19.05	18.10	18.35	20.80	20.52	19.40
22. Total heat in 1 lb. of steam on discharge ... "	*1189.26*‡	1168.17	1148.77	1128.82	1109.42	1091.62	1072.57	1054.47	1036.12	1015.32	994.8	975.4
23. Sensible " " " " " ... "	314.40	286.59	265.0	239.61	217.59	197.90	179.20	160.27	141.19	120.4	101.0	83.36
24. Actual latent " " " " " ... "	*874.86*‡	881.58	883.77	889.21	891.83	893.72	893.37	894.20	894.93	894.92	893.8	892.0
25. Latent heat of dry steam at same pressure ... "	871.9	891.54	906.67	924.38	939.8	953.4	966.5	979.73	993.02	1007.6	1021.0	1033.4
26. Volume of " " " " cub. ft. per lb.	3.599	5.067	6.790	9.865	14.00	19.54	27.40	39.39	58.38	92.39	147.0	231.7

* Semi-wing blades. † Ω = mean circumference × $(h + \sigma c)$ × sin $\alpha \div 144$. ‡ Superheated steam.

from the total heat available between the initial pressure and the exhaust. They assume that this velocity of inflow is directly proportional to the square root of the available heat, but this is incorrect unless the turbine is specially designed for the particular value assumed for the available heat. In fact, an increase of vacuum from 27 in. to 29 in. will increase the total heat of the steam by nearly 17 per cent., and on the hypothesis in question such a change in the vacuum should increase the speed into the first row of the turbine by about 8½ per cent. Actually there is no measurable change of speed accompanying such an alteration in the vacuum. However the latter changes, the speed of inflow into the first row of the turbine is unaltered, and the same remark is nearly true when the initial pressure of supply is altered. Reducing the steam pressure in front of the first row of blades from 160 lb. down to 40 lb. hardly affects the velocity of inflow into the first row of the turbine.

Having obtained the general proportions of the turbine, a detailed analysis of it may be made by means of the curves in Figs. 18 to 21, page 661 *ante*.* The whole calculation is shown in Table X., above. A 10-in. slide-rule has been used for effecting the various multiplications and divisions involved, and each individual result may therefore be slightly in error. Owing to the fact that computation is started at the exhaust end, any such error in an individual result tends to be eliminated in making the next calculation. Thus, if the value of x (line 14) for group 5, say, is too high, through a slight arithmetical error, this means that the value of p_N for group 4 will also be too high, and hence the volume V_N for group 4 will be too small. In that case the velocity of flow will be too small, and the value of x found for group 4 will be smaller than it should be, thus compensating for the too high value taken for group 5. Where the calculations are made the other way about, starting at the high-pressure end, the reverse of this would be the case. Any error then made would be increased on making the calculation for the succeeding group, and thus be multiplied again and again all the way down the turbine.

The flow of steam through the low-pressure blading was taken as 9 lb. per second. Calculation gave the low-pressure dummy leakage as 0.21 lb. per second, that of the intermediate dummy as 0.39 lb. per second, whilst the high-pressure dummy passed 0.82 lb. per second. Hence 8.39 lb. per second pass through the high-pressure blading, and 8.82 lb. through the intermediate blading. The process of calculation was explained in detail on page 661 *ante*, and need not be repeated here.

The final result is that to get the assumed flow under the conditions premised at the exhaust end, the initial pressure should have been 172.2 lb. absolute ($x\,p_N = 1.39 \times 124.2$) at a superheat of 25 deg. Fahr. The work done in the high-pressure section is 19.36 + 21.09 + 19.40 = 59.85 B.Th.U. per pound of steam passing through the blade, which is equivalent to $\frac{59.85 \times 8.39}{9.21} = 55.1$ B.Th.U. per pound of total steam. In the intermediate blading the work done was equivalent to 54.65 B.Th.U. per pound of total steam, the corresponding figure for the low-pressure section being 113.80, making a grand total of 223.55 B.Th.U. per pound of total steam. Hence the consumption per "indicated" kilowatt is $\frac{3412}{223.6} = 15.25$ lb. As the total weight passed is 9.21 lb. per second, the indicated capacity of the machine is $\frac{9.21 \times 3600}{15.25} = 2180$ kw., which, with a 28-in. instead of a 27-in. vacuum would be increased to about 2280 kw.

If the generator efficiency is taken as 94 per cent., and the mechanical efficiency of the turbine as 97 per cent., the consumption per kilowatt at the switchboard will be 16.75 lb. per kilowatt. The equivalent consumption of dry steam at the same initial pressure will be 17.18 lb. per kilowatt.

The designed initial pressure is, however, 165 lb., and not 172 2 lb. Hence to get the same efficiency with steam at this lower initial pressure, the pressure at discharge must be diminished from 3 in. of mercury to $\frac{3 \text{ in.} \times 165}{172.2} = 2.875$, equivalent to a vacuum in the exhaust-pipe of 27.125 in. A vacuum of 28 in. in the condenser corresponds at full load to one of about 27.9 in the exhaust-pipe. Correcting the vacuum to this figure by the curve given in Fig. 22, page 661 *ante*, the consumption will be 16.52 lb. per kilowatt. Taking gland leakage as 600 lb. per hour, the total will be increased to about 16.8 lb. per kw. measured at the switchboard, giving an over-all efficiency $\frac{\text{steam}}{\text{electric}}$ of 63.2 per cent. With a generator efficiency of 94 per cent., the efficiency ratio (turbine only) becomes 67.2 per cent., which agrees very well with the curve, Fig. 36, page 851.

As will be remembered, our preliminary calculation indicated that the height of blading adopted would be on the small side, and the results of the analysis made in Table X. above shows that, with steam at 165 lb. per sq. in. (absolute) before the first row of blades, the turbine would only just be about equal to giving the desired 2000 kw. at the switchboard. As has already been stated, with an increasing initial pressure the efficiency of the turbine will be unaltered if the exhaust pressure is raised in the same proportion. On the other hand, however, the output will be increased in the same ratio, so that, with an initial pressure of 185 lb. absolute, the proposed turbine would have a good margin of power available. Again, the by-pass may be used to increase the output by admitting steam direct to the second group, in which case the first rotates idly. The effect of this on the efficiency of the turbine can be ascertained by reference to the curve, Fig. 36, page 851. Cutting out the first group reduces the value of λ by one-twelfth —*i.e.*, from 104,300 to, say, 88,460. The former value on the curve corresponds to an efficiency ratio of about 68 per cent., and the corresponding figure for λ = 95,600 is about 66.7 per cent., so that the consumption per kilowatt under the standard conditions will then be $\frac{16.8 \times 68}{66.7} = 17.2$ lb. per kw. at the switchboard. Under normal conditions the eleven groups now active did about eleven-twelfths of the whole work, and with 165 lb. initial pressure, the pressure in front of the first row of the second group was $\frac{124.2 \times 165}{172.2} = 119$ lb. The output with the by-pass open will therefore be increased approximately in the ratio $\frac{165}{119} \times \frac{11}{12} = 1.27$, or by 27 per cent.

As matters go there is a marked tendency to increase the speed of rotation of electric generator turbines so as to obtain the same output at a lower cost. Such difficulties as arise are mainly due to the generator, since turbines can be built to run at almost any speed. Generators of 2000 kw. capacity have been built to run at 3000 revolutions per minute, and such a speed for 1000-kw. units is now common. If with the same value of λ we make the turbine speed 3000 instead of 1500 revolutions per minute, the diameter at the high-pressure end becomes only 9 in.; but the length of the turbine and number of rows will be the same as before. The stiffness of the rotor is correspondingly diminished, and hence there would be a considerable advantage in replacing the high-pressure end of the turbine by a velocity-compounded wheel to do about one-third the total work.

Taking the blade path of the latter as 42 in. in diameter and the number of moving rows as two per stage, a complete velocity-compounded turbine would consist of three wheels with a total of six rows of moving blades. Hence

$$\lambda = 6 \times \left(\frac{42}{10}\right)^2 \times \left(\frac{3000}{100}\right)^2 = 95{,}700,$$

for which an efficiency ratio under the standard conditions of about 65 per cent. might be expected Actually, owing to loss by disc friction, the efficiency of the first of these wheels would be considerably less, since a 42-in. wheel, with two rows of moving blades, running in steam of 40 lb.

* A misprint occurs in Fig. 19, where for

$$\phi = \left[\frac{v_N}{100}\right] \frac{N + \mu}{P_N V_N}$$

read $\left[\frac{v_N}{100}\right]^2 \times \frac{N + \mu}{P V}$.

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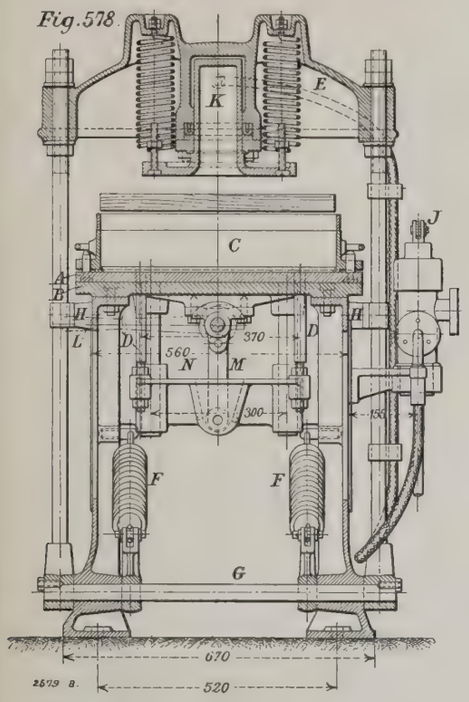
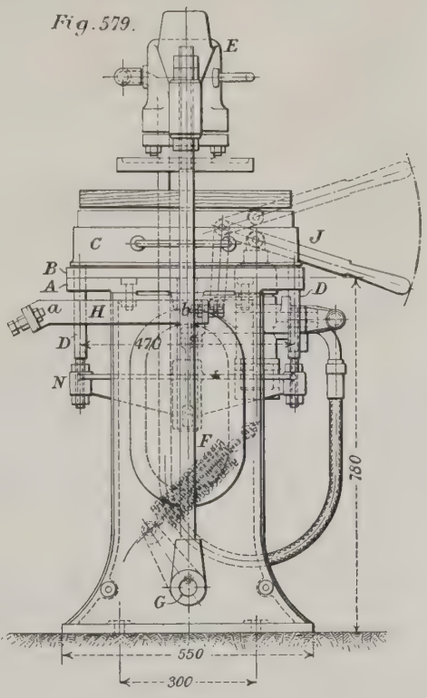




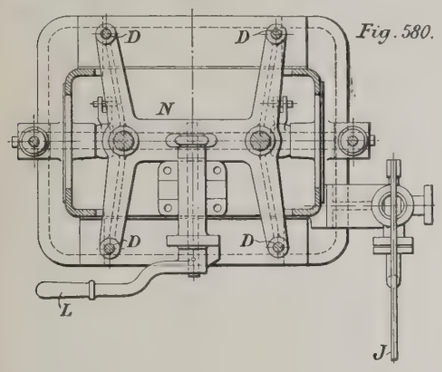


FIG. 578 TO 580. HYDRAULIC MOULDING-MACHINE HAVING THE RAM IN THE PRESSER-HEAD; THE BADISCHE MASCHINENFABRIK UND EISENGIESSEREI, DURLACH.

pressure, absorbs about 40 kw. to 50 kw., so that to bring up the efficiency of a turbine consisting of one velocity-compounded wheel followed by a reaction turbine doing two-thirds of the work, the value of λ for the latter must be increased, say, to 120,000. This is best done by increasing the diameter of the low-pressure end rather than by increasing the number of rows. With a low-pressure end only 18 in. in diameter, 6-in. blades would be much too long, and there would be hardly room to provide for a double-flow exhaust end. About the maximum value of $\frac{d}{10} \cdot \frac{\text{R.P.M.}}{100}$ yet used for this part of the turbine is 81, and if we adopt this we get 27 in. as the diameter of the low-pressure drum. The number of moving rows needed for a complete turbine with $\lambda = 120{,}000$ is 18.3. Hence for two-thirds of the turbine we may use 12 rows, divided into six groups of two moving rows each. Since a complete turbine would comprise nine such groups, the blade height ratio of successive groups may be made equal to $64^{\frac{1}{9}} = 1.59$, and this, speaking roughly, will also be the value of x for the first group. Taking the steam there as at 40½ lb. absolute, with a specific volume of 9.678, the speed of inflow into the group will be given by equation (1), page 246 *ante*, as about 500 ft. per second. This division of the turbine into groups with so high a common ratio of blade height does not tend to economy, but it is worth while adopting in this case, simply as an illustrative example. Calculating in the same way as in Table X., we get the results shown in the Table XI.

For 165 lb. initial pressure, expanding down to 39 lb., the velocity-compounded wheel should be about 37 in. disc diameter, so as to give a blade-speed equal to $\frac{1}{4.5}$ times the steam speed. Using Dr. Lasche's curves given in Fig. 35, page 785 *ante*, it appears that this wheel would convert into work under the best conditions about 67.5 B.Th.U. per pound of steam passed, which for this section may be taken as 9.21 lb. per second. The reaction section as calculated does work equivalent to 143.8 B.Th.U. per pound of steam through the blading, or about 140.2 B.Th.U. per pound of total steam. The sum of these two quantities is 207.7 B.Th.U., so that the consumption per indicated kilowatt with a 26.9 in. vacuum is 16.45 lb. per hour, equivalent to, say, 18.1 lb. at the switchboard. Reduced to a 28 in. vacuum, this is equivalent to about 17.1 lb. per kilowatt-hour at the switchboard, or not quite so good as was obtained with the "straight" reaction turbine in spite of the higher coefficient.

TABLE XI.—*Reaction Portion of 2000-Kw. Combined Turbine. Steam Pressure in Front of First Row of Blades, 39 Lb. per Sq. In. Absolute; Volume, 10.16 Cub. Ft. per Lb.; Drum Diameter, 27 In.; Six Groups with Two Moving Rows per Group; R.P.M. = 3000; 9 Lb. of Steam Passed per Second.*

Group No...	1.	2.	3.	4.	5.	6.
Blade height .. in.	⅜	1⅜	2½	3½	4*	4½†
Clearance .. .. ,,	0.030	0.030	0.040	0.045	0.050	0.050
Work done per pound of steam passing the blades .. B.Th.U.	23.52	24.92	24.25	28.22	19.95	21.72

* Semi-wing blades. † Wing blades.

With 180 lb. to 200 lb. initial pressure a 42-in. wheel could be used, and a better return obtained from this part of the turbine. The deficiency shown is in part due to the use of rather too high a ratio for successive blade heights, and in part to the use of wing blades for the last section, these being relatively inefficient, but practically unavoidable in this case, as longer blades than 4½ in. cannot well be used on a 27-in. drum. Indeed, were it proposed to actually construct the turbine in question, it would be necessary to investigate the safety of these blades under centrifugal forces, and under the bending moment due to the drive and the pressure drop. In some cases where very high speeds and relatively long blades have been used in reaction turbines, the rotor has been built up of a number of solid discs, and the blades have been thickened at the bottom. The latter is an expensive procedure, and could be avoided by using a stronger metal for the blades and making them wider, so as to reduce the bending stresses. There seems no real necessity for using a disc construction for drum speeds of 370 ft. per second or so, since a not unreasonable thickness of drum gives an ample factor of safety. If the blades are not thickened at the root, the stress on the longer ones in the turbine as above proportioned, due to centrifugal action alone, would be of the order of 5300 lb. per sq. in. of section at the root, and in addition they have to take a bending moment there. This moment is due in part to the drive on the blades and in part to the drop of pressure through them.

As stated at the outset, the method of proportioning, based on such a curve as Fig. 36, is semi-empirical, and if accurate results are wanted in the absence of actual test figures of turbines of approximately the same kind and dimensions, the methods of analysis already described in these articles should be employed, and these will sometimes point the way to improvements in blade proportions.

Some firms still "gauge" their blades; that is to say, they do not keep all the rows of a group identical, but increase the discharge angle every few rows, so as to keep the steam velocity approximately constant from row to row. Unless the total number of groups is small, this plan is disadvantageous. The efficiency of a blade is not dependent solely upon the ratio of blade speed to steam speed, but also on the cosine of the angle of discharge. In opening out the space between the blades, what is gained by keeping down the ratio of the steam speed to the blade speed is lost by the corresponding decrease in the cosine of the angle of discharge. Under the usual conditions of working any considerable departure from the usual ratio of width of opening = ⅓ pitch seems to lead to inefficiency. Again, with "gauged" blades of the same height as ungauged blades the amount of energy abstracted per group in the high-pressure and intermediate sections is reduced, thus crowding work on to the wing and semi-wing blades, which are less efficient than the normal type.

FOUNDRY PLANT AND MACHINERY.
No. XXXVI.

By JOSEPH HORNER.

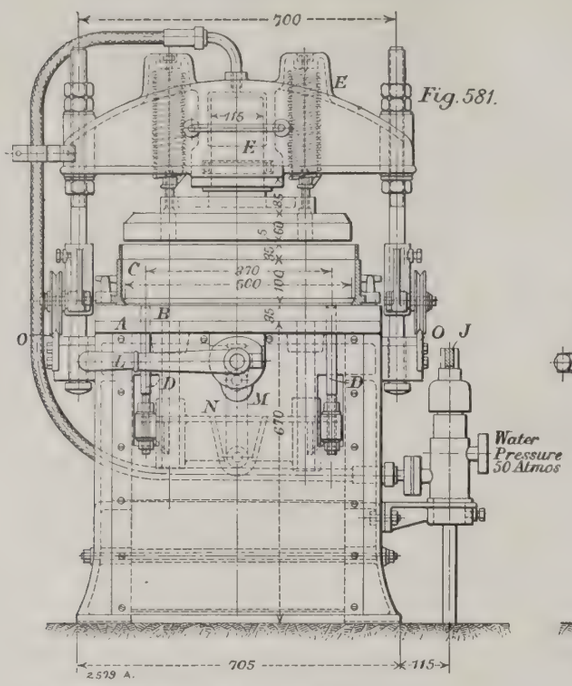
A NOVEL design of machine by the Badische Maschinenfabrik und Eisengiesserei, of Durlach, is shown by Figs. 578 to 580, on the present page. It resembles hand-machines of the same general construction; but, in order to quicken the rate of operation, the hydraulic cylinder is incorporated, being set in the unusual position seen, in the top cross-head. A box measuring 500 mm. square by 90 mm. in depth can be accommodated. The table A is of the non-turnover type, bolted to the uprights of the machine. On the table the pattern-plate B is mounted, receiving the box C with its sand-frame. Copes and drags are rammed separately, though, when a large volume of work is being done, the double machine, Figs. 581 to 583, page 854, on which both copes and drags can be arranged, offers better facilities. The box is lifted off by the studs D, D, of which there are four. The mechanism by which the ramming and lifting are actuated is as follows:—

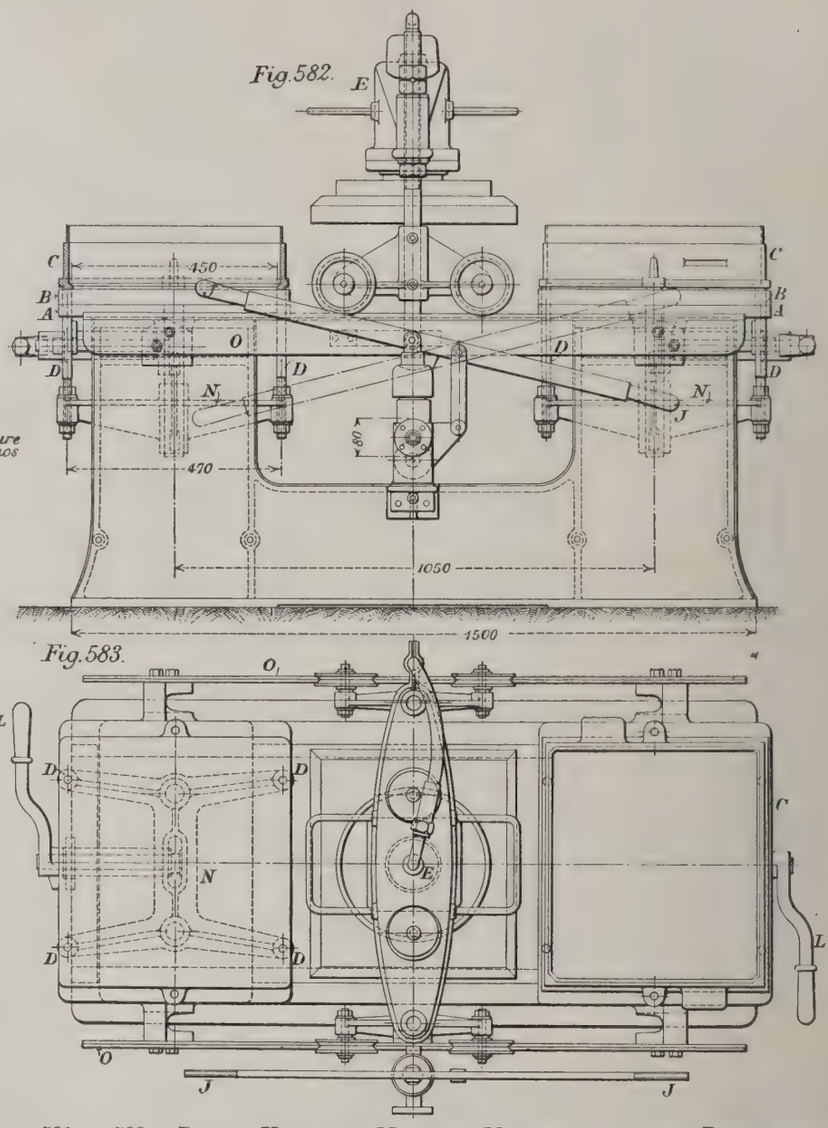
When the box part C is being placed on the pattern-plate and filled with sand, the presser-head E is swung back out of the way by hand. This is rendered easy of accomplishment by the counteraction of the springs F, F attached at one end to levers on the rock-shaft G, and anchored at the other to lugs on the uprights. When the presser-head is swung back, its rods rest against the studs *a* in the ends of the bars H, H attached to the uprights. When brought into the vertical position for pressing, they rest against the studs *b* in the same bars, which studs are adjustable.

When the sand has been filled in level with the top of the sand frame, and the presser-head brought over it, the lever J of the hydraulic valve is opened, by which the ram in the head is actuated. Pressing done, the handle is reversed, and the coiled springs anchored inside the crosshead E pull the ram back instantly out of the way, and the head is then swung back. Flexible metallic tubing is necessary, as shown, to connect to the ram, on account of this swinging movement. The hand-lever L is now lifted, moving a link M which lifts the frame N. This, sliding on pillars attached to the underside of the table A, lifts the studs D D, and delivers the box C from the pattern, thus completing a half mould.

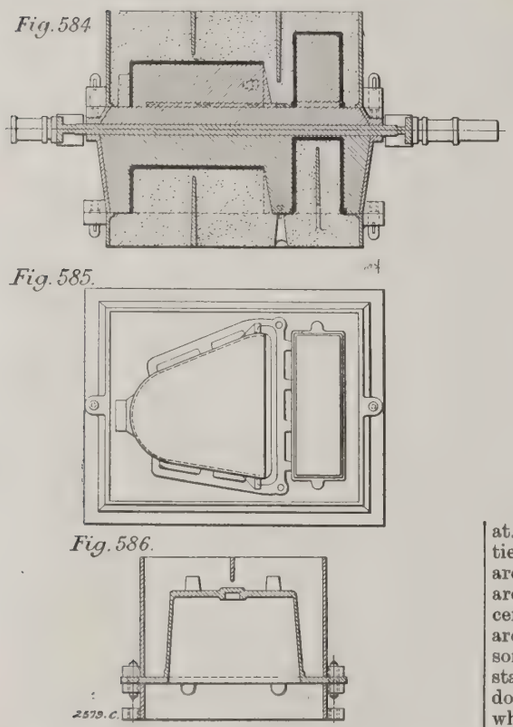
The double machine, shown by Figs. 581 to 583, page 854, is built substantially on the same design, the details of which need not be repeated. The modifications are, that the moulding-boxes are carried

FOUNDRY PLANT AND MACHINERY.





Figs. 581 to 583. Double Hydraulic Moulding-Machine having the Ram in the Presser-Head; The Badische Maschinenfabrik und Eisengiesserei, Durlach.



Figs. 584 to 586. Deep Patterns to Illustrate Difficulties in Ramming.

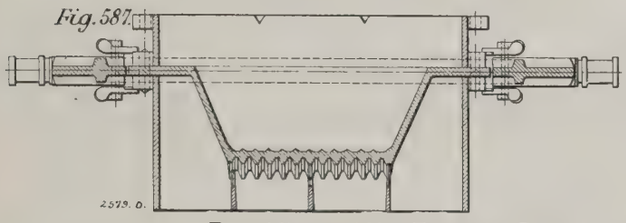
on opposite ends of a single main casting, and are rammed and delivered as just stated (the same reference-letters being retained), but the presser-head serves both box parts in turn, being ran along on tracks O O, which flank the machine. The lever J which actuates the valve is double-ended, so that two men can be operating the ram in turn, one at each box part, without moving from their positions. These and minor details are clearly shown by the drawings.

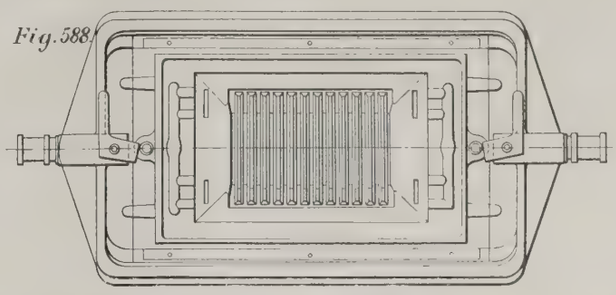
We have now seen enough of ordinary standard machine types to appreciate the fact stated earlier in the series—that of the immense variety which exists in the practice of machine moulding. It is this extensive variation which renders the system adaptable to the requirements of nearly all foundries, of the small and general shops, as well as the large, highly specialised ones. There need be no difficulty in selecting a suitable machine for the first kind; but in the latter several matters must be weighed well before a final conclusion is arrived at. In fact, in the large foundries, where specialities are handled, machines of more than one design are usually installed. Machines of standard types are also modified and built specially to deal with certain products only. Often, again, the machines are wholly specialised, as we hope to show later, some indeed very much so. But even when the standard designs of machines are going to be laid down, their selection is not always an easy matter, while their satellite equipment often becomes a problem of equal importance with that of the choice of the machine themselves. And, further, these matters lie mostly outside the question of the methods of operation themselves, whether by hand, air, steam, or water Some consideration may now be given to these aspects before illustrating some machines and systems which are in many respects different from those previously described.

With respect to the pattern-work and its method of mounting and delivery, each system which is commonly practised has been already illustrated, the case of some very special kinds excepted. We observe that the revolving machine-table divides favour with the non-turnover table; and the solid table, again, with the open frame; and the separate pattern-plate also with the system of attachment of the pattern parts directly to the machine-table. Also that methods of withdrawal vary, being sometimes upwards, sometimes downwards, and these may be due to a movement of the machine-table itself and the pattern, or to that of the moulding-box only. These numerous differences are not of a captious or indifferent character, notwithstanding that on the bordering areas, which are very wide indeed, almost any one method would be as suitable as another. But when differences become very marked, and when large quantities of castings are in question, the choice of one method or system in preference to another becomes a matter for serious consideration.

Little has been said about the actual preparation of pattern-plates, the details of which hardly come within the scope of this series. They have been touched on briefly, and illustrated. But we have seen enough to show that they are intimately related to the numbers required off a given pattern or patterns. Patterns of iron or brass or aluminium are used when large quantities of moulds have to be taken. But, in recent practice especially, much more attention has been given to the cheapening of patterns without sacrifice of durability. Iron patterns screwed to, or cast with, iron plates are expensive, because of the cost of accurately getting up such patterns. The custom is growing, therefore, of employing plaster-of-paris for plates, poured into iron frames. Into these the metal patterns, made separately, can be fitted, or prepared solidly. Figs. 584 and 585, annexed, illustrate a turnover plate used on one of the hydraulic machines of the London Emery Works Company, which is seen fitted with pattern-plates and moulding-boxes rammed up. The pattern parts here are of white metal set in plaster-of-paris. These patterns, though deep, are rammed by hydraulic pressure on a turnover table type of machine, in which the pattern is lifted from its box. But plaster-of-paris is also often used, as just stated, for patterns themselves, prepared in one with the plate, and these, like the odd sides

FOUNDRY PLANT AND MACHINERY.





Figs. 587 and 588. Turnover Plate by the London Emery Works Company, London.

Fig. 589. Turntable in Foundry of the Lancashire and Yorkshire Railway, Horwich.

or matches, which are made of sand tempered with linseed oil, are very durable, and are much less costly than the metal plates and patterns. But for absolutely permanent service the latter are superior to any others.

The screwing of divided patterns to opposite sides of the actual machine table, though not so suitably adapted to the most permanent work, is of high utility in the general shop, where a few scores or a few hundreds of similar articles only are wanted in a twelvemonth. These can be moulded, and the patterns removed, and others substituted several times over during the course of a year on the same plate. But when large quantities are required, the patterns must be permanently mounted, either on the machine tables or on intermediate plates. Frequently, too, copes and drags will be rammed adjacent on one machine or else on separate machines.

The question of the relative suitability of hand or of power-operated machines must be determined generally not only by the character of the work done, but also by reference to the power equipment which is available in a foundry. Obviously, though power machines are especially desirable in some classes of work, the heavier particularly, the power plant suitable may not be already installed, and its initial cost may be too heavy to be seriously contemplated. Fortunately, hand-machines are admittedly qualified to deal with all light and medium heavy work, and numbers are also made quite suitable for heavy duty. In these, compound and toggle-levers are used, worm-gears, and well-counterbalanced parts; yet they cannot be so economically handled as hydraulic machines, which are the best possible for massive work and for quick manipulation. The hydraulic system is also equally well adapted for lighter machines and moulds, so that where this is installed it is not worth while looking for any other power agent. The pneumatic system would have preference in many foundries, because compressed air is already in use for hoists and other mechanisms, chipping-tools, and sand-blast for cleaning castings. Where pressure water is not available, and compressed air is, the latter is a good agent, for the utilisation of which many machines are constructed. But its utilities have not so wide a range of application as the hydraulic system has, and the same observation applies to steam-power. The needs of the majority, perhaps, of foundries would appear to be better provided for by a good selection of hand-operated machines than by those using compressed air. General rules are hardly applicable in cases of this kind, but the special conditions and requirements of individual shops must be well weighed before laying down extensive machinery and plant of any kind.

The economies of machine-moulding, regarded mainly from the point of time-saving—that is, irrespective of the great value of uniformity in the dimensions of castings—involve several distinct problems. These relate to ramming, delivery,

mending up, and the service of the machines. Let us look briefly at these in turn.

The difference which is most obvious when comparing moulding-machines lies between those in which the ramming is done by hand and those in which it is performed by power agencies. The question of ramming affects differently patterns of various forms. On methods of ramming the greatest emphasis is usually laid by manufacturers of the more advanced machines, notwithstanding that in many excellent designs hand-ramming is still adopted. The application of power to ramming has presented great difficulties in the development of the moulding-machine, simply because there are cases in which its adoption is not wholly satisfactory. There are the cases of deep patterns with vertical sides, of patterns with very irregular contours, and patterns having projecting portions standing out laterally, above the lower parts of the pattern. Flat and shallow patterns, and deep patterns with convex sides offer no difficulties whatever, but each of the others do.

In moulds which are rammed by the pressure of the machine head alone, the sand is simply shovelled in, or fed in, and compressed either by one squeeze of the presser-head, or by a rapid succession of jars. The first is adopted in the hand-operated and hydraulic machines, the second in steam and pneumatic machines, and in the jarring or jolt, and the gravity machines. In all power ramming done thus, there are difficulties and risks due to two causes—namely, unsuitable shapes of patterns, or those which are ill-adapted to receive equal pressure of sand from top and bottom, and the risk of the sand lacking homogeneity. The second really results from the first, because the shape of the mould is such that uniformity of pressure cannot be imparted to the sand throughout, and therefore it will lack the homogeneity which is favourable to its stability.

With regard to deep patterns, the troubles are that the sand when rammed wholly with a presser-head is denser nearer the head than it is next the lower parts of the pattern, though the opposite condition is desirable, and the result may be fractured moulds, or lumpy or scabbed castings. These facts illustrate the desirability of making presser-heads roughly approximating to the contours of deep moulds. This, however, can be avoided by hand-ramming the lower strata first, and then finishing with the presser-head. The same remark applies to patterns which have very irregular contours, in which some portions stand up considerably higher than others, the case being analogous to the previous one. The lower portions can then be rammed by hand, and the higher parts squeezed. If the numbers required off will pay for it, a presser-head is properly prepared, corresponding approximately to the contour, and the sand is squeezed thus with equal pressure. Many interesting devices of this kind, some very curious, have been patented and tried with varying degrees of success or failure. In some of these devices for distributing the pressure equally over the sand elastic diaphragms have been made filled out with compressed air. In others, adjustable groups of rods of wood have been disposed vertically. In others, again, gutta-percha has been moulded to the shapes required. But usually blocks of wood are cut roughly to the approximate contours required. The reason why contour-pressers are required for deep moulds which have also uneven surfaces is that pressure is not transmitted through a mass of sand as it would be through a liquid, because there are spaces between the sand grains. When a moulder is ramming by hand he has to consolidate all the lower strata with the narrow pegging rammers before treating the upper strata with the flat rammers. He also often takes advantage of the character of the sand by ramming some portions harder than others where the conditions require it.

A method which is commonly adopted to avoid the use of contour-heads is to remove some of the sand, after dumping, from the higher portions, so that there is an uneven layer left on the top of the mould. Then, naturally, when applying the squeeze, the sand is pressed harder on the higher parts and softer over those portions from which the sand has been removed. The operator soon learns what quantity to take away. Thus in the example shown, Figs. 584 and 585, page 854, the sand should be tucked in by hand at the bottom part of the deep recess between the two cover patterns, and a couple of handsful taken away from the top of the higher pattern, after which the mould would be filled up with sand and compressed. The example, Fig. 586, should be treated similarly, but Figs. 587 and 588, page 855, might be pressed at once. Regarded from this aspect, the shallow moulds never offer any difficulty; while deep moulds, and especially those having sides perpendicular or nearly so, do. The moulds, therefore, which are the easiest to deliver are the easiest to ram. But the depths of moulds machine-rammed are much greater than formerly.

Of late years the jar or jolt ramming-machines have been employed with considerable success in these classes of moulds. In this design, the table on which the pattern and mould are carried is lifted and dropped on an anvil beneath, being operated very rapidly, generally by compressed air. The result is that the sand is packed closely next the lower parts, and less densely above, so that venting is not usually necessary. This method is better adapted for deep moulds than for shallow ones. The upper stratum of sand is gone over with the hand-rammer to consolidate it where it is least dense. The conditions are thus the reverse of presser-ramming.

When patterns have portions standing out laterally from the body, no method of mechanical ramming can deal with these portions satisfactorily. They must be rammed by hand, though the upper portions can still be pressed or jar-rammed. This may be got over in another way by putting prints on the sides underneath projections, and coring.

The time occupied, or saved, by the adoption of either of these power methods has to be set off against that of ordinary hand-ramming. In a machine where hand-ramming absolutely is employed there may still be some economy in time due to the fact that the moulder often occupies a position more favourable for working than he does when moulding work on the floor, with much consequent stooping. This last, however, is largely a matter of convenience and comfort; but the real essential economy of time is seen to result when hand and machine-ramming are contrasted. There are stages in the latter. The first stage is that in which some hand-ramming is combined with the use of the presser-head. The latter saves the hand-ramming of the upper strata of sand, and the use of the loose-sand frame saves time otherwise spent in shovelling in uncertain amounts of sand, as the top ramming proceeds. When the shapes and depths of patterns are such that the presser-head can be used without any hand-ramming, then the total saving is that which equals the difference in the time occupied by hand-ramming, and pressing, or practically nearly the whole of the time of hand-ramming. This increases directly with the dimensions of moulds, so that in large moulds the economy will be measured not by minutes, but by hours. This explains why so much attention has always been given to the problem of ramming moulds, and especially to those of large dimensions, by mechanical pressure, and to overcome the limitations imposed by the shapes of patterns, as has been previously explained. We therefore arrive at the conclusion that methods of compressing sand are related to depths of mould and shapes of patterns. That hand-ramming is suitable for all shapes, but its cost increases as the dimensions of moulds increase. That moulds with loose projections must have these portions dealt with by hand-ramming or by core prints. That deep moulds with plenty of slope can be treated by any power methods. Moulds having very irregular upper faces can, with suitable precautions, be rammed by mechanical pressure, either by removing the sand from the higher parts, or by making contour presser-heads. Very deep moulds with vertical, or nearly vertical, sides offer some difficulties in all mechanical pressing-machines, however operated. In these kinds, therefore, the new jar-ramming machines find the most satisfactory sphere to a far greater extent than in the shallower moulds. Very deep and heavy moulds are now regularly made on these machines, to be illustrated in an early article.

We next consider the delivery of patterns by machine. Delivery is not economical of time. It occupies practically no longer when done by hand than when performed by the machine. A minute or two suffices for any patterns. But that is not at all the way in which to regard the economy afforded by the machine lift over hand-lifting.

Mending-up so frequently follows a hand-lift that the two must be considered together. And, along with the fracture of portions of moulds which entails the mending-up, there occurs the variation from the pattern dimensions produced by rapping. So that though no real time is saved by mechanical delivery if regarded alone, a great deal of time, often one or two hours, is saved by the contingent and practically inseparable sequel of mould repairs. Because of this very few machines outside the simple mould-presses are built without provisions for mechanical delivery. This is so important a function that the best machines make provision for the take-up of wear in the sliding parts, and introduce protective coverings to preserve these vital parts from damage by the sand.

With regard to the methods of delivery which are adopted on different designs of machines, the following is a brief statement of their broad utilities. The commonest method employed is: (*a*) To withdraw the mould downwards away from the pattern; or (*b*) the pattern is withdrawn downwards from the mould, along with its plate or machine-table; or more often (*c*) in this case through a stripping-plate; or (*d*) the pattern and its plate are lifted from the mould; or (*e*) the moulding-box is lifted off the pattern; or (*f*) the top and bottom moulds are withdrawn simultaneously up and down respectively from the pattern parts carried on one plate. Another method, which will be described later under the head of "Special Machines," is a lateral withdrawal in a horizontal direction. It might seem that if the delivery between pattern and mould is effected, the method of delivery could not be of much consequence; neither is it on the bordering lines. But elsewhere the method selected is of great importance, and on the special machines some one method is adopted in preference to others.

To withdraw moulds downwards (*a*) is a method which is suitable for all patterns, deep as well as shallow, as also is (*e*) the lifting of the mould from the pattern. Provided that the shape of the pattern does not interfere with withdrawal, in which case method (*c*) must be selected, which is simply a modification of (*a*). Method (*a*) is used in machines with turnover tables, since the mould must be rammed when uppermost, and turned over before the pattern can be withdrawn. It is also adopted in non-turnover tables employing method (*f*), where the sand is pressed in top and bottom simultaneously. The methods (*b*) and (*d*) are only suitable for shallow patterns; within that sphere the work is simplified by the adoption of these methods.

The foregoing—namely, the pattern mounting, its ramming and withdrawal—are elements which receive most attention in the design of machines. They are, of course, of first importance; but they, nevertheless, concern the machine only, its output, the accuracy of the mould, and so forth. But there remains the service of the machines. There are here three elements involved, besides the speed and accuracy in actual moulding, which can be achieved on any machine. There are the supply of sand and flasks, and the removal and the handling of the moulds. There is no advantage in having a big mould rammed and delivered in a minute if several minutes are lost in bringing up flasks, fetching and shovelling sand, and carrying away the finished moulds. Hence the popularity of the small cheap hand-ramming and hand-delivery machines, and portable types in many small shops, in which with small capital outlay a very large output is obtained with no wasted time.

In the old foundries, where hand moulding alone was done, the need for conveying systems did not exist. In the majority of foundries to-day the only methods of transportation of sand, boxes, moulds, and castings are the trolley tracks, of floor or overhead types, or the various cranes, supplemented by barrows. Only with the growth of moulding-machine practice do these provisions become inadequate. When, as is often the case, the day's output for a single machine is from 100 to 400 moulds, something better than these devices becomes essential. In some cases the moulds are laid on the edges of bars leading from the moulding-machines to the casting area, along which edges they are slid by the labourers. A much better method to be seen in many shops is the turntable, or "circus," on which the moulds are placed, and which carries them round in succession to the moulding area. One of these is illustrated by Fig. 589, page 855. But this is not a complete system, neither is it suitable for heavy work. In a perfectly adequate system provision is made for bringing the sand and boxes to the machines as well as for taking the moulds away. These must always be designed with special regard to the requirements of the foundry. But they can

only be dealt with adequately by conveying systems. Generally these are wholly extraneous to the machine, but in some few instances the sand supply is partially embodied in the construction itself, as in the gravity-fed machines.

Up to one stage the large output of machines is met by having plenty of helpers, some bringing sand, others removing moulds, others coring and closing, and pouring them. The railway chair and brake shops afford familiar illustrations of this kind, whether they work on the plate-moulding system or utilise machines. In the next stage the portable machines, of which large numbers are made, meet the difficulty in another way. To save the labour of conveying sand, boxes, and moulds to and from a fixed machine, the sand is laid in a long heap, over or beside which the machine is moved on smooth wheels, and the boxes are arranged in rows alongside. The machine is travelled up and down the ranks, and as fast as the boxes are rammed they are laid in rows adjacent for casting. Although this system is mainly suitable for the lighter classes of work, some rather heavy machines are made portable. The economical limit, however, is soon reached, and then the conveying systems must come in. They are chiefly associated with the hydraulic methods of operation. Rail-tracks and trolleys supply the service, and there is no carrying at all for the men to do. The same occurs in the feeding systems for the jar-ramming machines. Less than a minute is occupied in jar-ramming the largest moulds containing several hundredweights, often a ton, of sand. So that, apart from a rapid conveying system, such machines cannot be worked to their full capacity. The need for prompt and adequate supply is increased when the work of a mould is divided between two machines, as is often done, one man preparing the cope, the other the drag of the mould. Usually, too, another man cores, closes, and pours. Thus the work of one man doing hand-moulding is frequently divided between three, in addition to the economy afforded by the use of the machine. All these conditions have to be weighed in considering the maximum economies which can be effected by machine moulding.

SIMPLIFIED METHODS OF CALCULATING REINFORCED-CONCRETE FLOOR-SLABS.

By RICHARD COULSON, Jun., Assoc. R.C.Sc.I.

THE following article shows a simple method of obtaining the thickness of a reinforced-concrete floor-slab, the superload and span being given. The case of slabs having a tension reinforcement only is dealt with, and the formulæ make an exact allowance for weight of materials of construction.

Notation.

- A —Area of reinforcement in square inches.
- E_c —Modulus of elasticity of concrete in compression.
- E_s —Modulus of elasticity of reinforcement.
- L —Span of slab in feet.
- M —Moment of load on 12-in. width of slab in pound-inches.
- R —Moment of resistance of 12-in. width of slab in pound-inches.
- T —Total thickness of slab in inches.
- a —Arm of resistance couple in inches.
- f_c —Maximum compressive stress in concrete in pounds per square inch.
- f_s —Tensile stress in reinforcement in pounds per square inch.
- m —Bending-moment factor.
- r —E_s / E_c.
- t —Thickness of slab from upper surface to centre of tensile reinforcement in inches.
- w —Load on slab in hundredweights per square foot.
- w_c —Weight of reinforced concrete in pounds per cubic foot.
- x —Proportionate depth of neutral axis from upper surface of slab.

The following assumptions are made :—

1. That the moduli of elasticity in both concrete and steel are constant.

2. That the tensile strength of the concrete is nil.

3. That the compressive stress in the concrete is directly proportional to the distance from the neutral axis ; therefore any cross-sectional plane in an unloaded slab will remain plane when load is applied.

4. That the stress in the reinforcement is constant over a cross-section.

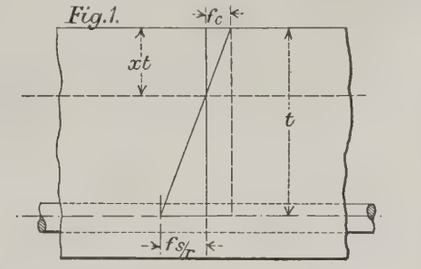
At equal distances from the neutral axis the stress in the reinforcement is r times the stress in the concrete ; so that if f_s be the stress in the reinforcement, the corresponding stress in the concrete is f_s/r ; then, from Fig, 1,

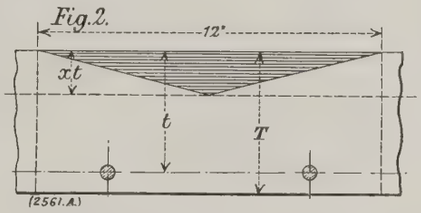
$$x\,t : t = f_c : (f_c + f_s/r)$$

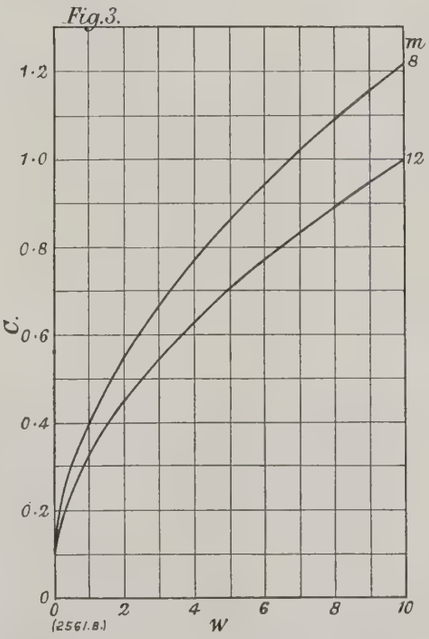
$$x = \frac{r f_c}{r f_c + f_s} \quad . \quad . \quad . \quad . \quad (1)$$

From assumption 3 the average compressive stress on the concrete will be $\frac{1}{2} f_c$, so that the compressive resistance of a 12-in. width of slab will be $6\,x\,t\,f_c$, as shown in Fig. 2, where the equivalent resistance area is represented by the shaded triangle.

The arm of the resistance couple is the distance between the centres of gravity of the equivalent







resistance area and the reinforcement ; therefore

$$a = t\,(1 - \tfrac{1}{3}\,x).$$

The moment of resistance of a 12-in. width of slab will be

$$6\,x\,t\,.\,f_c\,.\,a,$$

or

$$R = \frac{2\,t^2\,r\,f_c{}^2\,(2\,r\,f_c + 3\,f_s)}{(r\,f_c + f_s)^2} \quad . \quad . \quad (2)$$

Substituting the values recommended by the R.I.B.A. Joint Committee—namely, $f_c = 600\,.\,f_s = 16{,}000\,.\,r = 15$.

$$R = 1140\,t^2 \text{ lb.-in.} \quad . \quad . \quad . \quad (3)$$

The bending moment due to a uniformly distributed load of w cwt. per square foot on a slab of span L, using a bending-moment factor m, will be

$$\frac{1344\,w\,L^2}{m} \text{ lb.-in. per 12 in. width.}$$

The bending moment due to weight of slab of span L, using a bending-moment factor m, will be

$$\frac{w_c\,T L^2}{m} \text{ lb.-in. per 12 in. width.}$$

Therefore

$$M = \frac{L^2}{m}\,(1344\,w + w_c\,T) \quad . \quad . \quad (4)$$

Substituting the values $w_c = 150$, $T = t + \frac{3}{4}$ in.

$$M = \frac{L^2}{m}\,[1344\,w + 150\,(t + \tfrac{3}{4})] \quad . \quad . \quad (5)$$

Equating (3) and (5).

$$1140\,t^2 = 150\,\frac{L^2}{m}\,t + \frac{L^2}{m}\,(1344\,w + 112.5).$$

Solving the quadratic, and neglecting the first term under the root sign (which is small in comparison with the others),

$$t = 0.066\,\frac{L^2}{m} + L\sqrt{\frac{1}{m}\,(1.18\,w + 0.1)} \quad . \quad (6)$$

Denoting $\sqrt{\frac{1}{m}\,(1.18\,w + 0.1)}$ by C ; for slabs supported at ends ($m = 8$), equation (6) becomes

$$t = 0.0083\,L^2 + C\,.\,L \quad . \quad . \quad (7)$$

for slabs partially fixed at ends, or continuous over supports ($m = 12$), equation (6) becomes

$$t = 0.0055\,L^2 + C\,.\,L \quad . \quad . \quad (8)$$

Diagram Fig. 3 gives values of C corresponding to various values of w, for $m = 8$, and for $m = 12$.

EXAMPLE I.

A slab of 10 ft. span supported at ends is to carry a load of 1 cwt. per square foot ; find th thickness of the slab.

From the diagram the value of C for $m = 8$, and $w = 1$, is 0.4; therefore

$$t = 0.0083\,L^2 + 0.4\,L$$
$$= 0.83 + 4$$
$$= 4.83 \text{ in.}$$
$$t = \text{say } 4\tfrac{7}{8} \text{ in., } T = 5\tfrac{5}{8} \text{ in.}$$

EXAMPLE II.

A slab of 12 ft. span, partially fixed at ends, is to carry a load of 3 cwt. per sq. ft.; find the thickness of the slab.

From the diagram the value of C for $m = 12$, and $w = 3$ is 0.55.

Therefore

$$t = 0.0055\,L^2 + 0.55\,L.$$
$$= 0.79 + 6.6.$$
$$= 7.39 \text{ in.}$$
$$t = \text{say } 7\tfrac{3}{8} \text{ in., } T = 8\tfrac{1}{8} \text{ in.}$$

Area of reinforcement :

In a 12-in. width of slab the total tension must equal the total compression ; therefore

$$A_s\,f_s = 6\,x\,t\,.\,f_c$$

or

$$A_s = \frac{6\,t\,r\,f_c{}^2}{f_s\,(r\,f_c + f_s)} \quad . \quad . \quad (9)$$

The number of rods in a width of 12 in. will be

$$\frac{12}{\text{spacing of rods in inches}},$$

which must be equal to

$$\frac{A_s}{\text{area of one rod}}.$$

Therefore, spacing of round rods in inches will be

$$(\text{diameter of rod})^2 \times \frac{1.57\,f_s\,(r\,f_c + f_s)}{t\,r\,f_c{}^2} \quad . \quad (10)$$

Using $\frac{1}{2}$-in. diameter rods, and substituting for r, f_c, and f_s as before.

$$\text{Spacing of rods} = \frac{29}{t} \text{ in.} \quad . \quad . \quad (11)$$

Which gives

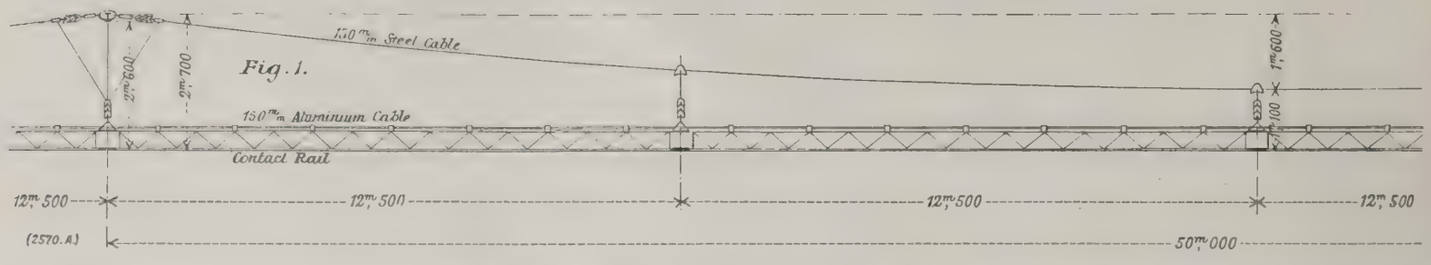
For example I., spacing of $\frac{1}{2}$-in. rods = 6 in.
For example II., spacing of $\frac{1}{2}$-in. rods = $3\frac{7}{8}$ in.

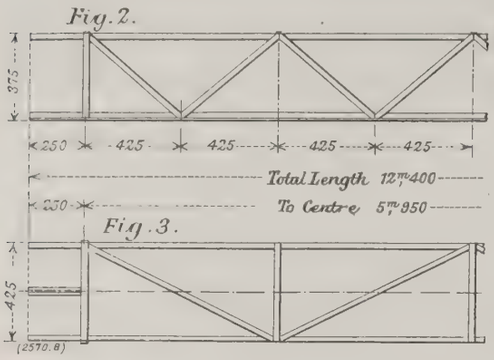
OVERHEAD SINGLE-PHASE RAILWAY EQUIPMENTS ON THE CHEMINS DE FER DU MIDI.

ALTHOUGH much work has already been done in the electrification of railways on the single-phase system with an overhead conductor, the amount of experience in practical running is, none the less, small as compared with that relating to the third-rail continuous-current form of construction. One result of this is that there is yet no general consensus of opinion among engineers responsible for single-phase work as to the form many of the mechanical details which are peculiar to the system should take. The question of the nature and method of suspension of the overhead conductor illustrates this, and the number of different forms of construction in use almost equals that of the number of electrified railways. There is little doubt but that such construction will ultimately settle down into a more or less standard form, but for the moment it would appear to be impossible to say

OVERHEAD SINGLE-PHASE RAILWAY EQUIPMENT; CHEMINS DE FER DU MIDI.

M. PAUL, CHIEF ENGINEER OF THE CHEMINS DE FER DU MIDI.





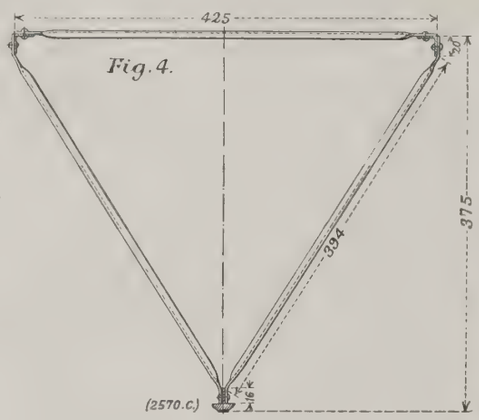


Fig. 5.

what that standard form will be. The whole problem, which is, of course, almost purely a mechanical one, is of much interest and importance, and is certainly well worth the study which is being given to it.

It is well known that in some cases in America the form of overhead construction adopted gave much trouble at first, although subsequent modification has resulted in satisfactory systems; while in other cases, as, for instance, the Brighton electrification in this country, the overhead conductor appears to have worked with every satisfaction without modifications of the form adopted at the outset. In most of the single-phase equipments which have been installed, the work would appear to have been carried through without any comparative experiments on an extensive scale between different forms of construction, and such procedure has in many cases undoubtedly resulted very satisfactorily. Nonetheless, the policy adopted by the Midi Railway of France is an interesting one, and should certainly lead to the final adoption of a very satisfactory form of suspension. This railway, which has decided on an extensive electrification scheme in the neighbourhood of Toulouse, is at the present time actually proceeding with the work for the conversion of some 175 miles of single track, and in order to obtain an entirely satisfactory form of overhead construction, has equipped six sections of the line, each some 2 to 3 kilometres in length, with six different forms of gear, so that practical and fair trials may be made of each on an adequate scale.

We are not in this article concerned with the whole of these equipments, nor with the experiments to be made with them, and propose only to describe the details of two of the forms of construction adopted. The gear built in accordance with these two forms has been supplied by Messrs. Vedovelli, Priestley, et Cie., of Paris, whose English agents are Messrs. Laing, Wharton, Limited, of 7, Great Newport-street, W.C. The first of the forms is to the design of M. Paul, chief engineer to the railway company, while the second is of Messrs. Vedovelli, Priestley's own pattern. M. Paul's gear is illustrated in Figs. 1 to 5, annexed, and it will be at once seen from these figures that the arrangement is a somewhat unusual one, and that a rigid girder-like structure takes the place of the more common semi-flexible conductor. This girder structure is made up in lengths of 12½ metres, and as the distance between the supporting pillars, or towers, is 50 metres, there are four lengths to each section of the line. The girder is carried from a steel catenary cable suspended above it, and connected to it through insulators at the points formed by the joints between the various lengths. The normal height of the lower side of the girder above the running rails is 5½ metres, rising to 6 metres at level-crossings, and falling to 4½ metres at some of the bridges and tunnels. These dimensions are general throughout the line, and apply to the Vedovelli-Priestley as well as to the Paul gear.

The construction of the conductor girder will be easily followed from Figs. 1 to 5. It is triangular in section, having angle-irons at its upper corners and a round-bottomed rail at its lower. The angle-irons and rail are fastened together with small angle-iron lattice-work riveted on. The various lengths of the girder are built up complete in the shops, and on erection are secured together with fish-plates, which are arranged with oval holes to allow for expansion and contraction. The conductivity of the girder is increased by running a bare aluminium cable along its upper side, this cable being connected to it at intervals by clips. No allowance for temperature difference is made in the suspending cables, as their expansion or contraction only results in the slight lifting or lowering of the position of the girder. It is obvious that the construction will present a very uniform surface for contact with the collector bow, and that there will be no hard points at the places where the suspension wires connect to it. The towers or pillars are built up with braced steel sections, and are of simple form, as will be seen from Fig. 5.

The Vedovelli-Priestley gear is illustrated in Figs. 6 to 11, on page 859. The construction in this case is radically different from that employed by M. Paul, and consists of a simple catenary type of suspension, with droppers connecting the catenary with the copper contact wire. The steel catenary is attached to the contact wire by droppers, the vertical examples of which consist of small rigid bars of cruciform cross-section, while the inclined ones are made from round rod. The features of greatest novelty in the gear have reference to the compensating devices which are fitted to both the conducting wire and the catenary. These devices are not fitted uniformly throughout the line, since a trial is being made of different methods and combinations, in order to ascertain the most satisfactory arrangement for the work in hand. Thus in Fig. 9, in which it will be seen that the conducting wire in the neighbourhood of the left-hand supporting post is attached by vertical droppers, while that in the neighbourhood of the right post is attached by inclined ones, the two different arrangements are necessitated by the fact that while the conductor wire close to the right-hand post has a tension gear, in the neighbourhood of the left-hand post it has none.

Two systems of compensating gear are employed, in the first of which a weight suspended by a chain acting over fixed pulleys maintains a constant tension on both the catenary and the conducting wire. This arrangement is shown in Figs. 6 to 9. In the second, a similar weight is employed, but acts only on the catenary, the constant tension in the conductor wire being maintained by spiral springs as shown in Fig. 11. The general lines of the tension gear will be followed from Figs. 6, 7, and 8. The arrangement consists in essence of a horizontal pulley carried by the fixed arm of the post. This pulley has two diameters, one relatively small and the other of 840 mm., as shown in the figures. The tension weight acts on the large diameter through a chain and pulley system, as shown, while the catenary or conductor-wire is attached to the small diameter in such a way that the pull of the weight on the larger diameter, tending to rotate the pulley, maintains a constant tension on it. The details of the gear will be followed from the illustrations, the hatched form at the bottom of the lower pulley in Fig. 7 showing the position of the collector bow when it is passing the gear. Various different forms of pole are being tried in connection with this installation, and mention may be made of the interesting ferro-concrete example shown in Fig. 11.

The insulators used for all positions of tension throughout this system, as also for the Paul gear, are of Messrs. Vedovelli-Priestley's special type, which is illustrated in Fig. 10. It would be difficult to describe the form of this insulator in words, but it is not necessary to try, as it is well shown in the figure, and it need only be said that the insulators are strung together by wire-rope links to form a chain of any length required to suit the voltage which is being dealt with. The appearance of such a chain is well shown in Fig. 11, and in this connection it should be mentioned that the whole of this gear has been designed to deal with an overhead conductor tension of 12,000 volts.

Alternating-Current Cable Telegraphy. — Béla Gáti, of Budapest, has resumed his researches on the use of alternating currents for rapid cable-telegraphy with a view of refuting the objection that the signals would run into one another even at moderate frequencies. While experimenting on the use of heavy-current microphones for telephoning on telegraph lines, he had occasion to study the disturbing noises with the aid of oscillographs, and he shows, in a communication published by the Vienna *Zeitschrift für Elektrotechnik und Maschinenbau* of last October, by means of oscillograph curves that the lengthening of the signals, which causes them to run into one another, can only occur with direct currents. The experiments were made with artificial cables several thousand kilometres in length. He refers particularly to the different views held by K. W. Wagner, who, Gáti objects, commits the mistake of regarding, for the sake of simplicity, alternating currents as alternating-current impulses, suddenly made, existing for a short period at maximum potential, and suddenly unmade again. Rapid ocean telegraphy with cables of 10^{-2} henry self-induction would, in Gáti's opinion, be possible and should be tried on new lines.

OVERHEAD SINGLE-PHASE RAILWAY EQUIPMENT; CHEMINS DE FER DU MIDI.

MESSRS. VEDOVELLI, PRIESTLEY ET CIE., PARIS.

(*For Description, see opposite Page.*)

Fig. 6.

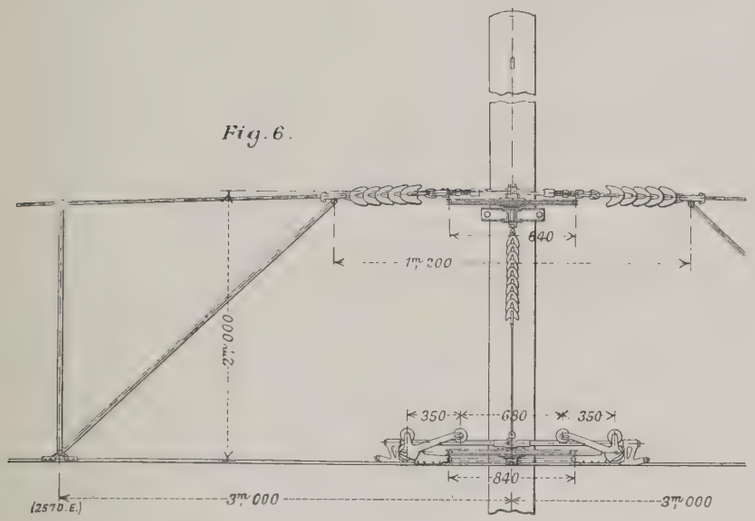


Fig. 7.

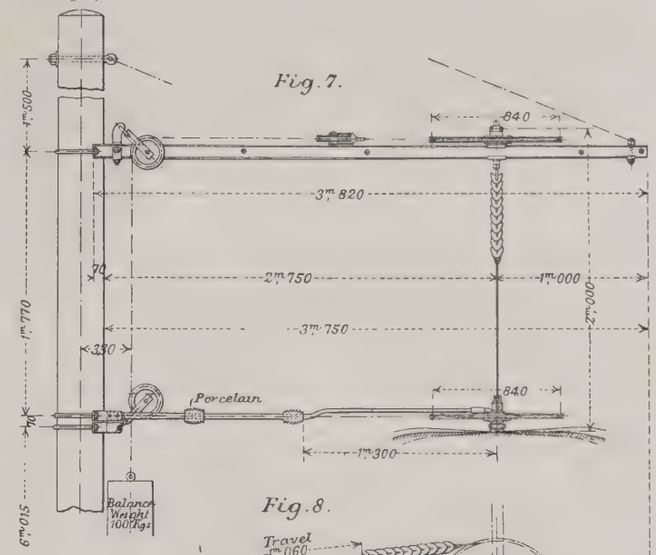


Fig. 8.

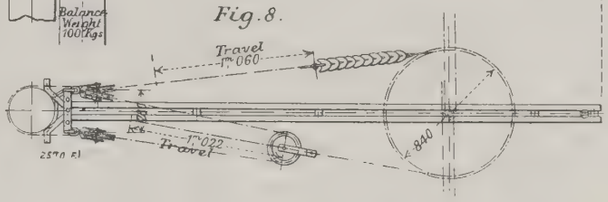
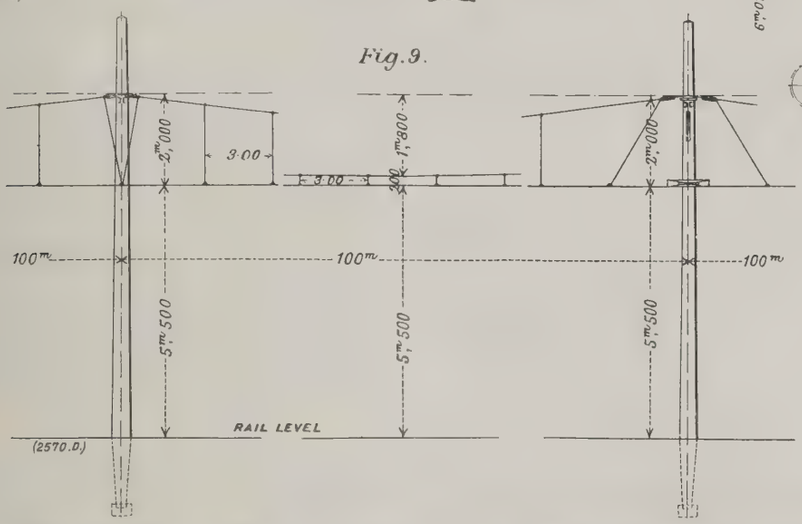


Fig. 9.



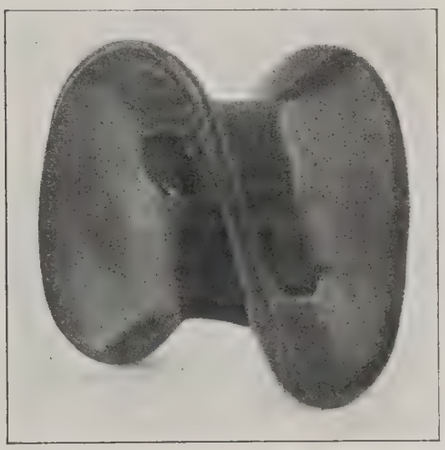


Fig. 10. Insulator.

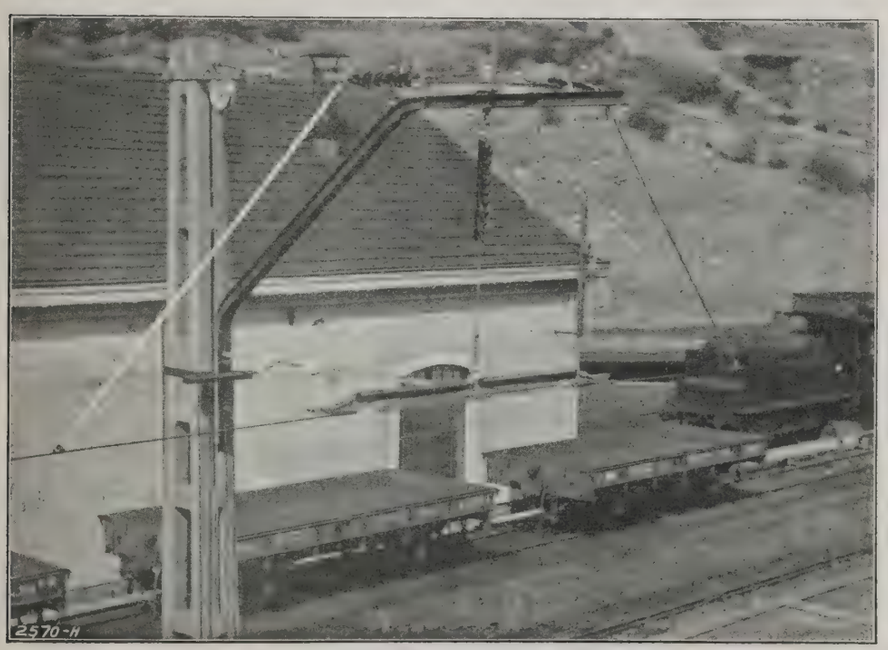


Fig. 11. Ferro-Concrete Pole and Tension Gear.

A Year-Book on China.—We understand that Messrs. George Routledge and Sons, Limited, 68, Carter-lane, E.C., have in preparation a year-book on China. This book, it is hoped, will be published in January next, and will constitute the first attempt to compile a comprehensive year-book in connection with this great Eastern Empire. Statistical and other definite information relating to China is extremely difficult to procure as a rule, and such as is available is nearly always confined to a few districts where contact with Europeans has necessitated the compilation of some figures for local commercial purposes. Nothing comprehensive has been achieved hitherto, but we understand that those responsible for this book, one of whom (Mr. H. T. Montagu Bell) has been at work on it at Pekin, have been able to interest the Chinese official world in the matter, and have thus received valuable assistance in their undertaking. The present internal movement in China can have but one end as regards the opening up of the country to commerce, and to ideas of Western civilisation. This opening to foreign trade cannot much longer be delayed, since now the movement is receiving impetus from the inside. Formerly, when it was a question of adopting ideas suggested by foreign people, it was only necessary to appeal to prejudice to hamper very effectively any attempted progress. The movement has other backing now, and once a large section of the people are determined to support the cause of progress, no Chinese Government will be able to stop it. It behoves our manufacturers, therefore, to be prepared for the opportunity which will shortly assuredly present itself of securing a very considerable trade in this country, and it is to be hoped that they will not let themselves be out-distanced by other countries which have already had the sagacity to put themselves already in the field in expectation of the good things to come. By sending out carefully chosen men, and allowing them sufficient discretion, as is done by other nations, our manufacturers, especially in the engineering branches of trade, should be able to secure a good foothold in these prospective markets. Under these circumstances the year-book to which we have referred above, if carried out in a thorough way, should prove of considerable service to our manufacturers. We hope to review the volume when it is issued.

INDUSTRIAL NOTES.

The threatened lock-out in the cotton trade in North-East Lancashire came into force on Wednesday, and practically the whole trade has been brought to a standstill. The effect will be best understood by a brief study of some figures. In the Blackburn and Burnley districts about 164,000 work-people are locked out, and as the spinning mills are only to work half-time, the total number of operatives affected is somewhere about 300,000. In Oldham alone there are more than 350 large mills, employing more than 50,000 operatives. In addition, many more mills in other parts of the country will be silent. This is an extraordinary state of affairs in a trade that is just now experiencing a wave of prosperity, consequent upon trade-union tyranny in not allowing free men to work without binding themselves to the unions. It is feared that if the lock-out lasts more than a few days, the mills in the Oldham district will have to be closed down whether the employers are agreeable or not. At present South-East Lancashire has nothing to do with the quarrel. If, however, they take sides with the employers in North-East Lancashire, the situation will probably become more serious, for the operatives in the former district will probably bring up a number of old-standing grievances which the men would try to have remedied before they would commence work again. Put briefly, the whole of the Lancashire cotton trade is threatened. On Tuesday there were meetings on both sides, and the committee of the Federation of Master Cotton-Spinners' Associations held a meeting in Manchester on Wednesday. At this meeting the following resolutions were adopted :—

1. That in consequence of the threatened stoppage of looms in North and North-East Lancashire, and the inability of disposing during such stoppage of the whole of the production of yarn, this general committee strongly recommend members of the Federation, until further notice, to close their mills each Saturday, Monday, and Tuesday, commencing Saturday, December 30.

2. That the above resolution applies to all spinning firms whose spindles are engaged in the production of yarn for looms stopped in consequence of the present dispute.

3. That a meeting be called as early as possible of the signatories of the Brooklands Agreement for the purpose of considering the position of spinners created by the present weaving dispute.

4. That a meeting of this general committee be held next Tuesday to consider the position further.

The spinners' interest in the situation arises from the fact that if manufacturers in North-East Lancashire stop their looms, there will be no demand for the yarn spun in South-East Lancashire, of which Manchester is the centre and the market.

After the usual Christmas holidays all the Rochdale mills commenced work on Tuesday, but on Wednesday morning notices were posted in practically all the local cotton-mills where weavers are engaged. While locked-out, trade-union weavers will, it is announced, receive 10s. a week from the funds of their associations, the Amalgamation and the General Federation of Trade Unions, which have been officially notified of the dispute.

As was expected might be the case, the Miners' Federation of Great Britain have decided to order a national strike ballot to be taken on the minimum-wage question. This was the outcome of a special conference which took place on Thursday in last week at Caxton Hall, Westminster, under the chairmanship of Mr. Enoch Edwards, M.P. The number of delegates present was 164, and they represented between 600,000 and 700,000 miners. The conference was adjourned till the following Wednesday, as the executive council wished to analyse the reports submitted on the negotiations which had taken place between masters and men on the minimum-wage question in different districts.

At the conference on Thursday in last week it was announced that the following resolutions had been carried :—"(*a*) That a ballot vote be taken. (*b*) That the ballot vote be taken on January 10, 11, and 12, 1912. (*c*) That no half-members be allowed to vote. This resolution refers to miners who pay half the ordinary subscription to their union. They are usually boys below a certain age, which, however, is not uniform in all districts. (*d*) That the result of the ballot in each district be sent to Mr. Ashton not later than January 16, 1912. (*e*) That in case the ballot vote results in a two-thirds majority in favour of a national stoppage, notices be given in every district so as to terminate at the end of February, 1912. (*f*) That each district send to Mr. Ashton a tabulated statement of what it desires to be its minimum wages, and that the executive of the Federation meet to consider these statements, and report to a national conference to be held in Birmingham on January 18, 1912. (*g*) That the form of the ballot-paper should be as follows:—Are you in favour of giving notice to establish the principle of a minimum wage for every man and boy working underground in the mines of Great Britain? (*h*) That during negotiations special machinery be set up in each district for dealing with exceptional cases, such as old and infirm workmen. Resolution (*e*) aims at a simultaneous laying down of tools in every part of Great Britain. It was decided that the question of the abolition of the three-shift system should not be mixed up with that of the minimum wage." From these resolutions it is now pretty clear that there is nothing to prevent a national stoppage of work in the coal-fields of Great Britain early next year except the failure of the ballot to show a two-thirds majority. The day has so far been won by the extreme party, whose stronghold is South Wales, and if the rest of the country allows itself to be governed by this party there is little doubt that there will be a strike. In Lancashire and Yorkshire also many extremists are to be found. Some of the miners' Members of Parliament are, however, strongly opposed to a national strike.

It was announced early this week, however, that unexpected complications had arisen which might prevent the ballot of the men on the strike issue being as clear and emphatic as such a verdict should be. There is, particularly in South Wales and Lancashire, a growing disposition to criticise the leaders because of the circumstances under which the ballot came to be taken. It is claimed that the executive have full power to declare a national stoppage without a ballot, and that the latter is not necessary. It is urged that, if the leaders must have a ballot, the course they should take would be to hand in notices in time to expire on February 1, and take the ballot while the notices were running out. The feeling against the leaders is said to be very bitter in Northumberland because of the refusal of the Federation of Great Britain to make a referendum on the three-shift system. The result of this feeling is that there is an inclination to boycott the proposed ballot. By the time the ballot is to be taken it is quite possible, however, that a good deal of this irritation may have passed away. If not, it may materially affect the result.

Labour troubles have again broken out at Llanelly, for 100 tramwaymen struck work on Thursday in last week, and in the evening the car service was stopped. Efforts were made to carry on the service with non-union labour, and these efforts were, to a certain extent, successful during the daylight hours, but failed when darkness came on. The men have, it is stated, pledged themselves not to return to work until terms as fair as those in operation at Swansea have been granted.

The strike of carters and lorrymen at Dundee is at an end, and on Monday last the town resumed its normal aspect, work being again in full swing. Great efforts were made on Sunday to get long-delayed supplies to their destination, and at midnight on that day coal contractors rushed large quantities of fuel to the mills, factories, and other works which had been closed down in consequence of the strike. During Monday work was resumed at most of the factories. Work was also busy at the docks, where a congested state of affairs existed owing to the heavy accumulation of goods.

Some time ago certain hands were discharged from the works of Messrs. Huntley and Palmers, of Reading. On Friday last Sir Rufus Isaacs, M.P. for Reading, received a deputation from these workpeople, as he had interested himself on their behalf. He told them that he had seen the directors of the firm, and had received from them the following intimation :—"(1) No person has been, or will be, discharged simply because of having joined a trade union; but if any servants of the company, whether trade-unionists or not, show disloyalty to the company by circulating false statements relative to their employers or employment, by impeding the proper discipline of the factory, or neglecting their work, by intimidating fellow-workers, by employing the time for which they are paid in the factory upon purposes other than their work, they will not be retained in the service of the company. (2) At the recent shortening of hands no persons (except temporary hands) have been discharged unless they have given rise to dissatisfaction in one or the other of the particulars mentioned in paragraph 1. No man is taken on at the factory at a lower wage than 19s. per week. Wages are considered by the directors themselves twice a year, when every employee has a chance in a personal interview of urging any claims which he may have. In addition to this, it has always been, and is, a tradition of our company, faithfully observed, that all employees have the right of access to their directors upon any subject concerning their interests and the welfare at the factory."

A special meeting will be held to-day to consider the question of a closer union between the four railway trade unions—the Amalgamated Society of Railway Servants, the Associated Society of Locomotive Engineers and Firemen, the General Railway Workers' Union, and the United Signalmen's and Pointsmen's Society. There is a very strong feeling among the rank and file of the four unions in favour of amalgamation, but it is doubtful whether the statutory two-thirds majority can be obtained in all the unions. Amalgamation is looked upon as more necessary now than ever since the amended conciliation scheme outlined by the Royal Commission report has been accepted, and it is understood that a draft scheme has been prepared providing for the pooling of funds, standardisation of benefits, and other changes necessary to give effect to the desire for amalgamation. The executive council of the Associated Society of Locomotive Engineers and Firemen do not care to go so far as to recommend amalgamation, but have prepared a scheme for the federation of the unions as an alternative; it is not thought likely that this will be accepted by the Amalgamated Society of Railway Servants.

It is proposed by the Carpenters and Joiners and Furnishing and Cabinet-Makers' Societies of London to make a number of important alterations in their working rules. An increase of 1½d. an hour in wages is to be stipulated for, bringing the minimum rate up to 1s. per hour. A reduction of the working hours in summer from fifty to forty-seven hours a week, and payment for overtime at the rate of double time is in the programme. The Master Builders' Association have had the new rules submitted to them, and if they are approved they will come into operation in June next. Such new rules certainly appear strange after the long spell of depression through which the building trade has passed.

In connection with the agreement arrived at on December 15 at a conference held under the chairmanship of Sir George Askwith, between the London Motor-Cab Proprietors' Association, Limited, and the London Cabdrivers' Trade Union, a court of arbitration has been appointed, consisting of Viscount St. Aldwyn (chairman), Mr. L. A. Martin (a managing director of Henry Tate and Sons, Limited), and Mr. C. W. Bowerman, M.P. (secretary of the Parliamentary Committee of the Trade Union Congress). The question to be referred to the court is :—"What are the fair and proper conditions of service and payment under which the taxicab drivers should work, on the assumption that the existing fares remain unaltered; without prejudice to either party being entitled to show what improvements might be expected if a change in fares, either by increase or decrease, were made."

The Hornsby Oil-Engine: Erratum.—In our notice, on page 772 of our last issue, of this engine as exhibited at the Smithfield Show, we stated that it was now built to develop as much as 270 brake horse-power. Messrs. Richard Hornsby and Co., of Grantham, inform us that this is an under-statement, and that they have supplied engines of 370 brake horse-power.

Contracts.—Messrs. J. W. Brooke and Co., Limited, Lowestoft, state that amongst recent important orders received for Brooke motors is one just to hand from the Greek Government for six sets of 25-horse-power Brooke marine motors, and full equipment of reverse gears, tail-shafts, propellers, &c., for revenue boats for use amongst their islands, and for six search-light plants to consist of 4-horse-power Brooke marine motors with dynamos on cast-iron base-plate, switchboards, and 6000 c.p. projectors.—In our last issue, on page 799, we stated inadvertently that Messrs. Ed. Bennis and Co., Limited, had recently secured contracts for sixteen of their stoking installations; the figure should read one hundred.—The Maschinenfabrik Augsburg-Nurnberg A.-G., whose London office is at Caxton House, Westminster, S.W., state that between October 1 and November, 30, 1911, they have received orders for a total of 29,030 brake horse-power of high power Nuremberg gas-engines, eleven engines in all, for Germany and France.

Personal.—Messrs. Moncrieff P. Ford and Co. engineers, Birmingham, state that their steadily increasing business has led them to secure premises within five minutes' walk from the Midland and London and North-Western stations. Their full address, on and after January 1, will be 12, Bromsgrove-street, and 64 and 65, Dean-street.—Messrs. H. W. Ward and Co., Limited, machine-tool makers, Birmingham, state that they have made arrangements with the purchaser of the freehold of the Lorraine-Dietrich Works, Bournbrook, for their occupation, to relieve the congested state of their present works, and afford greater facilities for the manufacture of their products. They have put down new machinery, and intend commencing operations immediately. Their head offices and show-rooms will remain, as before, in Lionel-street, Birmingham.—We are informed that Mr. E. C. Reed, chief publicity writer to the Westinghouse Companies' publishing department, has been appointed sales manager to Messrs. Miles, Sykes, and Sons, of Calder Works, Sowerby Bridge. Mr. Reed will take up his new duties early in the new year.

DOUBLE CANTILEVER 120-TON FLOA

CONSTRUCTED BY THE PRAGER MASCHIN

(*For Desc*

Fig.1.

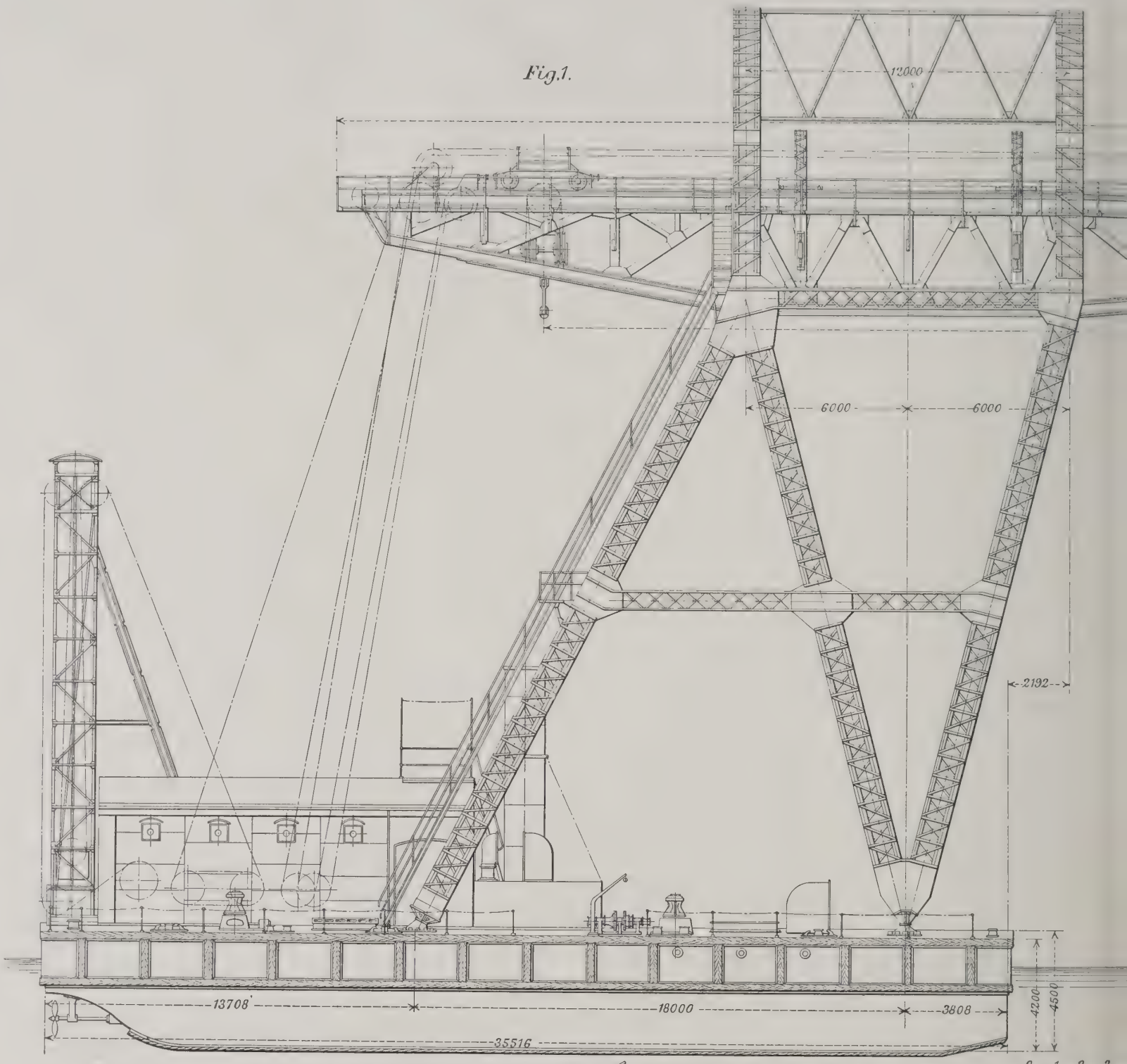
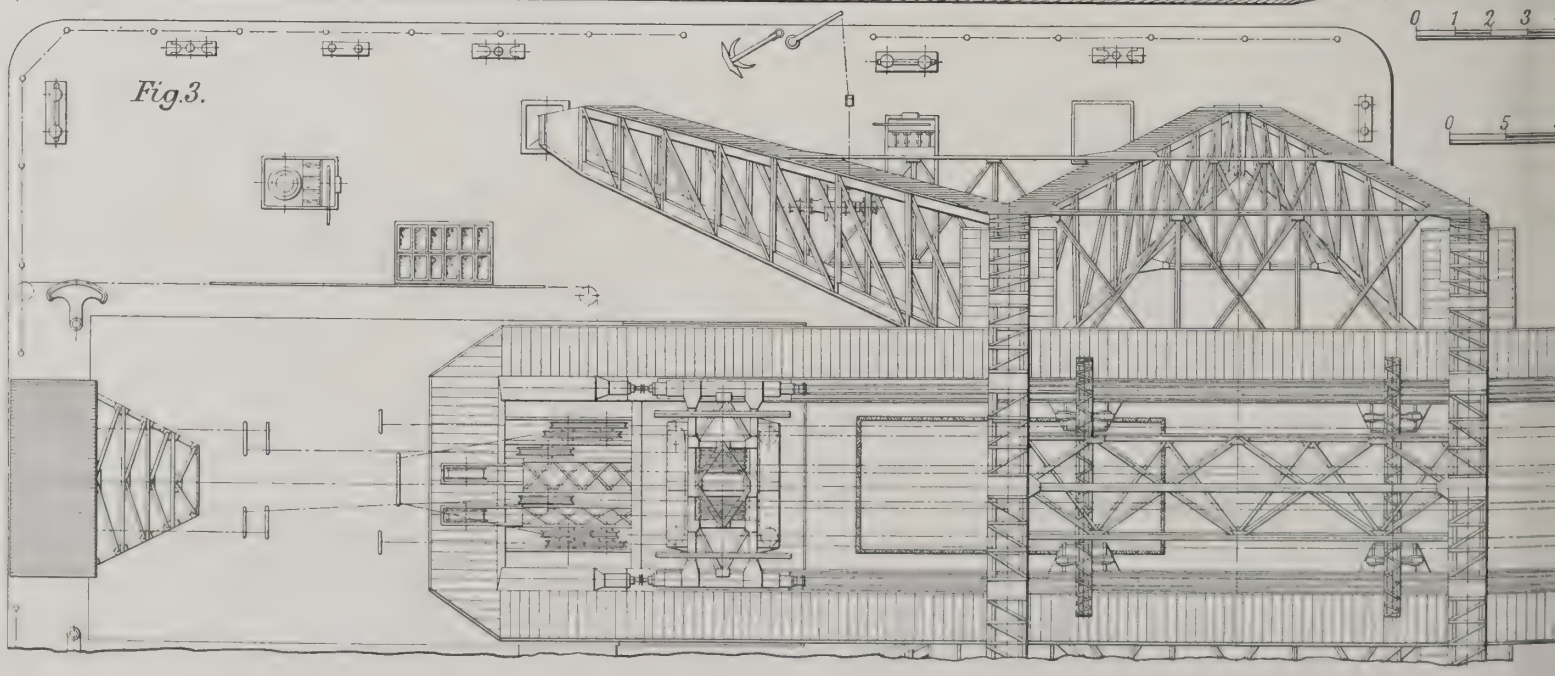


Fig.3.



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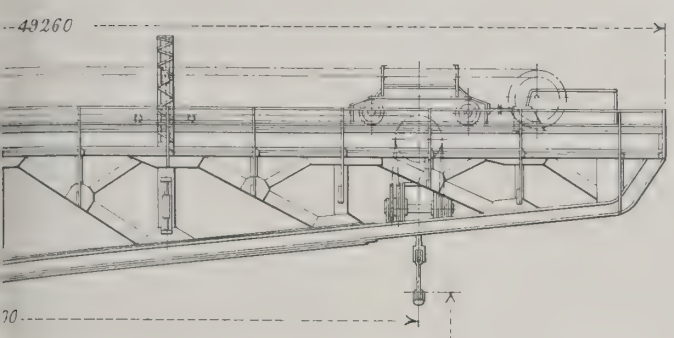
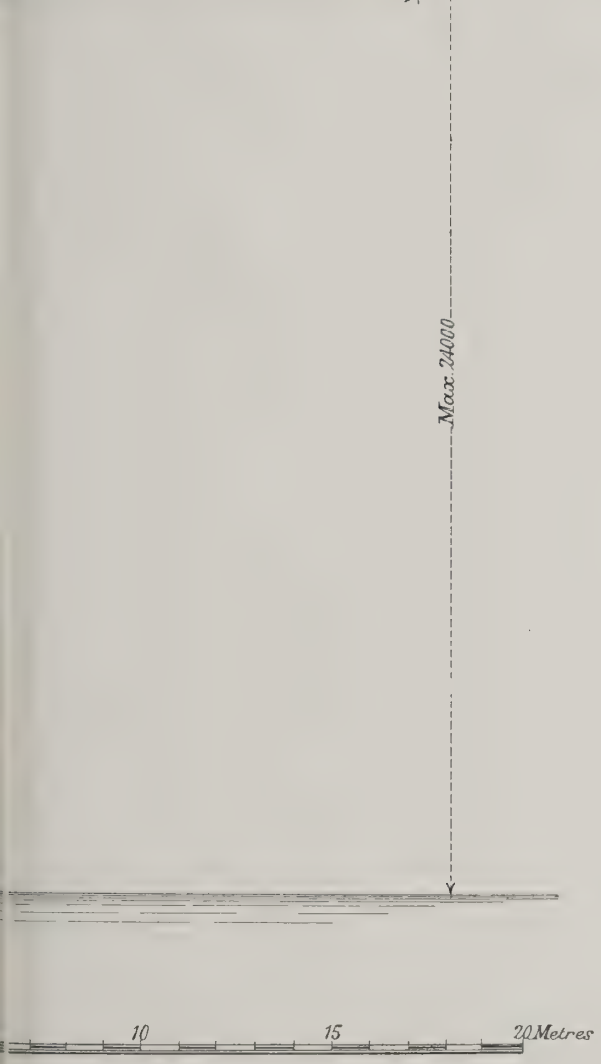
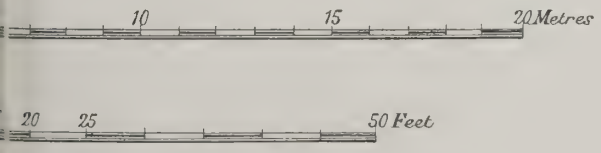
G CRANE AT THE POLA DOCKYARD.

ACTIEN-GESELLSCHAFT, ENGINEERS, PRAGUE.

(See *Page* 861.)







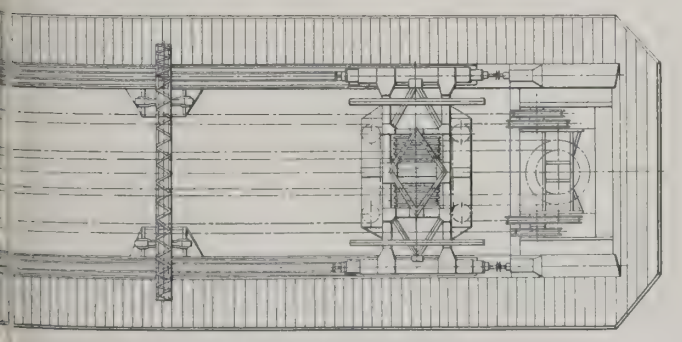


Fig. 2.

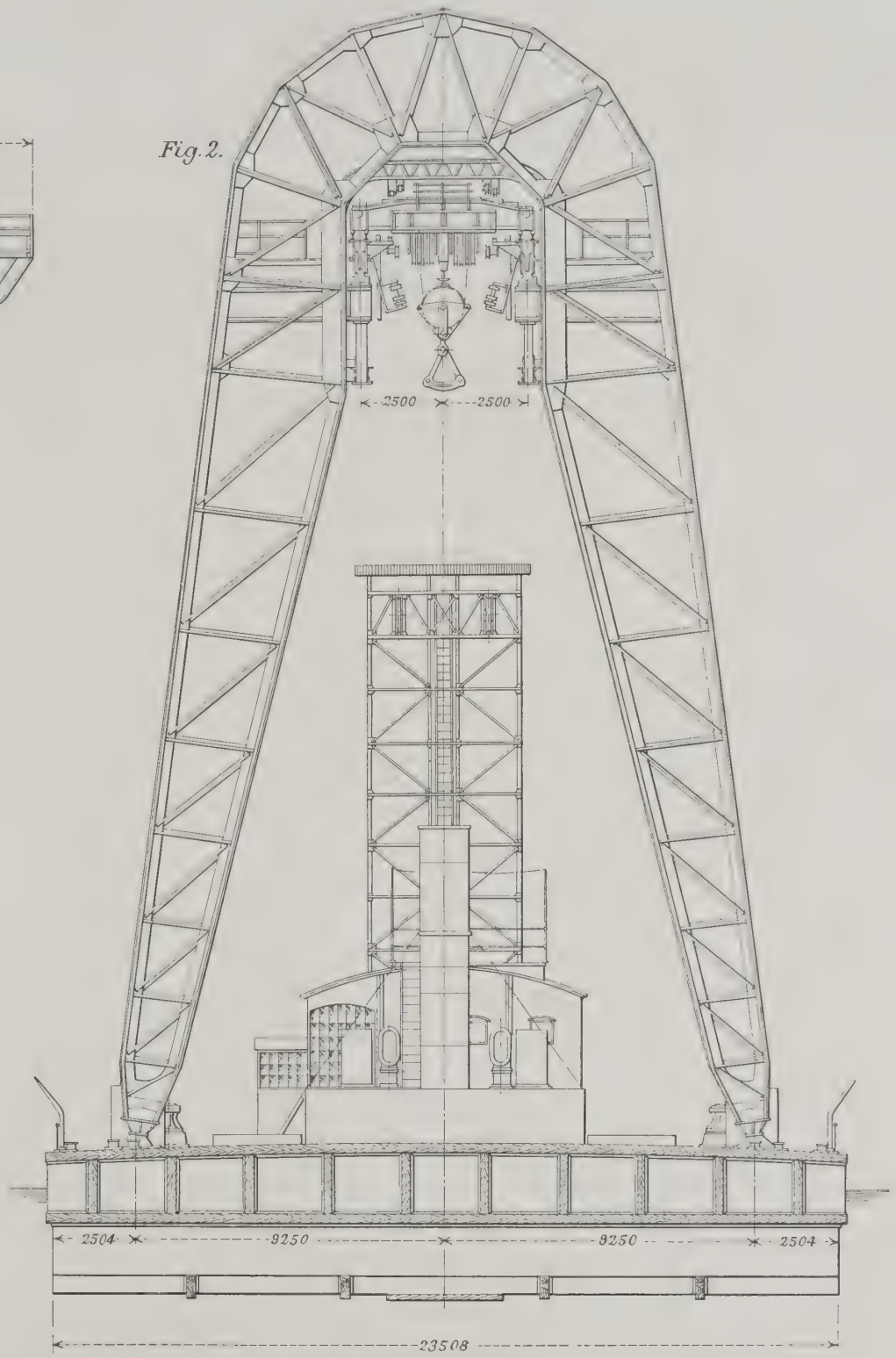


Fig. 4.

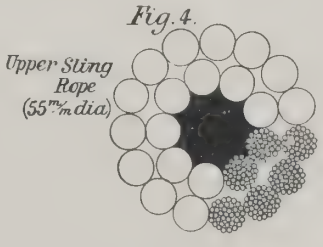


Fig. 5.

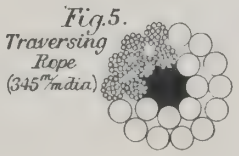


Fig. 6.

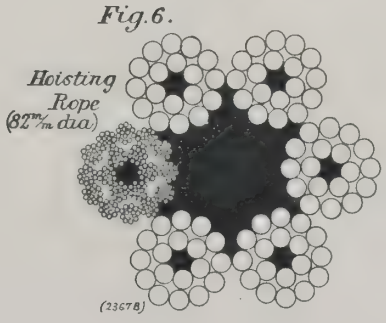
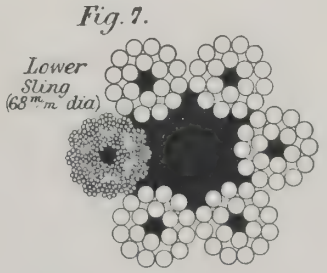


Fig. 7.



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DOUBLE CANTILEVER 120-TON FLOATING CRANE AT THE POLA DOCKYARD.

WE illustrate in our present issue a floating crane of exceptional size, which is now in use at the Austrian Naval Dockyard, Pola, on the Adriatic. The crane is designed to deal with the heaviest weights in ship construction and also, on an emergency, to raise sunken submarines. It was built by the Prager Maschinenbau-Actien-Gesellschaft, Prague, to whom we are indebted for the drawings from which our engravings have been prepared. Figs. 1 to 3, on Plate LXVI., are respectively a side elevation, an end elevation, and a plan of the crane; Figs. 4 to 7 on the same plate are sections through the various lengths of rope, to which we shall refer later. Figs. 8 and 9, above, give details of the winding gear. The lifting gear is illustrated in Figs. 10 and 11, on page 862, Fig. 12, on the same page, showing diagrammatically the arrangement of the winding and crab-traversing ropes. Fig. 13, on page 863, is a view of one side of the cantilever jib in course of erection on land, and Fig. 14, on page 866, is a general view of the crane afloat in Pola Dockyard.

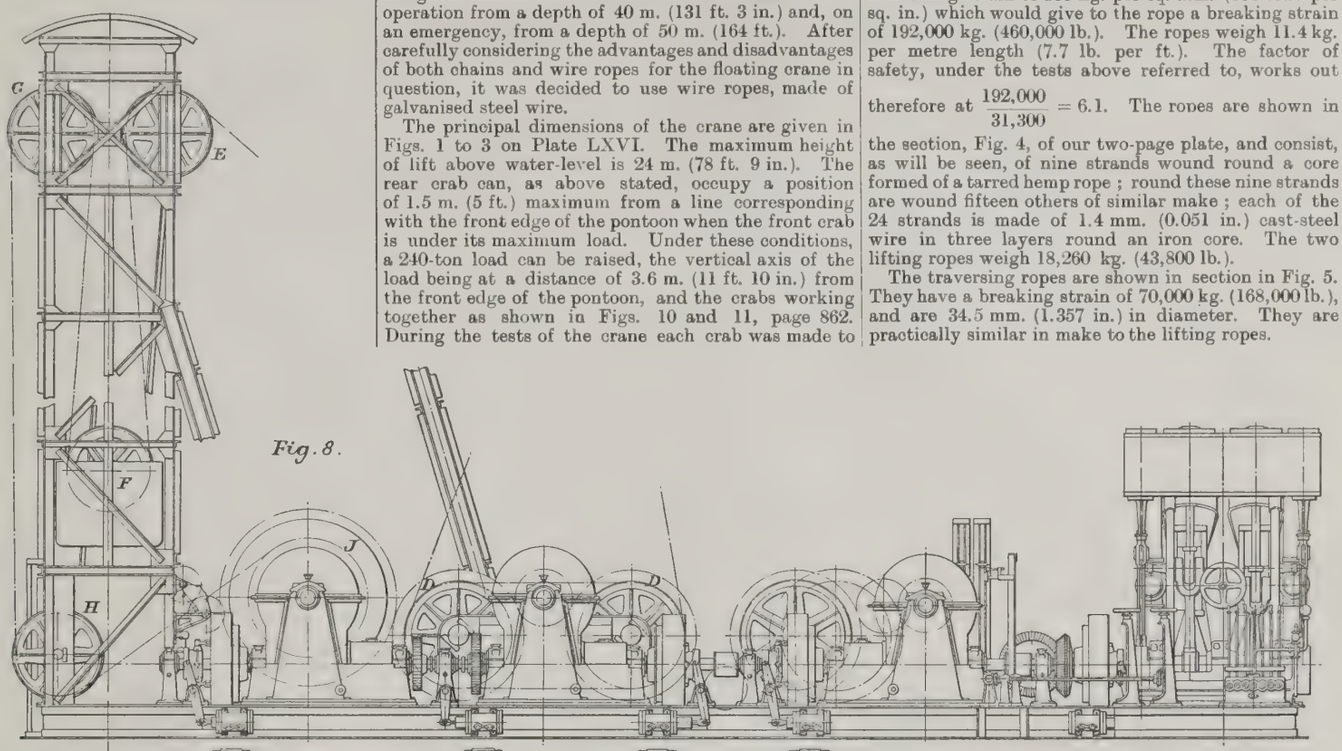


Fig. 8.

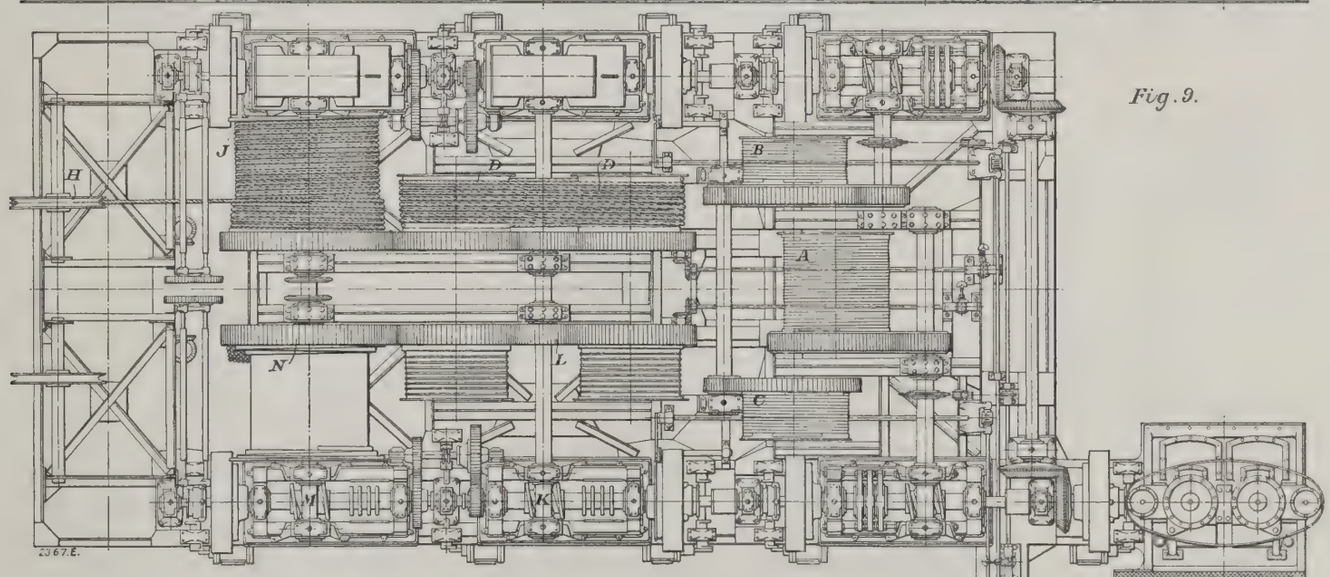


Fig. 9.

According to the specification, the crane had to be provided with two crabs, each having a lifting capacity of 120 tons, the crabs being so designed that both could be used simultaneously, especially for the lifting of submerged loads, in which case the rear crab has to work at a maximum distance of 1.5 m. (5 ft.) from a line corresponding with the front edge of the pontoon, the front crab being close against it. A kind of hatchway, measuring 7.6 m. (25 ft.) in length and 3.4 m. (11 ft. 2 in.) in width (see plan, Fig. 3) is cut through the whole height of the pontoon forward, through which the ropes from the rear crab can be led for lifting a sunken submarine. In this case, the ropes from the rear crab, passing down through the hatchway in question, would be secured round the aft end of the submarine, those from the front crab being secured round the forward end. By this means, the submarine could be raised sufficiently out of the water for rescuing the crew through the conning tower, when the necessary steps could be taken with more leisure for salving the submarine itself. The lifting gear and tackle are so designed that a sunken load can be raised in one operation from a depth of 40 m. (131 ft. 3 in.) and, on an emergency, from a depth of 50 m. (164 ft.). After carefully considering the advantages and disadvantages of both chains and wire ropes for the floating crane in question, it was decided to use wire ropes, made of galvanised steel wire.

The principal dimensions of the crane are given in Figs. 1 to 3 on Plate LXVI. The maximum height of lift above water-level is 24 m. (78 ft. 9 in.). The rear crab can, as above stated, occupy a position of 1.5 m. (5 ft.) maximum from a line corresponding with the front edge of the pontoon when the front crab is under its maximum load. Under these conditions, a 240-ton load can be raised, the vertical axis of the load being at a distance of 3.6 m. (11 ft. 10 in.) from the front edge of the pontoon, and the crabs working together as shown in Figs. 10 and 11, page 862. During the tests of the crane each crab was made to carry a load of 150 tons, the rear crab being at a distance of 1.5 m. (5 ft.) and the front crab at a distance of 14.5 m. (47 ft. 7 in.) from a line corresponding with the front edge of the pontoon.

When, in normal dockyard work, the front crab only is used, this can lift 120 tons at a distance of 14.5 m. (47 ft. 7 in.) and 90 tons at 18 m. (59 ft.) from the front edge of the pontoon. The arrangement of the ropes is shown in Fig. 12, page 862; as will be seen, all the ropes are placed symmetrically and all the forces converge towards a common centre. The traversing ropes are double for each crab and each direction of travel; they are on the endless system and run round the pulley at the forward end of the cantilever, Fig. 12. At first sight, the arrangement of the ropes appears somewhat complicated; but since both crabs travel on one and the same tracks, and the traversing and lifting ropes are designed to work simultaneously, provision had to be made for the ropes to run free one from the other. For the same reasons the tackle was designed wider than is usually the case. The purchase of the lifting tackle is 1 in 8, and the greatest pull of the rope on the capstan drum amounted to 31,300 kg. (75,000 lb.) under the test load above referred to.

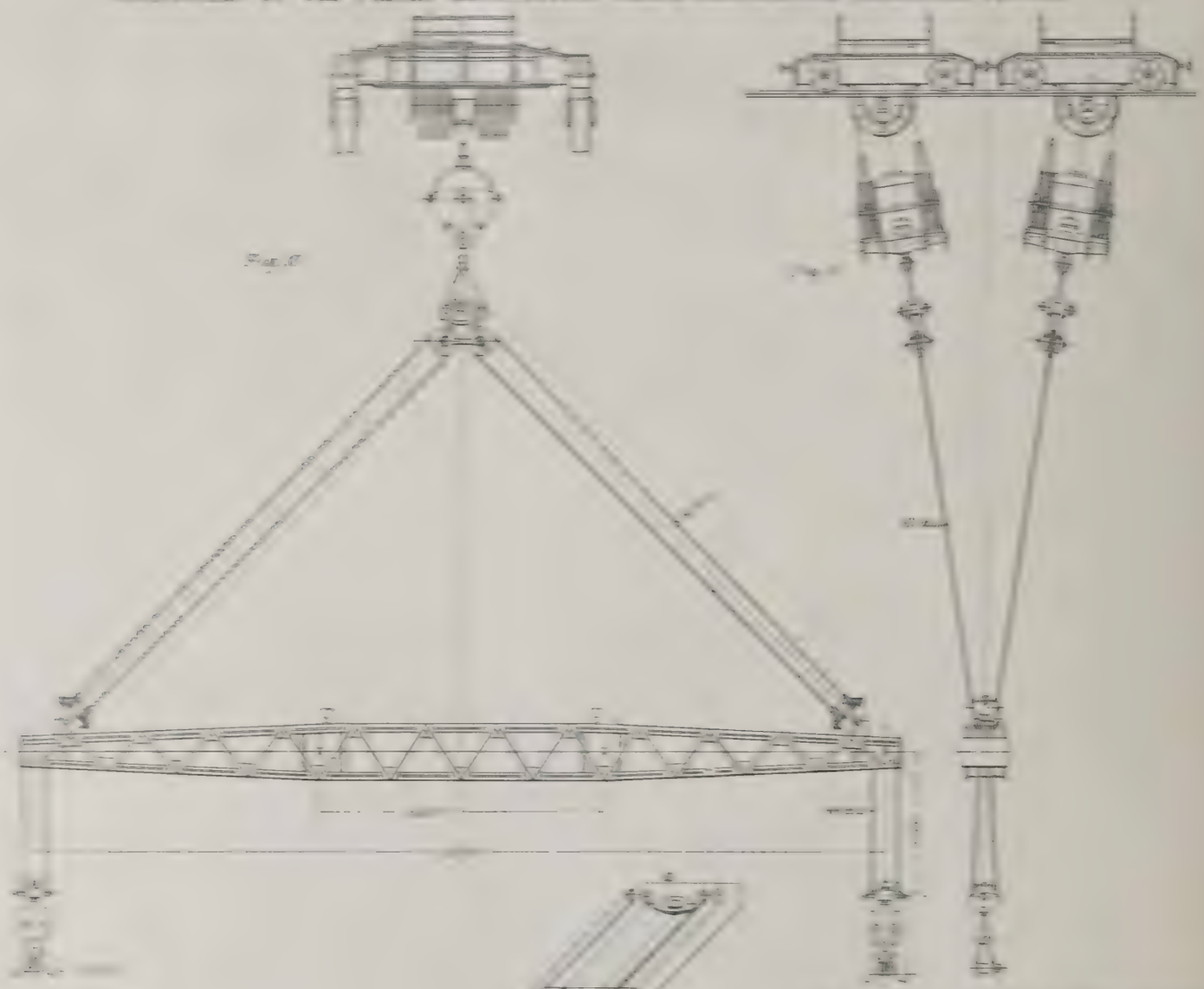
The ropes were manufactured by the St. Egyder Eisen- und Stahl-Industrie, Vienna. The strands are double, one on the other, so arranged that each part acts against the tendency of the other to twist; this ensures the rope remaining perfectly even and there is no risk of its turning. The two lifting ropes are each 800 m. (2625 ft.) in length, they are 55 mm. (2.16 in.) in diameter, and are made of 1.4 mm. (0.051 in.) cast-steel wire; the steel is stated to have a breaking strain of 160 kg. per sq. mm. (101 tons per sq. in.) which would give to the rope a breaking strain of 192,000 kg. (460,000 lb.). The ropes weigh 11.4 kg. per metre length (7.7 lb. per ft.). The factor of safety, under the tests above referred to, works out therefore at $\frac{192,000}{31,300} = 6.1$. The ropes are shown in the section, Fig. 4, of our two-page plate, and consist, as will be seen, of nine strands wound round a core formed of a tarred hemp rope; round these nine strands are wound fifteen others of similar make; each of the 24 strands is made of 1.4 mm. (0.051 in.) cast-steel wire in three layers round an iron core. The two lifting ropes weigh 18,260 kg. (43,800 lb.).

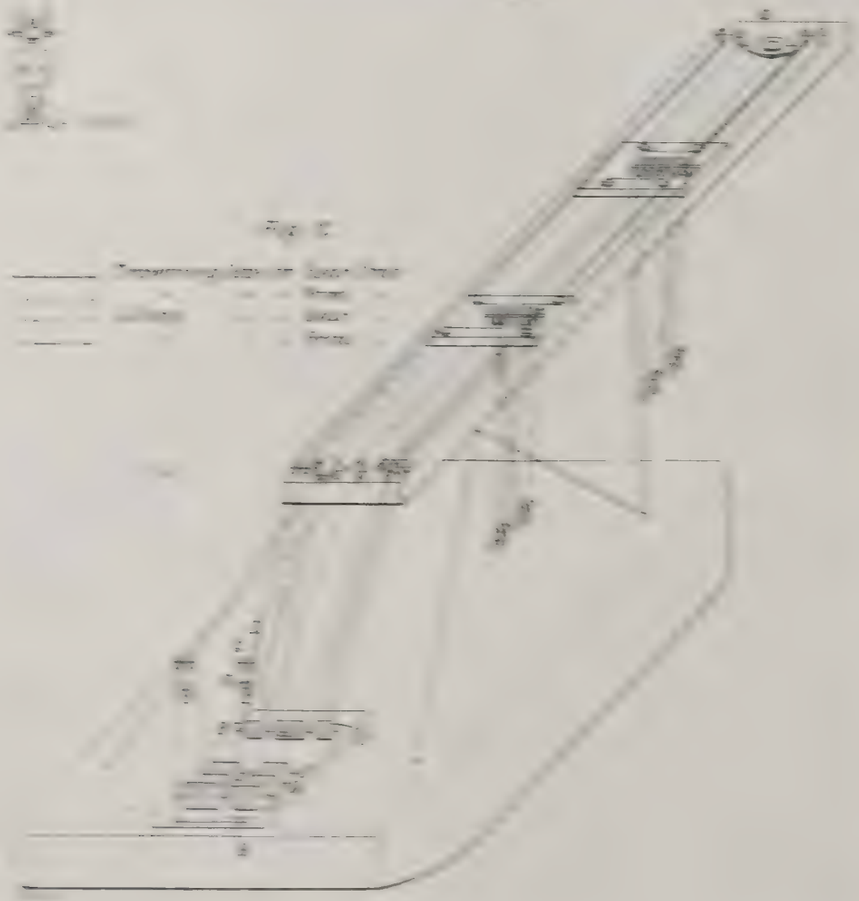
The traversing ropes are shown in section in Fig. 5. They have a breaking strain of 70,000 kg. (168,000 lb.), and are 34.5 mm. (1.357 in.) in diameter. They are practically similar in make to the lifting ropes.

The upper sling ropes of the lifting gear, shown in Figs. 10 and 11, are of cable type, and are illustrated in section in Fig. 6 of our two-page plate. They consist of a tarred hemp core, round which are wound six wire ropes; each of these ropes is formed of eighteen strands, wound round a tarred hemp core, each strand consisting of fourteen cast-steel wires, 1.25 mm. (0.049 in.) in diameter. The rope itself is 82 mm. (3.228 in.) in diameter, and has a 278,000-kg. (667,000 lb.) breaking strain. The lower sling ropes, shown in section in Fig. 7, are of similar make, of 1.1 mm. (0.042 in.) wires; they

DOUBLE CANTILEVER 150-TON FLOATING CRANE AT THE POLA DOCKYARD.

CONSTRUCTED BY THE MASCHINEN-BAU-GESELLSCHAFT ACTIEN-GESELLSCHAFT, DRESDEN. (With Plate.)





DOUBLE CANTILEVER 120-TON FLOATING CRANE AT THE POLA DOCKYARD.

CONSTRUCTED BY THE PRAGER MASCHINENBAU ACTIEN-GESELLSCHAFT, ENGINEERS, PRAGUE.

Fig. 13.

of the crane being 64 m. (210 ft.)—*i.e.*, 40 m. (131 ft. 3 in.) below, and 24 m. (78 ft. 9 in.) above water-level—and since the purchase is in the ratio of 1 : 8, each lifting-drum has to wind 8 × 64, or 512 m. (1680 ft.) of rope. The winding-drums are operated, according to the load, either by the endless screw and wheel K (Fig. 9) and the spur-wheel L, when the speed is a comparatively low one and the endless screw and wheel M runs loose, or the latter gear M is made to work, thus driving the spur-wheel N, when the gear K runs empty and the lifting speed is increased. The various couplings are set and released, and the change from slow to high speed are effected hydraulically from the driver's stand. The engine-room contains an hydraulic accumulator ; the pressure-pump connected with this is driven by a shaft with toothed-wheel gearing from the circulating-pump engine, from which it can be disconnected at will. Dial-plates show all the positions of the crabs and the loads. The crab-traversing mechanism is automatically cut out when the crabs have reached their extreme positions.

The crabs are shown on a small scale in Figs. 10 and 11 ; they are each carried on eight wheels cast in steel, means being provided to prevent all eccentric strains on the structure. There are four pulleys on each side of the vertical axis of each crab ; three of these are steel castings, and the fourth, which serves only to carry the hoisting-rope from one crab to the other, is of cast iron.

The crane proper, and the pontoon, are built throughout of ship-quality steel, having a strength of from 44 kg. to 55 kg. per sq. mm. (28 to 35 tons per sq. in.), and a minimum elongation of 20 per cent. on 200 mm. (8 in.). The legs of the crane are jointed on the deck of the pontoon, as shown in Figs. 1 to 3. On the deck are fitted four steam-capstans, of 5 tons each, two of which work in conjunction with a windlass. The boiler-room is below deck ; it contains three steam boilers and two steam feed-pumps. The engine-room contains two engines for propelling the crane, a small electric-lighting plant, a condenser, an air-pump, a steam-driven centrifugal cold-water pump, and a double-acting steam-driven centrifugal ballast-pump. The boilers are of the marine return-tube type, each of 94.3 sq. m. (1015 sq. ft.) heating surface, working at a pressure of 8 atmospheres (117 lb. per sq. in.).

The engines for propelling the crane are compound, having cylinders 350 mm. (13.78 in.) and 600 mm. (23.6 in.) in diameter, with a 380 mm. (15 in.) stroke, each developing 255 indicated horse-power at 165 revolutions. The cooling-water pumps have a capacity of about 1 cub. m. (220 gals.) per minute ; that of the ballast-pumps is about 8 cub. m. (282 cub. ft.) per minute. The condensing plant serves both for the propelling engines and the crane engines. The latter are twin-engines, with cylindrical slide-valves and link-motion reversing gear.

The pontoon was built by the Danubius Company, Fiume ; it is divided into ten compartments. The aft compartments are for the ballast ; a part of this is fixed ballast, consisting of concrete, and so proportioned that the crane when under no load floats approximately horizontally. The loads are balanced by adding water-ballast. Besides the bulkheads forming the compartments, longitudinal and transverse girders serve to strengthen the pontoon underneath the leg joints and the winding-drums. When the crane is under no load the pontoon has 1.8 m. (5 ft. 11 in.) freeboard, and the latitudinal metacentre of 22 m. (72 ft. 2 in.) ; when the crane carries a load of 240 tons, this latter is 14.83 m. (48 ft. 8 in.).

The following are the crane speeds :—

For lifting a load up to 30 tons in weight	4.5 m. (14 ft. 9 in.) per min.
For lifting a load up to 120 tons in weight	1.5 m. (4 ft. 11 in.) per min.
For lifting a load up to 240 tons in weight	0.75 m. (2 ft. 5 in). per min.

These speeds during the tests were exceeded by 20 to 25 per cent.

The crane can be propelled afloat at a speed of about 3.4 knots.

We have taken the above data from the "Mitteilungen aus dem Gebiete des Seewesens," Pola, drawings for the illustrations having, as we have already stated, been put at our disposal by the builders, the Prager Maschinenbau Actien-Gesellschaft.

The Trinity House Steamer "Alert."—Messrs. Ramage and Ferguson, Limited, launched on the 21st inst. the steel twin-screw steamer Alert for the Honourable Corporation of Trinity House, London. The dimensions are : Length, 198 ft. ; beam, 32 ft. ; depth moulded, 15 ft. 6 in. She is propelled by two sets of triple-expansion engines, having cylinders 12 in., 19¼ in., and 31 in. in diameter by 24 in. stroke, supplied with steam from two large boilers working at 180 lb. pressure. She is the third steamer built by Messrs. Ramage and Ferguson for the Corporation of Trinity House.

Trade Review.—We have received from Messrs. Bolling and Lowe, 2, Laurence Pountney-hill, E.C., an advance proof of their "Trade Review for 1911." This deals with the British coal and iron trade in general, with the copper and tin markets, and also with the situation in the iron and steel trades in the United States and in Germany. The opening statements in regard to the British trade are of a pessimistic nature, but the closing ones are very hopeful. The authors find at the present time "the political horizon to be clearer," there being besides "a feeling of confidence and cheerfulness as to the trade outlook for the coming year." This statement in regard to the trade outlook is a very satisfactory one.

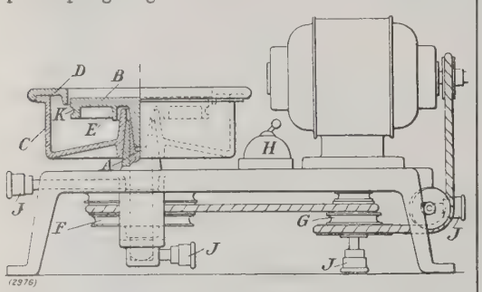
The Shipwrights' Company.—At the recent meeting of the Educational Trust Fund Committee of the Worshipful Company of Shipwrights, the annual grants were made to the following Universities and Institutions for the purpose of providing scholarships and prizes to students in naval architecture :—The University of Glasgow, a scholarship given by the Worshipful Company of Fishmongers ; the Royal Naval College, Greenwich, a scholarship given by the Worshipful Company of Skinners ; the University of Durham (Armstrong College), a scholarship. Sums of money for prizes, to be spent in books and instruments, were voted to the Portsmouth Education Committee, Devonport Municipal School of Science and Art, Sunderland Technical College, Glasgow and West of Scotland Technical College, the Education Department, Chatham, Sheerness Higher Education Committee, Clydebank Technical Institute, Sunderland Technical College, Dumbarton School of Science and Art, London County Council School of Engineering and Navigation, and the Technical Classes at Wallsend. Among those members of the committee who were present at the meeting were the following : Sir William H. White, K.C.B., F.R.S., chairman ; Mr. T. L. Devitt, Chairman of Lloyd's ; Sir Philip Watts, K.C.B., F.R.S. ; Professor J. H. Biles, LL.D. ; Dr. Clement Godson, V.D. ; Mr. J. Bell White ; the Right Hon. Sir Edward Clarke, K.C., P.C., and Mr. S. J. P. Thearle, D.Sc., the chief ship surveyor of Lloyd's. Application for assistance from young men studying naval architecture were laid before the committee, but owing to lack of funds had to be refused.

GRINDING AND POLISHING-MACHINE.

The use of the microscope in connection with metallurgical work has increased so much during late years that any appliance which lends itself to the reduction of labour in the production of specimens for examination under the microscope is worth consideration. We append an illustration of a simple and handy machine of this type. It has been designed and manufactured by Messrs. R. and J. Beck, Limited, 68, Cornhill, London, E.C., for grinding and polishing microscopical specimens for metallurgical work, and is shown in part sectional elevation in our illustration.

The spindle A is made of steel, and is bored out at the upper end to receive the disc upon which the polishing or grinding material is placed; the lower end is hardened to prevent undue wear. On this spindle is a speed cone F, with grooves of different diameters, driven by means of a cord from the driving-cone G, which is, in turn, rotated from the electric motor mounted at the end of the frame, as shown in our illustration. By shifting the belt on the cones a range of speeds varying from 300 to 1000 revolutions per minute may be obtained. The grinding disc B is made of brass, and fits into the spindle A by means of a tapered boss, which allows of its easy removal, and at the same time ensures accuracy in running. The grinding or polishing material is prevented from entering the bearing by the projecting lip E.

The polishing-cloth or the emery paper for grinding is fixed to the disc in a very simple way. A groove K is made in the edge of the disc, and the cloth or the paper is stretched over the surface of the disc, and is held there by means of a garter made of a stiff brass spiral spring ring which embraces the material and



presses it into the groove. It is found that with this arrangement the cloth or paper, no matter what its thickness may be, is held in close contact with the disc. In order to collect the spent polishing materials, a catcher C is placed round the disc. This catcher can be easily removed for cleaning, as it simply rests on a conical central support as shown. On to the top of the catcher C is fitted a guard-ring D, which, being wide, forms a rest for the hand. In addition, this guard-ring is continued downwards below the surface of the disc C, and as it nearly touches its edge, any specimens that should slip from the fingers while being polished are prevented from falling into the catcher. This ring is also used for stretching the paper or other material on the disc in the following way:—The catcher C being removed, the paper or polishing material is placed on the disc B, and the ring D is pressed over the paper until it is about half-way down the edge of the disc B. The spring garter is then stretched over the edge, and the ring D is pressed right down around the disc, and forces the garter spring home into the groove. Should it be desired to remove a piece of paper that has been fitted to the disc without disturbing the folds of the paper, the garter spring should be removed downwards, and the paper should be replaced in the manner described above. A cover is provided to protect the revolving disc from dust when it is not in use. Stauffer lubricators are provided at J.

Should a very delicate range of speeds be required, a rheostat can, in the case of direct current, be supplied to vary the speed of the motor. A switch H is supplied with the standard machine, and a flexible connecting-wire, with plug-adapter attached, for fitting to any ordinary electric lamp-holder. The motor can be supplied suitable for any direct current between 100 and 220 volts, or, if desired, it can be arranged to run on alternating current.

Empire Trade and Finance.—A series of addresses on the trade, industry, and finance of the British Empire will be delivered early in the new year by Mr. Ben. H. Morgan, F.S.S., F.R.C.I., at the London School of Economics (University of London). The first address will be given on January 24, and the subject will be "Problems of Empire." Five further addresses will be delivered fortnightly from the date mentioned, and will respectively deal with the material development of "Canada and Newfoundland," "Australia and New Zealand," "South Africa," "India and the Crown Colonies," and "The Empire's Resources," and will be open to men having business relations with the Empire over-seas, as well as to the students of the school.

THE TWELFTH INTERNATIONAL CONGRESS OF NAVIGATION.

This will be held in Philadelphia, beginning May 23, 1912, and H. E. William H. Taft, President of the United States, has accepted the invitation to be Head Patron. He will officially open the sessions in Philadelphia and receive the visiting scientists, engineers, and official representatives of foreign nations. The eleventh congress was held in St. Petersburg in 1908, under the patronage of the Czar. Popular interest in waterways development has largely increased in the United States within the last few years, and has resulted in the formation of a National Rivers and Harbours Congress, a body devoted to the general improvement of the waterways of the whole country.

Besides this there are special associations for the promotion of sectional improvements. One of these associations seeks to obtain the improvement of the Mississippi River, from the Great Lakes of the north to the Gulf of Mexico. Another is the Atlantic Deeper Waterways Association, which is promoting a system of inland canals to connect the navigable rivers along the Atlantic coast, as well as the deepening of these rivers. Many great engineering projects of this character are now under way in the United States, including the Cape Cod Ship Canal, which will cut off one of the most dangerous parts of the coastwise route along the stormy Atlantic coast, the deepening of the Delaware Channel above and below the port of Philadelphia, and the great canal connecting Lake Huron and Lake Superior.

It has been arranged that the delegates to the twelfth congress may see a number of these great engineering projects as guests of the Government. Excursions to the Cape Cod Canal, to the Great Lakes, and to other places have been planned. The proceedings of this congress will have an unusual importance, since it will be the last meeting before the opening of the Panama Canal, which will largely alter the shipping map of the western world. The papers and discussions will be divided between two general sections, one relating to ocean navigation and the other to inland waterways. The subjects to be covered are the maintenance and improvement of waterways, charting and protection of maritime routes, dimensions and construction of canals, docks and wharves, handling of water-borne commerce, &c. The offices of the United States Executive Committee are Room 344, The Bourse, Philadelphia, Pa.

The Royal Mail Steam Packet Company's New Intermediate Twin-Screw Steamers.—The Royal Mail Steam Packet Company have at present under construction at Messrs. Harland and Wolff, Limited, Belfast, three large twin-screw steamers, the Deseado, Demerara, and Desna, for the passenger service to Brazil and the River Plate. The second of this new class, the Demerara, was launched on the 21st inst.; her dimensions are:—length, 517 ft. 3 in.; breadth 62 ft. 3 in.; gross tonnage about 11,200 tons. The engines are arranged on the "balanced" principle.

The Air Resistance of Wires and Ropes.—With reference to the "Communications from the Göttingen Model-Testing Institute," published on page 548 of our issue of October 20th last, Dr.-Ing. Otto Föppl, the author of the notes on experiments on the air resistance of wires and ropes there dealt with, asks us to add that the results given in the *Zeitschrift für Flugtechnik* are only to be regarded in the light of a provisional abstract. The complete data concerning the results of tests with wires are published in the *Jahrbuch der Motorluftschiff-Studien-Gesellschaft*, 1910-1911, which was published in July last.

The British Fire-Prevention Committee.—Some tests were undertaken by this committee on Wednesday, the 13th inst., at their Regent's Park Testing-House Station. These comprised two high-temperature tests, with a thin metal fire-resisting partition, and with two thin-metal fire-resisting doors. The former was the 1½-hour standard fire-test, and the latter the 2-hour standard fire-test, both of them being followed by the application of water from a steam fire-engine. There was a large attendance of members and subscribers, including representatives from the Home Office, Admiralty, His Majesty's Office of Works, London County Council, and other public bodies, and the American Consulate was represented by its Vice-Consul, as the object under test was of American origin. An official report will be issued next month.

Oil-Engine-Driven Boat.—The German Petroleum Company has recently ordered a twin-screw boat from Messrs. J. Frerichs and Co., Limited, Osterholz-Scharmbeck and Einswarden (Oldenburg), which is to be propelled by crude-oil motors. The vessel will have a length of 94.8 m. (312 ft.) between perpendiculars; 13.4 m. (44 ft.) beam; and a moulded depth of 8 m. (26.2 ft.). Her total freight capacity is to be 4000 tons. She will be a full-decker, and will carry crude oil in bulk. The engines are to be installed at the aft end. They will consist of two reversible crude-oil marine motors, of approximately 1500 horse-power, giving the ship a speed of 10 knots. The engines are to be of Professor Junkers's type, for the construction of which Messrs. J. Frerichs and Co. have taken out a license. We gave an illustrated description of this engine on page 698 *ante*. The ship will be provided with a funnel to carry off the exhaust gases. An auxiliary boiler will be fitted for heating and for various other purposes. The ship is being built chiefly for the Roumanian oil trade.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning Cleveland warrants continued to advance, and dealing amounting to 10,500 tons took place at from 50s. 3d. to 50s. 5d. cash, 50s. 6d. six days, 50s. 7d. twenty-one and twenty-five days, 50s. 8½d. and 50s. 9d. one month, and from 51s. 3d. to 51s. 4d. three months. The closing quotations were 50s. 5½d. cash, 50s. 9d. one month, and 51s. 4½d. three months sellers. Hematite was quoted by sellers at 65s. cash and 66s. 1d. three months, and there were buyers for the latter position at 65s. 6d. The afternoon session was quiet, but Cleveland warrants were again on the rise, and 3500 tons were done at 50s. 6½d. cash, 50s. 10d. one month, and 51s. 1½d. February 13. Closing sellers quoted 50s. 7½d. cash, 50s. 11d. one month, and 51s. 6½d. three months. On Friday morning the market opened strong, but the close was weak, with sellers of Cleveland warrants at 50s. 1½d. cash, 50s. 5d. one month, and 51s. 1½d. three months. The business consisted of 11,000 tons at 50s. 5d. and 50s. 4d. cash, 50s. 2d. ten days, 50s. 9½d. and 50s. 9d. one month, and from 51s. 4d. to 51s. 2d. three months. One lot of hematite was done at 66s. three months, with closing cash sellers at 64s. 8d. In the afternoon the tone was a little firmer, and 1500 tons of Cleveland warrants were dealt in at 50s. 2½d. cash, and 50s. 6d. one month, and sellers' closing prices were 50s. 3½d. cash, 50s. 6½d. one month, and 51s. 2½d. three months. Buyers of hematite offered 65s. one month and 65s. 9d. three months, and sellers quoted 65s. cash and 66s. three months. Monday was a holiday, being Christmas Day, and the market also remained closed on Tuesday. When business was resumed to-day (Wednesday) the market was quiet, but Cleveland warrants were strong. The dealings totalled 5000 tons, at from 50s. 5d. to 50s. 6½d. cash, at 50s. 10½d. one month, and 51s. 5d. and 51s. 5½d. three months, with closing sellers over at 50s. 6½d. cash, 50s. 10d. one month, and 51s. 5½d. three months. Hematite was firmer, and 500 tons changed hands at 65s. 0½d. one month, with sellers over at 64s. 9d. cash, and 65s. 1½d. one month. In the afternoon the market was again strong, and 9500 tons of Cleveland warrants were put through at 50s. 7d. and 50s. 8½d. cash, 50s. 9d. seven and nine days, 50s. 10d. fourteen days, 51s. 6d. March, and 51s. 6d. and 51s. 6½d. three months. Closing sellers quoted 50s. 8½d. cash, 51s. 0½d. one month, and 51s. 7½d. three months. Hematite—1000 tons—changed hands at 64s. 9d. cash, and 66s. three months, with sellers over for the latter position. The following are the market quotations for makers' (No. 1) iron:—Clyde and Calder, 64s.; Gartsherrie, Summerlee, and Langloan, 64s. 6d.; and Coltness, 82s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 65s.; Shotts (at Leith), 64s.; and Carron (at Grangemouth), 65s. 6d.

Sulphate of Ammonia.—The demand for sulphate of ammonia has not been quite so urgent of late, owing to the holidays, but the price is well maintained. The current quotation is given as 14*l.* 5s. per ton for prompt delivery, Glasgow or Leith. Last week the total amount shipped from Leith Harbour was 303 tons.

Scotch Steel Trade.—The Scotch steel-makers are at present in the midst of a very busy time, and from all sides they are being inundated with pressing demands for delivery of material before stopping for the annual New Year holidays. Shipbuilders are requiring plates and angles in large quantities, and in endeavouring to overtake the demand producers are this week turning out a very heavy tonnage. Light steel material is also in good request, while sheet-makers are as busily employed as ever. The export inquiry is not so heavy at the moment, which is perhaps due to the Christmas holidays, but one or two satisfactory lines have been fixed up for different parts, including some of the Continental ports. The latter is mainly shipbuilding sections. Prices are very firm and the official quotations are being strictly adhered to. The holidays will commence on Friday evening of this week and work will not be resumed until the evening of Sunday, January 7, although some makers would have liked to make a re-start on Wednesday, January 3, if they could have been sure of getting the men in.

Malleable-Iron Trade.—There is little fresh to report in connection with the malleable-iron trade of the West of Scotland, and makers are experiencing a fair amount of activity. The pressure for delivery before the holidays is keeping the various works well employed this week. The stoppage will be similar to that in the steel trade.

Scotch Pig-Iron Trade: Advance in Prices.—At the end of last week the makers of Scotch pig iron raised their prices for prompt lots of the Nos. 1 and 3 qualities by 1s. per ton. Even at the advanced prices business in the ordinary qualities has been on a fairly heavy scale since last report. The bookings on local account have been done for the first three months of the New Year, and on English account for the first half of 1912, but sellers are not desirous of fixing up too much of their output at present values, as further advances are not improbable. Hematite is less active this week, but the current quotation is firmer at 68s. 6d. per ton.

British Columbia Electric Railway.—The gross earnings of the British Columbia Electric Railway Company in 1910-11 show an increase of 1,323,028 dols., or 43 per cent. The net income, including the amount derived from investments and subsidiaries, and allowing for renewals, shows an increase of 369,521 dols., or 34 per cent. For the quarter ending September 30 there was a further increase in the gross earnings of 401,783 dols., or 45 per cent., and in the net earnings of 63,283 dols., or 17 per cent.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

A Link with the Past.—In Sheffield the association of an industry with particular families through successive generations is no uncommon thing, but even in Sheffield a connection which extends back into the seventeenth century is rare. Such an industrial link with the past is about to be broken by the shutting-down of the works of Messrs. Thomas Staniforth and Co., Limited, scythe and sickle manufacturers, of Hackenthorpe, a village two or three miles outside the city's borders. Amongst earliest records of manufacturing in Sheffield the name of Staniforth is to be found, and a trade-mark in this name was one of the first to be granted in Sheffield of which any trace can be found. The oldest trade-mark at present in use by the firm is the "T. S.," which was granted to a Thomas Staniforth in 1743. At one time Messrs. Staniforth did the biggest English trade in sickles with the Russian market, and turned out as many as 1000 dozen of these implements per week. It was only quite recently that they also took up the manufacture of edge tools. The village of Hackenthorpe was formerly almost entirely dependent on the firm, which is now going into liquidation. In 1897, about the time of the death of the last surviving member of the family, Mr. William Staniforth, the firm was turned into a limited company.

South Yorkshire Coal Trade.—The coal trade locally remains in a very firm position. The small attendance on the Sheffield Exchange at the week-end was, of course, accounted for by the proximity of Christmas. Business in hard steam is very brisk, and the amount of work in the hands of the local manufacturers ensures a steady demand for some time to come. With the coal crisis looming on the near horizon, the exceptionally heavy buying in some quarters is easily understood. Shipments also are much bigger than at this time a year ago. Gas fuels are similarly well-placed, and a good deal of stocking is being done. All this activity means pressure at the collieries, and there is consequently no great quantity of coal on the open market, whilst prices are strongly held. In house coal, although there has been an improvement in inquiries both at pits and dépôts, the fact that the Christmas tonnages sent out are not on the usual large scale may be explained by the heavy buying during October. Mild weather has also, of course, exerted a considerable influence. In expectation of a rush of business within the next week or two, prices are being kept up, and there is likelihood of advances. Latest quotations are :—Best branch hand-picked, 14s. 6d. to 15s. 6d.; Barnsley best Silkstone, 12s. to 13s. ; Silkstone, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. to 11s.; large nuts, 9s. to 10s.; small nuts, 6s. to 7s. 6d.; Yorkshire hards, 9s. 6d. to 10s. 6d.; Derbyshire hards, 9s. 3d. to 10s. 3d. ; washed nuts, 8s. to 9s.; rough slacks, 6s. to 7s. 6d.; seconds, 5s. to 6s.; smalls, 2s. to 3s.

Iron and Steel.—As holidays have taken up most of the week under review there is little that is fresh to be said of the trade in iron and steel. But the Christmas stoppage this year is only a short one, so that there is no chance for any of the industries to lose ground, and, in fact, in many cases firms will resume work on orders which were due to be completed earlier, but have been held back by various circumstances which are so familiar to anyone interested in the local industries as not to need repetition. They include, of course, the effects, which are still felt, of the railway disturbances, and the pressure which was suddenly brought to bear on all departments, when the stemmed-up tide of orders was allowed to flow again. Looking back on the year there are few departments of Sheffield industry that have not abundant cause for satisfaction. Starting under good auspices, 1911 has proved in many ways a remarkable year. The armament firms, as it were, gave the lead, and the work in the hands of the three Sheffield firms by the second month in the year, estimated to be worth about 18 millions sterling, assured a solid foundation of prosperity for many months to come. That work has been increased by orders both from the home and foreign Governments and, latterly, it is of particular interest to note there has been marked activity in the projectile departments. A distinct revival in general engineering and in railway steel have also been features of the past twelve months, whilst the tool-makers have had one of the busiest periods in their history. So far as it is safe to make forecasts the first half, at any rate, of the New Year holds a rich store of prosperity. The iron market is strengthening its tone, and there is a stiffer tendency about hematite prices. Some makers have sold their output for months ahead, but there is a disinclination to quote too far forward as better prices are expected in the near future. Both the Derbyshire and Lincolnshire common-iron makers are doing well, and hold only light stocks. Bar iron also is active. New orders for all kinds of steels are coming in steadily, both on home and foreign account, and it is very probable that the New Year will see a general advance in the prices of many steel products. The railway steel firms are amongst the branches which are working overtime, as the companies are pressing for deliveries on contracts. The activity extends through the file trade, edge-tools, agricultural and mining implements and machinery, and all the lighter branches.

CANADIAN METALLURGY.—The Morgan Construction Company, of Worcester, Massachusetts, has been entrusted with the construction of a blooming mill, a continuous billet mill, and a continuous bar and rod mill for the Steel Company of Canada. The new mills are to be added to that company's plant at Hamilton, Ontario.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—For the year 1911 the estimated output of Cleveland ironstone was 6,250,000 tons, which is well up to the average of recent years. The largest output in twelve months was 6,756,055 tons in 1883; and the smallest, 4,625,530 tons in 1893. Foreign iron imported to the Middlesbrough district during the past twelve months is estimated at 1,730,000 tons, as compared with 2,091,624 tons for the previous year. During 1911 the highest price paid for best Rubio ore was 22s. 6d., and the lowest 19s. The total consumption of iron ore in the Middlesbrough district during the past year reached 7,980,000 tons. The estimated production of pig iron in the North of England in 1911 is given at 3,600,000 tons, as compared with 3,862,725 tons for the previous year. Of the 114 furnaces built in the North-Eastern district, 78 are in blast. The largest quantity of Cleveland pig iron ever stocked in the public warrant stores was 750,095 tons, at the end of 1906; and the smallest since the early days of the establishment of the stores in 1876 was 10,463 tons, in 1900. The stock of hematite pig iron in the public warrant stores disappeared altogether in March, 1906, and there has been no warrant hematite since.

Manufactured Iron and Steel.—All branches of the finished iron and steel trades are full up with orders, but this week holiday-making was pretty general. Prospects are bright and encouraging. Common iron bars are 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing-iron, 5*l.* 15s.; iron ship-plates, 6*l.* 10s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 7s. 6d.; iron girder-plates, 6*l.* 15s.; iron boiler-plates, 7*l.* 7s. 6d.; steel bars, 6*l.* 5s.; steel ship-plates, 7*l.*; steel ship-angles, 6*l.* 12s. 6d. ; steel boiler-plates, 7*l.* 10s.; steel strip, 6*l.* 10s. ; steel hoops, 6*l.* 12s. 6d.; and steel joists, 6*l.* 10s., all less the customary 2½ per cent. discount. Cast-iron columns are 6*l.* 10s. ; cast-iron railway chairs, 3*l.* 12s. 6d.; light iron rails, 6*l.* 10s.; heavy steel rails, 5*l.* 12s. 6d.; and steel railway sleepers, 6*l.* 10s., all net at works. Iron and steel galvanised corrugated sheets, 24 gauge, in bundles, stand at 11*l.* 10s., less 4 per cent. f.o.b.

THE HUMBOLDT COAL-SCREENING AND WASHING PLANT.—The British Humboldt Engineering Company, Limited, Dixon House, Lloyd's Avenue, E.C., are at the present time exhibiting at the Science Museum, South Kensington, the model of a coal-screening and washing plant built by them at their Cologne works for the Pit 5 of the Rheinpreussen Collieries, Westphalia. This plant washes the coal previous to classification. It consists of two units of a total capacity of 200 tons per hour. The model at the Kensington Museum is an exact reproduction of the actual installation, showing both the screening and the washing plant, the railway tracks, coal-towers, &c., and contains all the special appliances made use of, as, for instance, Humboldt jigs, double-crank screens, long fine-coal draining-belts, distributing-tables for coking coal, &c.

COLLIERY DEVELOPMENT NEAR DONCASTER.—The Barnsley bed has been reached at the Bulcroft Main Colliery, near Doncaster, at a depth of 657 yards, and the seam is 8 ft. 11 in. in thickness. The Bulcroft Main Colliery is one of the Sir A. B. Markham group, and sinking began in May, 1908. After going down 70 yards the sinkers were overpowered by a rush of water. The freezing process was introduced in November, 1910, and the progress made by the sinkers when they again got to work was slow, owing to the hardness of the rock, which had to be excavated. In March, this year, the sinkers passed through the strata which had been frozen, after which their progress became much more rapid. The result of the sinking supports the theories of mining experts with regard to the disposition of the eastern extension of the South Yorkshire coalfield. The Bulcroft Colliery Company was formed in April, 1908, to work the Barnsley seam under the estates of Messrs. Cooke, Anne, and others. The area to be worked comprises some 12,000 acres, and it is intended to sink two pairs of shafts.

THE GERMAN ELECTRICAL INDUSTRY.—The German electrical industry, or, in any case, the Siemens and Halske and Siemens-Schuckert Werke, has done exceedingly well during the last financial year. The two concerns are very closely allied, the former company, which has a capital of 63,000,000 marks, holding the greater part of the shares in the latter—viz., 45,050,000 marks—whilst the smaller part—viz., 44,950,000 marks—is held by the Elektricitäts Aktien Gesellschaft, vornals Schuckert and Co. Siemens and Halske, according to a preliminary notice from the Board, have had net profits, during the last financial year, amounting to 12,328,743 marks, against 11,504,258 marks for the previous year. As during the past few years, the dividend will be fixed at 12 per cent. The following table shows the continuous growth of the profits during the last eight years :—

	Net Profits.	Dividend.	Share Capital.
	marks	p.c.	marks.
1910-11	12,328,743	12	63,000,000
1909-10	11,504,258	12	63,000,000
1908-09	11,429,009	12	63,000,000
1907-08	9,688,263	11	54,500,000
1906-07	8,717,368	11	54,500,000
1905-06	7,964,729	10	54,500,000
1904-05	6,988,788	9	54,500,000
1903-04	5,537,404	7	54,500,000

As far as Siemens-Schuckert Werke is concerned, last year shows a still larger increase in the net profits—viz., 13,430,067 marks, against 10,602,481 marks for the previous year. The dividend will again be 10 per cent., 2,500,000 marks being placed to a new reserve fund.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Business in steam-coal has, of course, been a good deal affected by the holidays. Tonnage arrivals have continued scanty. Sellers have, however, been holding firmly for early shipment, as they expect that steamers delayed will shortly reach dock. A feature of the market has been an inquiry for tonnage for Italy, for loading, after the holidays. Smalls have been held forward firmly. The best Admiralty large coal has made 17s. to 17s. 6d. per ton, while secondary qualities have ranged between 15s. 6d. and 16s. 9d. per ton; best bunker smalls between 8s. 9d. and 9s. 3d.; and cargo smalls between 6s. 6d. and 7s. 3d. per ton. House-coal has been scarcely so firm; the best ordinary qualities have made 15s. 6d. to 16s. 6d. per ton; No. 3 Rhondda large between 17s. and 17s. 6d. per ton; and smalls between 9s. 9d. and 10s. per ton. No. 2 Rhondda large has brought 13s. to 13s. 3d. per ton; smalls, 6s. 3d. to 6s. 9d. per ton. Foundry coke has been quoted at 17s. 6d. to 20s. per ton, and furnace ditto at 15s. 6d. to 16s. 6d. per ton. As regards iron ore, Rubio has made 20s. 6d. to 21s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Aberpergwm Pits.—An undertaking has been registered under the style and title of the Aberpergwm Collieries, Limited. The company, which is to have a capital of 60,000*l.*, will adopt an agreement with Mr. G. R. J. Williams, of St. Donat's Castle, Llantwit Major, with respect to the Aberpergwm collieries.

Neath Water Undertaking.—A Bill has been deposited for the consideration of Parliament next session to extend the time for the construction of the works authorised by the Ystradfellte Water Act, 1902, and to confer further powers upon the Neath Rural District Council. By the Act of 1902 the Council was authorised to raise 162,300*l.* for lands and works, but that sum has been found insufficient, and a further 144,000*l.* is required.

Coastwise Coal Shipments.—The shipments of coal coastwise from Bristol Channel ports in November were 367,913 tons cargo and 19,983 tons bunkers, as compared with 395,287 tons cargo and 23,266 tons bunkers in November, 1910. In last month's shipments Cardiff figured for 208,693 tons cargo and 8654 tons bunkers.

Gauge Conversion Experience.—The death was announced on Monday of Mr. T. I. Allen, who, as superintendent of the line upon the Great Western Railway, and previously as a divisional superintendent, had a good deal to do with gauge conversion upon that important system. The conversion was commenced in 1868, and was not finally completed until 1892. In the first-mentioned year the Great Western Railway Company had 700 broad-gauge engines running over 1456 miles of track. Not only was the gauge changed, but longitudinal sleepers were also abandoned for cross sleepers. Mr. Allen passed his whole business life as a Great Western Railway official. He retired in 1903.

AMERICAN METALLURGY.—The production of pig in the United States in the eleven months ending November 30, this year, was 21,269,115 tons, as compared with 25,069,958 tons in the corresponding period of 1910, and 22,748,783 tons in the corresponding period of 1909. The total of 21,269,115 tons, representing the output to November 30, this year, was made up as follows :—First quarter, 5,724,946 tons ; second quarter, 5,745,108 tons ; third quarter, 5,696,807 tons; and October and November, over 4,100,000 tons.

THE STANDARDISATION OF COPPER TUBES.—The Birmingham and District Branch of the National Association of Master Heating and Domestic Engineers have drawn up a scale of tables of standardisation, which has been submitted for consideration at a meeting of the joint committee of the National Association and of the Institution of Heating and Ventilation Engineers, whose address is 12, Great James-street, Bedford-row, London, W.C. The tables, which deal with light, medium, and heavy tubes, are receiving the consideration of the Engineering Standards Committee.

CANADIAN RAILWAY EXTENSIONS.—The Grand Trunk Pacific Railway Company has built, this year, 98 stations upon its newly-developed line ; 27 more stations are in course of construction. The Canadian Northern Railway Company has considerably extended its system during the last twelve months. Steel rails have been laid to a point 61 miles west of the Sudbury and Port Arthur division, and a daily passenger service is being run to that point; there is also a tri-weekly freight service. Steel-rail laying on the last section of the Athabasca landing-line of the Canadian Northern Railway was commenced in November at Stoney Creek, 58 miles north of Edmonton. An unusually large working force is being maintained on the section, and it is expected that rails will reach the landing early in the new year. Notwithstanding that the equipment of Canadian railways is better and more extensive than at any former period, a car shortage has been experienced by farmers and grain-shippers in many parts of the Canadian West. The Valley Railway from St. John to Grand Falls is to be worked as part of the Inter-Colonial system, and will connect with the Grand Trunk Pacific Railway. A contract for the construction of the line is to be signed shortly, complete arrangements having now been made between the Provincial and Federal Governments. Freight from the West coming over the Grand Trunk Pacific Railway will reach St. John over the Valley Railway.

DOUBLE CANTILEVER 120-TON FLOATING CRANE AT THE POLA DOCKYARD.

CONSTRUCTED BY THE PRAGER MASCHINENBAU ACTIEN-GESELLSCHAFT, ENGINEERS, PRAGUE.

(*For Description, see Page 861.*)

Fig. 14.

AGENTS FOR "ENGINEERING."

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Turner and Henderson, Sydney, N.S.W.
T. Willmett and Co., Townsville, North Queensland.
W. C. Rigby, Adelaide, South Australia.
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EDINBURGH: John Menzies and Co., 12, Hanover-street.
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LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
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NORWAY, Christiana: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Long-street.
SWITZERLAND: Sole Agents for Advertisements: The Dean-Mayer Company, Linkstrasse 39, Berlin, W. 9, Germany.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
UNITED STATES, New York: W. H. Wiley, 43, East 19th-street.
Sole Agents for Advertisements:—The Wm. S. Parry Co., 315, Dearborn-street, Chicago, and 366, Fifth-avenue, New York, U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" can be supplied direct from the Publisher post free, for twelve months, at the following rates, payable in advance:—

For the United Kingdom	£1	9	2
For Canada—			
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NOTICES OF MEETINGS.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—A Christmas Course of Lectures, adapted to a Juvenile Auditory, on "The Childhood of Animals," by Mr. P. Chalmers Mitchell, LL.D., D.Sc., F.R.S., Secretary, Zoological Society of London. Saturday, December 30. (No. II.) The Duration of Youth. Tuesday, January 2, 1912. (No. III.) Colours and Patterns of Young Animals. Thursday, January 4. (No. IV.) Young Animals at Home. Saturday, January 6. (No. V.) The Feeding of Young Animals.

THE RÖNTGEN SOCIETY.—Tuesday, January 2, 1912, at 8.15 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. Papers on:—1. "The Clinical Significance of X-Ray and Radium Measurements," by Mr. Sidney Russ, B.Sc., Cancer Research Laboratory, Middlesex Hospital. 2. "The Right and the Wrong Side of the Picture; has a mistake been made?" by Mr. W. Cotton, M.D., Bristol.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 5, 1912, Presidential Address by Commendatore G. Marconi, on "Engineering Considerations in Wireless Telegraphy," has been postponed.

THE GEOLOGISTS' ASSOCIATION, LONDON.—Friday, January 5, 1912, at 8 p.m., at University College, Gower-street, W.C., when the following papers will be read:—"On the High Terrace Gravel and on a Palæolithic Implement Factory, Dartford Heath," by Mr. R. H. Chandler and Mr. A. L. Leach, F.G.S.; "On the London Clay and Bagshot Beds (Passage Beds), and on the Gravel of Shooter's Hill, Kent," by Mr. A. L. Leach, F.G.S. The lectures will be illustrated with lantern views.

READING-CASES.—Reading-cases which will hold twenty-six numbers of "ENGINEERING" may be had of the Publisher or of any newsagent. Price 6s. each.

ENGINEERING.

FRIDAY, DECEMBER 29, 1911.

RECENT PROGRESS IN WARSHIPS AND MACHINERY.

THE number and power of warships launched in a given year form as good an index as any of the extent to which provision is being made to conserve our sea supremacy, provided there are no abnormal conditions. This year there has been uninterrupted progress in connection with naval construction work, and as a result the warship tonnage launched has not been so high for many years, while the amount of new work ordered is satisfactory. Five battleships and three battle-cruisers have been launched, and this contribution of eight capital ships in one year must be reckoned as quite a good record, although two of the battle-cruisers are respectively to be the flagships of the Australian and New Zealand units of the Pacific Squadron, and are therefore not directly utilisable in the scheme of naval strategy in European waters. To take the place of these ships in the building-berths, four battleships have already been ordered, one each from the Devonport and Portsmouth dockyards, one from Messrs. Vickers, Limited, and one from Messrs. Wm. Beardmore and Co., Limited; a fifth ship—a battle-cruiser—will be ordered before the end of March. The light craft of the Fleet has been augmented by the launching of two protected and two unarmoured cruisers, twenty-three torpedo-boat destroyers, and five submarine-boats, while there are about to be ordered three unarmoured cruisers and six submarine boats, and there have already been ordered one protected cruiser and twenty torpedo-boat destroyers.

Forty-one fighting ships in all have thus been launched in 1911 for His Majesty's Fleet, being three more than in the previous year and twelve more than in 1909. The aggregate displacement tonnage of the ships launched in the year now closing makes up 220,980 tons, which compares with 130,851 tons in the previous year, and with 97,044 tons in 1909. The horse-power of the propelling machinery shows an equally marked increase, due to the steady advance in the speed of ships, notwithstanding their great size and, therefore, the greater driving power required. Thus the collective horse-power of the engines of all the fighting ships launched totals 722,300 horse-power; a small part of this is of the internal-combustion type for driving submarine-boats, but the preponderating part is turbine machinery. The total is 130,000 horse-power more than in the previous year, and 324,000 horse-power more than in 1909. The ships launched this year will, when completed, represent approximately a value 17,820,000*l.*, whereas last year the figure was about 11,000,000*l.*, and that for the previous year 8,700,000*l.* The detailed figures for several years are given in Table I. on page 868.

The battleships included in this year's list are the King George V. and the Centurion, launched respectively at Portsmouth and Devonport, and being supplied with their machinery by the Parsons Marine Steam-Turbine Company, Limited, and Messrs. Hawthorn, Leslie, and Co., Limited. Three ships of the line were also launched from private works—the Thunderer, by the Thames Iron-Works and Shipbuilding Company, Limited; the Conqueror, by Messrs. Wm. Beardmore and Co., Limited; and the Monarch, by Sir W. G. Armstrong, Whitworth, and Co., Limited. The two dockyard ships named belong to a new class; the three others are of the Orion type. All of them are fitted with 13.5-in. guns. It must be accepted as creditable and perhaps comforting that we have obtained such a great lead among the nations in the fitting of these more powerful weapons in our ships, as we have now afloat—all rapidly approaching commission—ten ships fitted with this new gun, while two others will be launched in a few months. The weapon proved on the trials of the Orion to be all that was desired, and it is further gratifying to know that notwithstanding the increase of power of attack, neither the defensive efficiency nor the speed of the ships has been adversely affected. The newer ships, in addition to mounting ten of the 13.5-in. guns, will have more powerful torpedo-repelling guns than any of their predecessors, and these, moreover, will be so arranged as to enable them to be effectually protected behind armour. It is not desirable at this juncture to say more than this.

The battle-cruisers launched are the Princess Royal, built by Messrs. Vickers, Limited, Barrow, the New Zealand, built by the Fairfield Shipbuilding and Engineering Company, Limited, Glasgow, and the Australia, built by Messrs. John Brown and Co., Limited, Clydebank, the turbines in each case being supplied by the builders of the ship. The two latter vessels are being built, under Admiralty supervision, to the order and at the expense of the Colonies, and they will serve as flagships for the units of the Pacific Fleet, to be maintained by the respective Governments for whom the vessels are being constructed. The colonial ships are of the Indefatigable class, their displacement being 18,800 tons (see ENGINEERING, page 70 *ante*). The Princess Royal is of the same type as the Lion, for which also Messrs. Vickers, Limited, have provided the machinery. This latter vessel is now at sea on her trials, and these will be watched with the greatest interest, as the ship is not only the most powerful cruiser yet built, but has an installation of turbine machinery which is only equalled by that in the Mauretania and Lusitania, so that her speed performance is expected to show a considerable advance on anything yet done by armoured fighting ships. A third battle-cruiser of the class—the Queen Mary—has been laid down this year at the works of the Palmer Iron and Shipbuilding Company, Limited, Jarrow-on-Tyne, and a fourth will be ordered in a few months. These vessels are 660 ft. long between perpendiculars and of 89 ft. beam, their displacement tonnage being 27,000 tons. They have armoured protection and a broadside gun-fire equal to any of our battleships.

Of protected cruisers there have been launched four, three of the "Town" class—the Dartmouth, by Messrs. Vickers, Limited, the Yarmouth, by the London and Glasgow Shipbuilding and Engineering Company, Limited, and the Chatham, from Chatham Dockyard, the machinery for this last being by the Thames Iron-Works. The fourth cruiser included in the list of the year's launches is of lighter type, the Active being about 3400 tons, with turbines of 18,000 horse-power, by Messrs. Hawthorn, Leslie, and Co. Quite a succession of these vessels have come from the Pembroke Dockyard, their feature being their high speed, their designed rate of 25 knots having in all cases been exceeded. The earlier boats were equipped with 4-in. guns, of which they carry ten, but in the later boats there has been an advance in this respect. Indeed, it might be said of almost all our ships that periodically there seems to have been exercised, voluntarily or compulsorily, a determination to reduce size, and it has not infrequently happened that in this reduction gun-power has suffered; thus, alike with battleships, armoured cruisers, scouts and destroyers, during the last few years, each successive ship has grown, in order that heavier guns might be installed. This upward trend continues. The higher results are achieved with a surprisingly small addition to displacement, without any diminution in speed, and with a comparatively small augmentation of the power of the propelling machinery.

In regard to destroyers, twenty-three have this year been launched, including one for the Colonies. Messrs. Denny, of Dumbarton, launched five—the

Sheldrake, Badger, Beaver, Defender, and Druid: and Messrs. Yarrow, Scotstoun, Glasgow, five also the Archer, Attack, Firedrake, Lurcher, and Oak. Messrs. Thornycroft, Woolston, launched three—the Minstrel, Acheron, and Ariel; Messrs. Hawthorn, Leslie, and Co., Newcastle-on-Tyne, three—the Nymph, Jackal, and Tigress; Messrs. John Brown and Co., Clydebank, two—the Hind and Hornet; and Messrs. Cammell Laird and Co., Birkenhead, two—the Lapwing and Lizard. One each was launched by Messrs. Vickers, Limited (the Phœnix); Messrs. Wm. Beardmore and Co., Limited, Dalmuir (the Goshawk); and Messrs. Swan, Hunter, and Wigham Richardson, Wallsend-on-Tyne (the Sandfly), this last being engined by the Wallsend Slipway and Engineering Company, Limited. There was launched also a coastguard cruiser by Messrs. Hall, Russell, and Co., of Aberdeen; two tenders for submarine depôt-ships—the Adamant and Electra—of 830 tons displacement, 1400 horse-power and 15 knots speed, by Messrs. Cammell Laird and Co., Limited, Birkenhead; and a surveying vessel. These latter, however, are non-fighting ships and are not included in the table already referred to.

Table I.—*Fighting Ships Launched.*

		No.	Tons.	Horse-Power.	Value of Ships Completed.
					£
In 1911.	Dockyards	6	55,600	106,200	4,370,000
	Private yards (H.M.S.)	35	165,380	616,100	13,450,000
	,, ,, (foreign)	3	5,494	17,000	700,000
	Total in 1911 ..	44	226,474	739,300	18,520,000
In 1910.	Dockyards	5	52,852	116,200	3,075,000
	Private yards (H.M.S.)	33	77,999	476,600	7,890,000
	,, ,, (foreign)	3	1,336	20,200	230,000
	Total in 1910 ..	41	132,187	613,000	11,195,000
In 1909.	Dockyards	6	46,320	109,200	4,390,000
	Private yards (H.M.S.)	23	50,724	288,800	4,315,000
	,, ,, (foreign)	9	28,016	96,600	2,920,000
	Total in 1909 ..	38	125,060	494,600	11,625,000
	Total in 1908 ..	36	74,976	219,850	8,235,000
	Total in 1907 ..	33	132,679	388,835	13,612,000
	Total in 1906 ..	27	108,040	217,200	10,636,000
	Total in 1905 ..	27	129,945	260,600	12,047,000
	Total in 1904 ..	40	127,452	363,200	10,737,000
	Total in 1903 ..	42	152,983	337,290	12,600,000
	Total in 1902 ..	22	93,044	193,550	7,076,000
	Total in 1901 ..	39	211,542	436,700	16,243,800

The vessels launched for foreign navies included two cruisers for China—one by Messrs. Vickers, Limited,* and one by Sir W. G. Armstrong, Whitworth, and Co., Limited, and a torpedo-boat for Denmark by Messrs. Yarrow, Limited.† The amount of foreign warship work in progress is greater than for a long time, and includes four capital ships, a battleship for Turkey, and a battle-cruiser for Japan, being built at Barrow; a battleship for Brazil, and one for Chili, being built at Elswick. These four ships represent the highest step yet taken in warship design in their respective classes, and establish the fact that our contracting firms are capable of leading the world in this branch of applied science. In addition there are a number of foreign torpedo-boat craft in progress.

The year has been a particularly busy one for the department of the Engineer-in-Chief, owing to the large number of important steam trials of new ships. The results of the trials of armoured and protected ships are set out in Table II., and of torpedo-boat destroyers in Table III. Before alluding to these trials, a word may be said regarding the remarkable success achieved, alike in the dockyards and in the contractors' works, in maintaining progress up to the completion of ships according to time estimates, and to the facility with which battleships are built in two years. The case of the Orion may be taken as typical, as she was the first of a new class, and is the prototype of the ships with 13.5-in. guns. In her case the keel was laid at Portsmouth on November 29, 1909, and the vessel was launched on August 20 following. The guns and gun-mountings, for which the Vickers Company were the contractors, involved new departures, particularly to ensure the same rapidity of fire as with the lighter projectile of the 12-in. gun, and to minimise not only the area of the barbette, but the weight of the ordnance machinery. The gun-mountings for the ten large guns were completed on board the Orion by June last. The whole of the armour was fitted in the ship between May, 1910, and June, 1911, the vessel for this purpose being placed in one of the dry docks at Portsmouth Dockyard. The propelling machinery was supplied by the Wallsend Slipway and Engineering Company, and equally rapid work was achieved by them. The contract was formally placed with the company on December 3, 1909. When it is stated that the machinery developed 29,000 horse-power at the full-power trial, a full measure of credit will be given to the contracting company for the construction of this machinery within eleven months, the machinery being assembled complete at the works by November 29 of last year. It was finished on board by August 25 last, six days in advance of the specified date. The steam trials were completed on September 18 last, and the acceptance trial was run on November 24. The vessel will be formally passed into the Fleet on January 3. These dates, of themselves, carry conviction regarding the remarkable organisation of the dockyard, which, like all the other Government establishments, is in charge of Sir James Marshall, K.C.B., Director of Dockyards. When one recalls the time taken to build ships fifteen or twenty years ago, it will be conceded that the Royal yards have been enormously improved, much to the financial and material benefit of the Service.

* See page 826 *ante*.
† See page 525 *ante*.

TABLE II.—Steam Trials of His Majesty's Armoured and Protected Ships in 1911.

Name of Vessel.	Type of Vessel.	Builders of Vessel.	Makers of Machinery.	Displacement, Tons.	Type of Boilers.	Low-Power Trial.		High-Power Trial.		Full-Power Trial.	
						H.-P.	Coal per H.-P. per Hour.	H.-P.	Coal per H.-P. per Hour.	H.-P.	Coal or Equivalent Coal per H.-P. per Hour.
Neptune	Battleship	Portsmouth Yard	Harland and Wolff	19,900	Yarrow	7,745	3.1	18,373	1.7	27,721	1.4
Hercules	Ditto	Palmers	Palmers	20,000	Ditto	12,571	2.4	18,063	2.1	26,599	2.0
Orion	Ditto	Portsmouth	Parsons	22,500	Babcock & Wilcox	..	..	18,966	1.8	29,108	1.6
Colossus	Ditto	Scotts	Scotts	20,000	Ditto	6,454	2.4	19,175	1.7	29,317	1.6
Monarch	Ditto	Armstrong Co.	Hawthorn, Leslie, and Co.	22,500	Yarrow	..	..	19,128	1.8	28,555	1.9
Indefatigable	Cruiser	Devonport Yard	John Brown and Co.	18,750	Babcock & Wilcox	10,808	2.1	31,717.9	1.6	47,135	1.5
Falmouth	Second-class cruiser	Beardmore and Co.	Beardmore and Co.	5,250	Yarrow	13,985	1.6	18,374	1.8	26311.7	1.4
Dartmouth	Ditto	Vickers, Ltd.	Vickers, Ltd.	5,250	Ditto	14,287	1.7	18,839	1.7	23,467	1.8
Weymouth	Ditto	Armstrong	Parsons	5,250	Ditto	13,661	1.6	18,076	1.4	23,532	1.4
Blonde	Small cruiser	Pembroke Yard	Cammell Laird	3,350	Ditto	4,339	2.0	15,333	1.6	18,770	1.5
Active	Ditto	Ditto	Hawthorn, Leslie, and Co.	3,500	Ditto	4,044	1.9	15,385	1.4	19,498	1.5

Table III.—*Trials of Turbine Torpedo-Boat Destroyers in* 1911.

Name of Vessel.	Builders of Vessel and Makers of Machinery.	Speed on Full-Power Trial.
		knots
Nautilus ..	Thames Iron-Works Company	26.7
Alarm*	J. Brown and Co.	27.2
Brisk*	Ditto	27.6
Goldfinch* ..	Fairfield Company	28.0
Fury*	A. and J. Inglis	27.3
Hope*	Swan, Hunter, and Wigham Richardson; Machinery by Wallsend Slipway and Engineering Co.	27.1
Martin* .	Thornycroft and Co.	28.9
Minstrel* ..	Ditto	28.9
Nemesis* ..	Hawthorn, Leslie, and Co.	27.0
Nereide* ..	Ditto	27.8
Nymph* ..	Ditto	27.5
Rifleman* ..	J. S. White and Co.	26.6
Ruby* ..	Ditto	29.3
Sheldrake* ..	Denny, Dumbarton	28.3
Staunch* ..	Ditto	28.6
Acheron ..	Thornycroft and Co.	29.4
Ariel .. .	Ditto	29.4
Defender† ..	Denny and Co.,	28.3
Ferret† ..	J. S. White and Co.	30.1
Forester† ..	Ditto	29.8
Hind† . ..	J. Brown and Co.	28.1
Jackal† ..	Hawthorn, Leslie, and Co.	26.9
Sandfly† ..	Swan, Hunter, and Wigham Richardson: Machinery by Wallsend Slipway and Engineering Co.	27.2

Five battleships, including the Orion, have passed successfully through their trials this year, two of them being Portsmouth Dockyard ships, while the others are by the firms named in Table II. The conditions attending the trials vary, and it would be a mistake to establish a close comparison between the performances. Moreover, the displacements of the ships differ: the Orion and the Monarch are of greater displacement than the others, and consequently greater power was required to ensure that the same high speed as in the earlier battleships would be realised—namely, between 21 and 22 knots. As typical of speed results, it may be noted that the last of the battleships tried—the Monarch—attained a mean of 21.88 knots on the measured-distance runs during the full-power eight hours' trial. The Admiralty are very wisely making practical experiments in all types of ships, in order to ascertain the most efficient propellers; this is most economically done by arranging for differently proportioned propellers in ships of the same class, so that results of running over a lengthened period, under service conditions, can be utilised to collate data. The propeller best suited for ships of given size and form is thus determined, and opportunity is taken, in renewing propellers, to fit the ships with the most suitable screws. This is the most reliable method of studying the problem, which can scarcely be solved accurately by the ordinary means of experimenting on models in tanks. As the possible gain in economy is considerable, the ultimate advantage in increased speed for a given power compensates liberally for the expenditure incurred in such trial of different propellers in the ships of a class. As regards the coal consumption of the battleships on the list, it will be seen that on the long trial at what is called high power the average is 1.8 lb., while on the full-power eight hours' test, when both coal and oil are used, the consumption, stated in terms of coal, averaged 1.7 lb. per shaft horse-power per hour. As every safeguard is adopted to secure service conditions, these results must be reckoned as satisfactory; the fuel required to generate steam for all the auxiliary machinery is included.

The Indefatigable is one of the large-powered ships, with a legend speed of 25 knots, which was far exceeded on the trial; in this case the fuel consumption at full speed worked out at only 1½ lb. per shaft horse-power per hour. There are three of the "Town" class of cruisers included in Table I. These are ships also of the legend speed of 25 knots, but on trial they each steamed practically 26 knots, and here the consumption, notably at full power, was remarkably low, being 1.4 lb. in the case of two of the vessels. The Blonde and the Active, built at Pembroke, have already been referred to, and both vessels, like their predecessors, have proved most economical ships, the consumption averaging, at both the high-power and full-power trials, 1.5 lb. In their case also the speed was practically 26 knots. In the case of all these ships the propelling machinery was of the Parsons turbine type.

Table III. records the results of the trials of the twenty-three torpedo-boat destroyers which have been passed into the Service during the year. Here, again, we deprecate any attempt at comparison. The destroyers which have an asterisk opposite to them have been built to the same design and specification, prepared by Sir Philip Watts, K.C.B.; but the machinery differs in many instances, and the conditions of trials varied. These vessels have a length of 240 ft., a beam of 25 ft. 6 in., and at a draught of 7 ft. 10 in. displace 780 tons. The machinery was designed to develop 13,500 horse-power, which, it was anticipated, would give a speed of 27 knots. It will be seen that this was exceeded in most cases, the rate ranging up to 29.3 knots. Allowance, however, must be made, not only for the weather conditions, but also for the depth of water over which the measured-mile speed trials were made, as this has time and again proved to be a factor greatly influencing results. An important fact, however, brought out by the table is that no difficulty has been experienced in getting under

service conditions the speed anticipated in the design. The vessels marked with a dagger have also been designed by Sir Philip Watts, and belong to the 1910-11 programme. Here also the results are obviously affected by depth of water.

Interest attaches to the Acheron and Ariel, included among the British torpedo-boat destroyers tried in 1911, as these two vessels are the first to be fitted with the Parsons compound impulse and reaction turbine. At the same time two vessels, the Attack and Archer, ordered from Messrs. Yarrow, are to be fitted with the Brown-Curtis turbine; while two others, the Badger and Beaver, to be built by Messrs. Denny, of Dumbarton, are being fitted with special turbine arrangements. All of these vessels are of the twin-screw type, and interest will attach not only to the speed attained, but to the fact that in each case the builders of the boat are the designers of the hull as well. This introduces a variant which somewhat affects the determination of relative efficiency, but gain will result from the point of view of experience, as the Admiralty will be placed in possession of reliable data when the vessels are in service, not only in respect of the fuel economy, but also of the propulsive efficiency. The tendency is distinctly towards the adoption of twin screws, both in destroyers and the smaller cruisers; all of the vessels of this class ordered this year have turbine machinery arranged in two separate units, and the trials of the three pairs of vessels already referred to must influence design in the future. At the same time, as has already been recorded, the engineering department at the Admiralty are vigilantly watching developments in the marine oil-engine, and work is proceeding with the building of a destroyer corresponding to those referred to, but fitted with an oil-engine on the centre shaft and turbines on the wing shafts. Other experimental work is in progress, and although the action taken may not be so rapid as the irresponsible critic contends for or the imaginative journalist records, it must be remembered that possibilities of failure in the machinery of a warship involve certainty of disaster, which would have a far-reaching effect. What, therefore, is required at the Admiralty in connection with the provision of material for the Fleet is progress tempered with that caution and discretion without which absolute reliability cannot be guaranteed. We have never lagged behind in the design of hulls, and in the provision of the most powerful armament, of effective armour, or of the most satisfactory propelling machinery, and absolute reliance can be placed, in the future, as in the past, on the technical officers responsible for this work, notably upon the Engineer-in-Chief of the Fleet, Sir Henry Oram; while, on the other hand, there is equal certainty that under Sir William Smith, the new Director of Naval Construction, as under Sir Philip Watts, the high traditions of the Royal Corps of Naval Constructors will be maintained.

NORWAY'S IRON-ORE DEPOSITS.

IT is only within the last few years that the importance of Norway's iron-ore deposits, thanks to more rational methods of handling them, has been duly realised; and it is particularly the electric smelting processes which have evidenced the value of the vast Norwegian iron-ore deposits. Some time ago the Department for Commerce, Shipping, and Industry appointed a special committee to investigate the question, and a very full and interesting report, or rather, two reports, is the result. The second portion, drawn up by Professor I. H. L. Vogt, deals with the above subject. The different kinds of Norwegian iron-ore are scheduled in a number of different classes, according to their geological origin.

The first class is ore more especially adapted for the concentrating process, as it only averages some 35 per cent. iron = about 50 per cent. magnetite, or specular iron ore, the rest being principally quartz. These deposits contain only magnetite, as in the vast deposits in South Varanger, or a mixture of magnetite and specular ore, as in the group of deposits in Fiskefjorden-Blokken-Gullesfjorden-Öksfjorden, in Vesteraalen and Lofoten.

The second class comprises ore richer in iron—from 50 to 55 per cent. and 65 per cent., and in some, but not all, deposits with a high percentage of apatite or phosphorus. Geologically, but not as regards extent, these deposits resemble the Gellivare deposits in Sweden. To this class belong a number of less important deposits in Lofoten. The Solberg mine, near Näs Iron Works, the Lyngrot mine (with much apatite), and the Söftestad deposits, with an average of 59 to 60 per cent. of iron.

The third class refers to iron ore in monzonite, at Hindö, with practically none, or a very small percentage, of titanium, several small deposits with 50 to 55 per cent. iron, and several larger deposits with concentration ore. The fourth class comprises iron-ore deposits in the pyrite districts, and geologically often in close connection with pyrite deposits. They are found in several places. Titanic iron constitutes classes 4 and 5; the former, ilmenite, occurs, for instance, in the large deposits at Ekersund; and the latter, titano-magnetite, in numerous deposits in various parts of the country. Iron ore, free from titanium in its various forms, accounts for classes 7 to 14, and refers to a number of deposits in some of which the ore is of exceptional quality, but the extent of the ore is often limited. Although the rational exploitation of the Norwegian iron-ore deposits may be said to be still in its infancy, the output (and export) has been many times doubled during the present century, the highest figures given, for 1907, being respectively 136,000 tons and 132,593 tons.

In Northern Norway, in the Tromsö district, there are some very important iron-ore deposits of the Dunderland-Salangen type, all of which only contain concentration ore, and the same, with less important exceptions, also applies to the South Varanger deposits in East Finmarken, and to the Hindön deposits. In Lofoten-Vesteraalen and adjoining districts there are several, mostly smaller, deposits of iron ore, free from, or at any rate very poor in, titanium; iron-ore deposits with titanium are also found in the locality. In the area, some 5 miles broad, between the Langfjord and the Pasvik River there is, in the striped gneiss-granite, an immense quantity of iron-ore deposits, more especially in a strip some 9 miles long and $1\frac{1}{4}$ to $2\frac{1}{2}$ miles broad, within which the South Varanger Company owns deposits of all sizes from 1 mile in length or more, and up to a depth of 170 m. to small pockets, a few feet in extent. The ore is markedly striped, resembling the Swedish Striberg ore. In some places the iron ore forms large surface mounds—at Urfjeld, for instance, where it rises to a height of 168 m. above sea-level. The average per cent. of iron in the deposits likely to be worked ranges between 35 and 37 per cent., that of phosphorus from 0.01 to 0.07 per cent., averaging about 0.04 per cent. The sulphur percentage is generally 0.01 to 0.07 per cent., and that of manganese only 0.1 to 0.4 per cent., the percentage of titanium likewise being low, 0.04 to 0.35 per cent. At the Björnevand are some large deposits, in the shape of a V, the two legs being respectively 1.2 and 1.5 kilometres long; it is continued beneath the level of the Björnevand; the horizontal thickness varies from 170 m. to 30 m., averaging 90 m. The area is 240,000 sq. m. above the level of the Björnevand, to which must be added the area under the water, measured magnetometrically to amount to 100,000 to 117,000 sq. metres. This submarine quantity can also be exploited, inasmuch as the lake can be emptied. By surface working down to 80 m. above the level of the sea, the available quantity of ore is carefully calculated at about 32,000,000 tons, in addition to which several million tons of ore can be worked at a lower level than 80 m. The percentage of iron in this ore averages 35 to 37 per cent. soluble in acid. The aggregate area of the South Varanger Company's iron-ore deposits is estimated at 1,250,000 sq. m. Confining the calculations to deposits more than 300 m. long, an average depth within this length of at least 25 m., and an iron percentage of not less than 34 per cent., the area may be reduced to some 750,000 sq. m. In addition there are deposits of 6000 sq. m. with ore containing 52 to 53 per cent. iron. From these 750,000 sq. m., some 100,000,000 tons of ore containing 35 to 37 per cent. iron can be broken by surface working. Of this ore some 2.3 tons make 1 ton of concentrate containing about 67 per cent. of iron. According to this, the residue, 1.3 tons per each ton of concentrate, will contain about 12 per cent. iron. With a calculated production of 600,000 to 700,000 tons concentrate (with 67 per cent. iron) in the year the company has ore deposits large enough to last for 75 years, with surface working more than 80 m. above the level of the sea. When this has been worked, lower working can be resorted to (with what remunerative results must be left an open question); but for every metre down working over the area of 750,000 sq. m., 2,500,000 tons ore, containing 35 per cent. iron, may be reckoned upon; that means 250,000,000 tons of ore for every 100 m., or rather more than 100,000,000 tons concentrate, with about 67 per cent. iron. The average height of the deposit above the sea is about 110 m.

The rich ore at Örnevand has a length of 400 m. (of compact ore), and a breadth of 10 m. on the average, that is about 4000 sq. m. area. Each metre of vertical working means about 20,000 tons, and 100 m. consequently 2,000,000 tons. This ore is expected to penetrate to a depth of 200 m., perhaps 300 m., with same area, which means 4,000,000 or 6,000,000 tons, or, under favourable conditions, 8,000,000 tons of ore, containing 52 to 53 per cent. iron. The working of these high-class deposits will probably be left in abeyance for the present, pending increased means of transport, the straight-line distance to the end of the company's railway being 9 km. Along the south side of the Varanger fjord, further west, there are also iron-ore deposits, though, so far as known up to the time of drawing up the report, of much smaller dimensions. There are also deposits in other parts of the Finmarken district, though of minor importance.

Of deposits of the Dunderland-Salangen type, in the Nordland and Tromsö districts, a large number are known, one or two of which were worked for a short time upwards of a hundred years ago; but it was not until about 1890 that the Dunderland deposits began to attract attention. Some discoveries are of quite recent date, and there is reason to believe that also in the future there will be found other iron-ore deposits in these regions. The class of iron ore found in this group of deposits is practically only fit for concentration. The percentage of iron for a deposit varies generally from 30 to 36 per cent., sometimes not fully 30 per cent.; in some places from 38 to 40 per cent.—only in exceptional cases beyond that. The percentage of apatite or phosphorus in iron ore of the Dunderland-Salangen class, on the average, is fairly high—as a rule 0.2 or 0.25 per cent. phosphorus, in some cases as much as 1 per cent.; it varies considerably even within a narrow compass. For the Dunderland ore the percentage of phosphorus is about 0.2 per cent.; at Tomö, Bogen, and Salangen, 0.25 per cent.; at Dolstad-Aasen an average of 0.5 per cent.; at Sjaafjäldet and Melkedalen even an average of 1 per cent. The percentage of sulphur, on the whole, is very low—in the Dunderland ore often 0.01 to 0.03 per cent.; at Sjaafjäldet and Melkedalen the percentage of sulphur, however, averages 0.1; at Salangen, 0.1 to 0.15; and at Bogen, 0.1 to 0.2 per cent. The percentage of manganese is generally very low—generally 0.15 to 0.4 per cent., more rarely 0.5 to 1 per cent. MnO in the raw ore. There are, however, places where the ore contains 3 to 5 per cent. MnO, and at Osmark, in Ofoten, right up to 14 per cent. MnO. The percentage of titanium is practically none—that is, as a rule, below 0.1 per cent. titanic acid.

The deposits, especially in the Dunderland Dale, often have a length of several hundred metres, and a depth of 50 metres or more; there are, however, also a number of smaller deposits. The percentage of iron generally lies between 30 to 36 per cent. iron, and from most of the deposits in question 3 tons of ore will make 1 ton of concentrate with an average of 65 per cent. of iron. The drawback of these deposits is principally the necessity of separation before the ore becomes saleable, while the advantages are that the capacity is so large that it allows of exploitation on a large scale, that the ore, on the whole, is cheap to break, and that it is easy or cheap to crush. Some very erratic reports have been published about the capacity of some of these deposits. In one case a foreign mining engineer made a certain deposit to contain 30,000,000 tons of ore, a subsequent colleague of his came down to 5,000,000 tons, whilst Professor Vogt says 750,000 tons for certain, probably 1,000,000 tons, and under favourable conditions, 1,500,000 tons.

The ore district in the Dunderland Dale proper extends from the vicinity of Vesteraali to a point called Hatten, some 4 km. north of Dunderland. The distance between the two extreme points being about 20 km. Most of the deposits are on the north side of the dale, a few on the southern, also some smaller ones at other parts.

The Dunderland Iron Company owns, in addition to others, some nine deposits, covering an area of

575,000 sq. m., calculated to yield, with surface-working to a depth of 30 m. to 60 m., an aggregate of 89,200,000 tons of iron ore; including other deposits not yet fully surveyed, the total capacity, with surface working, may be estimated at 100,000,000 or 110,000,000 tons of iron ore. Deposits owned by other than the Dunderland Company bring the aggregate area to about 700,000 sq. m., and, if including smaller or narrower deposits, though not less than 5 m. broad, a total of 1,000,000 sq. m. is arrived at. Only about 700,000 sq. m. can be considered of practical importance at the present day, which area, by working downwards, would yield about 2,250,000 tons of ore for each vertical metre, or for each 100 m. 225,000,000 tons—a figure which is of no actual significance at the present moment, but which may become so in another generation or two.

The percentage of iron, apart from the small Krutmeyer deposits, with its 53 per cent., and a poor deposit at Stordfjord, varies from 36.5 to 42.2 per cent., or on an average 39 per cent., according to some analyses furnished by the Dunderland Company, but Professor Vogt puts the average at 33 to 35 per cent., and for a few deposits as much as 36 per cent. The Dunderland Company from 1905 to July, 1908, when working was discontinued, broke 565,407 tons of iron ore; at the concentration works at Storforshej there were separated 366,345 tons of iron ore, from which there were produced 84,189 tons of briquettes and 3353 tons of concentrate, the former containing 64 to 65 per cent. of iron, the latter 1 per cent. more, about 4.2 tons of ore being required for 1 ton of briquettes. Professor Vogt states that the Dunderland Company had spent 29,000,000 kr., but he thinks that improved methods will enable the company to turn out perhaps some 300,000 tons of concentrates, containing about 65 per cent. of iron, and 0.03 or 0.04 per cent. of phosphorus per annum.

The Salangen deposits at Storhaugen and Renhaugen reach to a height of 657 m. to 670 m. above the level of the sea; length, about 1600 m.; breadth, 300 m. to 400 m.; the depth of the ore deposits may be put at an average of 30 m. The ore is somewhat intermixed with slate, &c., but each 85 per cent. of the broken substance is expected to be ore. The average percentage of iron is put at about 30 per cent., and when some of the poorest ore is removed, at 32 to 33 per cent.; a few portions will show somewhat higher; on an average there is 0.25 per cent. phosphorus, 0.1 to 0.15 per cent. sulphur, and 0.1 to 0.5 per cent. manganese, locally somewhat more manganese. The quantity of iron-ore at the above deposits is calculated at about 25,000,000 tons for surface working, likely to yield 7,000,000 to 8,000,000 tons of concentrate, with about 65 per cent. of iron. The separator works are built to produce annually 200,000 tons of concentrate when fully completed. Close to Storhaugen are some smaller, but well-positioned, deposits, at Leibivaama, which are not fully surveyed yet. In the same locality lie the Generalhaugen deposits, calculated to contain some 2,000,000 tons of ore with surface working; the Laukostjokka deposits, a little further down the fjord, are but little known, but supposed to contain, for easy working, 4,000,000 tons of 30 per cent. iron ore.

In the Bogen Bay, Ofoten, are a number of iron-ore deposits, of which the majority belong to the Ofoten Malmfält Company, which has installed concentration works. Taking the practically serviceable ore area to be 100,000 sq. m., which for each metre working would give some 270,000 tons of ore, the production would be 90,000 tons concentrate, with about 64 per cent. iron, for each metre. A likely surface working of 25 m. depth represents 2,250,000 tons concentrate; a similar quantity of ore can probably be broken by working deeper, making a total of 10 to 15 million tons of ore with comparatively cheap working expenses.

Of other deposits of the Dunderland-Salangen type there are the Eiteraadalen deposits in Vefsen, covering an area of some 200,000 sq. m., the ore containing about 30 per cent. iron, but they are not fully surveyed. There are also deposits at Dolstadaasen and Högaasen, some of the ore being richer in iron, and a quantity of other deposits of but minor importance, and in many cases but incompletely surveyed and known.

In Ofoten there are also numerous, mostly small, iron-ore deposits, those at Balangen, calculated to cover an area of about 86,800 sq. m. At Skriverfjeldet, Rollöen, are some deposits, expected, in the first place, to contain 5,600,000 tons of ore, with an average of 32 per cent. iron; experiments to turn it into concentrate have given good results.

In the Sörreisen district there are many iron-ore deposits, though none of special importance; nor is the working of some of the Lofoten iron-mines likely to prove remunerative, although at Madmoderen, for instance, ore containing as much as 66 per cent. iron has been found; expensive installations, railway, &c., have been built there by foreign capital—somewhat rashly, it would seem, as the deposits had not been duly investigated, and the ore-breaking, as a matter of fact, speedily came to an end. The same applies to the Smorten-Jörendal-Jendal deposits, and to the Björkö mine. In the Hindö Island there are several iron-ore deposits, the Vestpoltind being estimated to contain 5,000,000 tons, or perhaps considerably more.

The Selvaag deposits are calculated to contain 15,000,000 tons of iron ore, containing probably, on an average, 32 to 35 per cent. iron and 4 per cent. titanic acid; the conditions for magnetic separation are considered very favourable.

In the Drontheim district only less important iron-ore mines have hitherto been known, but recently extensive discoveries of iron-ore deposits have been made, and the district can now be said to contain the largest deposits in Norway of non-titanic iron ore. The ore from the Beitstaden-Aufjorden iron-fields, which have only been known, in part at least, for a couple of years, contains a high percentage of iron (51 to 61 per cent.). The only mine which so far has been worked here is the Malmo mine, simply because it was first discovered. The mine contains at least 200,000 tons of ore, possibly considerably more. Further west there are deposits, as yet incompletely examined, which for certain contain 7,500,000 tons of ore, probably at least 15,000,000 tons, and perhaps 20,000,000 tons or more. Conditions for working are not unfavourable, and there is considerable water-power in the vicinity; an important mining industry may therefore be developed.

Most of the iron-ore deposits on the so-called Vestlandet are titanic, although some to such small extent that the ore may be looked upon as iron-ore, whilst others have as much as 40 per cent. titanic acid. The Rödsand deposits, from which export to England takes place, contain some 150,000 to 200,000 tons good ore (50 per cent. iron and 8 per cent. titanic acid) and some 50,000 tons of ore requiring concentration. The Solnördal deposits are estimated to contain probably at least 2,000,000 tons, perhaps 5,000,000 tons iron ore, containing 50 to 52 per cent. iron. There are, besides, a large number of smaller deposits. Titanic ironstone (ilmenite) containing generally 40 to 47 per cent. titanic acid, and from 36 to 43 per cent. iron is found at Ekersund and Soggendal, and from the Ankerhus and adjoining mines some 100,000 tons have been exported to England. The Storgangen, east of Rägefjord, may be expected to yield 150,000 tons separated ore for each metre vertical working, and 20 m. to 30 m. depth can be attained with cheap surface working.

Among the iron-ore deposits east and south are the old mines in the Arendal district, which have been worked for many years, and probably yielded some 2,300,000 tons of ore, and the Langö mines at Kragerö some 450,000 tons of ore. From the Fehns district, where iron-mining likewise has been going on for a very lengthy period, export of ore has been going on for many decades, the aggregate export for the last decade being 355,000 tons, and altogether some 600,000 tons of iron ore have been broken here; another 500,000 tons, or, perhaps, 1,000,000 tons of ore can probably be taken here.

The apatite deposits at Söftestad may be expected to yield 750,000 tons, or, under favourable conditions, twice that quantity. There are in various parts of Norway iron ore deposits of minor importance, and as the most important iron ore deposits in Norway have only been discovered within the last few decades, there is reason to believe that further discoveries may be expected.

THE PHYSICAL SOCIETY'S EXHIBITION OF SCIENTIFIC APPARATUS.

(*Concluded from page* 839.)

The Evershed speed-indicator of Messrs. Evershed and Vignoles, of Acton Lane Works, Chiswick, W., depends for its action on the variation of pressure in a magnetic generator driven by the mechanism, the speed of which is to be indicated. Since the pressure generated by such a machine is proportional to the speed, an ordinary voltmeter, suitably calibrated, may be employed as an indicator. The instrument therefore consists of two parts: a transmitter or generator and the speed-meter itself, which is a galvanometer. The generator shown was fitted into a cast-iron case, about 1 ft. long, rubber packing having been moulded into the grooves for the lid to render the case watertight; all the glands were also packed with rubber. The bearings inside the case are of the standard Hoffmann ball-bearing type. The permanent magnets have a very high coercitive force, and special attention has been paid to their ageing. In the commutator air insulation is alone used, no mica being applied; the circuit leakage-paths have been made very long; the segments are of wrought copper, and the brushes are of carbon and supported on wires stretched by springs. The necessary pressure on to the commutator is supplied by a backing of rods of pure rubber, in order to ensure contact under strong vibrations, The driving-pulley has its bearing outside the casing; it is also a ball-bearing, and quite independent of the generator-shaft bearing. The indicator is of the Evershed moving-coil galvanometer type. The small generator exhibited could be run at speeds up to 800 revolutions; but the range of the instrument depends, of course, on the pulley ratio.

The Foster Instrument Company, of Letchworth, Herts, has improved its fixed-focus pyrometer, which has been noticed in our columns. The tube of the "inspector's outfit" consists of two halves screwed into one another, so as to fit into a small case 17 lb. in weight, and the indicator is provided with two scales, one in black for the fixed focus and a range of 700 to 1400 deg. Cent., and the other in red for the thermo-couple and the range 200 to 900 deg. Cent. The Hoskins base-metal thermo-couples of the firm consist of a nickel-chromium alloy and constantan; they can be used at temperatures up to 1360 deg. Cent., and are said to give an exceptionally high electromotive force. Such a couple is held in contact with a sample of steel in the small-recalescence point outfit, another exhibit, which is simply a stand for the test-piece and a Bunsen burner, joined to a portable direct-reading indicator. The use of this instrument was demonstrated; a recording instrument marking a dot every minute on a 24-hours chart was also on view.

The strain-meter of Mr. C. E. Foster is a very simple instrument for the determination of the actual strains in any part of a ship, bridge, &c. The instrument fits into a small wooden case, less than 1 ft. long. Two holes are drilled into the respective plate to be observed, 8 in. apart; the studs of the strain-meter are screwed into these holes. When holes cannot be drilled the studs can be fixed with the aid of clamps supplied. Each stud carries a rod about 4 in. in length. The one of the rods is rigidly connected to an hydraulic chamber made of metal, which is closed on the far side by a diaphragm of rubber; the other rod slides in its stud, and is brought up close to the diaphragm, against which it will bear with a certain pressure. From the chamber extends upwards a graduated tube. The pressure of the second rod will force the liquid up in this tube to a certain height, which forms the zero for the particular observation. When a stress is put upon the plate or bar under examination—the pressure of the finger, *e.g.*—the liquid at once rises. The zero can be adjusted with the aid of a screw, and the glass tube can be swung round parallel to the rods. The magnification used is 580 : 1, and one division in the tube corresponds to 0.000136 in. and to 0.221 ton per sq. in. It will be understood that in the instrument in use the two rods form a straight line, the hydraulic chamber being in the middle. The instrument has, we are informed, been used near propellers on ships out at sea, and also for the purpose of measuring the strains to which ships and the scaffolding are exposed during launching.

Messrs. Gallenkamp had several optical and physical apparatus for instruction on view, including the apparatus which Mr. Darling recently exhibited at the Physical Society for the study of drops forming within other liquids, and Manley's protector for balance-beams. Messrs. Gambrell Brothers exhibited A. E. Moore's new wattmeter of the "straight-through" dynamometer pattern, in which the current coil is able to take 1000 amperes without errors due to skin effects and eddy currents. They also showed Dr. L. Lownde's thermo-electric potentiometer (designed for measuring small

electromotive forces), having, with one accumulator cell, a range up to 5000 microvolts, and the standard low resistances and potential terminals of Professor C. H. Lees. In these terminals a fine cross cut, made with a saw, keeps the main current off the potential terminal. The low resistance shown consisted of four parallel bars of manganin, fixed edgeways in terminal clamps which were provided with the just-mentioned cross saw-cut; these bars are to be used in connection with millivoltmeters.

Mr. F. Harrison Glew gave some interesting radioactive demonstrations. His radioactive spirals are twisted copper wires coated with the sulphates of barium and (a little) radium; when one of these spirals was fixed on one pole of a Wimshurst machine (*e.g.*, the positive pole) and the other on an electroscope, the electroscope would become positively charged, and Mr. Glew pointed out that this charging with electricity of the same polarity was sometimes overlooked, when people thought they were merely observing discharge effects. A little actinium mixed with charcoal was contained in a glass tube, which was at one end connected to a small rubber balloon, and at the other to a flat glass tube, lined with zinc sulphide and open at the far end. A puff of air sent up this tube liberated enough actinium emanation to make the zinc sulphide fluoresce, the light travelling up the tube; a few seconds later enough emanation would have been re-formed to repeat the experiment; the half period of this emanation was four seconds. Mr. Glew also had some mesothorium in a brass cup; this salt, he said, was 300 times as active as radium, and 2 milligrammes of it cost only 20*l.*; the salt made a zinc sulphide screen fluoresce in a beautiful green.

Messrs. John Griffin and Sons, Limited, had various furnaces on view, comprising the Rosenhain electric muffle furnaces and his combustion furnaces for the determination of carbon in steel. We have noticed these furnaces in our report on the work of the National Physical Laboratory. The quartz-mercury thermometers also shown came from Germany; the thermometers are all quartz, the scale included, and mercury, and the tubes, if a little wavy, are perfectly clear quartz-glass.

The India-Rubber, Gutta-Percha, and Telegraph Works Company, of Silvertown, showed the newest form of Dittmar's decade Wheatstone bridge. As a rule the ebonite slab of a bridge carries a number of brass blocks connected by plugs; in this form the arrangement is reversed, the plugs are fixed to the slab, and connections are made by travelling sockets. A longer path is provided across the ebonite, and leakage is reduced. The E. Raymond-Barker two-tone transmitter was mentioned last year.

Messrs. E. Leitz, of 9, Oxford-street, Wetzlar, and other places, showed several of their beautiful lantern apparatus in use. All their lanterns are provided with lamps having their carbons at right angles to one another, which arrangement is to give a brighter and steadier light than the ordinary vertical disposition. Their micro-metallograph serves for the examination and the photomicrographic analysis of the surfaces of metallic specimens. The Edinger drawing and projection apparatus are due to Professor Edinger, of the Physikalische Institut, Frankfort. A mirror is placed above the eye-piece, so as to project the image on a drawing surface—*e.g.*, a horizontal plate of ground glass; the lantern is above, and underneath the stage is a nose-piece, into which different objectives can be screwed. The whole apparatus shown was mounted on a sliding stand, into the vertical guides of which a photographic camera could be fitted. As shown, the apparatus served for the drawing of biological specimens, but it can also be used for the projection and magnification of diagrams. The new ultra-condenser of Messrs. Leitz is a cavity fitted with two reflecting spherical glass surfaces. In the demonstration some cigarette smoke was blown through a small tube into the cavity; crowds of moving smoke particles were seen in the brilliant light.

The decremeter of Marconi's Wireless Telegraph Company, Limited, is an instrument which measures the rate of decay of the amplitudes in the electrical oscillations of high-frequency circuits. The parts of the complete instrument are contained in a box, and a table fixed in the inside of the lid enables the operator to read off the decrement, and in similar measurements, for which the instrument is also used, the wave-length, degree of coupling, capacity, or inductance. The principle is that the capacity of a coil and variable-condenser circuit is adjusted to the respective wave-length until a double-head telephone sounds. Resonance is indicated by the aid of a detector, consisting of a carborundum crystal (which need not have any particular or regular shape, of course) held between two

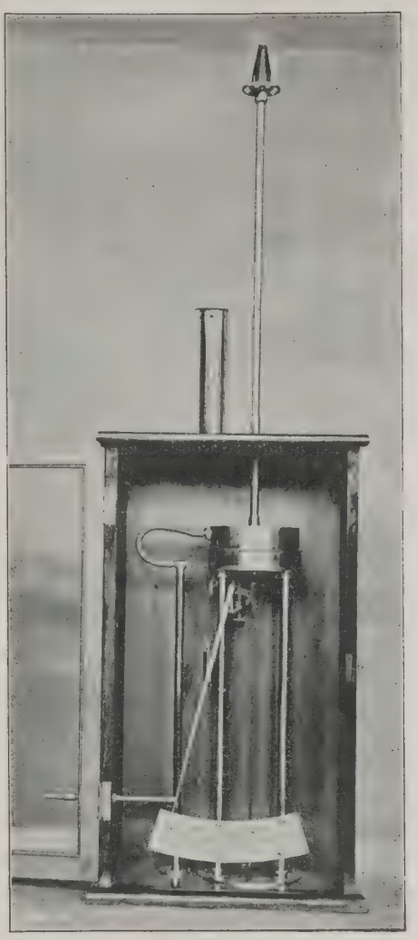


FIG. 7. AUTOMATIC GAS DENSITY INDICATOR.

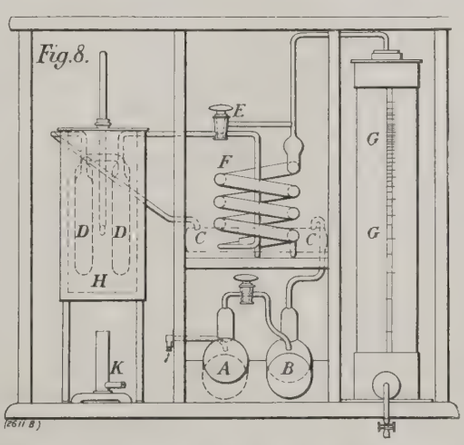


FIG. 8. APPARATUS FOR THE DETERMINATION OF CO.

upright, flat brass clips; crystals more than a centimetre in length are used. The wave-length is deduced from the condenser readings by means of the table, both in the decremeter and in a smaller wave-meter, which was likewise exhibited. Flat waves are difficult to tune up; for making measurements in such cases the instruments are provided with a sliding contact and a coil mounted on a switch.

The valve-receiver of Marconi's Company, now a standard instrument, was described by Professor Fleming during last year's exhibition. It consists of three inductively coupled circuits, each adjustable, combined in one instrument with a sensitive oscillation valve detector and its potential-regulating device. The multiple tuner, introduced by Marconi's Company two or three years ago, combines also three adjustable inductively connected circuits for the purpose of strengthening the incoming electromagnetic impulses of the desired wave-length, and to weaken all others. The instrument has a range from 100 up to 2500 metres, which covers ship installations and also small and fairly large land stations. In the "Std.-bi" (stand-by) arrangement a change-over switch connects the aerial to the detector circuit, which will then be ready to respond to impulses of all wave-lengths. A magnetic detector, the standard ship instrument, is preferably used with this arrangement. In this detector (which is not novel, of course) a steel tape belt is moving continuously (by clockwork) over two pulleys; it passes through a small glass tube surrounded by a coil; the coil consists of a primary winding for its oscillating impulses, and a secondary winding joined to the telephone. One or two horse-shoe magnets are fixed above the glass tube to produce the field.

The instructional buzzer, also exhibited, is an instrument devised for training operators, and especially for teaching them to read Morse signals when very weak. For this purpose the inductive coil of the receiving (telephone) circuit has very simply been so mounted that the coupling can be changed by turning a handle, and the signals can thus be more and more weakened. The company also showed a model, about 20 ft. high, of their hydraulic pressed-steel tubular masts, their actual standard pattern; the mast is built up in sections, and a new section is added below, when further height is desired; the top portion is always in wood.

Messrs. Nalder Brothers and Thompson, Limited, showed insulation testers for high-tension circuits on the dynamometer principle, portable precision galvanometers for direct and alternating currents, and their "ohmer" circulation measurer; this instrument is fitted with reeds for two definite pressures (500 and 1000 volts, *e.g.*), syntonised to vibrate vigorously when the speed of the generator corresponds to the required voltage; the maximum range was 0 to 100 megohms, reducible by a switch to 0 to 10 megohms.

The fine partly historical collection of meteorological and other apparatus of Messrs. Negretti and Zambra comprised deep-sea thermometers, the Anemo-biagraph, a new wind direction recorder, Lowne's electrical recorder for cup anemometers (pressure and total miles), and the "folding minim," a novel prism binocular.

Messrs. Newton and Co. showed, in addition to their demonstrator lantern (in which the mirror forms a fixture to the swing front), gyroscopes, harmonograph, &c., Dr. Leonard Hill's colour vision apparatus. This apparatus is a kind of optical bench on which two identical prisms are projected on to a pane of ground glass, the spectra being adjustable as to size, position, and illumination. The person under examination marks the extreme ends of the spectra such as they appear to him. There is also a screen for each spectrum, which obscures a whole spectrum, except a disc of red or green, &c., and the patient is asked to match the two discs of the two spectra.

The unipivot dynamometer thermo-couple indicators, &c., of Mr. R. W. Paul, of New Southgate, N., were noticed last year in connection with the Brussels Exhibition. The slide potentiometer of Mr. Paul is an inexpensive instrument which is provided with double-pole circuit-selecting switch, also arranged for reversing the polarity in cases of accidental wrong connection, seventeen potential points, coils adjusted to a standard value, and slide-wire adjusted to the same value by means of an internal shunt, from which the switch zero is tapped off. The ranges of the instruments are 1.8, 0.18, or 0.036 volt. The special feature of the ohmmeter of Mr. G. W. Harris, also exhibited by Mr. Paul, is the moving-coil system, the coils being made wider than the pole-faces, so as to cover 170 deg. of arc; up to four times the usual number of turns may thus be employed in the windings. The instruments are made for all ranges—from microhms to megohms—and are fitted also with a direct-reading resistance-thermometer indicator.

Messrs. W. G. Pye and Co., of Cambridge, demonstrated the use of several instruments for the testing-room, the laboratory, and lecture-hall. The "Granta" extensometer (patent pending)

—shown as working on a single-lever testing-machine—measures the extension or compression of test-bars of definite length and any section to $\frac{1}{50,000}$ in. The multiplying power is obtained by means of an optical lever, and the deflection of a mirror is watched through a telescope, or the light-spot is thrown on a scale. With the aid of various adjuncts such measurements can be taken on pillars and piers under construction. The Robinson centrifugal-force machine is an apparatus for demonstrating and measuring centrifugal force correct within about 1 per cent. As the speed of a horizontal rotating bar increases, balls sliding on a bridge move outward, until their force is balanced by a weight, the string of which is carried over a pulley and connected with the balls.

The Reason Manufacturing Company, of Lewes-road, Brighton, exhibited only Murday clocks driven by dry cells; three cells would hold out for two years, it was stated. The tempered steel spring forms a horizontal spiral, to which an invar steel ring is attached; this ring carries the armature for the electromagnet, and also a toggle-piece, which interrupts the circuit, as the spring oscillates to and fro in the horizontal plane.

The processes of the Ribbon Metals Syndicate, 50, City-road, E.C., have several times been mentioned in our columns. The products exhibited comprised gold, silver, and copper ribbon (not so smooth as the zinc and tin ribbon), aluminium and cadmium ribbon, and sheet metal, very uniform ribbons of solder (lead-tin), tin, and zinc, up to a foot in width and up to several millimetres in thickness. The lead ribbon is very convenient for producing a uniform white lead without exposing the workers to lead poisoning when handling heavy plates, and the ribbons of the noble metals are used in the electrolytic separations. Two apparatus were shown at work. In the one an upper and a lower receptacle for fused metal were joined by a curved tube so as to form a closed system; both receptacles were heated by Bunsen burners, and the molten metal passed, under hydrostatic pressure, from the lower cylindrical vessel through six perforations on to a brass cylinder (cooled by water circulation) revolving at moderate speed; six ribbons were thrown off in parabolic curves. The other apparatus also consisted of two heated vessels, but they were separated, the upper discharging through a feeder pipe into the lower open vessel, which was pushed up close to the revolving cylinder of steel. The molten metal overflowed from this lower box-shaped receptacle over a weir, 1 in. in width (the width determines the width of the sheet, of course), on to the cylinder; the thickness of the resulting sheet is adjustable within limits.

The Sanitas Electrical Company had a large collection of X-ray apparatus, &c., on view, fitted with "Sanax" interruptions; a very clear photograph of the intestines of the human body was prominent among the exhibits. Their "multostat" universal apparatus for administering currents to the body can be worked from any light circuit with the aid of a Leduc interrupter.

Messrs. Siemens Brothers and Co. exhibited, among other novelties, a wireless telegraphy set on the quenched singing-spark system, for simple experiments and demonstrations, a copy of a station apparatus, consisting of transmitter, receiver and antenna; two such apparatus would be required for an interchange of signals. The current of an accumulator battery (12 volts) is sent to a hammer induction apparatus for 350 interruptions per second, in which a thin U-shaped steel spring makes contact with the hammer; the practically undamped oscillations give a clear note. The vertical spark-gap consists of five separate sections, four of which may be cut out by means of clips; there are also clips (three fixed and one movable) on the primary self-inductance for obtaining three different (and also intermediate) wavelengths. The vertical coil for aerial lengthening is provided with a sliding contact and tuned with the help of a helium tube. The antenna is built up of two vertical tubes, each 3 ft. in length, supporting a horizontal cross at the top; this cross is a square of copper wires with brass rods as diagonals and a metal eye. The guaranteed range of the set is 1100 yards; double the range is obtained under favourable conditions, and a range of 5 miles secured with an antenna of 30 ft. height.

The "oscillothermex" of Messrs. Siemens Brothers may be described as an X-ray apparatus (for therapy, fluoroscopy, and radioscopy) worked with electric oscillations on the quenched arc system of radiotelegraphy, from alternating-current supply or from direct-current supply and a small rotary converter. The apparatus consists of diathermy apparatus with spark-gap and milliamperemeter on one table, transformer coil and coupling on a second table, and a high-tension cable, a yard in length, leading over to the cathode of the X-ray tube which is carried on a stand; the tables run on rubber wheels. The ray coil lies inside the self-induction coil of the Tesla transformer; its lower end is earthed, and the upper end joined (by the cable) to the X-ray tube, which has only one terminal on the Pflüger-Peukert method. About 10 amperes at 110 volts are required.

The two other instruments exhibited were frequency indicators. The first of these, a Frahm reed resonance indicator, was shown in operation by mechanical and electrical means, and also as a neat model, illustrating the way in which vibrations are picked up. On the top of a ring were fixed six reeds, and a heavy fly-wheel, mounted in the ring, was set spinning. The oscillations of the instrument would first be taken up by the shortest reed, the amplitudes of the oscillations increasing slowly at first and then rapidly, to go down again; then the second reed would begin to oscillate in the same way, and so on. The second instrument of Messrs. Siemens Brothers, the vibragraph of Mr. Pollard Digby, forms a square wooden case with a saddle roof; a small electric lamp is fixed in the one side of the roof, in the other a pane of ground glass or a photographic plate. On the bottom of the case stands a cup filled with mercury, on which floats a mirror, which is pivoted so as to avoid lateral movement. When the floor on which the instrument stands is steady, the reflected lamp marks a light spot on the ground glass; when the floor is vibrating, the spot describes more or less regular curves, because the mirror is vibrated by the mercury ripples. Each mercury cup has its own constants, and three types of cups are calibrated for vibrations ranging from 0.3 mm. to 0.02 mm. A steady-running motor will produce a long ellipse, nearly a straight line, a two-crank engine a peculiar spiral, a motor-car an ill-defined blot consisting of a confused mass of curves. Although the cup is a sensitive piece of mechanism, it may be tilted and transported without difficulty.

The beautiful collection of moulded and blown transparent quartz-glass articles of the Silica Syndicate, Limited, of 82, Hatton Garden, attracted considerable attention. There were prisms, complex chemical apparatus consisting of tubular and spherical parts, coils, dishes, watch-chains, &c., all of perfectly clear quartz, as regular as if made of glass.

We can only mention the astronomical regulator of the Synchronome Company; the varied chemical and physical apparatus of Messrs. Townson and Mercer; and the A.-C. switchboard instrument, dynamometer, and testing sets of the Weston Electrical Instrument Company.

Messrs. Alexander Wright and Co., of 1, Westminster Palace-gardens, exhibited several novel instruments for the control and analysis of gas-works products. The continuous automatic indicator of the gas density (Simmance and Abady) is really a balance, in which the coal-gas or other gas is weighed against air by the aid of a floating bell. The gas enters a cylindrical chamber surmounted by a long tube (Fig. 7, page 871) at the top of which the gas is burned after passing through the chamber; the burner is not very distinct in the photograph. The bell is suspended from below, and rises or falls in its oil-seat, as the gas is heavier or lighter than the air, and the specific gravity of the gas is indicated by the pointer, which is attached to the bell, on the open scale, which reads to 0.0025. The instrument is also made recording. In the recording calorimeter this density indicator is furnished with a valve and combined with a recording differential thermometer. One end of the thermometer is influenced by the temperature of the air, the other end by the temperature of the air together with that of the combustion products of the gas. If the gas-flame were supplied with gas at a rate which remained constant, however much the density of the gas varied, then the chart of the recording thermometer might be calibrated in heat units. Hitherto, it is claimed, the problem of a gas-feed at an unvarying rate has practically been impossible, because a change of rate must inevitably follow a change of density. Messrs. Simmance and Abady now control the rate by making the specific-gravity indicator actuate a valve which opens and closes the passage of the gas exactly in ratio to the increase or decrease in the gas density. The instrument is thus free from all measuring devices, and when set on gas of one density will accommodate itself to gas of any other density. The engineer who makes any kind of gas—producer, water, Mond, blast-furnace gas—can thus obtain a continuous record of the calorific value of his gas in heat units.

The two other apparatus concern the determination of carbon monoxide, and are due to Mr. Leonard Levy. The CO has so far been determined either by absorption with cuprous chloride or by exploding a residual after analysis; the former method is uncertain, the latter tedious. The direct determination of carbon monoxide, although of importance to engineers in power gas-plants, mines, &c., has rather been neglected for this reason. The apparatus by which Mr. L. Levy determines the percentage of CO in about five minutes is illustrated in Fig. 8, page 871. The gas passes through two vessels, A, in which all the unsaturated hydrocarbons are absorbed, and B, which retains any fumes coming from A and also the carbon dioxide (CO_2). The gas then flows through the drying-tubes C, indicated in dotted lines, and the selective oxidation tube D, and, further, the three-way cock E, one branch of which is a by-pass, while the other leads to the decolorisation vessel F. The flow of the gas is regulated by the discharge of water from the graduated aspirator G. In the oxidation tube the CO is oxidised by means of iodine pentoxide (I_2O_5), which is a white crystalline mass that can be handled without risk; it forms the anhydride of iodic acid. The CO is oxidised to CO_2, and the CO_2 is determined by changing the colour in the vessel F from red to white; 20 cub. cm. of CO_2 would effect this change, and the scale reading on the aspirator indicates the percentage of CO_2 and thus of the CO. The oxidation of the CO has to take place within certain temperature limits; the tubes D are therefore placed in an air bath H, which is heated by a small Bunsen burner. The apparatus fits into a portable glass case. In the other apparatus, the carbon monoxide recorder, the oxidation is effected in the same way, and records are obtained as in the Simmance-Abady combustion recorder on a circular 24 hours' chart.

Messrs. Carl Zeiss, Limited, exhibited a larger type of the new levels, which we described last year. The magnification is 36 diameters, the tripod stand is remarkably light and rigid, and the other advantages are retained. The bubble is seen without parallax, the final adjustment is rapidly made, the collimation may be tested within a few minutes from a single station, and the telescope can quickly be used in the reversed direction, and also be turned about its longitudinal axis. They also showed two new projection lamps, in one of which a five-ampere lamp gives sufficient light to cover a 10-ft. screen when a photographic objective from 15-cm. focus upwards is used as a projection lens. This apparatus is fitted with a triple-lens condenser, while in the apparatus for experimenting with polarised light an aplanatic condenser is used; beautitul effects are produced in both cases.

NOTES.

Japanese Finances.

The large numbers of people in this country interested in the future welfare of Japan were all much gratified to learn that there was no truth in the somewhat alarmist reports with regard to the state of the finances of that country, and to be assured that the Minister of Finance had taken a very firm stand in the matter of naval and military expenditure, and, in preparing the Budget for next year, had determined to cut down all unproductive outlay. There are some necessary increases, but, on the whole, the Budget has been framed on principles restricting the undue expansion of expenditure, maintaining the sinking fund, abstaining from fresh borrowing, and avoiding any increase of expenditure for any new schemes. The ordinary revenue is estimated at 500,500,000 yen, and the extraordinary revenue at 53,800,000 yen, making a total revenue of 554,300,000 yen (the yen is approximately 2s.). The increase over the current year is 5,600,000 yen in ordinary revenue, and 3,300,000 yen in extraordinary revenue, making a

total increase of revenue of 8,900,000 yen. The total expenditure is estimated at 571,000,000 yen, of which the ordinary expenditure is 409,500,000 yen, and the extraordinary expenditure 161,500,000 yen. The ordinary expenditure having diminished by 600,000 yen, and the extraordinary expenditure increased by 2,700,000 yen, the total expenditure is estimated at 2,100,000 yen over that of the current year. The excess of the total expenditure over the total revenue, amounting to 16,700,000 yen, will be met out of the realised surplus from the previous year, so that no recourse either to increased taxation or to borrowing is necessary. In Japan the announcement of the Budget is welcomed by public opinion as a fresh proof of the sound financial policy which the new Cabinet is determined to uphold, and it is felt that Japan's financial standing is stronger than it was last year. The Government's financial position, as well as the prosperity of the country, are better to-day. With regard to the naval estimates, it should be pointed out that the navy scheme decided upon last year was drawn up with a view of keeping pace with the industrial and commercial development of the country, and from this scheme there will be no departure. The main principle was that the general development of the country should not be hampered by undue expenditure. If the Finance Minister has not been able to comply with the subsequent demands of the navy, this has no reference whatever to the general status and efficiency of the navy, as already settled by the Government.

A Radium Perpetuum Mobile.

In 1903 a new kind of perpetuum mobile was described by Mr. R. J. Strutt in the *Philosophical Magazine*. It was a gold-leaf electroscope, which was charged up by the β rays coming from radium bromide, until one of the deflected leaves touched an earthed contact; the leaves collapsed then for a moment, but soon diverged again under a new charge. The vacuum of the vessel in which the electroscope was contained had to be maintained very high, otherwise the air remaining in the vessel would have become ionised, and would have allowed the charge to become neutralised. A more convenient modification of this little apparatus has been devised by Mr. H. Greinacher, of the University of Zurich. This new perpetuum mobile consists of two parts—a binant electrometer, which works in ordinary air, and a cylindrical portion fitting into the tubular upper portion of the electrometer and serving for the introduction of the rays. This latter cylinder contains, completely embedded in paraffin, a brass plate, from which a wire extends downward through the paraffin, ending below in a hook. The brass plate is near the top of the cylinder, and is separated by a very thin layer of the paraffin from the cover of the cylinder, a disc of aluminium, only 0.015 mm. in thickness. The radium salt is placed on the top of this aluminium disc, so that the rays are not much obstructed before they strike the brass plate. The negative charge imparted to the brass plate travels down the wire from the hook of which the electrometer is suspended. The very fine suspension wire (made after Wollaston's method by drawing out a silver-coated platinum wire and dissolving the silver with the aid of nitric acid) supports a fine horizontal needle of silver. When the needle is deflected, it is drawn into the space partly enclosed by the sectors of the electrometer, until it touches an earthed contact, when it returns. The period of the apparatus of Greinacher is about $8\frac{1}{2}$ minutes, when the experiment is first started; but it decreases slowly for several reasons. The needle begins to be re-charged on its return, so that the zero position of the needle is a little nearer the contact than it was at first; there is also some accumulation of the charge in the paraffin column, and leakage through it to the wire. The play of the needle is said to be very regular, however. When some radium salt is held close to the electrometer box, the period is prolonged, and the needle will remain stationary when the charge brought from above is balanced by the discharge through the ionised air. The apparatus, which is useful for comparative experiments with various kinds of rays, is supplied by the firm of G. Zulauf and Co., of Zurich.

Danger from Electric Shock.

There is no doubt that with the increasing higher electric potential now in use the increasing danger to life, particularly among linemen and others whose work brings them in contact with high-tension plant, will have to be more carefully considered. The persons who run the greatest risk are the linemen, owing either to poor construction or to ignorance on the part of the men. With regard to this ignorance, Mr. C. A. Copeland points out in the *Journal of Electricity* that in the United States, at any rate, it is a fact that the vast majority of linemen know absolutely nothing about resuscitation after shock, and he is also of opinion that this applies to other classes of electrical workers as well. Telephone linemen are said to be the most careless class of all electricians, which is probably due to companies employing men who have not been accustomed to work with voltages higher than 50, nor with amperages above unity. These men, being put to work among circuits carrying 2000 to 30,000 volts or more with no previous knowledge of them, not only run great risks themselves, but may cause great danger to other better-informed men who are working with them. A suggested remedy for this is to have a company physician or superintendent, or both, who will once a year at least, but oftener by preference, make trips and give proper instruction to every outside worker, so as to demonstrate how to resuscitate a person who has received a severe shock. The question has often been asked, What voltage will kill? As pointed out, however, this question as it stands is futile, and one might as well ask how many pounds falling on a person's head will prove fatal, so much depending on the velocity of the weight. A case is noted of a healthy man who, while in his bath, received a severe shock (from which he suffered for several weeks) while turning on the incandescent light, the pressure being only 27 volts. Mr. Copeland recounts a case of a student at Stanford, U.S.A., who was killed on a 110-volt circuit, while other persons have received shocks from 33,000 volts which have not proved fatal. There have also been, we believe, cases of direct ground shocks due to 60,000 volts which have not caused death, though many deaths have occurred from 2000 volts. From this Mr. Copeland concludes that currents of 30,000 volts are safer than those of 2000 volts. Such a conclusion, however, we cannot accept altogether until we know the exact circumstances of each case. The reason for this belief given by Mr. Copeland is that the higher voltages seem to exert their energy on the surface of the body instead of within—"a sort of skin effect as applied to a human conductor."

Normal Light Mercury-Vapour Lamps.

Mr. Cooper Hewitt has recently succeeded in improving his mercury-vapour lamps, and in turning their somewhat ghastly bluish-green light into a normal light, white with a slight suggestion of pink. The chief rays emitted by the mercury arc are a yellow ray (wave-length 0.578 μ), a green ray (0.546 μ), a blue ray (0.436 μ), a violet ray (0.404 μ), and several ultra-violet rays, of which only one (wave-length 0.366 μ) penetrates through the glass tubes of the Hewitt lamps. Various attempts have been made to supply the deficient red rays. Mercury-arc tubes charged with nitrogen appeared pink when plunged into ice; but at ordinary temperature the mercury-arc tint preponderated again. Tubes filled with argon and helium behaved similarly. When potassium amalgam was substituted for mercury, part of the tube appeared reddish. Heraeus obtained a certain amount of success with an amalgam containing about 20 per cent. of lead and the same proportion of bismuth in addition, to about 0.5 per cent. each of zinc and cadmium; but these alloys, as well as those containing thallium and antimony, practically yielded mercury arcs again, rich in ultra-violet rays. Mr. Hewitt therefore tried to produce the missing red rays outside his lamp by combining a mercury arc with an incandescent carbon filament; the complicated lamps were inefficient. He then turned to fluorescence, and success has been obtained with the aid of fluorescent screens. Fluorescent substances possess the peculiar property of absorbing light of certain wave-lengths, and emitting light of another wave-length; as a rule, the emitted light is of greater wave-length than the received light. Since there is absorption, there is always a loss of energy; if, however, the emission can be secured at the expense of ultra-violet rays, which are invisible to the human eye, and thus useless for illumination, this loss does not count. The tint of the emitted light varies with the substance employed; the fluorescent light of quinine is bluish, and that of fluorescein bright green. Mr. Hewitt experimented with rhodamine (meta-amidophenol-phthalein); this compound gives a pink solution in water, alcohol and acetic acid, which shows a brilliant orange fluorescence, particularly when the last-mentioned solvent is used. When such a solution is illuminated by the spectrum, the yellow and green, and again the violet and ultra-violet rays, are absorbed, while the red and blue pass; the transmitted light hence appears pink. The chief absorption takes place about wave-length 0.555 μ (green), the yellow and green rays of the mercury arc being absorbed. The blue mercury ray previously mentioned is reflected and is only slightly affected, assuming a mauve shade. The ultra-violet rays cause a red fluorescence. Rhodamine thus appeared promising. Mercury-arc tubes, surrounded with gauze veils dyed with rhodamine, were first applied; but the efficiency of the lamp was poor, and the effects of the transparent light were not pleasant. Experiments were then made with rhodamine reflectors placed behind the mercury tube, and by varying the shape and dimensions of these reflectors, a light of a pleasing tint was produced. Unfortunately, rhodamine, like fluorescein and eosin, to which it is chemically related, is not fast to light. A screen dyed with rhodamine loses its effectiveness after an exposure to mercury rays for about twenty-four hours. It was hence necessary to incorporate the rhodamine with some substance in order to render it more durable without interfering with the fluorescence. Such a substance has recently been found, we are informed by the Westinghouse-Cooper Hewitt Company, of 151 and 152, Great Saffron-hill, Holborn, E.C., and paper screens are now coated with a solution of rhodamine by a complicated process. Objects appear of the same tint, it is claimed, when examined in daylight and in the light of these new mercury arcs fitted with rhodamine reflectors.

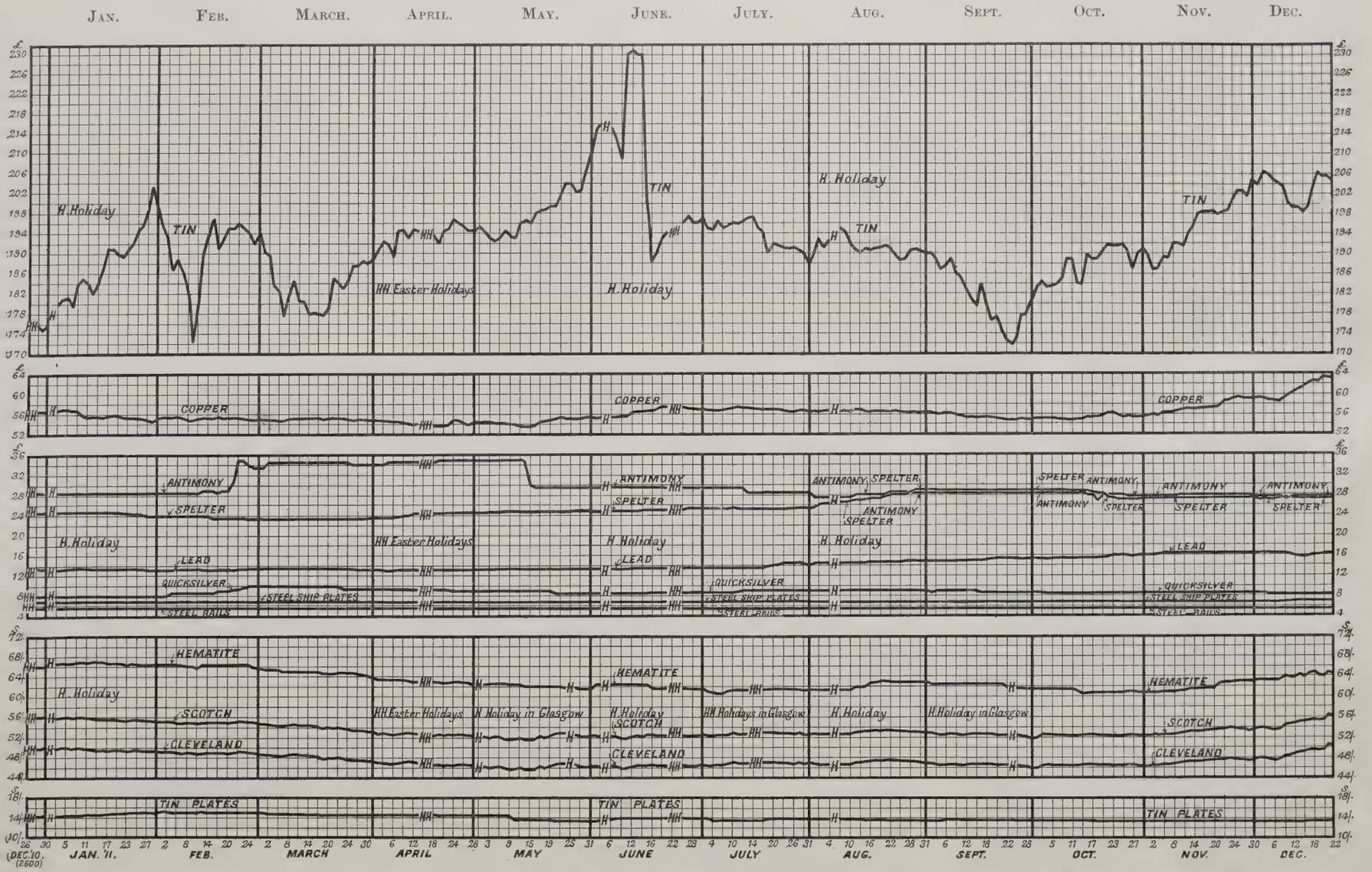
H.M. Torpedo-Boat Destroyer "Attack."—This destroyer was launched on the 21st inst. from Messrs. Yarrow's yard. She is the second of the five special destroyers which they have under construction for the British Admiralty. Her dimensions are 240 ft. long by 25 ft. 7 in. beam; she is propelled by twin screws, driven by turbines of the Brown-Curtis type, which have been built by Messrs. Yarrow. Steam is supplied by three Yarrow water-tube boilers burning oil-fuel, and fitted with a new form of superheater designed by them.

Montreal Harbour.—An expenditure of 400,000*l.* is to be made in 1912 in the improvement of Montreal Harbour. Work will be started with a view to providing sufficient new piers to furnish space for the docking of fourteen ocean-going ships. The piers will be of concrete and of the high-level type. Permanent and fireproof sheds are also to be provided. The business of the port of Montreal shows a satisfactory increase. The total quantity of grain exported during the past navigation season was 29,388,339 bushels, as compared with 26,349,514 bushels in 1909-10. Flour exports were almost doubled.

The Society of Engineers (Incorporated).—The second annual general meeting of the Society of Engineers (Incorporated) was held at the Society's offices, 17, Victoria-street, Westminster, on Monday, the 11th inst., Mr. John Kennedy, vice-president, being in the chair. The report of the scrutineers of the postal ballot for the election of council and officers for 1912 showed that the following had been duly elected:—President, John Kennedy; vice-presidents, A. Valon, H. C. H. Shenton, Norman Scorgie; members of council, Henry Adams, C. T. Walrond, Percy Griffith, T. E. Bower, H. C. Adams, J. R. Bell, S. Cowper-Coles, H. P. Maybury, B. H. M. Hewett, F. H. Hummel; associate member of council, E. Scott-Snell; hon. sec. and treasurer, D. B. Butler. It was announced that premiums for papers read at meetings and published in the Journal during 1911 had been awarded as follows:—The president's gold medal to Mr. W. R. Baldwin-Wiseman, for his paper on "The Administrative Aspect of Water Conservancy;" the Bessemer Premium of books or instruments to the value of 5*l.* 5s., to Mr. R. W. A. Brewer, for his paper on "Two-stroke Cycle Engines;" the Clarke Premium, value 5*l.* 5s., to Mr. T. J. Gueritte, for his paper on "The Mechanical Installation and Upkeep of Permanent Way on Railways;" a Society's Premium, value 3*l.* 3s., to Mr. E. Kilburn Scott, for his paper on "Nitrogen Products made with the Aid of Electric Power;" and a Society's Premium, value 3*l.* 3s., to Mr. Frank G. Woollard, for his paper entitled "Some Notes on Drawing-Office Organisation." A resolution was passed thanking the other gentlemen who had presented papers during the year, some of whom, being members of council, were not eligible to receive premiums. Messrs. W. B. Keen and Co. were appointed auditors to the society for the ensuing twelve months. Votes of thanks were passed to the retiring council and officers, to the scrutineers of the ballot-papers for the election of council, and to the hon. solicitors, for their respective services.

DIAGRAMS SHOWING FLUCTUATIONS IN THE PRICES OF METALS FROM CHRISTMAS, 1910, TO CHRISTMAS, 1911.

Specially compiled from Official Reports of the London Metal and Scotch Pig-Iron Warrant Markets.



In the accompanying diagrams each vertical line represents two market days, and each horizontal line represents 2s. in the case of tin plates, hematite, Scotch, and Cleveland iron, and 2*l*. in all other cases. The price of quicksilver is per bottle, the contents of which vary in weight from 70 lb. to 80 lb. The metal prices are per ton. Heavy steel rails are to Middlesbrough quotations. Tin plates are per box of I.C. cokes.

OIL-BURNING ON LOCOMOTIVES IN MEXICO.

To the Editor of Engineering.

Sir,—In your report of the meeting of the Institution of Mechanical Engineers on December 15 you make me say: "When they started burning oil, the consumption, in like circumstances, was 9 gallons, the equivalent of 67.5 lb. per mile, and costing 10.7d. There was not much saving there."

This is not a correct rendering of my remarks, and I should be much obliged if you would correct the paragraph quoted above to read as follows:—"When they first started burning oil they used 9 gallons of oil to the mile, equal to 67.5 lb., at a cost of 10.7d.; but during the period covered by Mr. Aston's paper the average price of oil per barrel increased to 5s. per barrel, at which price the cost per engine-mile would have worked out at 12.8d. At this rate there would not have been much saving in liquid fuel."

Yours very truly,
F. N. Poignand.

34, Victoria-street, London, S.W.,
December 27, 1911.

NEW ZEALAND HEMP.

TO THE EDITOR OF ENGINEERING.

SIR,—As a result of my letter appearing in your issue of October 27 last, several inquiries have been made to me by engineers, machinists, and chemists, to all of whom I have replied. It will, I am sure, be as gratifying to you and to your numerous readers to learn, as it is to me to be the means of this communication, that the recommendation I made as Trade Commissioner in 1898 has at last borne fruit; and the Hon. Thomas Mackenzie, the present Minister of Agriculture, has now issued under the date September 22, 1911, full particulars of the New Zealand Government offer of a bonus, which has been raised from 2000*l.* to the substantial amount of 12,000*l.* on exceptionally favourable conditions, which must attract many *bonafide* competitors for this valuable prize, apart altogether from the increasing annual revenue to be derived by the successful inventor.

I attach hereto the pamphlet referred to, and would respectfully direct attention to the extension of time granted—up to November 30, 1913.

As a loyal New Zealander, I hope an Imperialist will win this great reward.

Yours faithfully,
JOHN HOLMES.

14-18, College-street, York-road, Lambeth, S.E.,
December 15, 1911.

Particulars of the New Zealand Government's Offer of a Bonus of 12,000l. (nearly 60,000 Dols.) in Connection with New Zealand Hemp.

The New Zealand Government has agreed to pay 12,000*l.* as a bonus or bonuses for improvements in connection with—

1. The extraction and dressing of fibre from the New Zealand hemp plant (*Phormium tenax*); or
2. The utilisation of the by-products obtained during the processes of extracting the fibre;

on condition that the machine or process in regard to which the whole or any part of the bonus is to be paid shall be recommended by the New Zealand Flax-Millers' Association, and approved by the Government.

The 12,000*l.* will be paid, wholly or in part, for any of the following—viz. :—

1. A process of extracting and dressing the fibre of New Zealand hemp (*Phormium tenax*), whether by machinery or otherwise, whereby there shall be obtainable (*a*) a greatly improved quality of fibre marketable at a higher price, or (*b*) a substantial reduction in the cost of producing the fibre.
2. Any such process that shall produce a fibre fit for use in manufactures other than rope and twine-spinning.
3. Any such process that shall render unnecessary any of the present operations involved in extracting and dressing the fibre, such as stripping, paddocking, or scutching.
4. Any improved method of separating the green envelope or the flinty or coloured matter from the green leaf of the phormium plant so as to produce a strong white fibre, the whole of which can be saved with little or no tow or waste.
5. Any means whereby the by-products obtained during the processes of extracting and dressing New Zealand hemp-fibre—such as the gum, dye, stripper-slips, tow-dust, or waste vegetable matter—shall be converted into a marketable commodity.

Applications for the bonus must be addressed to the President of the New Zealand Flaxmillers' Association, Palmerston North, New Zealand, and must reach him not later than noon of November 30, 1912. They must be enclosed in an envelope clearly marked "Application for Bonus."

Each applicant shall state what lump sum (including the bonus of 12,000*l.*, or any part thereof) would be required to purchase the New Zealand rights of his machine or process in the event of such rights being acquired by the New Zealand Government for free use by the hemp-millers of this Dominion; or, if any applicant is unwilling to sell his rights, he shall state what amount of bonus (not exceeding 12,000*l.*) and what royalty he would require for the use of his machine or process.

As soon as possible after the expiry of the time for receiving applications for the bonus (November 30, 1913) the Flaxmillers' Association shall appoint a committee, of not less than six of its members, to open and examine the applications, to test such of the competing machines or processes as it considers worthy of trial, and to make recommendations to the Government as to the payment of the bonus.

On completion of all the demonstrations it deems necessary, the committee shall consider the whole of the machines or processes submitted for competition for the bonus, and in doing so shall take the following matters in connection with each one into consideration :—

1. The amount of the lump sum or royalty required for the rights.
2. The cost of purchasing, installing, and operating.
3. The labour and time occupied in operating.
4. The labour and time required after the operation and before the product is ready for packing.
5. The cost of producing the fibre, tow, or other product.
6. In the case of machines or processes for extracting and dressing the fibre, the percentage of fibre, and tow, if any, produced from a given weight of green leaves.
7. In the case of machines, the simplicity, durability, and safety of the working parts.

After considering the whole of the applications in the above respects, the committee shall forthwith submit to the Honourable Minister of Agriculture a report showing—

1. A complete list of all the applications received, giving the name and address of the applicant; the nature and purpose of the machine or process; the nature and value of the product; the quantity produced; the lump sum or royalty required for the rights; the estimated cost of purchasing, installing, and operating; the estimated labour and time occupied in operating; the estimated labour and time required after the operation and before the product is ready for packing; the estimated cost of producing the fibre, tow, or other product; the percentage of fibre, and tow, if any, from a given weight of green leaves; and, lastly, the simplicity, durability, and safety of the working parts.
2. Whether they consider any machine or process worthy of the whole bonus, and, if so, which one.
3. If they do not consider any machine or process worthy of the whole bonus, then, whether they consider any machines or processes entitled to a part thereof, and, if so, which ones and how much.

For the information of persons who are interested in the above announcement, but who have little or no knowledge in regard to New Zealand hemp (or, as it is often called, New Zealand flax), it may be pointed out that *Phormium tenax* is entirely different from any other hemp or flax plant. The leaves from which the fibre has to be extracted are sword-shaped, and about 4 ft. to 9 ft. long; they are moderately pliable, and of great tensile strength. The fibre is embedded in tough vegetable matter, containing a gum and a staining substance, and the greatest difficulty in the process of extraction is the removal of the vegetable refuse, gum, and dye without damaging or staining the fibre.

Specimens of New Zealand hemp (*Phormium tenax*) can be seen in many botanical gardens all over the world.

It would be of little use to send samples of the leaves outside New Zealand, as when cut they soon wither and become stiff and brown, and altogether useless for treatment by any known process.

THOMAS MACKENZIE, Minister of Agriculture.

Department of Agriculture, Commerce, and Tourists,
Wellington, New Zealand, September 22, 1911.

AN ACCURATE SUN-DIAL IN FERRO-CONCRETE.

TO THE EDITOR OF ENGINEERING.

SIR,—Electric signals will not be available everywhere just yet, and, for the regulation of clocks and watches, sun dials of an accurate type are by no means at the end of their service. For many, too, there will remain a certain satisfaction in a direct personal reference to our prime regulator.

It is curious that the method of calibration, in combination with pinhole images and a series of parallel straight lines on a flat surface, does not appear to have been applied to sun-dials. By applying it even an amateur may construct for a few shillings a dial which, with a single addition or subtraction, will give, within three or four seconds, standard time for ever after, and at any moment over several hours of the day. Corrections for longitude and refraction are, in effect, made by the dial itself.

The sun's image through a pin-hole falls upon the same straight line at the same local sun-time every day of the year, irrespective of the changes of declination, provided the line is parallel to the earth's polar axis. With 10 in. to 12 in. between pin-hole and screen the time of the bisection of the image by a line can be read to within three or four seconds. Thus readings closer by 400 or 500 per cent. than those of ordinary dials are obtained. Expensive engine dividing is avoided, because straight lines on a flat surface, the spacing of which does not matter, can be drawn by anyone. Not only does this dial show the time after being set up, but it finds its own time to a few seconds in the first place. A knowledge of the latitude taken from the map, a spirit-level, and a graduated inch or centimetre rule are all that are required for this purpose. By adding or subtracting the longitude the dial is then set once for all to give any standard time. Needless to say, it does not compete with the telescopic methods of transit, theodolite, or sextant used in astronomical or topographical work. In this dial the strong point of modern clocks and watches, phenomenal accuracy over short periods, is made use of for its calibration, while the dial itself, once so calibrated, removes the weak point of clockwork—the inability to keep time unaided for more than twenty or thirty consecutive days.

To embody these ideas the writer devised in 1909 a dial named the "B.D. Time-Box." It is not made for sale, and is unpatented. It may be a rectangular box some 10 in. to 15 in. from base to open mouth, and made of ferro-concrete, or built up or cast in metal. The base carries a flat screen of dull celluloid, upon which are scratched and numbered parallel straight lines square to its top edge. Across the mouth of the box are plates pierced with one or more pin-holes, also numbered if they are many. The box tipped up, with its base and screen-lines parallel to the earth's polar axis and its open end and pin-holes facing south, is fixed to a rigid pillar or wall. It is calibrated by the watch by reading to a second or two, and noting the times when the numbered screen-lines bisect the image of the sun as it passes over them. These readings do not fall at even hours and minutes, but this, of course, is of no consequence. From each reading the "equation of time" for the day is subtracted, and there results a table from which, by the simple addition or subtraction of the "equation" on any other day, the time is recovered. If later on standard time becomes more accurately known, a fresh table is produced at once by merely adding the correction. Errors due to refraction are eliminated by making, say, three other partial calibrations, and resulting tables at different seasons. These are correlated by taking a reading or two near the meridian in each case, as the effect of refraction is there nil.

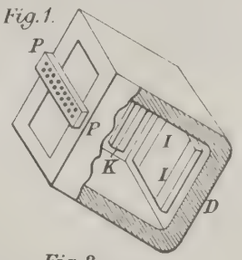
The annexed diagrams will aid in explaining the instrument. Fig. 1 is a diagram of a time-box, with central row of numbered pin-holes P, P—say 20 per inch—staggered, requiring two screen-lines I, I only, one on left and one on right of screen. The box, say, of ferro-concrete, two sides preferably movable to facilitate setting up. P, P of gun-metal, bolted across the mouth. Another row of pin-holes, one on each opposite side (not shown), as from P to D, and a narrow screen with one screen-line K, and the same on the opposite side; give the hours from 6 a.m. to 10 a.m. and from 2 p.m. to 6 p.m.

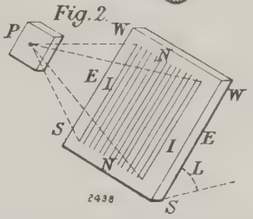
Fig. 2 is a diagram of essential elements. W S screen tipped up at the angle of the latitude L to the horizontal. Numbered screen-lines I, I, spaced alternately—say $\frac{1}{8}$ in. and $\frac{1}{10}$ in.—to prevent confusion of one line with its neighbour. Lines are accurately square to top edge W, W. Image crosses them parallel to W, W from left to right between, say, 10 a.m. and 2 p.m. Image passes from W, W at midwinter to E, E at the equinoxes, and S, S at midsummer. P is a single central pin-hole. Plane N N P normal to screen, and in the meridian. S, S and W, W horizontal.

There are two types of dial; in one the pin-holes are few and the lines many, and in the other *vice versâ*. In both types the height of the screen may be halved by substituting a row of pin-holes at both top and bottom for a single central row. The pin-holes may be carried down the sides of the box, thus giving readings between 6 a.m. and 6 p.m. Space forbids further discussion of details, but construction and setting up are both simple.

Ingenious dials are made, and are the best for the public, in which the correction for the equation of time is effected by a cam (Gibbs's "heliochronometer"), or by a sliding scale (Homan's "sun-clock"), set to date by the observer. They are necessarily expensive, and are subject to errors of 18 or 20 seconds, in addition to those due to refraction, because the equation differs so much for the same day in different years—*e.g.*, for 1897 and 1910, on January 1 the difference is + 35 seconds, on February 13 0 second, towards the end of December − 38 seconds; the differences are so irregular from month to month and year to year that mechanical correction for them is impossible, and when they happen to be additive to those due to refraction the total error may be well over the half minute, even for observations restricted to three hours from the meridian. A current almanack is therefore necessary, and the use of a shilling "Whitaker," kept handy, is but a trifling trouble.

It may be said that errors of half a minute or a minute even are near enough for ordinary purposes. That is true; it is also true, however, that such errors spoil the regulation of good clocks and watches (unless tested at





inconveniently long intervals), and thus reduce their effective value from good to poor. It is, indeed, the accuracy of the modern timepiece which demands accuracy in the dial, and it is that same accuracy which is in effect transferred to the dial by the method now advocated.

The errors are as follow :—Let L = latitude, H = the angle at the pinhole between a ray inclined and the ray normal to the screen, and let the time-box be about 13 in. in each dimension.

The only error possible in setting up is that the screen-lines may not be parallel to the polar axis :—(*a*) in the plane of the screen; (*b*) in the plane normal to the screen and containing the polar axis. An error in (*b*) is due to incorrect setting at the latitude, and matters only in so far as it produces an error in (*a*). A error in (*a*) means that a line is out of its direction on the surface of the screen, and the error is reckoned as a displacement at one end, so that readings at midsummer and at midwinter are discrepant by this amount; 0.001 in. corresponds to about 1 second (time) at mid-screen, and decreasing as $\cos^2$ H becomes 0.75 second when H=30 deg., *i.e.*, at 10 a.m. or 2 p.m. If t seconds = error in (*a*) due to 0.001 in. displacement in (*b*), $t = \cos^2 H \cdot \tan H = \frac{1}{2} \sin 2H$, and is zero at the meridian. This gives errors of 0.5 second at 10 a.m., and 0.25 second at 11 a.m. Readings before 10 a.m. and after 2 p.m., if desired, are taken on a screen square to the other, and from pinholes in plates in sides of the box. For them (*b*) errors vary as $\cos^2$ H, and are about double the above.

When standard time cannot be brought on the watch, it may be found as follows :—Set up as nearly in the meridian as possible, say by compass. (*c*) Level the screen's top edge. An error in level of 0.001 in. produces a noon error of S seconds, where S = sec. L = 1 sec. at lat. 5 deg., 1.2 sec. at 30 deg., 1.6 sec. at 50 deg. (*d*) Set a hair stretched across the screen to bisect the image horizontally in the morning. Alter the other end until it is truly parallel with the top edge. Compute the correction for hourly variation in declination (see "Whitaker"), or choose a season when it is less than 40 seconds of arc. If the image through the same pin-hole continues bisected to the other edge of the screen in the afternoon, the pin-hole ray normal to the screen is due south, and shows local noon. If not correct, halve the error by rotating the dial on its base. An error of 0.001 in. between the true path of the image and the hair produces a noon error of r = tan L secs. = 0.09 sec. at lat. 5 deg., 0.6 sec. at 30 deg., and 1.2 sec. at 50 deg. Thus the errors amount to a few seconds only, and the required accuracy is well within the compass of spirit-level and rule.

For rating purposes the small errors due to faulty setting up are the only ones, and they are spread over six months, and are thus greatly discounted.

It should be said that the angle H is measured on the plane of the equator, and is the projection on that plane of the actual angle between the rays, and equal to it only at the equinoxes. A "constant" is absent in all the equations, because, for the size of time-box taken, 0.001 in. corresponds to 1 second of time on the screen. In deriving the equations, the usual approximations for small angles were utilised, resulting in errors of much less than 0.01 second for small displacements.

It will be found that, although for oblique rays the

image is elliptical and, except at the equinoxes, on the skew as well, its bisection can be timed practically as closely as when the image is circular. This and the accuracy of timing possible to the pin-hole method may be tested at once by anyone. A piece of cardboard pierced with a pin-hole is placed facing the sun and parallel to and about 12 in. from a screen of smooth paper, upon which a line is ruled (dull pencil is better than ink) roughly pointing to the pole. Both must be propped up, so that vibration is excluded and the screen shaded. This shading is important, especially in hazy weather; it is done in the time-box by its sides, and, say, by the "Whitaker" held at its mouth. The material of the screen is also important; metal is unsatisfactory, and dull celluloid probably the best. Mr. Gibbs would find a strip of this an improvement in his "heliochronometer," which, with its elegant compensator, I admire.

Since the mean distance between pin-hole and screen is the radius, and not the diameter, of the virtual circle of reference, a time-box, 12 in. to 15 in. long, is equivalent to a 24-in. to 30-in. circular dial. This, together with the fact that a pin-hole image at that distance is a disc with well-defined margin, instead of a blurred shadow edge, explains its great advance over the ordinary dial in accuracy; and also, remembering its rigidity and the absence both of moving parts and graduated limb, why it approaches even the accuracy of telescopic instruments.

Your truly,

W. J. Bremner Davis,
Assoc. M. Inst. C.E.

"GAS-ENGINES FOR COLLIERY POWER-STATIONS."

To the Editor of Engineering.

Sir,—I wonder how many readers of your issue of the 15th inst. appreciated the full value of your remark that "electrical transmission has probably made the most progress of recent years, and for gas-engine driving it is likely that many people would be inclined at first sight to think that no competitive system need be considered."

May I make the additional remark that electrical winding-engines operated by gas-engine-driven dynamos would be comparatively inefficient alongside ordinary winding-engines operated by gas-engine-driven air-compressors.

To electricians and engineers in a hurry such a state of affairs is quite unthinkable. To the engineer who takes time to think it will have some significance.

Of course, were they operated in the usual isothermal open-circuit method, such engines would be very wasteful indeed, but even to propose doing so would be ridiculous.

If, however, they were operated on an adiabatic closed-circuit system with high artificial atmosphere, every advantage at present claimed for electrical winding-engines would be realised, and the running costs as well as all other costs would be less. Briefly described, an "adiabatic closed-circuit" installation would consist of a pair of high-pressure winding-engines, the exhaust-pipe of which would be connected to the inlet pipe of a gas-engine-driven air-compressor. The delivery-pipe of the air-compressor would be connected to an air-heater, from which the winding-engines would obtain their supply of air. The air-heater would be connected to the exhaust-pipe of the gas-engine. The capacity of the winding-engine exhaust-pipe would be equal to the capacity of the air-compressor delivery-pipe and of the air-heater. The total capacities for a given power would depend on the length of the wind and the duration of the stoppage for banking purposes. The gas-engine would run at a constant speed and for a working pressure of 150 lb. a pressure of 75 lb. would be maintained in the winding-engine exhaust-pipe, while a pressure of 225 lb. would be maintained in the air-compressor delivery-pipe and air-heater.

Just what these figures and "closed-circuit" operation signify may be understood from the following calculations.

The approximate heat distribution of a gas-engine is:—

30 per cent. converted into useful work at its crank-shaft.

30 per cent. lost in the water circulated in the cylinder jackets.

40 per cent. lost in the exhaust gases.

This latter figure means that a quantity of sensible heat equivalent to $1\frac{1}{3}$ times the total power of the engine will pass through the air-heater. To understand the possible effects of this heat it is necessary to make some air-compressor calculations. The compression curves of gas-engine and air-compressor indicator diagrams have a common characteristic $n = 1.33$, or, as I generally use it, $= \frac{4}{3}$.

If p = pressure of air entering cylinder in pounds per square inch absolute.
P = pressure of air leaving cylinder in pounds per square inch absolute.
W P = working pressure of air = $P - p$.
t = temperature of air entering cylinder in deg. Fahr. absolute; *i.e.*, = 61 + 461 = 522, say.
T = temperature of air leaving cylinder in deg. Fahr.
c = compression period as a fraction of stroke.
d = delivery period = $1 - c$.
M P^n = mean pressure throughout stroke in pounds per square inch for characteristic conditions.
M P^i = mean pressure throughout stroke in pounds per square inch for isothermal conditions.
W L = per cent. of work lost due to isothermal conditions; *i.e.* = $\frac{M\,P^n - M\,P^i}{M\,P^n}$.

then

$$T = \left(t \sqrt[4]{\frac{P}{p}}\right) - 461$$

$$c = \frac{\sqrt[4]{\left(\frac{P}{p}\right)^3} - 1}{\sqrt[4]{\left(\frac{P}{p}\right)^3}}$$

$$M\,P^n = 4\,p\left(\sqrt[4]{\frac{P}{p}} - 1\right)$$

$$M\,P^i = p\left(1 + \text{hyp. log of } \frac{P}{p}\right) - p.$$

The results of these calculations for a working pressure of 150 lb. on open and on closed circuit respectively are compared in the following table:—

Result.	Open Circuit.	"Closed Circuit."
p	15	90
P	165	240
W P	150	150
t	522	522
T	489 deg.	205 deg.
c	83 per cent.	51 per cent.
d	17 ,,	49 ,,
M P^n	49.26	99.72
M P^i	35.96	88.04
W L	26.99 per cent.	11.71 per cent.

The first fact that becomes evident from the table is that by operating on closed circuit the rise of temperature is very much less than on open circuit. That is to say, on open circuit the temperature rises almost $2\frac{1}{2}$ times as much as it does on closed circuit.

Similarly, the compression periods differ, with the result that the delivery period on closed circuit is almost three times as long as the delivery period on open circuit. This means, of course, that correspondingly smaller cylinders will be used on a closed circuit compressor, and that the cut-off in the motor or winding-engine cylinders for complete expansion would correspond exactly with the delivery periods. With regard to complete expansion it may be noted that on open circuit, if the cut-off is longer than the delivery period, there will be a loss from incomplete expansion, while on closed circuit there can be no such thing as incomplete expansion. The cut-off in the motor-cylinder may be longer or shorter than the delivery period, with corresponding differences of mean pressure in the motor-cylinder, but any expansion not completed in the motor-cylinder will be completed in the compressor-cylinder.

The mean pressures for characteristic conditions show that for a given size of cylinder over twice as much power will be delivered on closed circuit as compared with open circuit, thus demonstrating considerable constructional advantages for closed-circuit operation.

The mean pressures for isothermal conditions serve to show that the percentage of work lost under these conditions is in exact relation to the temperature difference. In other words, almost $2\frac{1}{2}$ times as much work is lost on open circuit as is lost on closed circuit.

On closed circuit, however, the air at a temperature of 205 deg. is passed through a heater in which exhaust gases of a temperature of 1000 deg. are also passing. The result is that the air, instead of losing any heat whatever, is further heated under constant-pressure conditions, and so has imparted to it a greater capacity for developing power than it had when leaving the compressor cylinder. It is here air transmission becomes more efficient than electrical transmission. If it is assumed that only one-sixth of the exhaust heat is imparted to the air, that the efficiency of the gas-engine compressor is 80 per cent., and the winding-engine efficiency is 90 per cent., then the over-all efficiency of an "adiabatic closed-circuit" system would be

$$\left(0.80 + \frac{0.85 \times 1.33}{6}\right) \times 90 = 88.99 \text{ per cent.}$$

If the same gas-engine driving a dynamo has an efficiency of 85 per cent. and the dynamo and motor have each an efficiency of 93 per cent., then the over-all efficiency of an electrical transmission would be

$$0.85 \times 0.93 \times 93 = 73.51 \text{ per cent.}$$

These figures would apparently show that some competitive system should be considered.

Yours truly,

Jas. Dunlop.

69, Armadale-street, Dennistoun, Glasgow,
December 16, 1911.

THE "HAWKE"-"OLYMPIC" COLLISION.

To the Editor of Engineering.

Sir,—The immediate cause of the collision appears, by the whole evidence given, to depend on something exceptional and abnormal, and therefore an appropriate subject for discussion in a scientific engineering journal.

Let us commence at the point when the Hawke was abeam of the Olympic, and going faster on a 15 deg. converging course. They approached until they came finally into practically a parallel course, by which time the Olympic had gathered way, and had become the faster vessel. Captain Blunt truly remarks that they must then have been much less than 300 yards apart, or "the Hawke could not have struck the Olympic under any helm," and he might, with equal truth, have said, under any swerve. Captain Blunt puts the distance before the swerve at "a shade under half a cable." Then the swerve commenced, and the Hawke was given 15 deg. port helm, but mocked at it, and swerved still more to port.

The Admiralty and its learned men plead "suction," but the evidence of Captain Pritchard (Cunard) and of Mr. R. Lewis, first class Liverpool pilot, cannot be regarded as anything but absolutely contradictory to such a theory. Mr. Lewis said that "he had been passed by the Caronia, 20,000 tons, at nearly her full speed, within 100 ft., without any trouble," but the size of his vessel was not stated, and comparative size is very important, as the Olympic and Hawke collision clearly indicates. A comparatively small vessel swerves and collides, and is "spun round like a top" (Captain Blunt), whereas on the large vessel Colonel Saxon-White "did not feel the shock," this immunity being due, firstly, to the Olympic's side being easily punctured, and, secondly, to her enormous inertia in the direction of her course.

Mr. Lewis agreed to something akin to suction abaft a moving vessel, and called it "displacement," and no doubt meant the motion of water into the wake of a vessel to fill her displacement, thereby causing following eddies. But this action again is counterpoised by the water thrown back by a steamer's method of propulsion. In the case of deeply-immersed screws, each screw throws back a cylindrical bar of water, which, by induction, becomes conical, until the whole is arrested; and the weight of the water thrown back × distance thrown each unit of time must equal the weight of the ship thrown forward × distance thrown.

The water that is seen to follow a steamer is consequently mainly on the surface, and a following vessel of any draught would get a good deal more backlash than tow.

In sailing ships, of course, there is no backlash, as their propulsion is caused by an extraneous force.

Assuming that "suction" on the side of a vessel at speed is all moonshine (in any waters except a narrow canal, and then only for steamers giving backlash that is replaced by the side waters), and assuming that the evidence on the Hawke is true—viz., that she never had any starboard helm at all—what caused the swerve?

At this point I read Mr. Haigh's letter published in Engineering of November 24; but his solution, although a *causa vera* under the conditions of his diagram, certainly seems to fail as a *causa sufficiens*. Moreover, his diagram shows the vessels much closer than even Captain Blunt's evidence indicated, and it seems necessary to look for the true cause further afield, say at least 350 ft. away from the Olympic, and the centres of the ships nearly abeam. Evidently, therefore, the wake of the Olympic could not act on the port screw of the Hawke.

On the 23rd inst. I wrote to a friend suggesting bow-wave action as causing the swerve, and again on the 25th as follows:—"Hawke steamed for some time parallel to Olympic and abeam of her."

"Then Olympic outspeeded Hawke, . . . so Hawke would now drop into Olympic's port bow wave *stern first*, and be struck by it on her (Hawke's) port quarter." . . .

"There would, moreover, be a great confusion of water at the intersection of the two bow waves . . . causing a troubled sea due to waves of interference." "This hubbub would also strike the Hawke on her port after-body, and the two combined would tend to turn the Hawke to port."

"The troubled water would also, a few seconds later, cause a very troubled helm on the Hawke."

This may also be an insufficient cause, but it seems odd that it has apparently received no consideration whatever during the trial.

In the model experiments at Teddington the Hawke swerved to port or to starboard, according to her *longitudinal* position with regard to the Olympic. This is precisely what one would anticipate if the swerve be due to bow-wave action.

If one may judge by Professor Boys' photographs of air disturbances due to the passage of projectiles at high velocity, bow-wave action (at about 36 deg.) is more powerful by far than the ripple action or suction apparent in the wake of the projectile.

These photographs indicate no suction whatever on the side of a projectile.

Yours faithfully,

J. T. Bucknill, Lieut.-Colonel.

November 26, 1911.

To the Editor of Engineering.

Sir,—*Re* the question of suction in the Olympic and Hawke collision, in my humble opinion there are two extremes. The one steaming in the open sea with many hundred fathoms of water beneath you, where the lateral suction is nil practically; and the other, which has been apparent to any seaman going East *via* the Suez Canal, where the water way is of the narrowest, and the suction, therefore, very great.

I went through the Canal in 1878, when it was not as broad or deep as now, and have passed through many times since. The effect of suction then was more apparent, the canal being narrower; from about abreast the bows on each side the water began to stream aft and towards the ship, leaving the banks bare for about 2 ft., while on each quarter followed a small wave or "bore," which filled the channel up again.

The effect of suction was most plainly shown by the buoys which mark the channel, whose moorings are practically "up and down;" as we passed them they were drawn astern and towards us. In those days there was no travelling at night; every ship gared at dark. So we had an instance which I do not suppose is ever to be had now. Our cruiser being new, and having done over 16 knots on trials, a high speed for those days, our captain wanted to get through into the "Bitter Lakes" before dark, so he increased the revolutions; I believe I remember the pilot strongly objecting on the ground of the damage we should do to the banks, and I don't think he was

wrong. We had been going 6 knots before how many revolutions we got I forget, but we got up to 7 knots over the ground, and no faster could we go however fast the engines ran. Though the rush of water off the banks was more, the size of the quarter-wave increased in proportion, and the buoys nearly under water were dragged towards the ship.

I should like to have a scientific opinion on the point. I think that in such a narrow channel the water in front of the ship has got to get behind her somehow, and that the screw draws it there, causing an increase of pressure on the bows more than the thrust of the screw can make up for; in fact, the action of the screw practically gives a strong foul tide. In the Olympic-Hawke collision the effect was something of the same sort, I believe, though modified, as the channel was broader. With her enormous displacement passing down, for her, a comparatively narrow channel and none too deep for her draught, increasing as she doubtless did her revolutions when she straightened up on her course (else why did the Hawke no longer gain, but drop astern), there was, no doubt, an increase of suction. This would continue until she gathered the speed due to the increased revolutions, which she would have done sooner had she been in broader and deeper water, when there would probably have been no collision, the Hawke being simply drawn over across her wake. Suction is perfectly understood in the Canal. So vessels are gared in hard.

Even then you have to attend your hawsers fore and aft, especially should a bigger vessel than usual pass; they would part if you did not, even though the passing vessels go dead slow or stop their engines altogether in order to lessen it. Personally speaking, I am surprised that no mention of the Suez Canal as an extreme case has been made at the trial, giving as it does the practical experience of 40 odd years' observation of suction in a narrow waterway.

Yours truly,
R.N. RETIRED.

CARBON DEPOSITS IN CYLINDER STEAM PASSAGES.

TO THE EDITOR OF ENGINEERING.

SIR,—Might we ask, through the columns of your valuable journal, for a remedy for removing carbon from the steam-ports of a compound road-locomotive?

We have three road-engines—one a Burrell compound, which has always given satisfaction; but this engine recently began to work badly, and shortly afterwards stopped dead. Upon investigation we found that the firm of whom we bought oil for years had sent us a cask of inferior cylinder oil, which had completely choked the steam-ports leading from the high-pressure cylinder to the low-pressure steam-chest with carbon deposit as hard as blue brick or iron.

It is important to note that the blocked steam-ports are not accessible to any tool, and the makers, who consider this case unique, say the only way they know of removing the deposit will be to drill holes in the front of the cylinders, afterwards plugging same; but, they add, care will be necessary to avoid ruining the cylinder by drilling through steam-ports. This looks serious for us. We had thought of simply plugging up all exits with corks or wood plugs, then filling the cylinders with paraffin, and letting the engine stand for a week or fortnight, to see if that would soften or remove the carbon.

Can any of your readers tell us of anything better than paraffin which would remove the deposit without damaging the cylinder surfaces? Never having heard of a similar case, we thought it of sufficient interest to ask you kindly to publish this inquiry, and invite the favour of comment on the same.

Yours faithfully,
JAMES W. HARRIS AND SON.

Hook Norton, Banbury, December 20, 1911.

SWEDISH MINING PROPERTIES.—The Commercial Intelligence Branch of the Board of Trade has received from His Majesty's Consul at Stockholm (Mr. H. M. Villiers, M.V.O.) a translation of parts of the Mining Law of Sweden of May 16, 1884, Cap. 7, Sec. 61, and Cap. 8, Sec. 68, and a translation of Sec. 57 of the Swedish Company's Law of August 12, 1910. In view of a "certain activity" which "exists at present in the sale and purchase of mines in Sweden," Mr. Villiers considers that it is of the utmost importance that the widest possible circulation should be given to Swedish laws affecting the ownership of mines in Sweden. The following are the translations received—viz.:—Mining Law of May 16, 1884 (Cap. 7, Sec. 61):—"When two or more persons take part in the same mining industry, it is necessary for them to appoint annually a manager for the mine, who shall carry out all the requirements and liabilities which the law prescribes. Such manager can only be a Swedish subject resident in the country." Mining Law (Cap. 8, Sec. 68):—"A foreigner may not in the country lay claim to a mineral deposit, neither may he, without the King's consent, own or work a claimed mineral deposit, or engage in mining industry, in consequence of which all claims or mining industry which a foreigner, without such permission, might possibly carry out, or allow to be carried out, shall be without effect as regards the protection of his or anyone else's rights in this respect. What is thus prescribed does not apply, however, to such rights as a foreigner may possess by concessions prior to this date (1884). Members of the Direction shall be Swedish subjects residing in the country, unless the King, for special reason, allows a certain proportion, not exceeding one-third of the whole number, to be subjects of another country, or Swedish subjects residing in a foreign country."

THE ROYAL METEOROLOGICAL SOCIETY.

THE monthly meeting of this Society was held on Wednesday evening, the 20th inst., at the Institution of Civil Engineers, Dr. H. N. Dickson, President, in the chair.

A paper on "*Solar Halos and Brocken Spectres*" was communicated by Mr. W. Larden. In this he described some phenomena round the sun which he had observed at St. Moritz in the Engadine. These included (1) brilliant colours not arranged in rings; (2) a series of rings; (3) the large halo of 22 deg. radius; and (4) parhelia, &c. He gave a description of a complicated system of halos and parhelia which he had observed on one occasion at Silvaplana in the Engadine.

Mr. W. H. Dines, F.R.S., read a paper on "*The Statical Changes of Pressure and Temperature in a Column of Air that accompany Changes of Pressure at the Bottom.*" It appears on investigation that the changes will depend on the manner in which the change at the earth's surface is produced, and also upon the initial vertical distribution of temperature. Furthermore, it is necessary to assume that the air column is bounded laterally by some rigid boundary, otherwise the pressure produced at any given height could not be maintained. The place of such a boundary is probably taken in nature by the lateral acceleration of strong winds, although we do not know how such winds are originated. We do know, however, that in the lower strata the differences of pressure that occur are on the average just balanced by this acceleration, and we may reasonably infer that it is also the same at higher levels.

Mr. Dines stated that the term "ascending current of a cyclone" has been used, but it appears to be incorrect. The actual phenomena seem rather to be a bulging upward of the strata between 1 km. or 2 km. and the isothermal, a bulging downward of the strata above the isothermal, accompanied with a lateral expansion of the strata below the isothermal.

COMPETITION IN SHIPBUILDING.—According to the *Otago Witness* the Dunedin Harbour Board has accepted the tender of a New Zealand firm—Messrs. Stevenson and Cook—for the construction of a new tug and salvage steamer, "provided it is built in Dunedin or Port Chalmers," the amount of the tender being 22,778*l.* 16s., whereas other tenders ranged from 18,500*l.* upwards. Naturally the other firms are disappointed and claim that there is thus "provided an example of protection in a British colony" and of unfair treatment of British shipbuilders. The contention of the colonists is that although they are paying 4278*l.* more than the sum quoted by the lowest tenderer, the Board is doing "what it can for the workers in Dunedin," and assisting in establishing shipbuilding. It was computed, too, that inspection at home instead of at a distant port would save 1000*l.* The firms and their tenders are as follow, and the list is significant, because it is headed by a Hong Kong firm:—The Hong Kong and Whampoa Dock Company, 18,500*l.*; Hawthorns and Co., Limited, Leith, 19,035*l.*; J. P. Rennoldson and Sons, South Shields, 20,100*l.*; Taikoo Dockyard Company, Hong Kong, 21,000*l.*; Ferguson Brothers, Port Glasgow, 21,500*l.*; Bow McLachlan and Co., Paisley, 22,044*l.*; Fleming and Ferguson, Paisley, 22,350*l.*; Stevenson and Cook, Port Chalmers, 22,778*l.*; J. McGregor and Co., Dunedin, 22,965*l.*; John I. Thornycroft and Co., Limited, Southampton, 23,250*l.*; J. T. Eltringham and Co., South Shields, 23,465*l.*; and the Ailsa Shipbuilding Company, Troon, 24,000*l.*

DIAGRAMS OF VALVE AND IGNITION SETTING FOR FOUR-CYLINDER AND SIX-CYLINDER PETROL-ENGINES.—Some very simple and ingenious diagrams have been brought out by the *Autocar* as an aid to the correct setting of the valves and ignition of petrol engines, and as a means of ascertaining the stroke upon which any piston of any of the cylinders is travelling at any instant. We have had two of these sent us for inspection, one for a four-cylinder petrol-engine and the other for a six-cylinder engine. Each of these card diagrams measures 5½ in. by 5 in. and consists of a disc about 5 in. in diameter, which is centred between two other cards and is free to revolve between them. The disc is marked with the different parts of one cycle of each engine—namely, suction, compression, working and exhaust, and these can be brought in succession under a zero line, and so the different positions of the crank can be ascertained from angles marked on the circumference of the disc. As the disc is turned round clockwise, the particular event going on in each cylinder is shown by following the vertical side of a large opening in the card, differently coloured circles on the disc representing the working of the different cylinders, the suction, compression, working, and exhaust of each cylinder being shown in turn; what is occurring in each cylinder being seen at the same time. Near the centre there is a small round opening, in which appears a diagram indicating the position of the crank, while at an orifice at the top of the card, marked "degrees," the amount the flywheel has rotated can be seen, in order that the valve-setting position may be clear. The position at which the spark occurs in each cylinder is indicated, and it is known when the spark is retarded and when it is advanced. As a means of setting the exhaust-valve cams on an engine the cards should be very useful. In order to facilitate setting by the fly-wheel, a table is printed on the back of the card which gives the amount a 12 in. diameter fly-wheel must be turned in order to equal different angles to which the wheel may be turned on the shaft. These cards are published by Messrs. Iliffe and Sons, Limited, 20, Tudor-street, London, E.C., the price being 1s. net each.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a series of colonial and foreign engineering projects, further data concerning which can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Australia: According to the *Australian Mining Standard*, provision is made in the Budget recently presented to the New South Wales Legislature for the expenditure, during the present financial year, in connection with the steam railways and electric tramways of the State of 1,290,000*l.* on works of a reproductive nature.

Russia.—The *Official Messenger* notifies that Messrs. Stakhovitch, Nikitin, and Yalovetz have applied to the Russian Committee for New Railways for a concession relative to the construction and working of a section of the proposed Donetz-Baltic Railway system—viz., from Lgof to Mitau, with a branch to Dunaburg. The projected line will comprise a distance of about 700 miles. The sum earmarked for the construction of lines giving connection between Donetz and the Baltic Sea amounts to 84,000,000 roubles (about 8,870,000*l.*).

Servia: The *Curier Financiar*, Bucharest, announces that the Servian Government have awarded to Mr. Taburno, a Russian engineer, a contract for the construction of the port of Raduievet, opposite Gruia. The harbour will be built on modern lines, and will be deep enough for small sea going vessels. This port will be the point of departure for the Trans-Balkan Danube-Adriatic Railway. Thousands of workmen are engaged on the construction of this line between Nish and Cneajevatz, particularly on the tunnels at Gramada and Cneajevatz. This section will shortly be ready.

BELGIAN COAL-MINING.—The production of coal in Belgium in the first half of this year amounted to 11,546,970 tons, as compared with 11,828,990 tons in the corresponding period of 1910, a decrease of 282,020 tons, attributable to the contraction of working hours.

THE SOLIDIFICATION OF AN IRON CASTING IN THE MOULD.—Before the London branch of the British Foundrymen's Association, on December 8, an illustrated lecture on "The Solidification of an Iron Casting in the Mould," was delivered by Professor Thomas Turner, M.Sc. A.R.S.M., F.I.C. Professor Turner, after remarking on the variations in the shrinkage experience with the different grades of iron, the shrinkage being greatest with a white iron and least with an open grade such as No. 1, defined the term "Solidification," which for practical work implied the cooling of the metal to the point at which it was stable enough to remove from the mould. At the conclusion of the lecture Professor Turner gave, among other information, the following as a suitable composition for general foundry work:—

Graphite carbon	2.7
Combined carbon	0.35
Silicon	1.5
Phosphorus	0.7
Sulphur	0.08
Manganese	0.5 to 0.6 or 0.7

For increased hardness the silicon should be reduced, and for softness it should be increased.

"OTTO" PETROL LOCOMOTIVE FOR 2-FT. GAUGE.—It may be remembered that we recenty described (page 696 of our last volume) a petrol locomotive made by the Gasmotoren Fabrik Deutz, Cologne-Deutz, and exhibited at the Manchester Colliery Exhibition in May last, by Messrs. W. Silverstein and Co., 147, Cannon-street, London, E.C. This locomotive has, we understand, been working since then in a gypsum mine in Nottinghamshire, and we have before us some figures relating to its performance during the time. The locomotive has been used for transporting gypsum from the mine to the wharf at the River Trent, the length of the line inside the mine being about 700 yards, and the length of the portion outside the mine about 1½ miles. With the previous horse traction one journey to and fro on the surface line occupied over two hours, including shunting at the wharf, and hauling a train of ten loaded wagons of about 20 tons total gross load. The locomotive does one trip with the same number of wagons in three-quarters of an hour generally, and in some cases in 35 minutes, making the output therefore more than double. The line is for the most part level, partly in favour of the load, and with the steepest gradient of 1 in 130 for full and 1 in 25 for empty wagons. The locomotive is fitted with two-speed gear in either direction—that is, for 3¾ and 7½ miles per hour. At the slow speed, which is used for starting and negotiating gradients and curves, a tractive effort of 600 lb. on the draw-bar was guaranteed, whilst the dynamometer during the trials registered over 800 lb. At the higher speed the tractive effort was 350 lb. The consumption of petrol during twenty-seven working days was 38 gallons, which equals 1.4 gallons per day from 7 a.m. to 5 p.m., and during this time 1274 net tons of stone were hauled. This was hauled over a mile and a half of track, the net average hauling per gallon being 33½ tons, which, at a tare of 10 cwt. per wagon, represents a total gross load of 47.6 tons on 1 gallon. Thus 71.4 ton-miles were thus covered with 1 gallon of petrol. The above locomotive has, we understand, replaced six horses, which cost 60s. per week in fodder alone, in addition to which it did away with four boys, the locomotive requiring only one driver, while there is one boy for shutting gates when crossing roads. The petrol consumption per week amounts to about 8½ gallons, which, at 8d., excluding rebate, amounts to about 5s. 8d. per week. The driving is very simple, and, as the starting occupies only a very little time, during long intervals the engine can be stopped to save petrol.

MASSEY'S EXPANSION VALVE GEAR FOR STEAM-HAMMERS.

CONSTRUCTED BY MESSRS. B. AND S. MASSEY, LIMITED, OPENSHAW, MANCHESTER.

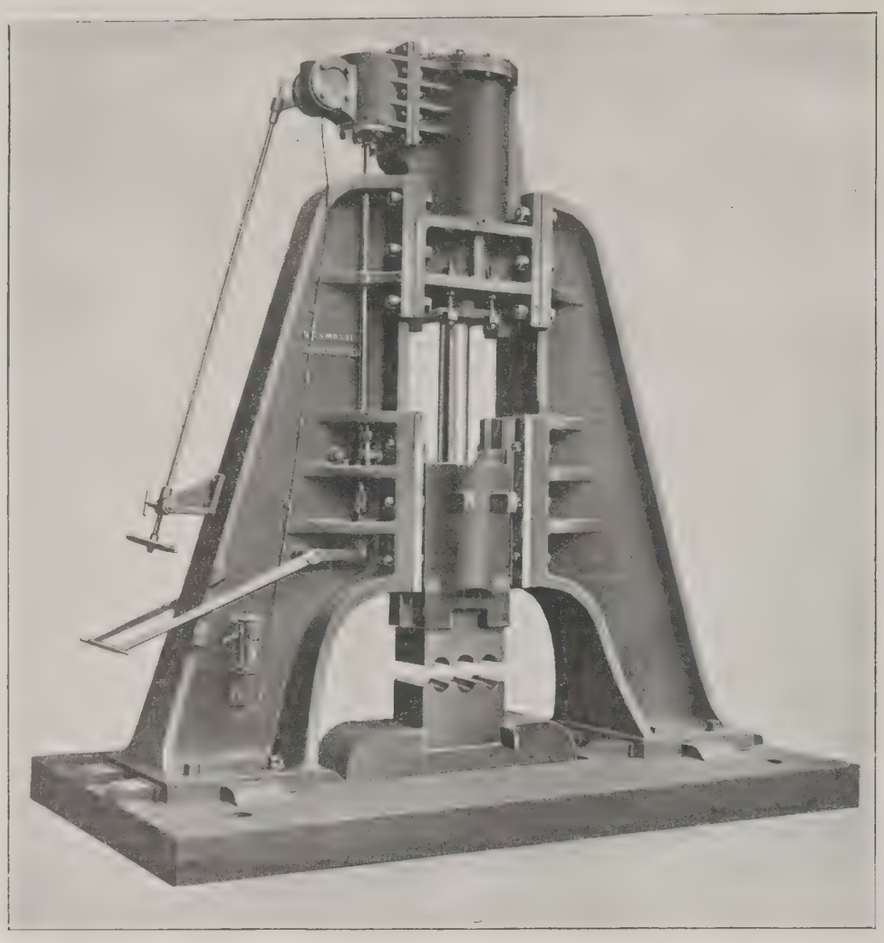


Fig. 1.

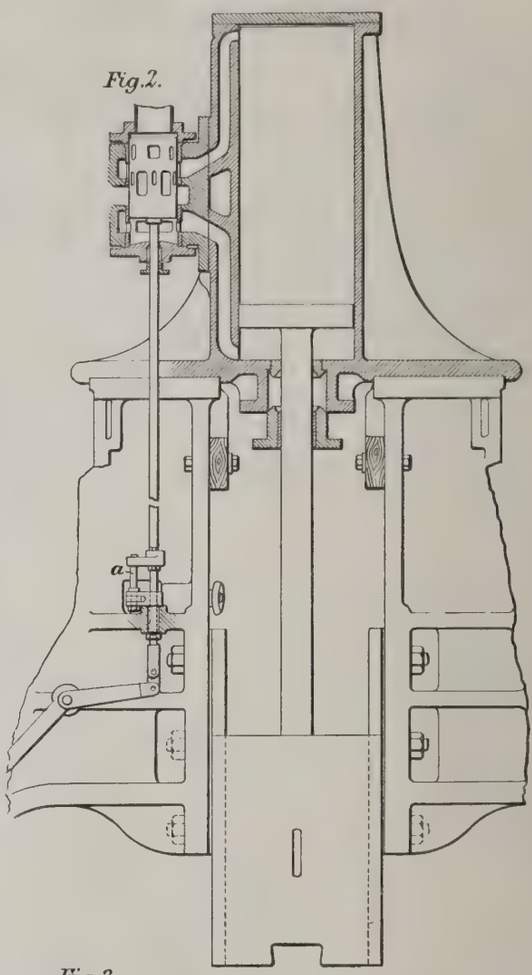


Fig. 2.

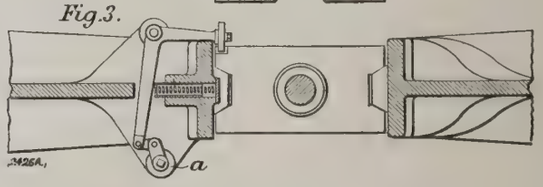


Fig. 3.

We illustrate on this page a piston-valve which has been designed and patented by Messrs. B. and S. Massey, Openshaw, Manchester, who also manufacture it. In our illustrations it is shown applied to a steam-hammer, for which it is particularly suitable. The valve as applied to a steam-hammer may be seen in the half-tone engraving, Fig. 1, and in the line engraving, Figs. 2 and 3, while Figs. 4 to 7 are sections illustrating different positions of the valve at varying points in the stroke. The main features of the hammer with this valve applied are, it is claimed, steam economy and easy control, two very important points in steam-hammer work.

The action of the valve is as follows:—On reference to our illustrations it will be seen that on moving the valve to the position shown in Fig. 4 the steam will be admitted to the bottom side of the piston for the commencement of the up stroke, and at the same time the top of the cylinder is opened to the exhaust. Following this admission the hammer rises, and in so doing rotates the valve by means of a roller mechanism, which is shown in Figs. 2 and 3, into the position Fig. 5, cutting off the steam and closing the exhaust.

The steam below the piston is, after this, used expansively, and the compression above the piston produces a cushion which checks the movement of the hammer and brings it to rest. The arrangement of the valve is such that when the hammer is at the top of the stroke just sufficient steam is admitted below the piston to keep it suspended. When it is required to admit steam to the upper side of the piston, the valve is moved to the position shown in Fig. 6, which opens the bottom of the cylinder to the exhaust, and the hammer is forced down. As the tup descends the valve is rotated round again until at half-stroke the steam is entirely cut off, and the steam is used expansively for the remainder of the stroke. When the hand-lever is placed a little below the middle position, some supplementary ports in the valve come into action, and the tup can be held down. These supplementary ports also serve for giving short strokes to the hammer; they are, however, closed when a long travel is given to the valve during ordinary work.

Fig. 4. VALVE LOWERED FOR UP STROKE.

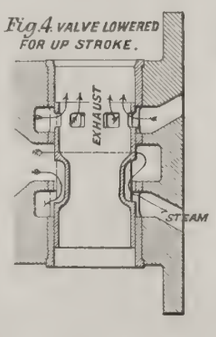


Fig. 6. VALVE RAISED FOR DOWN STROKE.

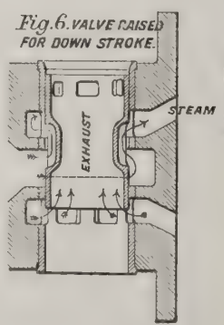


Fig. 5.

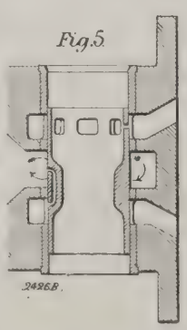
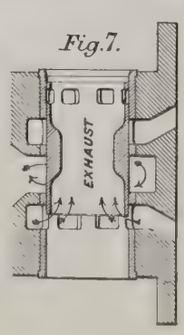


Fig. 7.



It is claimed that this gear gives an economy of 30 to 40 per cent. compared with ordinary valve gears, the reasons for which are that the steam is used expansively on both the up and down strokes; the serious loss caused by what is known as "after-flow" is largely prevented. Clearance is also, to a great extent, avoided, owing to the automatic compression occurring at the end of the up stroke, and direct leakage of steam past the valve when "holding up" is prevented, for the valve is so arranged that during this operation it occupies the position in which the lap is a maximum. In the usual form of construction the valve, when in mid-position, has the minimum lap, and consequently a very short leakage path from the steam side to the exhaust. It is claimed that the control is as simple as in an ordinary hand-worked hammer, and that less skill is required. There is also no danger of the piston striking the cylinder cover, and the hammer can be held up at the extreme top of the stroke, and stamping can be easily carried out.

The hammer we illustrate is classed as a 3-ton hammer for axle forging, and is very strongly constructed. The tup is a steel casting and works between forged-steel slides, which are separated from the standards and can be accurately adjusted to take up wear. The piston-rod is of large diameter and is connected to the tup by means of a ball-and-socket joint held in place by two large cotters. The stroke of the hammer is short, as it has been found that quick, short blows are preferable for this class of work. The automatic rotary motion of the valve is gained by means of the gear shown, which takes the place of the tripper usually employed on hand-worked hammers in order to prevent the piston rising too high and striking the cylinder cover, and the tripper is not always sufficient to prevent this, and great care has to be exercised by the operator even with it fitted.

African Railways.—The railways of Africa formed the subject of the issue of the *Railway Gazette* which appeared on November 28. There were articles on the Egyptian State Railways, Nigerian Railways, Uganda Railway, the New Cape Central Railway, the Rhodesian Railways, the Cape to Cairo Railway, the Benguella Railway, the railways in the Belgian Congo, the Sierra Leone Railway, the Lagos Railway, the Gold Coast Railway, the French and German Railways in Africa, and many others.

CATALOGUES.

Welded-Steel Tanks and Pipes.—We have received from Messrs. T. Toward and Company, Limited, St. Lawrence Iron Works, Ouseburn, Newcastle-on-Tyne, a leaflet illustrating a group of welded-steel fuel tanks, specially shaped for use on a large motor-boat. The leaflet also illustrates some welded wrought-steel jacketed exhaust pipes for oil-engines.

Milling-Machines.—We have received from Messrs. James Archdale & Co., Limited, of Ledsam-street, Birmingham, a copy of their sectional catalogue of high-speed milling-machines. Vertical, horizontal, and universal machines are dealt with, illustrations and general particulars being given of a large range of sizes in each type. Particulars of accessories such as arbors, circular tables, machine vices, dividing headstocks, &c., are also included. The catalogue, which is well printed and illustrated, also deals with a machine for grinding milling-cutters, reamers, &c.

Petrol-Motor Road-Rollers.—The Austin Manufacturing Company, of Chicago, U.S.A., have sent us a copy of a catalogue illustrating and describing their motor road rollers, and pointing out their superiority over steam rollers. The motor rollers are made in five sizes, from 7 to 15 tons in weight, each being driven by a single-cylinder slow-speed petrol-engine. Numerous illustrations show the rollers at work in various parts of the world rolling and scarifying roads, and also driving stone-breakers and other machinery. A large number of testimonials from users are reprinted.

Electric Wires and Cables.—A price list of insulated wires and cables, for electric lighting and other purposes, has been issued by the India Rubber, Gutta Percha, and Telegraph Works Company, Limited, of Silvertown, E. This list deals with different grades of single, twin, and concentric vulcanized cables, with various covering materials, and also includes particulars of single and twin flexibles for motor-cars, electric lighting, &c. Prices are also quoted for high-tension cables for working pressures of 2200 and 5500 volts. All the cables dealt with are manufactured in accordance with the rules of the Engineering Standards Committee.

Petrol-Gas Lighting.—The "Litz" Safety Gas Company, Limited, Lawkholme Works, Keighley, have sent us a copy of a catalogue illustrating and describing their system of producing petrol-gas, and pointing out its advantages. The gas-generator, which is driven by means of a falling weight, is automatic in action, starting as soon as the first burner is turned on, and stopping when the last light is put out. It is stated that, with petrol at 1s. 2d. a gallon, 1000 candle-power hours cost 1¾d. Prices are stated for seven plants, the capacities of which range from 12 to 150 burners, each of 40 candle-power. The catalogue illustrates a number of country residences in which Litz petrol-gas is used for lighting, heating, and cooking, and also includes several testimonials from users.

Steam-Turbines and Turbo-Pumps.—From the Southwark Foundry and Machine Company, of Philadelphia, Pa., U.S.A., a pamphlet relating to Rateau steam-turbines, as manufactured by them, has reached us. The pamphlet points out the advantages of the Rateau turbines, claiming that they are simpler, the clearances greater, and the efficiency less affected by wear, than is the case with turbines of the reaction type. Exhaust-steam and mixed-pressure turbines are also dealt with, and the principle of the Rateau mixed-pressure governor is explained. We have also received from this firm another pamphlet illustrating and describing Rateau turbo-pumps for water supply, boiler feeding, and hydraulic service. Several examples of these pumps, driven by steam-turbines and also by electric motors, are illustrated.

Power-Plant Accessories.—Messrs. T. Sugden, Limited, 180, Fleet-street, E.C., who are the agents in this country for Messrs. Hübner and Mayer, of Vienna, have sent us a copy of a very comprehensive catalogue of boiler mountings and power-plant accessories made by the latter firm. The catalogue, which is printed in German, contains 300 pages, and is bound in cloth covers. Full particulars, with prices, are given of a great variety of apparatus, such as pressure-gauges, pyrometers, thermometers, water-meters, steam-meters, injectors, water-level indicators, safety-valves, stop-valves and cocks, isolating-valves, reducing-valves, temperature regulators, steam and oil-separators, steam-traps, lubricators, &c. Some novel and interesting devices are included in this catalogue.

Primary Cells and Carbon Goods.—Messrs. James McMillan and Co., Clun House, Surrey-street, Strand, W.C., have sent us a catalogue of primary cells and carbon goods manufactured by Rylander and Rudolphs Fabriks Aktiebolag, of Henriksdal, Sweden. Prices are stated for various forms of wet and dry Leclanché cells and accessories for operating bells, telegraphs and telephones, and for use in connection with shot-firing, electric ignition, &c. The carbon goods dealt with include a great variety of brushes for electrical machinery, contact-pieces for circuit-breakers, filament moulds for glow-lamp manufacture, packing-rings for turbine-glands, cores for foundry work, carbon discs for microphones, and lightning-arrester carbons. Prices are stated for some of these articles.

Brazing Cast Iron.—Messrs. Wasserman and Co., of Lausanne, Switzerland, whose London address is 13, Fenchurch Buildings, E.C., have issued a pamphlet describing their process of brazing cast iron, especially for repairing castings. The substance employed is called "Castolin," and with this material it is claimed that a broken casting can be repaired on a smith's hearth or portable forge with no more difficulty than is caused by an ordinary brazing job. It is also stated that the joint has a tensile strength of 10 tons per sq. in., and that a casting repaired by this process will not break again in the same place, the joint being stronger than the original metal. Numerous testimonials are reprinted in this pamphlet, and examples of repairs carried out on castings of all shapes and sizes are illustrated.

Electrical Apparatus.—Messrs. Johnson and Phillips, Limited, 12, Union-court, Old Broad-street, E.C., have sent us a copy of an illustrated price-list of switch-gear, fuses, motor-starters, measuring instruments, and other electrical apparatus manufactured by them. In glancing through the list we notice three-pole oil switches and accessories for pressures up to 30,000 volts, isolating-switches, current and potential transformers, choking-coils and lightning-arresters, ammeters and voltmeters of the moving-coil, moving-iron, and hot-wire types, battery switches, ironclad switches and fuses, distribution boards, tubular switch fuses, quick-break knife switches, circuit-breakers, and various starters for direct-current and alternating-current motors. Full particulars are given of all these and other appliances.

Chains for Mortising-Machines.—Messrs. Hans Renold, Limited, Progress Works, Brook-street, Manchester, have recently brought out a new series of short-pitch cutting chains for wood-mortising machines. With these new chains it is possible to cut mortices only $\frac{3}{4}$ in. in length, whereas previously about 1½ in. was the minimum length for chain mortising. Prices and full particulars of chains, guide-bars, and sprockets for mortice lengths of $\frac{3}{4}$ in., $\frac{5}{8}$ in., 1 in., and 1¼ in., and widths ranging from ¼ in. to $\frac{7}{16}$ in., are given in a four-page leaflet, a copy of which has reached us. We have also received a catalogue of long-pitch chains, guide-bars, and sprockets, which are made in all sizes for cutting mortices up to 3 in. long and 1 in. wide; metric sizes are also listed. The catalogue also includes notes on grinding and repairing the chains.

Aluminium.—We have recently received from the British Aluminium Company, Limited, 109, Queen Victoria-street, E.C., several leaflets, &c., illustrating the application of aluminium to electrical and other work. Some of these leaflets illustrate overhead power-transmission lines employing aluminium wires; others deal with aluminium battery connections, feeder connections, bus-bars for switchboards, &c. A small pamphlet included among the number reprints an interesting paper by M. A. Mariage, read at the Brussels Congress of the Permanent International Tramways Union, on the use of aluminium wire for winding the field coils of traction motors. Another leaflet gives instructions for polishing, satin finishing, and frosting aluminium, while two others deal respectively with aluminium fittings for railway carriages and plant for chemical manufacturers.

Mortising-Machine.—From Messrs. J. Sagar and Co., Limited, Canal Foundry, Halifax, we have received a pamphlet illustrating and fully describing their combined chain-cutter and hollow-chisel mortising-machine. With the chain-cutter, mortices ranging from ¼ in. to 1 in. wide, and from $\frac{5}{8}$ in. to 2½ in. long, may be made at one cut, while the hollow chisel can be used for mortices from ¼ in. to $\frac{3}{4}$ in. square. The hollow-chisel mechanism can also be employed for boring circular holes. The machine is fitted with an exhaust fan for removing chips and dust, and is also provided with a device for preventing the wood from splintering at the part where the cutting-chain runs out. This device consists of a specially-shaped hardwood block attached to a weighted rod, which presses it firmly down on to the work at the edge of the mortice. Several other special features of the machine are pointed out in the pamphlet, which also contains numerous testimonials from users.

Vibratory Rectifier for Alternating Current.—We have received from the Adnil Electric Company, Limited, of Adnil Building, Artillery-lane, E.C., a pamphlet describing their vibratory rectifiers for charging accumulators and working direct-current apparatus for alternating-current circuits. Four sizes are listed for 45 to 60-cycle circuits from 100 to 250 volts, the direct-current output being either 2.2 amperes at 7.5 volts or 1.2 amperes at 15 volts; larger sizes can, however, be supplied. The pulsating current produced can be used for non-inductive work, such as charging accumulators or lighting incandescent lamps, and, with the addition of condensers, inductive apparatus, such as small motors, can be operated. We understand also that these rectifiers may be so connected to a three-phase circuit as to produce a non-pulsating continuous current. The efficiency of transformation, both at no load and full load, is stated to be equal to that of a transformer of similar output.

Anti-Rolling Tanks for Ships.—Messrs. Blohm and Voss, of Hamburg, have sent us a pamphlet illustrating and describing Frahm's anti-rolling tanks for damping the rolling motion of ships. The arrangements were fully described in a paper recently read by the inventor before the Institution of Naval Architects, and reprinted in our issues of April 14 and 21 last. The pamphlet contains some notes on the causes and consequences of rolling, and then explains the principle of the anti-rolling tanks, afterwards illustrating and describing apparatus for testing the effect of the tanks on models. The results obtained on some of the steamers on which the tanks have been fitted are illustrated by diagrams taken by means of specially designed pendulum apparatus. These diagrams show that a badly rolling boat can be rendered practically steady by the tanks. Anti-rolling tanks are to be fitted on several vessels of the Hamburg-Amerika Line, including the 50,000-ton steamer Imperator, now under construction. The Cunard liner Laconia has also been provided with the apparatus as fully described and illustrated on page 803 *ante*.

Steel-Sheet Piling.—We have received from the United States Steel Products Company, whose London office is at 36 to 38, New Broad-street, E.C., a booklet fully describing their system of steel-sheet piling, and giving numerous examples of its use in connection with cofferdams, trenches, foundations, shafts, sea-walls, dams, &c. The piles are rolled with one edge in the form of a slot crescent-shaped in section, and the other edge is swelled so as to fit into the corresponding slot of the adjacent pile, thus forming an interlocking joint of the ball-and-socket type. A small space is left in the slot so that, if necessary, a strip of wood can be inserted to make the joint perfectly water-tight. Three sections are employed—two 12 in. wide by ½ in. and $\frac{3}{8}$ in. in thickness, and one 6 in. wide by ¼ in. thick, the latter being suitable for sewers, trenches, and shallow pits when the pressure is not great and the soil not very stiff. The booklet deals with the methods of driving and pulling the piles, and also illustrates the formation of corners, partitions, junctions, and other constructional details. It also contains a diagram showing the correct spacing of walings for cofferdams to support various heads of water.

Feed-Water Softener and Purifier.—Messrs. Robert Boby, Limited, of 212, Upper Thames-street, E.C., have sent us a booklet dealing with "Neckar" water-softening and boiler-mud extracting apparatus. One of the special features of this plant is that the feed is heated by mixing with it a small quantity of water drawn from the bottom of the boiler, together with the sediment. The plant consists of two cylindrical tanks, each of which has a conical bottom part and contains a filter of wood-wool. The admission of untreated water, boiler water, and soda solution, which is the only chemical employed, is controlled in each case by a simple float-operated valve. The crude water and soda solution flow downwards, through a central dip-pipe, into the lower part of the first tank, where they mix with the hot boiler water, the heat of which assists the process of softening. In this part of the apparatus the sediment, which would otherwise collect in the boiler, is precipitated. The heated and softened water then rises through the filter, and flows from the top of this tank to the lower part of the next one. In the latter it rises through another filter, and is finally drawn off by the feed-pump, which is connected to the top of this tank. Among the advantages claimed for this system it is stated that all scale-forming material is continuously removed from the boiler, and that costs for maintenance and chemicals are very low. It is also pointed out that most of the heat in the water drawn from the boiler is utilised in raising the temperature of the feed, and that the heat of the water maintains the filtering medium in the best possible condition for entrapping the solids held in suspension. In conclusion, a number of testimonials from users are reprinted.

THE METROPOLITAN WATER SUPPLY.—The present financial year is witnessing considerable activity on the part of the Metropolitan Water Board. We only recently recorded the opening by the Lord Mayor of the Island Barn Reservoir. The Chingford reservoir works are approaching completion, and work is progressing with the buildings to accommodate the five sets of Humphrey internal-combustion gas-pumps to be installed there. At the new pumping station at Walton, opened in June last, trials of the engines have been proceeding, and, though not yet completed, show a steam consumption of between 10 lb. and 10½ lb. per indicated horse-power per hour. The pumping station at Hadley-road, Enfield, is complete, and the machinery there will be brought into operation very shortly. In addition to this constructional work, the Board obtained new powers with regard to abstraction of additional water from the Thames.

THE COPPER MARKET.—In their report dated the 18th inst., Messrs. James Lewis and Son state that the advance in the value of copper had made further progress, stimulated by the very satisfactory American statistics for the month of November, which showed a reduced production of 2847 tons, with an increased consumption of 1773 tons and of exports of 3109 tons, resulting in a diminished stock of 10,362 tons, as compared with the previous month. From 59*l.* 2s. 6d. on the 1st inst. cash Standard fell to 58*l.* 5s. on the 6th, but subsequently advanced to 61*l.* 11s. 3d. on the 15th, up to 62*l.* 8s. 9d. being paid for three months prompt, exceptionally large purchases being made by consumers as well as speculators. Closing values on the 18th were 62*l.* 6s. 3d. cash and 63*l.* 3s. 9d. three months; the transactions of the fortnight amounted to about 25,000 tons. American electrolytic had advanced to 14 cents per pound in New York and to 64*l.* per ton c.i.f., with large sales to both American and European manufacturers, most of the chief producers being sold out for delivery during the next two months, with the result that very little was now offering. A large business had also been done in Lake copper. Sulphate of copper was now held for 23*l.* 10s. by makers, though from second hands it was obtainable at 23*l.*, for spring delivery. Stocks in England and France had decreased 1263 tons, and those in Germany and Holland 1200 tons, during the fortnight. Messrs. Lewis's statistics showed an increased European consumption of 29,808 tons, but a decrease in American consumption of 27,773 tons as compared with last year. Imports into Europe from the United States had increased 27,934 tons, and from other countries 960 tons, exports from the United States being 18,454 tons and from Europe 662 tons larger. American and European stocks were 31,656 tons less than twelve months ago. American shipments from the three northern ports for the past fortnight were advised as 15,244 tons.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

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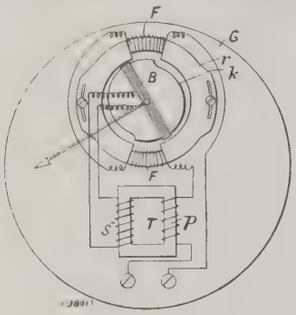
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

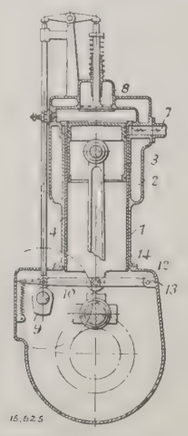
13,801/11. Siemens Brothers and Co., Limited, London (*Siemens and Halske Aktiengesellschaft, Berlin, Germany.*) **Ammeters.** [1 *Fig.*] June 9, 1911.—In ammeters of the dynamometer type, provided with an iron core so formed that the induction density of the magnetic field varies in the path of the moving coil, the inner and outer parts of the iron core are arranged so that they can be relatively rotated. The limit of the range of the instrument can thus be adjusted. The fixed coil F has two windings on a ring *r* of sheet iron. This ring has an inner iron core *k*. On the base-plate G is a transformer T, the primary



winding *p* of which is in series with the fixed coils F, and is in the circuit whose current is to be measured. The moving coil B is connected to the secondary winding *s* of the transformer. The periphery of one of the iron parts *k* or *r* is so constructed that the coil B, with increasing deflection, is always moving into a wider part of the air-gap. If one of the iron parts—for example, the part *r*—is turned about its centre, the field in which the coil moves is altered. This alteration of field alters the range of the instrument. For this purpose, the iron ring *r* is provided with slots and clamping screws. (*Accepted November* 1, 1911.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

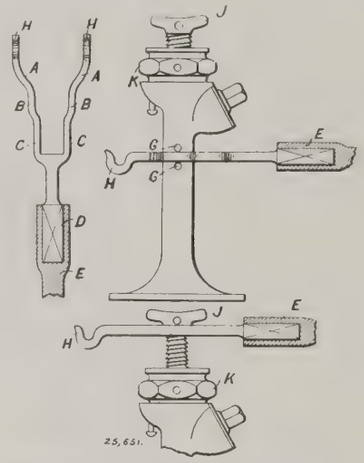
15,825/11. L. Renault, Billancourt, France. Internal-Combustion Engines. [5 *Figs.*] July 16, 1910.—This invention consists in arranging around the piston between its outer wall and the inner wall of the cylinder a cylindrical sleeve, which may, or may not, embrace the entire circumference of the cylinder, and which is provided at its upper part with a flange forming a valve. This valve, which is of very large size,



rests upon a seat constituted by the upper part of the cylinder itself. Owing to the large diameter given to the sleeve, this device permits of obtaining a very large passage for the gases with a relatively small lift of the valve, while at the same time the arrangement entails no increase in the dimensions of the cylinder. 1 designates the cylinder and 2 its water-jacket. Between the cylinder 1 and the piston 3 the sleeve 4 is arranged, its upper part resting on a seat formed in the cylinder. The sleeve 4 serves for the exhaust. The gases expelled after the explosion escape to the exterior through the conduit 7, either directly into the atmosphere or into a silencer. The inlet valve 8 is arranged at the upper part of the cylinder above the piston, and it may also be made of large size. The sleeve is operated by means of a cam 9 mounted on the cam-shaft 10 acting upon a roller at the extremity of the lever 12, pivoted at 13, and also connected at 14 to the lower part of the sleeve. As regards the inlet-valve, it is controlled by means of a rocker such as is ordinarily employed. (*Accepted November* 15, 1911.)

LIFTING AND HAULING APPLIANCES.

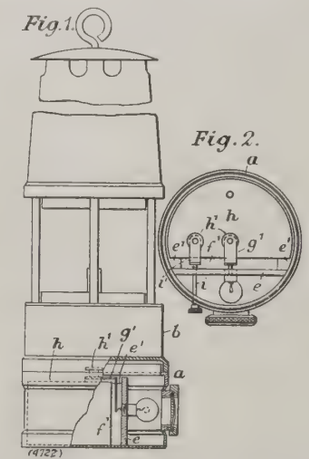
25,651/10. W. Adair, London. Lifting-Jacks. [7 *Figs.*] November 4, 1910.—This invention relates to lifting-jacks for motor-cars, and in particular to the operating means employed, which consist of a fork forming part of the operating handle, or of a fork attached to the pillar or lifting stem, the said latter fork being operated by the handle. The fork shown is adapted to effect the following operations :—(1) The placing of the jack in its proper position under the axle ; (2) the raising of the crutch pillar to the axle ; (3) the lowering of the jack ; and (4) the withdrawal of the jack from beneath the vehicle. The fork is attachable to the end of the handle used for operating the lifting mechanism. Fig. 1 is a plan of the fork, which has three different widths of prongs A, B, and C, and is provided with the plug end D to fit the socket E of the lifting-handle. Fig. 2 is an elevation



showing the portion B of the fork fitting between pins G, G on the base, the contracted part B^1 fitting against the wall of the base, and thus enabling the jack to be pushed readily into position beneath the axle. In Fig. 3 the part C of the fork is shown inserted under the crutch J for the purpose of lifting it up to the axle. The sides of the fork may be inserted under the side edges of the crutch J or under pins at each side of the crutch, one of which pins is shown. Pins are also fitted in the nut K, so that when the hooks H on the end of the fork-prongs engage therewith, and the lifting-handle D, with the fork attached, is moved to the right or left, the nut K is caused to partially rotate, and the expansible nut K, which is of known construction, is caused to open and allow the crutch pillar to fall and the jack to close. (*Accepted November* 15, 1911.)

MINING, METALLURGY, AND METAL-WORKING.

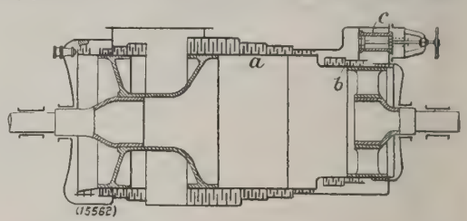
4722/11. T. Jones and T. R. Davies, Ystradgynlais. Miners' Lamps. [2 *Figs.*] February 24, 1911.—This invention relates to miners' safety lamps having an emergency electric light capable of being used when the main lamp for any reason is extinguished, and has for object to provide a self-contained



electric lamp capable of being detachably secured to the oil-container of a safety lamp of the usual kind. In carrying the invention into effect, a circular casing *a* for the electric lamp and battery is provided, and has a screwed upper end adapted to engage a screw-threaded base-ring on the lower end of the oil-container *b* of the miners' lamp. At one side of the casing *a* there is an aperture provided with a lens and protecting wire-gauze. Across the interior of the casing *a* there is a transverse bridge member *c* upon which is mounted a socket for the electric lamp bulb. An accumulator cell *h* fits in the casing at the rear of the bridge member and is retained at a determined distance therefrom by means of stop-blocks e^1 so as to leave a space f^1 into which may project spring contact members g^1, i^1 leading from the terminals h^1, and adapted the one to contact with the contact of the lamp bulb and the other with the switch contact *i*. The casing is locked to the oil-container so that it can only be separated from the oil-container by a person authorised so to do. (*Accepted November* 1, 1911.)

SHIPS AND NAUTICAL APPLIANCES.

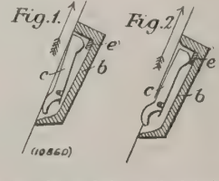
15,562/11. Aktiengesellschaft Brown, Boveri, Baden, Switzerland. Marine Turbine Installation. [2 *Figs.*] November 18, 1910.—In marine turbine installations having higher and lower-pressure turbines distributed over various shafts, one or more of the lower-pressure turbines are provided, according to this invention, with additional stages for smaller outputs, which stages, during increased outputs, are by-passed, the steam exhausted from the higher-pressure turbines being then directly passed to the lower-pressure turbines. One or more low-pressure elements *a* is provided with additional stages *b*, which are used during decreased outputs of the installation. When a greater output is required, however, the additional stages *b* are rendered inactive by the opening of a by-pass valve *c*, whereby the steam exhausted directly from a



higher pressure element of the installation passes therefrom directly to the lower-pressure turbine element *a*. By such an arrangement it will be seen that, although the output of the element *a* is increased, the ratio existing between the blade velocity and the steam velocity remains practically the same as during decreased outputs, the efficiency of the turbine elements being thus unaltered. Hitherto such additional stages precede the higher-pressure elements of the installation, and as they thus receive high-pressure steam, the leakage of steam on account of the short blades necessary in such stages is considerable. This disadvantage, however, is overcome in the present installation, since the blades of the additional stages can be made much longer on account of the greater specific volume of the low-pressure steam which enters the stages when the latter precede the lower-pressure elements. (*Accepted November* 1, 1911.)

TEXTILE MACHINERY.

10,860/11. A. J. Bally and L. Richard, Villeurbanne, France. Net and Tulle Machines. [3 *Figs.*] May 4, 1911.—In mechanism for automatically stopping net and like weaving-looms in the event of a hole or tear occurring in the woven fabric, pivoted contact-fingers are used and employed to close an electric circuit when the pressure of the fabric on the fingers is removed. According to this invention, the fingers are arranged closely together in a row, and are simply balanced and held out of electrical contact by the pressure of the fabric only, so that when the pressure is removed the fingers tilt and close the circuit. In the path of the piece of net, immediately above the point where the threads are woven together, a cross-bar *b* is fixed, extending from side to side of the loom. This cross-bar has a troughlike section, and the fabric passing to the winding-roller is supported on the two sides thereof. Behind the fabric, in the hollow of the cross-bar, a series of metal contact-fingers *c*, *c* is



arranged, the contact-fingers being articulated on a metal conducting-wire supported at intervals by insulators. At the upper part of the cross-bar a second conductor *e* is fixed. The contact-fingers are arranged sufficiently close to one another, so that an accidental hole in the fabric cannot pass between without meeting them. The cross-bar *b* is so inclined, and the contact-fingers so balanced, that any of the contact-fingers *c* will, when the fabric is not in contact therewith, by its own weight lie with its head bearing on the conductor *e*, as shown in Fig. 2. In this position it connects the two conductors, and the current then passes from one conductor to the other and acts on an electro-magnet which stops the loom by known means. When the fabric in a sound state presses upon the contact-fingers *c* (Fig. 1), the light pressure exercised by the fabric on the lower rounded ends of the contact-fingers keeps the fingers out of contact with the conductor *e*, and the loom can continue operating. (*Accepted November* 1, 1911.)

THE END OF THE NINETY-SECOND VOLUME.

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